



Fraunhofer

ITWM

FRAUNHOFER INSTITUTE FOR INDUSTRIAL MATHEMATICS ITWM



ANNUAL REPORT
2016/17

Front page

The Center Materials Characterization and Testing is part of the Fraunhofer ITWM since the beginning of the year 2017. Its laboratories and offices are situated in the left wing of the Fraunhofer Center.

ANNUAL REPORT
2016/17



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FRAUNHOFER ITWM



OPTIMIZATION



FLOW AND MATERIAL SIMULATION



MATHEMATICAL METHODS IN DYNAMICS AND DURABILITY



SYSTEM ANALYSIS, PROGNOSIS AND CONTROL



TRANSPORT PROCESSES



IMAGE PROCESSING



COMPETENCE CENTER HIGH PERFORMANCE COMPUTING



FINANCIAL MATHEMATICS



CENTER MATERIALS CHARACTERIZATION AND TESTING





ITWM increased its revenues by 8 % and the share of business revenue in the operating budget reached an all-time high of 52.3 % in 2016. A major portion of the industrial revenues is accounted for by follow-on projects with existing customers, and, in addition, many new customers were acquired from quite different sectors. These numbers clearly show the efficient performance, economic relevance, and timeliness of our research at the Institute. Naturally, we also benefit from the stable economic conditions in Germany. Revenue forecasts for 2017 are optimistic, the staff is highly motivated for new challenges, and we anticipate a resurgence of economic growth in the future. More orders, the expansion of business areas, and new research challenges all demand more human resources. Overall, 17 new employees were hired at ITWM and it is particularly rewarding that the percentage of women among the new hires reached 41 % in 2016.

One of the special highlights of the year was the opening of the High Performance Center Simulation and Software-Based Innovation presided over by our President, Prof. Dr. Reimund Neugebauer. In three application-oriented priority research areas, the Center promotes intensive cooperation between the Fraunhofer Institutes, the two Kaiserslautern universities, the Science Alliance, and the regional economy. In the past year, ITWM significantly expanded its research and technology portfolio through the integration of a new unit. In 2016, following intensive coordination talks, the Fraunhofer Institute for Physical Measurement Techniques IPM in Freiburg, the State of Rhineland-Palatinate, and Fraunhofer ITWM came to an agreement to integrate the IPM Department of Materials Characterization and Testing located in Kaiserslautern with Fraunhofer ITWM. Over the past decade, under the umbrella of the IPM, this department advanced the development of the terahertz technology to maturity for the industrial sector. The department, well-positioned economically, scientifically, and in terms of personnel, is under the leadership of Prof. Georg von Freymann. The Science Minister of Rhineland-Palatinate, Prof. Dr. Konrad Wolf welcomed the integration of the department and the creation of the ITWM Center Materials Characterization and

Testing: "This step marks another cornerstone in the sustainable development of Kaiserslautern as a technology center and a strengthening of the Fraunhofer activities in Rhineland-Palatinate. The close collaboration between the various actors at the same location promises additional opportunities for innovation."

2016 was also the year of farewell. Two people who greatly influenced the direction of ITWM: The administrative director Dr. Marion Schulz-Reese has transitioned to a well-deserved retirement and our former director, Prof. Helmut Neunzert, has moved back to Chiemsee in his home state of Bavaria. Their exceptional service to ITWM as well as the City of Kaiserslautern was recognized at farewell ceremonies organized in their honor. Many colleagues and guests contributed to the entertainment with numerous anecdotes, photos, films, and music. Following the departure of Marion Schulz-Reese as head of administration, ITWM established a new structure with Holger Westing and Dr. Markus Pfeffer dividing the functional responsibilities, which has proven to work very well over the past year. The main activities at Kaiserslautern's Felix Klein Center for Mathematics, having been strongly influenced by Helmut Neunzert, are now bundled in the Felix Klein Academy under the leadership of department head Karl-Heinz Küfer. Based on a sustainable concept of support, networking, and training, the aim of the Academy is to provide specific support to outstanding Math students and young scientists.

The "Radiation Therapy" research group in the Optimization Department received a great honor from the Stifterverband für die Deutsche Wissenschaft in winning the category "Collaborative Research Prize 2016." The aim of their project, as part of the Harvard Medical School collaborative research association, was to develop an innovative concept of radiation therapy together with researchers at DKFZ, the University Clinics of Heidelberg and Munich, and Massachusetts General Hospital.

The GPI programming model (Global Address Space Programming Interface) developed at our Competence Center High

PREFACE

Performance Computing was nominated for the European Commission's Innovation Radar Prize in the category "Excellent Science." In a hard fought competition with 40 European digital innovators, GPI successfully made it into the final round of four. Coming after the Fraunhofer Prize 2013, this represents a further international recognition of GPI as a key innovation for the development of parallel software.

Technology innovations were driven in a number of projects with partners in industry on the basis of our core competencies in mathematical modeling, simulation, and optimization. Besides a major expansion of the project with BASF to improve process planning methods in the area of chemical manufacturing, a project with Swiss chemical firm Lonza achieved savings of more than 10 % in energy costs at a production facility through the use of multiple criteria optimization.

Our IPS Cable Simulation product has been substantially improved. Advances in dynamic simulation and durability have made it possible to perform a simulation-based evaluation of the operational stresses on cables and hoses. Additionally, after consulting the data supplied from the simulation models, we built the MeSOMICS measuring system, a patent pending technology already purchased by partners in the automobile sector.

Another ongoing research subject is the use of additive manufacturing techniques in the fully computer-aided development and optimization of porous microstructures and their subsequent actual production. The first micro-filter structures are already being developed and built with 3D nanoprinting capabilities.

Our software products, FPM for flow and continuum dynamics and FIDYST for fiber dynamics, are now achieving significant licensing fees in addition to the application projects. The flow dynamic process design has successfully been established as a unique selling feature in the area of optimal design of hot melt distributors.

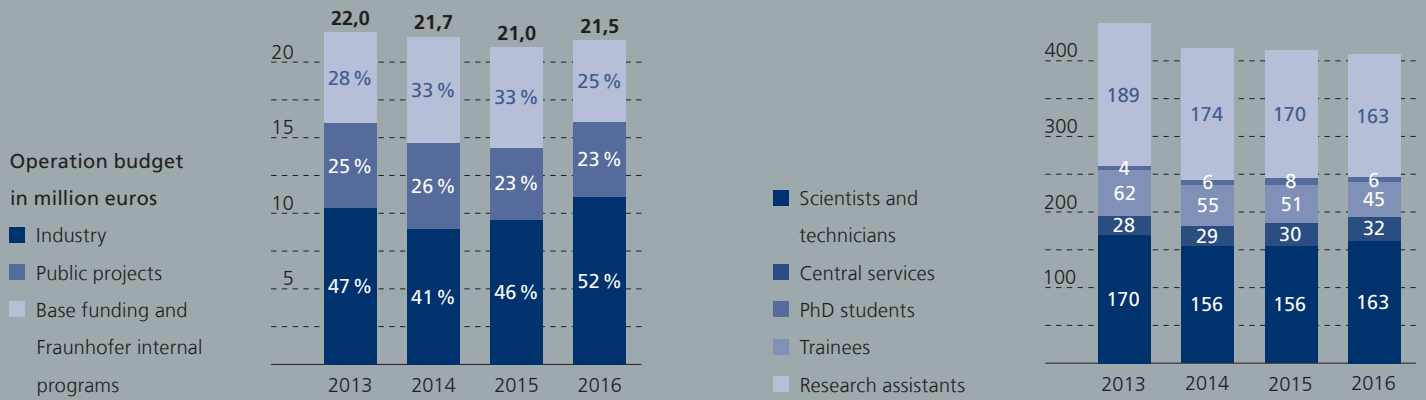
In a joint venture with the "Pension Information Center" located at ITWM, every pension plan tariff over four different terms marketed in Germany in 2016, together with its specific features, was modeled, simulated, and classified on the basis of the simulation results.

The feedback received from our customers is characterized by a high degree of satisfaction. The following quote from an official blog of SAP perfectly documents this: "After almost two years of collaboration, we are convinced that partnering with the ITWM was the best thing SAP could do to streamline the development process of SAP S/4HANA for advanced variant configuration."

My appreciation goes out to our staff and our PhD candidates, who demonstrated again in 2016 high levels of identification and autonomy in a variety of projects and created a climate of mutual respect and recognition of one another's abilities, which is what makes the scientific and economic success of ITWM possible. I also thank our customers and project partners for placing their trust and confidence in ITWM and look forward to accepting new tasks and challenges together in the year 2017.



Prof. Dr. Dieter Prätzel-Wolters
Director of Fraunhofer ITWM



INSTITUTE PROFILE

Computer simulations are an indispensable tool in the design and optimization of products and production processes, services, communication processes and work processes. Real models are replaced by virtual models. Mathematics plays a fundamental role in the creation of this virtual world. Mathematical models cut horizontally across a landscape of vertically arranged scientific disciplines and technological applications. This transverse character of mathematics makes it a “generic technology”; as a basis for bridging into the simulation world, however, it also becomes the key technology for computer simulations which have found their way into nearly all areas of economic life. Increasingly more small and medium-sized companies utilize simulation for cost reduction. It is specifically these companies that the Fraunhofer ITWM supports with consultation and computing power. They profit in the market through the use of simulation as identification for innovation and quality assurance of their products.

Of course, we also work together with large companies, especially in the motor vehicle sector, in machine construction, the textile industry, in microelectronics, with banks and the computer industry. Consultation in R&D questions, support in the use of high-performance computer technology and provision of custom-tailored software solutions are integral building blocks of our work.

Along with the implementation of this technology in application projects and its further development in research projects, the close collaboration with the Department of Mathematics at the University of Kaiserslautern is also a point of emphasis of the Fraunhofer ITWM. The classical disciplines of applied mathematics such as numerics, optimization, stochastics and statistics as well as differential equations are cornerstones.

The specific competencies of the ITWM are

- Processing of data acquired from experiments and observations
- Drafting of mathematical models
- Implementation of mathematical problem-solving in numerical algorithms
- Summarization of data, models and algorithms in simulation programs
- Optimization of solutions in interaction with the simulation
- Visualization of simulation runs in images and graphics

The ITWM is member of the Fraunhofer ICT Group as well as associated member in the Fraunhofer Group for Materials and Components – MATERIALS. In addition, the good networking within the Fraunhofer-Gesellschaft documents the participation in numerous Fraunhofer Alliances: Automobile Production, Battery, Big Data, Cloud Computing, Lightweight Design, Simulation, Textile, Traffic and Transportation, and Vision.



INDUSTRIES – WHO DO WE WORK WITH?

Thanks to the comprehensive methods resident in our departments and the broad spectrum of application areas, our customer base may range across many sectors. Fraunhofer ITWM provides core competencies in the areas:

- Modeling and simulation
- Optimization and decision support
- Data analysis and visualization

and addresses companies and organizations in the sectors:

- Process / Mechanical / Systems engineering
- Automotive and suppliers
- Pharmaceuticals and medical systems
- Power industry
- Technical textiles
- Information technology
- Finance

As a result of the long term cooperation with our regular customers, a considerable domain competence has evolved in some areas of individual sectors; to name a few in particular, the automobile sector, process engineering, and the energy sector. For all sectors: Fraunhofer ITWM's modeling and simulation competence creates a real competitive advantage in the marketplace.

CUSTOMERS AND COOPERATION PARTNERS SELECTION 2016

- AbbVie Deutschland GmbH & Co. KG, Ludwigshafen
- ACC Technologies, Turku (FIN)
- Alois Kober GmbH, Kötz
- Altair Engineering Software Co., Ltd., Troy (USA)
- ante holz GmbH, Bromskirchen-Somplar
- AUDI AG, Ingolstadt
- BASF SE, Ludwigshafen
- Bayer CropScience AG, Monheim
- Biffar GmbH & Co. KG, Edenkoben
- BJS Ceramics GmbH, Gersthofen
- BMW AG, München
- BorgWarner Turbo Systems GmbH, Kirchheimbolanden
- BPW Bergische Achsen KG, Wiehl
- Brückner Group GmbH, Siegsdorf
- BSN Medical GmbH, Emmerich
- Continental Automotive Systems AG & Co. OHG, Frankfurt
- DAF Trucks N. V., Eindhoven (NL)
- Daimler AG, Stuttgart
- Dassault Systemes, Waltham (USA)
- delta h Ingenieurgesellschaft mbH, Witten
- Dilo Machines GmbH, Eberbach
- Eagle Burgmann GmbH, Wolfratshausen
- ebm-papst Mulfingen GmbH & Co. KG, Mulfingen
- ESI Group, Paris (F)
- FLSmidth, Kopenhagen (DK)
- Ford-Werke GmbH, Köln
- Freudenberg Filtration Technologies SE & Co. KG, Kaiserslautern, Weinheim
- Gebr. Pfeiffer SE, Kaiserslautern
- GEF Ingenieur AG, Leimen
- General Dynamics European Land Systems-Germany GmbH, Kaiserslautern
- GKN Driveline Technology Centre, Lohmar
- GKV Spitzenverband, Berlin
- Goldbeck Solar GmbH, Hirschberg
- Goodyear S.A., Colmar-Berg (L)
- GRS mbH, Köln
- Hexagon Metrology GmbH, Wetzlar
- Hilite Germany GmbH, Nürtingen
- Hubert Stüken GmbH & Co. KG, Rinteln
- Human Solutions GmbH, Kaiserslautern
- Hüttenwerke Krupp Mannesmann GmbH, Duisburg
- IBS FILTRAN GmbH, Morsbach-Lichtenberg
- Imilia Interactive Mobile Applications GmbH, Berlin
- Institut für Textil- und Verfahrenstechnik (ITV), Denkendorf
- Institut für Textiltechnik (ITA), Aachen
- IsoDev GmbH, Wegscheid
- John Deere GmbH & Co. KG, Mannheim, Kaiserslautern
- Johns Manville Europe GmbH, Bobingen
- Just Vacuum GmbH, Landstuhl
- Kreisverwaltung Mainz-Bingen, Ingelheim am Rhein
- Kronion GmbH, Landau
- KSB AG, Frankenthal
- KTM-Sportmotorcycle AG, Mattighofen (A)
- Lenzing, AG Lenzing (A)
- Liebherr, Kirchdorf, Colmar (F)

- Lonza AG, Basel
- MAGMA Gießereitechnologie GmbH, Aachen
- MAN Truck & Bus Deutschland GmbH, München
- Marathon Oil, Houston (USA)
- Math2Market GmbH, Kaiserslautern
- Max-Planck-Institut für Dynamik komplexer technischer Systeme, Magdeburg
- mfd Diagnostics GmbH, Wendelsheim, Luckenwalde
- Netze BW GmbH, Stuttgart
- Nissan, Kanagawa (J)
- NOGRID GmbH, Mainz
- Odenwald Faserplattenwerk GmbH, Amorbach
- OPTIRISK, London (GB)
- Paul Wild GmbH, Kirschweiler
- Plastic Omnium, Brüssel (B)
- Porsche AG, Weissach, Stuttgart
- proALPHA Software AG, Weilerbach
- Procter & Gamble, Schwalbach, Euskirchen, Cincinnati (USA)
- Produktinformationsstelle Altersvorsorge, Kaiserslautern
- Progress Rail Inspection & Information Systems, Bad Dürkheim
- PSA Peugeot Citroën, Velizy-Villacoublay Cedex (F)
- PSI AG, Aschaffenburg, Berlin
- Repsol, Houston (USA)
- Robert Bosch GmbH, Stuttgart
- SAP Deutschland SE & Co. KG, Walldorf
- Scania CV AB, Södertälje (S)
- Schleifring und Apparatebau GmbH, Fürstenfeldbruck
- Schmitz Cargobull AG, Altenberge
- Schott AG, Mainz
- Seismic Imaging Processing SIP , Aberdeen (GB)
- Sharp Reflections, Stavanger (N), Kaiserslautern
- Siemens AG, Frankfurt, Erlangen, München
- Statoil ASA, Stavanger (N), Trondheim (N), Oslo (N)
- Stryker GmbH & Co KG, Freiburg
- Stadtwerke Kaiserslautern SWK, Kaiserslautern
- Technische Werke Ludwigshafen, Ludwigshafen
- ThinkparQ GmbH, Kaiserslautern
- Toyota Motor Europe NV/SA, Zaventem (B), Brüssel (B)
- TRW Automotive GmbH, Alfdorf
- UFI Filters spa, Porto Mantovano (I)
- Uhde Inventa-Fischer GmbH, Berlin
- Umicore AG & Co. KG, Hanau
- Uniper Anlagen Service, Gelsenkirchen
- Universities: Berlin, Bordeaux (F), Chemnitz, Dortmund, Freiburg, Kaiserslautern, Karlsruhe, Mainz, Nancy (F), Paris I-Fontainebleau (F), Ulm, Saarbrücken, Münster, Bremen, Heidelberg, Freiburg, Aachen, Saarbrücken, Kassel
- Universities of Applied Sciences: Darmstadt, Kaiserslautern, Mainz, Berlin, Lübeck, Birkenfeld
- Varian Medical Systems International AG, Cham
- Venios AG, Frankfurt
- Voith Hydro GmbH, Heidenheim
- Volkswagen AG, Wolfsburg
- Volvo CE, Konz, Göteborg (S)
- Woltz, Wertheim
- Xella Fermacell, Calbe/Saale

ADVISORY BOARD

- August Altherr, JOHN DEERE European Technology Innovation Center
- Prof. Dr. Nicole Bäuerle, Karlsruhe Institute of Technology
- Dr.-Ing. Erwin Flender, MAGMA Gießereitechnologie GmbH
- Dr. Werner Groh, Johns Manville Europe GmbH
- Johannes Heger, HegerGuss GmbH
- Dr. Wilhelm Krüger, Blue Order AG (Chairmen)
- Prof. Dr. Volker Mehrmann, Technische Universität Berlin
- Dr. Hannes Möller, Daimler AG
- Barbara Ofstad, Siemens AG
- Richard Ortseifer, Ministry of Economic Affairs, Transport, Agriculture and Viniculture of the State of Rhineland-Palatinate (MWVLW)
- Ingo Ruhmann, Federal Ministry of Education and Research
- Prof. Dr. Helmut J. Schmidt, President University Kaiserslautern
- Dr. Mattias Schmidt, Procter & Gamble Service GmbH
- Prof. Dr. Wolfgang Wahlster, DFKI GmbH
- Dr. Carola Zimmermann, Ministry of Science, Further Education, and Culture of the State of Rhineland-Palatinate (MWWK)

NETWORKING AND COOPERATIONS

ITWM is integrated in a network of national and international partnerships and a member of several associations within the Fraunhofer-Gesellschaft:

- Fraunhofer ICT Group
- Fraunhofer Group for Materials and Components – MATERIALS (as associated member)
- Fraunhofer Alliances: Automobile Production, Battery, Big Data, Cloud Computing, Lightweight Design, Simulation, Textile, Traffic and Transportation, and Vision
- Fraunhofer Innovation Cluster Digital Commercial Vehicle Technology
- High Performance Center Simulation and Software-Based Innovation

Further cooperations

- **Center for Mathematical and Computational Modeling (CM)²** co-located in the Mathematics department of TU Kaiserslautern, is focused on mathematical applications in the engineering sciences.
- **Felix Klein Center for Mathematics FKZM**
The FKZM is an institutional pooling of resources from the Mathematics department at TU Kaiserslautern and Fraunhofer ITWM, with a focus on the promotion of young researchers, to include modeling weeks for schools, scholarships, and a mentor program for students of mathematics.
- **Science Alliance Kaiserslautern**
Network of academic and research institutes as well as regional enterprises in the area of Kaiserslautern



HIGH PERFORMANCE CENTER SIMULATION AND SOFTWARE-BASED INNOVATION

The Fraunhofer-Gesellschaft concept of High Performance Centers supports the goal of sustainable site development. The Fraunhofer concept builds on existing cooperation with other actors in the scientific community and the regional business networks. In this way, all dimensions are included: research and academia, promotion of young talents, comprehensive infrastructures, innovation, and knowledge transfer to SMEs as well as to major companies. The concept may be understood as an instrument for innovation and ensuring sales oriented excellence in key areas for selected regions. The intensive exchange between the Fraunhofer Institutes with both universities in Kaiserslautern and good relations with the local economy have been institutionalized in a High Performance Center since January 2016: The name “Simulation and Software-Based Innovation” already expresses the scientific excellence that has emerged in Kaiserslautern over the past two decades. The official opening event in March was attended by many representatives from government, science, and business.

The High Performance Center is divided into R&D labs and application centers, which differ in focus and industry orientation. The research and development labs tend to focus on methods. They develop concepts and algorithms in various fields with different priority research subjects. These, in turn, become the basic technologies available to the three application centers. The centers reflect the expertise of this research center in the area of simulation. The cooperation between the Innovation Cluster for Digital Commercial Vehicle Technologies and the Commercial Vehicle Alliance is a good example. Technical processes and products are simulated using MSO-based process engineering at the application center for “Modeling, Simulation, and Optimization,” which applies mathematical optimization methods on the basis of physical and data based modeling. And, at “Smart Ecosystems” research focuses on new methods and techniques of software engineering in specific application scenarios. Currently, the priority subjects are medical science and green energy grids.

In the first two years, the High Performance Center receives start-up funding of five million euros from State of Rhineland-Palatinate. Over this same period, industrial partners – including BASF, Daimler, John Deere, Liebherr, Procter & Gamble, Robert Bosch, Schmitz Cargobull, and Volvo Construction Equipment – also contribute another five million euros, while the Fraunhofer Institutes provide an additional one million euros.

1 *Inauguration of the High Performance Center (from left): Dr. Mattias Schmidt (Procter & Gamble), Dr. Christoph Großmann (BASF), the spokesman of the center Prof. Dr. Dieter Prätzel-Wolters (Fraunhofer ITWM), Prof. Dr. Arnd Poetzsch-Heffter (TU Kaiserslautern), Prof. Dr. Peter Liggesmeyer (Fraunhofer IESE) and the Fraunhofer President Prof. Dr.-Ing. Reimund Neugebauer*





FRAUNHOFER-CHALMERS RESEARCH CENTRE FOR INDUSTRIAL MATHEMATICS FCC

One of the most important international partners of Fraunhofer ITWM is Fraunhofer-Chalmers Research Center for Industrial Mathematics (FCC), founded by the Fraunhofer-Gesellschaft and Chalmers University in Göteborg in 2001. Its mission is very similar to that of Fraunhofer ITWM and the center works most closely with our Mathematical Methods in Dynamics and Durability department as well as the Optimization and System Analysis, Prognosis and Control departments. In 2015, an international committee evaluated the scientific and business development as well as the future strategy of FCC. The successful rating confirms the Institute is an outstanding research facility that has become a center for industrial mathematics in Sweden. Its portfolio covers contract research, service, algorithms and software, all based on modern mathematical methods in the area of modeling, simulation, and optimization (MSO) that flow into industrial innovations for products and production systems. Areas of application include mechanical engineering, life sciences, paper and packing industry, electronics, and information and communication technologies (ICT).

The Fraunhofer-Chalmers Research Center for Industrial Mathematics is structured in three departments:

- “Geometry and Movement Planning” works in close cooperation with Chalmers Wingquist Laboratory to develop simulations for automated path planning, sealants, flexible materials (e. g., cables and hoses) and human movement models. This last area is important for the ergonomic design of assembly processes.
- “Computational Engineering and Design” works on innovative numerical methods, fast algorithms, and engineering support tools for virtual product and process development. Applications include fluid dynamics, structural dynamics, and electromagnetism.
- “System and Data Analysis” supplies expertise in dynamic systems, forecasting and controls, image and video analysis, statistics, and quality engineering, in addition to technical, biological and biomedical applications.

The FCC currently has a staff of 45 employees and a budget of five million euros in 2016.

THE FRAUNHOFER-GESELLSCHAFT AT A GLANCE

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.

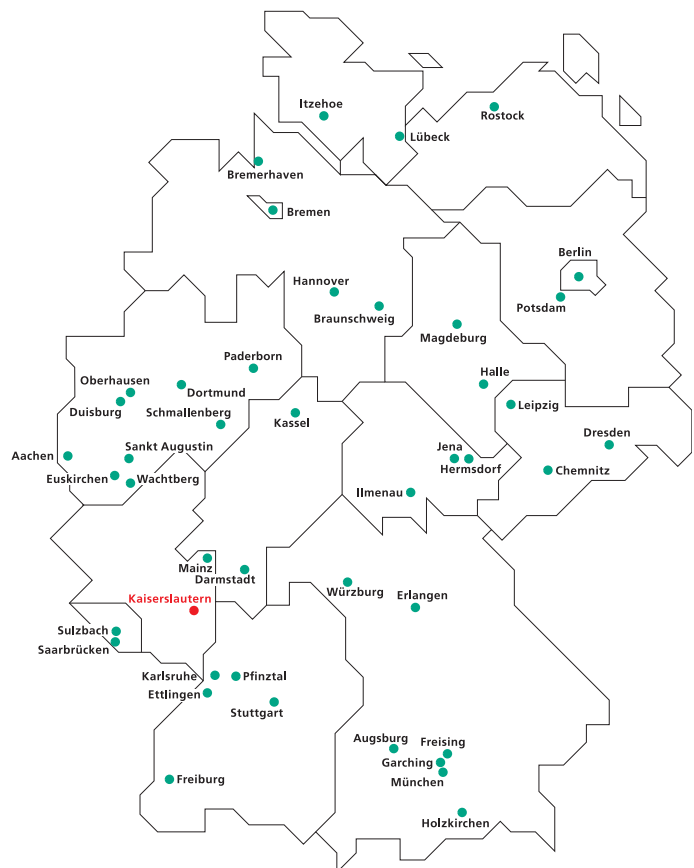
At present, the Fraunhofer-Gesellschaft maintains 69 institutes and research units. The majority of the 24,500 staff are qualified scientists and engineers, who work with an annual research budget of 2.1 billion euros. Of this sum, 1.9 billion euros is generated through contract research. More than 70 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 state governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

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

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

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

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





FAREWELL CEREMONY FOR DR. MARION SCHULZ-REESE

1 *“Can’t stop me now” – with much warmth and a touch of sadness, the administrative director says farewell to her Institute.*

Dr. Marion Schulz-Reese, administrative director at ITWM, retired after a long career mid-way through 2016 and was given an official send-off – attended by many friends and guests who contributed anecdotes, photos, films, and music. This participation ensured a very entertaining evening under the motto: “Farewells are the doors to new worlds.”

Marion Schulz-Reese reminisced about the key stations in her long professional career together with institute founder Professor Helmut Neunzert and other colleagues. The current Finance Minister of Rhineland-Palatinate, Doris Ahnen, was among the long-time supporters of ITWM; first as a state minister and later as the Education and Science Minister. She spoke about the successful support programs in the state of Rhineland-Palatinate, and of course, the successful women in various positions who have had the occasion to meet over the course of the years – for example, as a government minister and an administrative director.

Dr. Dietmar Albrecht, head of human resource development strategy at Volkswagen, first learned to appreciate industrial mathematics at the end of the 1980s. He sent a sincere video message from Beijing in which he remembered the early days of applied mathematics in Kaiserslautern. The topic of knowledge transfer was of most interest to him and he described Marion Schulz-Reese as the “epicenter” of this field. Checking in from India was Professor Subbiah Sundar, one of the original alumni ambassadors of Kaiserslautern, who paid homage with his song “Marion means success.” Other speakers included Prof. Vincenzo Capasso, who organized the first European Consortium for Mathematics in Industry Workshop in 1988 – effectively making industrial math a topic in Europe; and, Dr. Winfried Eschmann from the mathematics department at TU Kaiserslautern, who co-founded the mathematical modeling week for students and teachers. Professor Jens Struckmeier reminded the audience of the days from 1995 to 2000 when ITWM was a state institute; during this period, the institute demonstrated its performance abilities and was eventually admitted into the Fraunhofer-Gesellschaft.

After thanking the speakers, Elisabeth Ewen, Corporate Director of Personnel, had another small surprise to present: the “Fraunhofer Taler”, made of porcelain. With this symbol, Fraunhofer-Gesellschaft recognizes deserving employees for their outstanding service to the society. The event came to an emotional close when the children of Kita Klammeräffchen (company child-care service) bid farewell in song to their mentor. The existence of the Kita at the Fraunhofer Center is, to a large extent, because of the persistent efforts of Marion Schulz-Reese, who managed to persuade the city, state, and Fraunhofer-Gesellschaft of the necessity and practicality of workplace oriented day care.



FESTIVE COLLOQUIUM FOR INSTITUTE FOUNDER, PROFESSOR HELMUT NEUNZERT

On the occasion of institute founder Helmut Neunzert's 80th birthday, ITWM organized an official celebration at the Fraunhofer Center at the end of September. Alongside friends and colleagues, were many of the doctoral students who earned PhDs under the supervision of Helmut Neunzert during his professional career. Among them was Prof. Jens Struckmeier, who in his "Stories of Happy People" traced Neunzert's career in three parts: The happy years before industrial mathematics – the arrival of mathematical modeling at TU Kaiserslautern – and the new millennium. The last phase bore witness to significant events like the admission into the Fraunhofer-Gesellschaft, the State's Mathematics Initiative, the establishment of the Felix Klein Center for Mathematics, and many individual honors such as the award of the Fraunhofer Medal and the Order of Merit from the State of Rhineland-Palatinate.

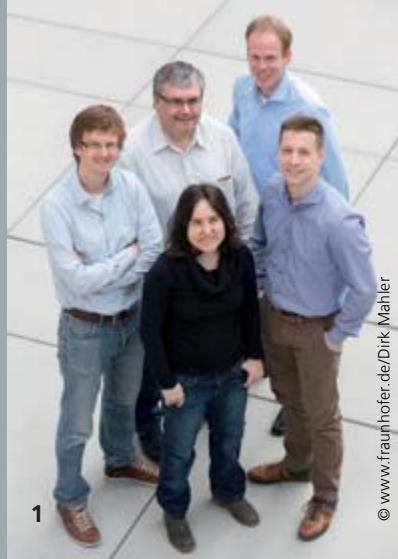
He offered a quote as his motto for the coming years "There is nothing against which an old man should be so much on his guard as the urge to give in to casualness and inaction," as he promised to remain a distant, but interested observer of ITWM.

1 *The "Neunzert-Doctorates Choir" singing the favorite song of Helmut and Renate Neunzert: "Die Gedanken sind frei"*

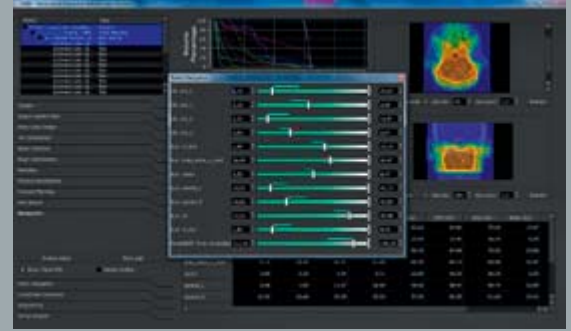
2 *Process engineers from scientific and business communities joined the workshop at the end of September.*

INTERNATIONAL WORKSHOP: MATHEMATICAL METHODS IN PROCESS ENGINEERING

The High Performance Center Simulation and Software-Based Innovation organized an international workshop at Fraunhofer ITWM – wholly in line with the Fraunhofer strategy of promoting excellence through the bundling of existing expertise in science, applied research, and industry. The subject of the 2-day event held in mid-September was "Mathematical methods in process engineering" and it was attended by approximately 100 invited speakers and guests from various universities and industry. Modeling, simulation, and optimization are key technologies in the design and control of production processes to improve productivity and flexibility to the needs of the global marketplace. The workshop was intentionally designed to focus on the areas of process optimization and process simulation; the application-oriented topics were "Granular flows," "Filtration," and "Fibers and nonwoven fabrics." A summary of participant comments reads: "The workshop is an outstanding opportunity that facilitates exchange between mathematicians, engineers, and scientists working in the field of process engineering and should be repeated on a two-year cycle with changing focus topics."



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PRESTIGIOUS AWARD FOR CUSTOM RADIATION THERAPY

1 *The prizewinners:*
 Philipp Süss, Karl-Heinz Küfer, Katrin Teichert, Alexander Scherrer and Michael Bortz

2 *Screen shot of the user interface: With the techniques developed at ITWM, all aspects of a therapy plan can be directly influenced.*

The Stifterverband Science Prize is awarded for scientific excellence in applied research projects conducted by Fraunhofer Institutes in collaboration with industry and/or other research organizations. In 2016 this prize was given to a group of researchers from Fraunhofer ITWM, together with colleagues from Cancer Research Center, University Hospital Heidelberg, and Harvard Medical School/Mass General Hospital. In close cooperation with their partners from the medical application the ITWM researchers developed a software for the more efficient design of radiation therapy planning for tumor patients.

The result was an interactive and easy-to-operate software product. It shortens the duration of radiation therapy planning, makes finding a good balance between therapy potentials and possible side-effects easier and ultimately increases the patient's chances of recovery. The jury specifically recognized the broad viability of the method in treating the wide-spread illness of cancer as well as the relevance to international markets.

The objective of the therapy is to kill tumor cells while protecting healthy tissue. In the past the physician formulated his wishes and the radiation physicist turned these demands into a therapy plan. If the physician wasn't satisfied with the results, the physicist did follow-up work. Gradually the optimum solution was found. The new thing about the mathematical approach is that from the very beginning a variety of solutions is calculated; the physician can then choose the best solution for the patient. In order to improve the process, ITWM researchers Karl-Heinz Küfer, Michael Bortz, Alexander Scherrer, Philipp Süss and Katrin Teichert considered therapy planning as a multi-criteria optimization task, in this case a balanced compromise involving around ten to fifteen in part contradictory planning goals. The principle of the Pareto solution is a better concept here than the previous trial-and-error strategy. With the new planning system the tumor can be better brought under control, since it could be irradiated with a higher dose. This means the probability of permanently eradicating the tumor is also higher.

By the end of 2015 vendor RaySearch Laboratories had sold several hundred systems all over the world. With additional licensing through world market leader Varian Medical Systems since 2016, the technology will be available at over 20,000 therapy planning stations around the world.



INTEGRATION OF THE CENTER MATERIALS CHARACTERIZATION AND TESTING

Measuring technologies and mathematics got even closer connected at Fraunhofer ITWM at the beginning of 2017, when the Center Materials Characterization and Testing was reorganized from Freiburg's Fraunhofer Institute for Physical Measuring Techniques to the mathematics institute in Kaiserslautern. Spatially, the physicists were already present in Kaiserslautern as they occupied an expansion of the Fraunhofer Center in 2015. Now, the 20-plus employees are also organizationally assigned to Fraunhofer ITWM. The expansion provided a total additional floor space of 1400 square meters. The new construction houses high frequency measuring systems, spectroscopic systems, metal and electronics workshops, a chemical lab, and a robot work station.

In partnership with Kaiserslautern Technical University, the project group "TeraTec" of Fraunhofer IPM began to exploit terahertz radiation for use in industrial applications in 2005. In 2010, the TeraTec Application Center was established to provide customers a one-stop access to the benefits of terahertz measuring technology. The successful cooperation in the field of industrial terahertz measuring systems provided the justification for the establishment of the new Center Materials Characterization and Testing. Over the past decade, under the umbrella of the Fraunhofer IPM, the material characterization and testing department developed the terahertz technology to maturity for use in the industrial sector. In particular, the development of the non-contact measurement of coating thickness opened a field of application where success is determined in large part by the physical modeling and parallel numerical evaluation of the measured data.

The clever combination of precise measurement with highly capable evaluation algorithms enabled this technological breakthrough. Non-contact, non-destructive material testing facilitates the detection of defects in ceramics, plastics, or even fiber reinforced composites. There is also special interest in coating thickness measurement, for example, for use with painting processes. Terahertz radiation and millimeter wave measuring technologies, in particular, are an alternative to ultrasonic measurement in cases where mechanical contact is not desired or not possible, and even x-ray radiation where the ionization poses a problem.

The state of Rhineland-Palatinate, Fraunhofer-Gesellschaft, and Fraunhofer IPM are supporting the integration process over the next three years with a funding in the amount of 1.6 million euros.

1 *The section of the building occupied by the Center Materials Characterization and Testing*