



Fraunhofer



ANNUAL REPORT 2013

LIVING IN THE DIGITAL WORLD

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 more than 23,000 staff are qualified scientists and engineers, who work with an annual research budget of 2 billion euros. Of this sum, more than 1.7 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.

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Ladies and gentlemen,

“Dedicated to the future” is the motto we have given ourselves at Fraunhofer. It is a simple message, summing up the key aspects of our mission – namely that research and innovation form the basis for future value creation, jobs and prosperity in Germany. Fraunhofer stands by its obligation to help create a sustainable future in which life is worth living.

There is much to suggest that we have succeeded in living up to our motto thus far. Sixty-five years ago, the Fraunhofer-Gesellschaft was established with just a handful of motivated volunteers; in 2013, our total business volume exceeded two billion euros for the first time. More than 23,000 employees were instrumental in achieving this and they can be justly proud of the contribution they have made.

This growth was possible only because our customers were satisfied with us. They consider Fraunhofer to be a strategic partner in their value chains – not only for our scientific excellence, but also for our expertise in applying our knowledge in their companies. Taken together, these two aspects form the foundation for success and make forward-looking innovations possible – innovations that not only improve products and technologies, but combine or develop them in a completely different way to create something entirely new and original.

There are many examples of how society and the business world benefit from the research projects pursued by the Fraunhofer Institutes. For instance, Fraunhofer research labs have developed a new, flexible and economical process for producing vaccines as well as software that extracts more performance from the multi-core processors used in today's PCs. And in a project centered around a combined-cycle power plant, we are examining how to ensure maximum security and stability in power supplies despite fluctuations in the feed-in of electricity from renewable sources.

Applied research is a key component of the system of science and innovation, and helps enhance the performance of enterprises as a whole. Innovative products are as much a part of that as the evolution of industrial production. The concept of Industry 4.0 combines the strengths of mechanical and manufacturing engineering with the possibilities presented by information technology. This combination opens up new opportunities for manufacturers, namely high flexibility that allows companies to respond to market requirements in a fast and targeted manner, and efficient production methods that save energy and materials – yet another competitive advantage. We need to leverage the potential promised by this and ensure it can be utilized by German and European businesses. Our lead article in this year's Annual Report is given over to this topic.

Over the past decades, Fraunhofer has grown to become an essential competitive factor for industry. From this success we derive an obligation for the future, which is to consolidate and continue to strengthen our role as an innovation driver in the long term. We must continue to enhance our performance, efficiency and effectiveness because, in any competitive situation, marking time is tantamount to falling behind.

Our objective is to promote value creation in order to safeguard jobs and allow our customers, Germany and Europe to prosper over the long term.

Sincerely,

A handwritten signature in black ink, appearing to read 'R. Neugebauer', with a long horizontal flourish extending to the right.

Reimund Neugebauer
President of the Fraunhofer-Gesellschaft

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REPORT OF THE EXECUTIVE BOARD



THE EXECUTIVE BOARD

MANAGEMENT REPORT 2013

REPORT OF THE SENATE
ON THE FINANCIAL YEAR 2013

THE EXECUTIVE BOARD



“Improving people’s lives through applied research is an extremely motivating undertaking. The strong growth in contract research for industry, in particular, is proof positive of the business world’s intense demand for our services, with their focus on scientific excellence and cognitive innovations for original products and processes.”

Reimund Neugebauer is Professor of Machine Tools and Forming Technology at the Technische Universität Chemnitz (TU Chemnitz). After leadership roles in the mechanical engineering industry, he set up the Fraunhofer Institute for Machine Tools and Forming Technology IWU in 1991, which grew to become an international center for manufacturing engineering in his 21 years of service as its director. He was founding president of Industrieverein Sachsen 1828 e. V., an industrial network in the Land of Saxony, and has been offered several professorships, including one at the ETH Zurich. He has been President of the Fraunhofer-Gesellschaft since October 2012.

Prof. Dr.-Ing. habil. Prof. E. h. Dr.-Ing. E. h. mult. Dr. h. c. Dr. h. c.
Reimund Neugebauer
President, Corporate Policy and Research Management



“For the first time since it was established, Fraunhofer’s business volume has exceeded the two-billion-euro mark. Our decades-long history of continuous growth owes much to our ability to constantly readjust to the ever-changing market for R&D services.”

Alfred Gossner initially pursued a career with the Allianz Group, including various international postings. Before joining the Fraunhofer-Gesellschaft in 2002, he served as a member of the board of management of Allianz Versicherungs-AG.

Prof. (Univ. Stellenbosch) Dr. rer. pol.

Alfred Gossner

Senior Vice President Finances, Controlling and Information Systems



“Fraunhofer has excellent, highly motivated researchers. The top priority of our human resources policy is to expand, encourage and make the most of this potential in the long term.”

After studying to become a lawyer, Alexander Kurz worked as a manager and board member for major research organizations such as CERN and the Karlsruhe Institute of Technology (KIT). He has been a member of the Executive Board of the Fraunhofer-Gesellschaft since June 2011.

Prof. Dr. rer. publ. ass. iur.

Alexander Kurz

Senior Vice President Human Resources, Legal Affairs and
IP Management



“Fraunhofer is very well placed in application-oriented scientific fields. We want to continue building on our leadership position in many technologies and make better use of the existing marketing potential by means of comprehensive partnerships with industry.”

Alexander Verl worked as a design engineer at Siemens and the German Aerospace Center (DLR) before founding AMATEC Robotics GmbH in 1997. Today, he is director of the Institute for Control Engineering of Machine Tools and Manufacturing Units at the University of Stuttgart. He was founding director of the Wissenschaftliche Gesellschaft für Montage, Handhabung und Industrierobotik – MHI (Scientific Society for Assembly, Handling and Industrial Robotics – MHI) and is chair of the Research Committee of the International Federation of Robotics (IFR). From 2006 onwards he was director of the Fraunhofer Institute for Manufacturing Engineering and Automation IPA and was appointed to the Fraunhofer Executive Board in April 2014.

Prof. Dr.-Ing. Dr. h.c. mult.

Alexander Verl

Senior Vice President Technology Marketing and Business Models

MANAGEMENT REPORT 2013

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Summary of the Fraunhofer-Gesellschaft's business development in 2013

	2012	2013	Change	
Business volume in € million	1926	2010	+84	+4%
Contract research	1614	1661	+47	+3%
Defense research	113	114	+1	+1%
Major infrastructure capital expenditure	199	235	+36	+18%
Breakdown of expenditure in %				
Personnel expense ratio	50	50	0	
Non-personnel expense ratio	30	29	-1	
Capital expenditure ratio	20	21	+1	
Contract research funding in € million				
Project revenue	1137	1200	+63	+6%
Industrial revenue	570	578	+8	+1%
Public-sector revenue ¹	567	622	+55	+10%
Base funding including changes in reserves	477	461	-16	-3%
Sources of funding for contract research in %²				
Projects	70	72	+2	
Industry	37	37	0	
Public sector ¹	33	35	+2	
Base funding including changes in reserves	30	28	-2	
International revenue in € million³	233	250	+17	+7%
Patent applications per year	499	603	+104	+21%
Active patent families at year end	6103	6407	+304	+5%
Employees	22 093	23 236	+1143	+5%

1 Public sector funding includes Germany's federal and *Länder* governments, the European Commission and other revenue (research grants, other R&D, non-R&D).

2 Funding sources for the operating budget including imputed depreciation of investments (excluding institutions in start-up phase).

3 Revenue from work with international customers and partners (including income generated by international subsidiaries with third parties).

Profile and structure of the Fraunhofer-Gesellschaft

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949 and based in Munich, the Fraunhofer-Gesellschaft is a non-profit research organization that undertakes applied research and development (R&D) in economically relevant areas of the natural and engineering sciences. It currently operates 67 Fraunhofer Institutes and other research institutions across Germany. Fraunhofer's more than 23,000 employees generate an annual business volume in excess of €2 billion.

With a current annual business volume of almost €1.7 billion, the contract research segment embraces the core activities of the Fraunhofer-Gesellschaft. They include areas of research that are important not only to industrial enterprises and service providers, but equally to government and society as a whole – such as resource-efficient manufacturing, transportation and mobility, energy and housing, information and communication technologies (ICT), protection and security, not to mention healthcare, nutrition and the environment.

Around 70 percent of Fraunhofer's contract research budget is accounted for by projects for industry and by publicly funded research projects. Together with their customers and project partners, the Fraunhofer Institutes develop and optimize processes, products or equipment to the point of industrial maturity/marketability. 30 percent of Fraunhofer's contract research budget is accounted for by base funding provided by the German Federal Ministry of Education and Research (BMBF) and the *Länder* governments in a ratio of 90:10. Fraunhofer utilizes these funds to finance strategic activities as well as the institutes' in-house and pre-competitive research. In so doing, it is constantly striving to meet the requirement that the institutes remain competitive at both national and international level.

The R&D activities of the Fraunhofer Institutes enhance the competitiveness not only of their local regions, but also of Germany and Europe as a whole. They foster innovation, buttress technological performance, increase the public's acceptance of modern technology and ensure that urgently needed young scientists and technicians receive proper initial and further training. In order to ensure optimum collaboration within the organization, the Fraunhofer Institutes work together in seven Groups on the basis of their core competencies:

- Information and Communication Technology
- Life Sciences
- Light & Surfaces
- Materials and Components – MATERIALS
- Microelectronics
- Production
and
- Defense and Security VVS

The Fraunhofer Group for Defense and Security VVS also carries out research on behalf of the German Federal Ministry of Defense (BMVg). Activities that are funded solely by the BMVg make up the defense research segment, which is reported separately in the Fraunhofer-Gesellschaft's annual accounts.

Funds invested in the building infrastructure of the Fraunhofer Institutes and in furnishing new institute buildings and equipping them with scientific apparatus are reported separately from the other segments under major infrastructure capital expenditure.

Fraunhofer's subsidiaries across Europe, North America and South America as well as its representative offices in Asia and the Middle East form a bridge to the world's main regions of current – and future – economic and scientific interest. Numerous strategic partnerships with organizations of excellence round off Fraunhofer's international portfolio.

Economic and political background

- German economy posts moderate growth
- Share of R&D in GDP reaches 3-percent target
- Federal government remains a reliable partner for R&D

The German economy proved stable in 2013, continuing to defy the recession still gripping a number of other European countries. While the influence of foreign trade as a growth driver weakened, this effect was partially offset by stronger domestic consumption. According to initial estimates, gross domestic product (GDP) grew by a moderate 0.4 percent year on year in real terms, and thus at a lower rate than in the previous two years (2012: +0.7 percent; 2011: +3.3 percent). Viewed over the longer term, economic growth was well below the ten-year annual average of 1.2 percent.

GDP growth in 2013 was characterized by contrasting developments in the German economy. The service sector again put in a very strong performance, while the manufacturing sector hardly grew at all compared with the previous year. The construction industry even posted another contraction, primarily due to a weaker commercial construction sector and sluggish public works. A similar contrast was observable on the consumption side. Although public and private consumption together rose by 0.8 percent, gross capital expenditure, at –1.1 percent, was down marginally year on year.

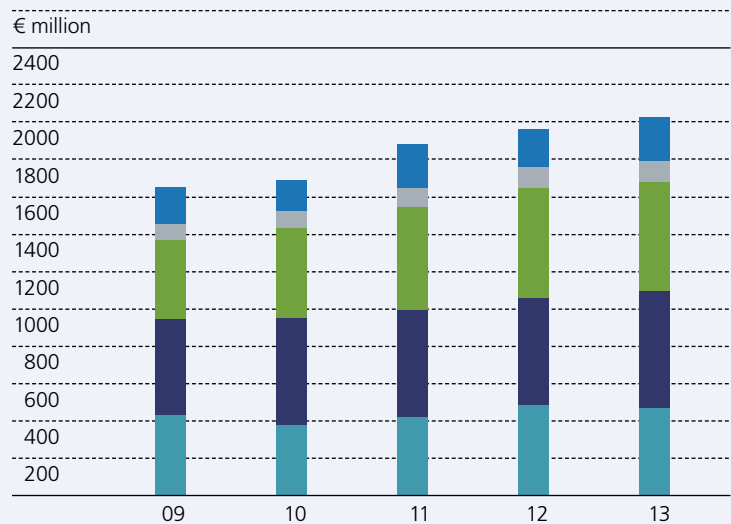
Companies and the public sector remain aware of the key importance of R&D expenditure for ensuring their innovative strength and competitiveness going forward. According to recent surveys carried out by Stifterverband für die Deutsche Wissenschaft, a not-for-profit innovation agency, R&D expenditure in Germany reached a record amount of around €80 billion in 2012. As a result, the share of GDP accounted for by R&D for the first time reached the 3-percent target formulated by the European Union. German businesses' R&D

expenditure in 2013 increased accordingly, rising by a substantial 5.3 percent. At 6.0 percent, the increase in R&D expenditure by universities was even stronger. Other public-sector research institutions recorded a plus of 4.8 percent, meaning that private enterprises and the public sector have almost doubled their R&D expenditure since the mid-1990s. By comparison, GDP rose only by a good two-thirds over the same period. According to the latest planning estimates of industry for 2013, R&D expenditure increased yet again, by about 4 percent.

Governments continued to rein in public spending in 2013. Overall, in Germany, the federal, *Länder* and local governments, as well as the social security funds, almost managed to achieve a balanced budget, with the federal and *Länder* governments again succeeding in reducing their deficits substantially compared with the previous year. Despite the general trend toward budget consolidation, expenditure on education and research was again given high priority in the 2013 federal budget. Whereas the federal government's planned total expenditure decreased slightly, from €311.6 billion in 2012 to €310.0 billion in 2013, the budget of the Federal Ministry of Education and Research (BMBF) rose by 6 percent or €800 million to €13.7 billion. The draft budget for 2014 provides for a further increase of around €224 million in the BMBF budget, taking it to a total of €14 billion. The future-oriented portfolios of education and research thus remain an important focus of the federal government.

The federal government remains one of Fraunhofer's most important and reliable partners. On the basis of the Joint Initiative Pact for Research and Innovation II, the base funding provided by the German Federal Ministry of Education and Research in 2013 for the Fraunhofer-Gesellschaft's contract research and major infrastructure capital expenditure increased by 5 percent, as it had the previous year. A further 5-percent increase is also planned for 2014.

Fraunhofer-Gesellschaft total business volume (cash basis) 2009–2013



	2009	2010	2011	2012	2013
■ Major infrastructure capital expenditure ¹	190	162	236	199	235
■ Defense research	87	93	98	113	114
■ Contract research	1340	1402	1515	1614	1661
■ Projects for industry ²	407	463	531	570	578
■ Publicly financed projects ³	509	567	570	567	622
■ Base funding including changes in reserves	424	372	414	477	461
= Business volume in € million	1617	1657	1849	1926	2010

1 As of 2011, includes minor building projects (< €1 million) previously recognized under contract research.

2 Project volume externally financed by customers from industry (including license-fee income).

3 Project volume externally financed by Germany's federal and Länder governments or the European Commission as well as from other sources.

Business performance

- Business volume exceeds the two-billion-euro mark for the first time
- Fraunhofer-Gesellschaft continues on its growth trajectory

The Fraunhofer-Gesellschaft remained on its growth trajectory in 2013. Fueled by the growing demand for R&D services from industry and the public sector alike, the progress made in research and development also translated directly into economic gains. The Fraunhofer-Gesellschaft was thus able to continue its success and constant growth of the previous years. In 2013, the Fraunhofer-Gesellschaft's business volume grew by 4 percent year on year to reach a total of €2010 million, thus surpassing the two-billion-euro mark for the first time.

The business volume is made up of budgeted expenditure on both contract and defense research as well as major infrastructure capital expenditure. The budgeted expenditure of the two research segments includes personnel and non-personnel expenses in the commercial sense as well as capital expenditure, the latter being recognized at the actual amount spent at the time of purchase. This means that depreciation and amortization do not have to be taken into account. In the year under review, budgeted expenditure for contract research activities rose by 3 percent to €1661 million. More than two-thirds of that amount was accounted for by research projects for industry (€578 million, including license-fee revenue) and publicly financed research projects (€622 million) that are often carried out in close cooperation with industry. Base funding and reserves of the Fraunhofer-Gesellschaft contributed an amount of €461 million to cover budgeted expenditure. Budgeted expenditure in the defense research segment rose by 1 percent to €114 million. At €235 million, major infrastructure capital expenditure came in just below its record level.

In the following, we report on expenditure and income items of the performance statement for each separate research segment. For information on the accounting principles used by the Fraunhofer-Gesellschaft, please refer to the Notes to the financial statements.

Contract research segment

- Contract research segment budget reaches €1.7 billion
- Revenue from publicly funded projects exhibits strongest growth

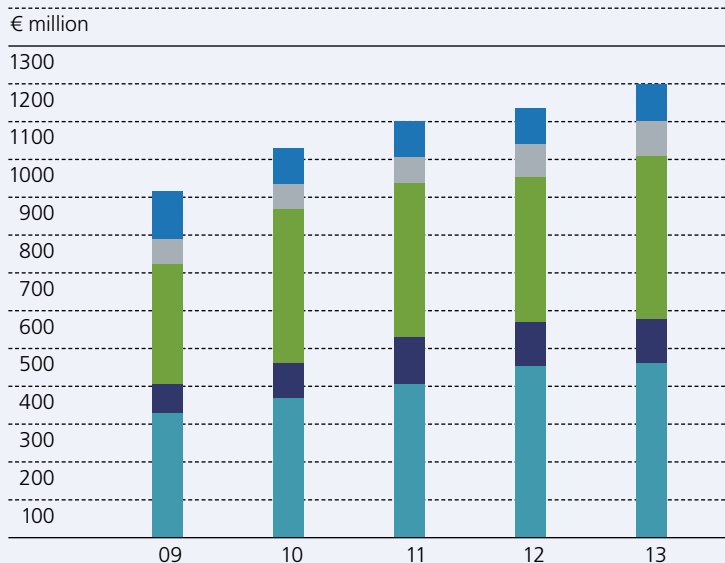
Contract research forms the focus of the Fraunhofer-Gesellschaft's activities. By carrying out R&D work for industrial enterprises and service providers, the Fraunhofer Institutes help translate the results of basic research into practical applications. In doing so, they function as a key innovation driver in Germany and Europe. The goal of many of the Fraunhofer-Gesellschaft's publicly funded projects is to improve existing infrastructure, for example in the fields of energy, transportation and healthcare. Above and beyond that, these projects make an important contribution toward networking within the public research and education system, and supporting innovation in the business world.

In 2013, budgeted expenditure for the contract research segment climbed by 3 percent to reach €1661 million, continuing the constant growth trend of recent years. Personnel expenses rose by 9 percent to €945 million, mainly due to the recruitment of over 1000 additional employees and to the two collectively agreed 1.4-percent wage increases that took effect on January 1, 2013 and August 1, 2013. Non-personnel expenses grew by just 1 percent to €549 million. There was a marked increase in capital expenditure, which climbed by 11 percent to €167 million.

Expenditure and revenue in the contract research segment 2009–2013 (in € million)

	2009	2010	2011	2012	2013
Personnel expenses	697	745	784	868	945
Non-personnel expenses	428	443	514	543	549
Change in the special license-fee revenue reserve and allocation to foundation capital	55	56	74	52	0
Current capital expenditure	160	158	143	151	167
= Expenditure	1340	1402	1515	1614	1661
Base funding including changes in reserves	424	372	414	477	461
Project revenue	916	1030	1101	1137	1200
■ Other (public sector)	127	96	94	97	99
■ European Commission (public sector)	65	65	71	88	92
■ Federal and Länder governments (public sector)	317	406	405	382	431
■ License-fee revenue (industry)	78	93	125	117	116
■ Industrial research (industry)	329	370	406	453	462
= Revenue	1340	1402	1515	1614	1661

Project revenue



Project revenues for contract research rose faster than budgeted expenditure, increasing by 6 percent to a total of €1200 million. They include all revenue that does not stem from internally utilized base funding, i.e. external funds from industrial research projects or property rights (industrial revenue), and funding provided by the federal or *Länder* governments and the European Commission for specific research projects. It also includes other funds from miscellaneous sources.

Industrial revenue grew by a slight 1 percent to a total of €578 million. It includes revenue from research projects for industry, which reached a new record level of €462 million, up 2 percent year on year. With a total volume of €116 million, license-fee revenue remained high, but below the record level of 2011. That year's figure, however, owed much to non-recurring effects.

Revenue from the federal and *Länder* governments was particularly gratifying in 2013. Following a slight drop in the prior year, it grew by a substantial 13 percent to €431 million, primarily due to the strong growth (21 percent) in revenue from the *Länder* governments, which reached €144 million. In addition to the federal and *Länder* governments, the European Commission is an important source of public-sector funding for Fraunhofer research projects. In 2013, revenue from the EU rose by 5 percent to €92 million. At €99 million, other revenue was around 2 percent above the prior-year level.

Defense research segment

- At €114 million, budgeted expenditure for defense research activities roughly on a par with the prior year
- Dual-use research model remains a success factor for innovation

The defense research segment unites the activities of the seven Fraunhofer Institutes involved in defense and security research that are funded by the German Federal Ministry of Defense (BMVg). The objective of this research is to provide people, infrastructure and the environment with the best possible protection against the entire spectrum of potential security threats. Within the context of dual-use research, these defense-related institutes also have contract research departments and, together with partners from industry and public-sector customers, are equally successful in developing solutions for civilian applications.

The defense research segment's budgeted expenditure increased by 1 percent in 2013 to reach €114 million. Of that amount, €68 million was accounted for by personnel expenses, €28 million by non-personnel expenses and €18 million by capital expenditure, which was recognized at the amount spent at the time of purchase. This expenditure was funded by the BMVg, which contributed €61 million in base funding and a further €53 million for specific research projects.

Major infrastructure capital expenditure

- At €235 million, major infrastructure capital expenditure only just below its record level
- One-third of infrastructure spending funded by the EU

In 2013, the Fraunhofer-Gesellschaft spent a total of €235 million on building infrastructure at its research institutions. That equated to a year-on-year increase of 18 percent and was only just below the record level of 2011, when Fraunhofer was provided with additional funds through publicly financed economic stimulus programs. Capital expenditure on land and buildings amounted to €174 million, while €61 million went toward furnishing new institute buildings and equipping them with scientific apparatus.

In addition to new buildings and extensions, major infrastructure capital expenditure includes minor building projects that extend the functional scope of existing buildings and require a comparatively small amount of spending (less than €1 million in any one case). In 2013, €45 million was posted for projects of this kind.

Funding for new buildings and extensions is customarily provided on a 50:50 basis by the German Federal Ministry of Education and Research and the respective *Land* in which the project is located (taking any possible co-financing into account). Minor building projects are funded by the federal and *Länder* governments on the regular 90:10 basis. Overall in 2013, the federal and *Länder* governments together provided about €163 million in infrastructure funding. Around one-third (€71 million) of the total spending on major infrastructure was co-funded by the European Regional Development Fund (ERDF).

The following is a brief run-down of some of the main infrastructure projects.

In 2013, Fraunhofer invested around €19 million in the new AdaptSys Center in Berlin, which has a planned investment volume of €40 million. The center, for which the Fraunhofer Institute for Reliability and Microintegration IZM is responsible, will focus on development work in the fields of medicine, energy and security. Half of the funding is provided by the ERDF and one-quarter each by the federal government and the *Land* of Berlin.

In May 2013, the new "Technikum" complex of the Fraunhofer Institute for Silicate Research ISC was opened in Würzburg. The new building, which has been praised for its eye-catching urban design, is an extension to the head office of Fraunhofer ISC. Covering 2500 m², it offers space for offices and different types of labs for the development of innovative non-metallic materials. The construction costs of almost €33 million were funded by the ERDF (with over €12 million) and the federal and Bavarian governments (with €10 million each).

Major infrastructure capital expenditure 2013 (in € million)

Institute / Research Institution	Location	Total	ERDF ¹	Federal/Länder governments ²
Reliability and Microintegration	Berlin	18.7	9.4	9.4
Silicon Technology	Itzehoe	15.1	7.5	7.5
Ceramic Technologies and Systems	Hermsdorf	13.1	8.2	4.9
Machine Tools and Forming Technology	Chemnitz	10.1	6.1	4.0
Center for Silicon Photovoltaics	Halle	10.0	7.5	2.5
Clinical Research Center	Hannover	9.8		9.8
Silicate Research	Würzburg	8.5	2.1	6.4
Laser Technology/Production Technology Competence Center	Aachen	8.1		8.1
Integrated Circuits	Fürth	7.0	3.5	3.5
Manufacturing Engineering and Automation	Stuttgart	7.0		7.0
Secure Information Technology – CASED ³	Darmstadt	6.6		6.6
Marine Biotechnology	Lübeck	6.0	3.0	3.0
Building Physics	Holzkirchen	5.9		5.9
Biomedical Engineering	Saarbrücken	5.2	2.6	2.6
Integrated Systems and Device Technology	Erlangen	4.1	2.0	2.0
Cell Therapy and Immunology	Leipzig	4.0	2.6	1.4
Institute Center Dresden	Dresden	3.7	2.2	1.5
Wind Energy and Energy System Technology	Kassel	3.6		3.6
Integrated Circuits	Waischenfeld	3.5	2.2	1.3
Integrated Circuits	Nürnberg	3.4	0.1	3.3
Wind Energy and Energy System Technology	Bremerhaven	3.3	0.3	3.0
Technology Center for Semiconductor Materials	Freiberg	3.3	2.0	1.3
Organics, Materials and Electronic Devices	Dresden	3.1	1.9	1.2
Structural Durability and System Reliability	Darmstadt	3.1		3.1
Silicate Research	Bayreuth	2.7	1.4	1.4
Material Cycles and Resource Strategies ⁴	Alzenau	2.7		2.7
Chemical Technology	Augsburg	2.6	0.7	1.9
Solar Energy Systems	Freiburg	2.0		2.0
Manufacturing Technology and Advanced Materials	Bremen	2.0		2.0
Manufacturing Engineering and Automation	Rostock	1.9	1.4	0.5
Electronic Nano Systems	Chemnitz	1.5	0.9	0.6
Manufacturing Engineering and Automation	Bayreuth	1.3	0.7	0.7
Electron Beam and Plasma Technology – RESET ⁵	Dresden	1.2	0.7	0.5
Physical Measurement Techniques	Kaiserslautern	1.2	0.6	0.6
Other construction work		4.9	1.1	3.8
Measures financed by federal/Länder governments and/or ERDF¹		190.2	70.6	119.6
Minor building projects		44.8		44.8
Major infrastructure capital expenditure		235.0	70.6	164.4

1 ERDF = European Regional Development Fund.

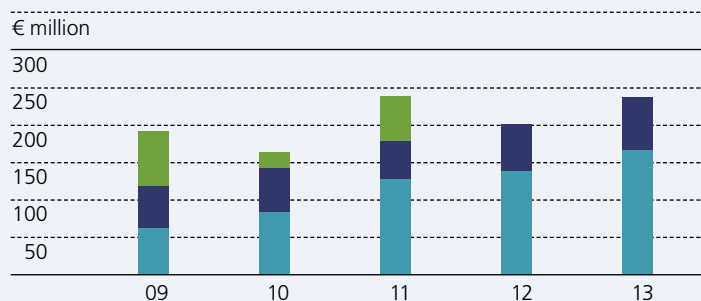
2 Including other funds of €1.2 million.

3 CASED = Center for Advanced Security Research Darmstadt.

4 Project group of the Fraunhofer Institute for Silicate Research ISC.

5 RESET = Resource-Conserving Energy Technologies (planned extension to the Institute Center Dresden).

Major infrastructure capital expenditure and funding sources 2009–2013



	2009	2010	2011	2012	2013
■ Economic stimulus programs I and II	73	22	59		
■ European Regional Development Fund	55	57	51	62	71
■ Federal and Länder governments ¹	62	83	126	137	164
= Funding of major infrastructure capital expenditure in € million	190	162	236	199	235

¹ Figure for 2013 includes €1.2 million in other funds.

The new building for the Fraunhofer Development Center for X-ray Technology (EZRT) in Fürth-Atzenhof celebrated its official opening in July 2013. The total costs of the building project amounted to €20 million and were jointly borne by the federal and Bavarian governments. The building, which has 140 offices, labs and workshops covering an area of 5300 m², is designed to accommodate 220 people. The new development center forms part of the Fraunhofer Institute for Integrated Circuits IIS in Erlangen and will concentrate on non-destructive testing of materials and objects, some as large as wind turbine rotor blades. The center also houses the world's largest CT scanner.

The new building for the Fraunhofer Center for Silicon Photovoltaics CSP in Halle (Saale) was inaugurated in September 2013. Covering an area of 4000 m², it will provide space for 85 employees working in a mix of offices and various types of laboratories. The building costs of around €47 million were funded by the ERDF (75 percent), with the federal government and the government of Saxony-Anhalt also bearing a 12.5 percent share each. Focusing on the latest silicon crystallization technologies, Fraunhofer CSP is helping to make the generation of electricity through photovoltaics more efficient.

Fraunhofer Groups

Collaboration in competence-based groups enables the Fraunhofer Institutes to develop cross-institute research strategies and to coordinate the procurement and utilization of strategic equipment. What is more, the chairs of the Groups can bring the influence of the institutes to bear on the overall policy of the Fraunhofer-Gesellschaft. The Fraunhofer Institutes and other Fraunhofer Research Institutions cooperate in six Fraunhofer Groups within the contract research segment. The institutes funded by the German Federal Ministry of Defense have joined forces in the Fraunhofer Group for Defense and Security VVS.

With budgeted expenditure of €465 million in 2013, the **Fraunhofer Group for Materials and Components – MATERIALS** is the largest group within the Fraunhofer-Gesellschaft. It encompasses 14 institutes with a focus on material sciences, whose activities include developing new materials and improving existing ones, developing production techniques, characterizing materials, and evaluating their behavior. The group covers the entire spectrum of metallic, inorganic non-metallic and polymer materials as well as those created using renewable raw materials. In 2013, Dr. Marcus Tegel and Dr. Lars Röntzsch of the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM were able to celebrate a very particular success. They were awarded the Fuel-Cell Innovation Prize 2013 for developing favorably priced hydrolysis-based supercapacitor materials for use in the fuel cells used in mobile applications.

The group's budgeted expenditure was around 8 percent higher than in the prior year. Although its industrial revenues were down 4 percent to €140 million, this decrease was more than offset by a marked rise of 15 percent in public-sector revenue, which reached €197 million. Overall, project revenue

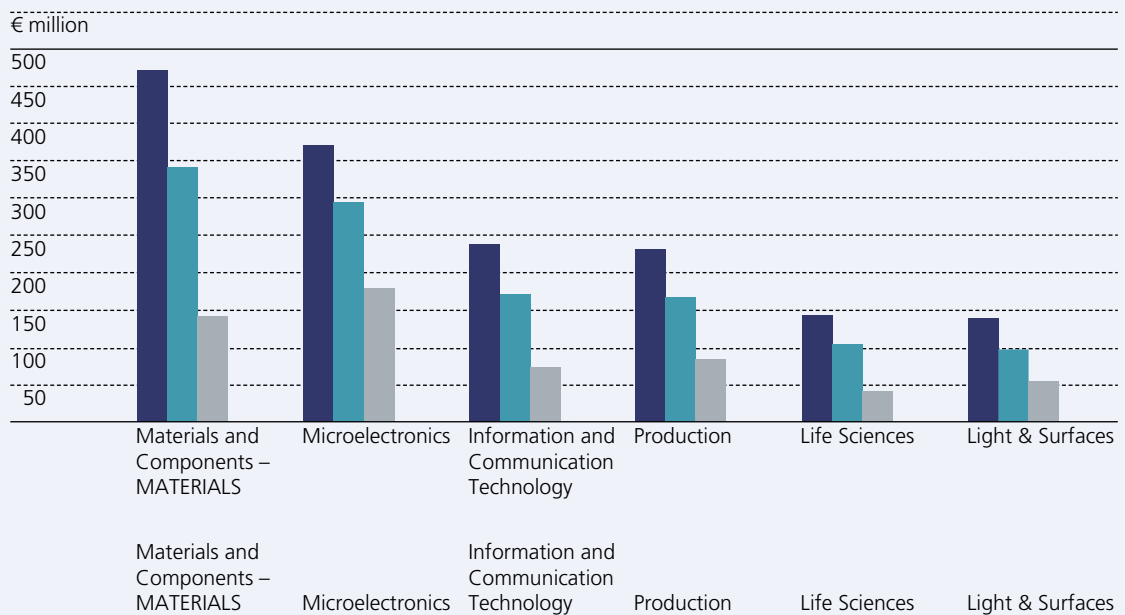
increased by 7 percent to €337 million, with the proportion of operating expenditure covered by project revenue reaching a very high 83 percent.

At the reporting date, the **Fraunhofer Group for Micro-electronics** was made up of 12 research institutions active in the fields of microelectronics and microintegration. The group offers forward-looking research and application-oriented innovations in the business areas of semiconductor technology, communication technology, ambient assistance systems, energy-efficient systems and e-mobility, lighting, security, and entertainment. Prof. Dr.-Ing. Nils Pohl of the Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR deserves a special mention here, having been awarded the Karl Arnold Prize of the North Rhine-Westphalian Academy of Sciences, Humanities and the Arts for his work in developing a radar chip boasting hitherto unmatched specifications.

The group's budgeted expenditure grew by 6 percent in 2013 to reach €366 million. The surge in project revenue to €290 million was mainly due to a substantial increase in industrial revenues. The group not only had the highest proportion of operating expenditure covered by project revenues (86 percent), but also the highest proportion of operating expenditure covered by industrial revenues (52 percent).

The **Fraunhofer ICT Group** focuses the activities of 17 research institutions that offer tailored IT solutions, professional technology consulting, and pre-competitive research for new products and services in the business areas of digital media, e-business and e-government, information/communication technologies, energy and sustainability, medicine, production, security, financial services and automotive manufacturing. Among its other achievements, the group has developed imaging techniques for medical technology as well as integrated software solutions not only to interconnect a variety of media, but also to digitalize historic cultural assets.

Expenditure and revenue of the Fraunhofer Groups in the contract research segment 2013



	Materials and Components – MATERIALS	Microelectronics	Information and Communication Technology	Production	Life Sciences	Light & Surfaces
■ Budgeted expenditure						
in € million	465	366	235	228	141	137
Operating expenditure	405	337	219	207	124	119
Capital expenditure	60	29	16	21	17	18
■ Project revenue in € million	337	290	168	165	103	99
■ Industrial revenue	140	176	72	83	40	54
Public-sector revenue ¹	197	114	96	82	63	45
Growth in %						
Budgeted expenditure	+8	+6	+4	+10	+5	+3
Project revenue	+7	+16	+6	+10	+3	+3
Industrial revenue	-4	+22	+7	+7	+15	-2
Public-sector revenue ¹	+15	+7	+5	+14	-3	+10
Breakdown of revenue in %²						
Projects	83	86	77	80	83	83
Industry	34	52	33	40	32	45
Public sector ¹	49	34	44	40	51	38

1 Public sector funding includes Germany's federal and *Länder* governments, the European Commission and other revenue (research grants, other R&D, non-R&D).

2 Breakdown of revenue used to fund the operating budget.

In 2013, the group's budgeted expenditure reached €235 million, corresponding to a rise of 4 percent. Project revenues grew at a higher rate of 6 percent, reaching €168 million. Overall, the group increased the proportion of its operating expenditure covered by project revenues to 77 percent.

The **Fraunhofer Group for Production** brings together 7 Fraunhofer Institutes. In its business areas – namely product development, manufacturing technologies, manufacturing systems, logistics, production processes, and production organization – the group offers a range of services along the entire product lifecycle or value chain. The group's research focuses, among other things, on energy- and resource-conserving manufacturing technologies and efficient logistics systems. Of particular note within this group is the research factory for resource-efficient production operated by the Fraunhofer Institute for Machine Tools and Forming Technology IWU, which was among the prizewinners in the Germany-wide competition "Landmarks in the Land of Ideas 2013".

Of all the groups, the Fraunhofer Group for Production recorded the strongest growth in budgeted expenditure (10 percent) to reach €228 million. This growth was for the most part covered by project revenues, which likewise increased by 10 percent. Public-sector revenue increased as well, by 14 percent. The proportion of operating expenditure covered by public-sector revenues and industrial revenues reached 40 percent in both cases.

The **Fraunhofer Group for Life Sciences**, the Fraunhofer-Gesellschaft's newest group, pools expertise in the biological sciences, biomedicine, pharmacology, toxicology and food technology. The group's 7 research institutions offer its customers innovative knowledge in the areas of medical translational research, biomedical engineering, regenerative medicine, healthy foodstuffs, biotechnology, and safety issues pertaining to processes, chemicals and pesticides. Examples of noteworthy projects pursued by the group are: supporting SMEs

in developing gluten-free foods that are widely accepted by consumers; developing artificial blood vessels that can be manufactured using 3D printing techniques; and maintaining a cryobank containing the viruses and microorganisms required to develop HIV vaccines.

In 2013, the group recorded a 5-percent increase in budgeted expenditure, with its operating budget growing by 9 percent. Capital expenditure fell marginally year on year. The outstanding rise of 15 percent in industrial revenues to reach €40 million is testimony to the fact that these areas of research are highly relevant to industry. Despite a slight drop in public-sector revenues, the group recorded the highest proportion of operating expenditure covered by public-sector revenue.

Comprising 6 member institutes, the **Fraunhofer Group for Light & Surfaces** carries out research into surface engineering and photonics, key technologies that are deployed in a large number of applications – including manufacturing technology, optical sensor systems and biomedical engineering. The group's core competencies include the development of coating processes, the functionalization of surfaces, materials processing, optical measuring techniques, and the development of micro-optical and precision-engineered systems.

The Fraunhofer Institute for Applied Optics and Precision Engineering IOF in Jena was particularly successful in the year under review. In December 2013, German Federal President Joachim Gauck presented Prof. Dr. Stefan Nolte and two of his industrial partners with the German Future Prize for the development of an ultra-short-pulse laser suitable for use in industrialized mass production.

The group increased its budgeted expenditure to €137 million in 2013 and grew its project revenue by 3 percent to €99 million. At 45 percent, the group had the second highest proportion of operating expenditure covered by industrial revenues among all the Fraunhofer Groups.

The Fraunhofer Group for Defense and Security VVS brings together the expertise of the 7 defense-related Fraunhofer Institutes and their respective contract research departments. This group's research focuses on infrastructure security, the protection of people, active crisis management and the monitoring of both civilian and military risks. In Germany, the group has already become a driving force within the entire area of defense and security. It is very active at European level, too, where it functions as an enabler for intensive networking and joint research activities.

The group's budgeted expenditure increased by 4 percent in 2013 to reach €201 million. This rise was almost entirely due to the growth achieved by the civilian contract research departments, which succeeded in posting an almost 10-percent year-on-year rise in budgeted expenditure to €90 million. Project revenue for the group as a whole amounted to €120 million, up 5 percent, while the proportion of operating expenditure covered by project revenue reached 70 percent.

Financial position

- 72 percent of contract research financed through project revenue
- Wide variations in *Länder* project funding
- Higher funding ratios needed

The Fraunhofer-Gesellschaft's funding rests on three pillars – base funding, revenue from contracts with industry, and revenue from public-sector project funding – each of which contributes roughly one-third of total funds.

Base funding in the contract research segment is split between the federal and *Länder* governments in a ratio of 90:10. These funds are made available for strategic initiatives of the Executive Board as well as for the institutes' in-house and pre-competitive research. Under the Joint Initiative for Research and Innovation II, Fraunhofer has received annual increases of 5 percent in its base funding since 2011.

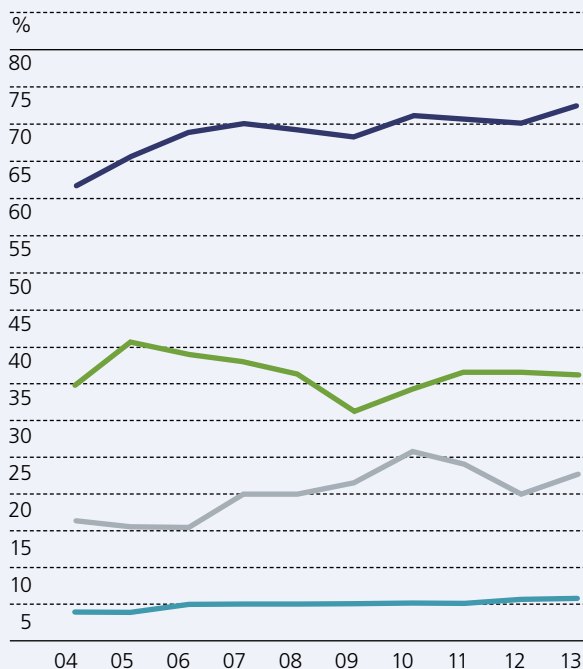
In recent years, the Fraunhofer-Gesellschaft has expanded its key research areas, actively exploiting its opportunities in the contract research segment for its industrial and public-sector project partners. The Fraunhofer-Gesellschaft's strong growth demonstrates how attractive its R&D activities are in the market for such services, and is also an indicator of the German economy's demand for innovation. As increases in base funding have not kept pace with Fraunhofer's excellent growth, the proportion of contract research covered by base funding has fallen continually in recent years.

For this reason, the proportion of the operating budget (including imputed depreciation of investments) covered by project revenues (excluding institutions in start-up phase) rose further to reach 71.8 percent at the balance sheet date (2012: 69.5 percent). The proportion of operating expenditure covered by industrial revenues amounted to 36.5 percent (2012: 36.9 percent). Funds provided by the federal and *Länder*

governments accounted for 23.1 percent of operating expenditure (2012: 20.6 percent). Revenue from projects with the European Commission reached a share of 5.9 percent (2012: 5.6 percent).

Public-sector funding of research projects is subject to the Federal Budgetary Regulations, and to the principle of budget transparency anchored in them. Fraunhofer's political mandate requires it to use the funds it receives to develop new areas of strategic interest in pre-competitive research. Inadequate funding ratios and forms of project financing that do not cover all of the costs incurred pose problems because they tie up resources from base funding that would otherwise be used to finance pre-competitive research. For many years, binding rules for calculating funding ratios have been in place at the German Federal Ministry of Education and Research. The key principle is that a funding ratio of 100 percent – i.e. covering all of the project-related costs – applies for every research project carried out by Fraunhofer. Even in the case of joint projects involving external partners, it is ensured that Fraunhofer's share of the financing is covered without the organization having to dip into its own funds. In Fraunhofer's view, this practice has proven its worth.

Sources of project funding in the contract research segment 2004–2013



- Project funding (total)
71.8% (2012: 69.5%)
- Industrial funding (industry)
36.5% (2012: 36.9%)
- Project funding from Germany's federal and Länder governments
23.1% (2012: 20.6%)
- Project funding from European Commission
5.9% (2012: 5.6%)

By contrast, project funding by the *Länder* governments varies markedly due to the wide variety of legal and financial requirements involved. Especially when funds from the European Regional Development Fund (ERDF) or the European Social Fund (ESF) are used for refinancing, allocation practice between the *Länder* differs. As a result, the actual funding ratios diverge substantially.

In view of both public-funding objectives and budgetary constraints, the framework for project funding by the *Länder* governments needs to be harmonized across the board to enable financing that actually covers costs. Fraunhofer should not be restricted in any way from using its base funding resources for in-house pre-competitive research. In that way it can continue enhancing its innovative strength and thus contribute towards securing Germany's growth and prosperity.

Net asset position

- Total assets exceed €2.6 billion
- Prefinancing down by €9 million

The Fraunhofer-Gesellschaft's total assets at December 31, 2013 amounted to around €2657 million, up 5 percent year on year.

Fixed assets increased by a total of €136 million to around €1859 million, of which €1832 million was for property, plant and equipment. At December 31, 2013, property, plant and equipment represented 69 percent of total assets and was thus the predominant item on the assets side of the Fraunhofer-Gesellschaft's balance sheet. Intangible assets amounted to €12 million and financial assets to €15 million.

Accounts receivable and other current assets fell by €28 million to €474 million, while trade receivables rose by €4 million. Receivables from the federal and *Länder* governments decreased by €23 million, and receivables from associated companies by €6 million. Other assets decreased by €3 million.

Inventories net of advance payments received increased by €9 million.

Current securities declined by €15 million to €215 million. Additions in the amount of €51 million were more than offset by disposals of €66 million, which comprised the sale of shares for prefinancing purposes. The Fraunhofer Fund's available assets were invested in low-risk liquid securities in 2013. On average, the split over the year was 29 percent in money market instruments, 23 percent in bonds, 18 percent multi-asset funds, 18 percent in equities, 3 percent in commodities and 9 percent in renewable-energy investments. In view of the uncertain market environment, the Fraunhofer Fund's asset allocation policy favored low risk investments, with the Fund steering and proactively containing its investment risks through dynamic and systematic management of the allocations to the individual segments and through risk overlay with threshold control.

Cash assets (cash and cash equivalents including the Fraunhofer-Gesellschaft's current bank accounts) rose by €14 million to €30 million, €29 million of which was funds earmarked for investment taken from the special reserve for license-fee revenue. In the year under review, the Fraunhofer-Gesellschaft made no use of funds carried forward under its management statutes; no funds were carried forward to 2014.

Prepaid expenses and deferred charges, which primarily include prepaid rent, maintenance contracts, and services, fell to €11 million.

Equity grew by €0.4 million – an amount representing the net profit for the year from the association's accounts – and totaled €14 million at December 31, 2013. The non-profit organization's capital is that portion of the Fraunhofer-Gesellschaft's assets that has not been acquired out of public funds. In addition to the capital of the non-profit organization and the restricted reserves, equity is also deemed to include the special reserve for license-fee revenue and for grants relating to fixed assets.

The special reserve for license-fee revenue was unchanged over the previous year and stood at €244 million on the balance sheet date.

Funds received for the purpose of acquiring and constructing fixed assets are transferred to a special reserve, which is reduced each year by an amount corresponding to the annual depreciation expense on the related assets. The special reserve for grants relating to fixed assets increased by €136 million to €1845 million in 2013, in line with the carrying amount of the assets financed by such external funds.

The special reserve for funds used to finance current assets is used to account for income not yet received or expenses not yet paid by the balance sheet date. In 2013, prefinancing decreased by €9 million to €183 million.

Provisions for pensions and similar obligations amounted to €10 million. The Fraunhofer-Gesellschaft has a reinsurance policy in place to cover its existing pension obligations, as a means of offloading biometric risks and converting uncertain long-term liabilities into foreseeable, calculable costs. The pension provisions are measured using the capitalized value calculated by the insurance company on the reporting date.

Other provisions rose by €6 million to €138 million, mainly due to higher provisions for performance-based bonuses. By contrast, provisions for phased early retirement and for inventors' bonuses were lower. With the exception of provisions for compensated leave, the change in other provisions had no impact on the funding situation due to the simultaneous change in the special reserve for funds used to finance current assets. In the case of pension and compensated leave provisions, corresponding balancing amounts are entered on the assets side of the balance sheet.

In 2013, liabilities decreased by €16 million to €212 million, and included €105 million in grants from the federal and *Länder* governments still to be appropriated, €85 million in trade payables, and €22 million in other liabilities.

Deferred income rose to €10 million, and relates primarily to lump-sum license fee payments received for mp3 technology before the reporting date and not yet recorded as revenue.

No subsequent significant events have arisen since the reporting date that are material to assessing the development of the organization's business in the year under review or which have a substantial impact on its financial position, net assets or operating results.

Risk management and risks

- Constant monitoring of risks at Fraunhofer
- No anomalies in the overall risk situation

In carrying out its applied research, the Fraunhofer-Gesellschaft takes calculated risks in order to create innovations that will benefit both the economy and society at large. The risk management system is designed to identify existing and potential risks at an early stage and to manage them by means of appropriate measures in such a way that they either do not materialize at all or do not have consequences that could jeopardize the fulfillment of Fraunhofer's mission in accordance with its statutes or its ability to meet its own business objectives.

The risk management process is set down in the Fraunhofer-Gesellschaft's risk management manual. The central departments inform the Executive Board of risks – both routinely and on an ad-hoc basis – via the reporting channels in place. Fraunhofer supplements these activities by preparing a dedicated annual risk report, which summarizes and prioritizes the results of a survey of risk experts.

The Fraunhofer-Gesellschaft understands "risk" to mean all internal and external events and developments jeopardizing the fulfillment of its business objectives. These include both risks that can be given a monetary value and those of a qualitative nature.

Business risks include those risks arising out of changes in the political, legal and economic framework of applied research.

Political decisions concerning a reduction in planned funding contributions or restrictions placed on transferring unused portions of the previous year's funding can affect Fraunhofer financially. Fraunhofer's base funding increases currently by 5 percent every year (2011–2015) under the provision of the Joint Initiative for Research and Innovation. At the *Länder*

level, however, there are indications that the debt brake anchored in the German constitution is prompting some governments to look for cost savings in the area of research. Even if public-sector funding were moderately reduced in real terms, we would presumably still have enough time to take appropriate countermeasures.

As a non-profit organization and beneficiary of public funds, Fraunhofer is also subject to federal and *Länder* government regulations and wider EU legislation. The rules of participation of the EU's "Horizon 2020" framework program, which is due to start in 2014, constitute a departure from the principle of full-cost funding, with the introduction of lump sum payments to cover general administrative expenses. For the Fraunhofer Institutes, this change will, on average, lead to a deterioration in the funding ratio for EU-sponsored projects. Fraunhofer is closely examining the shift in focus as regards funding topics and instruments that Horizon 2020 will bring about. Optimized support for the institutes will ensure that EU-funded research remains an attractive option for Fraunhofer even within this altered framework.

With reference to the ERDF funds being used to enhance project funding at *Länder* level, the European Commission largely accepted the Fraunhofer Institutes' full-cost method of financing for the ERDF funding period just expiring. However, there is a fundamental risk that, in the next funding period, the lump-sum funding model from Horizon 2020 will begin to influence projects refunded by the ERDF. Fraunhofer is taking a proactive approach in its negotiations with the funding agencies in order to ensure that the "full-cost" method of financing is retained and even extended for *Länder*-funded projects in general and ERDF projects in particular.

In view of the ongoing globalization trend, the Fraunhofer-Gesellschaft is closely monitoring the offshoring of R&D activities and assessing its effects on the applied research market with a view to making the necessary adjustments to its international strategy. The diversification and ongoing enhancement of Fraunhofer's research portfolio makes it possible to spread risks and thus limit the danger of strategic misjudgments. Tried-and-tested strategy processes are in place that ensure a permanent feedback loop with market players.

Financial risks are those that are rooted in the non-profit association's financial activities.

When it comes to potential tax risks, we are closely monitoring the risk that Fraunhofer (or parts of its organization) might be deprived, for its operational activities, of the status of a business entity, as the tax authorities are beginning to take a more restrictive approach to this subject. To this end, Fraunhofer has enacted a package of measures, and is maintaining a dialog with the relevant tax authorities so as to keep abreast of possible changes in the tax framework.

Capital market risks can arise when the non-profit organization capital and reserves of the Fraunhofer-Gesellschaft are invested with a view to earning a return. The investments are concentrated in open-end funds within the meaning of the German Investment Act and in closed-end funds. The organization pursues what is fundamentally a risk-averse investment policy and, in view of the uncertainty prevailing in the money and capital markets, keeps a constant watch on the risk situation. Comprehensive measurement and control of risks is carried out in real time, thus making it possible to respond rapidly to any market changes.

Continual monitoring of prefinancing and accounts receivable, coupled with effective dunning and contractually agreed payment terms, help to minimize credit risk, which essentially relates to project prefinancing and unrecoverable payments.

The Fraunhofer-Gesellschaft channels the results of its research – such as patents – into existing companies or its own start-ups. This may involve subsequently disposing of the equity investments or generating income for Fraunhofer through research contracts. The performance of these investments is closely monitored by means of an investment controlling process.

Operational risks include the risk of losses being incurred as a result of the unsuitability or failure of internal processes, people and systems, or due to external events.

Recruiting highly qualified scientists and encouraging them to stay with Fraunhofer is the key to preserving and expanding the organization's research expertise. Through Fraunhofer's close partnerships with universities, talented young scientists can get to know the organization at an early stage. Fraunhofer's already very favorable reputation in the employment markets is reinforced by a personnel policy that is sustainable and geared to the long term.

The provision of research services calls for a reliable and secure IT infrastructure. Fraunhofer takes targeted measures to mitigate potential risks in the IT field – for instance from the trend toward the centralized provision of IT services – and has described these measures in a binding IT security manual.

Fraunhofer is constantly improving its rules and processes and, in response to ever stricter requirements, ensures that its business processes are designed and implemented in compliance with the rules and regulations in force. A compliance management system is in place to guarantee that the subject of rules, and compliance with them, is dealt with in a systematic manner.

Through its contract research projects for industry, Fraunhofer is exposed to liability and performance risks such as product liability and warranty. It manages these through suitable liability restriction clauses in its standard terms and conditions of business and in its standard contracts, as well as through a multi-tier approval process based on competent legal advice.

The current **overall assessment** of the Fraunhofer-Gesellschaft's risk situation reveals nothing that could endanger its existence in the long term.

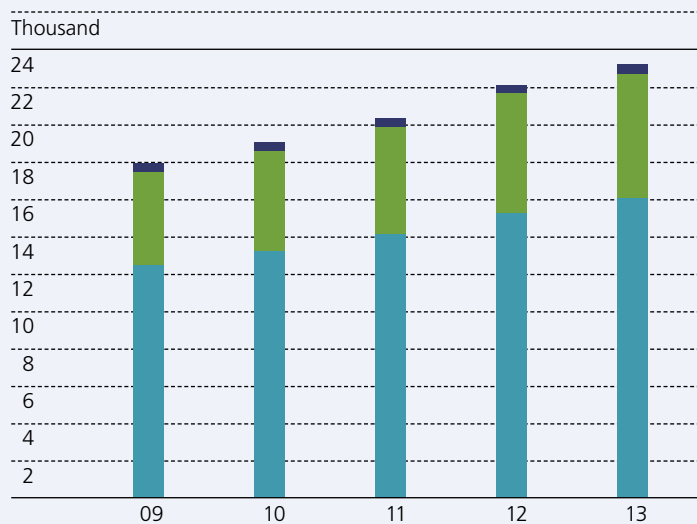
Employees

- Over 23,000 employees
- TALENTA program launched to support and develop women scientists
- Fraunhofer receives HR Excellence Award 2013

At December 31, 2013, the Fraunhofer-Gesellschaft had 23,236 employees, up by more than 1000 year on year. Within the research community, a unique selling point of Fraunhofer is its mission to facilitate the transfer of its personnel to positions in science and industry and to self-employment. In accordance with this principle, some 800 excellently trained scientists leave the Fraunhofer-Gesellschaft every year. Given this fact, and due to normal turnover as well as the need to increase staff numbers, Fraunhofer had to recruit almost 2000 new employees – mainly graduates of mathematics, IT, science and technology – in 2013.

When recruiting talented young scientists, the Fraunhofer-Gesellschaft is also driven by its commitment to take on more women and to support their career development. Fraunhofer has formulated this commitment in clear targets, and intends in 2014 to achieve a share of 33 percent of female scientists in its intake of new personnel across all its institutes. This is an ambitious goal, given that the current share of women among graduates in the subjects of relevance to Fraunhofer is substantially lower. In spite of all its efforts, Fraunhofer was not quite able to reach the corresponding target it had set itself for 2013.

Growth in the Fraunhofer-Gesellschaft's workforce 2009–2013



	2009	2010	2011	2012	2013
■ Trainees	488	487	488	470	494
■ Graduate, undergraduate and school students	5009	5313	5765	6403	6694
■ Scientific, technical and administrative personnel	12410	13202	14073	15220	16048
= Employees	17907	19002	20326	22093	23236

Following intensive discussions with the relevant internal committees, Fraunhofer developed and adopted its own specific cascade model. Even though Fraunhofer only just fell short of its targets in the first year of the model, it remains committed to the goal of raising the share of female scientists in its ranks by around 2 percentage points to reach 21 percent in 2017 (taking 2013 as a baseline). The organization already put together and launched a whole raft of measures in this regard in 2012, and these were augmented by the "Fraunhofer TALENTA" support program, which got underway in 2013.

The latter is a centrally coordinated program whose purpose is to achieve a significant increase in the proportion of female scientists and female managers at Fraunhofer. Initially set to run until 2017 (and with support measures continuing until 2019), the program provides additional funding for the institutes to finance personnel growth and win over female scientists. TALENTA targets a number of different stages in the careers and development of the women concerned, thus doing justice to the underlying idea of fostering them in particular phases of their lives.

In summer 2013, for the first time, recent female graduates of mathematics, IT, science and technology as well as corresponding students at an advanced stage of their studies were invited by the Science Campus to attend a four-day Summer School organized jointly by Fraunhofer and the universities in question. The Summer School offered a wide variety of workshops, presentations and guided tours of research facilities, all of which aimed to raise the young women's enthusiasm for pursuing careers in science and taking on management positions in the field of applied research. After this successful premiere of the Science Campus for some 60 women, the plan is to organize several Summer Schools at other Fraunhofer locations in 2014. Fraunhofer was honored with the HR Excellence Award 2013 for its Science Campus format. All in all,

Fraunhofer has earmarked an average of €14 million a year over the next few years to cover the measures it has planned to raise the share of women scientists in its workforce.

Managers at Fraunhofer must fulfill special requirements if they are to facilitate outstanding applied research. They must not only grant their staff the greatest possible freedom to create and innovate, but at the same time ensure they get measurable results out of the ideas the researchers come up with. These requirements give rise to a specific leadership profile for managers at Fraunhofer. In 2013, Fraunhofer elaborated its Leadership Principles. They serve as a guideline for managers and provide the basis for developing a Fraunhofer leadership skills model and for honing the organization's centralized system of management training in collaboration with the University of St. Gallen.

In order to recruit suitable personnel for scientific and technical positions and retain them in the long term, Fraunhofer made career management for specific target groups one of its HR development priorities in 2013. The career system determines that the majority of scientists remain at Fraunhofer for only a limited period. For those wanting to work for Fraunhofer for a longer period, a specialist career path was created alongside the existing one for managers. Career development is geared to the different phases of the employees' lives, with emphasis being placed on the ability to switch between the two career paths. At Fraunhofer, career and development planning is a fixed component of the annual employee assessment interview.

For the Fraunhofer-Gesellschaft, providing occupational training to young people is not only an obligation it bears toward society, but a contribution to safeguarding its own non-scientific workforce. That makes occupational training an essential component of strategic personnel development.

At the moment, the organization has 494 trainees and apprentices in 36 different occupations. Dual educational/vocational courses are attracting growing interest from both the institutes and applicants. The apprentices' specialist training in the institutes is supplemented by a range of seminars focusing on overarching mandatory topics, social skills and information about all aspects of the Fraunhofer-Gesellschaft. This encourages the apprentices and trainees to network with each other. In 2013, a further option was added enabling apprentices at different institutes to swap places with each other for several days at a time. The system is an ideal supplement to the apprentices' individual training programs, allowing them to get to know alternative work processes or technical facilities.

Mobility in career development – i.e. offering employees the option of spending time abroad – is gaining in importance at Fraunhofer, too. Sometimes it is a requirement of participation in international projects, sometimes a necessary or self-chosen stepping stone in an employee's personal career plan. It is of strategic importance to the institutes as well that their employees spend phases of their career abroad because it adds value in the shape of enhanced international networking. In order to support and intensify the international mobility of its researchers, Fraunhofer became a signatory to the European Commission's "European Charter for Researchers – Code of Conduct for the Recruitment of Researchers" in October 2013.

Fraunhofer has a reputation as a very attractive employer. That is underscored by annual employer rankings such as the survey carried out in 2013 by personnel consultants Universum, in which Fraunhofer was rated third best employer by science students. This means, however, that Fraunhofer is a direct competitor of German companies with international operations. That is why it is so crucial for Fraunhofer to be able to pay competitive salaries if it is to recruit and retain employees. However, that is possible to only a limited extent under Germany's

public-sector collective wage agreement (TVöD). Fraunhofer makes use of the existing options to honor exceptional individual performance by granting research bonuses. What is more, a system for assessing the performance of staff employed under public-sector collective bargaining agreements was introduced and has been functioning successfully for many years.

Fraunhofer welcomes Germany's Academic Freedom Act and the possibility it brings to utilize funds acquired neither directly nor indirectly from public-sector sources for salaries or salary components, with a view to rewarding outstanding individual performance. In line with the Fraunhofer model, it is only natural that compensation should be based on the industrial revenues earned through a project. On condition that only the addressees mentioned in the Academic Freedom Act – namely scientists and employees in science-related areas – should be beneficiaries, Fraunhofer has defined three elements – "profit sharing", "non-cash benefits" and "additional remuneration" – for which it will make the most of the flexibility granted by the act.

Taking into account the recommendations of the German Federal Ministry of Education and Research, Fraunhofer described these three elements in a guideline entitled "Implementation of the provisions of Section 4 of the Academic Freedom Act at the Fraunhofer-Gesellschaft," which was submitted to the Fraunhofer-Gesellschaft Policy Committee in June 2013. On the basis of this guideline, Fraunhofer concluded an agreement with the Central Works Council to implement Section 4 of the Academic Freedom Act as from 2014.

Patents and licenses

- More than two patent applications every working day
- Fraunhofer-Gesellschaft among the Top 100 Global Innovators

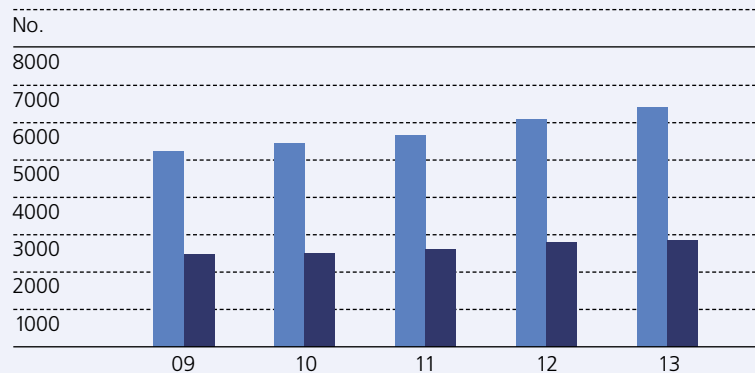
Given the dynamic nature of technological progress, the ability to innovate quickly has become a decisive competitive factor for industry and science. Short, expensive innovation cycles mean that new technical solutions have to be made available as fast as possible. In order to safeguard a competitive edge that is based on innovation, newly developed technical solutions have to be protected with patents, as they allow those solutions to be turned into commercially viable goods.

The Fraunhofer-Gesellschaft is one of the most active and important sources of patent applications in Germany. In 2013, our research institutions produced a total of 733 invention disclosure reports – more than ever before. Over 80 percent of these inventions – or 603 to be exact – were registered for patents. On average, Fraunhofer files more than two patent applications every working day. Fraunhofer's portfolio of active rights (patents and utility models) and patent applications had risen to a total of 6407 at year end 2013. That includes 2847 patents granted for the German market. The number of exploitation contracts concluded increased from 3167 in the prior year to 3450 in 2013. Fraunhofer was one of only three German organizations to be ranked among the Top 100 Global Innovators in 2013, an award presented by the Thomson Reuters media group on the basis of the number and quality of patented inventions.

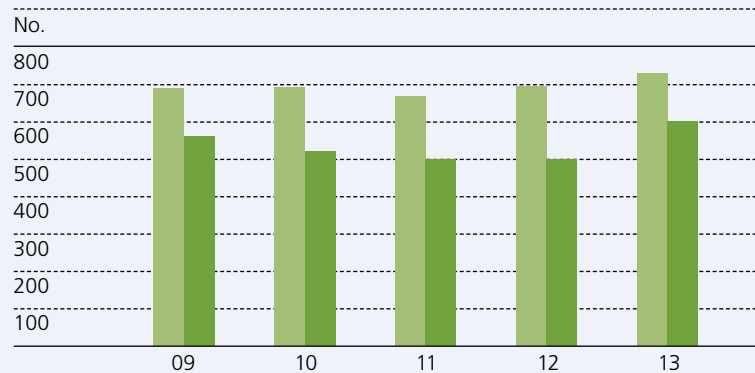
In order to compensate better for fluctuations in its traditional sources of income, Fraunhofer has implemented a results-oriented system of intellectual property (IP) management. Its main instrument is a patent strategy process, which 20 Fraunhofer Institutes have already introduced. This process enables the institutes to improve management of their IP portfolios and tap additional sources of income to supplement their contract research activities by offering licensing agreements to a wider clientele.

Following an analysis of their patent portfolios, the institutes involved are given recommendations for reducing the patent-related costs of less attractive patent clusters and for stepping up their patenting and exploitation activities in more profitable areas. Whereas the recommendations for cost reductions are largely put into practice, it is evident that the institutes need further support in implementing the recommendations for stepping up their patenting and exploitation activities. For this reason, a three-year pilot phase was launched that targets the enhanced exploitation of patents. Licensing projects were identified that have the potential to generate substantial license-fee revenue in the medium term. Above and beyond that, the pilot institutes devised and tested structures that are designed to perpetuate the patent strategy process and systematically generate license-fee revenue.

Invention disclosures and patent applications 2009–2013



	2009	2010	2011	2012	2013
Active patent families at year end ¹	5235	5457	5657	6103	6407
Of which patents valid in Germany	2490	2505	2605	2794	2847



	2009	2010	2011	2012	2013
Invention disclosure reports per year	691	694	671	696	733
Patent applications per year	563	520	500	499	603

¹ Portfolio of active rights (patents and utility models) and patent applications at year end.

The positive trend in license-fee revenue of recent years continued in 2013. With license-fee revenue totaling €116 million, Fraunhofer remains among the top research organizations in the world. To succeed in generating license-fee revenue going forward, Fraunhofer needs to support a long-term program of pre-competitive research in selected fields of technology, regardless of changing economic conditions, with the aim of building up comprehensive patent clusters. In order to accelerate the licensing of research results to technological companies, the Fraunhofer-Zukunftstiftung (Fraunhofer Future Foundation) promotes those in-house research projects of the Fraunhofer-Gesellschaft that are of pronounced relevance to the market and look set to generate broad demand. The Fraunhofer Future Foundation thus helps the organization to make a contribution to innovation and competitiveness in Germany.

Subsidiaries, equity investments and spin-offs

- Stakes in a total of 78 companies
- Continued growth of international subsidiaries
- Ongoing high pace of spin-off activities
- New program FFI to enhance the spirit of innovation

At the balance sheet date, the Fraunhofer-Gesellschaft held equity investments in a total of 78 companies across a wide variety of sectors. The transfer of technology to industry formed the focus of activities at 56 of the companies in the investment portfolio, while the remaining 22 equity investments were of a strategic nature. The total carrying amount of equity investments amounted to €5.2 million on the balance sheet date. In 2013, the Fraunhofer-Gesellschaft acquired stakes in the equity capital of three companies, and disposed of its investment in eight others.

With a view to institutionalizing its R&D activities outside Germany, the Fraunhofer-Gesellschaft operates four international subsidiaries as well as two foundations and one association, which in turn run their own research units. Due to the negligible effect of the revenues generated by the subsidiaries on the overall organization's net assets, financial situation and operating results, Fraunhofer does not draw up consolidated financial statements.

Established in 1994, **Fraunhofer USA, Inc.**, is a wholly owned, non-profit subsidiary of the Fraunhofer-Gesellschaft, with headquarters in Plymouth, Michigan. Under the auspices of Fraunhofer USA, seven Fraunhofer centers carry out research on behalf of industrial enterprises, public-sector customers and academic institutions. In addition, the marketing activities of two Fraunhofer Institutes in the United States are incorporated in Fraunhofer USA. The budgeted expenditure of Fraunhofer USA in 2013 amounted to the equivalent of €30 million in U.S. dollars (provisional figure). With U.S.-dollar revenues equivalent to €11 million, the Center for Molecular Biotechnology CMB was again the best-performing institution. Fraunhofer USA generated project revenues of around €17 million (provisional figure).

Fraunhofer's Austrian subsidiary, **Fraunhofer Austria Research GmbH**, started operations from its headquarters in Vienna in 2009. The Fraunhofer-Gesellschaft is the sole owner of this non-profit, limited-liability company. The legal entity Fraunhofer Austria Research GmbH covers the Austrian activities of two Fraunhofer Institutes in two separate units: the Production Management and Logistics unit in Vienna and the Visual Computing unit in Graz. Based on the entity's provisional financial statements for 2013, Fraunhofer Austria's operating budget amounted to €2.9 million, with project revenues totaling €2.1 million.

Together with the Trade Association of South Tyrol, the Fraunhofer-Gesellschaft established the non-profit subsidiary **Fraunhofer Italia Research Konsortial-GmbH** with headquarters in Bolzano in 2009. The Fraunhofer-Gesellschaft holds a 99-percent stake in this subsidiary, which functions as legal representative for the Fraunhofer centers located in Italy. They include the Fraunhofer Innovation Engineering Center IEC, which the government of the state of South Tyrol initially provided with base funding until 2013. It has already been decided to continue this base funding in 2014. On the basis of its provisional figures for 2013, Fraunhofer Italia generated revenues of €0.5 million with budgeted expenditure of €1.3 million.

Fraunhofer UK Research Ltd., a wholly owned subsidiary of the Fraunhofer-Gesellschaft headquartered in Glasgow, UK, was established in 2012. Together with the Fraunhofer Institute for Applied Solid State Physics IAF, it operates the Fraunhofer Centre for Applied Photonics CAP in close cooperation with the University of Strathclyde in Glasgow. Fraunhofer UK's provisional budgeted expenditure amounted to €2.0 million in 2013, with provisional project revenues totaling €0.2 million.

Three further international subsidiaries take the legal form of an association or foundation.

Domiciled in Santiago de Chile, the **Fundación Fraunhofer Chile Research** was set up in 2010 with the Fraunhofer-Gesellschaft as its sole owner and operates as a non-profit foundation. Under the auspices of the foundation, the R&D unit of the Center for Systems Biotechnology CSB was officially opened on December 24, 2010 in cooperation with the Fraunhofer Institute for Molecular Biology and Applied Ecology IME. Based on provisional figures, Fraunhofer Chile's budgeted expenditure in 2013 amounted to €3.6 million.

The **Associação Fraunhofer Portugal Research** is located in Porto and was set up in 2008 as an association under Portuguese law, with the Fraunhofer-Gesellschaft and the German-Portuguese chamber of foreign trade acting as its founding members. The Fraunhofer Center for Assistive Information and Communication Solutions AICOS currently operates under the umbrella of the association. Fraunhofer Portugal's budgeted expenditure in 2013 came to €2.4 million, while project revenues totaled €1.3 million (both provisional figures).

In conjunction with Chalmers University in Gothenburg, Sweden, Fraunhofer founded the **Stiftelsen Fraunhofer-Chalmers Centrum för Industrimatematik** in 2001, a non-profit foundation under Swedish law. Fraunhofer and Chalmers University have equal voting rights on the foundation's board of trustees. In cooperation with the Fraunhofer Institute for Industrial Mathematics ITWM, the foundation established the Fraunhofer-Chalmers Research Centre for Industrial Mathematics FCC. The foundation's budgeted expenditure in 2013 came in at €4.3 million (provisional figure).

In addition to its international activities, the Fraunhofer-Gesellschaft takes an active interest in its spin-offs, taking minority stakes in them for a variety of different reasons.

The establishment of spin-offs is a very important avenue for the Fraunhofer-Gesellschaft to exploit its industrial property rights. The Fraunhofer Venture department typically provides support to the founders during the preparation phase of the spin-off and contributes its know-how; in return, the Fraunhofer-Gesellschaft receives a minority stake in the equity of the fledgling company. As well as generating returns from the transfer of technology, spin-offs also help promote entrepreneurial thinking and the establishment of cooperative networks with businesses operating in the same sphere as the respective

Fraunhofer Institutes. Moreover, spin-offs are of great economic benefit to the national economy in that they lead to the creation of new jobs and enhance Germany's competitiveness through product innovation. In 2013, the Fraunhofer-Gesellschaft provided support for 33 new spin-off projects, and 7 companies were spun off in the course of the year.

Since its support program for spin-offs, known as "FFE – Fraunhofer Fosters Entrepreneurship," was first launched, Fraunhofer has helped 104 teams start up their own companies. In 2013, funds totaling €1.7 million were granted to 12 new projects. Overall, the Fraunhofer-Gesellschaft expects the positive trend in its spin-off activities to continue in the medium term.

The "FFM – Fraunhofer Fosters Management" program, which was transformed into a spin-off support measure in 2012, kicked off in 2013 by providing support for four equity investments. The goal of the program is to strengthen the management skills of the new executives and guide them through the highly critical early phase of their business.

August 2013 marked the start of "FFI – Fraunhofer Fosters Ideas," a three-year research project sponsored by the German Federal Ministry of Education and Research. A toolbox of different measures and methods is designed to enhance the spirit of innovation at the Fraunhofer Institutes, encourage start-ups and improve entrepreneurial activities. The FFI program focuses in particular on achieving ideal conditions for developing new ideas and creating a space in which the development of innovations can be driven forward outside the context of ordinary project work.

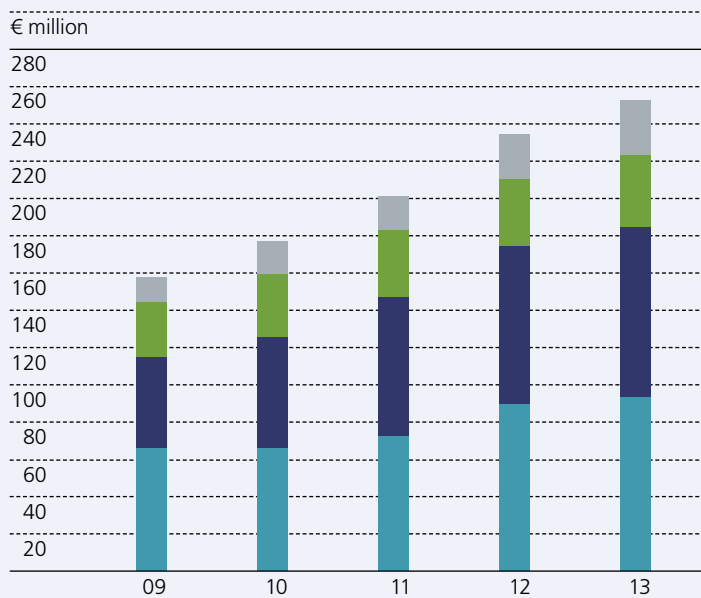
International activities

- Ongoing growth in international revenues
- Biggest increases in revenues in Asia
- Continuing expansion of international partnerships

Ongoing globalization has made not only sales markets more international, but also the supply chains of German companies, while international networks are giving rise to new knowledge and innovations. The Fraunhofer Institutes, too, have been gradually expanding their role as key drivers of innovation worldwide. The Fraunhofer brand has raised its international profile, and research services from Fraunhofer are in demand around the world.

The utilitarian purpose of Fraunhofer's international activities is to engage in scientific projects that generate added value for Germany and Europe. In 2013, revenue (excluding license-fee income) generated together with international partners reached a total of €250 million. That figure includes €21 million in revenue earned by Fraunhofer's international subsidiaries in partnerships with third parties. Overall, the Fraunhofer-Gesellschaft succeeded in growing its international revenues by more than 7 percent.

Revenue from work with international customers and partners 2009–2013



	2009	2010	2011	2012	2013
Asia	13	17	18	24	29
North and South America	29	33	35	35	38
European countries	48	59	74	84	90
European Commission	65	65	71	88	92
Other countries	1	1	2	2	1
= International revenue in € million	156	175	200	233	250

International revenue generated in Europe grew by 6 percent in 2013 to a total of €182 million. Almost €90 million of that figure was accounted for by revenue from customers in European countries other than Germany, which rose by 7 percent. With total revenues of €14 million, Austria was the most important European market for Fraunhofer outside Germany, followed by the Netherlands with almost €13 million in revenues and Switzerland with just under €12 million. Above and beyond that, the European Commission is an important source of public-sector funding for Fraunhofer research projects. Funds from its R&D Framework Program reached €92 million, up €4 million year on year. In the European Research Ranking, an assessment carried out on the basis of figures published by the European Commission, Fraunhofer has been ranked the most successful German participant in EU-funded research programs in three categories – “Funding & Projects,” “Networking” and “Diversity” – every year since 2007. The strategic networking of the Fraunhofer Institutes and Fraunhofer Groups with the Directorates-General of the European Commission will be further reinforced by the appointment of three new National Expert Representatives from the ranks of the Fraunhofer-Gesellschaft. Their job is to disseminate Fraunhofer expertise at the European Commission and, in turn, act as a conduit for the transfer of specific EU knowledge to the Fraunhofer Institutes.

Through projects in North and South America, Fraunhofer increased its revenues in 2013 by almost 8 percent to €38 million. It generated revenue of €32 million in the U.S. alone, €17 million of which was accounted for by its subsidiary Fraunhofer USA. With total revenues of €3 million, Brazil constitutes Fraunhofer's most important market in South America.

In Asia, Fraunhofer earned revenues of €29 million, up by an outstanding 19 percent year on year. Japan is the clear leader in Asia, generating total revenues of €12 million for Fraunhofer. China follows with €6 million, and South Korea with €5 million.

France, Germany's most important economic partner in Europe, is also among the countries with which Fraunhofer has its closest project partnerships. Revenues earned in France amounted to €9 million in 2013. Alongside contract research for French businesses, collaboration with France in the scientific field was again expanded in 2013. The Fraunhofer Institute for Solar Energy Systems ISE is strengthening its strategic collaboration with CEA Tech as part of the ICON program and setting up a joint virtual lab for ultra-efficient photovoltaics. Fraunhofer's successful collaboration with this excellent and highly innovative partner is based on the Carnot project SOLARBOND, which was honored with the Franco-German Business Award in 2011 as an outstanding example of the “Programme Inter Carnot Fraunhofer (PICF)”. In 2013, the partnership between Fraunhofer ISE, CEA LETI and Soitec succeeded in setting a new world record for converting sunlight into electrical energy, with a conversion efficiency of 44.7 percent. With the new virtual lab, Fraunhofer now has an opportunity to drive forward the development of new approaches to photovoltaics and to tackle, in a unique and efficient manner, the challenges posed by the photovoltaic market in unison with an exceptional partner offering complementary expertise.

The new **Fraunhofer Center for Energy Innovation CEI**, which went into operation in 2013, is a valuable addition to Fraunhofer USA's portfolio. Functioning as a branch of the Fraunhofer Institute for Ceramic Technologies and Systems IKTS, this new center is located on the campus of the University of Connecticut (UConn) and will focus on research into fuel cells and technologies for storing and distributing energy. Work at the center will be closely coordinated with the

Fraunhofer Center for Sustainable Energy Systems CSE. The state of Connecticut has undertaken to co-finance the center for a four-year period, while the university will make non-cash contributions.

The Fundación Fraunhofer Chile Research has expanded, too, opening another center. Following a successful application in 2013, the new **International Center of Excellence for Solar Energy ICESE** – the idea for which was proposed by the Fraunhofer Institute for Solar Energy Systems ISE – will go into operation in the first half of 2014. Chilean funding agency CORFO will provide the ICESE with US\$8.5 million in funds over an eight-year period. This collaboration between German and Chilean scientists covers research into concentrator photovoltaics (CPV), concentrated solar power (CSP), including heat storage, solar process heat and energy efficiency in the mining sector, solar-powered water treatment and desalination as well as electrical grids and economic system analyses.

In late 2012, the **Fraunhofer Center for Assistive Information and Communication Solutions AICOS** in Portugal received a positive assessment from a panel of German and international experts from industry, science and the public sector. The center was particularly commended for the high levels of professionalism and “Fraunhofer mindset” of its employees, and for the added value it offers its industrial customers in Germany and Portugal. The center’s R&D portfolio is geared to the future and coincides to a large degree with the prospective development needs of the German industrial enterprises that participated in the assessment (Deutsche Telekom, SAP). In April 2013, the Fraunhofer Executive Board resolved to continue activities at the center for a further five years, after which time another assessment will be carried out. The research conducted at Fraunhofer AICOS focuses on applications for Ambient Assisted Living and ICT for Developing Countries (ICT4D). Portugal offers ideal conditions for this type of research and for the field testing of innovative solutions, partly

due to the wide acceptance of IT among the general population, where many people – particularly the elderly – have only restricted access to local support, and also due to its close ties with Africa. 2013 was the most successful year to date for Fraunhofer AICOS, which succeeded in achieving all its KPI targets despite the still weak economic environment.

Strategic development and outlook

- Internal programs – a key tool in managing the R&D portfolio
- Integrating and establishing new institutions
- Setting up national centers of excellence
- Clear principles for internationalization
- Establishment of the new board function “Technology Marketing and Business Models”

The **Fraunhofer-Gesellschaft’s R&D portfolio** is generally the result of the individual institutes’ quality-tested strategic planning. In its role as a centralized coordinating body, the Executive Board influences the composition of the portfolio as well, e.g. by appointing new institute directors or by establishing or integrating new institutions in the Fraunhofer-Gesellschaft. Above and beyond that, the Executive Board also has at its disposal the instrument of internal programs. These can be used to promote particular research topics and encourage the institutes to compete against each other to acquire additional funds. Overall, around 10 percent of base funding is allocated via this mechanism. Fraunhofer’s internal programs pursue different strategic objectives, for instance collaboration between the institutes for the joint development of new business areas, support for SMEs through market-oriented research, or the promotion of creative new ideas that harbor a high risk. Sometimes the institutes themselves put forward ideas; sometimes the Executive Board sets the agenda. The transferability of ideas between programs is also ensured: once a creative idea has proved its worth in one program and has received a positive assessment, it can continue being developed as part of another program.

Lead projects are a new tool developed in 2013. Their purpose is to drive forward specific topics considered urgent from a social standpoint. For example, “E³ Production” is a lead project that addresses one of the key guarantors of growth and prosperity in Germany’s industrial production. From 2014

onward, the new “Discover” program will promote original ideas with a high scientific risk and short-term implementation horizon. Short project terms, rapid evaluations and multiple requests for proposals per year are all designed to stimulate the discussion of innovative ideas and new areas of business across Fraunhofer as a whole.

In addition to the organic growth achieved by its institutes in 2013, Fraunhofer also expanded its R&D portfolio by **integrating existing research institutions and setting up new ones**, its aim being to continue offering industry research services of the highest caliber. The new units enable Fraunhofer to expand into selected research areas with outstanding future potential.

In fall 2013, the Bremer Energie Institut (BEI) was integrated into the portfolio of the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM. This new department focuses on the scientific analysis of energy systems and also serves to enhance the institute’s collaboration with the University of Bremen and Jacobs University Bremen. After an integration phase that concluded with a positive assessment, the Fraunhofer Institute for Medical Image Computing MEVIS was included in the joint system of funding organized by the federal and *Länder* governments. What is more, in 2013 ten Fraunhofer project groups and the Kassel branch of the Fraunhofer Institute for Wind Energy and Energy System Technology IWES were given a positive evaluation and earmarked for full integration into the Fraunhofer-Gesellschaft in the long term.

In the *Land* of Rhineland-Palatinate, Fraunhofer incorporated the Mainz Institute of Microtechnology GmbH (IMM). The IMM employs around 170 people and has made a name for itself internationally as a provider of research services. Through the development of chemical and biochemical analytical systems, it bridges the gap between basic research and practical applica-

tions. For the duration of its five-year integration period, the unit will be operated as a branch of the Fraunhofer Institute for Chemical Technology ICT.

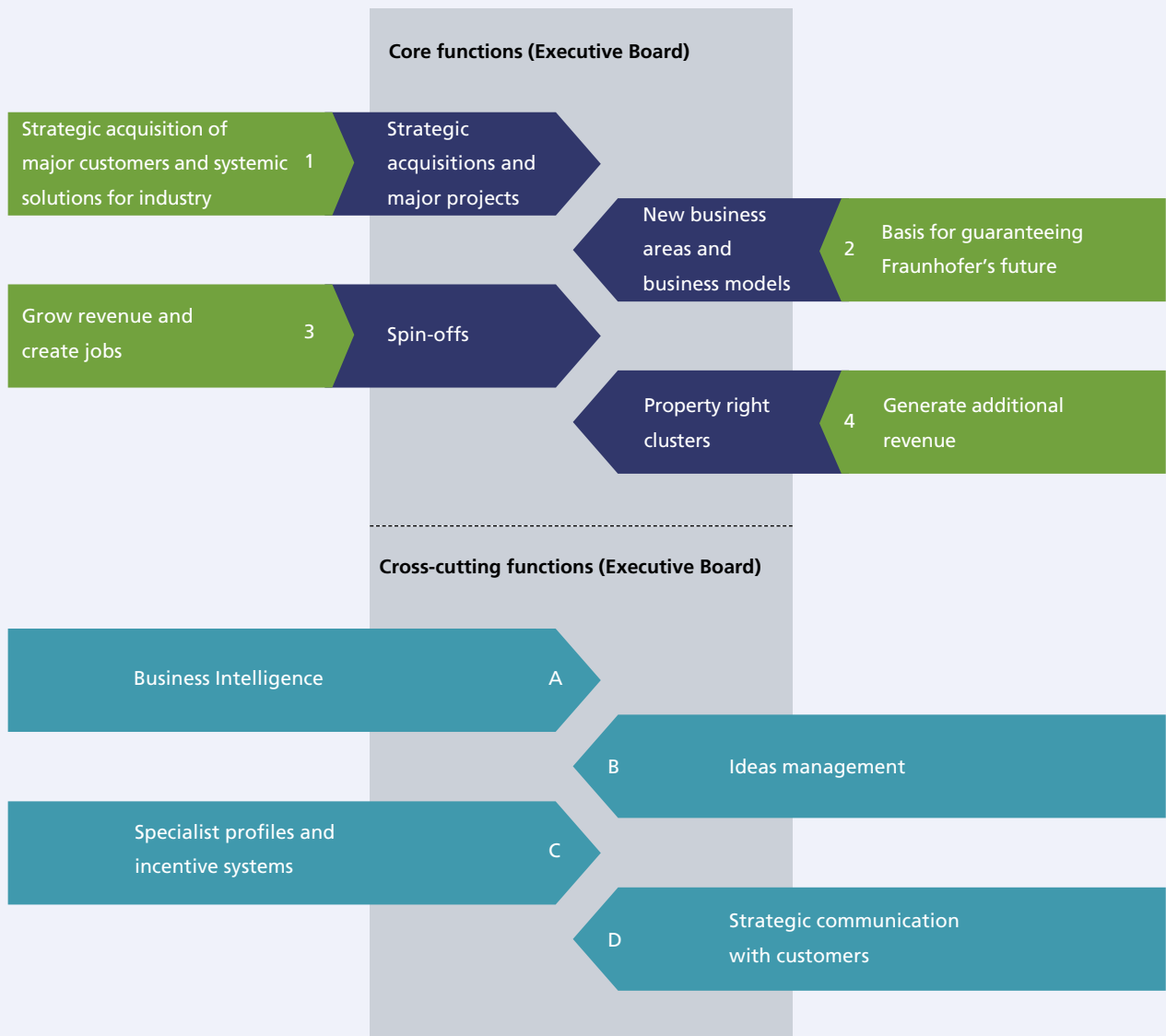
Following a positive assessment, the Fraunhofer-Gesellschaft also granted the Fraunhofer Research Institution for Applied and Integrated Security AISEC the status of an independent institute in December 2013. With this move, Fraunhofer is demonstrating its responsibility toward society and reinforcing its role as a pioneer of applied IT security research, a field that is essential to Germany's position as an industrial hub. What is more, four innovation clusters—among them the “Next Generation ID” cluster recently established in the Berlin-Brandenburg region—are systematically addressing the topic of IT security.

At the moment, **cyber security and data protection** are hotly debated subjects in the public arena. Information technologies influence and indeed control people's lives in both obvious and hidden ways, which is why the security and reliability of these systems have such a high priority. After all, both private and commercial data have become an attractive target for criminals and, sometimes, for agencies in other countries. Strong protective measures against systematic industrial espionage are vital to the survival of Germany's high-tech industry and, especially, its SMEs (Mittelstand). Companies that make use of cloud computing for their data processing need to be able to rely on that data being processed in a proper and secure manner. In recent years, Fraunhofer has expanded its core competencies in this business area to quite a considerable extent and is now in a position to cope with the expected rise in demand for corresponding development services. Fraunhofer experts summarized their recommendations for keeping Germany a strong IT nation in a position paper, which was presented by Prof. Dr. Reimund Neugebauer to Dr. Johanna Wanka, the German Federal Minister of Education and Research, and to Dr. Thomas de Maizière, the German Federal Minister of the Interior, at the CeBIT 2014 trade fair.

Going forward, Fraunhofer aspires to establish partnerships of a new quality and intensity within **National High Performance Centers**. Universities represent Fraunhofer's key point of contact within the academic community, and the organization typically appoints the directors of its institutes in conjunction with a parallel appointment at a partner university. Mirroring this relationship, the collaboration between university chair and Fraunhofer Institute is like a single coin, with each side addressing different aspects of the same issue. As a high-profile driving force at the interface between science and business, Fraunhofer offers to redouble its efforts, in collaboration with partner universities, to make the sustainable growth of outstanding research hubs a reality.

A strong university as the core, a vigorous Fraunhofer presence at local level and the integration of additional research partners from outside the academic world all make for an integrated hub approach and for a thematic profile that is not only unique in Germany and abroad, but that functions as a beacon. The particular expertise of each partner is drawn on—uniting excellent research and teaching with basic and further training and a closely knit business/knowledge-transfer network to create a high-performance innovation engine. The basis for establishing a center of excellence is a “roadmap” of binding measures developed together with the university and relevant government agencies. The measures set down in the roadmap focus on a particular topic for which expertise has already been built up at the location in question.

**Recommendations for the strategic orientation of the new board function
"Technology Marketing and Business Models"**



International partnerships with top-class researchers and innovative companies from all over the world serve as a benchmark for Fraunhofer's own ability to perform, and constitute a key factor in boosting its innovative strength and ability to survive in the future. Fraunhofer seeks to collaborate with the world's best in order to come up with innovative answers and future-proof solutions to global challenges. Esteemed and sought after by partners from across the globe, Fraunhofer is well placed to drive forward its international activities in the coming years in a targeted, results-oriented manner.

The Fraunhofer-Gesellschaft's internationalization strategy – which was formulated in 2013 and bears the title **"Research in the context of international competition"** – follows clearly defined principles. The objective of the organization's international research activities is to achieve an efficient exchange of knowledge that is to the mutual benefit of the parties involved and enhances the competitiveness of Germany and its partner countries alike. The European Research Area (ERA) represents the central focus of Fraunhofer's activities abroad.

To ensure that Fraunhofer's international research activities remain clearly focused in scientific, economic and regional terms, it is vital that specific research markets and scientific partners be subjected to a thorough assessment. The specialists in the Fraunhofer Institutes and Fraunhofer Groups are responsible for making such assessments, which are complemented by overarching analyses, e.g. of the innovative strength of potential target countries and their links with German business. Factors of increasing interest in this regard include not only the current strength of a country but also its rate of economic growth. Markets with future potential for German industry are often to be found in emerging economies and sometimes even in developing nations.

Fraunhofer has developed sophisticated tools and internal guidelines to help ensure the long-term success of its international research activities. All these activities are monitored for quality and the outcomes evaluated on a continuous basis. International research partnerships achieve lasting success when complementary expertise creates added value for both partners and produces work of new scientific value.

There is increasing demand from industrial customers for complex system solutions that individual Fraunhofer Institutes are unable to produce on their own. In response to this trend, Fraunhofer established the new Executive Board function **Technology Marketing and Business Models** in April 2014. The new area focuses on the economic sustainability that can be achieved by means of new exploitation and acquisition strategies. Its key areas of responsibility include strategic acquisitions and large-scale projects, new business areas and business models, spin-offs and cross-institute property right clusters. It is also responsible for the cross-cutting function of business intelligence, which covers data and studies on trend-spotting and acquisitions, ideas management, specialist profiles and incentive systems as well as strategic communication with customers.

Fraunhofer expects that the new board-level function will open up additional opportunities to win large-scale projects that require the participation of more than one institute. Activities already launched include the centralized management of customer inquiries and the coordination of topics via the Fraunhofer Alliances. The internal rules governing collaborative projects involving multiple institutes are being reviewed and revised. By taking a top-level approach, we also intend to tap synergies between Fraunhofer's exploitation activities in the area of spin-offs, on the one hand, and property right clusters, on the other.

Fraunhofer was able to secure Prof. Dr.-Ing. Alexander Verl as senior vice president with responsibility for the new Executive Board function. Alexander Verl has a Ph. D. in electrical engineering and has been director of the Institute for Control Engineering of Machine Tools and Manufacturing Units (ISW) at the University of Stuttgart since 2005. Since 2006, he has also been director of the Fraunhofer Institute for Manufacturing Engineering and Automation IPA. Prior to that, for eight years he was managing director and partner at AMATEC Robotics GmbH.

In line with Fraunhofer's intention to step up its contract acquisition efforts, the organization is also in the process of developing a structured **fund-raising strategy** with a view to obtaining additional funds that it can use to finance research projects. A comparison with other players in the R&D market reveals that Fraunhofer is yet to fully exploit its potential as regards private donations and financial contributions of a similar nature.

The **Fraunhofer-Zukunftsstiftung** (Fraunhofer Future Foundation) is already a valuable channel for funding pre-competitive research projects. Its objective is to provide long-term funding for selected projects of the Fraunhofer-Gesellschaft in order to create valuable intellectual property that has the potential to generate income, whether through license fees or sales. In July 2013, the German Council of Science and Humanities gave the Foundation a positive appraisal, stating that it was a useful addition to the funding options in place and recommending it be maintained in the long term.

The Fraunhofer-Gesellschaft takes a proactive approach to its responsibility for the future and to requirements as regards **sustainable management**. That includes not only an intensive internal focus on sustainability (in research, human resources, building, etc.), but also the systematic implementation of the goals it sets itself. A sustainability report is the established tool for depicting an organization's various strategies for sustainable corporate management. Fraunhofer will present its first such report for the year 2013. Preparatory to publication of the report, intensive discussions will be held, centering in particular around the question of which specific areas should be examined in order to evaluate Fraunhofer's contribution to sustainable development. These include not only the results of our research and our HR policy, but equally our role as an applied research organization within the overall research community.

Fraunhofer's overarching objective for the future is to enhance excellence in applied research in an alliance with the academic and business communities for the benefit of society in Germany and the rest of Europe. Fraunhofer is well placed to solve problems in the field of applied science. One important challenge that Fraunhofer faces is to manage growth – both in terms of funding and research content – with a business volume that has now surpassed €2 billion. As for research content, considerable potential lies in the exploitation of collaborative structures with national research partners, primarily universities.

In terms of funding, our growth will be driven by two factors – on the one hand, by increasing demand for applied research and development from both business and the public sector, on the other, by the base funding provided through our reliable partnership with the federal and *Länder* governments. Fraunhofer is optimistic that the providers of funds will continue to support the ongoing growth of the Fraunhofer-Gesellschaft in order to enhance the German economy's international competitiveness.

Given the current level of contracts – and on condition that general economic trends remain stable – we expect our industrial revenue to increase marginally in 2014. We also anticipate a substantial increase in public-sector revenue through projects funded by the federal and *Länder* governments and the European Commission. All in all, this will enable Fraunhofer to remain on its established growth trajectory in 2014.

The Executive Board would like to thank the organization's members, patrons, friends and, most of all, its staff for their support and dedicated work during 2013.

Fraunhofer-Gesellschaft zur Förderung der angewandten
Forschung e. V.

The Executive Board

Prof. Dr.-Ing. Reimund Neugebauer

Prof. (Univ. Stellenbosch) Dr. rer. pol. Alfred Gossner

Prof. Dr. rer. publ. ass. iur. Alexander Kurz

REPORT OF THE SENATE ON THE FINANCIAL YEAR 2013

The 2013 financial year was characterized by moderate growth in the German economy, fueled mainly by domestic demand. The Fraunhofer-Gesellschaft remained highly successful in its role as an important and attractive innovation partner for business. As a result, it too was able to post strong growth in 2013, with total business volume surpassing €2 billion for the first time. The Fraunhofer-Gesellschaft's positive financial statements for 2013 again received an unqualified audit certificate from the independent auditors.

In 2013, the Senate fulfilled the tasks it is charged with under the statutes of the Fraunhofer-Gesellschaft. It convened twice in the course of the financial year, at the Hannover Congress Centrum on June 10, and in the Fraunhofer Forum in Berlin on October 16.

The main decisions taken in accordance with the statutes concerned the Fraunhofer-Gesellschaft's structure as well as matters related to human resources and the Executive Board.

- The Senate decided to make the Fraunhofer Institute for Transportation and Infrastructure Systems IVI, previously a branch of the Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB, an independent institute under the leadership of Prof. Dr.-Ing. Matthias Klingner with effect from January 1, 2014.
- The Senate approved the guideline on "Implementation of the provisions of Section 4 of the Academic Freedom Act at the Fraunhofer-Gesellschaft". The Senate further approved application of the "Principles for special payments at the Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V." in the version effective as from January 1, 2013. These principles are designed to make it easier for Fraunhofer to offer competitive remuneration, to fend off attempts by German business and from abroad to headhunt employees, and to grant it more scope in countering the dwindling availability of qualified staff.

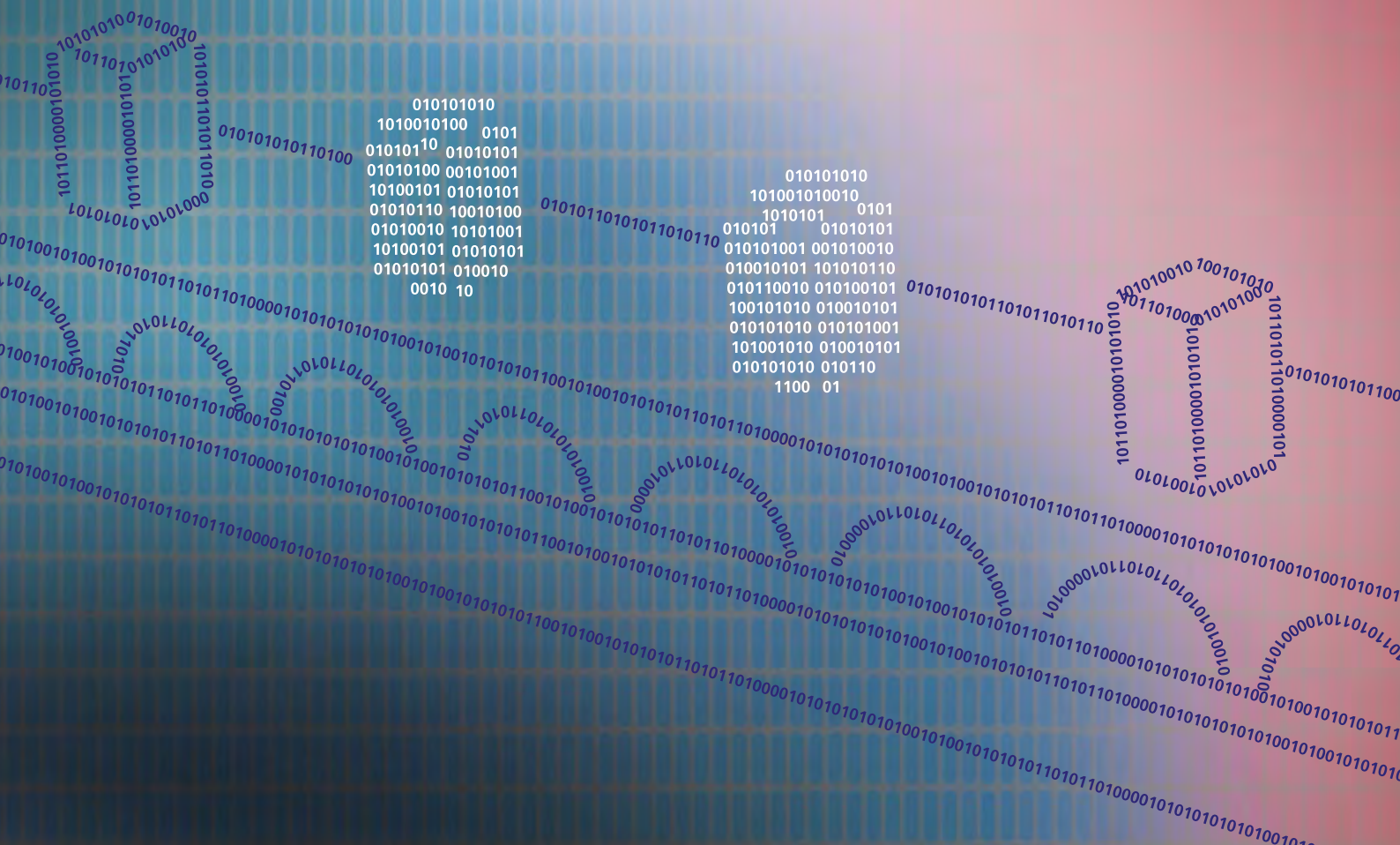


- The Senate approved the “Principles for the application of the federal system of professorial remuneration at the Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V.” in the version valid as from January 1, 2013, as well as the provisions passed by the German Federal Ministry of Education and Research in this regard.
- On May 31, 2013, Prof. Dr. rer. nat. Ulrich Buller stepped down from the Executive Board at the end of his term of office and retired. He had been Senior Vice President Research Planning since June 1, 2006. Ulrich Buller carried out his management duties with a high degree of expertise and empathy, and the Senate wishes to express its gratitude to him for his outstanding dedication.
- The Senate unanimously elected Prof. Dr.-Ing. Dr. h. c. mult. Alexander Verl to the Executive Board to lead the newly created function of Technology Marketing and Business Models for the period from April 1, 2014 through March 31, 2019.

The Senate takes this opportunity to thank the entire staff of the Fraunhofer-Gesellschaft for their commitment and their successful work in the financial year 2013.

Prof. Dr.-Ing. Ekkehard D. Schulz
Chair of the Senate of the Fraunhofer-Gesellschaft

REVIEW OF FRAUNHOFER RESEARCH



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INNOVATION REQUIRES INFORMATION

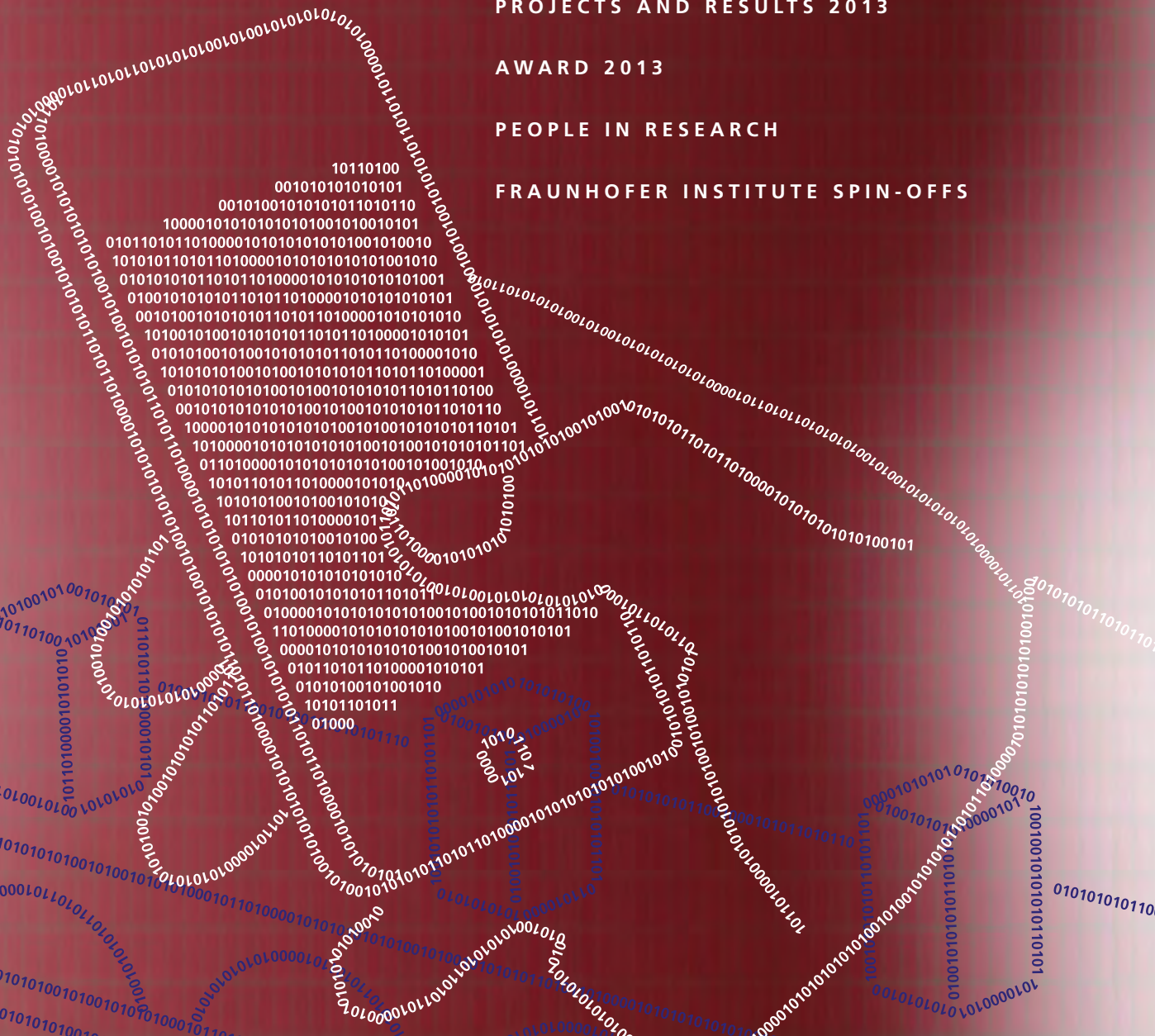
INNOVATIVE I.T. IS REVOLUTIONIZING
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FRAUNHOFER INSTITUTE SPIN-OFFS



INNOVATION REQUIRES INFORMATION

What is information?

A simple question on the face of it, since we all have an intuitive feel for what information is. Messages, user guides, videos, conversations, books, data stored on a hard drive – these are all things we would recognize as information in its broader sense. Information helps us, educates us, drives us, entertains us, gives us the opportunity to make things happen: when we absorb it, it changes something inside us. And that is something reflected in the most basic definition of what characterizes information: the ability to bring about change in the recipient system.

If the definition of information is multifaceted, so too is the importance we attach to it. Advertisers care about their commercials, journalists about news stories, politicians about their speeches and engineers about construction data.

How is information created, and why?

If you look at the common definition of information, it would not be far-fetched to conclude that creating and storing information is something that began with human civilization and has been developing unabated ever since – from the first primitive cuneiform inscriptions to today's Internet. And it's a valid statement – at least from a purely cultural perspective. Nevertheless, it is also true to say that organisms have been generating and storing information since the dawn of time, since without the genetic information stored in DNA there would be no life on Earth.

Each and every organism draws on information stored as part of a genetic code. With its four base pairs, the sequence of which maps out the genetic blueprint of whole living organisms, the simplicity of this code is reminiscent of the even simpler storage mechanism of the digital world, where each piece of information is contained within strings of 0s and 1s.

To see how important digital information is, just consider a computer without any programs or files – it would be completely useless. This is why computing centers and server farms back everything up several times over. Living systems behave in exactly the same way, with each individual cell containing the information for the entire organism – a redundancy in the storage system that offers increased protection against malfunctions. At the same time, this reduces the load on the central control system, since many metabolic processes can be overseen autonomously on a local level. These analogies go to show that there are important overlaps if complex information-driven systems are to remain in good working order over the long term – whether we are talking about a living being or a technical system.



What's the difference between data and information?

In daily speech, the terms “data” and “information” are often used interchangeably even though they have different meanings. The international technology standard defines data as “information set out in a usable form so that it can be interpreted and thus communicated, analyzed or processed”. Put simply, data is the raw material – and information the product that you obtain when you use and interpret it.

Take the example of data stored on an old floppy disk – the data is there, but if you don't have a drive to read the disk then it no longer contains any information. It's a similar story with the data found in the natural world – data that could not become information until human civilization developed the tools to do so. Fossils and geological strata are good examples of data that did not yield information until mankind discovered how to understand their significance. Today, we can even reconstruct the evolution of Earth's climate and extrapolate pointers about what we can expect for the future – and all this from the patterns left behind in this seemingly random data.

How is information preserved?

Information systems, then, are not so much something created by man as the basis of life itself. Nevertheless, the process of developing an information system outside of a living organism on the cultural level is still a relatively new phenomenon and has made a significant contribution to man's dominance of our planet.

Using the brain as a storage center for the information we acquire is a function that we share with many animals. Elephants, for example, have a particularly strong memory for places –

something on which they rely to relocate watering holes in dry areas. Many living things also have the capacity to process information relating to noise, language, optical signals or smells.

What sets our human culture apart is that humans began to bolster and develop these communication pathways – taking the decisive step of setting information down externally, multiplying it and communicating it. What began with cave paintings gradually developed into the printing press and finally today's Internet, in which anyone can communicate with anyone in real time and access the knowledge stored on the worldwide web.

Information as the basis for development

There seems to be no end to technological progress, and it's speeding up all the time. What makes it all possible?

Just look at nature: evolution can create new things, for instance through mutations that trigger a new development that gives the organism and its progeny a fundamental advantage. Progress is also often achieved by rearranging the information available, slightly modifying it and then examining it for its utility. A big advance might be comparable to developing a whole new technology, while small advances are what business would refer to as “Kaizen” or the “continuous improvement process (CIP)”. Small and large advances alike must be documented and evaluated in order to build on them and drive the improvement process forward.

Innovation requires information

This is just what Joseph von Fraunhofer did, keeping meticulous notes each time he melted glass: the materials he added, the technique he used and the result he obtained. This allowed him to achieve a quality of glass unrivalled at the time. Fraunhofer's methodical approach was the forerunner to many of today's simulation techniques used in the development of new materials and processes, except that his information technology consisted simply of pen and paper.

Today, developers almost invariably work with complex information technology, using design programs, powerful computers and the exchange of data in real time to aid and accelerate their work. Every research department and ambitious researcher makes the most of these tools in order to keep pace with the competition. But while we work more quickly and efficiently than Joseph von Fraunhofer, the development principle remains the same. We try out new ideas, document the results and learn from them so we can change the setup and try it again. Development is about evolution, a continual process of improvement that relies on information technology.

Does information technology bestow power?

Given that information is so important and given that it has become the basis of technological development, we are reminded of the words of the English philosopher Francis Bacon, who at the end of the 16th century came up with the maxim: "Knowledge is power." Since information technology stores, manages, multiplies and disseminates knowledge, it takes little imagination to conclude that the individual with the most information will be able to make the better decision.

For instance, if a farmer has a smartphone that warns him of an impending hailstorm, he has time to save his crop – while his smartphone-less neighbor reacts too late, if at all. Or take the more complex scenario of today's working groups, which these days are often purely virtual: their members can be scattered across the world, using digital media to communicate and collaborate on the design of their product, which is finally delivered in the form of a CAD model. It is an efficient method of collaboration that allows those with the requisite expertise to be brought together quickly, saving on office expenses and cost of travel. However, it is open only to participants that possess the required technology.

This goes to show that having access to information technology can bestow a decisive advantage. But it also highlights a problem: that of the digital divide. Not everyone has the money to buy a smartphone, and not everyone has access to an Internet connection or lives in a country with the capability to build up an effective IT infrastructure. And once an individual has been excluded from the maxim of "power through knowledge", either completely or in part, then that person is no longer able to change their situation. Assuring that each individual has access to information and knowledge is a pressing task for policy-makers who believe in sustainability.

How important is data security?

Knowledge can be very valuable. For instance, the information relating to a technological development is the result of a lot of investment capital and work. This data must be protected. If this is not done, then there is the risk that the information could be lost – and with it the proprietary knowledge and all the money spent to acquire it.

Safeguarding information is not an easy task. Data violation is something that can be observed in the natural world as well – which is why data technology draws on analogies echoing the vocabulary of naturalists. Biological viruses, for instance, infect host cells with a genetic sort of malware that makes them produce viral proteins. Often the virus is successful, at least for a certain time, and we come down with an illness such as the flu. However, there are ways to protect against the misuse of data. Take the 17-year cicada, for instance, which surfaces to reproduce exactly every 17 years. Any natural predator would have to imitate and align with this reproductive cycle to have the best chance of capturing its prey – and yet to this day, none of the cicada's natural enemies have been successful in cracking this prime number code.

As in nature, IT is a domain where data protection and data misuse are in constant competition. That is why continually working on data protection is equally as important as developing product and production data.

What can we learn from nature's systems?

There are some astonishing parallels to be drawn between biological and technological systems and the way they have evolved. Most important for us is the way information technology has proved to be the key to rapid progress in products and technology. As in nature's systems, information technology serves as a development tool, central control component and essential decentralized part of a product development or production process. Nature and technology are alike: innovation requires information.

Applied research needs to aim to make quantum technical leaps, as this could mean an advantage over the global competition for years to come. Nevertheless, a steady process of evolutionary development remains a common way to assure success on the marketplace.

Progress never stops, whether it's in technology or in nature. The moment a company stops developing is the moment it begins to fall behind the competition. And that is why it is so important for us – as an organization, as a country, as a region – to keep on investing in researching and developing technology. By consistently focusing on the practical applications of our research work, we will be able to remain ahead of the competition and assure our prosperity.



INNOVATIVE I.T. IS REVOLUTIONIZING INDUSTRY

Thomas Bauernhansl, Jürgen Beyerer, Michael ten Hompel



Innovative I.T. is revolutionizing industry

In Germany, the industry 4.0 initiative has become a driving force in business, research and politics, and other countries are watching these developments with interest. What exactly is industry 4.0? What's new about it? On what principles is it founded, and what technologies will we need to implement it? And, ultimately, how will it change the way we manufacture, work and do business?

One of the ways technological change manifests itself is in the development and introduction of autonomous cyber-physical systems (CPS). This includes "intelligent" machines and devices that have their own identity, communicate with one another and with their environment, configure themselves automatically, store information and, ultimately, will be able to manage themselves on a decentralized basis. These systems are destined to bring about a technological revolution in production and logistics, accompanied by a significant increase in productivity and all that means for the workforce. That is to say, they will change the way people and technology work together, and the way industry is managed.

Some of the technologies that today we refer to under the umbrella of industry 4.0 are not actually fundamentally new. The basic ideas have been around for some time, but it's only now that they are being brought together in a usable way, incorporated into an overarching concept and developed in line with the vision of a fourth industrial revolution. And in the case of many of these approaches, it is only today that we have the information and communication technology at our disposal to put the ideas into practice.

Industry 4.0 gets underway

Germany is in a particularly good starting position when it comes to software-intensive embedded systems – one of the critical enabling technologies for industry 4.0. This means equipping devices with integrated processors that are becoming increasingly networked thanks to Internet technologies. Many everyday devices and production tools rely on this sort of control. Information and communication technology is becoming more and more important at every level of industrial production, whether it's sensors, machine control, networked facilities or company-wide value chains.

What we need if we are to meet the increasingly stringent demands of production is ICT expertise coupled with product- and process-specific know-how. Engineers, computer scientists and automation specialists need to work closer together than they have to date, and learn to understand how each discipline operates. Only then will it be possible to exploit the considerable potential of industry 4.0 to its fullest extent.

One of the key aspects of industry 4.0 involves collecting the information contained within value creation processes and chains, making this information available in real time and in all places and then exploiting it in a consistent and coherent manner so as to become faster, better, safer and, ultimately, more economical. Random access calls for more than collecting all the relevant data and information and storing it somewhere. The key point is that the knowledge must be processed with consideration for user and usage requirements, and made readily available.

Another yardstick in the implementation of industry 4.0 is to ensure that production components from different manufacturers are interchangeable on both the device and software level so that they can work seamlessly alongside each other



(interoperability). This calls for common and, most importantly, standardized interfaces such as those being developed at the Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB. As the Internet of Things assumes a more prominent role in industrial production, the focus is on using Internet technology throughout the entire production process. This has given rise to a more decentralized approach to production planning and optimization, culminating in the development of self-organizing systems – an endeavor that calls for a common understanding of data and processes. Of course, the key requirements remain the same: systems must be safe, robust, reliable and capable of responding in real time.

Fraunhofer is currently working alongside industry to develop a reference model – a standard architecture for end-to-end processing that can be used to make industry 4.0 ideas a reality. The requirements are many, and translating that step by step into market-ready and industry 4.0 compatible products and systems will call for standardized terms, modelling languages, notation methods, standards and reference architectures across the board.

1 Industry 4.0 aims to make production technology more flexible, efficient and intuitive by drawing on information and communication technology.

Keeping people at the heart of production

Industry 4.0 isn't just about the technical side though and, as the key players in value creation, people remain at the heart of the concept. With their strengths and flaws, individual talents and abilities, industry 4.0 places people at the center of the action – providing them with new interaction, collaboration and safety technologies so that they can interact intuitively with their high-tech environment. This leaves people with the freedom to concentrate on their own tasks and ensures that human creativity, ingenuity and intuition will remain a crucial part of the production process in years to come.

Making sure that people are integrated smoothly and unconstrained into a substantially automated value creation chain is of particular importance. The range of solutions encompasses everything from innovative interfaces that allow operators to instruct machines directly to analysis of operators' actions so that they can be provided with context-sensitive assistance and interfaces adapted to match their particular needs.

Observing people and their patterns of behavior is usually the task of video-assisted sensors that can capture a lot of information about the visible environment. The Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB has come up with techniques that automatically register and identify people, deducing a person's activity from their posture and gestures. This means it is possible to use pointing and hand gestures to interact intuitively with individual machines or workpieces. For instance, workpiece errors can be flagged simply by pointing to the area in question, as Fraunhofer IOSB has demonstrated in a project for the automotive industry.

Innovative I.T. is revolutionizing industry

Personalized data optimizes processes. For instance, workers can use a tablet PC to view information tailored in line with their role, abilities and interests. Information can also be limited to the machine nearest to the worker, for instance an industrial robot without security fence.

Monitoring people using sensors allows for innovative operating concepts as well as dealing with safety issues. For instance, it is possible to determine if an employee is approaching a machine with due care. If it is deduced that they are not, the robot's movements are slowed down or modified instead of bringing production to a halt by initiating the emergency shutdown that would be required today. This is one way in which the information from sensors is used to make machines aware of humans and their intentions.

It is not viable for a single institute or company alone to develop industry 4.0 solutions for the factories of the future, especially if they are to be open rather than company-specific solutions. Partners from research and industry must work together to develop and test innovations, and new technologies need to be explained in an easily understandable manner in demonstration factories. That's why we need "living labs", where the public can come and see the opportunities and potential that new technologies offer.

How will our factories change?

In terms of production, industry 4.0 means bringing together decentralized intelligence in a network using smart objects – meaning the end of strictly horizontal and hierarchical control structures. New factory planning techniques based on digital models will enable energy and resource-efficient production: industry 4.0's primary goal.

Using and processing data within computing clouds on a decentralized basis will see the fragmented factory develop into the smart factory, with physical data immediately captured by sensors and made available through worldwide services. Results of analysis can be played back directly and so optimize the factory in real time with the help of smart actuators.

In this way, networking using digital communications technologies allows us to influence the physical world. This is done using multimodal human-machine interfaces, which can take the form of touch displays as well as voice or gesture control.

¹ Simple gestures such as finger-pointing tell the computer to flag an error in the component.



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revolutionizing industry





A factory that organizes itself ...

Cyber-physical systems organize themselves on a decentralized basis. In terms of companies' IT and control infrastructures, this means increased service orientation, a move away from hierarchical structures and a need for open standards. "Use it but do not own it" – that's the motto that has come to define many areas of our lives today, and will apply just as much to the digital factory. We will see service-oriented IT architectures find their way into all areas of industrial production, bringing with it the opportunity to develop apps for the value production process, for instance by planners, as well as the possibility of conducting simulations in real time. This calls for open standards, as only then can we harness all the efficiency advantages offered by the cloud.

... and is flexibly interlinked ...

The new method of production can be well illustrated with reference to the automotive industry. While today the steps for producing an automobile are rigidly set out along a production line, in the future production systems will be independent, fully flexible and highly integrated. Such a concept envisages assembly stations that are no longer rigidly interlinked and that are capable of both assembly and individual processing work such as painting. This combines defined production and assembly steps into process modules – and by combining many such process modules provides all the individual technologies needed to assemble the vehicle.

During production, the wheels are added at an early stage along with the appropriate control and communication technologies. This means that the chassis can roll itself to the individual stations to initiate further assembly – and without needing any propulsion technology or master computer to guide it. The result is a decentralized and extremely robust system that can react quickly to new developments.

Modules work at varying rates, and this is used to integrate scalable production steps into assembly. The vision of the barrier-free factory will soon become a reality as human-machine collaboration is intensively studied within large research projects such as those at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA and the Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB.

Fraunhofer IPA has developed a mobile helper for use in internal logistics – another example of a cyber-physical system. The mobile robot picks up pallets and transports them to assembly stations. The system is relatively simple to configure and can be used without a security barrier. The robot's 3D monitoring of its environment, ability to grip, loading space and a manipulator operable in all directions make it a highly flexible production helper. It is also able to help workers during assembly from the interior of the vehicle. After five stations of a specified duration the robot is sent back to the loading bay and the car moves on to the next process module according to its individual model.

1 Cellular transport units assume responsibility for internal logistics.

2 Special robot systems help workers with tricky assembly operations.

Innovative I.T. is revolutionizing industry

... and safe! For instance with the Virtual Fort Knox

Drawing on cloud technologies to bring together information technology and mechanical engineering through the intelligent, networked and secure use of data is the key to industry 4.0's smart factory. But first, users need to be sure that the sensitive data they share is as secure as the U.S. gold reserves held at the legendary Fort Knox. Fraunhofer IPA's Virtual Fort Knox (VFK), developed in collaboration with industry partners, is an intelligent, networked, scalable and secure platform for a community cloud that facilitates a host of new production business models.

Sprawling corporate structures, an aversion to change, and the difficulties these pose when introducing end-to-end IT solutions still cause problems for production in the smart factory, as IT infrastructures remain very heterogeneous. The federative VFK cloud platform is a chance for small and medium-sized enterprises to exploit the many possibilities of digital production tools flexibly, affordably and in line with their individual needs. High set-up costs are thus bypassed, removing one of the chief barriers to using digital tools in production. In developing the platform, project partners put particular emphasis on protecting sensitive company data.

The VFK security concept differentiates between various areas, including physical security, IT system availability and network, software, data and business security. Taking into account all these aspects builds acceptance and trust with the users – manufacturing companies or software manufacturers.

Logistics 4.0 moves the economy ...

Soon cyber-physical systems such as automated vehicles or smart containers will enter service as a microscopic part of the global logistics chain and use their cyber currency to bid for the resources of a global market. Dynamism is crucial to this sort of development, and the pace of development will determine which technologies and which new markets emerge.

In our economy, logistics governs transportation, and is responsible for efficiently directing and networking all the parties involved. More and more, it is also becoming responsible for managing flows of information. This brings new requirements:

- The ability to adapt: logistics systems have to strike a balance between flexibility and standardization. In the automotive industry, for instance, the range of models is growing and product lifecycles are becoming shorter just as efforts are being made to streamline processes across a growing number of production locations.
- Transparency: logistics systems must be transparent. Examples are the increasing demand for the traceability of food products and the information demanded by the global "green logistics" movement.
- Mastery of complexity: logistics networks are becoming more and more complex and dynamic within shorter and shorter periods of time. Social media and Internet shopping, coupled with same-day delivery and increased complications (weather, traffic, theft) mean that the complexity and dynamics of logistics is increasing at a breathtaking pace.
- Efficiency: traditionally, logistics systems have been under pressure to cut costs. At the same time, logistics operators have to be able to show how logistics add value.



... and leads to the Internet of Things and Services

The herculean task of managing global logistics networks efficiently demands a high level of decentralization and use of virtualization. Doing so will trigger a fourth industrial revolution and bring the Internet of Things and Services to logistics. Thanks to smart holders and containers such as the inBin from the Fraunhofer Institute for Material Flow and Logistics IML, in the future the flow of goods will be organized and overseen on a decentralized basis. inBins manage their own content and show human operators which parts need to be taken out at different points in the process. They also measure ambient temperature and connect with one another and with the Internet. And using their agent software, they can receive and manage orders themselves.

Getting things moving will see the use of cellular transport systems in the future. Imagine swarms of automated vehicles using laser scanners to monitor their surroundings and propelling themselves automatically to their destinations. The newest generation is even capable of driving into the storage rack, calling a lift and loading and unloading containers. At Fraunhofer IML, the 50 shuttles of the cellular transport system busily organized themselves like a colony of ants.

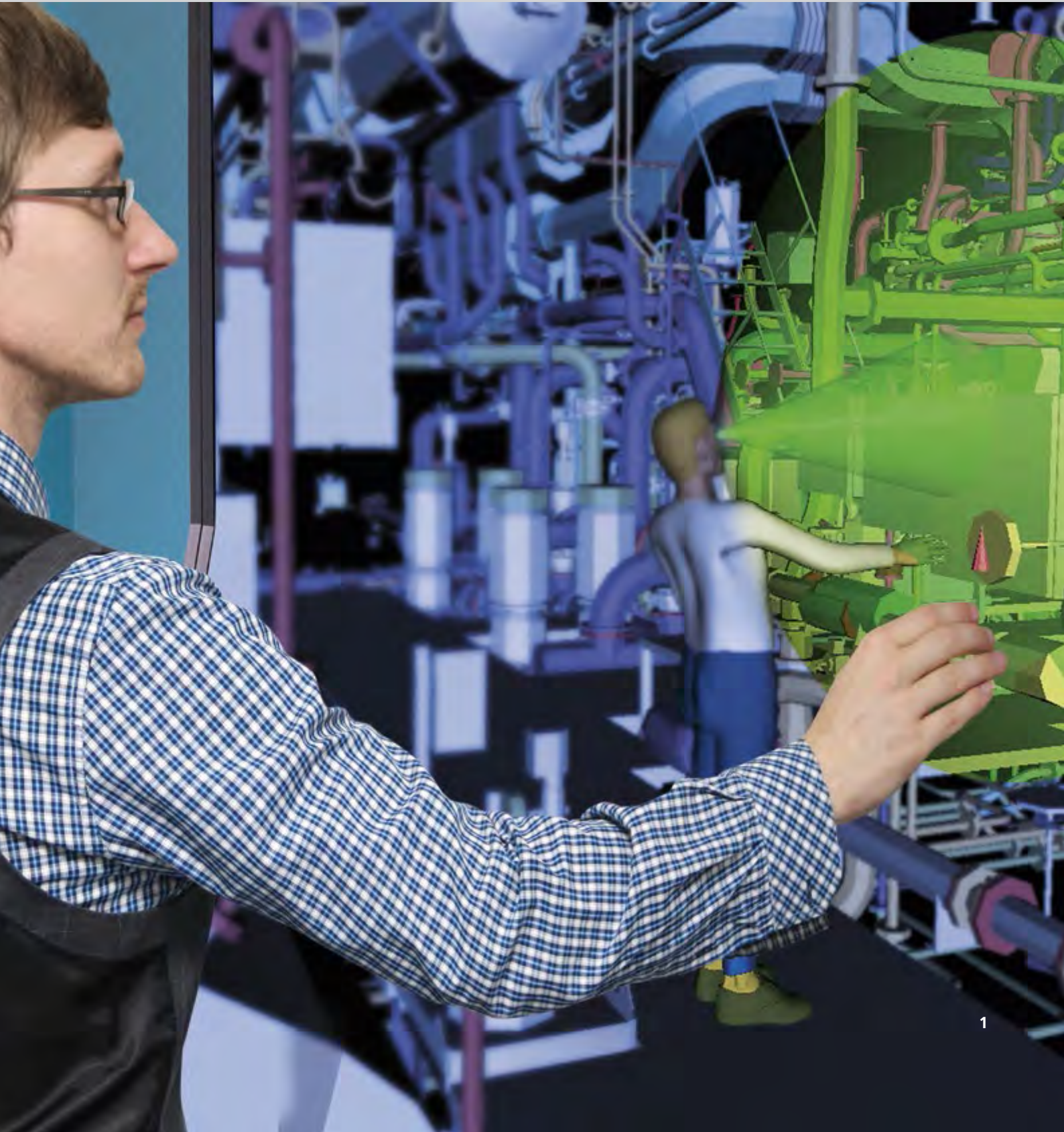
A rack acts as a virtual anthill and storage place for containers. In front of it are work stations served by the shuttles with materials from the containers. The shuttles agree how they are going to transport the items and construct "ant trails" to the respective destinations. They negotiate right of way and inform one another where they have encountered "colleagues" in order to determine the position of the swarm. Since each shuttle processes its information individually and finds its own path, the complexity of the system as a whole is spread across many virtual shoulders. If a disruption does occur, the swarm responds independently and order is soon restored.

All cyber-physical systems, including the inBin or cellular transport vehicles, network with one another and the Internet. An Internet of Things is formed.

Add this to coordination of the global flow of goods and you get an Internet of Services. Now researchers from the Fraunhofer Institute for Material Flow and Logistics IML and the Fraunhofer Institute for Software and Systems Engineering ISST have together developed the "Logistics mall" to illustrate the new world that comes with a network of networks. Here a sort of virtual mall offers the opportunity to buy logistical services such as transportation and storage and to join them with information services such as networking and data storage. The result is a new market of hybrid services that can be bought and administrated via the logistics mall.

¹ Smart containers known as inBins organize logistical tasks on a decentralized basis, supplying components and indicating what items need to be removed.

Innovative I.T. is
revolutionizing industry





2

To sum up: industry 4.0 is a great opportunity!

For production, the fourth industrial revolution really is all about the smart factory. This is the place where technologies from information and communication technology, machine tools and systems engineering all come together. In Germany, we are specialists in multi-variant series production. Industry 4.0 is the next step in ensuring even more variety while keeping productivity extremely high, producing in even smaller batches while getting the customer more involved in the production process. Since in Germany we bring disciplines together and work across institutions, production today is extremely well prepared for industry 4.0, and this is where we are seeing the systematic emergence of innovations with significant market value.

In logistics, the arrival of the fourth industrial revolution will see the smart containers and cellular transport systems that make up the Internet of Things connect with the Internet of Services. Logistics will be transformed, from the moment an order is placed online all the way to home delivery. For Germany as a production location, industry 4.0 presents the following significant challenges:

- maintaining Germany’s competitiveness as a high-wage production location
- establishing Germany as a leading market and leading provider of industry 4.0 technologies
- giving a more prominent role to resource and energy efficiency in industry and demonstrating why this needs to be a factor in planning
- finding solutions for the demographic changes with which we are confronted, and all that means in terms of adapting production workplaces to suit an aging workforce, e.g. through new solutions that enable intuitive interaction between humans and machines
- explaining the technological advantages and opportunities that industry 4.0 offers, thereby removing obstacles and reservations and kindling a new passion for technology.

The potential is there, with a possible increase in productivity of 30 percent. Reason enough for German industry to set its course for a fourth industrial revolution and so seek to assure its competitiveness on the global stage.

Prof. Dr.-Ing. Thomas Bauernhansl is the director of the Fraunhofer Institute for Manufacturing Engineering and Automation IPA.

Prof. Dr.-Ing. Jürgen Beyerer is the director of the Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB.

Prof. Dr. Michael ten Hompel is the executive director of the Fraunhofer Institute for Material Flow and Logistics IML.

1 Virtual reality systems help people guide and monitor production.

2 Equipped with a camera, the COASTER networks automatically, is simple to operate and comes with a host of functions that make it a tireless helper in the warehouse.



PROJECTS AND RESULTS 2013

HEALTH AND ENVIRONMENT

Joseph von Fraunhofer Prize Growing vaccines in plants 1

Vaccines are an essential part of our public health services. But one of the weak links in the present drug supply chain is that it takes from six to nine months to produce vaccines, using chicken eggs, and manufacturers do not have enough capacity to produce the quantity required to meet worldwide demand. Alternative methods based on bacterial, yeast, insect or mammalian cell cultures require huge technological investments and also involve long production times. Two Fraunhofer researchers in the USA, Professor Andre Sharon, executive director of the Fraunhofer Center for Manufacturing Innovation CMI, and Professor Vidadi Yusibov, executive director of the Fraunhofer Center for Molecular Biotechnology CMB, have developed a new approach in which therapeutic proteins are grown in plants. This offers numerous advantages: the risk of contamination by animal pathogens is eliminated, production time is short, and the process can be scaled to meet any demand. The required technological investments are reasonably low, making plant-based protein production a viable option for small and medium-sized businesses. The two researchers received the 2013 Joseph von Fraunhofer Prize for their fully automated process.



Hugo Geiger Prize

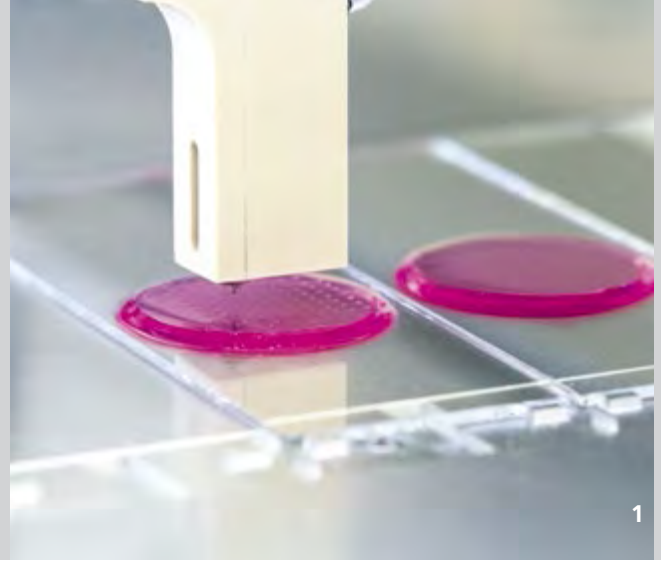
Using hops as food preservatives 2

Demand for fresh and minimally processed foods is growing, but these products have a greater tendency to spoil. This combined with stricter food safety regulations means there is a need for effective methods of preservation that also meet consumer acceptance criteria. Breweries have been using hops for centuries as a natural preservative in beer, and this prompted Dipl.-Ing. Andrea Hickisch of the Fraunhofer Institute for Process Engineering and Packaging IVV to investigate the antimicrobial properties of hop extracts. Her research revealed that lupulone, one of the beta acids present in hops, was the best candidate for this purpose because it has a more potent bacteriostatic effect and less bitter taste than other compounds. These findings open up a new avenue in the quest to provide consumers with "natural" fresh foods that are free of artificial preservatives. Andrea Hickisch received the 2013 Hugo Geiger Prize for her work on this project.

Fraunhofer Human-Centered Technology Prize

Cultivating stem cells for research 3

Stem cell research is one of the great hopes for medical progress. The methods used to cultivate these cells must comply with high quality standards. Currently, cell culture vessels have to be opened in order to manipulate the cells, but this increases the risk of contamination. An interdisciplinary research team has found a new way of growing stem cells that is significantly simpler and safer than previous processes. Dr. Kristina Lachmann and Dr. Michael Thomas of the Fraunhofer Institute for Surface Engineering and Thin Films IST, together with Dr. Kurt Dittmar and Dr. Werner Lindenmaier of the Helmholtz Centre for Infection Research, and Dr. Henk Garritsen from Braunschweig Municipal Hospital, have jointly developed an atmospheric-pressure plasma process that allows cells to be cultured on the inner surface of standard, medically approved plastic bags. Sterile tubes are used to inject the growth media and extract the cells. This labor-saving method thus also minimizes the risk of contamination. In recognition of this work, the researchers were awarded the 2013 Fraunhofer Human-Centered Technology Prize.



Hugo Geiger Prize

New avenues for biotechnology

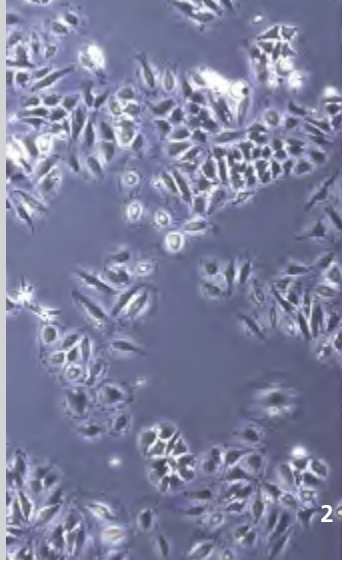
Proteins are essential components of all living organisms. By adding synthetic amino acids that do not occur in nature, it is possible to create entirely new proteins that could be of interest to medical scientists and industrial researchers in the field of biotechnology. Dipl.-Ing. Yannick Bantel of the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB employed this technique to expand the genetic code of *Candida albicans* with the unnatural amino acid p-azido-L-phenylalanine (AzF), for application in in-vivo binary protein interaction analyses. The results of this research provide a basis for potentially ground-breaking innovations leading to the next generation of biotechnology processes. The biologist was awarded the 2013 Hugo Geiger Prize 2013 for this work.

Organic inks for 3D tissue printing 1

The creation of artificial organs is one of the more ambitious goals of medical science. Researchers at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB have come one step closer to this goal by developing an organic ink made of components of the natural tissue matrix and living cells. They can control the chemical modification of the biological molecules to produce gels that imitate the properties of natural tissue, from solid cartilage to soft adipose tissue. Given the precision of this technique and its ability to handle very fine structures, the next challenge of producing vascularized tissue, i.e. tissue with its own system of blood vessels, would seem to be realistic goal.

What type of meat am I eating?

Consumers have become increasingly attentive to the source of imported food products, after several scandals involving false declarations of origin – even if there is no directly associated health risk. It is nevertheless true that the practices of the food production industry have become increasing complex and opaque. Researchers at the Fraunhofer Institute for Molecular Biology and Applied Ecology IME have developed a test capable of identifying 50 types of meat in food products in a single run. After only minimal preparation, patterns of DNA sequences can be identified that indicate the species of animal contained in meat samples. This provides rapid and unequivocal proof of the types of meat contained in industrial products. This information benefits not only the consumer and the retail trade but also the manufacturers who process the meat.



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High-tech targeting of tumors

One of the most important aims of cancer therapy is to locate and eliminate all malignant tumors as soon as possible. Fraunhofer researchers are providing a helping hand to oncologists by developing new tools that enable tumorous tissue to be distinguished from healthy or benign tissue, thus increasing the precision of surgical interventions. The project group for Automation in Medical Engineering and Bioengineering at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA has developed a multi-spectral fluorescence camera system for this purpose. Meanwhile, a team at the Fraunhofer Institute for Computer Graphics Research IGD is working together with project partners on the development of a novel system for automated segmentation of organs and structures within the head and neck region, based on tomography data, for use in radiation therapy. A task that usually requires several hours of manual post-processing by the clinician is thus reduced to a few minutes of computer time. Both solutions will lead to greatly simplified and more precisely targeted anti-tumor therapy.

Fighting cancer with nanoparticles 2 and 3

Chemotherapy can be a very effective weapon against cancer, but often has extensive side effects that impact the patient's entire body. The Fraunhofer Institute for Applied Polymer Research IAP is working on an advanced development project that promises relief. The chemotherapy drugs are encapsulated in nanoparticles that have detector molecules attached to their surface. These enable the particles to dock with specific cell receptors on the tumor, permitting a precisely targeted drug release. In-vitro tests have demonstrated that chemotherapy performed this way can be many times more efficient and less traumatic for the patient.



COMMUNICATION AND KNOWLEDGE

Joseph von Fraunhofer Prize

Boosting the performance of multicore processors

For many years, the performance of microprocessors has been on the rise thanks to the use of multicore technology. But the present industry standard for the development of parallel software, the Message Passing Interface (MPI), doesn't utilize the full potential of such systems. The Global Address Space Programming Interface (GPI) developed by Dr. Carsten Lojewski of the Fraunhofer Institute for Industrial Mathematics ITWM is a programming model based on a new technology that allows the parallel architecture of high-performance computers to be used with maximum efficiency. The new model was tested and evaluated by Rui Machado M. Sc., who also works at Fraunhofer ITWM, and Dr. Christian Simmendinger of T-Systems Solutions for Research GmbH. GPI is an end-to-end asynchronous communication model designed specifically for multicore processor environments. It is a fault-tolerant programming interface with the potential to revolutionize algorithmic development for high-performance software. The three researchers were awarded the 2013 Joseph von Fraunhofer Prize for their work.

Liberating 3D from viewing constraints 1

We have become accustomed to watching 3D movies, despite the inconvenience of having to wear special glasses. Researchers at the Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut, HHI have been working on improvements that will make it possible to enjoy 3D viewing at home and in public spaces – without glasses. Their latest invention is a new image processing technique that allows several people to view 3D images from different positions or angles without glasses and without any degradation of image resolution or depth of field. The algorithm can be integrated in various 3D display controllers – even those of previous generations.

Hugo Geiger Prize

Ultra-compact microscope

Multichannel micro-optical systems provide fascinating new possibilities and insights thanks to their compact build and wide visual field. As well as developing an integrated illumination module for ultra-compact microscopes, René Berlich M. Sc. of the Fraunhofer Institute for Applied Optics and Precision Engineering IOF also enhanced the design of this class of microscopes, enabling them to be used for the first time to study the spatial resolution of fluorescence signals. With their ultra-compact design, large image field, and low manufacturing costs, they can be employed in automated systems and lend themselves to other applications in the fields of safety engineering and materials science. The researcher received the 2013 Hugo Geiger Prize for this work.



3D in-car audio 2 and 3

The acoustics inside a car represent a major challenge for sound system engineers, because the listening environment is a small, confined space containing many different materials that reflect sound differently and is exposed to varying levels of background noise. The audio experts from the Fraunhofer Institute for Integrated Circuits IIS have developed a novel solution for this specific application: the Symphoria audio system, which allows users to enjoy music in three dimensions. It creates an impressive dimensionality and spaciousness which dissolves the geometry of the car, and reproduces the genuine richness of the music with ultimate precision for an unrivalled music experience. The revolutionary new 3D audio technology was unveiled to the public at the Consumer Electronics Show (CES) in Las Vegas in January 2013, installed in a concept car designed together with project partners Audi and Bang & Olufsen.

App improves cellphone audibility

Voice over IP is an ingenious technique that allows phone calls to be transmitted in real time and free of charge to any place in the world. But sometimes the quality of speech is less than ideal, and this is particularly trying for people who have physiological hearing problems. For them, researchers at the Fraunhofer Institute for Digital Media Technology IDMT have created AuditoryVoIP, an iPhone app that allows people with impaired hearing to optimally adapt cellphone audibility to their specific requirements. Its distinguishing feature is that the phone signal is adapted to each user's personal hearing capacity, rather than being optimized on the basis of a general technical standard.

New wireless data transmission record

Demand for data transmission capacity is steadily increasing, and researchers are constantly looking for new ways of improving the relevant technologies. With the support of colleagues at the Karlsruhe Institute of Technology (KIT), the Fraunhofer Institute for Applied Solid State Physics IAF has set a new record for wireless data transmission. Their record-breaking achievement involved transmitting data over a radio link at a rate of 40 gigabits per second over a distance of 40 meters, and at 24 gigabits per second over a distance of one kilometer. These data rates equal those of fiber-optic cables, demonstrating that radio relay systems are now a viable option for integration in high-speed optical networks.

More creative options for filmmakers

Once a scene has been shot on set, the cutting room remains the only place where the movie director can make changes to the final images. A new technology being developed by the Fraunhofer Institute for Integrated Circuits IIS provides much more scope for creative editing, even after the recorded scenes are in the can. The researchers' invention consists of an array of 16 cameras, each of which records a partial light field of the scene, enabling the perspective, framing and depth of field of the camera images to be modified after recording. It even allows virtual traveling shots to be created from recorded material.



SECURITY AND PREVENTION

Protecting apps against malware

IT experts consider that too little attention is being paid to smartphone security. For instance, freely downloadable apps may be infected with malicious software capable of stealing passwords and other confidential data. To provide protection against such malware attacks, researchers at the Fraunhofer Institute for Secure Information Technology SIT have developed the Appicaptor test framework, which works on all common smartphone platforms. It can compile white lists of secure applications and black lists of apps that represent a security risk. The system is continuously updated and adapted to new operating systems.

The end of the world has not yet come

An asteroid strike could change the face of our planet, and in the worst case even destroy it. The probability of such events is small, but nonetheless more than zero. One past example is the extinction of the dinosaurs, which is generally believed to be the result of a massive asteroid impact. As part of an EU-funded research project, the Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI is investigating ways in which a specially designed space probe could be used to knock an asteroid off its collision course with Earth. Their experiments showed that firing rockets at a large asteroid would only slightly modify its trajectory, but that this would suffice to avoid a collision with Earth if the probe was launched several years before the calculated date of impact.

Gloves change color to warn of danger 1

The hands are the part of the body most likely to come into contact with harmful substances. The risk is particularly high for lab or production workers who may be exposed to odorless or otherwise undetectable toxins. Researchers at the Fraunhofer Research Institution for Modular Solid State Technologies EMFT in Regensburg have developed a simple, fast-acting solution to this problem: gloves containing a special indicator dye. If the fabric comes into contact with a toxic substance – on its surface or in the air – it changes color to alert the wearer. Different indicator dyes can be used depending on the specific chemicals handled in the workplace.

Fish reveal presence of harmful chemicals

The adverse effects of hormonally active substances (also known as endocrine disruptors) have been a major issue in efforts to assess environmental risks associated with anthropogenic substances for the past two decades. In particular, the decline in fish populations is thought to be related to the presence of such chemicals in the water. The Fraunhofer Institute for Molecular Biology and Applied Ecology IME has established a toxicology test based on the life cycle of the zebra fish, and refined it for use in different types of study. The life cycle test allows data covering all relevant life history stages of the fish to be recorded within a relatively short period of time. The most important aspects are the animals' sexual development and reproductive capacity, in addition to embryonic development and growth. Fraunhofer IME's world-leading expertise in fish life cycle testing is highly esteemed by regulatory authorities and industrial users alike.



2

Ensuring clean water supplies 2

We tend to take it for granted that the water from our faucets is clean and safe to drink. But this can only be guaranteed if its quality is constantly monitored. The Fraunhofer Institute for Applied Solid State Physics IAF has developed a quantum cascade laser that forms the key component in an analysis system designed for day-to-day quality control of drinking water supplies. The automated system takes samples of the water at three-minute intervals without interrupting routine operations, and exposes them to infrared light to test for the presence of impurities. This process rapidly and accurately detects all anomalies indicating that the quality of the water might be impaired.

Non-toxic fire protection

Accidents involving fire are one of the greatest dangers that people might encounter in their daily lives. The materials used to manufacture vehicles, furniture, clothing, electrical appliances, and electronic devices are therefore commonly treated with flame-proofing agents or flame retardants. The Fraunhofer Institute for Structural Durability and System Reliability LBF devotes a great deal of time and effort to developing easy-to-process, non-toxic, functional compounds for flame-proofing agents that can prevent the outbreak of fire or at least retard flame propagation for as long as possible. Its latest product is a halogen-free, non-polluting, polymer-based flame retardant for fabrics, suitable for use in applications such as car seat covers. The flame retardant can be easily incorporated in the synthetic fibers during the extrusion process.



3

Big data analytics combats credit card fraud 3

MINTify Rule is a module of a novel system designed to combat credit card fraud. It reliably detects fraudulent activities, thus helping to prevent card misuse. The system is the result of a joint project between PAYMINT AG and the Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS. Fraunhofer's contribution was the development of smart fraud mining mechanisms capable of automatically detecting new fraud scenarios and fraud patterns in very large datasets. On the basis of this information, it delivers transparent and legible rules that can be immediately applied to block new attacks by fraudsters.

Tracking pirates with radar

Commercial ships are equipped with radar to enable them to navigate safely. But current radar systems have difficulty in detecting small objects at sea. A new radar system developed by the Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR uses a coherent signal processing technique that largely suppresses interference due to the reflection of signals off ocean waves. As a result, floating buoys and small boats can be more easily detected and either used as orientation points or identified as a threat and tracked. The system's phased array antennas use semiconductor components in place of the traditional magnetron tubes, which are highly susceptible to wear. This also significantly reduces manufacturing costs, making phased array antennas an affordable navigation aid for commercial shipping fleets.



MOBILITY AND TRANSPORTATION

Rapid road quality testing

Road surfaces suffer just as much wear and tear as the vehicles that use them, especially on routes frequented by heavy trucks. Winter weather also takes its toll on the roads. Regular inspections are necessary to determine where and when urgent repairs must be carried out to ensure road safety. Laser scanners such as the Pavement Profile Scanner (PPS) developed by the Fraunhofer Institute for Physical Measurement Techniques IPM offer a faster, simpler, and more reliable method of inspecting roads for damage. The technology, which has already proved its worth in railroad applications, has now been approved for measuring the evenness of roads. Measurements are unaffected by outdoor lighting conditions and can be executed while the test vehicle is traveling at speeds of up to 100 km/h.

Film replaces release agents 1

Flex^{PLAS}® release film, which is suitable for deep-drawing processes, was developed at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM in order to be able to manufacture large FRP components, such as those used in the construction of aircraft or wind turbines, without using release agents. The elastic polymer film has a flexible plasma-polymer release layer that allows easy removal of components from molds, even when stretched by 300 percent. The innovative film has already been used in a prepreg facility to manufacture full-scale demonstration models of large,

three-dimensional, curved carbon-fiber-reinforced structures without the use of release agents. After being cured in an autoclave at 180 °C, the components can be immediately joined or coated without the need for further costly, time-consuming process steps to remove release agent residues.

The lite approach to fuel efficiency

The EU Clean Vehicles Directive calls for a reduction in average CO₂ emissions, and since this implies lower fuel consumption, which is in turn related to vehicle weight, the obvious consequence for car manufacturers is that they have to build lighter cars. But of course this mustn't come at the cost of safety. This challenge prompted technologists at the Fraunhofer Institute for Material and Beam Technology IWS in Dresden to develop a lightweight construction method that allows a vehicle's mass to be reduced without compromising crash safety. Their solution is based on the idea of minimizing the wall thickness of car body components by using inexpensive low-strength steel and simply reinforcing the areas that are subject to most stress with the aid of a laser beam melting process. This new design concept provides extra strength only and precisely where it is needed, enabling the weight of car body components to be reduced by up to 20 percent without jeopardizing the safety of the vehicle's occupants.

Eliminating unwanted engine noise 2

Torsional vibration is a natural phenomenon in all machines containing rotating parts, and vehicle engines are no exception. Good mechanical design normally ensures that such vibrations are effectively damped, but the sophisticated engine control systems deployed in modern vehicles to improve efficiency sometimes have the opposite effect when it comes to suppressing torsional vibration. This is perceived in the form of an audible humming noise at very low engine speeds, or when a



cylinder is deactivated, or when switching from one energy source to another. This problem can be resolved by a centrifugal pendulum, a special type of which has been developed by researchers at the Fraunhofer Institute for Structural Durability and System Reliability LBF. Its oscillations provide a counteracting force not only at the (first-order) frequency set by the engine speed but also at intermediate, 0.5th order frequencies. As a result, the pendulum's vibration-reducing effect is enhanced, which in turn improves passenger comfort and prolongs the service life of the engine.

The connected wheelchair

Modern communication technologies are a boon for disabled people who want to live a normal life despite being confined to a wheelchair. The Advanced System Technology branch of the Fraunhofer Institute for Optronics, System Technology and Image Exploitation IOSB has developed a useful add-on module that expands the functionality of electrically powered wheelchairs. Its Bluetooth interface enables the existing wheelchair control system (e.g. joystick, chin control) to communicate with a cellphone, PC, TV, games console, etc. The module allows users to carry out all mouse functions – on their notebook or smartphone, say – and thereby check their e-mails, surf the web, or send an SOS in the event of an emergency. It also has a second Bluetooth interface for monitoring wheelchair data such as the remaining battery charge and transferring these data to a smartphone app that calculates how much further the user can safely travel and displays this information on its screen.

Joseph von Fraunhofer Prize Major advance in sensor technology 3

Magnetic field sensors are used to measure the position of machine parts and other objects with zero contact and zero wear. Modern cars contain 100 or so such sensors, which are utilized for a wide range of monitoring functions. This particular application calls for very robust sensors that are capable of operating reliably under even the most extreme conditions. Three research engineers at the Fraunhofer Institute for Integrated Circuits IIS – Dipl.-Ing. Michael Hackner, Dr.-Ing. Hans-Peter Hohe and Dr.-Ing. Markus Stahl-Offergeld – have developed a new generation of Hall sensors that can be integrated in a single CMOS chip capable of measuring all three spatial axes of a magnetic field simultaneously. The new, patented 3D sensors literally open up a new dimension in magnetic position sensing that could be of potential benefit in a multitude of different applications, including the control systems of computers and construction machines, driver assistance systems, and automated production systems. The researchers were awarded the 2013 Joseph von Fraunhofer Prize for this work.

Coaxing more power out of batteries

The main factor holding back the wider use of electric vehicles is the limited range of their batteries. Few electricity storage devices are able to compete with the energy density of a full tank of diesel, but researchers at the Fraunhofer Institute for Material and Beam Technology IWS have nonetheless made a significant step forward. By modifying the design of lithium-sulfur batteries, they have succeeded in extending the lifespan of LiS cells to over 1000 cycles for the first time. Over the long term, the researchers expect lithium-sulfur batteries to reach an energy density twice as high as that of the lithium-ion batteries currently in use today.



PRODUCTION TECHNOLOGY AND SERVICES

Plants that stay young forever 1

“Forever young” is an unrealizable dream for humankind, but within reach for certain tobacco plants. In a joint research project between the University of Münster (WWU) and the Fraunhofer Institute for Molecular Biology and Applied Ecology IME, a genetic switch has been discovered that can halt the ageing process in tobacco plants. The genetically modified plants produce no flowers, after which they would normally die, and instead just keep on growing. If these same principles could be applied to crop plants such as potatoes, it would be possible to guarantee a sustainable supply of food for the world’s growing population.

Aerial monitoring of crops

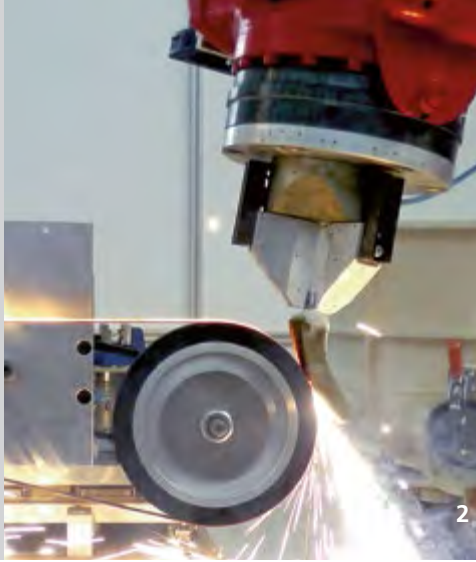
A new instrument promises to take the science of plant phenotyping to new heights – quite literally, using a special hyperspectral camera that can detect the biochemical composition of plants from an aircraft. The camera records spectral images in very narrow bands of the visible light spectrum. Software developed by the Fraunhofer Institute for Factory Operation and Automation IFF then processes these data in order to deliver a precise analysis of the plants’ constituents. This information is of great value to agriculturists, who can use it to monitor the health of their crops and manage even large cultivated areas more efficiently. Initial field trials in Australia have demonstrated the enormous potential of this new technique.

Adhesive tape replaces nails

Speed is of the essence in many industrial processes, and the same applies to the assembly of prefabricated houses. Adhesive bonding would be the method of choice for joining certain components – if only it didn’t take so long for the glue to set. In collaboration with colleagues at the Technische Universität Braunschweig, researchers at the Fraunhofer Institute for Wood Research, Wilhelm-Klauditz-Institut, WKI have come up with a new solution that combines the advantages of adhesive bonding with the speed of nailing or stapling. They have developed an adhesive tape that sets in under a minute to reliably and durably bond together the individual components. The key to the invention is a strip of metal coated on both sides with a layer of adhesive. The tape merely has to be placed on the timber support, and the board fitted in the right position. An electrical current applied to the metal strip heats the adhesive, causing it to melt and fuse with the wood, creating a permanent joint within a minute. The process is currently being refined in collaboration with an industrial partner.

Saws made of nanotubes

Single crystals of silicon have to be cut into extremely fine slices in order to produce wafers for electronic circuits or solar cells. Researchers at the Fraunhofer Institute for Mechanics of Materials IWM, working together with colleagues from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia, have developed a method that reduces the kerf loss associated with the very fine, diamond-impregnated steel wires used in the past. Instead they use threads made of carbon nanotubes with a diamond coating, applied using a highly complex process. The new ultrathin saws made of nanotubes have a much higher tensile strength than conventional steel wires, enabling them to make more precise cuts with less kerf loss.



Robot-assisted blade repairs 2

Compressor and turbine blades are subject to very high loads. Their complex manufacturing process makes such components so expensive that it is often cheaper to repair a damaged blade rather than buy a new replacement. But repairs are also work-intensive and many tasks have to be carried out manually by specially trained experts. Now a more efficient, automated method has been developed by the Fraunhofer Institute for Production Systems and Design Technology IPK. A robot automatically transfers the turbine blade from one repair station to the next, cleaning the component, measuring its geometry and machining its surface. This makes blade repairs cheaper, faster and more precise.

Sustainable schnitzel

Vegetarian alternatives to meat are popular with consumers who want to eat healthy food made from sustainable resources but still enjoy the rich flavor of meat dishes. Traditional Asian products such as tofu, tempeh and seitan are good sources of protein but their taste is nothing like that of meat. As part of the EU-funded LikeMeat research project, coordinated by the Fraunhofer Institute for Process Engineering and Packaging IVV, a process has been developed for manufacturing meat surrogates from vegetable proteins derived from wheat, peas, lupines, soybean and other plants. The products are very similar to real meat in terms of taste, texture, and nutritional value. They can be used to prepare familiar dishes such as schnitzel, rolled steak, goulash, stroganoff, burgers and meatballs. Fraunhofer IVV received the 2013 FERCHAU Innovation Prize for this work.

Sustainable aircraft design 3

A full assessment of an aircraft's environmental compatibility is based on its fuel consumption and on the environmental impact of all resources used throughout its life cycle, from manufacturing to recycling and end-of-life disposal. The European aviation industry aims to improve the eco-efficiency of its aircraft. But current computer programs for compiling and evaluating life cycle assessment (LCA) data are complicated and require specialist training. Researchers from the Fraunhofer Institute for Building Physics IBP have collaborated with the Fraunhofer Institutes for Computer Graphics Research IGD and for Chemical Technology ICT to develop a program that allows the environmental impact of aircraft components to be assessed during the design phase. Their "eco DESIGN[®] software tool" is based on a database containing LCA datasets for a host of reference components. A click on the relevant item shows how much "environmental baggage" a specific component has already accumulated as a result of the raw materials used in its production, thus accounting for aviation-specific environmental issues even before the product leaves the drawing board.

Automated cable inspection

Wire ropes and rigging cables commonly feature in many engineered structures including elevators, cable cars, industrial cranes and bridges. They are exposed to enormous stress and strain, so need regular inspections. The Fluxcrawler, a robotic system developed by the Fraunhofer Institute for Nondestructive Testing IZFP, simplifies and automates necessary test procedures. It climbs up each cable following a spiral path, measuring magnetic flux leakage signals that indicate the presence of surface micro-fissuring and deeper cracks. The robot's special design permits it to inspect ropes and cables of different diameters. The battery-powered test platform is controlled using a standard PC via a Bluetooth interface.



ENERGY AND RESOURCES

Stabilizing supplies of wind and solar energy

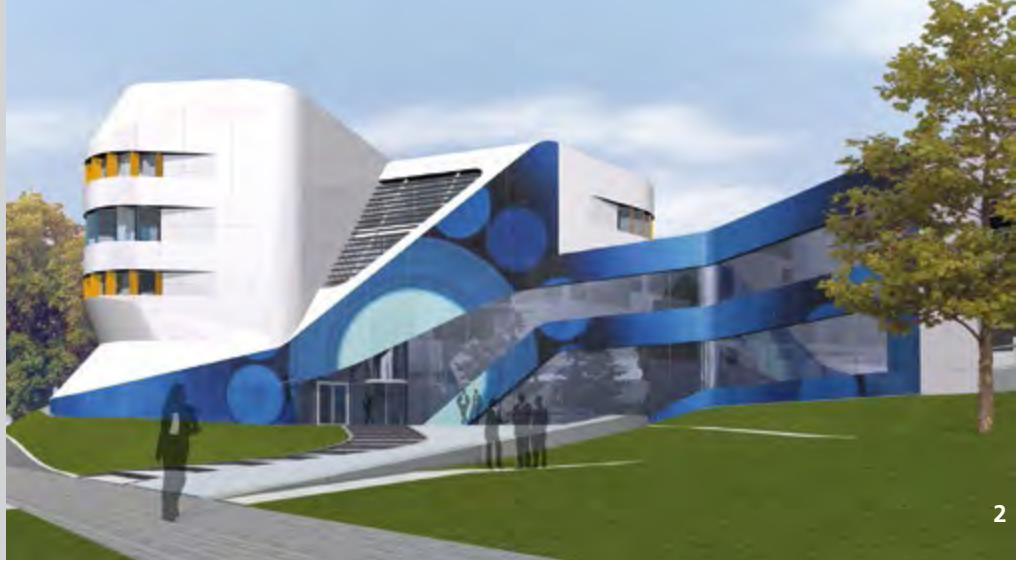
All renewable energy sources have their strengths and weaknesses – depending on whether they are based on biogas, wind, solar, or hydroelectric power. If these various characteristics could be combined in the right way, it would be possible to create a balanced mix of power sources that offsets these strengths and weaknesses, resulting in a stable supply of electricity. In the “Combined Power Plant 2” research project sponsored by the German Federal Ministry of Education and Research (BMBF), numerous partners are conducting studies to determine the possible operating modes of a power grid based exclusively on renewable resources, including the necessary system controls and the way in which these could be implemented in alternative power generation plants to provide services that contribute to power network stability.

Natural insulation materials 1

The demand for thermal insulation is increasing in proportion with fuel prices, because nobody wants to burn more money than is necessary to heat their homes. Naturally sourced, efficient insulation materials are a sought-after product, especially when they contain no chemical additives. Researchers at the Fraunhofer Institutes for Chemical Technology ICT and for Building Physics IBP have been testing the efficiency of various natural materials for use in home insulation. Neptune grass (*Posidonia oceanica*), for example, is a marine flowering plant that can be processed for use as an insulating material and demonstrates better insulation properties than wood-based products. Cattail (bulrush in UK English) is another plant species, of the *Typha* genus, with similar properties, with the added advantage that its cultivation in Central Europe could help to regenerate low-lying moorlands.

Cutting supermarkets' electricity bills

Electricity charges are one of the major costs of running a supermarket. Artificial lighting is required to illuminate the products displayed on the shelves during the long opening hours, and refrigerated display units must be kept at the prescribed temperature to prevent spoilage of perishable food products. Researchers at the Fraunhofer Institute for Solar Energy Systems ISE have been working together with real estate managers, planning teams and manufacturers to devise a more efficient, integrated solution that reduces energy consumption by 30 percent compared with regular supermarkets. Through the use of a centralized refrigeration system in combination with a heat exchanger unit, instead of separate cooling cabinets, it is possible to reduce the amount of power required for cooling by 50 percent. Lighting requirements were also significantly reduced by installing strategically placed daylighting systems. These solutions resulted in significantly reduced costs for the stores in which they were implemented.



World record for solar cell efficiency

The technologies used to convert sunlight into electricity are becoming increasingly efficient. In a joint project with Soitec, CEA Leti and the Helmholtz Center Berlin, the Fraunhofer Institute for Solar Energy Systems ISE has set a new world record of 44.7 percent. This record efficiency was achieved using a new four-junction solar cell – a structure consisting of four solar subcells. High-performance cells of this type are utilized in combination with a Fresnel lens in concentrator photovoltaics (CPV), a technology which achieves more than twice the efficiency of conventional solar power plants in sun-rich regions of the world. This latest record demonstrates the immense potential inherent in the four-junction solar cell design. The scientists' next goal is to reach an efficiency of 50 percent.

Generating electricity from whey

The wastewater from dairies contains organic compounds such as lactose, proteins and milk fats, which have to be removed if the water is to be reutilized. This can be done using biological treatment plants, but the cost of their operation makes this option barely affordable for small-scale dairy producers. In the EU-funded REWAGEN project, a European consortium led by the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB is developing a multistage electrochemical water treatment system for the dairy industry. Its modular structure enables the system to be adapted to the relatively low volume of effluent generated by smaller dairies. The electrochemical process yields hydrogen as a by-product, which the project partners intend to convert to energy in a fuel cell that can be used to power the water treatment system.

More creative freedom for solar designers 2

The take-up rate of new technologies is largely dependent on customer acceptance. Design plays an important role in this respect. Until now, the choice of photovoltaic (PV) systems – one of the main forms of renewable energy – was mostly limited to the standard, dark, roof-mounted panels. Researchers at the Fraunhofer Institute for Applied Optics and Precision Engineering IOF have developed a new thin-film coating for PV cells that can transform solar modules into works of art. Modules of almost every color and shape can be created without any significant loss of efficiency. This means that PV systems can even be integrated as design elements in buildings without being recognizable as solar panels.

Door with built-in CO₂ sensors

Thermal insulation is a good thing, and well-sealed doors help to keep the heat inside. But if there is no exchange of air with the exterior, a stuffy atmosphere can soon build up. Excessive concentrations of CO₂ affect the wellbeing of the building's occupants, who start to feel tired, complain of headaches and have difficulties concentrating. The traditional solution is to give the room a good airing by opening windows and doors. A new alternative is the intelligent, electronically controlled door seal system developed by the Fraunhofer Institute for Microelectronic Circuits and Systems IMS in cooperation with industrial partner Athmer. As well as eliminating the need for regular airing, the door seal also has an insulating function, blocking the inflow of cold air to create the ideal indoor climate at all times.



AWARD 2013

IN ADDITION TO MANY PRIZES FOR FIRST-CLASS SCIENTIFIC ACHIEVEMENTS, FRAUNHOFER RESEARCHERS REGULARLY WIN MAJOR NATIONAL AND INTERNATIONAL AWARDS FOR THEIR CONTRIBUTIONS TO THE ADVANCEMENT OF APPLIED RESEARCH. WE WISH TO HONOR THEM HERE FOR THEIR OUTSTANDING WORK.

- 1 Laboratory setup incorporating the new optical components.*
- 2 Ultra-short-pulse lasers enable the ultraprecise machining of components such as these sapphire molds.*
- 3 Prizewinners Dr. Jens König, Prof. Dr. Stefan Nolte and Dr. Dirk Sutter (from left).*

2



3

German Future Prize

Manufacturing with light flashes

Modern laser systems offer a multitude of exciting possibilities for industrial applications, now that these light sources have become even easier to control. By significantly enhancing the performance of ultra-short-pulse lasers, a team of three researchers has created a tool that is ideally suited to industrial mass production.

The industrial lasers currently in use work by melting the material to be processed, which can result in the need for substantial reworking. By contrast, ultra-short-pulse lasers simply remove a thin layer of material only a few nanometers deep, which evaporates immediately without causing heat damage to the underlying layers of material. This technology is so precisely controllable that it can even be used to engrave structures in a match head without causing it to ignite. Dr. Jens König from Robert Bosch GmbH, Dr. Dirk Sutter from TRUMPF Laser GmbH + Co. KG and Prof. Dr. Stefan Nolte from the Fraunhofer Institute for Applied Optics and Precision Engineering IOF have developed such systems to the point where they are now ripe for use in industrial applications.

The innovative technology enables almost any type of material – from diamonds and tempered glass to steel, semiconductors, ceramics and even highly sensitive plastics – to be machined in a non-contact process. The laser is a universal tool capable of drilling, cutting, structuring and milling components of practically every size and shape. And the new processing method is so precise that it can be used to manufacture products that until now were extremely difficult or even impossible to make. Ultra-short-pulse lasers are already being used in the manufacture of products such as extremely fine nozzles for direct fuel injection valves and biocompatible stents for use in cardiovascular surgery, and for cutting tempered glass for smartphone displays. The researchers have filed more than 40 patent applications relating to their innovative process. The three researchers were presented with the German Future Prize 2013 by German Federal President Joachim Gauck in recognition of this scientific achievement.

PRACTICAL UTILITY LIES AT THE HEART OF ALL RESEARCH ACTIVITIES CONDUCTED BY THE FRAUNHOFER-GESELLSCHAFT: REAL RESEARCH BY REAL PEOPLE.

OUR SUCCESS IS FOUNDED ON THE ENTHUSIASM AND EXCEPTIONAL SKILLS OF PEOPLE AT ALL LEVELS OF THE ORGANIZATION. HERE WE PRESENT PORTRAITS OF FIVE PEOPLE WHO ARE REPRESENTATIVE OF THE EXCELLENT STANDARD OF WORK AND FIRST-CLASS RESULTS REPEATEDLY OBTAINED BY OUR RESEARCHERS – BUT WE COULD HAVE CHOSEN MANY MORE.



DR. RER. NAT. SIMONE TOELSTEDE

Food chemist | Head of the ProFerment Attract group for research into “Fermentation of plant proteins for the development of new food products with high consumer acceptance”

We are what we eat: The link between scientific research and people’s daily lives is rarely more immediately visible than in the field of food chemistry. Every day we are repeatedly confronted with scientific data concerning the content of our plates – and the ingredients used by the food processing industry. Many people are concerned about the quality of the food they eat. Simone Toelstede has gone one step further, and uses her analytical skills and knowledge of chemistry to find out more about the food we eat.

Simone Toelstede first became interested in chemistry during her schooldays – but what fascinated her most was its practical application. She had the opportunity to explore this aspect while studying for a degree in food chemistry at TU Dresden. She then went on to write a thesis paper on the flavor characteristics that make Gouda cheese so popular, as part of her Ph. D. work at the University of Münster (WWU). One of the major findings of this thesis project was that even minimal concentrations of specific peptides have a significant impact on the flavor of the cheese. These and many other chemical compounds form naturally in certain varieties of cheese; they are responsible for the distinctive roundness of flavor and complex aromas typical of a well-matured cheese. This was the cue for the young researcher to take a greater interest in aroma chemistry and flavorings. After obtaining her Ph. D., Simone Toelstede immediately put her knowledge to work, setting up a flavor analysis laboratory for the startup company aromaLAB AG. Two years later she joined RAPS GmbH, a traditional family-run business specializing in spices and flavoring ingredients, as head of the company’s research

laboratory in Weihenstephan. This enabled her to gain management and leadership experience and also broaden her scientific horizons by learning more about food technology.

Simone Toelstede’s interest in research was reawakened when she was invited to establish a research group at the Fraunhofer Institute for Process Engineering and Packaging IVV as part of the Fraunhofer Attract program. She and the three Ph. D. students who make up the group aim to develop a fermentation process for vegetable proteins that can be used to produce new, tasty substitutes for dairy products such as yoghurt, buttermilk and cheese. To make these products acceptable to consumers, it is important that they should have the right sensorial properties, as well as the right structure and consistency. Simone Toelstede aims to prove that it is possible to eat a balanced and varied diet that actually tastes good without using animal products: “We want to process vegetable raw materials by means of traditional fermentation techniques in order to produce nutritious, healthy foods that add variety to our meals, appeal to our taste buds and help to preserve nature.”

The research group intends to study a wide range of raw materials based on plants from the oilseed, legume, cereal and pseudo-cereal families to determine their suitability for creating new products. Special emphasis will be placed on indigenous varieties of plants such as lupine, millet and sunflower, because consumer acceptance increasingly means taking a product’s sustainability into account, and not just its aroma and taste. Eating is more than simply a question of nourishment – it also reflects an attitude to life.

People in research



PROF. DR. RER. NAT. KARSTEN BUSE

Ph.D. in physics | Director of the Fraunhofer Institute for Physical Measurement Techniques IPM in Freiburg and Kaiserslautern

Karsten Buse was still a schoolboy when he first discovered the joys of science and technology. He took part in an after-school project to rehabilitate an abandoned water mill and equip it with a new generator. This zero-budget project was realized with recuperated components – an early example of renewable energy generation made in 1984. Buse left school to study physics at the University of Osnabrück, near his home town of Georgsmarienhütte in the Teutoburg Forest region of northern Germany. He was taken under the wing of Professor Eckhard Krätzig, who supervised his studies and added a strong practical emphasis to his theoretical learning. It was the perfect introduction to application-oriented science, and the results bore this out: Buse's dissertation on the use of optical materials for data storage won several research prizes.

Success gives you wings, and Karsten Buse was no exception. His Ph.D. studies were financed by the Volkswagen Foundation, enabling him to conduct research leading to the development of holographic Bragg gratings, to this day considered as the ultimate in optical color filters. This technological achievement also provided the incentive to found the Californian company Ondax Inc., which Buse still supports in an advisory role. The successful company manufactures and sells tens of thousands of color filters each year, used to stabilize the output of high-power laser diodes. Buse was also awarded the prestigious Karl Heinz Beckurts Prize for his research on Bragg gratings.

From then on, the emphasis on practical applications became a key element of Karsten Buse's scientific work. And the time he spent working overseas, notably at Unicamp in Campinas, Brazil, and at the California Institute of Technology (Caltech), only confirmed to him that research is all the more exciting –

not least for the people doing it – when it is implemented in real life. So he did not hesitate, in 1999, to accept the Heinrich Hertz chair endowed by Deutsche Telekom AG at the Physics Institute of the University of Bonn.

At this point in an already successful career, Karsten Buse encountered another tempting opportunity: he was asked to take over as director of the Fraunhofer Institute for Physical Measurement Techniques IPM in Freiburg, in conjunction with a professorship in the Laboratory for Optical Systems at the University of Freiburg. This was the ultimate challenge for a researcher with a passion for applied science like Buse, who immediately accepted the offer.

He has never regretted this decision, which has allowed him to exercise his social skills and professional talents in an environment that suits him perfectly. Buse comments: "What I like most about working here is the contact with fellow researchers, both at the Fraunhofer Institute and in the university's Department of Microsystems Engineering. Their enthusiasm and research skills help to create an excellent working atmosphere. They share my vision of generating applications capable of sustainably improving quality of life for millions of people."

Karsten Buse's colleagues clearly share his research passion, and if their thirst for knowledge is constantly stimulated and renewed by new challenges, we can expect even more interesting developments to emerge from Fraunhofer IPM in the future.

PROF. DR. RER. NAT. DORIS HEINRICH

Physicist | Head of the “3D NanoCell” Attract Group at the Fraunhofer Institute for Silicate Research ISC in Würzburg | Professor of Biophysics at the Leiden Institute of Physics (LION), Leiden University, Netherlands

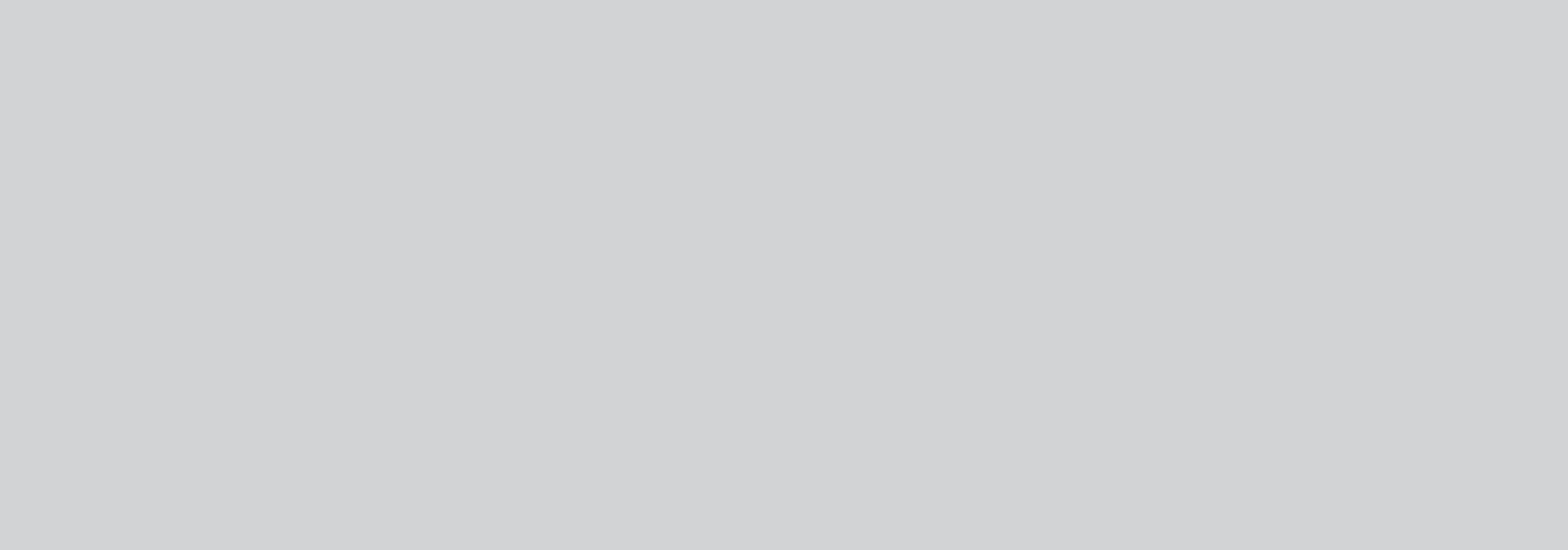
The work of a true scientist is fueled by curiosity, a fascination with the unknown, the desire to uncover hitherto unseen relationships and draw conclusions from this knowledge. Doris Heinrich’s career is proof that productive research is also a result of the willingness to venture beyond the security of well-trodden paths, because this opens the way to enriching experiences that allow new ideas to emerge.

Doris Heinrich graduated from the University of Texas in Austin, USA, with a master’s degree in physics. As a postgraduate researcher, her work revolved around central questions in the field of physics. Her masters’ topic was near-field scanning optical microscopy of semiconductor nanostructures, and her Ph. D. topic was optically induced charge storage in self-assembled semiconductor quantum dots. She started to apply this knowledge to living systems during her period as a postdoc researcher in Heidelberg, Munich and Los Angeles, where she investigated the viscoelastic properties of living cells. The physicist thus became a biophysicist, and then added another string to her bow when she began to take an interest in business consulting and was immediately recruited by one of the leading companies in this field. While working for McKinsey & Company, she participated in a number of different international projects including the restructuring of the tertiary education system in a Middle East country and several other projects for major high-tech companies in Germany, France and the United States. This experience gave her valuable insights into the way international corporations think and work. The ability to tackle questions from a new perspective

is one of the qualities that distinguish leaders from followers in the research world – combined with an unusually rich range of experience and the desire to break with traditionally held, one-sided views and to find new approaches. So it is not surprising that Doris Heinrich accepted the challenge of setting up a research group as part of the Fraunhofer Attract initiative, while continuing her activities as a professor at Leiden University. For the opportunities offered in her field of work are as diverse as they are compelling.

Her “3D NanoCell” Attract Group intends to make targeted use of the human body’s self-healing capacities in the design of the next generation of smart implants. The initial aim of the project is to develop standardized diagnostic assays to monitor cell functions such as adhesion, migration and cell division. Nanoscale structuring will be used to create three-dimensional structures on the surface of the assay system, systematically adapted to the specific task. At a later stage it will be possible to integrate these “3D nanocells” in applications such as smart implants, which monitor their own condition and provide information on their efficacy, or 3D scaffolds, used in tissue engineering as a structural support for new tissue grown from cells harvested from the patient’s own body and subsequently re-implanted.

This example shows how an eclectic mix of professional experience and personal interests can prove to be distinctly productive. For the research led by Doris Heinrich holds the promise of delivering highly interesting results of benefit to science and medicine and, in all probability, new business opportunities.





PROF. DR. RER. NAT. ANDREAS HORNING

Fellow of the Institution of Chemical Engineers and of the Royal Society of Chemistry | Director of the Sulzbach-Rosenberg branch of the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT | Chair of Chemical Engineering and Applied Chemistry at Aston University in Birmingham, UK

Andreas Horning is an energetic researcher, and he has chosen to work in a matching energy technology. Advances in this area of research have become a topic of growing interest since the dawn of the new energy era was proclaimed, i.e. the shift to renewable energy sources. For while wind and sun offer an inexhaustible supply of energy, they share the same drawback: yields fluctuate widely and they don't always deliver electricity at the times it is most needed. Solutions to this problem inevitably involve some kind of energy storage – and this is precisely where Horning's inventive talent and passion for these fascinating technologies can make a difference.

Andreas Horning has systematically worked his way up the career path leading to his present key position in applied research. He studied for a first degree in chemical technology at TU Darmstadt, followed by a Ph. D. at the University of Kaiserslautern. He then held various academic research posts in Karlsruhe and Kaiserslautern and worked for industrial partners in Italy and Austria. He was working at the Karlsruhe Research Center (now part of the Karlsruhe Institute of Technology – KIT) when, in 2007, he was called to the chair of Chemical Engineering and Applied Chemistry at Aston University in Birmingham, UK, where he helped to found the European Bioenergy Research Institute (EBRI). And in January 2013 he accepted a parallel appointment as director of the Sulzbach-Rosenberg branch of the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT.

The main emphasis of his research lies on energy conversion and storage using processes based on biomass – a plentiful resource of growing interest given the prevailing energy

policy. Biomass processes can be used to harvest energy from secondary sources such as sewage sludge or agricultural waste, and as well as to store surplus electricity in the form of solids, liquids or combustible gases, which can be reconverted into electricity on demand. A new term has been coined for this: the "biobattery".

For Andreas Horning, one of the main aims is to develop decentralized processes for the reversible conversion of electricity and biomass waste streams into stable biomass products. This would facilitate a power supply system that allows for more regional and local autonomy, in a new departure that reduces dependence on centralized generating plants and the associated need for high-capacity transmission lines. He sees this as an important factor that will enable the transition to the new energy economy.

Leading institutes in Birmingham and in Sulzbach-Rosenberg while living in Karlsruhe with his family clearly takes a huge amount of organization. But for a scientist as agile-minded as Andreas Horning it's manageable, because motivation is his greatest source of personal energy: "Our research will make us a pillar of the new energy economy in Germany. And we provide active guidance to companies willing to take our products on to the marketing and application stage." He can also rely on the support of his family to maintain the intense rhythm of his life as a researcher: "My family stands behind me 100 percent. Everyone has their mission in life, and I think I know what mine!"

PROF. DR. ANDRE SHARON

Mechanical engineer with a Ph.D. in robotics | Executive Director of the Fraunhofer Center for Manufacturing Innovation CMI | Professor of Mechanical Engineering at Boston University, USA

What motivates a man to devote his heart and soul to engineering? Andre Sharon's father had a very good strategy: Whenever his son wanted him to buy something expensive, he replied: "I won't buy it for you, but if you build it yourself I will pay for all the materials you need." In this way, his son got everything he wanted, including a boat, a sail car, an electric guitar and big speakers to listen to rock and roll – but only by building them himself. This experience gave Sharon a strong sense of self-reliance: Whatever the problem, he was sure to find a solution. This attitude has served him well throughout his professional career. After obtaining a bachelor's degree in mechanical engineering, he found his first job with IBM. After a year there, the plant manager agreed to let him study for a master's degree at the Massachusetts Institute of Technology (MIT), with the aim of perfecting his knowledge of automation and robotics and afterwards returning to IBM to apply what he had learned. This proved a profitable investment. Sharon was the first person to control a commercial robot with the original IBM PC. If he succeeded where others had failed, it was partly because, as a mechanical engineer, he took no notice of the computer scientists who tried to explain why it wouldn't work, because he didn't understand their reasoning. After this successful achievement, IBM sent him back to MIT to continue his studies and obtain a Ph.D.

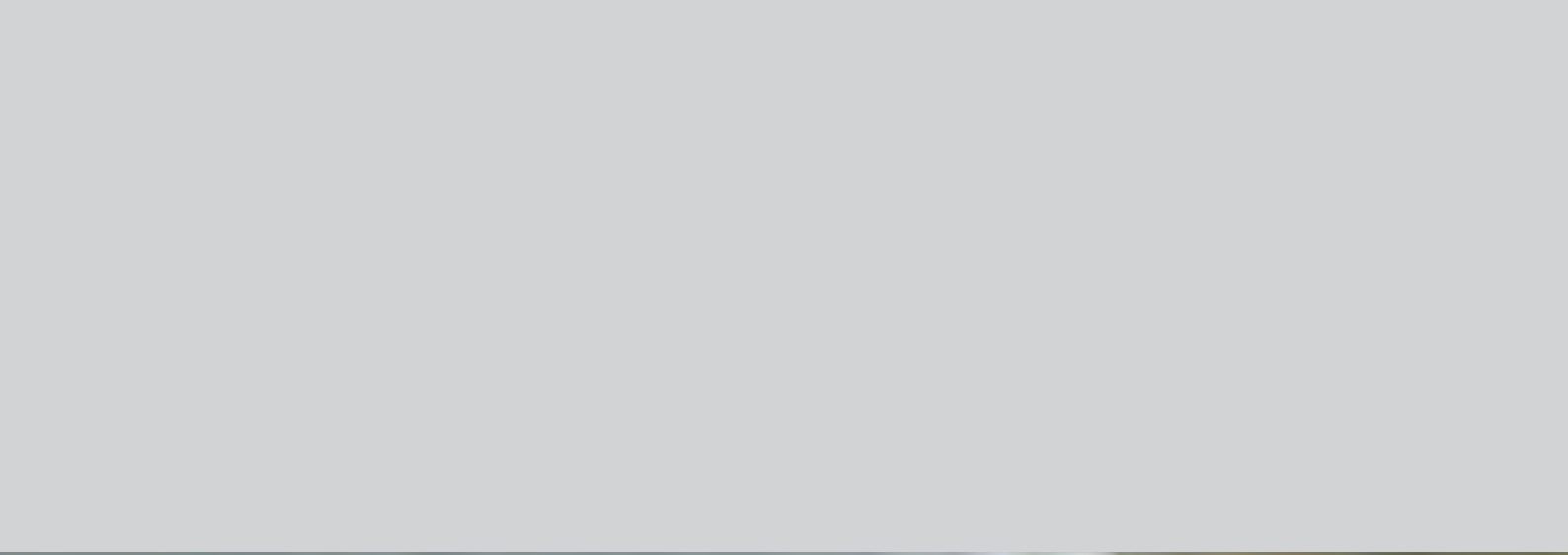
Andre Sharon continued to pursue his interest in robotics when he later returned to work for MIT, where he developed new automation technologies for the manufacture of fiber optic systems. This idea was unheard of at the time, but it coincided with a growing demand for fiber-based transmission systems to cope with the rapid expansion of the Internet.

This provided Sharon with the opening he needed to start his own company in this specialized market. The company he founded, kSARIA Corporation, is still thriving.

Sharon's talents as astute researcher and businessman were obvious. The combination not only matched MIT's philosophy but also proved to be what Fraunhofer was looking for. Professor Fritz Klocke, director of the Fraunhofer Institute for Production Technology IPT, convinced this world-class researcher, inventor and entrepreneur to accept the post of director of the institution today known as the Fraunhofer Center for Manufacturing Innovation CMI, in conjunction with a teaching post as Professor of Mechanical Engineering at Boston University.

Sharon is pleased about his present work: "I think I have the best job in the world. I've one foot in academia and one in industry, so I get to see our research actually get deployed and used. I find that very satisfying." His coworkers also appreciate the stimulating environment at Fraunhofer CMI. One of the results was that Sharon won the 2013 Joseph von Fraunhofer Prize – conjointly with Professor Vidadi Yusibov of the Fraunhofer Center for Molecular Biotechnology CMB in Newark.

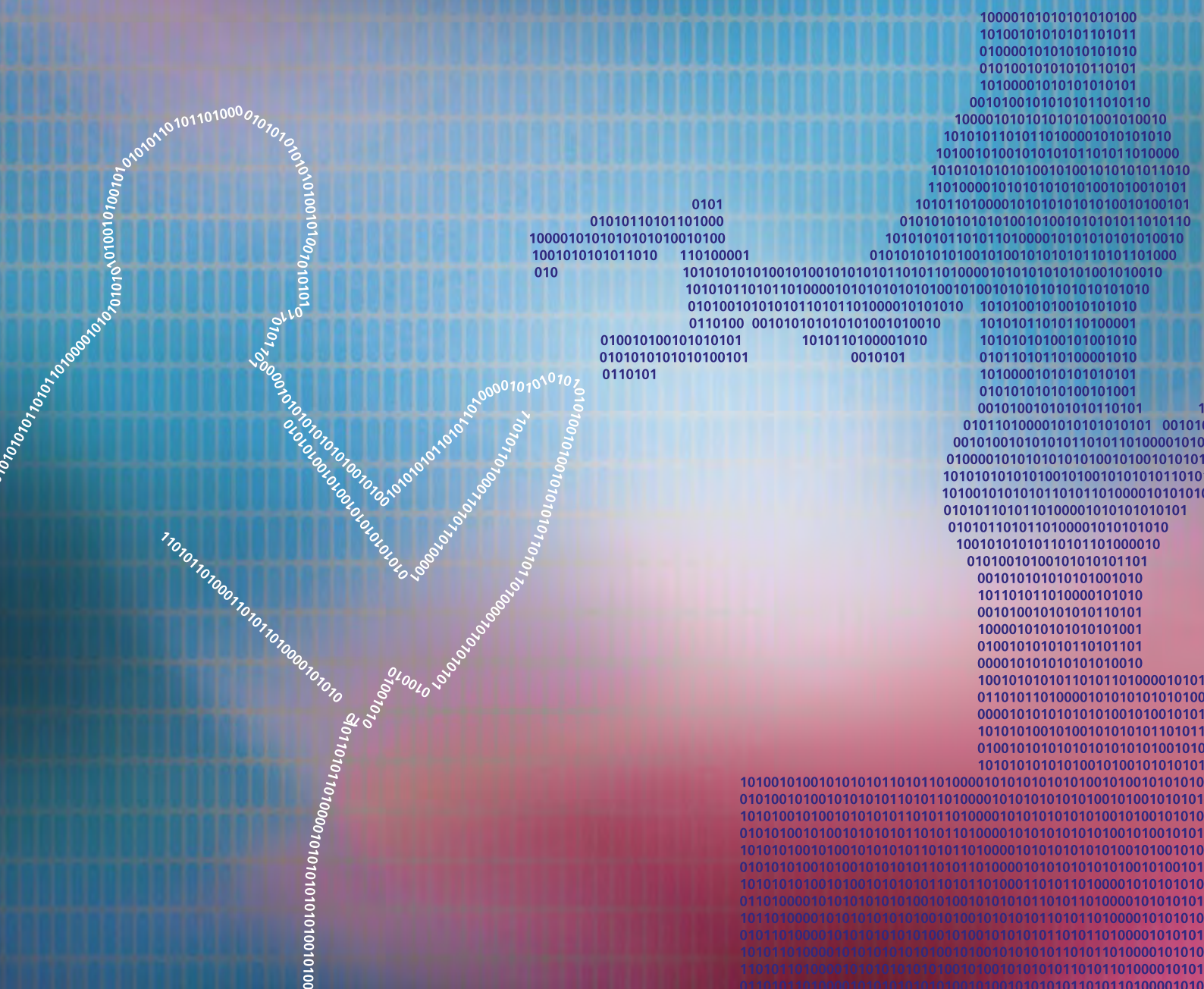
The two American researchers received this prize for their work in developing a fully automated factory for making vaccines and other plant-based pharmaceuticals – in a process that is faster, more flexible and cheaper than anything previously available on the market. This project perfectly illustrates the goal that scientists aim to achieve through applied research: promoting human welfare.



FRAUNHOFER INSTITUTE SPIN-OFFS

THE FRAUNHOFER INSTITUTES ARE PRIZED BY BUSINESS AND GOVERNMENT ALIKE BECAUSE THEY DRAW EXISTING COMPANIES INTO THEIR ORBIT AND PROVIDE THE SEED FROM WHICH NEW COMPANIES ARE BORN.

EVERY YEAR, MORE THAN 50 EMPLOYEES OF FRAUNHOFER INSTITUTES USE THE KNOWLEDGE THEY HAVE AMASSED THERE TO START UP THEIR OWN BUSINESSES. HERE ARE JUST SOME OF THE COMPANIES FOUNDED BY FRAUNHOFER EMPLOYEES.



ArtGuardian GmbH

Seamless microclimate monitoring for artworks

Works of art are irreplaceable documents of our cultural history and must be preserved at all cost. By the same token, it would be lamentable if, in the interests of their preservation, paintings and sculptures had to be kept locked away from public view. But exhibitions of artworks and their removal to other locations on loan present big challenges for museums and collectors. The works are highly sensitive to environmental factors such as humidity, light and fluctuations in temperature. In view of this, the loaning of just a single artwork is an expensive process in terms of logistics, organization and personnel.

ArtGuardian GmbH, a spin-off of the Fraunhofer Institutes for Reliability and Microintegration IZM and for Software and Systems Engineering ISST, offers museums and collectors technological support when exhibiting or loaning cultural assets. The ArtGuardian concept rests on three pillars. First, a set of rules for preventive conservation helps evaluate possible risks for an artwork and reveals what measures are necessary to counter them. Second, autonomous sensors attached to the artwork continually monitor the micro-climatic influences to which it is subjected and transfer the corresponding data to an IT platform. Third, authorized persons can access the system securely at any time to inform themselves of the current state of the artwork and the environmental influences to which it is exposed. It is above all in the combination of sensors and cloud-based IT technology that managing director Dr. Stephan Guttowski sees the new company's USP. The fledgling business can already boast a high-caliber customer: the Kunstmuseum Basel wants to deploy two of ArtGuardian's sensors.



Custom Cells Itzehoe GmbH

Tailored battery systems

Wherever we go, we are never without a cell phone, notebook or iPad. Rechargeable lithium batteries provide the power that ensures these devices function reliably at all times. Compared with conventional rechargeable batteries, these very efficient storage media have a high energy density. In principle at least, that makes them an attractive option for an array of demanding niche products such as drilling head sensors, cordless endoscopes, or satellites. In reality, however, the lithium cells available in the market often fail to meet the very special requirements of these applications.

Now, Custom Cells Itzehoe GmbH, a spin-off of the Fraunhofer Institute for Silicon Technology ISIT, wants to close this gap. Founded in October 2012, the company utilizes lithium polymer technology to develop custom-made electrode foils, battery cells or complete energy storage systems for niche markets, manufacturing them in small-scale series. The customers' special requirements can include, for instance, high temperature stability, vibration resistance, a special shape or high intrinsic security. In its development work, the young firm can draw on the experience, licenses and production facilities of Fraunhofer ISIT. This close cooperation means that, when needed, the start-up can develop new technologies for extreme requirements, dramatically reducing the time to market for innovative solutions. In this way, managing directors Leopold König and Torge Thönnessen want to expand the available system platforms in the years ahead and establish the company in the marketplace as a leading provider of integrated battery solutions.



GMA – Gesellschaft für Marine Aquakultur mbH **Efficient and sustainable fish farming**

Fish is a dietary staple for most people. But demand for this tasty and nutritious food is so high that it can no longer be met solely with fish caught in the wild. More than half of the fish consumed worldwide already comes from aquaculture – and the proportion is rising.

GMA – Gesellschaft für Marine Aquakultur mbH was set up in 2004 with the goal of developing environmentally friendly aquaculture systems based on innovative technology.

Business operations commenced in 2010, and the Fraunhofer-Gesellschaft has had a stake in the company since December 2012. A focal point of the research carried out at GMA is to make aquaculture more sustainable, e.g. by recycling the water in which the fish are kept so that less surface water is used in production. In addition, the scientists are working on adapting the systems used to rear the fish, trying to feed the fish using residual products from agriculture, and examining which conditions are best for reproduction.

All these activities are closely coordinated with the corporate partners, one of which is the Kiel University Managing director Dr. Guido Austen hopes that Fraunhofer's stake in the company will help accelerate the translation of research findings into industrial applications. Over the next few years, GMA wants to establish itself as the center for marine biotechnology and aquaculture in northern Germany and as a strong partner for industry.



mifitto GmbH **Fewer bad buys online**

From running shoes to cocktail dresses – a few clicks on the Internet is all it takes to have the latest fashion items delivered straight to your door. But even if you order the goods in the size you normally wear, there is no guarantee they will actually fit you when they arrive. Clothing measurements are not standardized and can differ from one manufacturer to another. Consequently, many mail order companies have to contend with return rates for textiles of over 50 percent.

mifitto GmbH, an equity investment of the Fraunhofer Institute for Integrated Circuits IIS, has developed an online “size advisor”, which recommends customers the right size for the individual item of clothing they are interested in. It is based on a combination of x-ray technology and imaging techniques that enables each range of items to be measured and scanned in quickly and easily. The “size advisor” for shoes is already market-ready, and the developers are currently extending the system to cover all textile products. To make use of the service, all that customers have to do is to measure their feet using a simple method – mifitto then uses these measurements to find the right size for the selected item.

The technology has another advantage: when the items are scanned, high-quality product photos suitable for use in online shops are produced as a by-product. mifitto has already been successfully tested by Otto Group, Germany's biggest mail order company, and QVC. SportScheck, a sporting goods store located in downtown Munich, also offers its customers a special service when buying ski boots: they can use the mifitto technology to measure their feet in 3D so as to quickly find the perfect boot.



Multiphoton Optics GmbH

Resource-conserving and fast: optical data transfer

In order to cope with the rising flood of bits and bytes, computers have to be ever more powerful – which in turn means they consume more and more energy. Optical data transfer is mooted as a key future technology for transferring information much faster, but for a fraction of the energy required today. However, with as many as 20 process steps, the production of optical waveguides is a material-, time- and energy-intensive undertaking – and thus not at all suitable for industrial production.

Multiphoton Optics GmbH, a spin-off of the Fraunhofer Institute for Silicate Research ISC, offers a substantially more efficient and resource-conserving process that is based on an innovation devised by the company's chief technology officer, Dr. Ruth Houbertz. The physicist developed a process using a material that transmits light exceptionally well and combined it with a new technology – two-photon absorption. In this way, the optical waveguides can be mounted directly on pre-assembled components. The new process makes around 70 percent of the conventional production steps unnecessary, thus drastically reducing the amount of energy and materials consumed. For this achievement, Ruth Houbertz and her team were honored with the International Society for Optics and Photonics' Green Photonics Award 2013 in the "Optical Communication" category. The process can be easily integrated into standard procedures used in the production of electronic systems.

Mass-producible optoelectronic components could help optimize many communication technology products. They would make large data centers more powerful and, at the same

time, lower their energy consumption. Financially, optical data transfer between buildings is a very interesting proposition. Dr. Ruth Houbertz (CTO) and Dr. Markus Riester (CEO) are currently working on honing the technology and getting together the necessary production equipment, and have already won over investors and collaboration partners for their project.





FINANCIAL REPORT

BALANCE SHEET
AT DECEMBER 31, 2013

INCOME STATEMENT FOR THE
FINANCIAL YEAR 2013

RECONCILIATION BETWEEN INCOME
STATEMENT AND PERFORMANCE
STATEMENT (CASH-BASIS ACCOUNTING)

PERFORMANCE STATEMENT FOR
INDIVIDUAL FRAUNHOFER ENTITIES

EXCERPTS FROM THE NOTES
TO THE FINANCIAL STATEMENTS

INDEPENDENT AUDITOR'S REPORT



BALANCE SHEET AT DECEMBER 31, 2013

FRAUNHOFER-GESELLSCHAFT ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG E.V., MÜNCHEN

ASSETS	€	€	2013 €	2012 €(1000)
Current assets				
Cash and cash equivalents		29,556,810.39		15,714
Marketable securities		214,834,670.65		230,152
Accounts receivable and other current assets				
Trade receivables	188,376,454.74			184,220
Receivables from the federal and <i>Länder</i> governments relating to base funding	30,391,743.81			26,979
relating to project billing including contract research	153,267,990.09			181,643
relating to pension and compensated absence provisions	<u>60,122,832.00</u>			<u>58,145</u>
	243,782,565.90			266,767
Accounts receivable from associated companies	933,666.09			6,917
Other current assets	<u>41,030,719.38</u>			<u>43,971</u>
		474,123,406.11		501,875
Inventories		68,598,684.27		59,568
Prepaid expenses and deferred charges		<u>10,975,946.83</u>		<u>8,398</u>
Total current assets			798,089,518.25	815,707
Intangible assets			11,830,454.99	12,752
Property, plant and equipment			1,832,304,234.03	1,694,305
Financial assets			<u>15,051,175.03</u>	<u>15,659</u>
Total assets			<u>2,657,275,382.30</u>	<u>2,538,423</u>
Trust assets			67,068,288.09	41,288

LIABILITIES AND EQUITY	€	€	2013	2012
			€	€(1000)
Current liabilities				
Trade payables		84,957,813.19		84,506
Unappropriated grants from the federal and <i>Länder</i> governments relating to base funding	30,596,137.81			26,997
relating to project billing	<u>74,088,856.55</u>			<u>104,284</u>
		104,684,994.36		131,281
Accounts payable to associated companies		33,121.00		25
Other current liabilities		<u>22,343,922.74</u>		<u>12,292</u>
Total current liabilities			212,019,851.29	228,104
Deferred income			10,355,941.59	8,376
Provisions for pensions and similar obligations			10,422,832.00	10,545
Other provisions			137,643,136.00	131,596
Special reserves				
License-fee revenue reserve		244,142,209.38		244,142
Grants relating to fixed assets		1,844,915,047.08		1,708,855
Grants used to finance current assets		<u>183,480,441.32</u>		<u>192,953</u>
			2,272,537,697.78	2,145,950
Equity				
Capital of the non-profit organization				
Carried forward	13,835,916.21			13,333
Retained earnings	<u>445,132.43</u>			<u>503</u>
		14,281,048.64		13,836
Restricted reserve		<u>14,875.00</u>		<u>16</u>
Total equity			<u>14,295,923.64</u>	<u>13,852</u>
Total liabilities and equity			<u>2,657,275,382.30</u>	<u>2,538,423</u>
Trust liabilities			67,068,288.09	41,288

INCOME STATEMENT FOR THE FINANCIAL YEAR 2013

FRAUNHOFER-GESELLSCHAFT
ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG E.V., MÜNCHEN

	€	€	2013 €	2012 €(1000)
Revenue from base funding				
Federal government		554,474,253.24		536,617
<i>Länder</i> governments		<u>121,481,353.07</u>		<u>111,757</u>
			675,955,606.31	648,374
Revenue from own activities				
Revenue from research and development activities				
Federal government: Project funding	326,230,808.62			305,010
Contracts	9,928,337.94			11,827
<i>Länder</i> governments: Project funding	202,090,325.01			184,231
Contracts	2,838,461.70			2,461
Business, industry and trade associations	567,262,969.14			558,336
Research funding organizations and other sources	<u>140,550,674.55</u>			<u>112,061</u>
		1,248,901,576.96		1,173,926
Increase in work in progress		31,362,696.22		37,425
Other internally constructed and capitalized assets		5,905,974.71		8,184
Other operating income		38,870,354.11		35,018
Other interest and similar income		<u>31,977.05</u>		<u>246</u>
			1,325,072,579.05	1,254,799
Total base funding and revenue from own activities			2,001,028,185.36	1,903,173
Changes in special reserves				
License-fee revenue reserve		–		– 1,761
Grants relating to fixed assets		– 134,779,101.43		– 93,384
Grants relating to current assets		<u>9,472,704.68</u>		<u>22,998</u>
			– 125,306,396.75	– 72,147
Total income available to cover expenditure			<u>1,875,721,788.61</u>	<u>1,831,026</u>

	€	€	2013 €	2012 €(1000)
Cost of materials		302,200,739.23		305,294
Personnel expenses		1,001,088,939.98		923,342
Amortization of intangible assets and depreciation of property, plant and equipment		283,041,229.63		276,428
Other operating expenses		286,287,905.23		274,911
Amortization of financial assets and current marketable securities		<u>2,659,242.11</u>		<u>546</u>
Total expenditure			<u>1,875,278,056.18</u>	<u>1,780,521</u>
Net income on ordinary activities			443,732.43	50,505
Extraordinary expenses				
Allocation to foundation capital			<u>–</u>	<u>–50,000</u>
Net income for the year			443,732.43	505
Transfer from reserve			5,000.00	–
Transfer to reserve			<u>–3,600.00</u>	<u>–2</u>
Retained earnings			445,132.43	503
Allocation to capital of the non-profit organization			<u>–445,132.43</u>	<u>–503</u>
			<u>–</u>	<u>–</u>

RECONCILIATION BETWEEN INCOME STATEMENT AND PERFORMANCE STATEMENT (CASH-BASIS ACCOUNTING)

Income/receipts	Performance statement €	Non-profit organization capital €	Reconciling items €	Income statement €
Income/receipts				
from base funding	673,977,682.31		1,977,924.00	675,955,606.31
from research and development activities	1,280,665,815.56		-31,764,238.60	1,248,901,576.96
Increase in work in progress			31,362,696.22	31,362,696.22
Other internally constructed and capitalized assets	5,905,974.71			5,905,974.71
Other income	37,795,428.68	705,360.10	401,542.38	38,902,331.16
Total income/receipts	1,998,344,901.26			
Grants relating to fixed assets				
Allocations to special reserves (capital expenditure)			-419,867,566.63	-419,867,566.63
Reversal of special reserves (depreciation)		43,762.92	285,044,702.28	285,088,465.20
Grants used to finance current assets	9,472,704.68			9,472,704.68
Change in grants receivable relating to pension and compensated absence provisions	1,977,924.00		-1,977,924.00	
Total business volume (cash basis)	2,009,795,529.94	<u>749,123.02</u>	<u>-134,822,864.35</u>	<u>1,875,721,788.61</u>

Expenditure / disbursements	Performance statement €	Non-profit organization capital €	Reconciling items €	Income statement €
Expenditure/disbursements				
Cost of materials	305,049,745.68	32,251.47	–2,881,257.92	302,200,739.23
Personnel expenses	1,012,139,781.19	5,640.00	–11,056,481.21	1,001,088,939.98
Amortization of intangible assets and depreciation of property, plant and equipment		186,058.11	282,855,171.52	283,041,229.63
Other operating expenses	272,695,533.62	81,441.01	16,170,172.71	288,947,147.34
Expenditure as per the income statement				1,875,278,056.18
Capital expenditure (current and major infrastructure)	419,910,469.45		–419,910,469.45	
Net income for the year		443,732.43		443,732.43
Total business volume (cash basis)	2,009,795,529.94	<u>749,123.02</u>	<u>–134,822,864.35</u>	<u>1,875,721,788.61</u>

The Fraunhofer-Gesellschaft prepares its annual financial statements in accordance with the German Commercial Code (HGB) as applicable to large corporate entities.

The annual financial statements for the year ending December 31, 2013, have been audited and fully certified by the auditing firm Rödl & Partner GmbH, Nuremberg.

The income statement is reconciled to the format required by the relevant public funding authorities.

PERFORMANCE STATEMENT FOR INDIVIDUAL FRAUNHOFER ENTITIES

Fraunhofer Institute/ Research Institution for	Expenditure				Revenue				
	Operating expenditure		Capital expenditure		From external sources		Base funding		
	2012 €(1000)	2013 €(1000)	2012 €(1000)	2013 €(1000)	2012 €(1000)	2013 €(1000)	2012 €(1000)	2013 €(1000)	
Fraunhofer ICT Group									
Algorithms and Scientific Computing SCAI	Sankt Augustin	9,348.5	9,148.6	944.2	172.0	7,207.0	6,614.8	3,085.8	2,705.8
Applied and Integrated Security AISEC	Garching	4,667.7	5,471.0	394.6	312.8	5,893.4	6,095.3	-831.1	-311.5
Applied Information Technology FIT	Sankt Augustin	10,817.5	11,227.8	567.9	415.4	8,587.1	8,909.8	2,798.2	2,733.5
Communication, Information Processing and Ergonomics FKIE	Wachtberg	4,255.6	5,971.2	287.1	440.4	3,638.9	5,269.7	903.8	1,141.9
Computer Graphics Research IGD	Darmstadt	14,913.3	14,397.2	1,094.6	891.3	10,944.8	11,151.6	5,063.1	4,136.9
Digital Media Technology IDMT	Ilmenau	12,016.9	13,358.1	531.4	209.6	9,585.7	9,753.0	2,962.7	3,814.7
Experimental Software Engineering IESE	Kaiserslautern	11,351.9	11,792.0	544.8	685.9	7,948.8	9,431.4	3,947.9	3,046.5
Industrial Engineering IAO	Stuttgart	23,952.6	24,671.0	1,264.7	876.5	17,597.5	19,926.1	7,619.9	5,621.4
Industrial Mathematics ITWM	Kaiserslautern	21,033.6	21,979.2	1,042.0	3,733.6	15,069.1	15,970.8	7,006.5	9,742.0
Intelligent Analysis and Information Systems IAIS	Sankt Augustin	15,484.2	14,705.4	508.1	644.0	9,880.9	8,303.7	6,111.4	7,045.7
Medical Image Computing MEVIS	Bremen	7,401.2	8,357.3	360.3	776.2	6,897.3	7,859.5	864.2	1,274.0
Open Communication Systems FOKUS	Berlin	32,458.3	32,315.6	2,588.5	1,873.5	21,889.7	23,235.7	13,157.1	10,953.4
Optronics, System Technologies and Image Exploitation IOSB	Ettlingen, Karlsruhe	30,200.3	31,478.7	3,719.3	4,120.0	23,506.7	26,075.6	10,412.9	9,523.1
Secure Information Technology SIT	Darmstadt	8,773.4	9,180.1	250.4	242.7	6,732.7	7,703.1	2,291.0	1,719.7
Software and Systems Engineering ISST	Dortmund	5,062.5	4,642.8	376.5	369.1	3,223.6	1,634.8	2,215.4	3,377.1

Fraunhofer Institute/ Research Institution for		Expenditure				Revenue			
		Operating expenditure		Capital expenditure		From external sources		Base funding	
		2012 €(1000)	2013 €(1000)	2012 €(1000)	2013 €(1000)	2012 €(1000)	2013 €(1000)	2012 €(1000)	2013 €(1000)
Fraunhofer Group for Life Sciences									
Biomedical Engineering IBMT	St. Ingbert	21,211.2	22,938.4	3,378.0	4,837.7	17,958.9	18,837.1	6,630.3	8,939.0
Cell Therapy and Immunology IZI	Leipzig	9,434.5	12,619.5	477.3	2,210.2	8,550.4	12,527.6	1,361.3	2,302.2
Interfacial Engineering and Biotechnology IGB	Stuttgart	20,395.6	22,206.0	9,105.4	2,291.9	20,071.2	18,334.1	9,429.8	6,163.8
Marine Biotechnology EMB	Lübeck	3,080.3	2,968.3	481.4	269.1	3,472.2	1,886.3	89.5	1,351.1
Molecular Biology and Applied Ecology IME	Aachen, Schmallenberg	21,363.7	24,119.5	4,537.7	3,840.7	20,728.5	22,804.5	5,173.0	5,155.8
Process Engineering and Packaging IVV	Freising	15,343.2	16,405.5	716.2	1,659.0	10,814.4	11,057.5	5,245.0	7,007.0
Toxicology and Experimental Medicine ITEM	Hannover	22,979.7	22,962.1	1,698.5	1,809.3	17,846.9	17,404.8	6,831.2	7,366.7
Fraunhofer Group for Light & Surfaces									
Applied Optics and Precision Engineering IOF	Jena	22,538.9	23,911.8	6,585.9	6,310.2	21,841.5	23,449.5	7,283.3	6,772.5
Electron Beam and Plasma Technology FEP	Dresden	12,569.1	16,133.6	1,450.2	1,503.4	9,969.3	12,751.6	4,050.0	4,885.5
Laser Technology ILT	Aachen	30,286.6	29,166.2	6,739.0	5,067.4	27,156.1	25,007.3	9,869.6	9,226.4
Material and Beam Technology IWS	Dresden	23,541.5	23,246.5	2,319.3	3,280.1	20,301.4	18,170.5	5,559.4	8,356.1
Physical Measurement Techniques IPM	Freiburg	13,708.0	15,328.8	1,008.4	725.6	9,246.7	11,185.3	5,469.7	4,869.1
Surface Engineering and Thin Films IST	Braunschweig	11,646.8	11,614.3	362.2	714.9	7,284.7	8,371.6	4,724.3	3,957.5

Fraunhofer Institute/ Research Institution for		Expenditure				Revenue			
		Operating expenditure		Capital expenditure		From external sources		Base funding	
		2012 €(1000)	2013 €(1000)	2012 €(1000)	2013 €(1000)	2012 €(1000)	2013 €(1000)	2012 €(1000)	2013 €(1000)
Fraunhofer Group for Materials and Components – MATERIALS									
Applied Polymer Research IAP	Potsdam-Golm	14,693.9	15,618.4	3,379.5	1,295.3	11,397.1	10,382.9	6,676.3	6,530.8
Building Physics IBP	Stuttgart, Holzkirchen	25,538.9	27,653.8	1,935.6	1,630.2	20,218.2	20,882.1	7,256.3	8,401.8
Ceramic Technologies and Systems IKTS	Dresden, Hermsdorf	35,481.5	36,084.2	3,385.0	3,485.8	27,402.0	28,002.6	11,464.6	11,567.4
Chemical Technology ICT, Polymer Engineering Department	Pfinztal	24,898.8	28,373.8	4,393.6	5,820.6	22,910.3	27,347.7	6,382.1	6,846.7
High-Speed Dynamics, Ernst-Mach-Institut, EMI	Freiburg	6,786.7	7,983.4	2,074.3	1,341.9	6,101.7	6,658.4	2,759.3	2,666.9
Manufacturing Technology and Advanced Materials IFAM	Bremen	35,010.8	37,178.8	7,396.2	8,922.5	32,230.7	33,373.3	10,176.4	12,728.1
Mechanics of Materials IWM	Freiburg, Halle	33,253.6	35,461.9	3,902.3	4,395.2	24,050.3	25,647.1	13,105.5	14,210.0
Nondestructive Testing IZFP	Saarbrücken	31,601.6	27,317.8	1,349.5	1,851.4	19,670.4	15,383.5	13,280.8	13,785.7
Silicate Research ISC	Würzburg	20,396.8	23,749.9	1,643.9	3,787.1	14,668.2	17,312.6	7,372.5	10,224.4
Solar Energy Systems ISE	Freiburg	66,838.7	73,192.6	10,208.6	13,521.5	63,110.0	67,138.6	13,937.3	19,575.6
Structural Durability and System Reliability LBF	Darmstadt	27,268.0	28,027.4	5,632.7	3,416.5	24,703.8	23,776.6	8,197.0	7,667.3
Systems and Innovation Research ISI	Karlsruhe	21,411.0	23,712.9	587.8	676.5	16,970.1	17,820.6	5,028.7	6,568.9
Wind Energy and Energy System Technology IWES	Bremerhaven, Kassel	27,303.9	30,458.9	3,070.2	8,719.9	24,536.4	34,222.8	5,837.7	4,956.0
Wood Research, Wilhelm- Klauditz-Institut, WKI	Braunschweig	10,154.6	10,476.0	777.5	1,027.1	8,146.3	8,771.8	2,785.7	2,731.3

Fraunhofer Institute/ Research Institution for		Expenditure				Revenue			
		Operating expenditure		Capital expenditure		From external sources		Base funding	
		2012 €(1000)	2013 €(1000)	2012 €(1000)	2013 €(1000)	2012 €(1000)	2013 €(1000)	2012 €(1000)	2013 €(1000)
Fraunhofer Group for Microelectronics									
Applied Solid State Physics IAF Embedded Systems and Communication Technologies ESK	Freiburg	9,881.0	11,036.4	2,508.1	1,851.6	8,812.8	9,015.8	3,576.2	3,872.2
Electronic Nano Systems ENAS	München	5,577.4	6,403.5	347.6	433.2	4,441.8	5,085.2	1,483.2	1,751.6
High Frequency Physics and Radar Techniques FHR	Chemnitz	9,600.8	10,588.4	1,895.3	1,780.1	8,862.0	9,838.9	2,634.1	2,529.6
Integrated Circuits IIS	Wachtberg	3,880.7	3,796.1	730.4	567.0	2,598.7	3,375.9	2,012.4	987.2
Integrated Systems and Device Technology IISB	Erlangen	120,091.4	127,870.4	4,299.7	9,913.6	93,774.7	119,098.1	30,616.4	18,685.9
Microelectronic Circuits and Systems IMS	Erlangen	17,258.3	17,228.0	757.7	2,427.6	13,899.3	16,311.0	4,116.7	3,344.6
Modular Solid State Technologies EMFT	Duisburg	23,762.6	23,152.1	667.1	1,281.8	18,738.7	16,587.6	5,691.0	7,846.2
Photonic Microsystems IPMS	München	9,975.2	10,675.4	779.4	1,030.7	6,532.4	5,449.5	4,222.2	6,256.6
Reliability and Microintegration IZM	Dresden	27,867.3	28,939.1	2,148.5	2,646.7	19,720.1	23,634.1	10,295.6	7,951.6
Silicon Technology ISIT	Berlin	28,522.0	29,345.2	3,284.6	2,369.1	24,258.4	22,945.7	7,548.2	8,768.6
Telecommunications, Heinrich-Hertz-Institut, HHI	Itzehoe	21,057.6	22,487.4	1,271.1	1,180.9	17,169.0	17,968.6	5,159.7	5,699.6
	Berlin	42,867.7	45,305.6	6,939.6	3,941.3	31,775.0	40,374.7	18,032.3	8,872.1

Fraunhofer Institute/ Research Institution for		Expenditure				Revenue			
		Operating expenditure		Capital expenditure		From external sources		Base funding	
		2012	2013	2012	2013	2012	2013	2012	2013
		€(1000)	€(1000)	€(1000)	€(1000)	€(1000)	€(1000)	€(1000)	€(1000)
Fraunhofer Group for Production									
Environmental, Safety and Energy Technology UMSICHT	Oberhausen	27,763.2	31,761.0	2,733.4	2,772.1	21,589.7	25,350.6	8,906.9	9,182.5
Factory Operation and Automation IFF	Magdeburg	17,641.0	17,508.3	864.4	2,237.9	12,674.5	14,693.1	5,830.9	5,053.1
Machine Tools and Forming Technology IWU	Chemnitz	30,535.8	33,313.4	3,023.6	5,375.7	26,596.9	28,356.2	6,962.5	10,332.9
Manufacturing Engineering and Automation IPA	Stuttgart	48,084.9	56,191.7	3,171.2	3,461.1	37,321.5	43,967.2	13,934.6	15,685.6
Material Flow and Logistics IML	Dortmund	24,264.1	23,585.0	1,139.4	1,386.1	18,199.2	17,016.9	7,204.3	7,954.2
Production Systems and Design Technology IPK	Berlin	16,248.5	17,050.0	3,028.7	1,471.1	12,638.3	12,883.7	6,638.9	5,637.3
Production Technology IPT	Aachen	25,231.2	27,927.6	3,935.5	4,233.1	21,173.8	23,004.7	7,992.8	9,156.0
Fraunhofer Group for Defense and Security VVS									
Applied Solid State Physics IAF	Freiburg	12,603.8	13,638.7	5,252.0	5,067.6	10,305.5	10,718.9	7,550.3	7,987.5
Chemical Technology ICT, Department of Energetic Materials	Pfinztal	11,060.9	11,439.4	1,230.1	2,069.5	3,213.2	4,532.5	9,077.8	8,976.4
Communication, Information Processing and Ergonomics FKIE	Wachtberg	19,292.8	19,489.1	1,914.8	2,412.7	9,710.1	10,889.5	11,497.5	11,012.4
High Frequency Physics and Radar Techniques FHR	Wachtberg	14,290.3	14,445.9	1,757.3	5,164.2	6,557.1	7,557.9	9,490.5	12,052.3
High-Speed Dynamics, Ernst-Mach-Institut, EMI	Freiburg	11,750.0	12,515.3	2,013.5	1,611.6	4,865.6	4,670.8	8,897.9	9,456.1
Optronics, System Technologies and Image Exploitation IOSB, Ettlingen branch	Ettlingen	16,183.6	16,363.8	8,102.9	1,650.4	19,113.3	12,893.9	5,173.2	5,120.2
Technological Trend Analysis INT	Euskirchen	5,541.8	5,594.7	366.0	296.3	1,414.6	1,426.4	4,493.2	4,464.7

Fraunhofer Institute/ Research Institution for	Expenditure				Revenue				
	Operating expenditure		Capital expenditure		From external sources		Base funding		
	2012 €(1000)	2013 €(1000)	2012 €(1000)	2013 €(1000)	2012 €(1000)	2013 €(1000)	2012 €(1000)	2013 €(1000)	
Other entities, not included in the Fraunhofer Groups									
Center for Central and Eastern Europe MOEZ	Leipzig	4,060.1	4,382.3	81.1	106.2	1,543.0	2,064.6	2,598.2	2,423.9
Information Center for Planning and Building IRB	Stuttgart	7,096.3	7,118.6	100.5	144.0	2,574.6	2,536.3	4,622.2	4,726.3
Organics, Materials and Electronic Devices COMEDD	Dresden	8,338.7	7,947.5	252.5	515.0	4,770.6	5,082.3	3,820.6	3,380.2
Polymeric Materials and Composites PYCO	Teltow	3,946.3	3,966.5	757.1	445.6	3,048.7	3,402.8	1,654.8	1,009.3
Technological Trend Analysis INT	Euskirchen	1,604.6	2,013.2	1.1	20.2	1,326.8	1,732.5	279.0	300.9
Centrally managed entities									
Fraunhofer headquarters	München	93,828.7	102,251.6	2,068.1	3,315.2	4,904.9	4,183.9	90,991.8	101,382.8
Institute Center Birlinghoven	Sankt Augustin	998.3	908.3	22.6	28.7	69.8	94.4	951.0	842.6
Institute Center Stuttgart	Stuttgart	164.1	70.1	322.8	1,217.4	14.0	96.1	472.9	1,191.4
General overhead costs		14,424.4	-44,030.9	406.4	361.0	48,125.3	19,254.4	-33,294.5	-62,924.3
Major infrastructure capital expenditure				198,800.0	234,950.3	62,339.0	71,829.7	136,461.0	163,120.5
Performance statement		1,555,770.9	1,589,885.1	370,044.6	419,910.5	1,254,633.8	1,324,367.2	671,181.8	685,428.3

EXCERPTS FROM THE NOTES TO THE FINANCIAL STATEMENTS

I. Accounting principles

The Fraunhofer-Gesellschaft prepares its annual financial statements in accordance with the German Commercial Code (HGB) as applicable to large corporate entities. The annual financial statements for the year ending December 31, 2013 have been audited and fully certified.

The basis of the Fraunhofer-Gesellschaft's accounting is the performance statement, from which the annual financial statements are derived.

The performance statement is adapted to the requirements of the public funding authorities in terms of format and reconciliation. It provides a breakdown of operating expenses and capital expenditure at three different levels: individual institutes, headquarters, and the organization as a whole.

The components of the operating budget are presented as income or expenses in accordance with standard accounting practice.

Capital expenditure on property, plant and equipment and on financial assets, on the other hand, is immediately recognized at the full cost of acquisition. Therefore, the operating budget does not include any depreciation/amortization expenses on these items.

In order to provide full accountability for grants received from funding agencies, the performance statement for the organization as a whole is reconciled to the income statement format required by public authorities by eliminating the effect of non-cash income and expense items.

Presentation of annual accounts of the Fraunhofer-Gesellschaft

Annual financial statements of the Fraunhofer-Gesellschaft		Reconciliation with income statement format required by public funding authorities
Balance sheet	Income statement	
Management report	Reconciliation between income statement and performance statement	
Notes to the financial statements	Performance statement	
	Budgeted operating expenses and capital expenditure at Fraunhofer-Gesellschaft level "total business volume"	
	Individual financial statements of the institutes/headquarters	
	Operating expenses	Capital expenditure
	Costs (excluding depreciation/amortization)	Expenses
	Income	Income

The amounts presented in the income statement include items showing the changes in payables and receivables and in depreciation/amortization charges compared with the previous year.

These reconciliation items are presented in the balance sheet as special reserves for grants relating to fixed assets and for grants used to finance current assets.

II. Recognition and measurement methods

Intangible assets and property, plant and equipment are measured at amortized cost, i.e. the cost of acquisition or construction less depreciation/amortization calculated on a straight-line basis.

Since in most cases fixed assets are financed by government grants, a corresponding amount is allocated to the special reserve for grants relating to fixed assets. These adjustments therefore have no impact on equity.

Financial assets and current marketable securities are measured at the lower of cost of acquisition or fair value.

Work in progress is measured at the lower of cost of construction or fair value. Construction costs include applicable personnel expenses, cost of materials, general administrative expenses, and depreciation/amortization charges. Prepaid expenses (including VAT) are disclosed in a separate line item. Trade receivables are recognized net of related valuation allowances, if any. Cash and cash equivalents, and other current assets, are recognized at their nominal value. Foreign currency holdings are recognized at the exchange rate prevailing on the reporting date.

Payments made in the current year for which the associated benefits will be received in a future period are recognized in the balance sheet as prepaid expenses.

The retained earnings presented in the Fraunhofer-Gesellschaft's annual financial statements, i.e. remaining net income for the year after transfers to/from reserves, are allocated in full to the capital of the non-profit organization, in accordance with the Executive Board resolution concerning the appropriation of net income. The special license-fee revenue reserve was created in accordance with Section 58 (6) of the German Tax Code (AO).

Funding used to finance non-current assets is allocated to the special reserve for grants relating to fixed assets. A similar special reserve exists for funding used to finance current assets.

The Fraunhofer-Gesellschaft makes use of the instrument provided for in its financial statutes to recognize a balance sheet reserve that will enable the organization to use revenues from the licensing of audio-encoding technologies as a means of financing its own pre-competitive research in areas of importance to its medium-term strategy. The special license-fee revenue reserve remained unchanged during the year compared to the previous year.

Provisions for pensions and similar obligations for which the Fraunhofer-Gesellschaft has a reinsurance policy in place are measured on the basis of the capitalized value calculated by the insurance company at the reporting date. In all other cases, pension provisions are accounted for at the service cost as measured by actuarial methods. Other provisions consist of amounts set aside to cover all identifiable risks and contingent liabilities. These provisions are measured in accordance with Section 253 para. 1 of the German Commercial Code (HGB) on the basis of a reasonable estimate of the probable outcome, including future cost increases. Other provisions for liabilities due in more than one year are discounted at the average market interest rate for loans of a similar residual maturity as calculated by the Deutsche Bundesbank in December 2013, pursuant to Section 253 para. 2 of the German Commercial Code (HGB). Provisions for part-time early retirement working arrangements are measured on the basis of existing contracts and a forecast of expected future contracts.

Provisions for part-time early retirement working arrangements amounting to €0.1 million were offset against the existing insolvency insurance.

Liabilities are measured at the settlement amount.

Payments received in the current year for benefits to be delivered in a future period are recognized in the balance sheet as deferred income.

Transactions in foreign currencies are recognized at the applicable hedging rate for the currency in question. Open items are translated at the exchange rate prevailing on the reporting date.

Items in transit are noted in a separate line at the foot of the balance sheet for the Fraunhofer-Gesellschaft as trust assets and trust liabilities.

INDEPENDENT AUDITOR'S REPORT

We have audited the annual financial statements, comprising the balance sheet, the income statement and the notes to the financial statements together with the bookkeeping system, and the management report of the Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V., Munich, for the business year from January 1 to December 31, 2013. The maintenance of the books and records and the preparation of the annual financial statements and management report in accordance with German commercial law and supplementary provisions of the articles of incorporation are the responsibility of the Company's management. Our responsibility is to express an opinion on the annual financial statements, together with the bookkeeping system and the management report based on our audit.

We conducted our audit of the annual financial statements in accordance with § 317 HGB (German Commercial Code) and German generally accepted standards for the audit of financial statements promulgated by the Institute of Public Auditors in Germany (Institut der Wirtschaftsprüfer, IDW). Those standards require that we plan and perform the audit such that misstatements materially affecting the presentation of the net assets, financial position and results of operations in the annual financial statements in accordance with principles of proper accounting and in the management report are detected with reasonable assurance. Knowledge of the business activities and the economic and legal environment of the Company and expectations as to possible misstatements are taken into account in the determination of audit procedures. The effectiveness of the accounting-related internal control system and the evidence supporting the disclosures in the books and records, the annual financial statements and the management report are examined primarily on a test basis within the framework of the audit. The audit includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall presentation of the annual financial statements and management report. We believe that our audit provides a reasonable basis for our opinion.

Our audit has not led to any reservations.

In our opinion, based on the findings of our audit, the annual financial statements comply with the legal requirements and supplementary provisions of the articles of incorporation and give a true and fair view of the net assets, financial position and results of operations of the Company in accordance with principles of proper accounting. The management report is consistent with the annual financial statements and as a whole provides a suitable view of the Company's position and suitably presents the opportunities and risks of future development.

Nuremberg, March 20, 2014

Rödl & Partner GmbH

Wirtschaftsprüfungsgesellschaft, Steuerberatungsgesellschaft
(Auditors, Tax Consultants)

Vogel

Wirtschaftsprüfer (Auditor)

Hahn

Wirtschaftsprüfer (Auditor)

SERVICE



STRUCTURE OF THE
FRAUNHOFER-GESellschaft

MEMBERS, CONSTITUENT BODIES,
COMMITTEES

FRAUNHOFER GROUPS

FRAUNHOFER ALLIANCES

ADDRESSES IN GERMANY

INTERNATIONAL ADDRESSES

EDITORIAL NOTES



STRUCTURE OF THE FRAUNHOFER-GESELLSCHAFT

Constituent bodies and their tasks

The **Executive Board** consists of the President and several other full-time members. Its duties include managing the Fraunhofer-Gesellschaft and representing its interests both inside and outside the organization. It formulates the basic principles of the Fraunhofer-Gesellschaft's scientific and research policy, plans its growth and its finances, ensures its base funding, organizes the distribution of funds among the individual institutes, and appoints the institute directors.

A total of 67 **institutes and research entities** at locations across Germany operate under the umbrella of the Fraunhofer-Gesellschaft. Each cultivates its own market presence and manages its own budget. They are organized in seven **Fraunhofer Groups**, each devoted to a specific area of technology. The purpose of the groups is to coordinate thematically related areas within the Fraunhofer-Gesellschaft and harmonize the market presence of the respective group members. The chairs of the groups, together with the Executive Board, make up the **Presidential Council** of the Fraunhofer-Gesellschaft. The Presidential Council participates in Executive Board decision-making processes and, as such, is entitled to make proposals and recommendations and has the right to be heard.

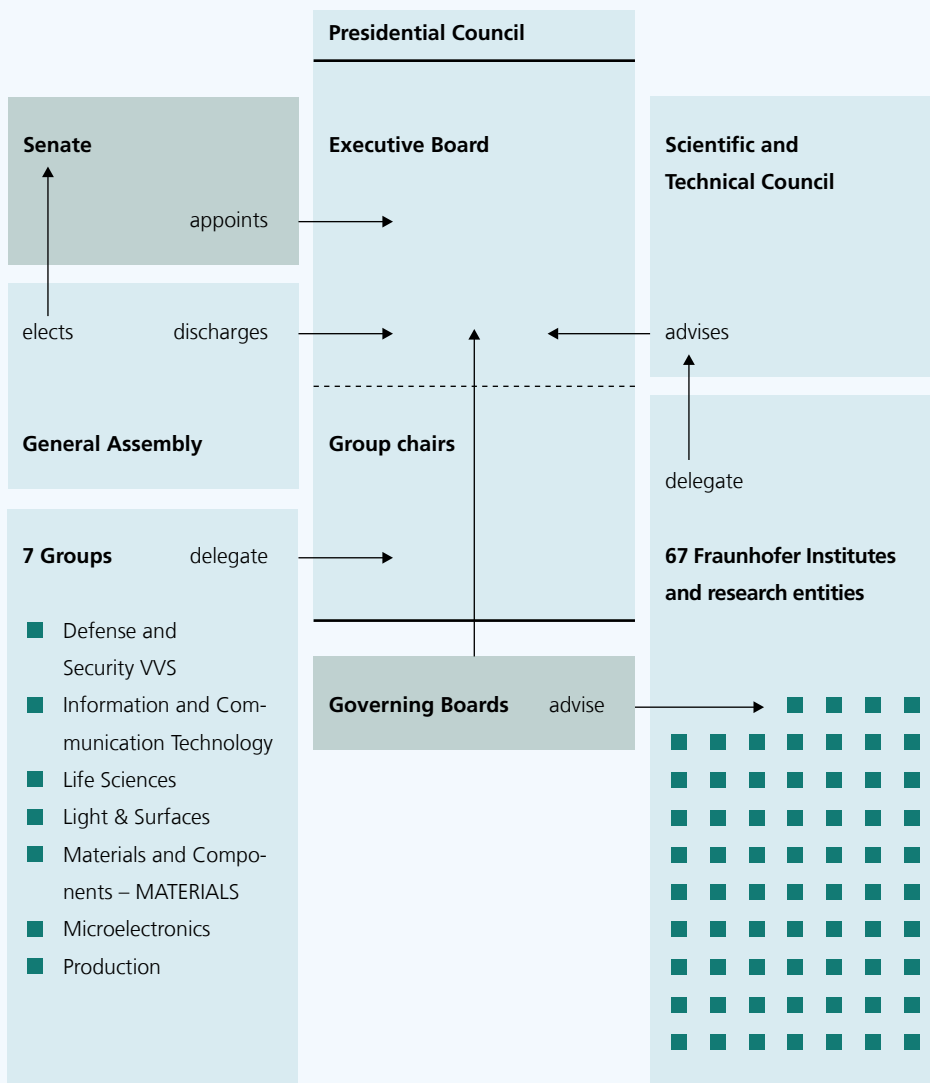
The **Senate** has around 30 members, who are eminent figures from the worlds of science, business and public life, plus representatives of the German federal and *Länder* governments, and members of the Scientific and Technical Council. The Senate is responsible for decisions concerning basic science and research policy. It also formulates decisions concerning the establishment, incorporation, devolution, merger or dissolution of research entities belonging to the Fraunhofer-Gesellschaft.

The **General Assembly** is made up of the members of the Fraunhofer-Gesellschaft. Official membership is open to members of the Senate, the Executive Board, institute directors and senior management, and the governing boards. Ordinary membership is open to individuals and legal entities who wish to support the work of the Fraunhofer-Gesellschaft. Honorary members may be elected from among the research staff and patrons of the Fraunhofer-Gesellschaft in recognition of outstanding services to the organization. The General Assembly elects the members of the Senate, discharges the Executive Board of its responsibilities and formulates decisions concerning amendments to the Statute.

The **Scientific and Technical Council** is the organization's internal advisory body. It consists of the directors and senior management of the institutes and an elected representative of the scientific and technical staff of each institute. The Scientific and Technical Council provides advice to the Executive Board and other constituent bodies in matters of fundamental importance. It makes recommendations concerning research policy and personnel policy, issues statements on the creation of new institutes or the closure of existing ones, and participates in the appointment of the directors of the institutes.

The **Governing Boards** are external advisory bodies of the institutes. They consist of representatives of science, business and public life. For each institute, approximately twelve members are appointed to the Governing Board by the Executive Board with the approval of the director(s) of the institute. The Governing Boards act as advisors to the directors of the institutes and the Executive Board on matters concerning the research orientation and any structural changes to the institute.

Structure of the Fraunhofer-Gesellschaft



Although the Fraunhofer-Gesellschaft is basically a decentralized organization, its structure also allows for a centrally agreed strategy and effective centralized management. Various bodies and committees are responsible for coordination, consultation and leadership across the organization as a whole.

MEMBERS, CONSTITUENT BODIES, COMMITTEES

Members

The Fraunhofer-Gesellschaft has 1,074 members, including 208 ordinary members, 867 official members, one honorary senator and 12 honorary members.

Honorary members

- Dr.-Ing. Peter Draheim
- Prof. Dr. rer. nat. Nikolaus Fiebiger
- Dr. mult. h.c. Dipl.-Ing. Hermann Franz
- Dr. Alfred Hauff
- Dr. Axel Homburg
- Dr.-Ing. Horst Nasko
- Dr. Dirk-Meints Polter
- Prof. Dr. rer. nat. Erwin Sommer
- Prof. Klaus-Dieter Vöhringer
- Prof. em. Dr.-Ing. Prof. h.c. mult. Dr. h.c. mult. Dr.-Ing. E.h. Hans-Jürgen Warnecke
- Dr. rer. pol. Hans-Ulrich Wiese
- Prof. Dr. phil. nat. Dr.-Ing. E.h. Dietrich Wolf

Senate

Members from the science and business communities, and from public life

- Dr. Günter von Au
Vice Chairman, Clariant AG
- Dr. Lutz Bertling
President and CEO, Bombardier Transportation GmbH
- Dr. Christine Bortenlänger
CEO, Deutsches Aktieninstitut e.V.
- Prof. Dr.-Ing. habil. Prof. e. h. mult. Dr. h. c. mult. Hans-Jörg Bullinger
Professor of Industrial Science and Technology Management, University of Stuttgart
- Prof. Dr.-Ing. Heinz Jörg Fuhrmann
Chairman of the Executive Board, Salzgitter AG
- Prof. Dr. rer. pol. Dr.-Ing. E.h. Jochem Heizmann
Member of the Board of Management, Volkswagen AG
- Prof. Dr.-Ing. E.h. Hans J. Naumann
Chairman and CEO, NILES-SIMMONS-HEGENSCHEIDT GmbH
- Dipl.-Ing. Eckhardt Rehberg
Member of the German Bundestag, CDU/CSU parliamentary group

- Prof. Dr. phil. nat. Dipl.-Phys. Hermann Requardt
Member of the Managing Board, Siemens AG
- Carsten Schneider
Member of the German Bundestag, SPD parliamentary group
- Prof. Dr.-Ing. Dr.-Ing. E.h. Dr. h. c. Ekkehard D. Schulz
Chairman of the Senate of the Fraunhofer-Gesellschaft
- Prof. Dr. phil. habil. Dr.-Ing. Birgit Spanner-Ulmer
Director of Production and Technology, Bayerischer Rundfunk
- Regine Stachelhaus
Former member of the Board of Management, E.ON SE
- Prof. Dr. rer. nat. Christiane Vaeßen
Prorector, FH Aachen, University of Applied Sciences
- Prof. Dr. Fritz Vahrenholt
Chairman of the Supervisory Board, RWE Innogy GmbH
- Michael Vassiliadis
National chairman of the industrial trade union IG Bergbau, Chemie, Energie
- Dr.-Ing. Hubert Walzl
Member of the Brand Management Board, Volkswagen Passenger Cars, Production and Logistics
- Dr.-Ing. E.h. Manfred Wittenstein
Member of the Management Board, Wittenstein AG

Members representing government institutions

- Prof. Dr. Thomas Deufel
State secretary, Thuringian Ministry of Education, Science and Culture
- MinDirig Dr. Rainer Jäkel
German Federal Ministry of Economics and Technology (BMW i)
- Thomas Rachel
Parliamentary State Secretary, German Federal Ministry of Education and Research (BMBF)
- MinDirig Dr. Susanne Reichrath
Special Representative for Universities, Science and Technology in the Prime Minister's Office, State Chancellery, Saarland
- MinDirig Rolf Schumacher
Ministry of Finance and Economics, Baden-Württemberg
- Harald Stein
President, German Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support

Members delegated by the Scientific and Technical Council

- Prof. Dr. Dieter Prätzel-Wolters
Director of the Fraunhofer Institute for Industrial Mathematics ITWM
Chair of the Scientific and Technical Council
- Dipl.-Ing. Stefan Schmidt
Fraunhofer Institute for Material Flow and Logistics IML
Deputy chair of the Scientific and Technical Council
- Prof. Dr. rer. nat. habil. Andreas Tünnermann
Director of the Fraunhofer Institute for Applied Optics and Precision Engineering IOF

Honorary senator

- Prof. em. Dr.-Ing.
Prof. h.c. mult. Dr. h.c. mult.
Dr.-Ing. E.h.
Hans-Jürgen Warnecke

Permanent guests

- Dr. Walter Dörhage
Head of the Universities and Research department,
Office of the Senator for Education and Science, Bremen

- Prof. Dr. Peter Gruss
President of the Max Planck Society
- Andrea Hoops
State secretary, Ministry of Science and Culture, Lower Saxony
- Wolfgang Lux
Deputy chairman, Fraunhofer-Gesellschaft general works council
- Prof. Dr.-Ing. Wolfgang Marquardt
Chairman, German Council of Science and Humanities
- Manfred Scheifele
Chairman, Fraunhofer-Gesellschaft general works council
- Prof. Dr.-Ing. Johann-Dietrich Wörner
Chairman of the Executive Board, German Aerospace Center (DLR)

Governing Boards

A total of 762 members of Governing Boards work for the institutes of the Fraunhofer-Gesellschaft; some belong to more than one Governing Board.

Scientific and Technical Council

The Scientific and Technical Council has 137 members, 74 of whom are delegated institute managers, while 63 are elected representatives of the scientific and technical staff of each institute.

Chair of the Scientific and Technical Council

- Prof. Dr. Dieter Prätzel-Wolters
Fraunhofer Institute for Industrial Mathematics ITWM

Presidential Council

The Presidential Council of the Fraunhofer-Gesellschaft consists of the four Executive Board members and the seven chairs of the Fraunhofer Groups listed below:

- Prof. Dr.-Ing. Peter Elsner
Fraunhofer Institute for Chemical Technology ICT
- Prof. Dr. rer. nat. Thomas Hirth
Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB
- Prof. Dr. Matthias Jarke
Fraunhofer Institute for Applied Information Technology FIT

- Prof. Dr.-Ing. Dipl.-Phys. Hubert Lakner
Fraunhofer Institute for Photonic Microsystems IPMS
- Prof. Dr.-Ing. habil. Prof. E. h. Dr. h. c. mult. Michael Schenk
Fraunhofer Institute for Factory Operation and Automation IFF
- Prof. Dr. Klaus Thoma
Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI
- Prof. Dr. rer. nat. habil. Andreas Tünnermann
Fraunhofer Institute for Applied Optics and Precision Engineering IOF

Executive Board

- Prof. Dr.-Ing. habil.
Prof. E.h. Dr.-Ing. E.h. mult.
Dr. h.c. Dr. h.c.
Reimund Neugebauer
(President)
- Prof. (Univ. Stellenbosch)
Dr. rer. pol. Alfred Gossner
- Prof. Dr. rer. publ. ass. iur.
Alexander Kurz
- Prof. Dr.-Ing. Dr. h.c. mult.
Alexander Verl
(since April 1, 2014)

As of March 1, 2014

FRAUNHOFER GROUPS

The Fraunhofer Groups are organizational units of the Fraunhofer-Gesellschaft in which institutes and research institutions specializing in related areas of technology have joined together to coordinate their research and development activities and present a single face to the market. They also help to formulate the organization's business policy and implement its working methods and funding model.

- Fraunhofer Group for Defense and Security VVS
- Fraunhofer ICT Group
- Fraunhofer Group for Life Sciences
- Fraunhofer Group for Light & Surfaces
- Fraunhofer Group for Materials and Components – MATERIALS
- Fraunhofer Group for Microelectronics
- Fraunhofer Group for Production

For further information on the Fraunhofer Groups, please consult our website:

www.fraunhofer.de

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Fraunhofer Group for Production

Group chairman:

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Fraunhofer Institute for Factory Operation and Automation IFF

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39106 Magdeburg

www.produktion.fraunhofer.de

FRAUNHOFER ALLIANCES

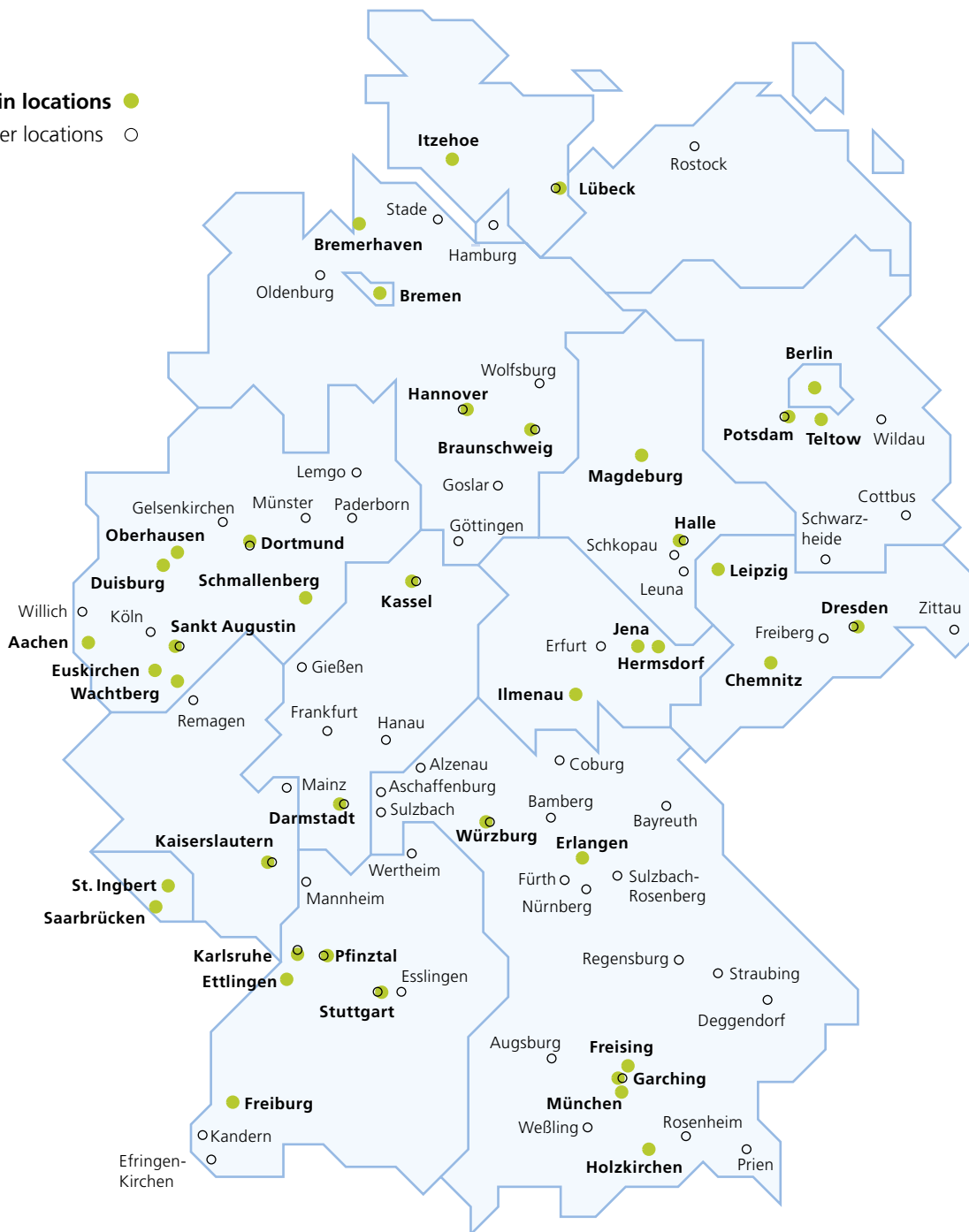
Interdisciplinary alliances have been established between Fraunhofer Institutes or individual research departments to enable them to jointly develop and market solutions for specific business sectors.

For further information on the Fraunhofer Alliances, please consult our website:

www.fraunhofer.de

Fraunhofer Adaptronics Alliance
Fraunhofer Additive Manufacturing Alliance
Fraunhofer AdvanCer Alliance
Fraunhofer Ambient Assisted Living Alliance AAL
Fraunhofer Automobile Production Alliance
Fraunhofer Battery Alliance
Fraunhofer Big Data Alliance
Fraunhofer Building Innovation Alliance
Fraunhofer Cleaning Technology Alliance
Fraunhofer Cloud Computing Alliance
Fraunhofer Digital Cinema Alliance
Fraunhofer Embedded Systems Alliance
Fraunhofer Energy Alliance
Fraunhofer Food Chain Management Alliance
Fraunhofer Lightweight Design Alliance
Fraunhofer Nanotechnology Alliance
Fraunhofer Photocatalysis Alliance
Fraunhofer Polymer Surfaces Alliance POLO®
Fraunhofer Simulation Alliance
Fraunhofer Space Alliance
Fraunhofer Traffic and Transportation Alliance
Fraunhofer Vision Alliance
Fraunhofer Water Systems Alliance (SysWasser)

Main locations ●
 Other locations ○



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(Senior Vice President Finances, Controlling and Information Systems)
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www.fraunhofer.de





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The Fraunhofer-Gesellschaft has subsidiaries in Europe, North America and South America. Fraunhofer Representative Offices and Fraunhofer Senior Advisors form a bridge to local markets in Asia and the Middle East. An office in Brussels, Belgium, acts as an interface between Fraunhofer and the institutions of the European Union. For contact addresses, please consult our website:

www.fraunhofer.de



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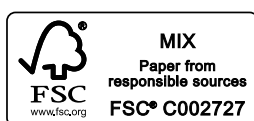
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