Fraunhofer
INT

FRAUNHOFER INSTITUTE FOR TECHNOLOGICAL TREND ANALYSIS INT

ANNUAL REPORT 2016

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FOREWORD

Dear Reader,

we are living in a supposedly post-industrial society. Since selecting the nation's Word of the Year 2016, we in Germany also know that we are moving in "post-factual" times (Germany's choice for 2016 was "postfaktisch", pretty close to "post-truth", the English language choice for the year). At least, this is the society some politicians say we are living in; and others even tell us that there are "alternative facts" – if you like, a separate reality that's not behind, but within our real world.

Yet isn't it strange that those who see us in a post-industrial state - where facts belong to the past - speak in one and the same breath about digitalization, biologization, artificial intelligence and other things that can only become reality in the future – so to say "post-present"?

Duden, the universally-accepted authority on German, defines the Latin-origin "post-" as a prefix that, when used with verbs and adjectives, refers to what comes subsequently, later in time.

So, if today we are working intensively on realizing the "Internet of Everything" and Industry 4 (the term coined by the German Government that suggests the 4th Industrial Revolution), then are we not rather a pre-industrial society? And are not future technologies, which we feel to be affecting our daily lives in ever-faster succession, based on facts (which in turn may even create new facts themselves) that are still waiting to be found? If so, it's more a case of living in increasingly pre-factual times.

Of course, INT has much to do with alternative facts – but in no way in the meaning intended by the lady who created the term. After all, technology foresight is always associated with the construction of various futures, and it's simply a fact that these are based on alternative assumptions, i.e. anticipated but not yet realized facts.

To avoid falling behind in the coming years and to keep the facts in focus, we need sophisticated, specific methods, and we concentrate our efforts on developing them. For more than 18 months, an essential part of this has been research into a partially-automated support system, known under its working title "Project KATI", that should help us keep pace with the increasing flood of scientific publications.

Many research programs on future themes are creating new facts for coming technologies. Such themes are modern crisis management methods, Smart Grid component security, the effects of high-energy atmospheric particles on modern power electronics – as used in electric mobility and aircraft construction – new methods for detecting radioactive materials, and many other fascinating research areas.

In 2017, our range of pure technology research work will be expanded in a new direction for the first time: recognizing the ever growing interdependency between social and technological development, INT will be cooperating in several projects with socio-economics oriented Fraunhofer Institutes that want to go down this road with us. By working together in conjunction, our partners will be adding their skills in given economics and social science areas to our competence in science and technology.

In other areas, too, work is forging ahead on safeguarding the future of INT. With investments amounting to more than € 6 million, nearly-complete building work (the seminar and new office complex, the library and the connecting passage) and the newly-constructed laboratory complex are greatly improving work potential as well as making space available for more expansion.

Post fact: placing itself between "post-" and "pre-", INT is standing firm on solid facts, operating as an intermediary between the technologies of today and tomorrow. Something of our work as go-between has been brought together in this Annual Report, in the hope that it gives you an overview of what our Institute does.

I wish you a lot of pleasure collecting facts,
Best wishes,

Prof. Dr. Michael Lauster

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DEPARTMENTS AND BUSINESS UNITS

FRAUNHOFER INT IN PROFILE

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

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

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

THE BUSINESS UNITS IN THIS ANNUAL REPORT:

BUSINESS UNIT
DEFENSE TECHNOLOGY FORESIGHT

BUSINESS UNIT
PUBLIC TECHNOLOGY AND INNOVATION PLANNING

BUSINESS UNIT
CORPORATE TECHNOLOGY FORESIGHT

BUSINESS UNIT
NUCLEAR SECURITY POLICY AND DETECTION TECHNIQUES

BUSINESS UNIT
ELECTROMAGNETIC EFFECTS AND THREATS

BUSINESS UNIT
NUCLEAR EFFECTS IN ELECTRONICS AND OPTICS

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FRAUNHOFER INT FACTS AND FIGURES

Staff

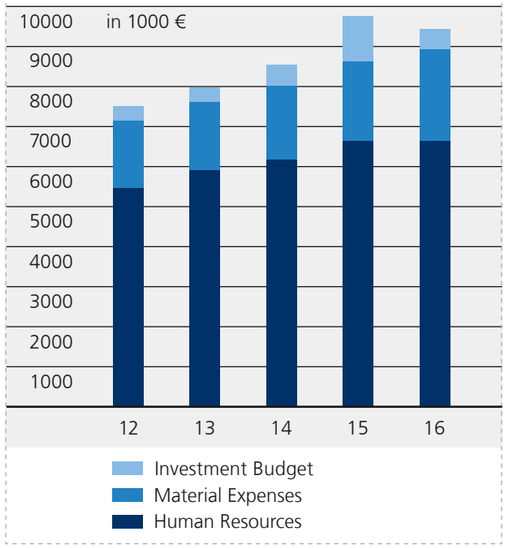
INT personnel numbers remained constant with approx. 98 staff on permanent contract, plus about 20 assistants. With meanwhile 56 scientists, the Institute staff covers a wide range of natural and engineering sciences, as well as economics, social and human sciences. The researchers are supported by graduate engineers, technologists and administration specialists. INT also has a network of freelance scientists who are regularly involved in the Institute's work.

Budget

The Fraunhofer Gesellschaft distinguishes between operating and investment budgets. The operating budget covers all staffing and administrative expenditure, the investment budget concerns the procurement of capital goods such as scientific apparatus and technical equipment. The operating budget in 2016 rose by approx. 4 % to € 8.9 million. Together with investments totaling € 549,000, the total budget amounted to more than € 8.9 million. As well as the amounts shown for investment in scientific infrastructure there is also the expenditure for extensions to the office building and for renovation and extension of laboratory capacity, which is billed on the central budget. With these investments, INT was again able to considerably improve its potential for research in radiation effects, and is now well-positioned for the future.

Along with basic funding from MoD, 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 SMS companies to DAX-30 groups, and also include associations and international organizations.

Budget from 2012 – 2016



Financial Development from 2012 – 2016

Human Resources	2014		2015		2016	
	Manned positions	People	Manned positions	People	Manned positions	People
Scientists	53.4	56	53.9	57	53.0	56
Graduates	24.5	25	23	23	23.8	24
Technicians, Others	11.8	15	13.8	17	14.8	18
Assistants, Trainees	5.7	22	4.3	18	4.6	20
Total	**95.4**	**118**	**95.0**	**115**	**96.2**	**118**

In the public sector, we have for 40 years been an in-depth con-sultant in research and technology planning for MoD, which is also the largest client for the research facility in Eus-kirchen. In addition, research assignments are also carried out for other ministries and public institutions. A considerable share of income comes from EU projects which are jointly conducted with partners from many European nations.

Budget in 1000 €	**2012**	**2013**	**2014**	**2015**	**2016**
Expenses					
Operating Budget	7146.0	7607.9	8027.6	8643.4	8914.7
of which Human Resources	5461.0	5915.7	6189.4	6660.5	6760.7
of which Material Expenses	1685.0	1692.2	1838.2	1982.9	2154.0
Investment Budget	367.0	372.0	514.2	1116.2	549.4
Total	**7513.0**	**7979.9**	**8541.8**	**9759.6**	**9496.1**
Funding					
Basic Funding	4772.0	4820.9	5405.8	5233.6	6004.9
Contract Research Projects	2741.0	3159.0	3136.0	4526.0	3459.2

ADVISORY BOARD

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

Members

- Mister Udo Becker, Vorstand Kreissparkasse Euskirchen
- Mister Klaus Burmeister; Z_punkt GmbH The Foresight Company
- Mister Dr.-Ing. Karsten Deiseroth; IABG GmbH
- Mister Prof. Dr. Horst Geschka; Geschka & Partner Unternehmensberatung Innovarium
- Mister Dr. Wolf Junker; Bundesministerium für Bildung und Forschung (BMBF)
- Mister DirBAAINBw Rainer Krug; Bundesamt für Ausrüstung, Informationstechnik und Nutzung der Bundeswehr
- Mister Dir Prof. Dr. Winfried Schuhn; Wehrwissenschaftliches Institut für Schutztechnologien – ABC-Schutz (WIS)
- Mister MinR Norbert Michael Weber; Bundesministerium der Verteidigung (BMVg)
- Mister Dr. Thomas Weise; Rheinmetall Aktiengesellschaft
- Mister Dr. rer. pol. Hans-Ulrich Wiese
- Mister Prof. Dr. Dr. Axel Zweck; VDI Technologiezentrum GmbH

1 *Advisory Board Meeting on June 15, 2016*

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 67 institutes and research units. The majority of the nearly 24,000 staff are qualified scientists and engineers, who work with an annual research budget of more than 2.1 billion euros. Of this sum, more than 1.8 billion euros is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 percent is contributed by the German federal and Länder governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

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

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

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

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

FRAUNHOFER VVS – GROUP FOR DEFENSE AND SECURITY

Fraunhofer VVS

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The Fraunhofer Group for Defense and Security VVS was founded in 2002, chaired by Prof. Dr. Klaus Thoma.

The total budget of the Fraunhofer Group amounts to approximately 250 million euros per annum, and more than 2500 employees work for the ten VVS institutes.

The group considers its main objectives as follows:

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

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

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

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

Tasks and functions

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

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

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

This implies the following tasks and functions:

- Providing advisory support for national and international R & D-policy
- Providing advisory support for the Fraunhofer management board
- Basic assessment and consulting capabilities for defense research
- Longtime oriented, collective platform of planning and action
- Coherent market communication
- Strategic orientation and further development of the Fraunhofer competences

Future Security Conference

An important activity of the VVS is the Future Security Conference, organized annually since 2005. The conference in 2016 was hosted by Fraunhofer IAF. It took place in Berlin from September 13-14 under the slogan "Sensor Systems for Safety and Security". To foster the communication and interaction among these different communities on this very topic, the "Future Security" conference series provides an interdisciplinary exchange platform for scientists, experts and actors from research, industry, public bodies and authorities. This conference offers direct insight into current security research activities and hot topics in this field.

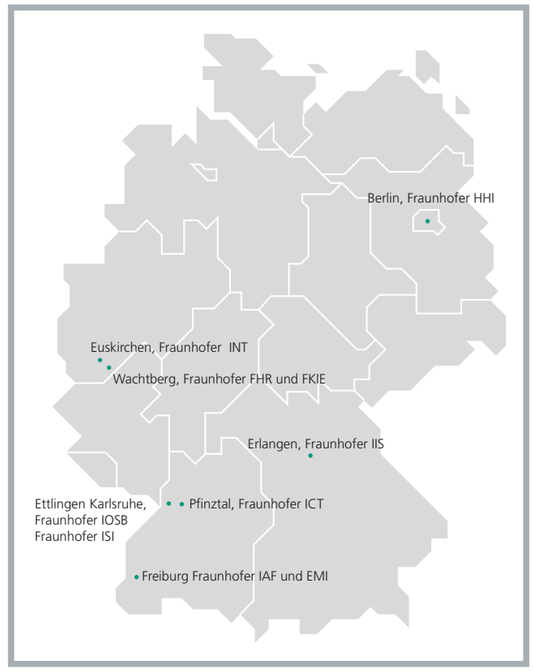
Position Paper on the "Continuation of civilian security research" in Germany

Security is and remains one of the most important needs of our society. Due to changing threats, this issue is still highly topical. Civilian security research is successfully established in Germany as a cross-cutting research discipline. From the outset, embedded in the Federal Government's high-tech strategy, many actors from science, research, business, authorities and security organizations contribute to the development of concrete solutions to overcome complex challenges in collaborative projects. The latter have greatly expanded recently due to security policy, social and technological changes.

The new research program of the federal government of Germany for 2017 must take these changes – structurally and in terms of content. In close collaboration with the VVS, the Fraunhofer-Gesellschaft has formulated its recommendations to the Federal Government in the position paper on the continuation of civil security research.

Member institutes are the Fraunhofer institutes for

- High-Speed Dynamics, Ernst-Mach-Institut, EMI
- Applied Solid State Physics IAF
- Chemical Technology ICT
- Technological Trend Analysis INT
- High Frequency Physics and Radar Techniques FHR
- Communication, Information Processing and Ergonomics FKIE
- Optronics, System Technologies and Image Exploitation IOSB
- Systems and Innovation Research ISI (guest institute)
- Integrated Circuits IIS (guest institute)
- Telecommunications, Heinrich-Hertz-Institut, HHI (guest institute)



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Deputy Chairman of the Group
Prof. Dr. Peter Martini; Fraunhofer FKIE

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

TECHNOLOGICAL ANALYSES AND STRATEGIC PLANNING

Dr. René Bantes

Social, technological and economic development is inextricably linked, since the forces behind them influence each other. In both the political and private sector, decision-making processes that affect the medium and long term – with lasting and far-reaching consequences – need the support of appropriate "systemic" analysis and consultation. This requires not only solid anchoring in individual areas of technology, but also the ability to analyze and evaluate the overarching importance of these areas, as seen with an interdisciplinary approach from many perspectives, and taking account of different social dimensions.

The Department Technological Analyses and Strategic Planning (TASP) has the task of analyzing and evaluating global technological developments as well as their social and economic impact, and deriving from its results potential implications for strategic research and technology planning, as well as for planning and organizing innovation processes for the clients. To achieve these ends, TASP is staffed with around 40 specialists from a wide variety of disciplines, but mainly from science and technology.

The Department produces results that serve the conceptual, introduction and implementation phases of innovation processes, with a pronounced focus on technological questions. This core competence is based on a skills profile made up of three, mutually complementary fields.

Using a comprehensive, systematic and continuous technology foresight process, TASP's scientists generate the ability to identify technological developments, to evaluate and categorize them extensively, and to estimate future development prospects.

Years of experience in researching national and international security and crisis management, and the ensuing knowledge – especially of participative approaches for innovation support – add a system-oriented view to the technological focus.

With TASP's continually expanding portfolio of approaches and methods, including participative and creative work formats, quantitative, IT-backed procedures for data analysis, and innovative visualization techniques, the Department has created a methodological basis for a wide range of issues and application scenarios.

From this foundation of skills, TASP derives client-specific products. These range from the general future potential of a technology, to the relevance of national and international stakeholders and of plans and programs in research and technology.

Over and above this, highly-specialized studies are conducted on request, tailor-made to a field of application or technology, to identify concrete decision pointers for the client. This can lead to specific recommendations for action to support the client in making choices for strategic research and technology management.

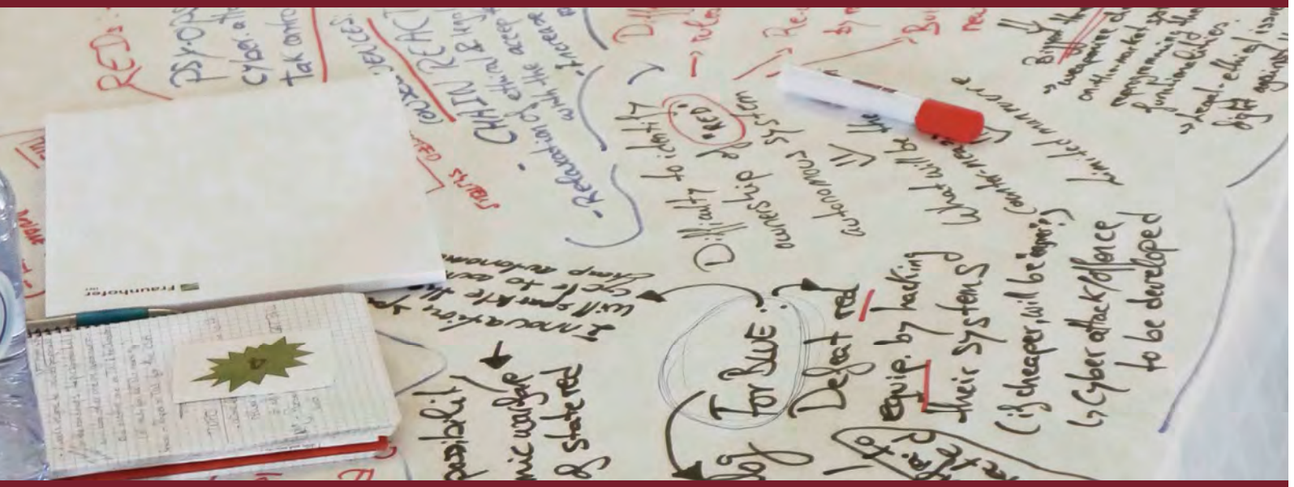
Although the underlying methods are largely generic, the formats, conclusions and recommendations derived vary, depending on client requirement. To best serve these requirements, TASP is structured in three Business Units, each of which addresses different clients and their varying analysis requirements:

- Defense Technology Foresight
- Public Technology and Innovation Planning
- Corporate Technology Foresight

These Business Units and their activities in 2016 are described in detail on the following pages. The Business Units are supplemented by the Group Tools and Methods, which concentrates on developing fundamental methods for scientific work. In addition, specific work was done in internal projects, providing a basis for the Department's work in 2017 and the years to come.

BUSINESS UNIT “DEFENSE TECHNOLOGY FORESIGHT”

Hans-Martin Pastuszka



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

The technology-oriented futures research of WZA provides its clients with reliable knowledge for their orientation and decision-making guidance on likely future developments in science and technology and their potential defence technological and military implications. This includes in particular the early detection of emerging technologies and their specific assessment for defence clients, for example with regard to identifying inherent risks and opportunities for their use in military operations. As well as focusing on technological issues, relevant international research planning processes and strategies are observed, analyzed, and for example provided as country reports.

From these analyses of technological developments and planning processes WZA derives research and technology planning recommendations for the client. WZA is thus making its contribution to gaining insights into global long term technological developments in the future, ensuring a broad analysis and assessment capability for clients in defense research and technology (R&T).

These services are provided by an interdisciplinary team of scientists within TASP. This guarantees overall competence in all relevant science and technology fields, supplemented by comprehensive expertise in methodology and processes. The results are made available to the client, in particular through the quarterly “Defense Technology Forecast” (WTV, restricted), the business unit’s key product. The knowledge gained from the activities in defense technology forecasting proves to be valuable for a number of inter-departmental projects. In particular, this includes the organization and content support of INT’s “New Technologies“ column in the journal “Europäische Sicherheit und Technik“ (European Security and Technology).

2016 was marked by intensive project work, for both the main client and EDA. In contract research, WZA’s main task lay in continued work on the Defense Technology Forecast, which the client makes available to a wide-ranging readership in BMVg, its downstream bodies and in the Bundeswehr. As in the years before, altogether 11 articles were written and published on a number of technology topics and long term system concepts. Three workshops on the individual results were conducted together with the client. Also in 2016, WZA took over the content management of the annual report “Wehrwissenschaftliche Forschung“ (Military Science Research), which is edited by INT and published by BMVg for a number of years.

Over and above WZA’s main task, several projects on selected topics were also conducted during the year. As well as continuing brief technology analyses for the Swedish Defence Material Administration (FMV), study work for EDA was intensified. Continuing cooperation begun the previous year with the Spanish state-owned engineering and consultancy firm Isdefe (Ingeniería de Sistemas para la Defensa de España), where a prototype IT tool to support EDA’s Technology Watch activities was developed (see report in the Annual Report for 2015). INT led two work packages in the follow-on study this time: in the first, functionality and subject coverage for the “Tech-Watch tool” were improved, in the second, a methodological approach for EDA was developed to round off aspects of a long term technology outlook. The latter was tested in two workshops with EDA. This Annual Report carries a special article on this project (see page 19). EDA also ordered a study for a consortium made up of FOI (Swedish defense research agency), Isdefe, TNO (Netherlands) and Fraunhofer INT, for a comprehensive analysis of current R&T planning in EDA’s CapTech working groups and their strategic research agendas. The study included developing and partially implementing recommendations for harmonizing plans, and deriving a common EDA agenda (Overarching Strategic Research Agenda – OSRA).

WZA's numerous EDA activities were rounded off with a guest presentation given on "Emerging technologies and long term technological trends impacting defence" at EDA's R&T conference in Amsterdam (Netherlands) in April 2016.

The business unit WZA was again involved in a series of educational and panel activities at the end of the year. A highlight was the jointly-conceived course module "Methods of Futures Analysis" at the Bundeswehr Staff College in Hamburg, organized and staged in November 2016 by the Futures Analysis section of the Bundeswehr Office for Defence Planning. As in the years before, WZA contributed two individual talks on defense technology foresight and WTV, using examples from Artificial Intelligence, and the Disruptive Technology Assessment Game. A third talk on Quantitative Methods was given by the TASP Group Tools and Methods. Other notable teaching activities concerned content support for past and present Institute Directors at lectures for the specialist faculties at the universities of Bonn-Rhein/Sieg and Ravensburg-Weingarten.

Finally, as part of NATO's program "Science for Peace and Security", the two colleagues appointed for its "Independent Scientific Evaluation Group – ISEG", together with their international colleagues, shaped the work of this Group. Among other duties, they evaluated approx. 50 submitted research applications, for which they and the other ISEG members developed a common position.

For the year 2017, again an increasing demand for WZA's services from national and international clients and partners is expected.

TECHNOLOGY WATCH AND TECHNOLOGY FORESIGHT FOR EDA

Dr. Matthias Grüne, Hans-Martin Pastuszka

In 2015, the Council of the European Union revised its assignment for the European Defence Agency (EDA), the body founded in 2004. Accordingly, EDA's main tasks are to support the development of common European military capabilities, to promote European defense-related research and technology (R&T), and to function as a military-political interface. In order to plan and manage these activities, EDA needs a systematic view of future technology developments. In consequence, Fraunhofer INT's Business Unit Defense Technology Foresight and its Spanish partner Isdefe (Ingeniería de Sistemas para la Defensa de España) were commissioned to set up an initial operating capability in defense-oriented technology foresight.

In 2015, an initial study under the leadership of Isdefe saw the development of an IT tool for the partially-automated support of EDA staff in Horizon Scanning and Technology Watch. Prototype implementation followed in EDA's IT environment (see INT Annual Report 2015).

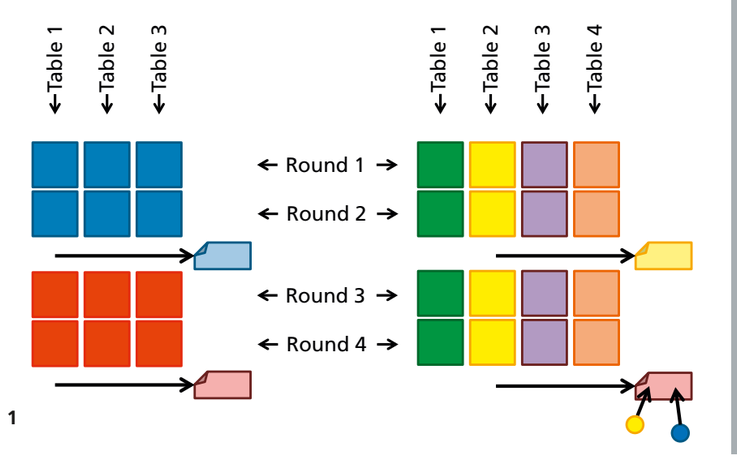
The follow-on study in 2016/2017, under INT leadership, focused on two tasks. First, the full coverage of all relevant technology fields by the IT tool was to be checked and ensured by an augmentation of the tool, in order to achieve better and more reliable scanning results. This task, including the compilation of additional technology profiles, was in the main addressed by Isdefe. Second – the point of reference for this article - was the concept of widening EDA's fundamental capability for early technology recognition and monitoring by adding the aspect of long-term Technology Foresight. In this context, the idea is to identify technological topics that are either newly emerging or significantly gaining in importance within a time horizon of 20 to 30 years, and to make an initial assessment of their potential relevance for defense.

With regard to the methodology to be adapted and tailored for EDA's technology foresight, EDA had formulated a number of specific requirements that had to be taken into account or implemented. For example, the methodological approach selected was required to take adequate account of EDA's specific characteristics regarding its internal work processes and strictly limited human and time resources.

It should nonetheless be scalable, in order to be able to react to possible requirement changes. In addition, one of EDA's requirements was targeted support for the tasks of EDA's CapTech working groups. Also to be taken into account were relevant long-term-oriented findings from EDA's Capability Development Plan (CDP), including military scenarios and relevant activities in EU Commission research programs. Finally, the new approach should be as user-friendly as possible and open to possible adaptation in the future.

A major challenge for the study team was to develop a methodological study design that would make compatible the above requirements as regards minimum resource use, robust and complete results, scalability, and user friendliness. To this end, first-class "best practices" of technology foresight were initially compiled and assessed, and their adaptability to EDA's specific requirements was examined. Based on the many years of intensive practical experience of the two project partners in identifying and assessing future technology developments and their military relevance, the result was to propose a multi-stage procedure for the required work. This allows a scalable approach at every stage, which takes account of predetermined concepts, framework conditions and possible and necessary effort.

The first phase of the procedure serves to identify potential topics. Candidate topics are those whose future potential, anticipated military significance and, in particular, granularity (topic range), promise maximum interest in the discussion and evaluation that follow in the third phase. To identify such candidates, the technique of metascanning was chosen, that is, the analysis of studies that already focus on identifying such topics ("scanning the scanners"). Thus the effort required in this phase can be minimized. The result was a list of 23 topic candidates. Owing to the broad, discursive approach chosen and the long-term time horizon, especially suited topics proved



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to be those of a more paradigmatic character, which bring together many single technology topics in one research trend.

In the second phase, those topics best suited for further processing were selected. The well-tested Weighted-Bit Assessment Method (WBAM) developed at Fraunhofer INT was put to use here.

The essence of the third phase was two participative "Technology Foresight Exercises" – participatory workshops in which the topic concerned was discussed and evaluated with regard to its defense-technology significance, foreseeable research needs and consequences for (European and adversarial) military capabilities. The workshop approach was to use variants of the "World Café" method. For a one-day event, the study team found that this method caused the least effort in preparation, execution and follow-up work, while at the same time making the best structured use of EDA expertise, both technological and military. The method allows a scalable number of participants to discuss in parallel in a relaxed atmosphere that is open to ideas and focused at the same time. By systematically re-mixing the groups, it is possible to network discussion threads and renew inspiration after each session. The choice of focus and guiding questions makes it possible to take up different perspectives in succession, even to build up an intellectual "question dramaturgy".

The subject of the first workshop was "Really Autonomous Systems". It was held in September 2016 in Brussels with the participation of all EDA CapTech moderators. The focus was on the question of the possible effects on future military capabilities. For this reason, the "War Café" format was selected. Comparable to a military war game, this World Café variant calls for the strictly separated discussion of the "blue" view of friendly forces, or of the "red" view of the enemy or of the threat perspective. Separation may occur between discussion rounds or between discussion tables. In this case, the former approach was chosen.

By contrast, the second workshop focused on deriving defense-oriented research needs and opportunities for European R&T cooperation. Participants of the workshop, held in October 2016 in Brussels, were EDA CapTech "Materials" members. The subject matter was accordingly restricted to the working group's field of activities. Of the four discussion themes selected from the main heading "Materials 2050", three came from CapTech work, and one was identified in this project. The workshop also served to demonstrate the procedure in real EDA committee work.

As expected, the presence and active participation of a sufficient number of experts from various fields, especially from the armed forces, proved paramount for the quality and greater value of the workshop. Highly important was also the quality of the focus questions defined for each table, and of the respective guiding questions for each discussion round. The skill lies in finding the right balance: On the one hand questions must be open enough to trigger and encourage an open-minded discussion (without already prejudicing possible findings due to question formulations), on the other hand they should be specific enough to take discussion beyond the limits of long recognized platitudes. Together with EDA, the two workshops highlighted a number of lessons and findings that set their sights at the future. However, none of the workshop results should be viewed as final conclusions. It is more a case of different stakeholders repeatedly running through the whole process, serving development and continual adaptation, and agreement on future scenarios ("pictures of the future").

For the fourth and final phase of the overall process, a pro-cedure was worked out for processing all the extensive and diverse documentation from the workshop discussions (tablecloth scribblings, notes, interim presentations, Metaplan cards with or without evaluation stickers, etc.), producing an easy, straightforward summary of the main messages. For future work, the results were made available on EDA's IT platform.

Developed for technology foresight at EDA, this method and the examples seen in practice aroused great interest. Currently, EDA is internally considering how this approach can be implemented for future updates and further development of the strategic research agendas for the twelve EDA CapTechs.

1 *Schematic flow of the two World Café variants*

2 *Draft results on a World Café table (Photo: M. Grüne)*

BUSINESS UNIT “PUBLIC TECHNOLOGY AND INNOVATION PLANNING“

Dr. Merle Missoweit

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

The Business Unit came into being at the start of last year by merging the two Business Units IFT (International Research and Technology [R&T] Management) and ÖFT (Public Research and Technology Management). The purpose was to make better use of the synergy effects between international and national issues and key focal points. Last year already recorded the first positive effects of the step taken.

In research, the Business Unit's focus is on decision-making support for research and innovation planning in the field of security research, but increasingly in other areas as well. This mainly means foresight and scenario activities, technology assessment, roadmapping and concepts for research projects, and contributing to capability development. One of our principle skills in this context is the application of participative methods for integrating relevant experts and players. This way, we reach a consensus-based, state of the art research result.

As regards content, a lot happened during the year: In **innovation management for state players**, decision support is now being developed outside of security research. Worth special mention is the project SONNETS (Societal Needs Analysis and Emerging Technologies in the Public Sector, scheduled to run 2016 - 2017). This identifies and analyzes technologies for digitalizing public sector work and promotes implementation by networking the individual players. TIP has charge of the work package that is setting up a corresponding roadmap (see page 25). There was also activity in the area of security research. The project CARONTE (Creating an Agenda for research on Transport Security, runtime 2014 - 2016) was brought to a successful conclusion at the beginning of the year, and more research applications were submitted. In the sub-section **Implementation and Operationalization**, we assist individual offices and organizations in fulfilling their specific tasks more efficiently by applying research results. In the year under review, successful preparatory steps were taken, and in the current year, these are to be implemented jointly with our partners in the public sector.

In **Resilience Management**, new expertise was acquired through starting up the two projects Smart Resilience and ResiStand. Smart Resilience (runtime 2016 – 2019) addresses the resilience of critical infrastructures in smart cities, i. e. cities that have already reached a high level of digitalization and networking in their infrastructure and, in certain circumstances, are thus more vulnerable. TIP's role is to analyze already existing approaches for measuring resilience. The project ResiStand (Increasing disaster Resilience by establishing a sustainable process to support Standardisation of technologies and services, runtime 2016 - 2018) is tasked with promoting standardization in resilience by proposing new standards, better explaining the potential of standardization, and by setting up a process for effectively standardizing new resilience solutions. TIP's role in ResiStand is to run the work package that is building up a user community and identifying, adapting and validating numerous standardization requirements (see page 26). Both projects represent important steps to be able to support our clients in the area of resilience management and planning in the near future.

In cross-section to these three main activities, we have for some time given greater consideration to the link to social questions on the acceptance of technologies and concepts. Ongoing in this field is the European *Network of Excellence SOURCE – Virtual centre of excellence for research support and coordination on societal security* (runtime 2014-2019; see page 76), as well as other activities in other projects.

TIP's broad expertise is not only clearly visible through its membership of the Horizon 2020 *Protection and Security Group*, but also of the interdisciplinary H2020 Advisory Group for

International Cooperation. In addition, the Business Unit provides experts for NATO's *Partnership for Peace* program and for projects in the EU research program Horizon 2020, and also represents the Fraunhofer Group for Defense and Security (VVS) at the Security Working Group of EARTO (European Association for Research and Technology Organisations). Additionally, several TIP staff members act as consultants in major research projects.

H2020 PROJECT "SONNETS" – SOCIETAL NEEDS ANALYSIS AND EMERGING TECHNOLOGIES IN THE PUBLIC SECTOR

Dr. Sonja Grigoleit

Since March 2016, Fraunhofer INT has been working on the EU Horizon 2020 Project SOcietal Needs aNalysis and Emerging **T**echnologies in the public **S**ector (SONNETS), which aims to transform the public sector into one of the leading adopters for new information and communication technologies, in short: ICT). This implies the identification of the needs of the society and the public sector, and a compilation of emerging ICTs. A comparative analysis of both aspects will lead to the development of a research agenda and specific recommendations for the European Commission.

On the basis of secondary research, interviews in four EU countries and workshops, a list of needs was compiled as a first step. The survey was conducted among three different stakeholder groups:

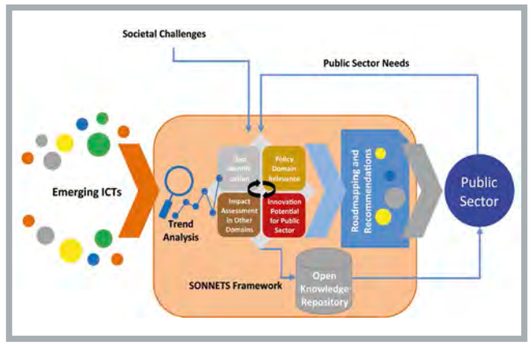
1) society in general, as represented by individual groups within the population, such as welfare organizations for the elderly, or charities for migrants,
2) the businesses

and

3) representatives from the public sector.

First results can be summarized as follows: while for example the society wishes a transparent and interactive public sector, business companies would vote for easier bureaucratic processes (especially for start-ups), easy access to important information and generally faster interaction between companies and the public sector, with user-friendly platforms. The public sector itself sees skilled workers, further training and digitalization as key factors for the future.

In addition, the consortium has used interviews, workshops and literature research to compile a list of emerging IT technologies and trends with the potential to transform the public sector. This includes areas like big data[1], or online identification (the e-ID function). In the upcoming months, these technologies will continue to be analyzed for their potential for innovation in the public sector, and to identify research gaps.



The project is coordinated by the Spanish firm ATOS, and has a budget of 500 000 Euro. The four partner organizations from Germany, Greece, Italy and Spain have 18 months until August 2017 to create a network in the area of emerging ICTs for the public sector and to advise decision-makers in the European Commission regarding necessary research activities. The aim is to give recommendations how the public sector could get the maximum benefit of the usage of emerging ICTs.

More information on the project can be found at http://www.sonnets-project.eu

SONNETS

[1] Technologies that can capture, store and analyze large quantities of data.

H2020 PROJECT "RESISTAND" – INCREASING DISASTER RESILIENCE THROUGH STANDARDISATION

Michael Löscher

Since May 2016, Fraunhofer INT has been contributing to a strategically important Coordination & Support Action (CSA) as part of the European Horizon 2020 research program. The two-year project is titled "Increasing disaster Resilience by establishing a sustainable process to support **Stand**ardisation of technologies and services (ResiStand)". It shares the European Commission view that by harmonizing and standardizing technologies, processes and services in crisis management and disaster control, Europe's resilience against natural and terrorist threats can be strengthened. Standards can, for example, help resolve existing technical and semantic interoperability problems faced by emergency services; standards can help small and medium-sized suppliers of innovative products and services to reduce their development costs; standards can help public procurers to pinpoint and define clear performance and quality requirements.

To be able to develop such standards, ResiStand is working on two central project lines. The first is to produce a roadmap which should set priorities for future standardization activities. The roadmap will also inform whether further research needs to be carried out for certain standardization projects, in order reach the required consensus for the solution under consideration. The second is to develop a sustainable process during the project – done in close coordination with participating and associated European standardization institutes – that will support future planning for standardization work in the security sector. After ResiStand is concluded, this process is to be taken up and continued by CEN, the European Committee for Standardization, and CENELEC, the European Committee for Electrotechnical Standardization.

The ResiStand process (see the simplified chart in figure 1) foresees the listing of the end users' requirements and standardization needs, comparing these with current and planned standards, and finally, developing the roadmap while taking into account new solutions from the supplier side (industry, SMEs, research). In developing the ResiStand roadmap, the prime focus will be on feasibility and the expected impact and benefit of a future standard. This assessment is done by means of a new and dedicated framework. It helps institutes and organizations that wish to develop standards in deciding whether they should realize a planned or potential investment in a specific standard development or not. This can prevent misjudgments and subsequent decisions for protracted development work on questionable standards, while freeing up resources for more promising agendas elsewhere.

ResiStand's central approach for improving standardization processes is to secure the early and continuous participation of all stakeholders (see figure below). ResiStand divides the stakeholders into three groups: end users, suppliers and standardization experts. They define needs, provide solutions, and support and participate in the actual development of standards. Accordingly, the project spotlight is on the fullest possible involvement of public bodies, first aid workers, emergency services, industry, SMEs, research facilities and standardization experts.

Fraunhofer INT has dedicated its efforts to one of these groups, being mainly responsible for collecting and specifying end user standardization needs. The project is scheduled to end in April 2018, at which time the results are to be presented at a final conference, organized by the project partner DIN (German Institute for Standardization).

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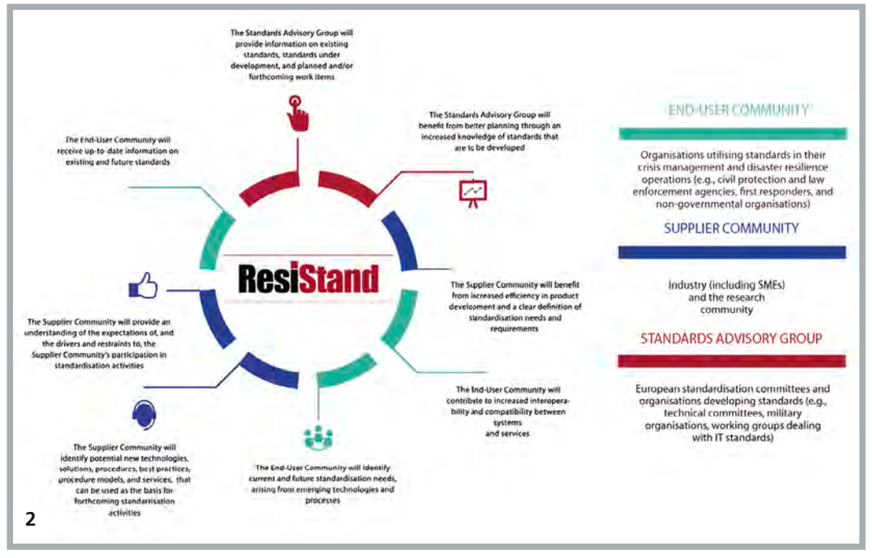


2

1 *Simplified chart of the ResiStand Process*

2 *Interest groups and their roles in ResiStand*

BUSINESS UNIT “CORPORATE TECHNOLOGY FORESIGHT”

Dr. Martin Brüchert

The Business Unit Corporate Technology Foresight (CTF) focuses on technology, innovation and the future for the business world. With in-depth scientific methods applied research by the unit supports a wide range of companies in questions of long term successful strategies and innovation management. CTF shows up future technological changes, analyzes and assesses them and, together with the client, develops solutions and plans. Broad technology screening reveals trends, risks and the potential of new technologies for the business community.

In general, the starting point is the comprehensive overview that the whole Technology Analysis and Strategic Planning Department has of almost the entire future technology landscape, with a time horizon stretching from current changes to the long-term. In an age where innovations change whole business sectors, this supports companies in the timely recognition of cross-industry innovations and in taking a look beyond the company horizon. This can also benefit specific company strategy by pointing up and breaking down complex technological changes, such as foreseen in the German Government’s high-tech strategy “Industry 4.0”.

As well as the overall perspective (360°), the entire planning horizon is covered, from short to long-term forecast. Developing such competence internally is usually too costly, especially for small and medium sized enterprises. This keeps long-term complex technological developments out of reach for many, although they are of great importance for a company’s long-term success.

CTF closes this gap for companies or supplements a company’s own vantage point with a neutral perspective, thus helping to develop a sustainable, long-term technology strategy for each client.

The basic questions are: What technological developments can we expect? What technology is sustainable and can be used as long as possible until the next change? What new technologies will change my business operations or even make them obsolete? What new products or services can be realized with future technologies?

With CTF answering these questions, trends and technological developments are moved into a company-relevant context, possible development paths are identified, their meanings are analyzed and recommendations for action are developed. At the same time a strategy can be applied to match expected long-term developments. Especially the latter cannot succeed without expertise on participatory methods and a close, trusting relationship – as is customary with Fraunhofer INT.

These services are based on the central skills of technology analysis and strategic planning and the systematic technology monitoring of the department TASP. This generates fundamental knowledge on trends across virtually the entire technological spectrum; knowledge that can be quickly absorbed into projects and customized to client requirement. A business-oriented view of technology trends is a CTF characteristic. The following presents several examples of technological developments. In future, such examples will be reviewed quarterly and circulated via our CTF newsletter. To register for our newsletter, please visit our homepage: www.int.fraunhofer.de/ctf.

MACHINE LEARNING – A KEY TECHNOLOGY FOR TOMORROW'S PRODUCTION

Dr. Martin Brüchert, Dr. Anna Schulte

Whether autonomous driving, developing new materials or analyzing and optimizing production processes (Industry 4.0) – the future cannot be imagined without artificial intelligence. Machine learning processes are among the key technologies in this field and they are becoming increasingly important for the intelligent analysis of ever-larger and more complex networked data sets. It's about methods that generate knowledge from data. The systems are first of all »trained«, which enables them to learn from experience and improve themselves constantly.

Machine learning is a multifaceted, complex research field, in which the development and user communities merge seamlessly. The various learning methods can provide a preliminary sorting of the field, making it possible to distinguish between supervised learning, semi-supervised learning, unsupervised learning, reinforcement learning and active learning. Depending on the method of learning, different algorithms are employed.

Using bibliometric procedures, Fraunhofer INT has examined this research field with regard to its main methodological approaches, the relevant players and their research areas. Bibliometry is an important quantitative analysis tool, and Fraunhofer INT uses it to be able to achieve a better assessment of a technology's future importance and development progress.

Indicators such as the giant component provide information on the degree of cross-linking of individual research communities, and so indirectly give information on the potential scientific maturity level of a technology. Player analyses identify the key scientific protagonists, while overlay maps can project an institution's key expertise fields on to a type of "Map of the Sciences", allowing the players to be aligned in relation to the landscape of research themes.

The analyses confirm the general perception that machine learning in the factory of the future – in production, for example – will play an increasingly important role. The concept is highly developed and is becoming more and more widely used in a very broad variety of application fields. Within their technology and innovation management, companies should carefully analyze the future benefits they could reap from this technology, and arrange for timely planning accordingly.

BIOPRINTING – OUR FOUNTAIN OF YOUTH FOR THE FUTURE?

Stefan Reschke

In Germany, there is a long waiting list for donor organs. In 2015 alone, more than 10 000 people were on the waiting list, but only about 3300 organs were transplanted. In other industrial nations, the shortfall is even much greater. A future solution for this organ shortage can be bioprinting, which at the same time could be an alternative to animal testing.

Bioprinting is an emerging application field in additive manufacturing (3D printing) that promises revolutionary use in all regenerative and restorative medicine, also in cosmetic surgery or pharmacological research. Looking into the future, bioprinting could make it possible to prolong human life considerably by repeatedly replacing aged organs, and to increasingly forego animal testing.

The special feature of bioprinting is that with very high spatial precision, living body cells, proteins, biochemical growth and differentiation factors as well as other biologically active substances can be bonded in layers with soft substances (connective tissue, fasciae, organs) and hard substances (bones). The first steps have already been taken in other application fields, such as biological tissue for pharmaceutical drug research and model tissue for research into diseases like cancer at cellular level.

Medicinal applications are mainly tailor-made bone and organ replacements that can be fitted exactly to the patient's body. Using endogenous cell material from the patient, tissue and organs can be produced that do not cause the immune system to trigger a rejection reaction. This means that in the future, transplants would be more successful and the risk of side effects would be greatly reduced. Moreover, cosmetic surgery could increasingly forego the use of silicon-based implants and non-biological substances.

For some time it has been possible to print hard substances as an exact copy of the original that needs replacing, whereas research in functional tissue – organs such as skin, liver or kidneys, even neuronal structures as in the brain – is still in its relatively early stages. However, models of various organs have already been produced and successfully tested in lifelike conditions.

In recent years, many new insights have been published that suggest a disruptive potential for this technology in medicine, pharmacology and biotechnology, which in turn indicates interesting new business models.

ATMOSPHERIC WATER GENERATION – NEW CONCEPTS AGAINST WATER SCARCITY

Dr. Anna Schulte, Dr. Diana Freudendahl

As the writer Arthur C. Clarke already stated in 1973: "Any sufficiently advanced technology is indistinguishable from magic". This sentence can also be applied to modern Atmospheric Water Generation (AWG) technologies, which can remove water from the air and seemingly fill bottles from „nothing". Such technologies can counteract water scarcity in the world, especially in low-precipitation, arid areas.

The atmosphere is potentially a large alternative water source that is gaining in importance, industrially too. 98 percent of the water suspended in the atmosphere is the humidity in ambient air. Although collecting water from the atmosphere is a very old concept, with continued climate change and the growth of the world's population, it is becoming more important. In consequence, developments in relevant sub-technologies, especially in materials sciences as well as new overall systems, are forging ahead.

To collect atmospheric water, it is possible to use condensation technologies as well as methods of dehumidifying air with the use of desiccants. In both cases, water extraction from the air can be active or passive. Active systems which function similar to air conditioners for example, mostly need a high-energy input, and are rarely economical, particularly where seawater desalination is possible. So, active AWG systems that use energy from renewable resources such as solar power are highly interesting for current research.

As well as these active systems, much attention is also being paid to passive AWG systems, especially if they are easy to install and require little maintenance. These devices are based on the condensation of dew and ambient humidity (such as fog) on surfaces or meshes. In particular, research work is focusing on promising bionic approaches. Research here falls back on a great diversity of hierarchically structured surfaces that very different organisms already use to collect water.

Frequently, as well as the special structuring, corresponding chemical surface characteristics and, in some cases, even effective temperature gradients are used.

Fraunhofer INT has run an analysis of new AWG approaches and concepts that are still under research. From economic, ecological and social perspectives, they have great potential, which is why interest in the field has been growing in recent years. Future AWG systems will thus also benefit from current research on new surface materials and their production.

KINETIC ENERGY FOR PORTABLE POWER CONSUMERS

Dr. Sabine Müller

People who use smartphones and other mobile electronic devices know the problem: the battery is flat and there's no power point in sight. In future, the energy required could be generated simply by walking or climbing stairs. The technological principle is called "Energy Harvesting": making use of kinetic energy by transforming it into electric power. With the development of triboelectric nanogenerators (TENGs), a new technology is almost ripe for the market. By integrating TENGs into clothing or shoes, it could soon be possible to generate electricity with every step you take.

The underlying physical principle is simple: when two layers of differing materials (e. g. rubber soles or PVC) are brought into contact, they exchange electrons and charge each other (the triboelectrical effect). When the two layers are separated from each other, electrostatic induction causes a charge, and by applying electrodes to the two layers it becomes possible to tap a current. Continually moving the two layers towards and away from each other creates a periodic current pulse.

New is that with some TENGs only one triboelectric layer needs to be integrated. What serves as a second layer is for example the floor or human skin, something that offers a great variety of possible applications. In addition, TENGs are mechanically flexible and very robust; various types of them are constantly being improved. For example, optimizing the surfaces greatly increases the nanogenerator charge transfer. Combining TENGs with already established piezoelectric nanogenerators allows for even more innovative applications.

TENGS can be integrated into various textile fabrics. Power could be generated by just walking on a carpet, or small batteries could be charged by tapping the movement of the clothes a person is wearing. With TENGs, it will also be possible to develop touchscreens that not only supply their own energy, but can also be bent, rolled up or folded.

In the near future, TENGs could also be used to equip smartphones with smaller batteries. With autonomous sensor networks and other small power users there is already a large demand for further self-sufficient, reliable energy sources. In addition to existing technologies such as solar cells, TENGs will help address this demand.

THE STRATEGIC PROJECT “TOOLS AND METHODS”

Dr. Miloš Jovanović

New Central Group for implementing the Tool Strategy

How does TASP, the Technological Analyses and Strategic Planning Department, fulfill the various tasks assigned to it every year? The projects undertaken in this department cover a large task spectrum and a large diversity of themes, and each project calls for an appropriate strategy. As well as the professional expertise of the range of scientists, graduates and infrastructure staff, the department has been using a wide variety of tools and methods for many years. Owing to the large number and heterogeneity of these tools and methods, Fraunhofer INT launched a strategic project and set up the group **Tools and Methods (TM)** within TASP in 2016.

Already in 2015, preparatory steps were taken for launching the new strategic project, which itself supersedes the strategic project Technology and Trends and Strategies (TPM, see Annual Report 2015). In line with the project Further Development of the Tool Strategy, we assessed the current state of the tools and methods used, and posed the question: “For what purpose should we be using these tools?” Among the answers were: improving the efficiency of scientific studies and raising the quality of project results. Looking to the future, we then considered how to develop a strategy that guarantees the implementation and further development of tools and methods in TASP.

The group, finally set up in April 2016, is a strategic project, and as such is initially scheduled to run for two years. The group’s task is to implement the tool strategy of the TASP department, including the use and further development of tools and methods that could prove useful for the department over the next two years. To this end, we defined various in-group topics and projects that are to be implemented by the end of the strategic project. The group sees itself as a developer of new tools and methods, as well as a service provider for the business units. Daily work for the latter will benefit in the short term from support through expertise in methods and tools, and in the long term through the development of new tools and their implementation, for example using workshops and seminars. The group works in cooperation with the Staff Position Methods and Training, for example in the jointly organized Method Forum, a flexible format where every Fraunhofer INT staff member can present, discuss and trial their experience with tools and methods.

Theme Categories, Tools and Projects in the TM Group

TASP is a department which first and foremost concerns itself with the research, analysis, documentation and publication of knowledge. Themes and projects are thus classified in interrelated categories that constantly keep their handling of knowledge and information in focus (see Fig. 1).

In considering these categories chronologically, the usual procedure is first to try to extract information, for example, from a data bank. At TM, the themes **bibliometrics and patentometry** fall under information extraction, for example. Using these methods, researching for scientific articles and patents can be optimized and conducted more efficiently.

However, as the science of science, bibliometrics also deals with the quantitative analysis of scientific publications and their citations, and thus falls under the category information measuring. When a sufficient amount of knowledge has been extracted, it can then be measured in a next step. Within the TASP department, bibliometrics is in the main used for technology foresight and research evaluation. For example, we analyze publications and citations in a variety of science and technology themes. Similar analyses may also be conducted regarding patents, something of major importance for technology analyses.

In general, **statistical analyses** for various applications are also highly versatile. In this context, TM is currently focusing on the use of R, a free programming language, with the inten-

1

STILL SEARCHING, OR ALREADY ANALYZING?

Beate Becker, Frank Fritsche, Dr. Daniela Lieberz, Sylvia Scheid, Dr. Marcus John

tion of making various statistical analyses available to a larger number of users within TASP. These analyses are a field located in the category knowledge modeling and structuring, which is concerned with recognizing patterns in data sets for example.

In addition to these first three fields, *knowledge organization and documentation* is an important fourth category for TASP. This is where, after being accessed and processed, knowledge is collated and rendered retrievable. A major task in this category is **knowledge management**, for which an example is the central Wiki platform that our staff can use to document and exchange their knowledge. A new development was the Information Platform "New Technologies" (IPNT), which is where results from work in Technological Foresight are to be stored. IPNT is currently undergoing tests. Apart from IT tools, TM is also developing knowledge management concepts, for example on how the Wiki can be structured and how knowledge stored in it can be classified and saved. For both the Bundeswehr Office for Defence Planning and internal use, the TM group is analyzing current and past literature on trend management systems, a task it shares with the department's business units. The concept is to translate results from this analysis into a trend management tool that can also be used at Fraunhofer INT.

The last category in chronological sequence is *knowledge presentation*. TM is using the latest **visualization** methods in order to convey complex subject matter efficiently. Against this background, TM specialists covering a wide variety of fields are working on the development of new visualization forms, and adapting existing forms to the needs of TASP.

None of the categories, themes and projects outlined above stands alone. Naturally, a trend management system is also part of knowledge management, and bibliometrics would be only half its worth without linking it to visualizations that convey results more effectively. Statistical analyses are also used in bibliometrics, and R possesses its own visualization forms. What makes this strategic project particularly appealing is precisely the networking of all TM themes and projects. All the tasks pursue one goal: to make future work at TASP department (and also looking ahead, work for the whole Institute) better and more efficient.

Another versatile and multi-faceted project is addressing IBM's Watson software. The project, which is named KATI, is covered in detail in the following article.

1 *The TM Group and its Theme Categories TM Group*

Data, information, knowledge – this is the raw material for the work done in the Department TASP. Essential for technology foresight is the constant monitoring of recent developments in almost all areas of science and technology, as well as gaining a regular overview of the planning landscape. The challenge, however, is that this Science Observatory, as we call it, provides too much data and information rather than too little.

It is not just the sheer volume that TASP staff has to deal with, it is more a question of having to link data together and identify the patterns and trends contained. Many clients are not only interested in the content of a technology field, or in its current state and possible future developments; the client focus is also on exactly who is concerned with which sub-aspects of a technology, to be able, for example, to identify suitable partners for specific cooperation. Another challenge is to identify relevant key publications as fast as possible. This means scientific articles that are particularly well-suited for incorporating into a topic and for identifying current developments.

In most cases, such literature research very quickly shows up a large number of publications of potential interest. Of these, however, only a small number can be read in the context of one particular project.

Developing an Assistance System for Technology Foresight

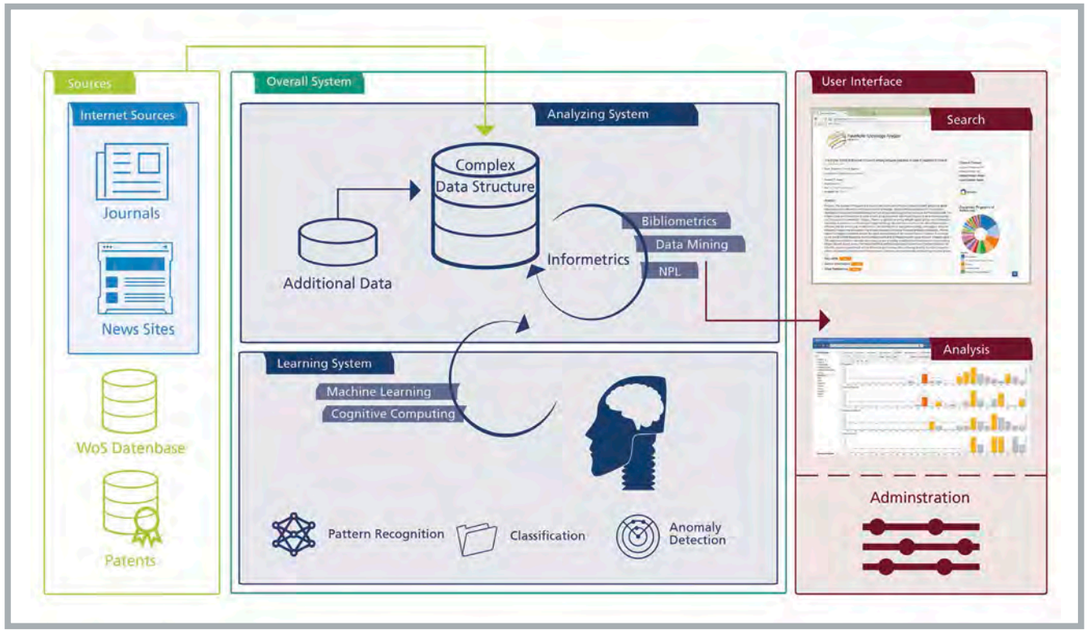
These factors were the starting point for the TM Group's work on its "Watson Project". The project aims to develop an IT and data-based analysis system for TASP, in support of Department staff in many facets of their daily work. This primarily concerns research. The system is intended to reduce significantly the time it takes to search for relevant publications, and thus provide more time for content analysis. This is also to be supported by, for example, accelerating and automating analyses of the players' landscape. This is the point where the project benefits from the know-how in bibliometrics, the statistical analysis of publications, which the Fraunhofer INT generated in recent years.

The assistance system which is currently being developed is intended to utilize methods stemming from the field of cognitive computing. The idea is to use software to attempt to simulate human cognition by using technologies from various areas. Methods from Natural Language Processing are necessary in order to open up and analyze texts. These are supplemented by algorithms from data mining, machine learning and big data. The concept is to cluster large amounts of text, to identify patterns in them, to classify them and detect anomalies.

At the end of 2015, Fraunhofer INT acquired and installed a software package as part of the project. The software components for computer linguistics and machine learning are intended for foresight to this end, the system has to be redesigned and adapted to the special requirements of technology foresight. Usually such systems are only implemented in one single field, for example medicine. Considerable adjustments are necessary before the system can be used for all the various fields of science and technology that the Institute observes and analyzes. This is a challenge where Fraunhofer INT uses the support of external system consultants in addition to its own expertise.

Project Structure and System Design

The basic structure of the project subdivides into three processes. First of all, it is important to access the relevant data. Essentially, these are bibliographic databases for scientific publications (especially the citation index of the Web of Science), news sites, blogs and patents. The selection of these sources depends on the needs of the staff and their availability. The process of information integration is followed by the analysis



of the data, a method of information measurement which also mainly orientates towards staff needs and the requirements of technology foresight. This applies processes from data mining, natural language processing and bibliometrics, and interlinks them. In addition, suitable visualization techniques are developed and tested. In the third and final step, the data obtained serves as the basis of a learning system which, with the help of machine learning, attempts to identify and classify patterns.

Development work is currently focusing on preparing the data sources and implementing suitable analysis methods. This helps to realize different use cases that address important aspects of technology foresight. This includes the identification of key sources, actor analysis or, which possible (new) application areas come into question for a new technology. Another key factor is developing processes that can identify emerging topics.

Contribution to a Secure Future for Fraunhofer INT

The project thus basically rests on three pillars of TASP work. First is the staff's substantive competence in technology foresight and technology analysis. Next is the staff's methodological competence in quantitative processes in technology foresight and information visualization. Finally, these are supplemented by the new possibilities that result from cognitive computing.

This way, the project makes a double contribution to securing the future for Fraunhofer INT. First, it is a question of using the new and widened research and analysis options in order to extend information and consulting capacity and thus remain competitive in the market. The research possibilities in particular benefit all staff members. What also serves is developing and using new, scientifically challenging methods of networking Fraunhofer INT with the appropriate science communities. With the help of in-house central IT services, it was possible to implement a pre-alpha version of the system at the end of 2016. This is currently being tested and extended.

NUCLEAR AND ELECTROMAGNETIC EFFECTS

Dr. Stefan Metzger

For the Division Nuclear Effects (NE), 2016 was a very challenging year – as for INT in general – since NE Business Units were also severely affected by BMVg's cuts in its R&D budget. Some projects were not commissioned in 2016 as planned. Thanks to the staff acquiring customers in other markets, this deficit was kept at a tolerable level.

An outstanding event in the year at Department level was certainly relocation to the top floor of the new office complex, which now houses all of NE with the exception of WTI. We would also like to use this opportunity to thank all those who supported us in the move. Closer proximity for all the NE team makes for more efficient internal communication, strengthens the feeling of togetherness and helps us to identify with the Department. After completing final laboratory reconstruction in 2017, we also expect greatly improved working conditions in state of the art laboratories.

The implementation of an ISO 9001 quality management system is steadily progressing. This was proven in an internal audit conducted on October 12 and 13 by Mr. Olaf Vieweg from Fraunhofer IML. All hitherto uncertified working groups fulfilled requirements to an average of 85 percent, so that nothing stands in the way of an external audit in early summer, 2017.

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

- Representing the entire EME Business Unit, Christian Adami, Michael Jöster and Dr. Michael Suhrke received the NATO Scientific Achievement Award for their contributions to the CI-250 Task Group on Radio Frequency Directed Energy Weapons in Tactical Scenarios. Again, my warmest congratulations (see also page 76).
- As part of an ESA project, the Business Unit NEO for the first time undertook large scale Single Event Effects (SEE) tests on external accelerators such as the Proton Irradiation Facility (PIF) at the Paul Scherrer Institute in Villigen, Switzerland, or the RADiation Effects Facility (RADEF) for heavy ions at the University of Jyväskylä, Finland. This is an important milestone in the development of SEE competence (more is outlined on page 61).
- In line with the policy of diversifying the customer base, the Business Unit NSD was able to win the North Rhine-Westphalian Ministry of Economics, Energy, Industry, SMEs and the Craft Trades as a new client in the public sector.

My personal highlight for the year was undoubtedly RADECS 2016, the European conference on radiation effects held in Bremen – with Germany hosting for the first time in conference history. As Technical Program Chair, I organized the content of the individual sessions and led the selection process for the total of more than 150 presentations – five of which were contributions from INT or the Business Unit NEO. See the separate report on page 63.

The Department's work was documented in numerous publications and reports. Keeping pace with the current state of research in the many scientific communities, a key task for Department NE continues to be acting as expert reviewer for renowned journals, as well as participating in or chairing international conferences. NE staff also applied their expertise to the work of various standardization bodies such as DIN and IEC, or of NATO. Details are given elsewhere in this Annual Report.

In the course of the year, NE welcomed two new colleagues: Charlotte Bornhöft in NSD, and Heinrich Herrmann in WTI.

MAXIMUM SECURITY RESEARCH WITH RADIOACTIVE SUBSTANCES

Dr. Theo Köble, Udo Weinand

With today's global risk of terror and the fear that radioactive substances could be used as part of an explosive device, the safe storage of radioactive materials has become even more important. Guarded around the clock and with meter-thick massive concrete shield walls, Fraunhofer INT's premises have hitherto been considered sufficiently secure for storing radioactive materials. Following the change in how the risk potential with such substances is perceived, the public authorities and INT reappraised the safety installations, and this led to far-reaching additional safeguards for the Institute.

Storage of radioactive materials, especially high activity substances, has to meet high safety standards and must therefore constantly be adapted to satisfy extended requirements.

Basic Requirements

In Germany, requirements for the safe storage of radioactive materials are laid down in the DIN Standard 25422 "Storage and keeping of radioactive materials – Requirements on protection against radiation, fire and theft". This standard is based on the stipulations in the IAEA Implementing Guide Nuclear Security Series No. 11 "Security of Radioactive Sources". The Guide says that the standard applies to the storage and keeping of other radioactive materials in accordance with Section 2 of the German Atomic Energy Act (Atomgesetz – AtG). The standard also applies for nuclear facilities and installations according to Sections 6, 7 and 9 AtG. The standard does not apply to the final disposal of radioactive substances.

System

Radiation sources are classified according to their activity class (see Table 1). Considered are four classes of activity, which are defined by multiples of the exemption thresholds. This classification differs from IAEA's radiation source security classification, which is based on D values.

Activity Class	Activity (in number of exemption limits[1])
1	$1 – 10^4$
2	$10^4 – 10^7$
3	$10^7 – 10^{10}$
4	$> 10^{10}$

[1] Exemption limits according to Radiation Protection Ordinance (StrSchV), Annex III, Table 1, Column 2

When several substances are stored, the additivity formula is applied, i.e. exemption values for individual isotopes need to be totalized before they are compared with the exemption limits for the activity class. The general rule is: the higher the activity class, the higher the safety requirements.

In addition to the activity class, the requirements for fire and theft protection are then determined by the type of storage permitted. Examples of permissible storage are lead castles, transport containers, lead or concrete radiation protection cabinets, or irradiation facilities.

Fire and theft protection can be applied to either the storage facility or place of installation, or to both. As a rule, several different combinations are possible.

The main focus of DIN 25422 is on anti-theft provisions. In contrast to fire protection, where there are other regulations on fire prevention, such as mandatory cooperation with fire services, DIN 25422 outlines specific details regarding theft protection.

Improving Theft Protection in the Institute

In times of increasing threats from international terrorism, the safe storage of radioactive substances is becoming increasingly important. Our Institute uses sealed radioactive sources for researching the properties of radiation detectors, the possibilities for detecting radioactive and nuclear substances, and the sensitivity to irradiation in electronic and optoelectronic components. Especially sources in the higher activity range play a role in radioactive material security.

INT stores radioactive materials at different locations. This i ncludes radiation rooms with Co-60 sources that are also stored in their shielding containers when not in use. The sources are high-activity classed, and the containers are kept in windowless rooms with thick shielding walls.

Another area is a storage space for radioactive isotopes. This houses several lead cabinets cast together in concrete, as well as a neutron cabinet with particularly thick shielding, and several shielding and transport containers with sources.

At all access points, the steel doors were replaced with burglar-resistant fire protection doors. In addition, alarm systems were installed in each storage area. Since the doors are also the only escape route from these areas, a complex escape and rescue route system – approved and certified – was installed, making it possible to exit such a room even when the alarm has been activated.

There is also an irradiation room with massive concrete shielding where several D-T neutron generators are operated and stored. In the case of tritium, where activity is only low class, it sufficed to install just a new burglar-resistant door.

Outlook

Meeting the increased demands for fire and theft protection at a relatively small research institute was a complex task that required a great deal of time. Necessary changes in the inventory were difficult to carry out, space was often very limited. Companies with expertise in both radiation protection and fire and theft protection are rare. In addition, it is difficult to integrate the necessary work into the running operation; a great deal of flexibility is required of the companies involved.

Nevertheless, the additional gain in security – especially in the light of today's global security situation – is certainly worth the effort. This is particularly true when considering that any feasible terrorist use of a stolen radiation source would have unforeseeable consequences for the technical, industrial – perhaps even medicinal – application of radioactive substances.

BUSINESS UNIT “NUCLEAR SECURITY POLICY AND DETECTION TECHNIQUES“

Dr. Theo Köble

The Business Unit “Nuclear Security Policy and Detection Techniques (NSD)” conducts theoretical and experimental research in the areas of nuclear security policy and nuclear detection methods. Besides fundamental studies, research projects are carried out for industrial clients (nuclear research and nuclear engineering) and public authorities (mainly for emergency service and major research institutions). In addition, with basic funding from the Federal Ministry of Defense (MoD), NSD continues to intensify and expand the national capacity to judge nuclear and radiological weapons and associated asymmetrical threats. Projects are also carried out with the Bundeswehr Research Institute for Protective Technologies (WIS) in Munster.

NSD’s work is supported by its ultra-modern technical equipment. For simulating physical processes a Linux cluster with 64 processor cores is available. Besides coupled neutron and gamma transport calculations, e.g. for simulating detector spectra, NSD also performs coupled neutron and hydrodynamics calculations. The Business Unit operates several neutron generators (14 MeV and 2.5 MeV) and an isotope laboratory to carry out experiments. The isotope sources and experimental facilities are occasionally made available to external users for their own investigations. To operate the irradiation facilities safely and to be able to deal with numerous radioactive substances, INT has the appropriate radiation protection organization and a permit to work at external locations (e.g. research reactors, nuclear power plants). All experimental work is supported by a precision engineering workshop and an electronics laboratory.

NSD continuously pursues political and technological developments, in particular with regard to nuclear disarmament and possible proliferation. In analyzing this area, the focus is placed on their physical and technical aspects. In particular, nuclear developments in Iran and North Korea were observed, analyzed and evaluated. As part of the collaboration in the ESARDA (European Safeguards Research and Development Association) Working Group on Verification Technologies and Methodologies (VTM), which is organized by the Non Proliferation and Nuclear Safeguards Unit at the Joint Research Centre (JRC) in Ispra, the Business Unit investigated developments in international disarmament agreements, including export controls and new safeguard technologies for the International Atomic Energy Agency (IAEA). Of special interest were the negotiations that culminated in the nuclear agreement with Iran.

NSD also participates in technical preparation work for the Comprehensive Nuclear-Test-Ban-Treaty CTBT. The business Unit continues to participate regularly in the annual INMM conference in the USA, the US counterpart to ESARDA.

In March, the Fraunhofer-Gesellschaft organized an event at Fraunhofer IOSB in Karlsruhe, to introduce the DeGeN neutron and gamma measurement vehicle to German police forces dealing with new counter-terrorism technology.

NSD also continues its work as partner in several international projects dealing with CBRNE threats (Chemical, Biological, Radiological, Nuclear, Explosives) and countermeasures that deal with them. The unit logically contributes its R and N expertise to the respective consortia concerned. The following introduces these projects in brief.

The large EU demonstration project EDEN (end-user driven demo for CBRNE) had the goal of demonstrating a comprehensive system of measures against CBRNE attacks or accidents and their consequences. More than 30 partners from across the EU were involved in the project. One NSD task was its involvement in the needs and gaps analyses of the end-users. These analyses incorporate the results of earlier EU projects, which were in turn rounded off with end-user workshops. The Business Unit also participated in the development of RN scenarios and in RN demonstrations. Under the aegis of INT, a demonstration on nuclear smuggling was staged at the home of the project partner ENEA in Frascati, Italy. ENEA itself mounted a demonstration on the subject “dirty bomb”. The purpose of the demonstrations was to show the effective interaction of the comprehensive system of measures against CBRNE attacks

and accidents, and to close gaps with the use of systems newly developed within the project. At year end, project results were presented at a CBRN fair in Brussels. This also presented improvements to the DeGeN measurement vehicle – including improved gamma detection – which had been made as part of the EDEN Project.

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

In addition, in a project under the German support program for IAEA, NSD undertook comparative measurements with multi-channel analyzers made available by IAEA, which also provided the detectors powered by the analyzers.

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

COMPARISON OF TWO MCAS FOR MOBILE USE

Dr. Olaf Schumann

In line with the Nuclear Non-Proliferation Treaty, the international community has decided to prevent non-nuclear weapon states from arming themselves with nuclear weapons and to reduce the arsenals already existing.

To this end, the International Atomic Energy Agency (IAEA) has been tasked with safeguarding the civilian use of nuclear energy and with preventing the non-peaceful use of nuclear material. IAEA does this amongst others by means of on-site inspections in the member states.

The necessary measuring technology requires continuous further development to keep pace with changing requirements. IAEA is particularly dependent on member state support programs that develop specialized measuring devices and processes.

Developed as part of Germany's support program to the IAEA were the multichannel analyzer MiniMCA-166 and it successor MiniMCA-527. The MiniMCA-166 is a compact measuring device that integrates high voltage and preamplifier supply, amplifier and analog multichannel analyzer. It offers an internal battery for mains-free operation as well as automated spectrum recording. Apart from detector and computer, it provides everything that is necessary for a radiation detection system for use in on-site inspections.

The MCA-166 was introduced in 1997, and some of its components are meanwhile no longer available. In consequence, the MCA-527 was developed as the successor. This has a modern digital architecture and has some significant improvements over its predecessor.

It offers a greater selection of high voltage modules as well as a network interface in addition to the the serial RS232 and the USB port and a trigger input. In on-site inspections the MiniMCAs are connected to a computer and a detector to enable the analysis nuclear radioation.

As part of a project for Germany's support program to the IAEA, tests to compare the MCA-166 and MCA-527 were carried out at Fraunhofer INT. The main focus was on comparison of the two devices at high count rates.

In on-site operation, the results support IAEA in determining the degree to which results from the MCA-166 match those from an MCA-527 used in substitution.

Much of the tests concerned the influence of varying count rates, temperature and varying peak-shape parameters on the stability of the recorded spectra. Available were NaI and LaBr scintillation detectors, and a CTZ semiconductor detector.

Also tested were long term stability, battery life and other parameters. High count rates between 10 000 and 200 000 impulses per second were generated using Co-60 and Cs-137sources with large activities..

For further tests, Ba-133 and Eu-152 sources were used. Using a climatic chamber, it was possible to determine the effect on the quality of spectal data as function of temperatures in a range between – 15° C and +60° C.

In a 24-hour period, a temperature profile was run, using defined heating rates and dwell-times. Measurement work recorded more than 45 000 spectra, most of which were evaluated automatically. In cooperation with Business Units NSD and EME, tests were also conducted on the possible electromagnetic influence of MCA-527.

Using the Institute's waveguide, this involved subjecting the MCA-527 to electromagnetic radiation in a frequency range

1

from 80 MHz to 2.7 GHz, while simultaneously recording the spectrum of a weak radioactive source.

This research and development project was promoted with funds from the Federal Ministry for Economic Affairs and Energy, as part of the subsidy instrument „Joint Programme on the Technical Development and Further Improvement of IAEA Safeguards between the Government of the Federal Republic of Germany and the International Atomic Energy Agency“ (Task C.40 / A1791).

1 *The analog MiniMCA 166 and its digital successor, the MiniMCA 527*

FP7 PROJECT EDEN: COMPREHENSIVE PROTECTION AGAINST ATTACKS OR ACCIDENTS

Dr. Sebastian Chmel

In December 2016, Europe's joint EDEN Project – with Fraunhofer INT scientists participating – came to an end after three and a half years. It was one of four large-scale projects that the European Commission had initiated and funded in the context of the Security Theme of the seventh Research Framework Program. 36 universities, research organizations and companies from 15 European states plus Israel had come together to develop an overall system to improve protection for the world against terrorist attacks or accidents. More specifically, the scope was protection from major attacks or accidents involving hazardous substances, such as chemical, biological, radioactive or nuclear material, and explosives.

The aim of the project was to demonstrate a comprehensive system of measures against such events, either preventing them from the outset or softening their impact. The fact that practical use and final application were to the fore, could already be recognized in the project's name "EDEN", the acronym for "End-user driven DEmo for CBRNE", which in turn stands for Chemical, Biological, Radiological, Nuclear and Explosive material. The addressed end-users were e.g. fire brigades, police forces and specialist CBRNE units. Within the scope of the project, dozens of different technical and methodical tools were combined into systems, further developed, tested and demonstrated in training scenarios.

The spectrum ranged from new methods to determine the resilience of systems or to model the population's reaction to dangers, to instruments for remote sampling and detection, and to the endeavor – using the example of a nuclear reactor – to develop a common multi-level understanding of the situation across Europe (nuclear reactor core integrity sensing).

The project also saw the development of different new tools to provide valuable support for forces dealing with CBRNE situations. Of these tools, two are already fully available on the market, while the others are in different stages of development. Altogether, over 100 tools were included (also contributed by partners that do not belong to the consortium.)

A concept for integrating these innovations into existing systems was also presented in the demonstration exercises.

Fraunhofer INT continued development of two of our own tools that can be used in case of a radiological or nuclear incident: the measuring vehicle DeGeN and the surveying cabin NaNu. The DeGeN car is a measuring vehicle that detects gammas and neutrons, helping in the search for radioactive and nuclear material. The project included the integration of plastic scintillators of greatly-enhanced volume into the vehicle, which considerably increased the efficiency of gamma detection. The NaNu surveying cabin is a new mobile laboratory that can be transported by truck or helicopter when needed. For project purposes, it was adapted to immediate requirements.

This was preceded in the project by an analysis of gaps and needs, and by a survey of how far these needs were already met by existing systems. This was done in part by falling back on the results of earlier EU projects – including DECOTESSC1, in which Fraunhofer INT also participated – as well as in new surveys and workshops. An important role was played here by the End-user Platform, a large group of experts that included end-users outside the project partnership.

The 15 practical demonstrations, in which altogether more than 200 end-users acted as either observers or participants, covered three thematic scenarios: first, emergency situations arising from biological and chemical contaminants in the food chain; second, attacks with chemical agents; and third, radiological and nuclear security. Numerous technical devices and tools were demonstrated interactively – large-scale measures involving the extensive deployment of specialist forces. Tabletop exercises were also conducted in simulated settings.

After the demonstrations, the end-users analyzed the tools' suitability for closing the gaps identified in the project, and assessed the realization potential of improvements.

One task for Fraunhofer INT was acting as coordinator of a practical demonstration on smuggling radioactive material, conducted at the Italian research center ENEA, in Frascati. The scenario was made up of two parts. The first looked for evidence for detecting and identifying radioactive substances at a border station, and the second was a covert search for such materials in a parking lot. Fraunhofer INT also participated in the final demonstration of the theme radiological and nuclear security, conducted in Pripyat within the restricted zone of Chernobyl, in the Ukraine. The main purpose was to demonstrate the functionability of technical equipment and systems in an authentic contamination environment.

The demonstrations attached great importance to the inclusion of small and medium-sized enterprises (SMEs). Nowadays, SMEs play a major role in security R&D. Their contribution to EDEN was coordinated by specially set up SME and Supplier Platforms.

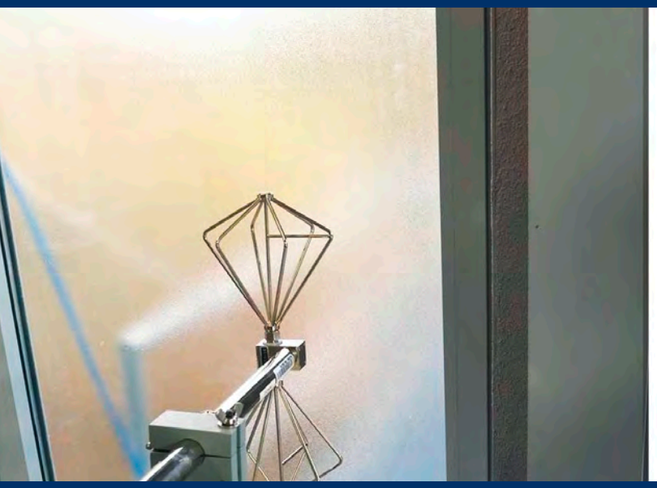
The project's concluding conference was held in Brussels on Octob > eroer 11-12, 2016. Apart from the considerable number of talks – which presented single aspects of project work – the participants were introduced to the final version of the EDEN Store. This is an internet platform that offers end-users and developers in CBRNE a wide variety of functions. These, for example, include a catalog of more than 280 tools with different capabilities and functions, a simulation and real-time crisis management environment, training modules and user manuals, as well as a secure user forum on which information and expertise can be posted centrally. The EDEN Store is available to selected registered users (https://eden.astrium-eu-projects.eu).

A major element of the final conference was the CBRNE INNOVATION FAIR 2016, where EDEN Project partners and members of the SME and Supplier Platforms presented solutions developed during the course of the project. End-users and other interested parties had a practical opportunity to get to know the project and its results. The fair was ideal for exchanging research ideas, discussing product developments and intensifying cooperation between organizations, with a view to strengthening the European community's fight against CBRNE threats.

The EDEN Project was on the whole a valuable contribution to the improvement of security in Europe.

BUSINESS UNIT “ELECTROMAGNETIC EFFECTS AND THREATS“

Dr. Michael Suhrke



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

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

The Unit has developed its own TEM waveguide (Transverse Electromagnetic Mode) housed in a shielded hall and serviceable for frequencies up to several Gigahertz. This allows linear coupling measurements for determining transfer functions and studies on electromagnetic compatibility (EMC), as well as susceptibility investigations with constant and pulsed signals at field strengths of up to several kV/m on objects with dimensions up to several meters.

For measurement tasks outside the Institute, EME relies on its own mobile HPM irradiation facility, which can generate field strengths of several kV/m over a wide frequency range by using various antennas. These systems are supplemented by a reverberation chamber equipped with high power sources for generating even higher field strengths in the Gigahertz range, in order to reflect the growing number of applications in modern sensor and communications technology at such frequencies. Added to this is a small anechoic chamber as well as a wide variety of high frequency and microwave measurement instruments.

Part of the work carried out for BMVg in 2016 was continuing project work for the Bundeswehr Research Institute for Protective Technologies (WIS) in Munster, with the development of an HPM detector and studies on generation dependency regarding HPEM vulnerability of electronics. Results from the latter were presented at the 2016 EUROEM Conference in London. Also carried out as part of the project, a measuring campaign at WIS in Munster on HPEM coupling into buildings was presented at the 2016 Future Security Conference in Berlin.

EME further participated in this conference by organizing the special session “Protection of Critical Structures”. In addition, EME hosted the meeting of the National Working Group (NAG) HPEM at Fraunhofer INT. Within the framework of a technical agreement on “High Power Microwave Test Methodology and Procedures”, a cooperation started with FOI Sweden on HPEM test methodology in 2016.

For its work in the NATO STO SCI-250 Task Group “Frequency Directed Energy Weapons in Tactical Scenarios”, EME was presented with the NATO STO 2016 Scientific Achievement Award. During the year, work began 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”. The Business Unit’s work focusses especially on HPEM vulnerability studies on UAVs (Unmanned Aerial Vehicles).

In civil security research, EME is one of 20 partners in the project “Smart Resilience Indicators for Smart Critical Infrastructures” started in 2016 in the European Commission’s security research program HORIZON 2020.

EME is also widely active in standardization. This includes the DIN working groups "TEM Waveguide and Reverb Chamber" and "EMC in Semiconductors", the VG (German defense equipment) standards boards on NEMP and lightning protection as well as on electromagnetic compatibility. The Business Unit also provides the national representative on the IEC's Joint Working Group "Reverberation Chamber". Further development of HPEM standardization is also to be the subject for the NATO STO SCI-294 Task Group, like with its predecessor. In addition, EME is involved in work on the IEEE EMC Society White Paper "The Risk of Intentional Electromagnetic Attacks to Critical Infrastructures", which began with a kick-off meeting trailing EUROEM 2016.

Doctorate work on the subject "HPEM vulnerability of the Smart Grid" was continued in 2016. Results on HPEM vulnerability in intelligent electricity meters as end-user devices, and on control systems in medium-voltage switching stations were presented at the 2016 EMV Conference in Düsseldorf and at the 2016 Future Security Conference in Berlin.

NO RECEPTION RIGHT HERE? ALL THE BETTER!

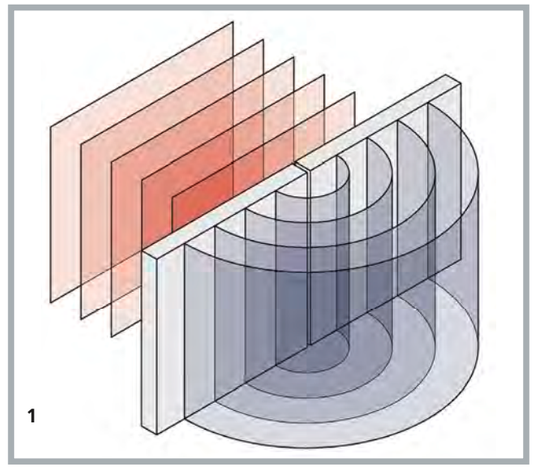
Michael Jöster, Marian Lazrath

For some time now, questions of security have become more prominent in the public's awareness. The classification of central societal facilities like energy and water supply within the concept of critical infrastructure reflects a growing need for protection – after all, our standard of living depends on their availability.

So what would come to mind if, for example, you had to protect a control station of the power grid against sabotage? You would probably think of fences and reinforced walls, steel doors, barred windows or armored glass. This might be helpful against physically destructive attacks, but there is a much more discreet way of trying to hit the nerve center of such facilities: by going for the information, communication and control systems. You don't even need a highly-qualified team of cyber-attack specialists; it's enough to have a powerful source for electromagnetic waves.

To imagine the set-up for such an electromagnetic attack, just think of a powerful TV transmitter, not at the top of a distant tower, but just opposite, on the roof of a house. The radio waves would not only hopelessly overload a domestic TV receiver, but other electric appliances in the household would be impacted or damaged, as well. The electromagnetic waves couple onto cables, circuit boards and electronic components, and cause additional currents and voltages for which the electronics are not designed. A systematic examination of each electronic device finds specific stress thresholds for first functional disturbances, further increasing the load then leads up to total failure.

In addition to transmission frequency, the amplitude of the electromagnetic field strength is decisive. Inside buildings, the electromagnetic field forms complex patterns of areas with higher and lower field strengths, which greatly depend on the type and location of coupling, as on the type of building and the objects in a room. So, for a given critical infrastructure, we need to know which structural factors can lead to what types of field patterns.



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If we assume that access to the premises that need protection is effectively restricted, an attacker's high-frequency transmitter would at least be outside the room concerned, if not outside the building itself. So the electromagnetic wave has to penetrate at least one wall in order to access the room. The walls of typical buildings are interrupted with windows, doors and other openings, and this affects the passing wave fronts in various ways and causes complex field patterns inside the room.

These are also shaped by waves reflecting from surfaces that conduct electricity, as with steel reinforcing in concrete walls. Similar to the harmonics of a guitar string, rooms also have natural frequencies which can resonate given the right stimulation. Using elementary geometric principles, it is possible to determine approximate areas with higher or lower field amplitudes. On systematic investigation, the characteristics of the field patterns can be directly ascribed to the geometric parameters in the room and its wall openings.

1 *Source: https://de.wikipedia.org/wiki/Datei:Diffraction_through_Slit.svg (public domain)*

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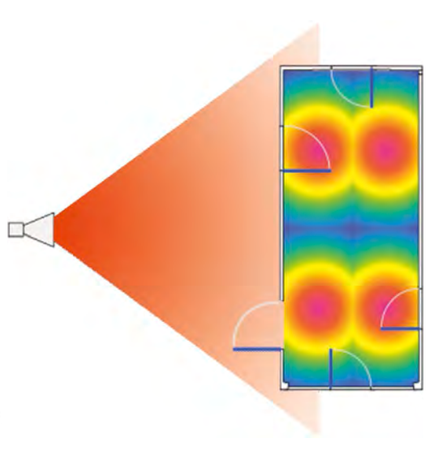

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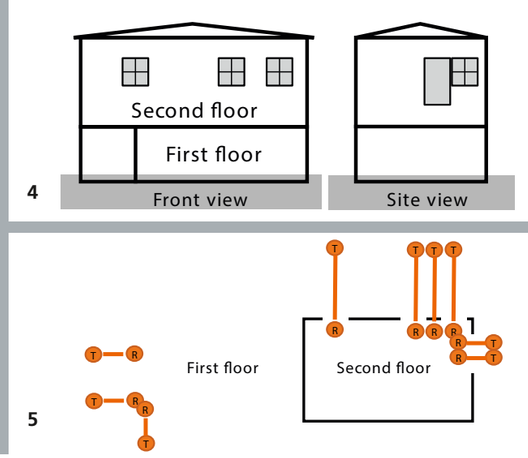

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To study such distribution and resonance effects, irradiation tests were conducted on a simplified model of a generic office building. The Bundeswehr Research Institute for Protective Technologies and CBRN Protection (WIS), in Munster, Lower Saxony, was our partner in this project. WIS has an open-air site for testing electromagnetic waves, where, owing to its isolated location, no interference can come to private households or facilities. Because of construction design and the materials used, a prefabricated garage without garage door, but with windows and a regular house door, can be considered as a close approximation to a realistic building.

For test purposes, such a room module can be mounted on a heavy-duty trailer to be mobile at the test site. By reducing a complex building to a room which nevertheless has the same principle properties of a large structure, it is possible to use computer simulations to allow for predictions about the energy penetrating inside the building as well as the electromagnetic field patterns with acceptable effort.

To study the question of how electromagnetic waves influence a computer in a typical work environment, two cross-linked PC workplaces were set up in the room module, using typical wiring. In a first test using laboratory measuring apparatus, the distribution of the electromagnetic field within the room was ascertained, with the irradiation source outside the module.

Subsequently, the disturbances coupled into the various cables were measured, in order to make predictions regarding the influence of previously determined field distribution on PC operation. In subsequent tests, irradiation with stronger transmitters showed the susceptibility of cross-linked computers as predicted based on the previous measurements, depending on their position within the room.

Following these tests on a simplified model, closer examination was made of the wall properties of a real critical infrastructure building. A public utility allowed us to examine an electricity

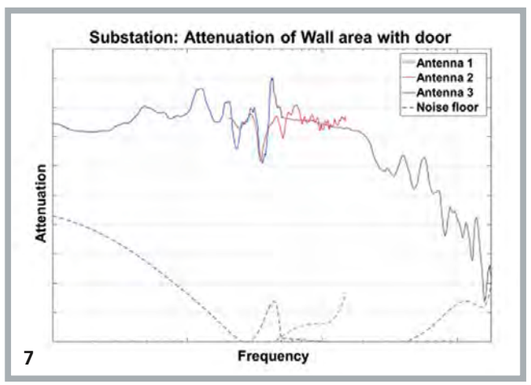
3

transformer substation that provides local industry and housing with power taken from plainly visible overhead power lines.

The substation can only be distinguished from the surrounding buildings because of the fence enclosing the switch field and the adjacent high voltage pylons. Computers in the building transmit readings to a distant control center, from which they receive remote control signals for the distribution switches, so that there is no permanent staff on site

Using a measurement set-up of precision transmitter and receiver, as well as two antennas, it is possible to gauge the attenuation properties of the walls, windows and doors. To get an overview of all paths of penetration, a large number of measuring points were defined at typical positions, such as windows and doors. For safety reasons, measurements were taken at low field strengths, whereby the results allow for extrapolation to the realistic threat scenario.

As the second floor could be attacked easily with a disturbance source from the slope behind the building, attenuation measurements have been performed also from there to cover this case.



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1 *Photo: Bundeswehr Research Institute for Protective Technologies and CBRN Protection (WIS)*

2 *Figure: Fraunhofer INT*

3 *Photo: Fraunhofer INT*

4 *Figure: Fraunhofer INT*

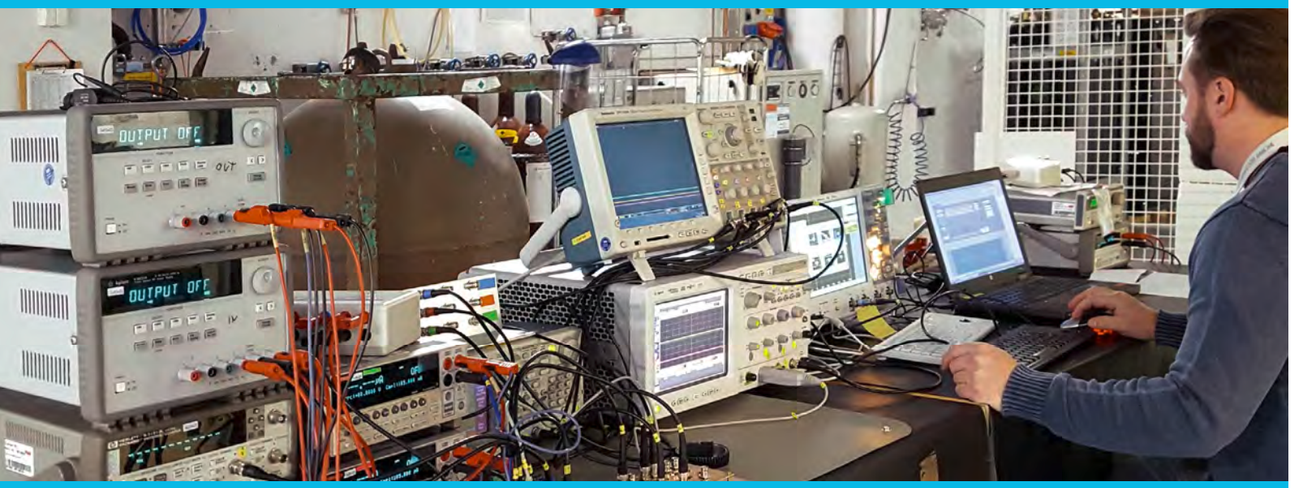
5 *Figure: Fraunhofer INT*

6 *Photos: Fraunhofer INT*

7 *Figure: Fraunhofer INT*

BUSINESS UNIT “NUCLEAR EFFECTS IN ELECTRONICS AND OPTICS“

Dr. Jochen Kuhnhenn



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

Widening competence in Single Event Effects (SEE) continues to be a key strategy for NEO. This objective is especially derived from the ever-increasing sensitivity of digital electronic systems and power electronics to penetration by single charged particles. Hitherto, these can cause malfunction or failure, particularly in space applications or high-energy accelerators. Even in airplanes or sensitive ground systems, cosmic radiation creates more and more challenging effects for manufacturers and users. This area brings with it new and scientifically exacting tasks for NEO. In the year under review, NEO ran several projects for aviation industry suppliers, to investigate the sensitivity of electronic systems to atmospheric neutrons.

In continuation of this work in 2016, extensive irradiation campaigns were conducted using the COSY accelerator and the Forschungszentrum research center in Jülich. Apart from initial project work, the focus was on beam characterization and the adaptation for SEE investigations.

The rapidly growing number of innovative space concepts with swarms of small-scale satellites, plus increasing commercialization in the area, places new demands on NEO. Speed, flexibility and cost-effectiveness play a much more important role in these markets than in most of the previous missions. A special article in this Annual Report gives an insight into these changes.

With the support of the Fraunhofer Space Alliance, a number of events brought the participating institutes together in 2016, with NEO taking part as well. As part of the Space Alliance, NEO was again present at the ILA Berlin Air Show, as well as at the International Conference on Space Optics (ICSO).

NEO’s highlight for trade fairs and conferences in 2016 was the first staging in Germany of RADECS, Europe’s most important irradiation conference. This event, which took place in fall 2016 in Bremen, is the subject of a separate article in this Annual Report (see page 63). To prepare for the conference, new marketing concepts were drawn up and a new Internet presence was designed, in order to give a detailed presentation of NEO in German and English.

Considerable progress was made in the project Smart Security Glass (see Annual Report 2014). In conjunction with several manufacturers, several prototypes were developed in order to put the patented sensor systems through various tests. Examination by VdS, one of Germany’s leading testing institutions for fire protection and security, brought this to a successful conclusion with certification of the system’s suitability.

After initial ISO 9001:2008 certification in 2013, NEO underwent the prescribed audit for re-certification in 2016. NEO’s quality management system was confirmed as fully effective. Particular attention was drawn to the steep improvement in processes and indicators over the past three years.

With the development of a hermetically sealed sample chamber, in which samples can be irradiated between –50° C and +250° C under various atmospheric conditions, test facilities at Fraunhofer INT were considerably widened. A special characteristic of the system is that it is possible to run very long periods of irradiation reaching high dose values without limitation at very varied temperatures.

To promote the next generation of scientists, NEO is actively involved in their education. In conjunction with the RheinAhr-

Campus at Koblenz University, two Master degree theses were commenced at NEO, dealing with different aspects of radiation detection. One thesis intends to enable a compact, autonomous radiation detection system that can be operated at both our own and external facilities for radiation characterization. The second paper is investigating the application parameters necessary for using digital memory modules for dose measurement, for example on a satellite.

COMPREHENSIVE ANALYSIS OF THE RADIATION SENSITIVITY OF DIGITAL ISOLATORS

Dr. Michael Steffens

Digital Isolators

In many electronic applications and circuits, there is a necessary data exchange between subsystems that are galvanically isolated from each other, either because of high sensitivity or in order to protect against possible surges. This communication is often achieved via optocouplers, in which an LED turns the original electrical data signal into an optical one.

After a short passage through an optical medium, the signal is picked up a by a photodiode and transformed back into an electrical signal. Commercially, optocouplers are common electrical components; they are also often used in space missions.

Especially in space application, however, optocouplers have two decisive disadvantages: first, double transformation of the signals is relatively power intensive; second, optocouplers are highly susceptible to displacement damage caused by impacts of charged particles from space radiation.

In contrast, CMOS-based digital isolators achieve input and output coupling purely electronically by the action of an electric or magnetic field in a dielectric, either inductively in the form of a coil pair, similar in capacity to a condenser, or by utilizing giant magnetoresistance (GMR). Their power consumption is considerably less than in the case of optocouplers, and furthermore, the underlying CMOS technology should provide inherent insensitivity to structural damage. Thus far, however, the usability of these components for space applications had not been proven.

REDI

In the Project REDI (Radiation Evaluation of Digital Isolators), digital isolators and the technologies behind them were examined for their space capability. The Project was carried out jointly with Seibersdorf Labor GmbH (Austria) on behalf of ESA. Work was done in parallel in both laboratories, using close coordination and planning, and different component types.

Component performance under gamma irradiation with cobalt 60 was investigated up to a total dose of 200 krad (Si). Also examined was susceptibility to the effects on single particles (SEE) from heavy ions or high energy protons, especially with regard to transients (SET) and latch-ups (SEL).

A transient is a volatile signal in the outgoing signal of the component that can spread to other areas of the electronic circuit. A latch up is the instant increase of the leakage current owing to a particle-induced short circuit (parasitic thyristor) in the CMOS structure of the components. SETs can be common, but usually have no disastrous consequences. By contrast, SELs always result in the destruction of the component through overheating, so long as they are not terminated by interrupting the power supply.

While data transfer under normal use is digital, the transients are analogue-type disturbances of the data, and as such have to be analyzed. To this end, INT colleagues from the Group Scientific-Technical Infrastructure (WTI) developed a complex readout electronic system that in the event of a transient both triggers a count and logs the waveform. Signal distortions and delays from cable loss or within the components themselves needed to be considered.

The SEE tests could not be applied equally with all technologies. For example, it was not possible to open the components with the use of inductive coupling technology, with the result that experiments were only possible with energetic protons, but not with heavy ions. SEE experiments were conducted at the Paul Scherrer Institute Proton Irradiation Facility (PIF) in Switzerland, and at the RADiation Effects Facility (RADEF, picture 2) at Jyväskylä University, Finland.

1

Results

In summary, none of the technologies (inductive, capacitive, GMR) can be certified as being generally insensitive to TID effects. All of them show that power consumption increases together with the dose; in part to an acceptable degree, in part by several orders of magnitude (picture 1).

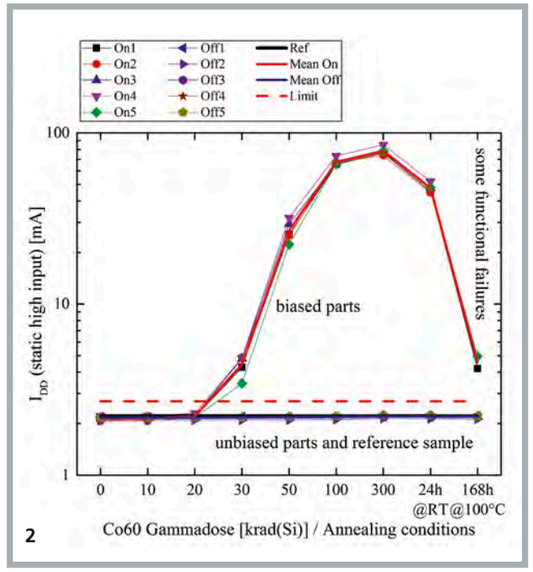
Significant differences in admissible radiation levels were found, in particular between different models of the same technology from the same manufacturer. Partial results suggest susceptibility to time-dependent rebound effects or to dose-rate effects. In all cases, however, use would be feasible in missions with lower radiation requirements, e. g. Earth observation missions.

It was possible to demonstrate the presumed non-susceptibility to displacement damage in an example on a neutron accelerator.

In the case of SEEs, considerable differences were observed, in particular regarding vulnerability to SELs – also between different models from the same manufacturer. SET response behavior probably depends on which chip sub-area is affected by a particle. Further investigation using INT's SEE laser system is available in this regard.

All in all, it may be said that for application in most space missions, especially in near-Earth missions with low overall dose values, digital isolators are a good alternative to optocouplers. Nevertheless, and depending on model and manufacturer, there is a great variance in their sensitivity to single particle effects.

We wish to thank ESA, the accelerator facilities at HIF and RADEF, Seibersdorf Labor GmbH, and WTI at Fraunhofer INT for their excellent cooperation. The results were presented at RADECS 2016, and test reports can be viewed at the document server www.escies.org.



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1 *Development of the leakage current of a digital isolator under Co-60 irradiation*

2 *Figure 2: Apparatus for measuring SET and SEL with digital isolators at RADEF (photo: Ari Virtanen)*

RADECS 2016

Thomas Loosen

On September 19, 2016, Fraunhofer INT completed a milestone in its 40-year history. Dr. Stefan Metzger took the Technical Chair to open the 24th RADECS conference, held for the first time in Germany. Staged in Bremen, the International Conference on RADiation Effects in Components and Systems, together with the US American NSREC Nuclear and Space Radiation Effects Conference, is the world's most important conference for discussing the effects of ionizing radiation on electronic components.

While INT took the role of Technical Chair, the comprehensive organization was in the hands of the two Conference Chairmen Johan Idestsröm, OHB System AG, and Sven Rakers, from Airbus Defence & Space. This alliance between OHB, Airbus DS and Fraunhofer succeeded in mounting a conference that met with full approval from all sides.

Bremen was a logical choice for the event, the town not just being the home of Airbus DS and OHB, Germany's two leading aerospace companies, but also one of the most important locations for German space research.

RADECS was held in the Bremen Congress Center, while the social program included a reception in Bremen Town Hall, the Conference Dinner in the Bremen Ratskeller, and, of course, a boat trip on the River Weser. There was also an opportunity to visit OHB's and Airbus's large production facilities. Parallel to the Conference was an industrial exhibition, which gave more than 40 companies a platform for presenting current projects and products to the specialist public.

From the expert view, the Conference was a success. Around 200 papers were submitted, of which 150 were accepted – either for the Poster Session or as a presentation in one of the 10 Technical Sessions. The program was rounded off with the Topical Day theme "Jupiter's Harsh Radiation Environment", a workshop that focused on the special requirements of Jovian missions. In all, 400 attendees from approximately 40 countries participated. The large proportion of participants from the USA, the People's Republic of China and other non-European states

showed the high significance of the Conference internationally. Among the many specialist presentations, one highlight was the talk given by Dr. Thomas Reiter, ESA astronaut and ESA Coordinator for international agencies, and also consultant for the General Director.

For many years, INT has made a substantial contribution to RADECS, submitting many papers and conducting individual scientific sessions. In 2016 as well, the NEO scientists Dr. Jochen Kuhnhenn and Dr. Stefan K. Höffgen co-chaired the sessions Radiation Effects in Photonics and Optical Fibres, and SEE in Devices and ICs. The latter was also a member of the Conference Awards Committee. In addition, five more of the papers presented had had the support of staff belonging to NEO and other groups within the Department NE. Details are given in the appendix as of page 78.

Fraunhofer INT was tasked with making sure that the single sessions ran smoothly, as well as all PR and marketing work – such as the website and the program booklet under Thomas Loosen's management.

Worthy of special mention is the personal commitment of Angela Haberlach, Tobias Kündgen, Simone Schmitz, Lukas Tilk, Udo Weinand, Raphael Wolf Michael Steffens, Stefan Höffgen and Max Baum, without whose efforts the Conference could not have taken place.

COMMERCIAL COMPONENTS FOR SPACE APPLICATIONS

Dr. Stefan K. Höffgen, Dr. Michael Steffens

NewSpace

A paradigm shift is currently happening in space, and among other things, it is attracting a lot of attention under the name NewSpace. This is an innovative approach being taken up by commercial companies (SpaceX, Virgin Galactic, OneWeb) that are planning faster, better and cheaper access to space than has so far been the case with government space projects dominated by politics. The companies want to achieve this by boosting efficiency through more competition and less bureaucracy, and by using commercial components.

Commercial Components

In classical space missions, satellite failure due to component malfunction was an event to be avoided at all costs. This made extremely high demands on the reliability of the components used. Electrical components that meet these tough requirements – also known as High Reliability, or HiRel components – are very expensive in production (hardening, processing control) and because of comprehensive testing. On top of this, market and production quantities are very small. Together with the high costs, this leads to long waits for delivery, and the long time needed for development and quality management also results in outdated technology.

The contrast came with CubeSats, small satellites of approx. 10 cm side length, a type often built for university student projects. As university budgets are very limited, commercial off-the-shelf (COTS) components are used, often without any kind of quality assurance. Being teaching projects, the early loss of a satellite was bearable, and this often used to be the case. However, just as frequently, the satellites functioned for long periods, sometimes even for years.

NewSpace is now working on a balance between the two ideas. Without a doubt, no commercial project can ignore the length of time a satellite functions, but it is possible to think of taking a greater risk. The current question is: when using commercial components, which qualification measures can one take to reduce the risk of failure, but without increasing the price too much. One can try to use components made for mass markets with high reliability requirements, as in the automotive industry, aviation, medicine, mining and so on. For these components, however, increased reliability only applies for classical failure mechanisms, and does not take account of the effect of radiation.

The Effect of Ionizing Radiation

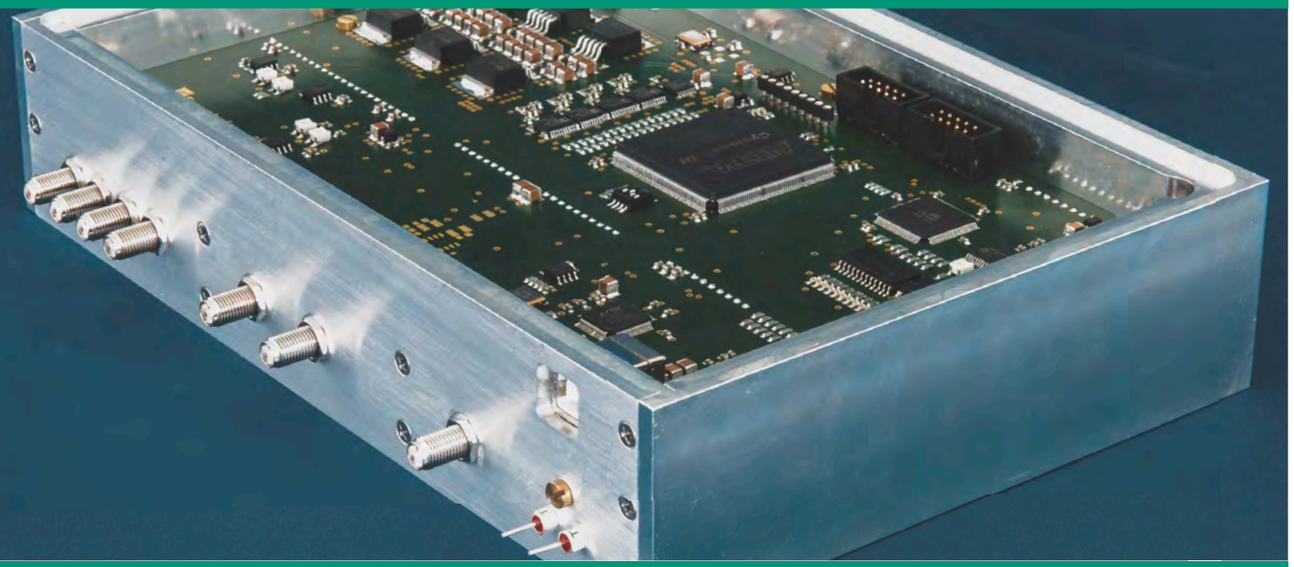
When using commercial electrical components, the Business Unit NEO also looks at the question of cost effective risk minimization through radiation.

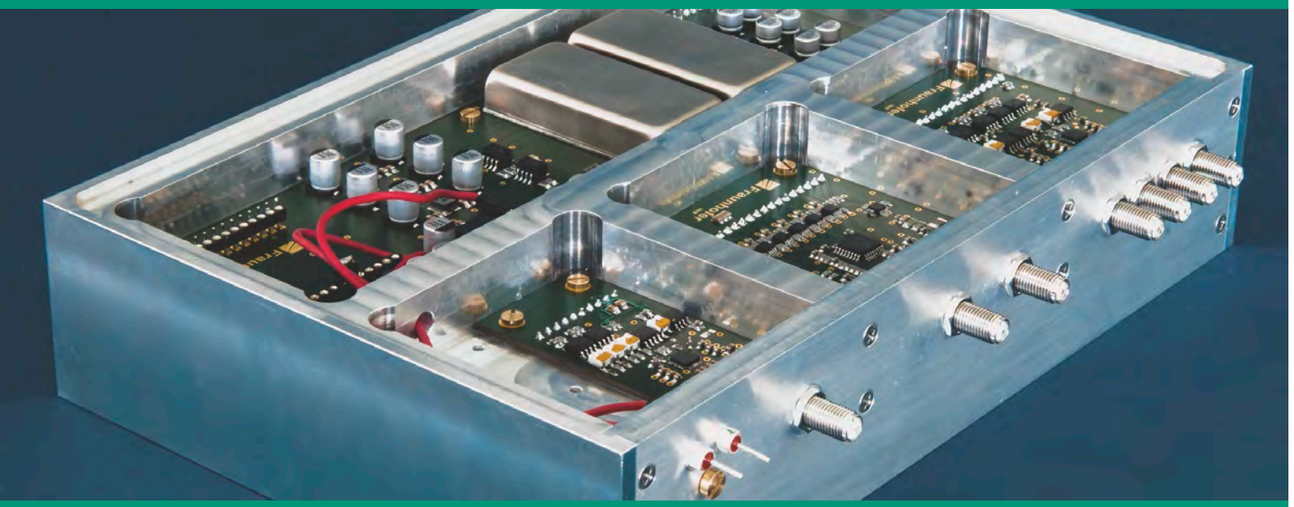
In the case of single particle effects, the main problem is destructive effects. While latch-up in CMOS components can be avoided by using external protective circuits, the only possibility for avoidance in power modules is to use them with greatly reduced voltage. Soft single particle effects – in which the state of memory cells is changed – can be controlled with software that uses redundancy and frequent system resets. Higher resource consumption from redundancy is compensated for by the exponentially increasing range of resources in modern commercial microelectronics.

With dose effects, there is in principle no external way of avoiding the effect of radiation on the components. Most commercial components are capable of resisting radiation doses of 1 krad, so that, for very short missions, commercial components can be used with little risk. With higher doses, only irradiation tests remain; but there are additional problems with regard to commercial components. Where the electrical properties are the same but radiation properties change dramatically, manufacturing processes can vary widely. It is sometimes not possible to trace components back to a production plant, let alone to the same wafer. This all leads to potentially wide dispersions, which makes it highly challenging to predict the failure risk of a component used in a satellite. NEO is currently conducting a series of studies to better quantify these effects and to develop cost effective test procedures.

SCIENTIFIC-TECHNICAL SUPPORT

Peter Clemens, Giesela Fuss





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

The Secretariat assists the Department NE:

- Providing organizational support for projects
- Formatting reports on experiment studies
- In Regarding radiation protection
- By cooperating on planning and running workshops
- Generating questionnaires (also online)

HPEM Detector Project

For a project of the Business Unit Electromagnetic Effects and Threats the hardware for a HPEM Detection System (a system for detecting high power microwaves) has been developed. This uses antennas to capture electromagnetic signals of high field strength which are then weakened by attenuators. In the detection system the HPEM signal is processed and digitalized. Signals are cached and sent to the evaluation computer, and pulse parameters relevant to evaluation are measured.

The upper picture shows the main board. Self-developed software controls the detector, and analyzes, compresses and transmits the raw data processed.

The lower picture shows the radio-frequency (RF) frontend, the amplitude detectors, the frequency detection module and the power supply.

As the detection system is operated under high field strength exposure, high RF proofness is required. This is ensured by a custom case milled by WTI.

Data evaluation takes place on a single board computer in a second RF case. A web interface developed in-house controls the detector and displays the data.

BUSINESS ADMINISTRATION AND CENTRAL SERVICES

Prof. Dr. Harald Wirtz

Business Administration and Central Services is the Department responsible for all commercial and administrative tasks in the Institute. As well as providing the central infrastructure, Department staff is also responsible for a number of employer functions, such as workplace safety and security.

The Department subdivides into Finance, Human Resources and Law (FPR), and Central Infrastructure (ZI). In addition, the sectors Library and Information Services as well as Marketing and PR operate independently.

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

Controlling covers all monetary processes within Fraunhofer INT, which includes the continuous supervision and control of the Institute's entire budget. There is also administrative support for project budgets in other departments. Since sponsors continuously conduct internal and external audits of the Institute, the Department also deals with all audit inquiries.

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

Central Infrastructure is responsible for Facility Management / Internal Services and Central IT Services. Facility Management continues to play an important role in coordinating the various construction projects on the premises. **Central IT Services** covers the Institute's entire IT infrastructure, providing first level support for the users.

The Central IT Services section is also intensively involved in preparing and implementing the project „Future Methods of Trend Analysis" (see also below, and report on page 37) and the project „Rahs". It advises and supports the Department TASP in procurement questions and operates the requisite IT components.

Marketing and Public Relations does all the necessary communications and marketing work for results produced by INT's individual business units.

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

In technology foresight, the Department continued its involvement in researching application possibilities for "cognitive computing". Since 2015, the expertise of the Department's technical information management has also regularly been used to identify and extend specialist IT and data-based methods and tools relevant to INT.

BUILDING PROJECTS

Thomas Loosen

Construction work at Fraunhofer INT continued unabated in 2016. Not least thanks to the coordination, planning and active support of Facility Management, some key construction phases were completed in the year under review. After five years of almost uninterrupted work, by December 2016 the INT premises ceased to look like a building site from the outside.

Most noticeable at first sight is the upward extension of the new office building. This extension provided 14 new offices, a conference room and another communications zone. At the same time, the lower floor offices were upgraded with new sound insulation to meet demands for confidentiality. By year end, office furnishing was as good as complete and most of the staff had moved in.

Playing a key role here is the new walkway that connects the old complex with the new. This passage, which runs along the experiment hall between the old building and the new library, keeps staff and guests warm and dry when crossing back and forth.

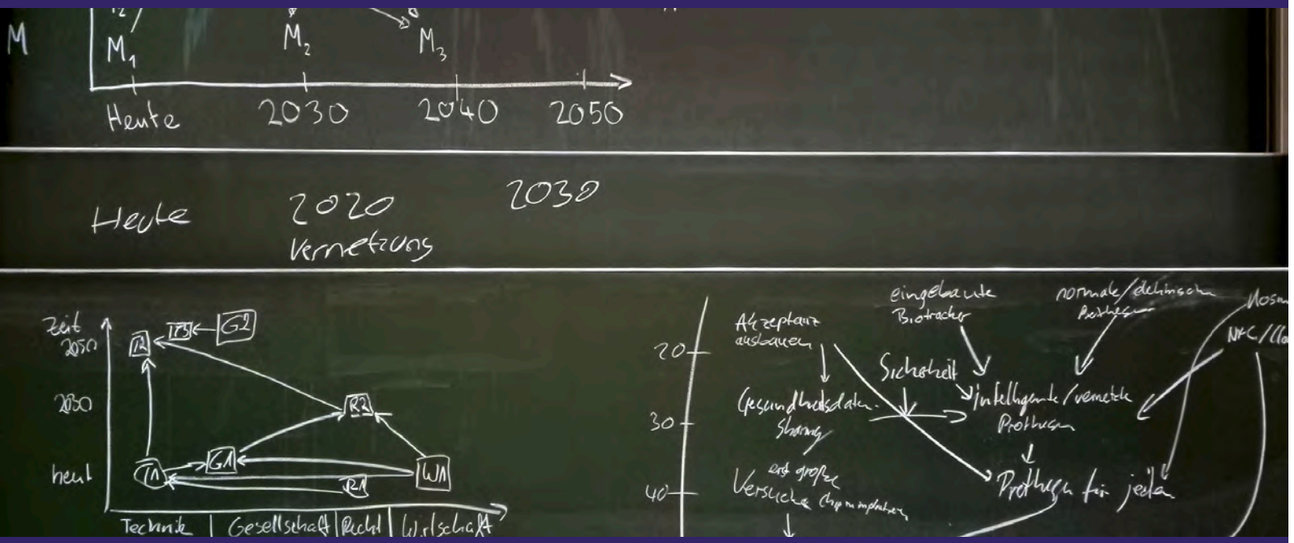
The Institute's newly-designed laboratory section used to house the old canteen and four smaller laboratories. In the course of reconstructing the ground floor, extensive changes in statics and installations were also necessary. At the end of 2016, reconstruction was finished, with the result that eight much larger laboratories can be equipped in 2017. With the new laboratories and offices, the provisional containers on the INT parking lot became redundant and have meanwhile been removed.

The new canteen and serving zone were also completed; they were approved and handed over for use at the beginning of 2017. So after a break of more than a year, the staff can now use these facilities and again take their lunch in the Institute. There is a new outside area for the canteen, with seating for the summer months. As before renovation, the terrace features a decorative fountain.

On the initiative of Facility Management, and working together with BImA (the Federal Agency for Public Property) and BLB (North-Rhine Westphalia's Building and Real Estate Authority), the roof over the canteen and laboratory was completely renovated. Cosmetically, the most important factor is probably the completion of the outdoor facilities. For most of the time since 2010 there were only piles of loose dirt and building material, but now, a lawn has been sown and apple trees have been planted to mark INT's address at Appelsgarten. So, after such a long time, visitors to the Institute no longer feel they are setting foot on a major building site. The "green belt" through the property, as foreseen in the original master plan, is meanwhile plainly visible.

With the new buildings, the Institute has reached the limits of its premises. In consequence, the dormant property on INT's south border was acquired by BImA in 2016. This land is to be opened up and developed for INT in 2017. There are several options for the use of the land, and a decision will be made after opening up and installing utility services.

On the whole, 2016 was a very successful year for INT's building projects. Since its beginning in 2009, the master plan has been revamped and extended several times, and it is now as good as completed. Reconstruction work for the Institute is not yet over, but the worst inconveniences that the staff has had to live with the last ten years are now a thing of the past. Another positive aspect is that the new buildings can be presented to the public, as part of the open day scheduled for July 8, 2017.



FRAUNHOFER SPACE ALLIANCE

Thomas Loosen

The Fraunhofer Space Alliance is a grouping of 15 institutes whose aim is the joint acquisition and processing of research projects for space travel. Since its founding in spring 2014, the Alliance has initiated numerous activities to feed applied Fraunhofer research results into the space industry.

One of the main goals is to enhance Alliance visibility externally. For this reason, the Alliance presents itself at appropriate trade fairs and conferences with parallel exhibitions and joint institute stands. Outstanding once again was the ILA 2016 International Aerospace Exhibition at the beginning of June in Berlin Schönefeld, where for the second time, the Alliance was present with a large-scale joint stand in the Space Hall.

In October, Airtec in Munich was another exciting trade fair with many interesting contacts. Worthy of special mention is Prof. Dr. Dr. Lauster's talk on "New Space – Old Earth", which he gave during the parallel conference. At the INNOSPACE conference "Earth Observation as Infrastructure of the Future" – staged in Augsburg in October by DLR Space Management – Prof. Dr. Dr. Lauster also conducted the workshop "Security and Critical Infrastructures".

Another special event was the International Conference on Space Optics, a prestigious scientific conference held by ESA at Biarritz in September. In particular, Alliance institutes which focus on optical technologies participated in the scientific program, giving numerous specialist lectures and presenting exhibits at the joint stand in the accompanying exhibition.

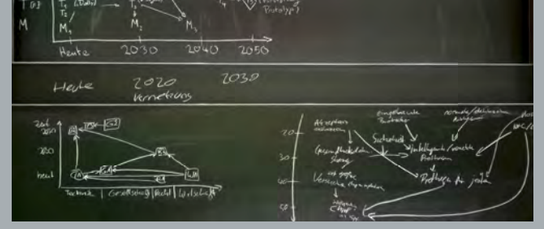
In order to promote cross-sector projects that combine the expertise of several institutes, the Alliance also organizes regular creative workshops to generate new ideas and to continue work on those already existing. During further internal meetings as well, there is ample space for developing projects. One such project, first exhibited in 2016, is an optical mirror based on carbon fiber reinforced composites (CFRP). This synthetic material was provided by Fraunhofer IAP-PYCO, and optical coating came from IST. The mirror was polished at Fraunhofer IPT. Compared with customary mirrors on a metal basis, the use of CFRP allows a weight-saving of 80 percent.

A real milestone for the Space Alliance in 2016 was the OHB Technology Meeting at the new headquarters of OHB System AG, in Oberpfaffenhofen near Munich. In total, eleven institutes were present at a large exhibition with six island stands for the Alliance's six business fields. OHB staff who visited the exhibition discussed technical problems and possible solutions with Fraunhofer representatives. In addition to the exhibition, projects were presented in a series of talks, similar to presentations at a scientific conference. To keep the event on record, Dr. Fritz Merkle, Executive Board member at OHB System AG, and Dr. Hans-Otto Feldhütter, Director of Business Models at the Fraunhofer-Gesellschaft, signed a Memorandum of Understanding in which further research cooperation was agreed. First concrete results will be joint expert workshops on special technology fields, to be held in 2017.

Further information on the Fraunhofer Space Alliance is available at: www.space.fraunhofer.de

CHAIR AT RWTH AACHEN UNIVERSITY

Stephanie Hansen-Casteel



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

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

Student numbers again increased in the period under review. In the 2016 Summer Semester, 75 students attended the lecture "Methods of Futures Studies". The number for the Winter Semester 2016/2017 was 160 students.

A major first-time success in 2016 was owed to the content and method concept for an interdisciplinary seminar conducted by chairholder, Prof. Dr. Dr. Michael Lauster, together with Prof. Dr. Dr. Axel Zweck (Sociology Chair at RWTH University Aachen). The basic concept is for students of engineering to collaborate with sociology students on the subject of technology assessment. The purpose is to analyze the different perspectives of the two academic disciplines. The students in the interdisciplinary team have the opportunity of developing specific tasks, while using key methods and instruments of technology assessment in the process. The seminar is titled "(Inter)Disciplinary Future – Tomorrow's Technologies from the Social and Engineering Science Views". The concluding event was held in July 2016, at Fraunhofer INT.

In addition, the Chair has supplemented its course offer with an advanced seminar on knowledge and science theory. Further seminars, on engineering ethics for example, are planned for the coming semesters.

Another success was the lecture series "Methods of Futures Studies", established at the Ravensburg-Weingarten University. The lectures, conducted by Prof. Dr. Dr. Lauster, give students of the Technology Management Faculty an application-based insight into the methodological principles of researching the future. The series, which takes place in block form once a year in Weingarten, is regarded by the students as a meaningful supplement to the regular course offer.

Prof. Dr. Dr. Lauster also supervises a dissertation on the topic of technology acceptance, which has the objective of developing an indicator toolkit for measuring the likely user's potential for accepting technology. In addition, the Chair supervises various Master, Bachelor and project papers, also with the cooperation of Fraunhofer INT.

STAFF POSITION METHODS AND TRAINING

Dr. Birgit Weimert

Together with specialist and procedural expertise, methodological skills are a major building block of competent technology analysis and forecasting. For this reason, the Staff Position Methods and Training was already set up as a Competence Center in 2013, and tasked with promoting method development and evaluation – the sustainable development of Fraunhofer INT's methodological expertise. Taking account of the area's importance, a complementary support group called Tools and Methods was established in spring 2016 within the Department Technology Analysis and Strategic Planning TASP.

Among the Staff Position's core tasks are working out and maintaining a comprehensive overview of the methods landscape, continuously updating methods and process knowledge, and our own research activities in the field. Over and above this, the Position again supported INT management with successful strategic acquisitions, through conceptualizing and establishing cross-institute project applications, through conducting and participating in projects, and by providing INT management with scientific advice. The Staff Position continues its function as point of contact for the Institute for Technology Analysis and Foresight in Security Research at RWTH University, Aachen.

Last year, the Staff Position added its methodological expertise to the KATI project, launched in 2015 to give technology foresight partially-automated support. In this regard, there is an enormous need for research in possible applications, in methods used and for processing and presenting the information obtained.

After successfully acquiring the Trend Management System Project for the Bundeswehr Office for Defence Planning, the methodological background for the project was developed and supplemented with practical information gained in numerous interviews with partners in industry and institutions.

New research cooperation with the Fraunhofer Center for Responsible Research and Innovation – CeRRI will be placing the main focus on the impact of technologies on society, as well as on technological developments. The first joint project will be looking at ways to make life outside urban areas attractive for senior citizens. This will require about three years. The work, scheduled to start in the first quarter of 2017, will be making intensive use of the Serious Gaming Framework FlexINT®, which became a registered trademark at the end of 2015.

20 YEARS OF THE "NEW TECHNOLOGIES" COLUMN

Jürgen Kohlhoff

"Multifunctional Materials" was the title of the first INT technology article in the monthly publication "Soldat und Technik (Soldier and Technology)". It appeared in February 1997 in the new column called "Das Fraunhofer INT berichtet über neue Technologien (Fraunhofer INT presents New Technologies)". The journal has since changed its name twice, arriving via "Strategie und Technik (Strategy and Technology)" at the current title "Europäische Sicherheit und Technik EST (European Security and Technology)". The column has survived all the organizational changes and continues to enjoy a constantly high level of interest. Meanwhile, thanks to the approval of the Mittler Report Verlag, the publisher, contributions are regularly posted on INT's own website as well.

The column gives INT a platform for brief presentations of highly abstract and complex scientific research material to a wider readership.

INT is responsible for choosing both subject and content of the articles, each covering one printed page. Responsible is the TASP Department at INT. In general, all Institute staff are invited to contribute articles. INT can thus focus on newly-emerging technology themes or other topics enjoying high current interest. This highlights the results of INT's comprehensive technology monitoring work, and presents them to a broader public. Covering all fields of technology, the 360° monitoring and scanning system forms the basis for gathering, analyzing and consolidating information that is passed on to public bodies and industry, to help them with their research planning.

Although "Europäische Sicherheit und Technik" in essence concentrates on defense and security, defense technology themes are not the main focus for the INT column (especially in view of the often immature development levels of the technologies in question).

It is much more a case of providing the technically interested layman with general answers to the following questions:

- What is it?
- How does it work?
- What are its applications?
- When will it be ready for use?

A centrally-organized editorial work guarantees the uniform layout expected of articles appearing in such a column. This always allows for a free-standing first paragraph, for example, which puts the spotlight on key aspects right at the start.

In the 20 years ending in December 2016, the column appeared more than 200 times (for editorial reasons, the space has been used for other articles once or twice a year). In recent years, typical topics included: "Post-Quantum Cryptography", "Personal Air Vehicles", "Brain-Computer Interfaces", "All-Electric Aircraft", and "3D Printers". Over the years there has been a general shift away from material-oriented articles toward contributions dealing with information and communication technology. There has also been a slight increase in the frequency of themes with a biological background. From an overall perspective, the technological top-level megatrends we have identified in our work can be summarized as follows:

- The generally increasing importance of electric energy (maximum use of sustainable generation)
- The development of automated or autonomous systems
- Universal networking for information technology
- The increasing exploitation of individualized technical systems.

You will find the column in the current edition of EST, and, after a brief period, on Fraunhofer INT's website.

http://www.int.fraunhofer.de/de/geschaeftsfelder/wehrtechnische-zukunftsanalyse/neue_technologien.html

MISCELLANEOUS

NATO STO Scientific Achievement Award

In recognition and appreciation of the outstanding work and significant scientific contribution in Working Group SCI-250, the NATO STO Scientific Achievement Award was granted to Fraunhofer INT's Business Unit EME.

Working Group SCI-250's produced the document "Radio Frequency Directed Energy Weapons (RFDEW) in Tactical Scenarios", for which the subject was the use of electromagnetic high energy sources to show RFDEW potential for computer networks, electronic systems, vehicles and IED detonators.

A demonstration of the possibilities and limits of such applications was staged for interested parties and decision-makers from NATO member states.


NORTH ATLANTIC TREATY ORGANIZATION
ORGANISATION DU TRAITÉ DE L'ATLANTIQUE NORD
S&T
SCIENCE AND TECHNOLOGY ORGANIZATION
Scientific Achievement Award 2016
SCI-250 Task Group on Radio Frequency Directed Energy Weapons in Tactical Scenarios
Dr Michael Suhrke
Albert HUSNAUX (Major General BELAF)
Chairman, Science and Technology Board
NATO Chief Scientist

SOURCE-Workshop in Bonn

As part of the EU FP7 Project SOURCE (Virtual centre of excellence for research support and coordination on societal security),

Fraunhofer INT was significantly involved in the organization and content planning of an Assessment Workshop held in Bonn in June 2016.

The purpose of the workshop was to test participative methods that can facilitate the scientific exchange between various interested parties in societal security.

The 16 participants from several EU states discussed security aspects of the internet.

SOURCE Societal Security Network

APPENDIX

University Courses, Lectures and Exercises

Bantes, R.: "Global IT Player Google, Facebook & Co, Fluch oder Segen?", Discussion Forum Technology and Society, Hochschule Bonn-Rhein-Sieg, University of Applied Sciences, Sankt Augustin, 04/21/2016

Chmel, S.: Lecture and exercise "Physics" in the Bachelor's course Naturwissenschaftliche Forensik (2nd semester), Hochschule Bonn-Rhein-Sieg, University of Applied Sciences, Sankt Augustin, summer term 2016

Chmel, S.: Lecture and exercise "Measuring Techniques" in the Bachelor's course Naturwissenschaftliche Forensik (3rd semester), Hochschule Bonn-Rhein-Sieg, University of Applied Sciences, Sankt Augustin, winter term 2016/2017

Chmel, S.: Lecture on "Wahrnehmung von Wissenschaft in der Gesellschaft" in the framework of the module "Technik, Politik und Gesellschaft" of Prof. Wiemken in the master degree course Technik- und Innovationskommunikation", Hochschule Bonn-Rhein-Sieg, University of Applied Sciences, Sankt Augustin, 04/28/2016

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, 01/18/2016

John, M.: „Das Cochlea Implantat: Funktionsweise, Entwicklung, Chancen, Risiken und Erfahrungen im Hinblick auf die logopädische Praxis", IB-Medical Academy, School for Logopaedia, Berlin, 02/05/2016 and 02/09/2016

John, M.: "Die Technisierung des Menschen – über Cochlea Implantate, Cyborgs und Human Enhancement", Bachelor´s course Technical Journalism/PR, lecture, Hochschule Bonn-Rhein-Sieg, University of Applied Sciences, Sankt Augustin, 05/25/2016

Jovanović, M.: Seminar "Projektmanagement", Bachelor and Master studies in Information Science, Heinrich-Heine-University Düsseldorf, winter term 2015/2016

Kohlhoff, J.: Lecture and exercise "Elektromobilität" in the seminar „Technik/Umwelt und Gesellschaft", Hochschule Bonn-Rhein-Sieg, University of Applied Sciences, Sankt Augustin, 05/04/2016 and 05/18/2016

Kohlhoff, J.: Introductory presentation "Autonome Robotik", University of Applied Sciences Ravensburg-Weingarten, Weingarten, 06/07 2 016

Kohlhoff, J., Reschke, S.: Exercise "Methoden der Zukunftsforschung" in the Masterstudiengang "Technologiemanagement", University of Applied Sciences Ravensburg-Weingarten, Weingarten, 06/06 – 09/2016

Lauster, M.: "Methoden der Zukunftsforschung I", RWTH Aachen University, winter term 2015/2016 and winter term 2016/2017

Lauster, M.: "Methoden der Zukunftsforschung II", RWTH Aachen University, summer term 2016

Lauster, M.: "Technologievorausschau – Zukunftswissen oder Spekulation? Anmerkungen zu den Erkenntnismöglichkeiten über das Zukünftige", im Rahmen der Ringvorlesung "Technik- und Umweltethik", Hochschule Bonn-Rhein-Sieg, University of Applied Sciences, Sankt Augustin, 04/14/2016

Lauster, M.: "Erkenntnis- und Wissenschaftstheorie für Ingenieure", RWTH Aachen University, winter term 2015/2016

Lauster, M.: Gemeinsames Seminar Ingenieure/Soziologen zur Technologiefolgenabschätzung, RWTH Aachen University, summer term 2016

Lauster, M.: Vorlesungsveranstaltung "Methoden der Zukunftsforschung", University of Applied Sciences Ravensburg-Weingarten, Weingarten, summer term 2016

Reschke, S.: Introductory presentation "Weltraumputze", University of Applied Sciences Ravensburg-Weingarten, Weingarten, 06/07/2016

Suwelack, K.: Presentation "Erzeugung, Aufbereitung und Nutzung von Biomethan" within the lecture "Verfahrenstechnik biogener Brenn- und Kraftstoffe", Bachelors' degree programme "Nachwachsende Rohstoffe", University of Hohenheim, Stuttgart, 01/12/2016

Wirtz, H.: Lecture "Finanzierung", Fresenius University of Applied Sciences, Cologne, winter term 2015/2016

Wirtz, H.: Lecture "Investitionsrechnung", Fresenius University of Applied Sciences, Cologne, winter term 2015/2016

Wirtz, H.: Lecture "Investition und Finanzierung", Fresenius University of Applied Sciences, Cologne, summer term 2016, witner term 2016/2017

Wirtz H.: Lecture "Change- und Innovationsmanagement", Fresenius University of Applied Sciences, Cologne, winter term 2015/2016, summer term 2016, winter term 2016/2017

Wirtz, H.: Lecture "Qualitäts-, Change- und Innovationsmanagement", Fresenius University of Applied Sciences, Cologne, summer term 2016, winter term 2016/2017

International Corporation

Adami, Ch., Jöster, M., Suhrke, M.: 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

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

Berky, W., Chmel, S., Friedrich, H., Glabian, J., Köble, T., Ossowski, S., Risse, M., Schumann, O.: In FP7 project EDEN (End-user Driven Demo for CBRNE), 38 project partners

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

Brandt, H., Heuer, C., Huppertz, G., Langner, R., Neupert, U., Offenberg, D., Pastuszka, H.-M., Ruhlig, K., Walther, G.: EDA project OSRA (Overarching Strategic Research Agenda and Captech SRAs Harmonization, 15.ESI.OP.162), 4 project partners

Burbiel, J., Grigoleit, S.: EU-FP7-project CARONTE (Creating an Agenda for Research ON Transportation sEcuity), 11 project partners

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

Grigoleit, S.: Horizon 2020 project SONNETS (SOcietal Needs aNalysis and Emerging Technologies in the public Sector), 4 project partners

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

Höffgen, S., Kuhnhenn, J., Kündgen, T., Lennartz, W., Metzger, S., Paschkowski, E., Steffens, M.: ESA-ESTEC, Noordwijk, Netherlands

Jöster, M., Jovanović, M., Lieberz, D., Müller, S., Pusch, T., Suhrke, M., Vollmer, M., Walther, G.: EU H2020 project SmartResilience (Smart Resilience Indicators for Smart Critical Infrastructures), 20 project partners, May 2016 – April 2019

John, M.: Research Stay at the Data Archiving and Networked Services (DANS) of the Royal Netherlands Academy of Arts and Sciences, Amsterdam, Netherlands, 01/19-23/2016

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

Linde-Frech, I., Löscher, M., Vollmer, M., Walther, G., Lieberz, D.: EU-FP7-Projekt DRIVER (Driving Innovation in Crisis Management for European Resilience), 36 partners, 4,5 years

Linde-Frech, I., Müller, L., Pastuszka, H.-M., Vollmer, M., Walther, G.: EU H2020 project ResiStand (Increasing disaster Resilience by establishing a sustainable process to support Standardisation of technologies and services), 14 project partners, May 2016 - April 2018

Missoweit, M.: Member ot the Advisory Board of the H2020 Project Pandemic Risk and Emergency Management (PANDEM)

Missoweit, M., Jovanović, M.: European Commission Directorate-General Migration and Home Affairs: Framework Contract on Impact Assessment , Evaluation and Evaluation related services in the area of Migration and Home Affairs, 8 partners, October 2015 – September 2017

Neupert, U., Heuer, C., Huppertz, G., Offenberg, D., Ruhlig, K.: FMV (Försvarets Materielverk)-project Teknisk Prognos 2015/2016 and Teknisk Prognos 2016/2017

Pastuszka, H.-M., Brandt, H., Grüne, M., Heuer, C., Huppertz, G., John, M., Kohlhoff, J., Langner, R., Neupert, U., Offenberg, D., Ruhlig, K.: "Technology Watch Follow-on: Technology Mapping and Foresight" (15.ESI.OP.201) on behalf of the European Defence Agency (EDA), project coordination, 2 project partners

Reschke, S.: Human Factors, TNO Soesterberg, Netherlands

International Reviews

Höffgen, S., Kuhnhenn, J.: IEEE Transactions on Nuclear Science

Höffgen, S., Kuhnhenn, J., Metzger, S., Steffens, M.: RADECS 2016 Conference

Jöster, M.: IEEE Transactions on Electromagnetic Compatibility

John, M.: Scientometrics

John, M.: Science and Public Policy

Jovanović, M.: ASLIB Journal of Information Management

Kuhnhenn, J.: Nuclear Instruments and Methods in Physics Research A, Elsevier

Kuhnhenn, J.: International Conference on Space Optics

Kuhnhenn, J.: Journal of Lightwave Technology, IEEE

Kuhnhenn, J.: Sensors

Kuhnhenn, J.: Journal of Applied Physics

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

Metzger, S.: IEEE Transaction on Nuclear Science

Neupert, U.: Mitglied der Independent Scientific Evaluation Group (ISEG) im NATO-Forschungsprogramm Science for Peace and Security (SPS)

Suhrke, M.: IEEE Transactions on Electromagnetic Compatibility

Suwelack, K.: International Journal of Industrial Chemistry

Suwelack, K.: Journal of Waste and Biomass Valorization

Suwelack, K.: Journal of Applied Energy

Suwelack, K.: European Biomass Conference and Exhibition

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

Thorleuchter, D.: Decision Support Systems

Thorleuchter, D.: Electronic Commerce Research and Applications

Thorleuchter, D.: Information Processing and Management

Thorleuchter, D.: Sustainability

Thorleuchter, D.: Information

Thorleuchter, D.: IEEE Transactions on Biomedical Engineering

Thorleuchter, D.: Knowledge-Based Systems

Thorleuchter, D.: Abstract and Applied Analysis

Collaboration in Committees

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

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

Hecht-Veenhuis, S.: Berufsbildungsausschuss NRW, subcommittee, "Geprüfter Fachwirt / Geprüfte Fachwirtin für Medien- und Informationsdienste in NRW"

Höffgen, S., Kuhnhenn, J.: Organization Committee of RADECS 2016 in Bremen, Germany

Höffgen, S., Kuhnhenn, J.: Session Chair, RADECS 2016

Metzger, S: Organization Committee of RADECS 2016 in Bremen, Germany (as Technical Chairman)

Metzger, S.: RADECS Council Board

Missoweit, M.. European Association of Research and Technology Organisations (EARTO) – Security Working Group

Missoweit, M.: H2020 Secure Societies Protection and Advisory Group. Brüssel, DG HOME

Missoweit, M.: H2020 Advisory Group on International Cooperation

Neupert, U., Walther, G.: Mitglied der Independent Scientific Evaluation Group (ISEG) im NATO-Forschungsprogramm Science for Peace and Security (SPS)

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

Pastuszka, H.-M., Grüne M.: Workshop on Technology Watch, European Defence Agency (EDA)

Reschke, S.: NATO-ACT Strategic Foresight Analysis (SFA)

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 2016 Business Management and Human Resource (BMHR), 10/15 – 16/2016, Suzhou, China

Walther, G.: Panel SAS-123 "Futures Assessed alongside socio-Technical Evolutions", NATO Science and Technology Office

Participation in Norming Processes

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

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

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

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

Köble, T.: DIN and VDE DKE/GUK 967.2 "Aktivitätsmessgeräte für den Strahlenschutz"

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

Kuhnhenn, J.: IEC SC86A/WG1, Erstellung der Norm IEC 60793-1-54

Suhrke, M.: National Representative of the "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.:
"Neue Methoden der Technologiefrühaufklärung: Zur Verknüpfung von Content Analytics, Bibliometrie und Visualisierung", 6th International Symposium „Neue Technologien" BKA; Kurhaus Bad Cannstadt, 10/05/2016

Bantes, R.:
"Future Technologies – to meet new operational requirements", Panel-Beitrag, Berlin Security Conference 2016, Berlin, 11/29/2016

Chmel, S.:
"Smuggling Radioactive Material - a Demonstration Exercise in the Framework of EU-project EDEN", 11th Future Security 2016, Security Research Conference, Berlin, 9/13/2016

Grigoleit, S.:
"From multifaceted information to coherent and well-founded suggestions for a land transport security research agenda: Proceedings and results of the FP7 project CARONTE", 11th Future Security 2016, Security Research Conference, Berlin, 09/14/2016

Grüne, M., Pastuszka, H.-M.:
"Technology Watch & Technology Foresight at EDA", EDA's 4th Technology Watch Workshop, EDA Brussels, 11/17/2016

Höffgen, S.:
„Radiation Tests on Optical Materials", Radiation Test Workshop, Seville, Spain, 03/31/2016

Jöster, M.:
"Influence of Buildings on HPEM Vulnerability of IT Infrastructures", 11th Future Security 2016, Security Research Conference, Berlin, 2016

John, M.:
"Bibliometrics and information retrieval: Creating knowledge through research synergies", Panel together with Bar-Ilan, J.; Koopman, R.; Wang, S.; Scharnhorst, A.; Mayr, P.; Wolfram, D., ASIS&T Annual Meeting (Association for Information Science and Technology), Copenhagen, Denmark, 10/14–18/2016

John, M.:
"Cognitive Computing für die Technologiefrühaufklärung: Vom Hype zur realen Anwendung", 7. Internationale Tagung des Netzwerks Technikfolgenabschätzung, Bonn, 11/16–18/2016

John, M.:
"Quantitative Methoden der Zukunftsforschung am Beispiel der Bibliometrie",Training Course "Methods for Futures Analysis", FüAkBw Hamburg, 11/29/2016

Jovanović, M.:
"Bibliometrische Analysen als Unterstützung der journalistischen Recherche", Lecture as part of the seminar "Technology and societal change" by Prof. Dr. Wiemken, Hochschule Bonn-Rhein-Sieg, University of Applied Sciences, Sankt Augustin, 03/30/2016

Jovanović, M., Lieberz, D.:
"Evolving Concept of Security (EvoCS) – Perceptions of popular security discourse in Europe", TÜV Rheinland – Symposium, Cologne, 05/10/2016

Jovanović, M.:
"Bibliometrische Analysen als Unterstützung der journalistischen Recherche", Lecture as part of the seminar „Technik und wissenschaftlicher Wandel" by Prof. Dr. Wiemken, Hochschule Bonn-Rhein-Sieg, University of Applied Sciences, Sankt Augustin, 05/12/2016

Jovanović, M.:
" Bibliometrie und bibliometrische Analysen – Möglichkeiten und Grenzen", Networkshop on Bibliometrics/Altmetrics, ZB Med, Cologne, 11/30/2016

Köble, T.:
"Comparative testing of the MCA-527 and MCA-166", Verification Technologies and Methodologies Working Group Meeting, Ispra, Italy, 11/30//2016

Köble, T., Weinand, U.:
"Umsetzung von Normen in einem Forschungsinstitut - Sichere Lagerung radioaktiver Stoffe nach DIN 25422", Annual Meeting 2016 - Fachverband für Strahlenschutz e. V, Heringsdorf/Usedom, 09/26/2016

Köble, T.:
"Internationale Projekte mit Bezug zur Nuklearen Gefahrenabwehr – Erkenntnisse aus dem EU-Projekt EDEN", 12th Information Exchange Event "Defence Against Nuclear Hazards", Berlin, 03/17/2016

Köble, T.:
"Gefahren der missbräuchlichen Verwendung radioaktiver Stoffe und deren Abwehr", Training Seminar for Members of the "Regionale Strahlenschutzzentren", Bad Münstereifel, 10/21/2016

Köble, T.:
"Nachweis von radioaktiven und nuklearen Gefahren", Fraunhofer Expert Meeting "Neue Technologien für die Terrorismusabwehr", Karlsruhe, 03/08/2016

Kuhnhenn, J.:
"Irradiation Tests on Optical Fibres: Lessons Learned and best practice", ISROS 2016, Otwock, Poland, 06/06/2016

Kuhnhenn, J.:
"Gamma Radiation Tests of Radiation-Hardened Fiber Bragg Grating Based Sensors for Radiation Environments", RADECS 2016, Bremen, 09/20/2016

Kuhnhenn, J.:
"Gamma Irradiation Test of Ge-Doped Single-Mode Optical Fiber at Cryogenic Conditions", RADECS 2016, Bremen, 09/20/2016

Lanzrath, M.:
"HPEM-Empfindlichkeit von intelligenten Stromzählern als Komponenten des Smart Grid", EMV 2016, Düsseldorf

Lanzrath, M.:
"HPEM Vulnerability of Substation Control Systems as Components of the Smart Grid", 11th Future Security 2016, Security Research Conference, Berlin, 2016

Lauster, M.:
"New Space und die Fraunhofer Allianz Space", BMWi Bonn, 01/19/2016

Lauster, M.:
"Panel-Teilnahme Zukunft der Forschung: Wie kann die Sicherheitsforschung der Gesellschaft dienen?", Forschungsforum Öffentliche Sicherheit, Berlin, 04/13/2016

Lauster, M.:
"Leben mit Technologien – Ausgewählte technologische Aspekte möglicher Zukünfte", a contribution from the seminar „Leben 4.0"der Begabtenförderung der Konrad-Adenauer-Stiftung, Königswinter, 05/07/2016

Lauster, M.:
"Langfristige Aspekte wehrwissenschaftlicher Forschung und Technologie", Strategiegruppe des BMVg, Bonn, 05/19/2016

APPENDIX

Lauster, M.:
"Fraunhofer-Allianz Space – Zwischen Projekten und Spitzentechnologien", OHB-Tag in Oberpfaffenhofen, 06/22/2016

Lauster, M.:
"Raumfahrt 2040+ – Ausgewählte Zukunftsaspekte der (deutschen) Raumfahrt", Workshop RFM – FhG IMW – FhG INT, Oberkassel, 07/07/2016

Lauster, M.:
"Fraunhofer-Allianz Space – Angewandte Forschung für Europas Raumfahrt", 1. BMVg-Workshop Weltraum, Euskirchen, 07/21/2016

Lauster, M.:
"New Space, Kleinsatelliten für militärische Anwendungen", 1. BMVg-Workshop Weltraum, Euskirchen, 07/21/2016

Lauster, M.:
"Messung der Effizienz technologischer Forschungsprogramme mit Hilfe stochastischer Prozesse", Euskirchen, 08/25/2016

Lauster, M.:
"Fraunhofer Allianz Space und Fraunhofer INT", BDLI Berlin, 09/02/2016

Lauster, M.:
Leitung des Panels „Die Rolle von Trends für vorausschauendes und strategisches Handeln", Planungsamt der Bundeswehr, Berlin, 09/22/2016

Lauster, M.; Enderle, W.:
"Sicherheit und Kritische Infrastrukturen", INNOspace Fachtagung, Augsburg, 10/06/2016

Lauster, M.:
"Langfristige technologische Trends mit wehrtechnischer Relevanz", Symposium "Forschung und Technologie für die Landstreitkräfte 2030+ – aus dem Labor in den Einsatz", Freiburg, 10/11/2016

Lauster, M.:
"When Technologies Merge: NewSpace meets OldEarth", AIRTEC Congress, München, 10/25–27/2016

Lauster, M.:
"Technologische Trends und Veränderungsprozesse frühzeitig erkennen", Symposium Weingarten, 11/09/2016

Lauster, M.:
"Vorstellung des INT; Fraunhofer Allianz Space – Angewandte Forschung für Europas Raumfahrt", 57. Treffen der Euskirchener Behördenleiter, Euskirchen, 11/16/2016

Lauster, M.:
Leitung der Arbeitsgruppe "Herausforderungen durch allgemeinen Technologiewandel und Konvergenz von Technologien", 2. BMBF Agenda-Workshop "Zivile Sicherheit-Technologischer Wandel", Berlin, 11/29/2016

Lauster, M.:
Podiumsteilnehmer "Grenzen der Forschung – Militär zwischen Innovation und Ethik", Liberale Hochschulgruppe Niederrhein/Friedrich-Naumann-Stiftung, Krefeld, 12/07/2016

Metzger, S.:
„Application of the FAIR Facility to Space Radiation Research", TEC-EES Final Presentation Days, Noordwijk, Netherlands, 10/25/2016

Metzger, S.:
"Practical Aspects of TID Testing", Lecture at the RADHARD Symposium of Seibersdorf Laboratories, Seibersdorf, Austria, 06/07–08/2016

Neupert, U.:
"Disruptive Technology Assessment Gaming (DTAG) – A Military Table-Top-Game for Technology Assessment", Lecture at the Führungsakademie der Bundeswehr, 11/30/2016

Pastuszka, H.-M.:
„Analyse der strukturellen Lage der Verteidigungsindustrie in Deutschland – Definition der Branche und Kennzahlen", Final Study Presentation, BMWi Berlin, 02/10/2016

Pastuszka, H.-M.:
"Emerging technologies and long term technological trends impacting defence", Panel Session "From Emerging to Critical Technologies", EDA R&T Conference, Amsterdam, Netherlands, 04/25/2016

Pastuszka, H.-M.:
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Exhibition booth: ILA 2016, Berlin

06/07–08/2016
Meeting Nationale Arbeitsgruppe (NAG) HPEM 2016, Fraunhofer INT

06/09/2016
WTV-Workshop Edition 2016-2 with BMVg, BAAINBw, PlgABw, MilOrgBer

06/22/2016
Exhibition booth: OHB Technologietag, Oberpfaffenhofen

06/28–29/2016
DWT/Fraunhofer ICT-symposium "Streitkräfte und Energiebedarf – Potentiale und Perspektiven", Bad Godesberg

07/21/2016
Workshop Space Themes with BMVg, BAAINBw, BDSV, DLR, Fraunhofer-Allianz Space

09/19–23/2016
Exhibition booth: RADECS 2016, Bremen

09/20/2016
Technology Foresight Exercise "Really Autonomous Systems" with EDA CapTech-Moderators, EEAS and TNO, Brussels, in the context of the TWFO project (Grüne, M., Huppertz, G., Pastuszka, H.-M., Ruhlig, K.)

09/23/2016
Career counselling event "Quo Vadis?" at the Marienschule, Euskirchen

10/04/2016
Kooperation talks with Isdefe (Ingeniería de Sistemas para la Defensa de España S.A.)

10/18/2016
Technology Foresight Exercise "Materials 2050" with EDA CapTech Materials, Brussels, in the context of the TWFO project (Brandt, H., Grüne, M., Langner, R., Pastuszka, H.-M.)

10/18 – 21/2016
Exhibition booth: ICSO 2016, Biarritz, France

11/14 – 15/2016
SCRUM-Workshop „SRA Update CapTech Information“ with TNO, FOI und Isdefe, The Hague, Netherlands, in the context of the OSRA project (Heuer, C., Pastuszka, H.-M., Ruhlig, K.)

Press Releases

Fraunhofer Technologietag bei der OHB System AG – Memorandum of Understanding unterzeichnet, 06/22/2016

Airbus Defence and Space, OHB System AG and Fraunhofer INT organize RADECS 2016, the European conference on space radiation effects in Bremen, Germany, 09/13/2016

Institute Course

Baaken, T. (FH Münster):
Forschungsmarketing: Communication is Shouting – Marketing is Listening, Euskirchen, 01/13/2016

Sauer, J. (Zentrum für Verifikationsaufgaben der Bundeswehr):
Die Integrated Field Exercise (IFE14) der Comprehensive Nuclear Test Ban Treaty Organisation (CTBTO), Euskirchen, 01/20/2016

Wolpers, M. (Fraunhofer FIT):
Aus- und Weiterbildung im Kontext der Industrie 4.0 “(R)evolution“, Euskirchen, 01/27/2016

Schumann, O., Weinand, U. (Fraunhofer INT):
Bestrahlungstests an optischen Fasern bei sehr tiefen Temperaturen, Euskirchen, 02/24/2016

Höffgen, S. (Fraunhofer INT):
Single Event Effects, Euskirchen, 03/02/2016

Wiemken, U. (Fraunhofer INT):
7 Thesen zum Weißbuch 2016, Euskirchen, 03/09/2016

Michael, K. (BBK Bonn):
Rahmenkonzeption für den CBRN-Schutz, Euskirchen, 04/06/2016

Köller, C. (Görgen & Köller GmbH):
Enabling Innovation – vom Forschungsergebnis zur Innovation, Euskirchen, 04/27/2016

Hoyningen-Huene, P. (Leibniz-Universität Hannover, Universität Zürich):
Zur Beziehung zwischen Vorhersagen und Erklärungen, Euskirchen, 05/11/2016

Walther, G. (Fraunhofer INT):
Biological Weapons, Bioterrorism and Life Science Research: Towards the Twilight of Man? , Euskirchen, 05/18/2016

Huppertz, G. (Fraunhofer INT):
Unmanned Combat Aerial Vehicle – Konzepte und Entwicklungen, Euskirchen, 05/25/2016

Risse, M. (Fraunhofer INT):
Radioaktiven Quellen auf der Spur. Projekt EDEN: Demonstration von Tools in Frascati, Euskirchen, 06/08/2016

Kretschmer, T. (Fraunhofer INT):
Klimawandel - Folgen, Szenarien und Strategien, Euskirchen, 06/22/2016

Grunwald, A. (ITAS, KIT Karlsruhe):
Wissenschaftliche Zukunftsforschung als Politikberatung – Möglichkeiten und Grenzen, Euskirchen, 08/24/2016

Moßgraber, J. (Fraunhofer IOSB):
“Integrierte Sensordaten, Simulationen und Lagevisualisierung zur Entscheidungsunterstützung“ (– an den Beispielen Schutz kritischer Infrastrukturen und Sicherheit im Fußball – unter Nutzung von WebGenesis), Euskirchen, 08/31/2016

Leopold, F. (Deutsch-Französisches Forschungsinstitut Saint-Louis, ISL):
Trends bei der Entwicklung von Lenkmunition, Euskirchen, 10/05/2016

Stübing, D. (Fraunhofer IFAM):
Green antifouling – umweltfreundliche Bewuchsschutz-Strategien für den maritimen Bereich, Euskirchen, 11/02/2016

Reschke, S. (Fraunhofer INT):
Bioprinting, beauty, and future longevity, Euskirchen, 11/09/2016

APPENDIX

Rosiwal, S. (FAU Erlangen):
Herstellung und Anwendungspotential von kristallinen CVD Diamantschichten: Tribologie – Wasserreinigung – Energiespeicherung – Stromerzeugung, Euskirchen, 11/16/2016

Jovanović, M. (Fraunhofer INT):
Das FP7-Projekt EvoCS: Ergebnisse und Erfahrungen, Euskirchen, 11/23/2016

Hansen-Casteeel, S. (Fraunhofer INT/RWTH Aachen-LTVS):
Dissertation Technologieakzeptanz, Euskirchen, 11/30/2016

Scharnhorst, A. (Royal Netherlands Academy of Arts and Sciences, Data Archiving and Networked Services):
Wie können Wissenschaftskarten zur Suche in grossen Informationsräumen eingesetzt werden, Euskirchen, 12/07/2016

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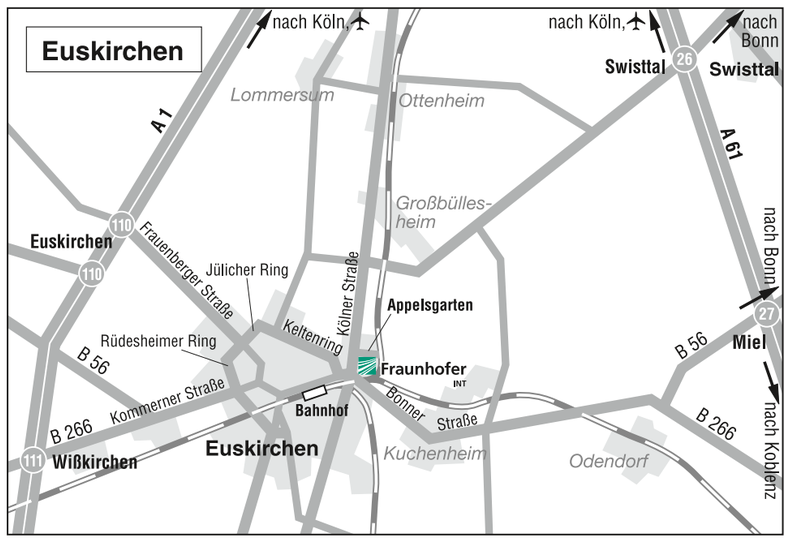

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