Fraunhofer
INT

FRAUNHOFER INSTITUTE FOR TECHNOLOGICAL TREND ANALYSIS INT

ANNUAL REPORT 2018

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ANNUAL REPORT 2018

FOREWORD

Dear Reader,

In 2018, Digitization, Artificial Intelligence, Genetic Engineering, Human Enhancement and a few other technological buzzwords – repeatedly prominent in the media – have had a decisive effect on discussions on further developments in technology and society.

The spectrum of opinions ranges from, at one end, blissful utopias where technology enables paradisiacal states, while at the other, dystopian scenarios portray humankind suffering under the yoke of the unfettered products of its technological developments.

As in all such cases, the truth lies between the two extremes. No matter what specific technology is involved, at least this much can be said: nothing just happens to us, none of this is natural. And above all, technologies are not our gods; they are our tools, created to serve people, to make life better, safer, more pleasant.

This also means that technologies only dominate us and our lives insofar as we allow them to. For example, the artificial intelligences currently under such intense discussion – doubtless superior to humans in such areas as pattern recognition, the numerical solution of complex tasks or the continuous, long term monitoring of measured values – will only take such decisions that we delegate to them. This is the point where we have to consider carefully just how much autonomy we are willing to give up, what we gain by it, and what price we pay for it.

At first sight from this perspective, there is little reason for dystopian alarmism. Instead, what is called for is a rationally-based optimistic view that technologies will help us solve the pressing problems of an ever-increasing global population, of the changing climate and of human intervention in ecosystems.

At the same time, however, it is absolutely clear that every new development also involves negative aspects that have to be recognized and evaluated even before they occur. It turns out that precisely the »new« technologies hold the potential for achieving global effects in a relatively short time. The uncontrolled release of nanoparticles into the environment or the alteration of evolution through germ line intervention could have significant consequences which may indeed threaten our very existence.

Here again, one basic remark stands out: there is no natural masterplan which delimits our development of a particular technology. We ought to (must!) take the time to think about the effects of new developments and to establish mechanisms that counteract their negative side effects. Man's wellbeing can be the only yardstick for this, and that on a global scale. Following Kant, a categorically imperative formulation would be: Only ever develop those technologies that you would also like others to be able to develop.

This will not completely eliminate the risks, but at least the attempt to minimize them is worth every effort.

For more than 40 years, Fraunhofer INT has been working to deliver science-based statements on the development and impact of advanced technologies.

As every year, we have tried to compile in this annual report an excerpt from our work, to give you an overview of the Institute's extensive research portfolio.

While reading, I wish you plenty of pleasure and inspiration, and a good dose of optimism for your own look at the (technological) future.

Best wishes,

Prof. Dr. Dr. Michael Lauster

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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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FRAUNHOFER INT FACTS AND FIGURES

Staff

Permanent staff numbers at INT in 2018 were approximately at the level of previous years. At the end of the year, we employed 109 people, of which 99.4 were full-time equivalents. Of these, 59 were scientists (55.5 full-time equivalents). 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 students 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, while the investment budget concerns the procurement of capital goods such as scientific apparatus and technical equipment. The operating budget in 2018 only rose slightly to € 9.5 million.

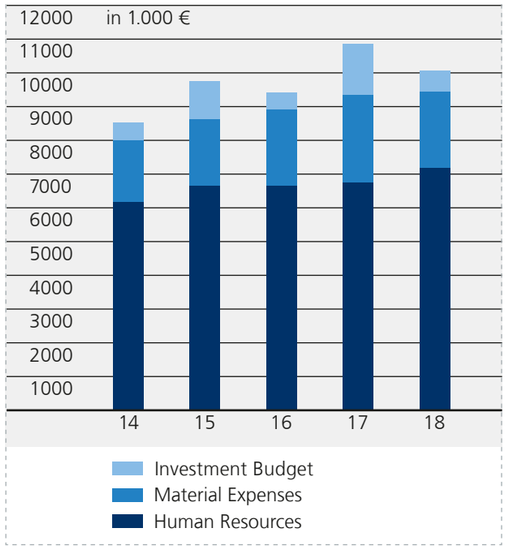
Together with investments totaling € 562,000, the total budget amounted to € 10 million. Currently under construction is an experiment hall, an investment of approx. € 1.5 million. This is again another significant expansion of the Institute's experiment capacity.

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 and Länder 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 SMEs to DAX-30 groups, and also include associations and international organizations.

In the public sector, Fraunhofer INT has provided BMVg – the largest client for the Euskirchen research institute - with in-depth consultancy expertise in research and technology planning for 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 from 2014 – 2018



Die Finanzentwicklung im Zeitraum von 2014 – 2018

Personal	2016		2017		2018	
	Manned positions	People	Manned positions	People	Manned positions	People
Scientists	53.0	56	53.3	60	55.5	59
Graduates	23.8	24	24.0	24	24.0	25
Technicians, Others	14.8	18	14.0	17	16.0	18
Assistants, Trainees	4.6	20	6.6	15	3.9	7
Gesamt	**96.2**	**118**	**100.9**	**116**	**99.4**	**109**

Budget in 1000 €	**2014**	**2015**	**2016**	**2017**	**2018**
Expenses					
Operating Budget	8027.6	8643.4	8914.7	9312.3	9509.3
of which Human Resources	6189.4	6660.5	6760.7	6858.3	7231.5
of which Material Expenses	1838.2	1982.9	2154.0	2454.0	2277.8
Investitionshaushalt	514.2	1116.2	549.4	1515.5	561.9
Total	**8541.8**	**9759.6**	**9496.1**	**10826.8**	**10071.2**
Funding					
Basic Funding	5405.8	5233.6	6004.9	5151.9	5862.3
Contract Research Projects	3136.0	4526.0	3459.2	5674.9	4208.9

ADVISORY BOARD

1

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, Institute supervisor by the 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; formerly Fraunhofer-Vorstand
- Sir Prof. Dr. Dr. Axel Zweck; VDI Technologiezentrum

1 *Advisory Board Meeting on June 14, 2018*

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 26,600 staff are qualified scientists and engineers, who work with an annual research budget of 2.6 billion euros. Of this sum, 2.2 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

1

The Fraunhofer Group for Defense and Security VVS creates 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.

The group 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 member institutes.

Fraunhofer Experts present »Grand Defense-Technological Challenges« for Europe post 2020

Inspired by the »grand societal challenges for Europe« of the EU's Framework Programme for Research and Innovation – Horizon 2020, the Fraunhofer VVS proposes to commonly identify »Grand Defense-Technological Challenges« for Europe post 2020. The position paper was presented to key stakeholders of the European Commission and the German government during an event in Brussels on November 8th.

From a technological point of view, the Fraunhofer VVS has identified seven grand challenges that are expected to become major technological drivers for the strategic autonomy of Europe and European industrial leadership in the area of defense. They should provide guidance and priorities for the programming of the research window of the upcoming European Defence Fund – EDF.

The Fraunhofer Group proposes to set the following seven »Grand Defense-Technological Challenges« as priorities for the defense research of the EU post 2020:

1. Artificial Intelligence and Autonomy
2. Digital Battlefield
3. Quantum Technologies for Defense Applications
4. Advanced Radar Technologies
5. Power Supply and Efficiency
6. Next-Generation Effectors
7. Human Performance Enhancement

The full paper can be downloaded via:
www.vvs.fraunhofer.de

VVS 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

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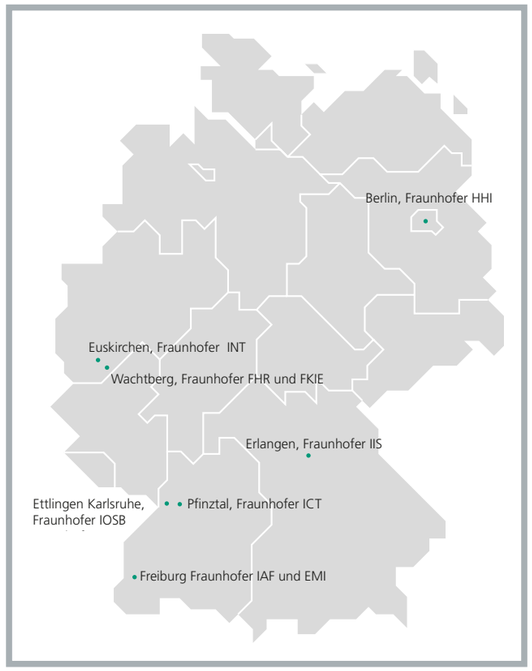
- Fraunhofer Institute for Chemical Technology ICT, Pfinztal
- Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR, Wachtberg
- Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE, Wachtberg
- Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut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

VVS 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*

INNOVATION IN 2030 – OPEN, DIGITAL, SYSTEMIC

How will we do research in the future? The Fraunhofer Group for Innovation Research, consisting of five institutes – Fraunhofer IAO, IMW, INT, IRB and ISI – has dealt with this question. The group has condensed its results into five theses and published them in the Fraunhofer Paper »Understanding Change – Shaping the Future – Impulses for the Future of Innovation«.

It was unveiled on 30th May 2018 to representatives from industry, politics, science and society. It is predicted that innovation will take place more and more outside industrial R&D departments. Complex value chains and digitization pose the greatest challenges. Knowledge will be freely available and a broad spectrum of actors will participate in innovation processes.

During the event Prof. Reimund Neugebauer, President of the Fraunhofer-Gesellschaft, drew attention to the complex challenges: »It is important to develop cross-sector application contexts and to think about new business models from the demand side«.

Prof. Wilhelm Bauer, Managing Director of the Fraunhofer IAO, added: »In our paper we have derived concrete tasks for business, politics, science and society. So every company today should already create a framework for action«.

Here are the five theses on innovation in 2030 at a glance:

1.
»In 2030, openness, the ability to learn and cooperation will be the guiding principles of innovation.«
Complex system transformations include social, technical and economic aspects. This is why innovation in 2030 can hardly be created in research and development departments isolated one from the other. It must be open, adaptive and cooperative beyond the boundaries of institutions and disciplines.

2.
»In 2030, integrated solutions will be the focus of innovation activities.«
2030, technology and user functions of innovations are often coordinated in early development phases. Individual companies can hardly achieve this because they are integrated into complex value creation networks. Innovation can only be economically successful in the long term if it takes place within user-centred and value-creating system.

3.
»In 2030, innovation processes will be fully digitalized.«
People will continue to be the central driving force behind innovation processes in the future. At the same time, the capabilities of artificial intelligence in 2030 will far exceed today's levels. For the development of products, services, processes and business models, it will therefore be important to optimally combine human creativity and computing power.

4.
»In 2030, knowledge will be open to all – the challenge will be to apply it profitably.«
»Open science« instead of an ivory tower: by 2030, publications, research data and software will be freely accessible with only a few exceptions. Innovation can be accelerated if relevant knowledge can be found purposefully by everyone – and if a broad base of actors actively participates in finding holistic solutions to the major societal challenges.

5.
»In 2030, Europe will enjoy unique global competitive advantages in terms of data security and sovereignty.«
In 2030 the digital transformation has led to profound structural changes in science, economy and society. Europe has seized the opportunities offered by this transformation and developed into the world's leading location in terms of data security and data sovereignty.

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- Fraunhofer Institute for Industrial Engineering IAO
- Fraunhofer Institute for Systems and Innovation Research ISI
- Fraunhofer Institute for Technological Trend Analysis INT
- Fraunhofer Information Center for Planning and Building IRB
- Fraunhofer Center for International Management and Knowledge Economy IMW
- Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB

Guest Institutes

- Fraunhofer Institute for Integrated Circuits IIS, Erlangen
- Fraunhofer Institute for Microstructure of Materials and Systems IMWS

BUSINESS UNIT »DEFENSE TECHNOLOGY FORESIGHT – WZA«

Hans-Martin Pastuszka

The Business Unit »Defense Technology Foresight (WZA)« conducts long term, technology-oriented future research (technology foresight) for public sector clients in the field of defense. The unit's institutional mission is to operate technology radar for the Federal Ministry of Defence (BMVg) and the Bundeswehr, and to provide evidence-based, technology-oriented decision support for the clients' strategic planning processes. For BMVg and the Bundeswehr, WZA is also an important information broker on findings from technology-oriented foresight research, and it ensures a continuous transfer of knowledge in this regard. It also serves international clients, such as the European Defence Agency and NATO.

For its clients, the Business Unit's interdisciplinary research into the future contributes to securing reliable knowledge for orientation and making decisions about likely future developments in science and technology and their potential military implications. In particular, this includes the early detection of emerging technologies as well as assessing technologies with regard to their risks and opportunities for defense.

WZA thus contributes to ensuring a broad-based competence for the client in analyzing and assessing long term technological developments and their potential relevance in global defense technology.

WZA's core product remains the »Defense Technologies Forecast (Wehrtechnische Vorausschau – WTV)«, which is compiled quarterly for BMVg and the Bundeswehr. In 2018, the Business Unit conducted a total of 13 analyses and updates on selected technology themes and long term system concepts for WTV, and ran – together with the client - the six-monthly workshops on the results and recommendations concerned.

The circle of WTV's civilian users grew again: as well as the Federal Criminal Police Office (Bundeskriminalamt – BKA), the Federal Office of Civil Protection and Disaster Assistance (Bundesamt für Bevölkerungsschutz und Katastrophenhilfe – BBK), and the Bundeswehr's central non-military IT service provider (Bundesgesellschaft BWI GmbH), the Federal Office for Materials Research and Testing (Bundesanstalt für Materialforschung- und Prüfung now receives a special WTV edition. Likewise, WTV goes to the Royal Netherlands Army in line with a bilateral agreement with BMVg.

As the client's long term technology foresight paper, WTV was also a key topic launcher for an activity headed »FuT-Vorausschau (R&T Forecast)«. This BMVg mandate is conceived to encompass all long term future issues currently identified in the widest range of BMVg and Bundeswehr activities – including BMVg-funded research institutes – summarized annually for BMVg in the »FuT-Zukunftslagebild (Future R&T Situation View)«. This was realized in the first Future F&T Situation Conference (FuT-Zukunftslagekonferenz), staged on 27-28 February. Conducted at Fraunhofer INT on behalf of and chaired by BMVg's R&T Director, 70 participants attended (see detailed report following p. 44). In the past year, brief technology analyses were conducted on selected topics in line with the continued mandate from the Swedish Defence Administration (FMV).

For the Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support (BAAINBw), an accompanying technology analysis for the METEOR guided missile was started. Under the direction of the Business Unit CTF, significant cross-departmental contributions were made to the future study task »Space 2040 (Raumfahrt 2040)«.

WZA's teaching and committee work includes in particular technical support for the Bundeswehr Staff College (Führungsakademie der Bundeswehr). For the fifth successive year, WZA contributed to the in-depth module »Methods of Analyzing the Future (Methoden der Zukunftsanalyse)«, with talks on both Defence Technology Foresight and WTV, as well as on the method of the »Disruptive Technology Assessment Game«.

Presentations on WZA and WTV were also in demand in the in-depth module »Future Development (Zukunftsentwicklung)« and in the national General Staff Course. Other teaching activities concerned the technical design of courses on »Methods of Analyzing the Future« at the universities of Bonn-Rhein / Sieg and Ravensburg-Weingarten. In addition, WZA continued its work in co-shaping NATO's »Science for Peace and Security« program through expert reviews for its »Independent Scientific Evaluation Group«. More than 30 research applications were assessed.

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

Dr. Sonja Grigoleit

TIP, the Business Unit »Technology and Innovation Planning for the Public Sector«, shapes strategic research and innovation planning for public sector clients such as the European institutions and authorities, as well as for national public bodies. Services range from consulting on research agendas at national and European level, to writing strategic plans for skills development in public bodies and authorities.

Thematically, the Business Unit's main focus is on technology and innovation planning in a variety of application fields. Areas outside defense research are now playing an ever increasing role, such as in demand-driven technology transfers to rural areas.

TIP offers its clients a wide range of methods for innovation and technology management:

- Needs assessment using participatory methods
- Analysis of possible (future) technological and non-technological solutions
  - Technology screening / monitoring
  - Taking account of organizational, social and political factors
- Developing research roadmaps for political policy-makers
- Writing innovation roadmaps for end users
- Developing critical success factors and key performance indicators for evaluating new technologies in tests and demonstrations
- Further developing and adapting knowledge transfer methods in order to set up cooperations and networks.

The main task for TIP is security research, where together with its European partners, it is developing innovative solutions in cross-border crisis management, innovation planning and resilience management.

In the EU project IN-PREP (an Integrated next generation PREParedness programme for improving effective inter-organizational response capacity in complex environments of disasters and causes of crises, duration term 2017 – 2020), TIP's work includes assessing end user requirements, evaluating tests and demonstrations for the platform under development, and writing a handbook on cross-border cooperation in crisis situations.

For the *Fire & Rescue Innovation Network* **FIRE-IN**, a project running from 2017 to 2022, TIP is supporting an international network of fire services and other first responders in their innovation planning methodology.

SmartResilience, running from 2016 to 2019, concerns itself with the resilience of critical infrastructures in smart cities – cities whose infrastructures have already reached high levels of digitization and networking. For this program, TIP is analyzing existing approaches for measuring resilience, describing legal and organizational frameworks, and heading a work package on the challenges of smart technologies and infrastructures.

The project **ResiStand** (*increasing disaster Resilience by establishing a sustainable process to support Standardisation of technologies and services*), running from 2016 to 2018, has the goal of promoting standardization and innovation in resilience. It proposes new standards, offers clearer explanations of the potential for standards, and is developing a sustainable process for effectively standardizing new resilience solutions.

For DG ECHO, TIP is collaborating with the consultancy firm Ecorys on the implementation of a **peer review** of crisis management systems in six states that have signed up to the EU disaster protection procedure. In 2018, this already included the Republic of North Macedonia, Cyprus and Tunisia. TIP's task is the scientific monitoring of the process.

In national security research, TIP is working together with the **Federal Agency for Technical Relief** (Technisches Hilfswerk – THW), to conceptualize a research and innovation planning process in a first step, and then to implement it in the future.

Parallel to these main activities, TIP also deals with social aspects of security and new technologies. In this context, TIP analyzes and tests methods for the transfer of knowledge for the *EU Network of Excellence* **SOURCE** – *Virtual centre of excellence for research support and coordination on societal security* (running time 2014-2018).

Outside the realm of security research is the BMBF project »**Horizonte erweitern – Perspektiven ändern** (Widening horizons – changing prospects)«, which is running from 2017 to 2020. The concept is to develop strategies for promoting the transfer of the results of scientific research to rural areas. TIP's task is to generate a demand-driven technology forecast, which includes surveying the needs of rural players, scouting out tailor-made technology solutions for rural areas, and deriving transfer strategies and action packages.

The Business Unit also provides an expert analyst for the NATO Science for Peace and Security Program, and it represents the Fraunhofer Group for Defense and Security (VVS) in the Security and Defense Research Working Group at the *European Association for Research and Technology Organisations* (EARTO).

In addition, TIP is active in the Fraunhofer EU Network, the Fraunhofer Group for Innovation Research, the Innovation Cluster on Civil Security Research »InCluSiF«, the innovation network »LAND: LEBEN: ZUKUNFT (LAND: LIFE: FUTURE)«, and is also a consultant for large scale research projects.

BUSINESS UNIT »CORPORATE TECHNOLOGY FORESIGHT – CTF«

Dr. Anna Schulte

Strategic foresight procedures that assume clear predictions are no longer enough to make technology-intensive organizations resilient to an uncertain future. Relationships between widely varying technological, social, economic or political spheres are just too complex. At the same time, in both scientific landscape and media, the information flood is increasing. Against this background, robust preparation for the future calls for a systematic, scientifically-founded analysis of these different fields of influence, combined with the comprehensive, structured capture and analysis of the technical information concerned. The Business Unit Corporate Technology Foresight CTF supports organizations in their search for answers to strategic questions.

Our focus is on technology-oriented research into innovation and the future, and we look back on many years of experience in technology foresight and strategic planning. To take account of a wider range of relevant aspects, for example in business or society, we cooperate with top-range partners. With the backing of customer-specific analyses and methods for technology-oriented research into the future, the short range perspective of 3 to 5 years often already found in companies is extended by a long range perspective of 5 to 20 years.

These analyses can show up and assess future technologies relevant to a company, highlight technical white spots, or break down complex technology areas and their implications for an enterprise. This is information which can be used to lay a scientific foundation for developing long term technology strategies.

Projects

Space Flight 2040 – a Forecast

As part of the project Space Flight 2040, Fraunhofer INT and IMW have developed and used a novel, science-based approach to writing a forecast. The project is for Space Management at the German Aerospace Center (DLR), with funding from The Federal Ministry for Economic Affairs and Energy (BMWi).

The procedure involved creating scenarios and backcasting methods, various technological analyses in the form of a technology foresight, in-depth socio-scientific analyses and various group discussion formats.

A one-year project, these were the key issues:

1. Which socio-economic trends and developments can influence German space flight development up to the year 2040?
2. What technological trends and developments can be expected within and outside the space industry between now and 2040?
3. Which scenarios can be derived? Which future roles for German space flight arise from these scenarios?
4. Which medium and long term objectives can be derived from this?
5. Which possible scenario-robust action options arise for DLR space management?

The process made it possible to derive extensive strategic options for action, and this supports space management in developing its own strategy. Finally, the result also produced a future vision of Germany's space industry in the year 2040.

Research Project »Berlin Waste Management Services (BSR) 2030+«

What will Berlin look like in 2030 and beyond? What are the tasks, opportunities and challenges for BSR as a city company? How can BSR prepare itself, what can BSR already start doing today? To deal with these questions, Fraunhofer INT and Fraunhofer IAO|CeRRI designed a participatory development process for aligning BSR long term with the time horizon 2030+. As part of the project, Fraunhofer INT conducted a technology foresight process to identify technological developments and changes relevant to BSR's context.

First, a capability-pull analysis captured the technological requirements of BSR and its core processes. Subsequently, a technology push analysis identified relevant technologies. This examined the impact of a technology on BSR's tasks, when BSR could acquire such a technology on the market, and which players are driving development forward. Fraunhofer INT also passed on to BSR a recommendation about which technology deserved further consideration.

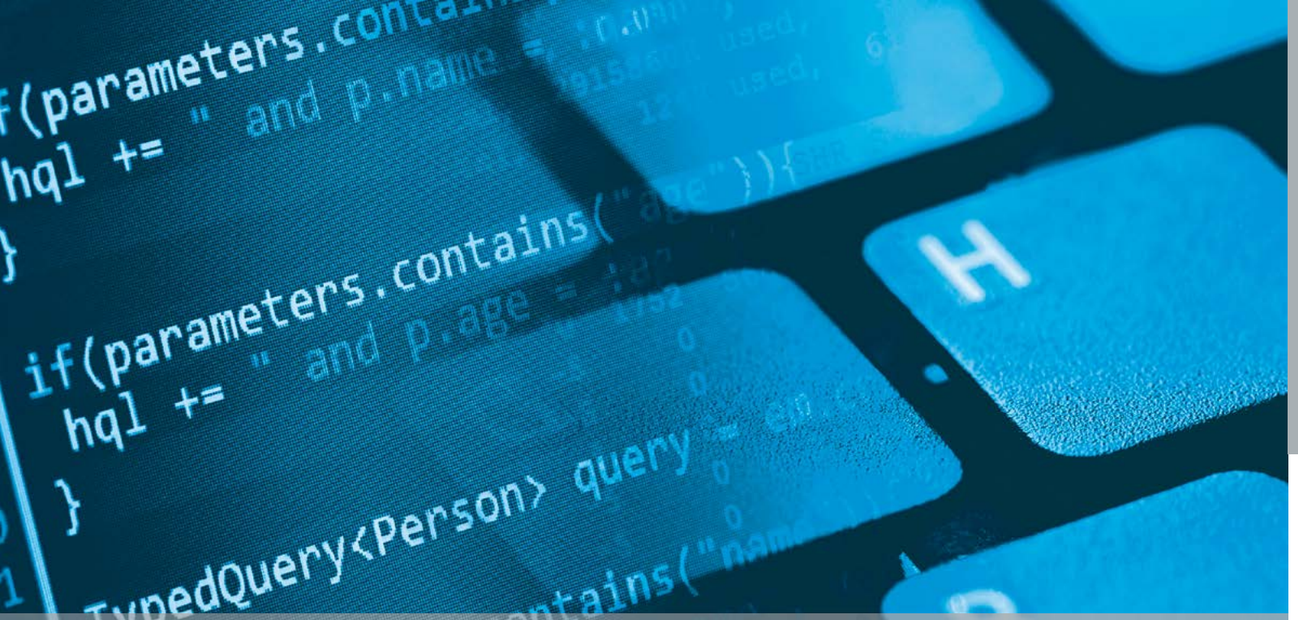
The result based on these criteria was a prioritized technology portfolio that supports BSR in strategically planning its products and technology.

Consultancy Project »Future Business Areas and Strategic Market Orientation for the ELIN GmbH«

ELIN GmbH is a limited liability company which markets individual solutions for the electrical engineering spectrum, with a focus on the power supply to buildings and infrastructures (such as airports, hospitals, sports stadiums). Services range from individual planning and conception, through procurement to the installation and commissioning of each solution concerned.

As part of ELIN's plans to expand the service range and to move into new markets – especially in the industrial area – the project asked in which type of sectors ELIN wants to become more involved. In industrial automation, for example, higher reliability demands can be expected than is the case for the current core business. There is also a need to build up know-how for the requirements in specific industrial branches, which in turn calls for corresponding investment.

Based on systematic research work and the analysis of a large number of public and non-public sources, Fraunhofer INT has pre-assessed the most promising sectors, and by using multi-criteria decision-making methods, paved the way for decisions at full management board level. Results were presented to the management board in a workshop, so that the managers can draw on the newfound knowledge and work towards a concrete market strategy.



GROUP »TOOLS AND METHODS«

Dr. Miloš Jovanović

In his 1966 book »The Psychology of Science: A Reconnaissance«, the psychologist Abraham Maslow wrote that it was tempting to treat everything as a nail if the only available tool was a hammer. Avoiding just such blind-alley thinking is what drives the group »Tools and Methods TM«. Their task: analyzing and developing a variety of tools (hammers included) to enable the Department TASP not just to bang in nails, but also to solve other challenges. From time to time, TM members themselves »hold the hammer« in research projects.

Of course, »hammer« is just a symbol for »Tools and Methods«, while the »nails« represent the variety of tasks and challenges that need to be addressed and solved in research projects.

To fulfill their missions, TM members participate in research projects of Fraunhofer INT's business units, review the literature on methods and tools, and actively continue to develop their own IT tools. TM members also run workshops and other exchange formats with agendas on new tools and methods, to give departmental and institute colleagues a discussion platform and greater understanding. Here are a few highlights that emerged over the past year in the TM Group and in cooperation with the business units.

Example Projects with TM Participation

TM's daily work involves acting in various projects in the business units – cooperation that comes about either on request from the business units or on the suggestion of TM itself. Support from TM is not only a matter of method, but where suitable and sensible, it also draws on TM's expertise in a specific subject.

Several TM members took part in the project Microelectronics Innovation Enhancement (**FRAME**), where currently the group is heading the module »Foresight and Roadmaps«. Further details on the FRAME project are given in the separate article in this Annual Report.

Several contributions came from TM for the project **Foresight Fraunhofer**. The project, being carried out jointly with other Fraunhofer institutes, compiled a list of 51 future topics in 2018. Called »spotlights«, these topics were assessed by approx. 400 Fraunhofer experts from the entire Fraunhofer Gesellschaft. TM listed up the topics already developed in earlier Institute projects, and then made a selection jointly with other Institute representatives. To make it easy to retrieve topics for future projects, the group continued listing them systematically in the internal Information Platform New Technologies (IPNT).

More »**country reports**« were compiled for the Business Unit WZA, methodologically using source material collection and analysis. In 2018, reports were completed for both France and Australia.

Internal Developments at TM

The Department TASP continued to add content to the Information Platform New Technologies (**IPNT**), while TM did preparatory work for improving IPNT's performance, system and efficiency. On the agenda is also the implementation of new features such as meaningful visualizations and other analysis options.

Also important last year was TM's emphasis on ongoing development work on **KATI**, the research and analysis tool **Knowledge Analytics for Technology & Innovation**. Part of this project – funded until the end of 2019 – was the implementation of new analysis and visualization options, such as the analysis of cooperation networks at the level of Germany's federal Länder.

Another focal point was exploiting new data sources, including economic data from the World Bank. Of major importance in 2018 was the transitioning of the system, together with Central IT, to new, high-performance servers. At the same time, Elasticsearch integrated a new, even more powerful search engine into the system. For KATI, both have resulted in much improved performance.

Other TM Activity

One of TM's permanent tasks in 2018 was again maintaining the in-house Wikis, which are used for various purposes such as documentation, communication and project management. This also involved updating the wiki software and maintaining user accounts, as well as periodically tidying up and redesigning each area. The wikis are also an important pillar for **Knowledge Management** in the Department.

The **Method Forum**, jointly organized with the Staff Position »Training and Methodology«, was held three times in 2018. The topics were »Quantitative and Qualitative Methods of Social Research«, »Methods from Seminars on Leadership «, and »Data-Driven Foresight – Technology Foresight in the Age of Big and Linked Data. A Workshop Report«. The titles illustrate the broad range of tools and methods that the group employs. For the business units, the Method Forum is an important communication channel for discussing and trying out new methods.

BUSINESS UNIT »NUCLEAR SECURITY POLICY AND DETECTION TECHNIQUES – NSD«

Dr. Theo Köble

The Business Unit »Nuclear Security Policy and Detection Techniques (NSD)« conducts theoretical and experimental research in 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 several neutron generators (14 MeV and 2.5 MeV) and two isotope laboratories. A large variety of radioactive radiation measuring instruments, especially for use in on-site measurement, is available for testing and comparison.

In the area of nuclear disarmament and possible proliferation, NSD continuously observes political and technological developments, looking especially from the physical-technical perspective. The Business Unit is collaborating with ESARDA (European Safeguards Research and Development Association) and INMM (Institute of Nuclear Materials Management), and participates in technical preparation work for the Comprehensive Nuclear Test Ban Treaty (CTBT). NSD is also a partner in international projects concerned with CBRNE.

Highlights

In the EU-Horizon 2020 project C-BORD, the Institute and a variety of European partners developed improved strategies and equipment for the efficient control of containers that carry bulk goods. The consortium partners in this large-scale EU project continued development work on various inspection systems for the primary and secondary inspection lines, as well as on their integration into one overall system and their verification in field tests. This takes account of requirements at major sea ports and at smaller and medium-sized container terminals – at inland ports, for example.

NSD took part in several work packages, leading the work package on the detailed assessment of technical solutions and of the whole system (see p. 34).

Within the EU DG Home Project ITRAP+10 Phase 2, a reference laboratory was assembled at Fraunhofer INT, for calibrating radiation gauges used for detecting the illegal transport of radioactive and nuclear substances. As part of this project, two measurement test systems were developed and set up: one for static, and one for dynamic measurements. INT is thus participating together with several European partners, in a round robin experiment in which different measuring instruments are tested in compliance with common standards.

As part of FORKA, the research program on decommissioning nuclear facilities funded by BMBF, the Federal Ministry of Education and Research, NSD is participating in the QUANTOM project, in a consortium that is developing a drum measuring plant for the material description of radioactive waste in 200 l waste drums. The Business Unit is cooperating with the partners Framatome GmbH and the Aachen Institute for Nuclear Training GmbH. NSD's task in the project is focusing on online and offline neutron measurement. As part of the project, the drum measuring system is to be developed, assembled and tested.

Investigations into alternative materials for neutron detection continued. Among other things, a novel neutron detector which uses an alternative material to the commonly-used helium-3 was found to be basically suitable for measurements on location.

In addition, as part of an ongoing doctoral thesis, fundamental research is being conducted on detector systems with novel detection materials.

The Business Unit took part in the 4. International Symposium on the Development of CBRN Protection Capabilities held by the German Society for Military Technology (DWT) from 3 to 5 September. NSD mounted an exhibition stand, gave a talk and presented the DeGen measuring vehicle. The stand staged a demonstration of the setup for static tests which had been developed as part of the ITRAP+10 Phase 2 Project. The talk addressed the qualification possibilities of measuring systems in accordance with standards. Also presented were the capabilities of Fraunhofer INT's measuring vehicle for the highly sensitive detection of neutron and gamma radiation.

The Business Unit also participated in the work of the International Atomic Energy Agency (IAEA). In IAEA's Technical Meeting on Modern Neutron Detection, this included the report on the possibilities of substituting helium-3 with other detection materials in neutron detection systems. An NSD staff member also acted as an expert on the revision of the document »IAEA Nuclear Security Series No. 1, Technical Guidance, Technical and functional Specifications for Border Monitoring Equipment«.

NSD continues its involvement in standards for radiation measuring devices, nationally in DIN/VDE, and internationally in the corresponding IEC body. A particular task is the supervision of illicit trafficking standards, which define the requirements for radiation detection systems at border crossings or similar checkpoints.

BUSINESS UNIT »ELECTROMAGNETIC EFFECTS AND THREATS – EME«

Dr. Michael Suhrke

With basic funding from the Federal Ministry of Defence (BMVg), the Business Unit Electromagnetic Effects and Threats (EME) is tasked with developing the capacity to evaluate electromagnetic effects in the case of a military threat. As there are limits for this task in BMVg itself, EME conducts its own theoretical and experimental research in consultation with the Ministry and in cooperation with the defense industry. This includes work on further developments in measurement technology. Over and above basic-funded research and contract research projects for BMVg, commissions from non-defense clients (civil security research) and industrial projects are also important.

The Unit's experimental work on electromagnetic threats, especially from High Power Microwaves – HPM, includes investigations into the coupling of electromagnetic fields into 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, especially on wired and wireless data transmission technology (network engineering), to civilian communications and components of critical infrastructure. Basic research and experimental work also continues on detection methods for electromagnetic threats, in particular from HPM.

The unit has developed its own TEM waveguide (Transverse Electromagnetic Mode), housed in a hall shielded against 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 interference susceptibility with constant and pulsed fields of strengths up to several kilovolts per meter (kV/m) on objects up to several square meters in size. For measurement work outside the Institute, EME has also developed 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 high-energy reverberation chamber for generating even higher field strengths in the Gigahertz range, to reflect the growing number of applications in modern sensor and communications technology in these frequency ranges. Additionally available are a small anechoic chamber and extensive high frequency and microwave measurement instruments.

As part of the research conducted for BMVg, work continued 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 continued into the generation dependence of HPEM susceptibility in electronics. In addition, a study analyzed interference susceptibility in sensors.

As part of a Technical Agreement on the Development of High Power Microwave Test Methodology and Procedures, cooperation with FOI in Sweden continued in HPEM test methodology. EME also concluded a further WIS project to procure a narrow band Magnetron source with pulse outputs in the megawatt range for field investigation work.

Work also continued in 2018 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«. EME is in particular working here on investigations into HPEM susceptibility for Unmanned Aerial Vehicles and Systems (UAV / UAS). Additionally, preparations were made for the 2019 RF-DEW Capability Demonstration at the NATO Missile Firing Installation (NAMFI) on Crete.

Results from counter-UAS investigations with HPEM materials, carried out jointly with WIS Munster, appeared in the Annual Report »Wehrwissenschaftliche Forschung 2017« and were presented at the symposium EME 2018 in Greding.

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. In 2018, the EU Commission approved the financing of the ETN Marie Curie project »Pan-European Training, Research and Education Networks on Electromagnetic Risk Management – PETER«, in which EME is one of 19 project partners.

EME is also broadly active in standardization. This includes the DIN working groups TEM Waveguide and Reverb Chamber, the VG (German defense equipment) standards boards on NEMP and lightning protection, and on electromagnetic compatibility. The Unit is also 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 previous group.

In EME last year, work continued on a doctorate on the HPEM vulnerability of the Smart Grid. Results on the HPEM sensitivity of various protection devices and communication units for the automation of switchboards were presented at the 2018 EMC Europe conference in Amsterdam.

BUSINESS UNIT »NUCLEAR EFFECTS IN ELECTRONICS AND OPTICS – NEO«

Dr. Jochen Kuhnhenn

Fraunhofer INT's Business Unit 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 curing, 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, again for example on satellites. In addition, NEO has the latest available technology for measuring even the smallest changes in parameter characteristics.

Much of the work in 2018 centered on Single Event Effects (SEE). There was wider investigation of neutron-induced SEEs in power components, with various effects on international neutron sources being measured in order to develop efficient and reliable test methods, for example.

Further SEE investigation projects were tests with neutrons at INT, with high-energy protons at the Paul Scherrer Institute in Switzerland, and with heavy ions at the Université Catholique de Louvain in Belgium. Here, complex commercial electronic systems were qualified for use in space.

In the area of the accumulated impact of radiation effects, research was conducted for various international partners in 2018. One example is a number of high-power laser diodes, for which new measuring stands were developed that permit the largely automated detection of optical and electrical parameters during characterization. Based on studies of the effect of radiation on optical fibers at extremely low temperatures, electronic components were also measured for the first time at less than 20 K during irradiation.

In 2018, NEO appeared at several international conferences and fairs with its own stands, in part with the support of Fraunhofer Space Alliance. At the International Astronautical Congress (IAC), NEO was present at the joint Space Alliance stand, and also gave two talks. In addition, lectures were given at the International Conference for Space Optics (ICSO), where NEO also mounted its own exhibition stand. Other appearances were at the International Aerospace Exhibition (ILA) in Berlin, and at the conference Radiation Effects on Components and Systems (RADECS). For the first time, NEO had a presentation stand at ESA's 2018 Industry Space Days.

In cooperation with the Institute of Nuclear Physics at the University of Cologne, research work began for a doctorate that involves developing new methods of single particle effects in special power components. The focus is on the use of modern gallium nitrite (GaN) components. In 2018, several campaigns were carried out on accelerators in England, Switzerland and France. Particularly important in this context is the comparison of varying particle types at the different accelerators.

In order to be efficient in qualifying components for their sensitivity to atmospheric neutrons, it is necessary to understand how to compare test results from spallation sources with results from single energy accelerators. These spallation sources emulate the neutron spectrum and thus provide an excellent simulation of the effect – but there are only few facilities of this kind in the world. If it were possible to compare the results with conventional accelerators, a much larger number of test facilities would be usable.

After nine years, one of Fraunhofer INT's gamma irradiation facilities was fitted with a new emitter in 2018. This significantly increased the range of available dose rates, which particularly improved the conditions for irradiating larger objects or for achieving very high dose values.

SCIENTIFIC-TECHNICAL SUPPORT

Peter Clemens, Dr. Monika Risse

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

Development and Construction of a Source Vehicle

Portal monitors and other measuring facilities are used to protect against the smuggling of radioactive material at external borders and airports. In order to qualify the measuring systems used, appropriate test regulations have been established under the »Illicit Trafficking Radiation Detection Assessment Program + 10« (ITRAP+10, which has received EU funding under grant agreement No. HOME/2015/ISFP/AG/CBRN/4000008453.

These measurement regulations are based on ANSI and IEC standards. The goal for Phase II of the program was to qualify laboratories in Europe for such measurement work, and Fraunhofer INT's laboratories were upgraded within this framework.

Dynamic measurements are part of the qualification procedure. This involves the use of a remote-controlled vehicle which drives sources – with or without shielding, at different heights and specified speeds – past a measuring system under qualification test. This source vehicle was developed by the WTI working group for and in cooperation with the Business Unit Nuclear Security Policy and Detection Techniques (NSD).

Source vehicle mechanics were designed and built in WTI's mechanics workshop, where various containers for the different radioactive sources were also designed and manufactured.

WTI's electronics workshop was responsible for developing and constructing the control system. The Business Unit NSD itself provided the software for operation and remote control including monitoring and remote display.

Thanks to intensive cooperation and coordination, the project was successfully completed. The cooperation process was presented as part of the audit (QM – ISO9001) and successfully tested.

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

The Department Business Administration and Central Services is responsible for all commercial and administrative tasks, and also provides the Institute's 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 **Finance, Human Resources and Law** group is responsible for purchasing, book-keeping, accounting, controlling, human resources and travel and event management. In the year under review, a newly implemented quality management system was used to evaluate, improve and document commercial processes.

The **Central Infrastructure** Group deals with 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.

Marketing and Public Relations manages all necessary communications and marketing work for the products of INT's business units. In recent years, this group has also organized and coordinated the increasing number of INT appearances at key specialist and industrial fairs, such as at the Hannover Messe.

Predominant tasks for the **Library and Specialized Information Service** are procuring and managing the media that the Institute requires, and supporting the scientists in their research work and accessing information for them. Depending on project needs, licenses are acquired for further specialized databases and other information sources, which are then made available. To meet new requirements from public sponsors, the library service also advises and assists project teams with their publication work.

RESEARCH HIGHLIGHT-REPORTS 2018

HIGH POWER ELECTRO-MAGNETICS (HPEM) AS DEFENSE AGAINST DRONES

Unmanned aircraft systems represent a threat to military and civilian facilities. High power electromagnetic radiation could prove to be a promising alternative to other defense systems.

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EXPANDING HORIZONS

The Federal Ministry of Education and Research joint project »Widening Horizons – Changing Perspectives« is focusing on rural areas as active innovation drivers, new areas of research emerge, as well as new measures and strategies for successfully implementing technology in these areas.

C-BOARD: CONTROLLING CONTAINERS AT PORTS AND BORDERS

Fraunhofer INT and 17 partners from nine European countries were involved in developing a complex system for improved cargo container inspection.

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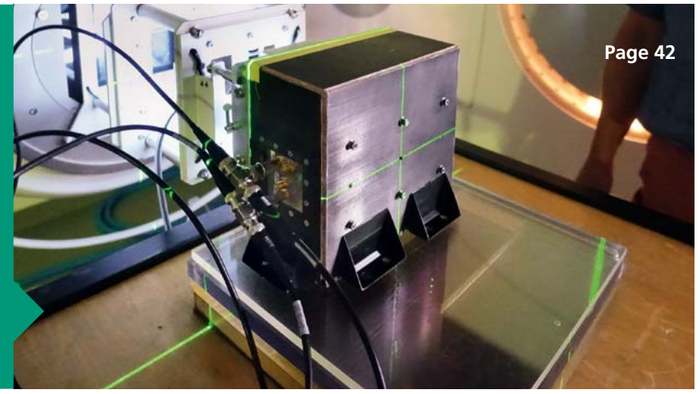
RAPRO

On behalf of ESA, several innovative multilayer systems for protecting electronics were designed, constructed and tested.



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FRAME

The project FRAME is underpinning the Research Fab Microelectronics Germany (FMD) management in setting up the FMD office, and its support with methodology and personnel is helping to ensure FMD's success.

1ST FUTURE RESEARCH AND TECHNOLOGY SITUATION CONFERENCE 2018

The Future R&T Situation Conference created the stage for bringing together the German MOD and all the Bundeswehr actors in defense R&T, which are engaged in identifying, analyzing and evaluating of future technology themes.

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EU HORIZON-2020-PROJECT C-BORD: CONTROLLING CONTAINERS AT PORTS AND BORDERS

Prof. Dr. Sebastian Chmel

Freight containers play a central role in global trade. Every year, millions of them cross the borders of Europe, on land and on water, and controlling this flow of goods is an immense challenge. Illegal and dangerous goods have to be identified. Seen against the background of omnipresent, recent terrorist activities, it is clear that smuggling weapons, explosives, harmful biological or chemical substances, or even nuclear material can lead to unpredictable, catastrophic consequences. Then again, the economic world calls for smoothly flowing goods traffic. This is why customs authorities worldwide are constantly working to improve inspection processes, with both technical and organizational innovations.

The joint European project C-BORD – Effective Container Inspection at BORDer Control Points – also served this purpose. The project, funded by the European Commission following a call for tenders in the Horizon 2020 Research Framework Programme's »Secure Societies« section, was successfully completed in December 2018. Fraunhofer INT and 17 partners from nine European countries – including the University of Bonn-Rhein-Sieg – were involved in developing a complex system for improved cargo container inspection. Not only universities and research institutes, but also customs authorities played an important role as consortium partners, which demonstrates the project's practical relevance.

Over a period of three and a half years, individual non-destructive detection technologies were further developed, tested and finally integrated into an overall system. This allows for combined interpretation of data, which generates more information through data fusion than is possible with separate analysis, as used to be the case. The whole thing can be operated via a special graphical user interface, into which elements for decision support have also been integrated.

New developments in five technology fields formed the basis of the C-BORD system:

1. Passive Radioactivity Detection using Portal Monitors

Improved detection and, above all, identification of radioactive material was the goal in further developing portal monitors with different detection techniques. The project succeeded in finding flexible, ad hoc, efficient and cost-effective solutions. Identification was a key factor for reducing false alarms triggered by naturally radioactive materials such as ceramics or fertilizers.

2. Improved X-ray Imaging

Significant improvements were also achieved in classical X-ray analysis. It was thus possible to reduce »mobile mode« image distortions which result when – instead of the container – the X-ray apparatus is itself moved to scan an image. Furthermore improvements were achieved in the area of material discrimination. With this discrimination objects can be distinguished, which are standing behind one another and therefore are overlaid on the X-ray image.

3. Rapid Re-locatable Tagged Neutron Inspection System

Somewhat more time-consuming, this particular neutron inspection process can be used as a second-line inspection in the case of a given suspicion. The system irradiates the container with neutrons, and the resultant gamma radiation gives information on the container's content. The ratio of carbon, nitrogen and oxygen can point up explosives, for example, or narcotics or cigarettes. New algorithms for material classification have been developed and successfully tested.

4. Photofission

As with the neutron process, photofission was designed for second-line inspection. The method helpfully uses the same linear accelerator as a high energy X-ray scanner. In contrast to X-ray imaging now only small suspect areas of the cargo container are irradiated, and then the particles, which are emitted as a consequence of the irradiation, are detected and analyzed. This can show up special nuclear materials, even when hidden behind a shielding.

5. Air Sample Analysis

This specially developed system sucks air samples from the cargo containers, and the samples are subsequently analyzed for volatile organic compounds. With machine learning, the system can be trained to recognize certain patterns of trace particles with the aim of identifying substances like drugs or explosives.

Fraunhofer INT's task in the C-BORD consortium was to coordinate the work package »Standards, Technology Assessment and System Validation«, and to contribute to radiation detection and neutron inspection in particular. Tasks for Fraunhofer INT scientists included participation in laboratory tests, using questionnaires, post-trial replays and interviews to provide feedback from end-users, preparing recommendations for future standardization, and analyzing the results from large-scale field trials. This produced a sound evaluation of each technological development and of the overall system.

The project culminated in three field tests in 2018. Each lasting two to three weeks, they were held in different environments in three countries: at the Röszke border crossing in Hungary, the Deep Water Container Terminal (DCT) in Gdansk, Poland, and at the Rotterdam Container Terminal in the Netherlands. It was even possible to integrate C-BORD technology into an existing tunnel that uses X-ray imaging for inspection. Using specially-prepared containers holding, for example, concealed radioactive sources, as well as commercial containers from daily operation, the detectors and the entire C-BORD system were subjected to realistic conditions.

Not all technologies had reached perfection, but great progress and some surprisingly good results were achieved in almost all areas. Even established techniques, as in detecting gamma and neutron radiation, showed clear improvements. A significant achievement was the integration of data into one system and in the clear presentation of different detection results in a unifying graphic user interface. The added value from data fusion became clearly apparent through the superimposition of X-ray and heatmap-like presentations of radioactive sources, which made it possible to locate problematic container contents rapidly – something much appreciated by the end-users. In a new process called threat-lensing, it was even possible to improve results of gamma radiation measurement by using information from the X-ray image.

In October 2018, project results and initial findings from the field trials were presented to a broader audience in a final workshop in Rotterdam. There was positive feedback in plenty.

»EXPANDING HORIZONS!« – DEMAND-ORIENTED TECHNOLOGY FORECAST FOR RURAL AREAS

Larissa Müller

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What shape should life in rural areas take in the future? What kind of local needs will people have, and how do we help policymakers address these needs? Scientists from Fraunhofer INT are working on these questions in »Widening Horizons – Changing Perspectives«, a project being conducted jointly with BMBF, the Federal Ministry of Education and Research.

By focusing on rural areas as active innovation drivers, new science research fields are emerging, as are new measures and strategies for successfully carrying technology to such areas. Running from March 2017 to February 2020, this joint project is being coordinated by the Fraunhofer IAO's Center for Responsible Research and Innovation (CeRRI). The client is the Federal Ministry of Education and Research. Other project partners are the Humboldt University Berlin, the Institute for Social Innovation e.V. (ISInova) and the Leibnitz Geographic Institute (IfL).

The Fraunhofer INT team focused on these questions:
Which technologies can help to realize the wanted future scenarios?
And on this basis, how can new innovation strategies and processes be derived for rural areas?

New Technologies for Rural Areas

In a first step, Fraunhofer CeRRI ran a thought leadership workshop to generate future scenarios that people in rural areas would wish for. Fraunhofer INT used these images of the future to identify technologies that can help translate the scenarios into reality. INT determined thematic options which were subsequently prioritized with the help of interviews with experts from the Fraunhofer-Gesellschaft.

The technology options were used to prepare workshops in three different model regions throughout Germany. To give participants a playful approach to the technologies, a cooperative, game-based format was developed to pinpoint what technology needs the residents have.

Workshop Schedule in the Model Regions

The workshops were held in three selected regions: Ilzer Land in Bavaria, Eiderstedt on the North Sea coast of Schleswig-Holstein, and the Werra-Meissner District in North Hesse. The interactive, playful way allowed the participants to superimpose future scenarios on well-known environments. Design-based methods were used to support the process, which allowed a region's future prospects to take account of demands on innovation and technological development.

On Day 1, workshop participants worked their way through three future task courses in the region concerned, with each course having four stages. This method made the courses tangible, something that the participants could negotiate their way through. Using »speculative artifacts«, participants explored the visions in their everyday environments (see Fig. 1). Then, with the help of a questionnaire and group presentations, they were able to consider what they experienced. The three future scenarios dealt with a variety of topics, from adaptive housing forms to new learning and educational cultures, from rethought logistics through to innovative working models. At each stage, the participants were confronted with different solutions; they discussed intelligent administration, the exploitation of regional values, or new community locations, for example.

On Day 2, the participants formed themselves into small groups for a »futures game«, where they devoted attention to their favorite ideas from the first day. Together, they picked out topics from the previous day, and used these topics as missions for the game. With the missions, the teams had to answer the question: What should local life look like in 2034? The playful approach turned the participants into designers of the future in their own region (see Fig. 2).

The participants' individual stances had a special impact in considering what was locally needed to achieve a successful conclusion of the mission. The teams contemplated concrete requirements and ideas for innovations, and they developed their own visions of their region's future. So the game let the participants themselves identify what steps could be taken, and they discussed solutions that they found to be missing.

The workshops closed with the teams presenting their visions of the future in a brief role play. Using specially-made props and a good portion of humor, they presented their ideas to the other participants and to representatives from politics and society in general.

Solutions for technology transfer between city and country

As a next step, the workshops will be evaluated so that tailor-made measures and technologies can be obtained for rural regions. Then result will be the basis for Fraunhofer INT to write a list of technologies based on the wishes in rural areas in the year 2034. Following that, expert teams will identify the critical technologies needed. Finally, lists of things-to-do will be put together for deciders in politics, regional developers, research strategists and managers in non-university research institutions. This is designed with the project's original goal in mind: an improved technology transfer between urban and rural areas, and the positioning of rural areas as drivers of innovation.

1 *A station of the future parcours*

2 *With the help of the »Futures Game«, the participants are designing the future of their own region*

HIGH POWER ELECTROMAGNETICS (HPEM) AS DEFENSE AGAINST DRONES

Marian Lanzrath, Christian Adami, Thorsten Pusch

1

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Because of their reconnaissance and payload capabilities – explosive devices for example – unmanned aircraft systems (UAS) represent a threat to military and civilian facilities. Given the increasing autonomy of UAS, effectors based on high power electromagnetic radiation (HPEM) could prove to be a promising alternative to other defense systems. Mainly developed for the civilian market, UAS electronics are designed only for the electromagnetic background levels permitted in public areas. Technical weapon systems that generate electromagnetic fields far beyond the limits of this legal protection framework can directly interfere with processes in on-board electronics.

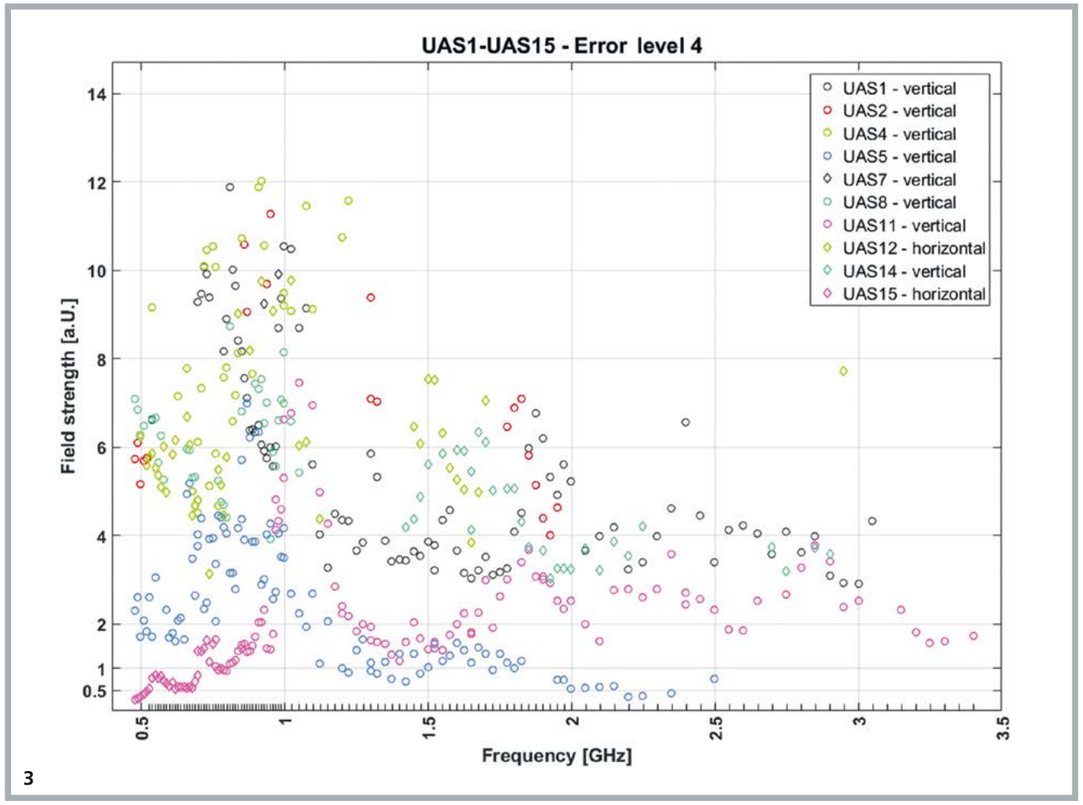
Recent years have seen a massive boom in the market for multi-rotor unmanned aerial vehicles, such as the quadrocopter. In particular, products weighing below 20 kilograms have arrived on the mass market and, for the untrained user, controllability has also been steadily enhanced in the last few years. Meanwhile, automation controls altitude, position and collision avoidance. More assistance systems are being used to execute flight maneuvers automatically; radio contact with the remote control unit is no longer necessary.

The combination of high accessibility for the layman, the capability of transporting larger payloads and greater freedom of movement through opening up airspace makes it possible to use UAS in various threat scenarios. As part of a research project initiated by the Bundeswehr Research Institute for Protective Technologies – ABC Protection (WIS), Fraunhofer INT conducted laboratory tests on a selection of 14 UAS types, to evaluate their sensitivity to electromagnetic interference (Fig. 1). The goal was to develop appropriate countermeasures on the basis of HPEM. In addition, free-field tests at WIS, using pulsed high-power magnetron sources, were able to form a basis for effectors with realistic operating ranges (Fig. 2).

To analyze HPEM sensitivity, a UAS test stand with video surveillance was set up in the laboratory, as well as a system for evaluating rotor speeds. The devices were tested either mechanically fixed in standby mode, or secured by cords and safety net in flight mode. These tests accurately recorded interference in the systems' operating processes, stretching over a wide range of individually controlled interference frequencies.

The UAS vehicles selected showed vulnerabilities to pulsed or continuous microwave signals over the entire frequency range studied, as shown in Fig. 3. The sensitivity thresholds determined, i. e. those electric field strengths which would cause a UAS in flight to crash, depended on the polarization of the waves, signal parameters such as the pulse-pause ratio, and the frequency. Free-field experiments at WIS showed that the impact of HPEM was reduced flight stability and crashes.

This is the basis for working out first approaches for the design of an effective system. The lowest disturbance thresholds were determined in those tests using continuous wave signals. However, for a long-range mobile device, pulsed microwave signals are more interesting because of the higher power output at the same energy level.



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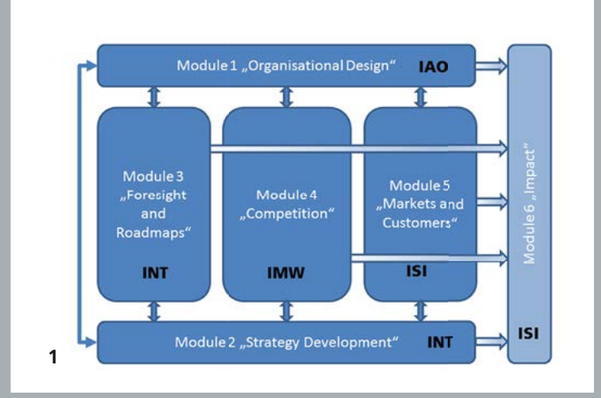
1 *Test apparatus in Fraunhofer INT's laboratory*

2 *Testing a long range mobile operating system under free-field conditions at WIS (Source: Bundeswehr Research Institute for Protective Technologies – ABC Protection (WIS))*

3 *Interaction results of all UAS types for the highest error class*

FRAME (FRAUNHOFER MICROELECTRONICS INNOVATION ENHANCEMENT)

Dr. Kay Suwelack, Flavius Sturm, Dr. Miloš Jovanović



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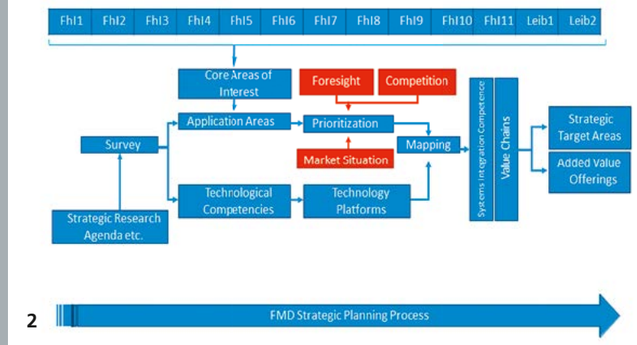

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From the start of the 21st century, society, the economy and the environment have been undergoing profound transformations because of demographic change, new mobility needs, the development of a zero-carbon society, or far-reaching digitization. Digitization is currently one of the most sweeping transformations; it is permeating the entire innovation spectrum and is impacting the competitiveness of Germany and Europe. Micro and nanoelectronics are the central technology behind digitization, which is being driven globally by large corporations and political initiatives, especially in Asian countries.

Research Fab Microelectronics Germany (the Forschungsfabrik Mikroelektronik Deutschland, or FMD), is taking up these challenges, with the aim of using a completely new concept to strengthen the position of Europe's semiconductor and electronics industry in the global market. For the first time within the scope of FMD, 11 institutes of the Fraunhofer Group for Microelectronics and two Leibnitz institutes are pooling their expertise and the patronage of the Federal Ministry of Education and Research (BMBF).

The goal is to achieve and expand new levels of quality in the research, development and (pilot)production of semiconductor-based micro and nano systems. Under the accompanying research project FRAME (FRAunhofer Microelectronics Innovation Enhancement), the Presidential Council of the Fraunhofer Gesellschaft is backing FMD with the Fraunhofer Group for Innovation Research.

This Group is to support FMD's work as a virtual organization platform for research and development. FRAME is underpinning FMD management in setting up the FMD office, and its support with methodology and personnel is helping to ensure FMD's success.

FRAME is supporting FMD in these specific areas:

1. Business Development
   a. Strategy Development
   b. Organization Development
2. Methodological Support
   a. Benchmarking & Best Practice
   b. Methodological Support in the Strategy Process
   c. Developing and Evaluating Questionnaires, Running Surveys
3. Innovation Analyses
   a. Analyzing the FMD Environment (Competition, Foresight)
   b. Determining Market Potential
   c. Derivation of Recommended Actions

To distribute tasks among the institutes of the Fraunhofer Group for Innovation Research, the FRAME project is structured in different modules (see Fig. 1). Overall coordination of the project is in the hands of the Fraunhofer Institute for Systems and Innovation Research (ISI).

The »Strategy Development« Module

As part of the Strategy Development module, Fraunhofer INT supported FMD in the conceptual design and development of its »Strategic Research and Innovation Plan 2018.« As shown in Figure 2, INT carried out a systematic analysis of technological competences and application fields common to all 13 FMD institutes. The purpose was to identify common activities as strategic target corridors, and so point up the possibilities for future FMD offers with added value through cooperation (horizontal and vertical integration) (Portfolio Analysis – Fig. 3 gives an example). The written survey was structured in line with the Strategic Research Agenda (SRA) for Electronic Components and Systems 2018, to ensure that the strategy would work internationally. Data collection was very successful (with a 100 % return rate) at both Fraunhofer and Leibnitz.

Results from the strategic survey were combined with results from the systematic market and competitor analyses of the corresponding FRAME modules and then documented in the FMD »Strategic Research and Innovation Plan 2018«. Part of FMD's interim evaluation, this initial FMD strategy document was submitted to BMBF at the end of 2018. It was very positively rated by BMBF, which matched FMD's own rating.

Plans for the Strategy Module in 2019 are to continue deepening the analysis of survey data, conduct strategy workshops at all 13 FMD institutes, prepare a strategy update and to conduct a white-spot analysis of FMD.

The »Foresight and Roadmaps« Module

In a nutshell, the »Foresight and Roadmaps« module has the task of reviewing and analyzing FMD's technological and social environment. As a time horizon, a period of about five to ten years and beyond was chosen. The goal is to prepare FMD to meet future challenges from technology and society. The consequence for Fraunhofer INT is that several experts in TASP, the Technology Analysis and Strategic Planning Department, have evaluated literature on microelectronics with a view to possible technology trends. Additionally, technology topics already developed in other projects in the past have been consulted and updated.

A multi-stage selection process produced a longlist of more than 60 trends. In internal workshops, this longlist was reduced to about 30 trends, forming a basis for further work in 2019. For each of these technology trends, a technology map was created which gave a general description of the topic, of its relevance to FMD, and of current developments.

In addition, the prerequisites were created for expanding the technology maps in the future, for example with bibliometric analyses and possible recommendations for action. Accompanying this was a literature database containing relevant scientific articles and planning documents that were used for the technology trends.

Parallel to the work on technological trends, the Fraunhofer Institute for Systems and Innovation Research (ISI) considered and selected trends in society. Subsequently, these technological and social trends were combined into trend clusters, which also serve FMD as a basis for strategic, systematic preparation for future topics.

The next major step will be a workshop in 2019, where analysts from INT and ISI, together with FMD experts, will jointly be discussing and evaluating the social and technological trends found. The concept is to cluster the trends from different perspectives, for example on a time scale, according to fields of application, and FMD technology parks.

The workshop will be based on the technology maps and clusters mentioned above, and, in turn based on workshop results, the challenges for FMD can be derived.

1 *FRAME Project Structure*

2 *Overview – FMD Strategy Process*

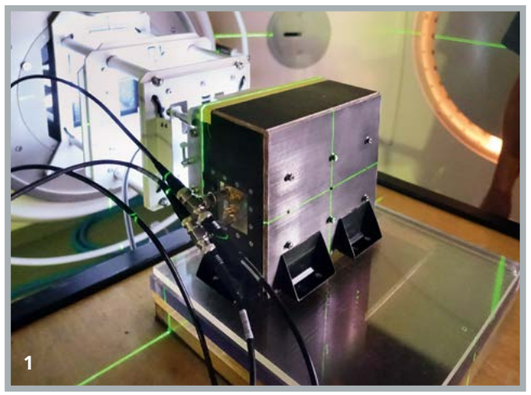
RAPRO

Dr. Michael Steffens, Dr. Ing. Lars Tiedemann (HPS GmbH)

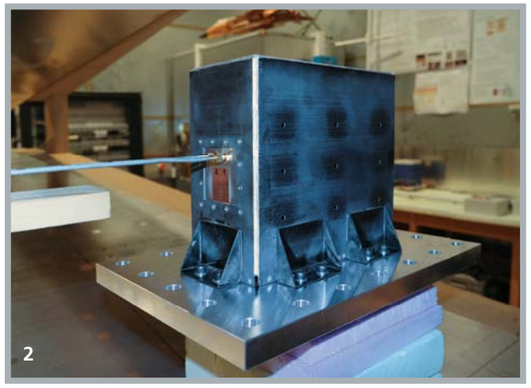
Electronic components can be seriously affected or even destroyed by ambient radiation in space (such as electrons, protons, cosmic radiation). To prevent this, radiation has to be isolated as effectively as possible. The greatest contributor to radiation shielding inside a satellite is the mechanical structure and the systems already on board. Where this is not enough for sensitive components, an additional solid shield is often used – mostly made of aluminum for larger areas, or tantalum shields for local individual components (known as spot shields).

One approach to making these shields more efficient – especially lighter – is to use a system of several layers of different materials. By utilizing secondary effects in the passing of radiation through the materials, it is possible to achieve a tailor-made optimum of the shielding effect for a specific satellite mission.

This area was addressed by the project RAPRO (Evaluation of Lighter and More Efficient **RA**diation **PRO**tection for Electronic and Sensitive Parts), headed by HPS GmbH in close cooperation



with OHB Munich. On behalf of ESA, several innovative multilayer systems for protecting electronics were designed, constructed and tested. From the most promising systems, an electronics casing and a spot shield for use in space missions were then constructed and tested as an engineering model.



A workshop organized and managed by HPS GmbH then developed and selected possible mission scenarios and the requirements arising from them.

The second phase involved the investigation of a variety of possible material combinations with regard to their feasibility, process safety and production economics, the expected shielding effect on particle and electromagnetic radiation, and many other factors. For all materials and combinations, the Business Unit NEO provided Monte Carlo simulations for the shielding effect of particle radiation [1].

Samples of the four most promising material combinations were produced by HPS GmbH. The samples were then subjected to mechanical, thermal and radiation tests, among others. NEO carried out the radiation tests in this phase on an electron accelerator of PTB Braunschweig and of the JULIC proton cyclotron at the research center FZ Jülich. In addition, an »aging test« was carried out on the Co-60 facilities at Fraunhofer INT.

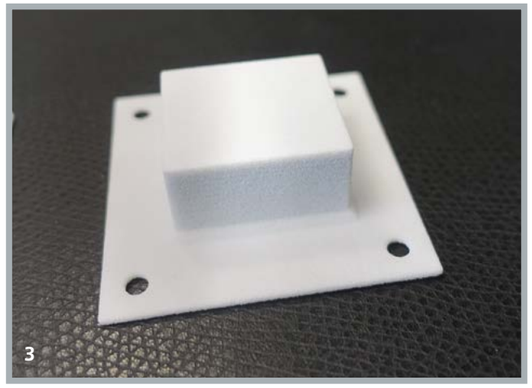
To construct the engineering models, two coating systems for producing demonstrators were selected: one material was used to produce a standard electronic housing, another for a local spot shield to protect sensitive single components. The demonstrators were manufactured by HPS, partly using specially developed production processes.

Both demonstrators were subjected to a thermal vacuum test and further radiation tests with electrons (see Fig. 1) and protons. In addition, the Business Unit EME at Fraunhofer INT cooperated with OHB Munich in running tests of the housing's shielding behavior against electromagnetic radiation.

The tests showed that the multi-coated materials selected have higher shielding effectiveness compared with comparable heavy aluminum housings. The electromagnetic tests showed equivalent shielding behavior to, or in part significantly better than, an aluminum box of the same construction.

Depending on the mission scenario considered, the shielding materials used show an increase in shielding effectiveness from 25 % to 69 % compared to mass equivalent aluminum. With these materials, the mass required for shielding can thus be significantly reduced, or low-cost commercial-off-the-shelf (COTS) components can be used in radiation environments.

[1] Steffens et al, »Characterization of Novel Lightweight Radiation Shielding Materials for Space Applications«, IEEE TNS, vol. 64, issue 8, 2325-2332, 2017



1 *Irradiation of the RAPRO electronics housing at PTB Braunschweig*

2 *RAPRO spot shield*

3 *RAPRO electronics housing*

1ST FUTURE RESEARCH AND TECHNOLOGY SITUATION CONFERENCE 2018

Dr. Matthias Grüne , Hans-Martin Pastuszka

At Fraunhofer INT, the Business Unit Defense Technology Foresight (WZA) conducts research into the future of technology. The Unit uses a scientific approach to generate future-oriented knowledge of expected long term technology developments and their implications for military use and capabilities. WZA's central product is the Defense Technologies Forecast (WTV), which appears quarterly on behalf of the Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support (BAAINBw). WTV contributions cover technology and system concept analyses to assess the Federal Ministry of Defence and the Bundeswehr (BMVg) with regard to new technologies or technology-driven developments in military capability.

This makes WTV a key factor in BMVg's technological, long term strategic foresight. Within BMVg and its field of operations, all the identifying, analyzing and evaluating of future technology themes is done at several departmental research locations. In particular, these include BAAINBw and its downstream technological and scientific agencies. Also included, and depending on technical orientation, are other Defense Department research institutions, the Bundeswehr Universities, BMVg-funded research institutes of the German Aerospace Center (DLR) and the Fraunhofer Group for Defense and Security (VVS) and the French-German Research Institute at Saint-Louis (ISL).

In 2017, WZA was tasked with writing a concept for a new yearly event as a platform for offering a comprehensive understanding of technology-related future issues of potential Bundeswehr relevance. With the involvement of the players just listed, this generates a »picture of future technology« for BMVg and the Bundeswehr. The concept produced and put forward under the leadership of Dr. med. Matthias Grüne led to the 1st Future R&T Situation Conference, held on 27/28 February 2018 at Fraunhofer INT. Under the chairmanship of BMVg's Research Director, there were 70 participants. This created the stage for bringing together all the Bundeswehr's actors in defense R&T – a knowledge-sharing theater.

The conference task was to consider both military and civil driven developments in technology. In the run-up to the conference, a total of 70 highly varied future topics was identified by the institutions listed above, and put forward using a common system of technology profiles. Examples for these included blockchain, quantum technologies for high-resolution magnetometry, or the protection of space infrastructures. In addition, Fraunhofer INT introduced the 11 WTV topics for the year 2018. As well as the topics for the future, the conference noted and discussed appropriate ministerial framework conditions, long term objectives and the procedural embedding of themes like equipment, cyber / IT and planning.

In addition to brief technical descriptions of the single themes, the presentations and discussions dealt with topic profiles including:

- criteria for rating topics, such as the estimated potential for military application or military threat of the technologies
- the expected time of market availability
- recommendations derived by the experts on how to deal with these defense technology and research themes.

The topic profiles were also the background for the Future R&T Situation Picture 2018 (FuT-Zukunftslagebild 2018), which was drawn up for the first time. Individual topics were visualized in various forms and summarized as an information »dashboard«, also for the management level at BMVg.

The BMVg Research Director concluded that the event added value to the strategic orientation of defense research and technology and should continue on a permanent basis.

OTHERS

SPACE ALLIANCE

Angela Haberlach, Thomas Loosen

In 2018, there were several pleasing developments for the Fraunhofer Alliance. First, a new member was welcomed, and second, the Alliance itself joined a key international space network. More on both below. Beyond that, the Alliance once again took part in numerous events at home and abroad, and also developed new tools to cater for the broad competence spectrum of the member institutes.

At the beginning of the year, the Alliance developed a Mission Wall and a Virtual Satellite Model, each of which aiming to provide a glance at as many of the member institutes' professional capacities as possible. The Space Wall lists all important space missions to which Fraunhofer space institutes have contributed, showing up an impressive flight heritage of Fraunhofer components that reaches as far back as the early 1980s. In the form of a large-scale plot for exhibition walls, it can be used in various ways, also online or as a give-away poster.

The Virtual Satellite Model is a large touchscreen designed as a trade fair exhibit. On it, a fictional satellite and some surrounding elements can be freely explored. The satellite has numerous Fraunhofer components covering a wide range of fields, from solar panels and sensors to on-board processors. Figuring in the satellite's environment is the sun (for describing radiation effects), a cloud of space debris, the small satellite ERNST, and finally, the Earth, which shows important capacities in the ground segment. For trade fair visitors, the Virtual Satellite is a vivid, interactive demonstration of the great variety of technologies that Fraunhofer is contributing to space travel.

Both the Mission Wall and the Virtual Satellite were premiered at ILA, the International Aerospace Exhibition in Berlin. The Alliance was itself an exhibitor, as were seven Alliance institutes. In all, the space exhibits were mounted on a 300 m^2 stand in Hall 4, in the immediate vicinity of ESA, DLR, OHB and other space players.

In September, it was announced that the Fraunhofer Institute for Microengineering and Microsystems IMM had acceded. Based in Mainz, IMM has been an independent member of the Fraunhofer-Gesellschaft since 2017, and as a specialist in extremely small structures, it adds another area of expertise to the Alliance. One of the items that IMM supplied for use in space was a double-slit spectrometer for the ENMAP mission.

In 2018, a special highlight was the Alliance's participation in the International Astronautical Congress IAC. The most important international conference for space issues, IAC attracts attendees from the USA, Asia and Europe. IAC was held in Bremen, the first time on German soil since 2003, and the Alliance used the opportunity to be present with seven of it institutes. During the event, Alliance membership of the International Astronautical Federation was also announced, a major step forward for international awareness and networking.

With the Industry Space Days (ISD) in Noordwijk and the International Conference on Space Optics (ICSO) on Crete, two smaller but finely focused events were added in the fall. At ISD, the presentations of the Mission Wall and the Virtual Satellite gave a good overall view of Alliance work. At ICSO, the emphasis was on the Alliance's optics institutes.

1 *Fraunhofer Space booth at the IAC 2018*

CHAIR AT RWTH AACHEN UNIVERSITY

Stephanie Hansen-Casteel

The Institute for Technology Analysis and Foresight in Security Research at the RWTH University in Aachen again continued the Chair's 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 suitability and optimization aspects of future research, 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.

Lectures offered by the Chair include »Methods of Future Research – Technology Foresight« in the Winter Semester, and »Methods of Future Research – Technology Analysis« in the Summer Semester. Student numbers again continued to increase. In addition to the theoretical content, students have the opportunity to develop their communication and presentation skills in practical exercises.

A particular success occurred when the Chair received the Teaching Award of the Faculty of Mechanical Engineering for very good didactic performance. This is presented in recognition of very positive assessment by the students.

For the third 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 cross-discipline seminar »(Inter)Disciplinary Future – Tomorrow's Technologies from the Social and Engineering Views«. The basic concept is for students of engineering to collaborate with sociology students in assessing the consequences of technology. The course goal is to analyze the view from each science field and to open up student awareness of the other view.

The Institute is again offering its seminar on knowledge and science theory for advanced students. More seminars will be offered in coming semesters, in engineering ethics, for example, as well as a course of lectures on security research.

Another success was the lecture series »Methods of Researching the Future«, established at the Ravensburg-Weingarten University. The lectures, given by Prof. Lauster, present students of the Technology Management Faculty with 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, the Chair is offering various Master and Bachelor degrees, as well as project work, also with the cooperation of Fraunhofer INT.

SHORTLY NOTED

Gina Frederick, Angela Haberlach, Thomas Loosen

Bundeswehr Open Day

With the motto »Welcome Curiosity«, the Bundeswehr Open Day on 9 June, 2018, attracted 220,000 visitors to a total of 16 locations. Helping to stage this major event was the Bundeswehr Education Center in Mannheim. More than 60 exhibitors, both military and civilian, presented themselves on the Neuostheim Education Campus with their own regional motto »The Bundeswehr Squared«. This was an opportunity for nine Fraunhofer institutes from the Fraunhofer Group for Defense and Security (VVS) (see p. X) to present their research work.

Fraunhofer INT gave the visitors a demonstration of the measuring vehicle DeGeN, which at first glance looks like a regular station wagon. However, the vehicle is packed with detectors, sensors and evaluation software that detect nuclear material. The Institute also presented its work in researching the future. Using augmented reality and a »crystal ball«, visitors were able to look at new technologies in defense.

Hannover Messe 2018

In 2018, Fraunhofer INT was again present at the Hannover Messe, where institutes of the Fraunhofer-Gesellschaft came together to show their latest exhibits and technologies.

Covering an area of 1054 square meters, the Fraunhofer-Gesellschaft presented itself with a total of 48 Fraunhofer units spread over three joint stands. Exhibits from INT were part of the largest Fraunhofer joint stand, located in Hall 2 and devoted to Research and Technology.

Fraunhofer INT, which has been analyzing Future Technologies for more than 40 years, was there with its latest concept for supporting scientists in their work: KATI (Knowledge Analytics for Technology and Innovation). Presented to the public for

the first time at the 2018 Messe, KATI is an IT and data-based assistance system developed by Fraunhofer INT as part of a research project. Its aim is to make literature research for technology foresight more efficient. The system aroused great interest among the visitors, and will be showing new functions when it is again part of the exhibition next year.

Contact Office in Ravensburg

In cooperation with the Ravensburg-Weingarten University, the City of Ravensburg and its local business development organs, Fraunhofer INT opened a contact office in the newly-created impulse and technology center »kup. Ravensburg«. The purpose is to advise local companies and starters on technological questions. Most businesses in the Ravensburg region are small and medium-sized enterprises that often lack the methodological know-how and resources to keep track of technological trends in detail. Fraunhofer INT's consulting opportunities on site help companies to respond to technological trends in good time and so to compete more successfully.

»kup. Ravensburg« is a platform for innovative, creative companies and start-ups with a technology orientation. Covering 5000 square meters, the location offers office and commercial

space, co-working and event facilities, a food court and support zones for people with disabilities. It took just under two years of construction work before the impulse and technology center was officially opened in June 2018.

Young Students' Contest

Also in 2018, Fraunhofer INT coached one of eight teams in the school pupils' contest »Go-Ing & Go-Job«, run just before the summer vacation by the zdi-Zentrum ANTalive (Center for the Future through Innovation). Senior scientist Jürgen Kohlhoff was in charge of the group that secured first place in the final presentations at the Sparkasse Düren on July 9. The young students inspired the 60-strong jury with a creative, very humorous presentation. Under the heading »Technology Advice for Decision-Makers«, the pupils took on the role of assistant to a board of management. The scenario set was a board meeting that had to decide on a major investment for developing personal robots. In advance of the meeting, the students had to write a recommendation that assessed chances and risks, taking account of social acceptance and legality.

The 2018 contest was the fifth to be held. Pupils from the Aachen, Euskirchen and Düren region spend a week in selected companies, developing real projects and tasks in small, mixed groups. In working out their solutions, they show their skills

in logical thinking and creativity. The contest also aims at introducing the students to the »MINT« professions (jobs in Mathematics, IT, Science and Technology).

Girls' Day

In 2018, Fraunhofer INT once again participated in Germany's »Girls' Day«. This gave 12 schoolgirls from the region the opportunity to spend a day in INT's research world. After an introduction to the institute and to the tests on the schedule for the day, the girls split into smaller groups and went on to conduct experiments. They were able to use a spectrometer to identify different types of light source, conduct an experiment on environmental radioactivity, solder a flip-flop circuit following instructions, and carry out a test with microwaves and their resonances.

Spread over the whole day, there was also the opportunity to talk in depth with several of INT's women scientists – the girls wanted to learn everything about training, everyday working life, and reconciling work and home. The following day, it was »back to school«.

Again in 2019, INT will be taking part in the day devoted to the future for girls. More information about this nationwide event will be found at www.girls-day.de.

APPENDIX

University Courses, Lectures and Exercises

Chmel, S.: Lecture and exercise »Physics« in the Bachelor's course Naturwissenschaftliche Forensik (2nd semester) at the Bonn-Rhein-Sieg University of Applied Sciences, summer term 2018

Chmel, S.: Lecture and exercise »Measuring Techniques« in the Bachelor's course Naturwissenschaftliche Forensik (3rd semester) at the Bonn-Rhein-Sieg University of Applied Sciences, winter term 2018/2019

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, 1/29/2018

John, M.: »Das Cochlea Implantat: Funktionsweise, Entwicklung, Chancen, Risiken und Erfahrungen im Hinblick auf die logopädische Praxis«, IB-Medical Academy, School for Logopaedia, Berlin, 2/12/2018, 2/14/2018 and 2/16/2018

John, M.: »Quantitative Methoden der Zukunftsforschung. Eine sehr kurze Einführung in Data Driven Foresight«, RWTH Aachen University, 6/12/2018

Jovanovic, M.: »Projektmanagement«; Seminar for the Institut Sprache und Information at the Heinrich-Heine-Universität Düsseldorf, 2/16-2/18/2018

Jovanovic, M.: »Bibliometrische Analysen als Unterstützung der journalistischen Recherche«; two lectures during the Discussion Forum Technology and Society, University of Applied Sciences Bonn-Rhein-Sieg, Sankt Augustin, 4/11/2018 and 4/26/2018

Kohlhoff, J.; Hemmers, C.: Exercise »Methoden der Zukunftsforschung« in the Master's Course »Technologiemanagement«, Ravensburg-Weingarten University of Applied Sciences, Weingarten, 4/18-4/20/2018

Kuhnhenn, J., »Radiation Testing of Photonics Technologies«, Lecture at the RADSAGA Summer School, Jean Monnet University, St. Etienne, France, 9/13/2018

Lauster, M.: »Methoden der Zukunftsforschung I«, RWTH Aachen University, Aachen, winter term 2018/2019

Lauster, M.: »Methoden der Zukunftsforschung II«, RWTH Aachen University, Aachen, summer term 2018

Lauster, M.: »Erkenntnis- und Wissenschaftstheorie für Ingenieure«, RWTH Aachen University, Aachen, winter term 2018/2019

Lauster, M.: Gemeinsames Seminar Ingenieure/Soziologen zur Technologiefolgenabschätzung, RWTH Aachen University, Aachen, summer term 2018

Lauster, M.: Lecture »Methoden der Zukunftsforschung«, Ravensburg-Weingarten University of Applied Sciences, Ravensburg, summer term 2018

Metzger, S.: Lecture »Experimental Techniques in Particle Physics« in the Master's course »Physik« at RWTH Aachen University, Aachen, winter term 2018/2019

Wirtz, H.: »Change- und Innovationsmanagement« in the Bachelor's course »Business Administration (berufsbegleitend) «, Hochschule Fresenius, Cologne, winter term 2017/18, summer term 2018

Wirtz, H.: »Qualitäts-, Change- und Innovationsmanagement« in the Bachelor's course »Betriebswirtschaftslehre«, Hochschule Fresenius, Cologne, winter term 2017/18, summer term 2018, winter term 2018/19

Wirtz, H.: »Qualitäts-, Change und Innovationsmanagement« in the Bachelor's course »Betriebswirtschaftslehre (berufsbegleitend)«, Hochschule Fresenius, Cologne, winter term 2017/18, summer term 2018, winter term 2018/19

Wirtz, H.: »Finanzierung und Investition« in the Bachelor's course »Automotive and Mobility Management«, Hochschule Fresenius, Cologne, winter term 2018/19

Wirtz, H.: »Controlling und Qualitätsmanagement« in the Bachelor's course »Automotive and Mobility Management«, Hochschule Fresenius, Cologne, winter term 2018/19

International Cooperation

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

Berchthold, C., Grigoleit, S., Müller, L., Sendrowski, P., Vollmer, M.:
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, M. C., Chmel, S., Friedrich, H., John, M., Lieder, E., Ossowski, S.:
H2020 Projekt C-BORD (Effective Container Inspection at BORDer Control Points), 18 project partners

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

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

Höffgen, S., Metzger, S., Schmitz, S., Steffens, M., Wolf, R., Wölk, D.:
SEE Collaboration with Steven P. Buchner of the United States Naval Research Laboratory (NRL), USA

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

Köble, T.:
IAEA Expert Group: Revision of IAEA Nuclear Security Series No. 1, »Technical and Functions Specifications for Border Monitoring Equipment«

Kuhnhenn, J., Metzger, S., Steffens, M.:
Seibersdorf Labor GmbH, Seibersdorf, Austria

Neupert, U., Ruhlig, K., Michael, K., Offenberg, D., Huppertz, G.:
FMV (Försvarets Materielverk)-Project Teknisk Prognos 2018

Pastuszka, H.-M.:
Panel-Moderation Final Conference H2020-Projekt ResiStand (Increasing disaster Resilience by establishing a sustainable process to support Standardisation of technologies and services), DIN e.V. Berlin, 3/22/2018

Pastuszka, H.-M., Grüne, M.:
European Defence Agency (EDA), Service Framework Contract »Technology Foresight Follow-on (TFFO)« (17.ESI.OP.373), in cooperation with Ingeniería de Sistemas para la Defensa de España (Isdefe, Spanien), 2018-2019

Pastuszka, H.-M., Ruhlig, K., Freudendahl, D.:
Trilateral D-A-CH meeting of experts »Technologievorausschau«, topics: WTV, quantum computers and exoskeletons, armasuisse, Switzerland 9/26/2018 and 9/27/2018

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

Pusch, T., Suhrke, M.:
FOI Sweden, Technical Agreement «Development of high-power microwave test methodology and procedures«

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

Suhrke, 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

Vollmer, M., Walther, G., Jovanović, M., Pusch, T., Suhrke, M.:
Participation in the EU-H2020-Project SmartResilience (Smart Resilience Indicators for Smart Critical Infrastructures), 20 project partners

Vollmer, M.:
Participation in the EU-H2020-Project ResiStand (Increasing disaster Resilience by establishing a sustainable process to support Standardisation of technologies and services), 14 project partners

International Reviews

Höffgen, S., Kuhnhenn, J.: RADECS 2018 Conference

Jovanovic, M.: ASLIB Journal of Information Management

Kuhnhenn, J.: Journal of Nuclear Materials

Kuhnhenn, J.: Journal of Lightwave Technology

Kuhnhenn, J., Metzger, S., Steffens, M.: Transactions on Nuclear Science

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

Kuhnhenn, J.: Journal of Optics

Kuhnhenn, J.: International Journal for Light and Electron Optics

Kuhnhenn, J.: Gutachter für »Agence nationale de la recherche« (French research funding)

Kuhnhenn, J.: Gutachter für »Research Foundation – Flandres (FWO)« (Belgian research funding)

Lanzrath, M.: IEEE Transactions on Electromagnetic Compatibility

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

Suhrke, M.: IEEE Transactions on Electromagnetic Compatibility

Thorleuchter, D.: Algorithms

Thorleuchter, D.: Applied Sciences

Thorleuchter, D.: Electronic Commerce Research and Applications

Thorleuchter, D.: Entropy

Thorleuchter, D.: Expert Systems with Applications

Thorleuchter, D.: Futures

Thorleuchter, D.: Information

Thorleuchter, D.: Journal of Intelligent Systems

Thorleuchter, D.: Sustainability

Collaboration in Committees

Chmel, S.: coordinator of the Fraunhofer EU-Network

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

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

Grigoleit, S.: Member of the advisory board for the project – Enabling Innovation by Simulation (EIS), European Academy of Technology and Innovation Assessment, Bad Neuenahr-Ahrweiler (?)

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

Neupert, U., Walther, G.: Member of Independent Scientific Evaluation Group (ISEG) in the NATO-research program »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)«

Suhrke, M.: Ombudsperson Fraunhofer INT

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 2018, 4/2-4/4/2018 Fez, Morocco

Vollmer, M.: EARTO Security and Defense Research Group

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)

Köble, T.: DIN and 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, Preparation of Standard IEC 60793-1-54

Suhrke, M.: National representative Joint Working Group 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

Bantes, R., Pastuszka, H.-M.:
»Zukunftsthemen WTV 2018«, 1. F&T-Zukunftslagekonferenz BMVg A II, Fraunhofer INT Euskirchen, 2/27/2018

Berchtold, C.:
»Success and Failure Factors in transboundary crisis management«, needs conference 2018, Amsterdam Public Library (OBA), 3/22/2018

Berchtold, C.:
»Success and failure factors in EU transboundary crisis management: A review«, 4th International Symposium on Development of CBRN Protection Capabilities, Berlin, 9/4/2018

Bornhöft, M. C.:
»Study of neutron detection technologies using Li-6 as a replacement of He-3«, annual meeting of DPG and DPG-spring meeting, work group »Physik und Abrüstung«, Erlangen, 3/7/2018

Bornhöft, M. C.:
»Untersuchung von Li-6 basierten Szintillatoren zum Nachweis von Neutronen«, German Conference of Women in Physics, Oldenburg, 9/30/2018

Grigoleit, S.:
»Das EU-Projekt IN-PREP«; work group »Grenzüberschreitende Zusammenarbeit im Katastrophenschutz«, Zwolle, 4/12/2018

Höffgen, S., Metzger, S.:
»Gefährdung elektrischer Luftantriebe durch atmosphärisch Neutronen«, presentation at the IISB Workshop, Erlangen, 4/17/2018

Höffgen, S., Kuhnhenn, J., Lennartz, W., Paschkowski, E., Weinand, U., Wolf, R.:
»Bestrahlung von Glasfasern und Elektronik bei sehr tiefen Temperaturen«, presentation at the DLR Bauteilekonferenz, Ulm, 4/18/2018

Höffgen, S., Kuhnhenn, J., Kündgen, T., Metzger, S., Steffens, M.:
»Fraunhofer On-board Radiation Sensors (FORS)«, presentation at the OHB Workshop, Bremen, 4/20/2018

Höffgen, S., Komrowski, C., Kuhnhenn, J., Kündgen, T., Metzger, S., Steffens, M.:
»Fraunhofer satellite radiation sensing systems«, presentation at the IAC, Bremen, 10/3/2018

Höffgen, S., Kuhnhenn, J., Metzger, S., Steffens, M.:
»Future Radiation Testing: Adapt or Fail« presentation at the IAC, Bremen, 10/4/2018

Huppertz, G.:
»Künstliche Intelligenz aus dem Blickwinkel der wehrtechnischen Zukunftsanalyse«, 1. Workshop Digitalisierung und Künstliche Intelligenz, Bundeswehr Office for Defence Planning, BMVg Bonn, 1/30/2018

Huppertz, G.:
»Künstliche Intelligenz und Autonome Systeme aus dem Blickwinkel der wehrtechnischen Zukunftsanalyse«, Bildungsveranstaltung Blauer Bund e.V., Donnerbergkaserne Eschweiler, 11/20/2018

John, M.:
»Suchst Du noch oder liest Du schon? Ein Werkstattbericht über das Projekt KATI«, Fraunhofer Fachforum Fachinformation, Karlsruhe, 10/10 and 10/11/2018

Kuhnhenn, J.:
»Wirkung von ionisierender Strahlung auf Elektronik und Optik«, presentation at the PTB Workshop, Braunschweig, 5/23/2018

Kuhnhenn, J.:
»Radiation Testing of Optical Coatings – Better Testing with Simulations«, presentation at the ICSO 2018, Chania, Greece, 10/12/2018

Lanzrath, M.:
»HPEM Vulnerability of Smart Grid Substation Secondary Systems«, EMC Europe 2018, Amsterdam, the Netherlands, 8/27-30/2018

Lanzrath, M.:
»Counter-UAS-Untersuchungen mit HPEM-Wirkmitteln«, Symposium Elektromagnetische Effekte 2018, WTD81 Greding, 9/25-27/2018

Lauster, M.:
»Zukunftsvorausschau Raumfahrt 2040, Szenarien für eine Weiterentwicklung der deutschen Raumfahrtpolitik«, Project introduction, Bonn, 2/19/2018

Lauster, M.; Beyerer; Jürgen:
»Wie disruptiv sind Technologien?«, DWT Veranstaltung »Angewandte Forschung für Sicherheit und Verteidigung in Deutschland«, Bonn, 2/20/2018

Lauster, M.:
»Zukunftsvorausschau Raumfahrt 2040«, Steuerungskreis Projektbesprechung, Bonn, 4/13/2018

Lauster, M.:
»Digitalisierung – Innovation oder Disruption? Der Mittelstand zwischen Aufbruch und Umbruch«, Wirtschaftsförderung Ravensburg, 4/19/2018

Lauster, M.:
Bundeswehr Office for Defence Planning, Workshop Best Practices, »Foresight – Science or Fiction?«, Berlin, 5/24/2018

Lauster, M.:
»Zukunftsforschung: Globale Trends und strategische Implikationen, Gedanken zu den Zielen technologischer Entwicklungen«, University of applied sciences Bonn-Rhein-Sieg, 6/14/2018

Lauster, M.:
»Langfristige technologische Trends mit wehrtechnischer Relevanz«, Förderkreis Deutsches Heer, Berlin, 7/5/2018

Lauster, M.:
Info-Besuch bei BMBF Referat 522 – Sicherheitsforschung, Bonn, 8/8/2018

Lauster, M.:
»Künftige Technologien und technologische Quantensprünge mit erwarteter Relevanz für Sicherheitspolitik und Strategie«, 52. Sicherheitspolitische Informationstagung der Clausewitz-Gesellschaft, Hamburg, 8/22/2018

Lauster, M.:
»Population Growth, Urbanization, Climate Change – Global Trends and their Implications on Security Research«, 4th International Symposium on Development of CBRN Protection Capabilities, Berlin, 9/3-5/2018

Lauster, M.:
Instituts- und Allianz Space-Vorstellung, Mr. Kinaci and Col. Szabo (NATO), Euskirchen, 10/4/2018

Lauster, M.:
Artificial Intelligence for Military Applications, ICOS, Bonn, 10/10/2018

Lauster, M.:
»Disruptive Technologies – On Some Aspects of a Buzz Word in the Context of European Space Flight«, Space4Inspiration 2018, Bilbao (Spain), 10/29-31/2018

Lauster, M.:
»Zukunft als Gebrauchserzählung – Narrationen in der Zukunftsforschung«, Lecture series at the Institute of English Studies, University of Freiburg, 11/7/2018

Lauster, M.:
»Neue Technologien mit erwarteter Relevanz für das Gefechtsfeld der Zukunft«, FOE-Workshop Bundeswehr Office for Defence Planning / IABG Berlin, 12/3/2018

Lubkowski, G.:
»Verträglichkeit mobiler Geräte gegenüber HPEM-Signalen – statistische Analyse«, Symposium Elektromagnetische Effekte 2018, WTD81 Greding, 9/25-9/27/2018

Metzger, S.:
»Zuverlässigkeit elektronischer Komponenten und Systeme unter besonderen Bedingungen«, presentation at the board meeting of the Fraunhofer Group for Microelectronics, Berlin, 3/22/2018

Metzger, S.:
»Effects of Exo-Atmospheric Nuclear Explosions on Satellites«, presentation at the OHB Workshop, Bremen, 4/20/2018

Metzger, S.:
»Gefährdung Smarter Infrastrukturen«, presentation at IHK event »Verletzlichkeit smarter Infrastrukturen, die unbekannte Seite der Digitalisierung«, Euskirchen, 4/23/2018

Metzger, S.
»Nukleare und Elektromagnetische Effekte«, presentation at BMBF, Bonn, 8/8/2018

Metzger, S.
»Effekte atmosphärischer Neutronen in Elektronik«, presentation at the PTB Workshop, Euskirchen, 8/9/2018

Metzger, S.:
»Fraunhofer Space Alliance – Applied Research for Europe's Leadership in Space«, presentation at the annual meeting Lenkungsausschuss »Rapid Space Capabilities«, Berlin, 11/7/2018

Neupert, U.:
»Defence Technology Foresight for the German MoD @ Fraunhofer INT«, NATO STO Technology Trends Workshop #1, Paris – Neuilly-sur-Seine, 2/27/2018

Neupert, U., Huppertz, G.:
»Long-Term Defence Technology Foresight @ Fraunhofer INT«, Royal Netherlands Army Land Warfare Centre - Tulip Time 2018, Amsterdam, 4/10/2018

Neupert, U.:
»Technologische Trends mit Relevanz für die Marine – ein Blick nach 2030+«, 20. DWT Marineworkshop, Linstow, 9/25/2018

Neupert, U.:
»Disruptive Technology Assessment Gaming (DTAG) – ein militärisches Table-top-Game zur Technologiebewertung«, Modulkurs »Methoden der Zukunftsanalyse«, Führungsakademie der Bundeswehr, Hamburg, 11/20/2018

Neupert, U.:
»Wehrtechnische Zukunftsanalyse – WZA«, Modulkurs »Methoden der Zukunftsanalyse«, Führungsakademie der Bundeswehr, Hamburg, 11/20/2018

Neupert, U.:
»Future Operating Environment – Impulsvortrag Technologie«, Workshop zum Future Operating Environment (FOE) der Bundeswehr, Berlin, 12/3/2018
Pastuszka, H.-M.:
»Wehrtechnische Zukunftsanalyse und Wehrtechnische Vorausschau«, Vertiefungsmodul »Zukunftsentwicklung«, FüAkBw Hamburg, 3/6/2018

Pastuszka, H.-M., Ruhlig, K.:
»Wehrtechnische Vorausschau am Beispiel des digitalen Gefechtsfelds der Zukunft«, Seminar »Technology Perspectives«, BWI GmbH Köln-Wahn, 4/23/2018

Pastuszka, H.-M., Ruhlig, K.:
»Technologische Auswirkungen der Digitalisierung auf das Gefechtsfeld«, Symposium »Weiterentwicklung der Fernmeldetruppe im System Heer«, AHEntwg Cologne, 5/17/2018

Pastuszka, H.-M.:
»Wehrtechnische Zukunftsanalyse und Wehrtechnische Vorausschau«, Lehrgang Generalstabs-/Admiralstabsdienst National (LGAN), FüAkBw Hamburg, 7/5/2018

Pastuszka, H.-M.:
»Wehrtechnische Zukunftsanalyse für die Bundeswehr«, trilateral D-A-CH Expertentreffen Technologievorausschau, armasuisse Thun (CH), 9/26/2018

Pastuszka, H.-M.:
»Quo vadis Quantum?«, panel discussion »Technology Perspectives«, BWI GmbH Bonn, 12/10/2018

Pusch, T.:
»HPEM-Detektor zur Erfassung von elektromagnetischen Angriffen«, Symposium Elektromagnetische Effekte 2018, WTD81 Greding, 9/25-27/2018

Risse, M.:
»Evaluation of measurement devices for radioactive and nuclear material«, 4th Berliner CBRN-Symposium, Berlin, 9/5/2018

Risse, M.:
»Qualification setup for systems for measuring nuclear and radioactive material«, 59th Annual Meeting Institute of Nuclear Materials Management INMM, Baltimore, USA, 7/26/2018

Schumann, O.:
»Simulation of a neutron multiplicity counter and comparison to validation experiments«, International Workshop on Numerical Modelling of NDA Instrumentation and Methods for Nuclear Safeguards, 49th ESARDA Annual Meeting, Luxembourg, Luxembourg, 5/16/2018

Schumann, O.:
»Alternatives to He-3 for neutron detectors«, 2nd Technical Meeting on Radiation Detection Instruments for Nuclear Security: Trends, Challenges, and Opportunities, Vienna, Austria, 4/18/2018

Steffens, M.:
»Wirkung von ionisierender Strahlung auf Elektronik und Optik«, presentation at Fraunhofer Group for Microelectronics, Berlin, 10/2/2018

Suhrke, M.:
»Electromagnetic Immunity of Mobile Devices – Statistical Analysis«, EMC Europe 2018, Amsterdam, the Netherlands, 8/27-8/30/2018

Suhrke, M.:
»IEMI Vulnerability Tests of Critical Infrastructure Components«, Tutorial »Protection of Civil Infrastructures against Intentional EMI«, EMC Europe 2018, Amsterdam, the Netherlands, 8/27-8/30/2018

Vollmer, M.:
»Collaboration between RTO and practitioners in DRS projects«, European Brokerage Event, 2019 topics: Disaster Resilience, Paris, 10/24/2018

Weinand, U.:
»Light-assisted monitoring of glass panels«, presentation at the Intersec Forum, Messe Frankfurt, 3/22/2018

Weinand, U.:
»Umsetzung der Norm 25422 (Aufbewahrung und Lagerung radioaktiver Stoffe) bei HRQ im Fraunhofer Institut«, presentation at conference »Strahlenschutz in Medizin, Forschung und Industrie«, Aschaffenburg, 12/11/2018

Publications

Bantes, René:
Longterm und Cross-Domain Foresight. »Warum Trendscouting alleine nicht ausreicht um strategische Entscheidungen zu unterstützen«: Presentation held at the event »Disruptive Technologies & Innovation Foresight Minds«, DTIM 2018, 18-20 February 2018, Berlin (event »Disruptive Technologies & Innovation Foresight Minds« (DTIM) <7, 2018, Berlin>), 2018,
URN urn:nbn:de:0011-n-4847813

Bantes, René:
»Was bedeutet technologische Entwicklung für den Fachkräftemangel? Gedanken zu technologischen Zukünften«: Presentation held at the event »Fachkräfteforum« der Wirtschaftsförderungsgesellschaft am Mittelrhein, 22 March 2018, Bendorf (event »Fachkräfteforum« <4, 2018, Bendorf>), 2018,
URN urn:nbn:de:0011-n-4876725

Bantes, René:
»Wissenstransfer 2068«: Presentation held at the event »Wissenschaft in der Region Koblenz trifft Wirtschaft«, Volume 1: »Zukunftsvision 2068 – Wie arbeiten Wissenschaft und Wirtschaft in 50 Jahren zusammen?«, 11.5.2018, Koblenz-Landau (event »Wissenschaft in der Region Koblenz trifft Wirtschaft« <1, 2018, Koblenz>), 2018,
URN urn:nbn:de:0011-n-5214362

Bauer, Wilhelm; Lauster, Michael; Morszeck, Thomas H.; Posselt, Thorsten; Weissenberger-Eibl, Marion A.; Schimpf, Sven; Reimoser, Cornelia; Bantes, René; Braun, Annette; Klages, Tina; Ohlhausen, Peter; Worms, Diana; Fraunhofer Group for innovation research:
Understanding change – shaping the future: Impulses for the future of innovation, Stuttgart, 2018,
URN urn:nbn:de:0011-n-5098877

Bauer, Wilhelm; Lauster, Michael; Morszeck, Thomas H.; Posselt, Thorsten; Weissenberger-Eibl, Marion A.; Schimpf, Sven; Reimoser, Cornelia; Bantes, René; Braun, Annette; Klages, Tina; Ohlhausen, Peter; Worms, Diana:
»Wandel verstehen – Zukunft gestalten: Impulse für die Zukunft der Innovation«, Stuttgart, 2018,
URN urn:nbn:de:0011-n-4915778

Berchtold, Claudia; Müller, Larissa; Sendrowski, Philip; Grigoleit, Sonja; Weller, Maureen (Contributor):
D2.1 Success and failure factors in responding to crises: Work Package WP 2 »User Needs and Ethical, Legal and Human Factors in System Development«, Euskirchen, 2018,
URN urn:nbn:de:0011-n-5215436

Berchtold, Claudia:
»Success and failure factors in EU transboundary crisis management: A review«: Presentation held at 3rd Northern European Conference on Emergency and Disaster Studies, NEEDS 2018, 22 March 2018, Amsterdam, (Northern European Conference on Emergency and Disaster Studies (NEEDS) <3, 2018, Amsterdam>), 2018,
URN urn:nbn:de:0011-n-4879440

Berchtold, Claudia:
»Sucess and failure factors in EU transboundary crisis management. A review«: Presentation held at 4th International Symposium on Development of CBRN-Defence Capabilities, Berlin, 4th September 2018 (International Symposium on Development of CBRN Defence Capabilities <4, 2018, Berlin>), 2018,
URN urn:nbn:de:0011-n-5214707

Berky, Wolfram; Glabian, Jeannette; Köble, Theo; Lehmacher, Thomas; Risse, Monika:
Highly efficient on-site detection of neutron sources with the INT measurement car DeGeNIn:
IEEE sensors letters, Vol. 2 (2018), No.1, Art. 3500304, 4 pp.,
DOI 10.1109/LSENS.2017.2786477

Beyerer, Jürgen; Lauster, Michael:
»Wie disruptiv sind Technologien? Gedanken über ein Modewort im Kontext von Sicherheit und Verteidigung«: Presentation held at the conference for applied research for safety and defense in Germany, 20 Februray 2018, Bonn, (Konferenz »Angewandte Forschung für Sicherheit und Verteidigung in Deutschland«), 2018,
URN urn:nbn:de:0011-n-4847808,
URN urn:nbn:de:0011-n-484780-13

Beyerer, Jürgen (Editor); Martini, Peter (Editor) Business Unit Defense Technology Foresight, Fraunhofer INT (Editorial Team); Fraunhofer Group for Defense and Security -VVS-:
Grand defense-technological challenges for Europe post-2020: Position paper, munich: Fraunhofer-Gesellschaft, 2018,
URN urn:nbn:de:0011-n-5214712

Brandt, Heike:
»Gradientenwerkstoffe«
In: » Europäische Sicherheit & Technik« : ES & T, Vol.67 (2018), No.11, pp.80

Brandt, Heike; Freudendahl, Diana; Langner, Ramona:
»Werkstofftrends: Gradierte Massivwerkstoffe«
In: Werkstoffe in der Fertigung«, (2018), No.3, pp.3

Broß, Lisa; Norf, Celia; Vondermaßen, Marcel; Berchtold, Claudia; Fekete, Alexander; Schuchardt, Agnetha; Warnstedt, Paul; Würth, Andreas:
»Integrative safety research«: Workshop of the BMBF postgraduate-Network »Zivile Sicherheit«
In: Bevölkerungsschutz, (2018), No.2, pp.35-37

Freudendahl, Diana:
Soft robots
In: »Europäische Sicherheit & Technik«: ES & T, Vol.67 (2018), No.6, pp.58,
URN urn:nbn:de:0011-n-5318501

Freudendahl, Diana; Brandt, Heike; Langner, Ramona:
Werkstofftrends: Superamphiphobe Oberflächen
In: »Werkstoffe in der Fertigung«, (2018), No.6, pp.3

Götz, Markus; Wüst, Dominik; Suwelack, Kay; Kruse, Andrea:
»Potenzial von Agrar- und Lebensmittelreststoffen zur Herstellung der biobasierten Plattformchemikalie 5-Hydroxymethylfurfural (HMF)«, (ProcessNet Jahrestagung <2018, Aachen>),
In: Chemie- Ingenieur- Technik, Vol.90 (2018), No.9, pp.1170,
DOI 10.1002/cite.201855083

Grigoleit, Sonja:
»IT-Entwicklungen für Innovationen nutzen«
In: »Innovative Verwaltung«, (2018), No.10, pp.18-20

Haberlach, Angela (Red.); Loosen, Thomas (Red.); Frederick, Gina; Müller, Sabrina; Fraunhofer-Institute for Technological Trendanalysis INT, Euskirchen:
Fraunhofer-Institute for Technological Trendanalysis -INT-. Annual report 2017, Euskirchen: Fraunhofer INT, 2018,
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2/5-6/2018
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2/20-22/2018
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2/21-22/2018
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1st Future Research and Technology Situation Conference of BMVg, BMVg-F&T-Director (UAL A II) at Fraunhofer INT, Euskirchen

2/27-3/2/2018
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3/13-15/2018
Workshop »Development of High-Power Microwave Test Methodology and Procedures«, FOI Sweden, Stockholm, Sweden

4/23-27/2018
Exhibition booth Hannover Messe, Hanover

4/25-29/2018
Exhibition booth ILA, Berlin

6/9/2018
Exhibition booth: Tag der Bundeswehr, BiZBw Mannheim

6/20/2018
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6/28/2018
Exhibition booth Wachtberg-Forum 2018, Fraunhofer FHR, Wachtberg

7/23-27/2018
Participation at the summer academy »Zivile Sicherheitsforschung«, Bad Pyrmont

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Exhibition booth 4th Berliner CBRN-Symposium, Berlin

9/17-21/2018
Exhibition booth RADECS 2018, Gothenburg

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Exhibition booth ICSO, Kreta

11/14/2018
Exhibition booth Unternehmenstag, University of Applied Sciences Bonn-Rhein-Sieg, Sankt Augustin

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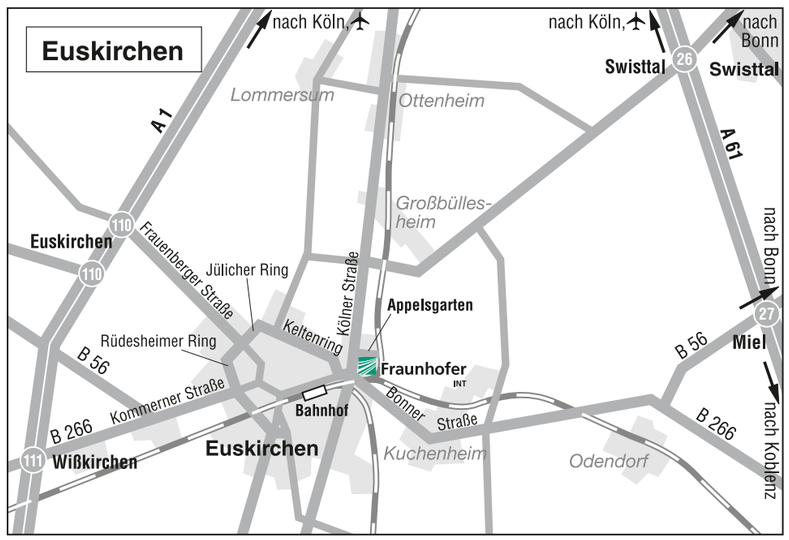

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