Fraunhofer
ITWM

FRAUNHOFER INSTITUTE FOR INDUSTRIAL MATHEMATICS ITWM

ANNUAL REPORT 2014/15

Front page

Mathematics inside: Evening view of the Fraunhofer ITWM

The motif is inspired by the book "Currents in Industrial Mathematics - From Concepts to Research to Education", edited by Helmut Neunzert and Dieter Prätzel-Wolters.
The book will be published in autumn 2015 by Springer-Verlag, Berlin, Heidelberg.

CONTENT

The year 2014 was for ITWM one of consolidation and positive results in the operating budget and further reductions in the carryover in the investment budget. The total budget, as in 2013, reflects a volume of about 25 million euros, however, the business revenues in 2014 decreased slightly as a result of the lower revenues from the gas and oil industry because of the sharp drop in the price of oil. We implemented the German Wissenschaftsfreiheitsgesetz, a law that made it possible for employees to hold shares and participate in the institute's success and have paid out premiums to all qualified employees. Overall, the benefit allowances and premiums reached an historic high of approximately 4 % of the operating budget. This also documents how much the institute appreciates our highly motivated employees. The 28 doctorates completed in 2014 represent another all-time high in the history of ITWM. In this respect, the extensive investments by the institute in basic research and doctoral programs have paid dividends. A significant share of the newly hired employees was recruited from our own training programs. Yet, for the first time in 2014, more people left ITWM than were hired. This is explained by the convergence of a number of special factors: Several staff members decided to start their own business or wanted to return to their home region; others transferred to our spin-off companies or moved to more attractive regions. It is particularly unfortunate that the departures of female employees could not be offset by new hires, which caused us to miss our goal of increasing the percentage of women on the staff.

ITWM is an active partner in many BMBF projects that call for Modelling, Simulation, and Optimization (MSO). Despite this and the fact that the innovation initiatives of Germany and the EU are seen around the world as positive framework conditions, it must be said that mathematics lies at cross angles to the major BMBF lines of support. The BMBF mathematics program is certainly a major financial resource for applied mathematics research in Germany; and, at the DFG, funding for mathematics also enjoys a high priority and mathematics figures prominently in all its funding instruments. However, mathematics as a technology still has no funding program of its own and the funds furnished to the BMBF program is rather modest in comparison to the funding volumes made available to other key technologies. In our opinion, the importance of applied mathematics must be seen as a driver of innovation and this is simply not yet adequately perceived in the policies. The research institutes and university chairs oriented on mathematics again and again find themselves dependent on docking their competence to domain oriented projects, while they receive very little exclusive support for methods development and the expansion of their core competencies. A funding program for large collaborative projects with industry is still lacking in which, under a lead manager, mathematical methods development oriented on the needs of the industry would be advanced and the companies themselves could receive the financial funding.

Nevertheless, it must be noted that applied mathematics has experienced an enormous boost in Germany in recent decades and is firmly entrenched as a "motor for innovation" in the economy and the society. A significant share of this positive development benefits the university graduates who are now going to work in industry, commercial enterprises, or, for example, at the Fraunhofer Institute. Yet, this group is not very visible. ITWM this year published a book titled "Currents in Industrial Mathematics" with the aims of focusing more attention on the work of these mathematicians, presenting the basic concept of a problem-driven, model-based, and solution-oriented mathematics together with their successful projects, and appropriately recognizing the importance of the related transfer of mathematics to the economy and society. Our book points out the incredible success of math today in finding solutions to a range of industrial problems and suggests how to integrate this math in the classrooms and to appreciate the important contributions it makes. We have already received much positive resonance to this publication and we look forward to getting more comments and constructive criticism.

Again in 2014, a large number of demanding projects were managed. The Mathematical Methods in Dynamics and Durability Department continued to develop the technology for the simulation of Vehicle-Environment-Human-Interaction. Another

milestone in 2014, after commissioning the interactive driving simulator RODOS®, was the market launch of the Virtual Measurement Campaign VMC®.

The Optimization Department once again confirmed its cross-industry competence. Besides the activities in the areas of chemical process engineering and medical technology, the department entered a new sector with the start of a BMBF funded project that has the aim of improving the energy efficiency in the area of drinking water supply. A new customer was acquired in the pharmaceutical industry with Merck KGaA as a joint research partner for an end-to-end simulation of the value stream in drug production.

The Competence Center for High Performance Computing successfully positioned itself for the global increase in data volumes and the strong growth in the demand for efficient file systems. In 2014, the "Fraunhofer Parallel File System" for HPC computers, which in the past has been successfully employed in the academic environment, entered advanced development and was renamed as BeeGFS.

The Transport Processes Department was able to compensate for declining revenues from publicly funded projects by expanding their industrial activities. The available simulation tools (including FIDYST – Fiber Dynamics Simulation Tool) enabled the fluids and flexible structures group to achieve the integrated treatment of complete production processes and contribute to the expansion and internationalization of our customer profile.

In the Flow and Material Simulation Department, major research projects were completed and many follow-on industrial projects were acquired. Ongoing BMBF and AiF projects with the aim of optimizing porous material structures have produced the first promising results, for example, for use in battery and fuel cells as well as light construction with plastics and natural fibers. The ongoing combination of microstructure simulation technology with traditional manufacturing and system simulation for complete components or units opens up the potential for numerous application projects.

There was a key personnel change in the Image Processing Department: Markus Rauhut and Henrike Stephani, two experienced and scientifically competent managers in acquisition and personal management accepted positions, respectively, as Head of Department and Deputy Head of Department. A topic highlight in image processing is the AMI4BLISK project, a part of the EU sponsored research program Clean Sky. It involves development of an integrated solution for surface inspection and measurement of turbines and engine components.

The Financial Mathematics Department addressed several new application areas, for example, the first major project with a German life insurance company, which falls under the new WISA (Economically Oriented Strategic Alliances) "Stochastic modeling and numerical simulation for risk management in insurance companies."

Under the framework of the Software Cluster, a top cluster in the federal and state Excellence Initiative, the System Analysis, Prognosis, and Control Department completed its demonstrator for evaluating the reliability of composite Internet services in the cloud, and presented it at the Hannover Messe. More information about this topic, the demonstrator, and additional project examples is provided in the departmental section.

I hope you enjoy reading the remainder of our annual report and also express my sincere appreciation to all project partners for the constructive support and pleasant cooperation.

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

A NIGHT WITH SCIENCE AND THE "SCIENCE SLAM"

A major attraction during the "Night with Science" event held at the end of April was the Science Slam. The doors to the auditorium at the Fraunhofer Center had to be opened so that all the visitors could listen to the competition, as four young scientists from Kaiserlautern, Saarbrücken, Munich, and Jena each had ten minutes to present their research topics in the fields of computer science, mathematics, and neurobiology. Compact, clever, and clear: all four have competed and won awards at Science Slams at the national level before with their topics: "Six legged pirates of the desert" (Dr. Siegfried Bolek, University of Ulm), "Complexity and predictability of fashion" (Johannes Kretzschmar, Friedrich-Schiller University, Jena), "Would you like fries with your fries?" (Johannes Schildgen, TU Kaiserslautern), and "Make it sharp, but really sharp" (Florian Kern, Saarland University). The voting in Kaiserslautern was decided by a show of hands – that is, whoever earned the loudest applause was the winner. The first ever Science Slam organized in Kaiserslautern ended in a tie between the two computer scientists Johannes Schildgen and Johannes Kretzschmar.

Beyond the competition, the 4th annual "Night with Science" created a showcase for the Institute and the Technical University. At the Fraunhofer ITWM, mathematics professor Ralf Korn gave an illuminating talk entitled "Randomness – Your Enemy and Helper," and the individual departments of the institute set up various exhibits in the atrium. Among the exhibits were a new surface inspection system for leather, paper, and metal; a mechanized ultrasonic inspection system using a robot; as well as the optimal cutting of colored gem stones. Visitors tried their skill at determining a better solution than the computer as the "Patienten-Navi" showed them the best route to follow to reach a destination in a virtual hospital. Crowds were also attracted to the presentations at the interactive driving simulator RODOS®, a real driver's compartment in a virtual working environment. Many visitors also joined the building tours which were offered on an hourly schedule.

No science night without music: This year's musical guest was "Ruppert spielt", a group from Kaiserslautern that was heard early in the evening in the corridors as a marching band and later, playing in the lobby until well past midnight.

1 *How many carats are there in the raw stone?*

2 *Moderator Prof. Dr. Norbert Wehn kept the Science Slam on schedule*

3 *Understanding energy consumption*

1

Fraunhofer
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FRAUNHOFER-INSTITUT FÜR TECHNO- UND WIRTSCHAFTSMATHEMATIK ITWM

SPINNERTE IDEEN ENTWICKELN UND DABEI NOCH ORDNUNG INS WIRRWARR BRINGEN GEHT NICHT.

DOCH.

Bei der Herstellung von Vliesen geht es ziemlich turbulent zu, denn Fäden und Fasern werden durch eine Luftströmung gewirbelt, bevor sie auf dem Transportband der Spinnvliesanlage landen. Damit diese Landung möglichst geordnet vonstattengeht und das Vlies auch die gewünschten Materialeigenschaften aufweist, simulieren und optimieren wir die Wechselwirkung zwischen Struktur und Strömung und sorgen damit für einen perfekten Vliesstoff.

Wir verknüpfen Deine Fähigkeiten mit unseren Herausforderungen.

Dr. Simone Gramsch
Wissenschaftliche Mitarbeiterin
www.itwm.fraunhofer.de

"DOCH"-CAMPAIGN/FEMTEC EXCURSION TO ITWM

The percentage of women at ITWM was suddenly increased when this year's "Femtec" course visited our Institute: The visitors were female students in the natural and engineering sciences from Berlin, Dresden, Aachen, and other top universities. They have all completed their bachelor degree or are currently at the end of a master degree program. The young women are participating in a career building program sponsored by Femtec, the women's career center established ten years ago at the Technical University of Berlin. This program includes: Excursions to cooperating partners to get acquainted with their structures and fields of activity, and obtain information about internships, graduation projects, doctorates, and initial entry jobs in addition to making important personal contacts. Further stations in this year's week-long Femtec excursion are BP, Thyssen, Bosch, and E.ON. Fraunhofer ITWM got to know the future engineers in lectures and workshops as they also had the chance to introduce themselves. There was also time for individual exchanges at the MINT-Café: Female members of the ITWM staff made themselves available for a question and answer session with these students and potential colleagues in the coffeehouse atmosphere of the atrium.

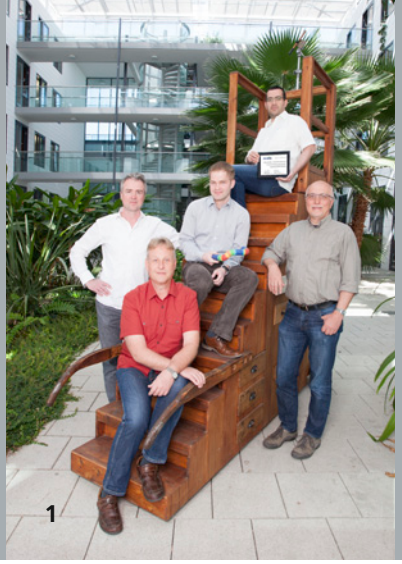
Three workshops were prepared and well attended: Quality control in manufacturing with an on-line inspection system (Image Processing Department), the optimal processing of precious stones (Optimization Department), and the interactive driving and operating simulation with the RODOS® simulator (Mathematical Methods in Dynamics and Durability Department). The simulated ride in an excavator was a real highlight of the day for the workshop participants.

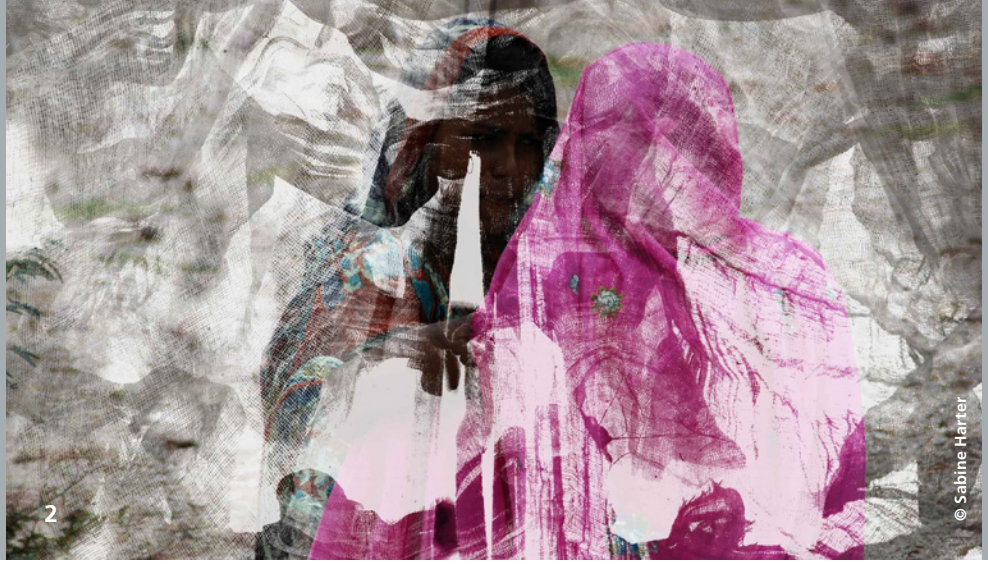
The overall feedback was very positive: Besides the open and friendly atmosphere, students were impressed with "all the places where mathematics can be used in practice throughout industry" and how interesting and exciting the fields of application really are. In particular, the math students gained a lot of motivation and inspiration for their studies and career planning and this included the doctorate program at ITWM. However, even the other visitors, who see their professional future more in business and less in research, will remember Fraunhofer "as an innovative and exciting workplace environment."

1 *Posters for DOCH Campaign of Fraunhofer-Gesellschaft*

2 *Group photo with tutors*

3 *The MINT-Café, still without visitors*





1 *Dr.-Ing. Joachim Linn, Oliver Hermanns, Dr.-Ing. Clément Zémerli, Dr. Klaus Dreßler, and Dr. Eder Santana Annibale*

2 *"The two of us" – Title photo for "In the light of India" exhibit*

BEST INTERNATIONAL PAPER AWARD

At the Congress of the Society of Automotive Engineers (SAE) last October in São Paulo, Brazil, Dr. Eder Santana Annibale of the Department of Mathematical Methods in Dynamics and Durability presented a lecture on the topic: "Virtual Design and Dynamical Simulation of Flexible Cables, Hoses, and Wires." For this effort, he and his co-authors were awarded the prize for "Best International Paper." The theme of the conference focused on pioneering technologies in the automobile and commercial vehicle industry as well as in the aerospace industry.

PHOTO EXHIBITION: IN THE LIGHT OF INDIA

"Layers of India," was the title of a series of digital collages by photo artist and Kaiserslautern native Sabine A. Hartert, who captured the diversity and mystery of India. The multiple exposure photographs remained on display for several weeks in the main lobby of ITWM. The opening reception was held in early October and although not literally in the light of India, it was certainly in the spirit of India: Indian food, Indian music ensemble ANUBHAB-ACADEMY from Cologne, and a lecture by Prof. Subbiah Sundar titled "Seen with Indian Eyes," as well as several songs made the opening exhibition an Indian evening. Subbiah Sundar, who teaches at the Indian Institute of Technology (IIT) in Madras, is an alumni ambassador of Kaiserslautern; he studied at the Department of Mathematics at TU Kaiserslautern and makes regular return trips to the Palatinate as a visiting professor.

COMPETENCE CENTER FOR MATHEMATICAL MODELING AT SCHOOL OPENS

In June, the grand opening for KOMMS (Kompetenzzentrum für Mathematische Modellierung in MINT-Projekten in der Schule) was held at the TU Kaiserslautern campus. The event was attended by Doris Ahnen, former Minister of Education, Science, Further Education, and Culture for the state of Rhineland-Palatinate. KOMMS is a research unit of the mathematics department and is supported by Fraunhofer ITWM for the purpose of consolidating school projects, teacher training, vocational education/certification, and research. The center targets its programs for schools and universities in Rhineland-Palatinate. Doris Ahnen cited in her speech the pioneering role of earlier mathematicians in Kaiserslautern and praised their foresight regarding the importance of the field of modeling.

KITA: BUILDING EXTENSION INAUGURATED

Ever since the opening day in January 2006, the day care center "Klammer@ffchen" on Tippstadter Straße has enjoyed widespread acceptance at the Fraunhofer Center. At that time, the facility was large enough for two groups of ten children each ranging in age from nine-week old babies to three-year olds. Because of the strong demand, Fraunhofer began work on an extension and the effort was successful: In July, the building was officially opened after a construction period of just one year. The construction provides an additional area of 325 sqm. and room for 30 more children; 16 seats are planned for children from the age of three and upwards to primary school age. The welcome remarks from Vera Reiß, former state secretary, Dr. Marion Schulz-Reese, ITWM Head of Administration, and the Lord Mayor of Kaiserslautern, Dr. Klaus Weichel, at the opening ceremony were embedded in a varied program, designed and performed by children of the day care center with songs and dance along with the participation of some of the actors of the Pfalztheater.

Each of the cozy group activity rooms has an adjoining sleeping area as well as a bathroom with a changing table. There is also a newly created exterior area with a cultivated garden and various playground equipment to have fun on and explore. All 16 teachers have supplemental qualifications in the area of early and preschool education. This ensures individual support and attention to the needs of the child while providing enough space for different projects and activities. The total cost for the project amounted to 715,000 euros and was funded up to 23 % by the state, and 50 % by the city. The remaining 27 % is shared by the Fraunhofer-Gesellschaft and the local Fraunhofer Institutes.

The owner of the facility is the Fraunhofer-Gesellschaft. However, it is managed and maintained by the non-profit "Initiative Kindertagesstätte an der TU Kaiserslautern e. V." The expansion of the day care center is further evidence of the strong commitment of the Kaiserslautern Fraunhofer Institutes to offer their employees a family-friendly work environment. Flexible hours and parental leave, a home office option, organized healthcare events, and sports as well as the parent-child office all contribute toward making the Fraunhofer Center in Kaiserslautern a uniquely attractive employer.

1 *Relaxed atmosphere after a successful opening*

2 *The simple exterior hides a cozy interior.*

3 *The kindergarten teachers at "Klammer@ffchen" day care center*

Viktoria Hieb, Dr. Marion Schulz-Reese, Manuela Hoffmann, Prof. Dr. Dieter Prätzel-Wolters, Prof. Dr. Helmut Neunzert, Prof. Dr. Ralf Korn, Elke Münch, Waltraud Dully, Alexander Basler, Anja Gordon, Brigitte Williard, Sabine Müller, Christian Peter, Ilka Blauth, Mirko Spell, Eva Schimmele, Martin Vogt, Michaela Grimberg-Mang, Dominic Schunk, Sylvia Gerwalin, Dominic Daneker, Gabi Gramsch, Markus Pfeffer, Katharina Parusel, Steffen Grützner, Erik Schnabel, Dieter Eubell, Tino Labudda, Martin Braun, Dr. Elmar Gerwalin, Michael Mannweiler, Klaus Linck

FRAUNHOFER ITWM

www.itwm.fraunhofer.de/en/

DR. MARION SCHULZ-REESE
HEAD OF ADMINISTRATION

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 for 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 Structures, Simulation, Traffic and Transportation, Vision (image processing) and Water Systems.

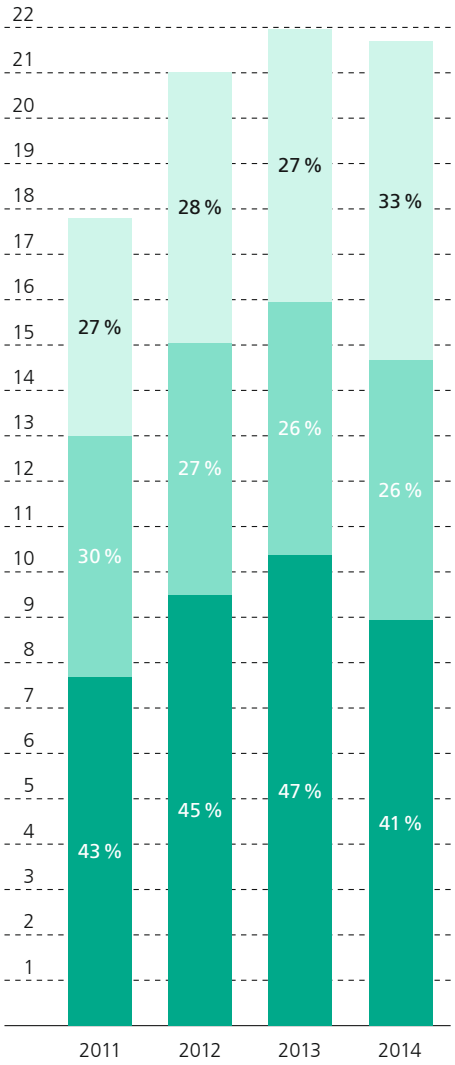
ORGANIZATIONAL CHART

Director	Prof. Dr. Dieter Prätzel-Wolters
Scientific Advisory Board	Prof. Dr.-Ing. Hans Hasse
	Prof. Dr. Axel Klar
	Prof. Dr. Ralf Korn
	Prof. Dr. Helmut Neunzert
	Prof. Dr. Stefan Nickel
Administration	Dr. Marion Schulz-Reese
IT	Dr. Elmar Gerwalin
Public Relations	Dipl.-Math. Steffen Grützner
Competence Center High Performance Computing	Dr. Franz-Josef Pfreundt
Transport Processes	Dr. Raimund Wegener
Flow and Material Simulation	Dr. Konrad Steiner
Image Processing	Dipl.-Inform. Markus Rauhut
System Analysis, Prognosis and Control	Dr. Patrick Lang
Optimization	Prof. Dr. Karl-Heinz Küfer
Financial Mathematics	Prof. Dr. Ralf Korn
Mathematical Methods in Dynamics and Durability	Dr. Klaus Dreßler

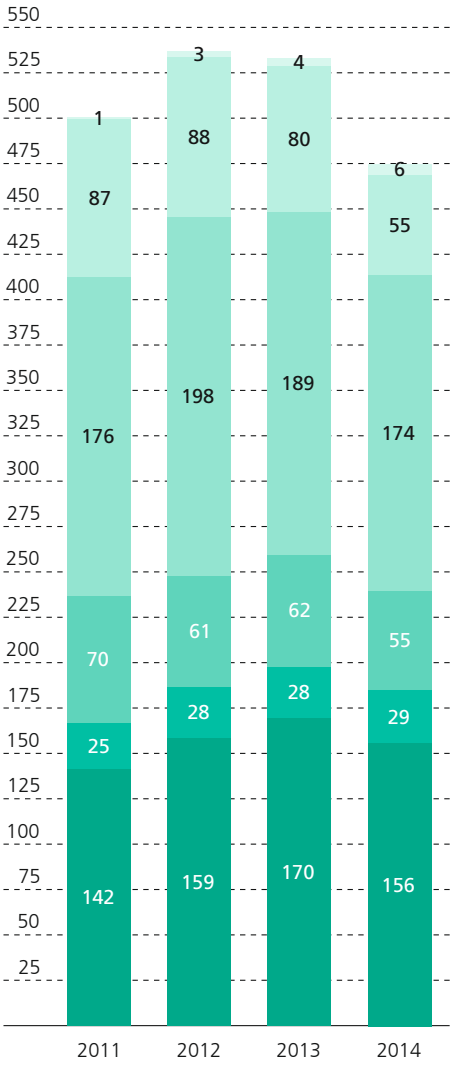
BUDGET AND PERSONNEL DEVELOPMENT

Operation budget in million €

- industry
- public projects
- base funding and Fraunhofer internal programs



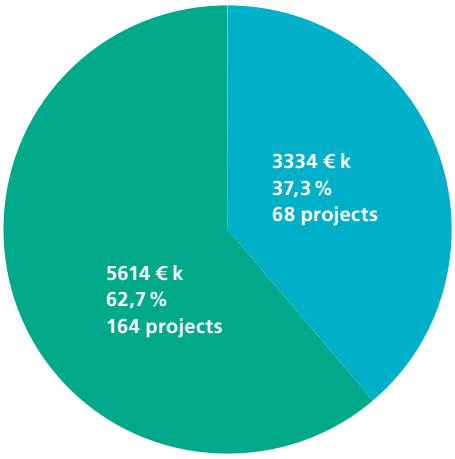
- scientists and technicians
- central services
- PhD students
- research assistants
- interns
- trainees



DETAILS ABOUT THE OPERATION BUDGET (9.0 MILLION €)

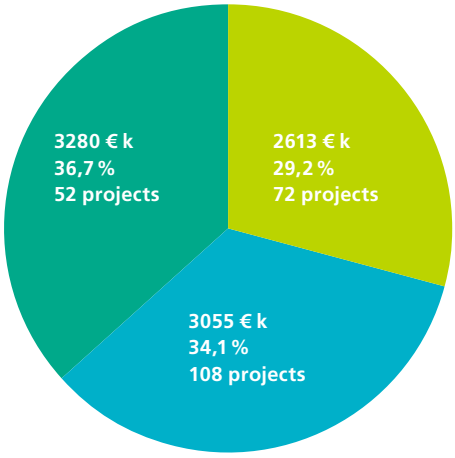
Breakdown by company size

- non-SME
- SME

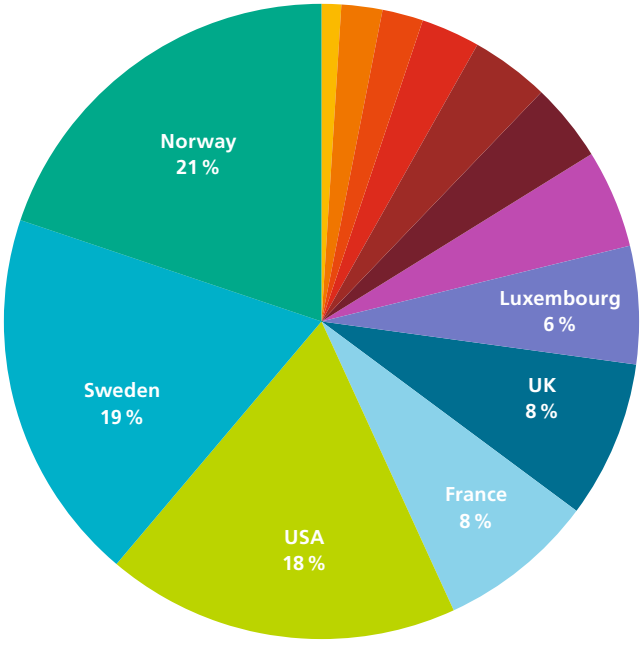


Breakdown by region

- regional companies (closer than 150 km)
- other companies in Germany
- foreign companies



Foreign income by countries



- Switzerland 5 %
- Netherlands 4 %
- Belgium 4 %
- Saudi-Arabia 3 %
- Ireland 2 %
- China 2 %
- Japan 1 %

CUSTOMERS AND COOPERATION PARTNERS SELECTION 2014

- AbbVie Deutschland GmbH & Co. KG, Ludwigshafen
- ACATIS Investment GmbH, Frankfurt
- Accenture CAS GmbH, Kaiserslautern
- Adam Opel AG, Rüsselsheim
- ante-holz GmbH, Bromskirchen-Somplar
- Assyst GmbH, Aschheim-Dornach
- AUDI AG, Ingolstadt
- Autefa, Friedberg
- Autoneum Management AG, Winterthur (CH)
- BASF SE, Ludwigshafen
- BMW Group, München
- BorgWarner Turbo Systems GmbH, Kirchheimbolanden
- Burgmann, Wolfratshausen
- Centrica, Stavanger (N)
- Clean Energy Sourcing AG, Leipzig
- Continental Automotive Systems AG & Co. OHG, Frankfurt/M.
- Cummins, Marktheidenfeld
- DAF Trucks N. V., Eindhoven (NL)
- Daimler AG, Wörth, Stuttgart
- delta h Ingenieurgesellschaft mbH, Witten
- Deutsche Apotheker Bank, Düsseldorf
- Dienes, Mühlheim/Main
- ebm papst, Mulfingen
- EDITA GmbH, Dortmund
- EI-QFM, Kaiserslautern
- EKF diagnostic GmbH, Barleben
- Elsevier Ltd., Kidlington (GB)
- ESB International, Dublin (IRL)
- ESI Group, Paris (F)
- EWE AG, Oldenburg
- Ford-Werke GmbH, Köln
- Frankfurt Trust GmbH, Frankfurt
- Freudenberg Filtration Technologies SE & Co. KG, Kaiserslautern, Weinheim
- Goodyear S.A., Colmar-Berg (L)
- Görlitz, Koblenz
- Grimme Landmaschinenfabrik GmbH & Co. KG, Damme
- Haag-Streit AG, Köniz (CH)
- HegerGuss GmbH, Enkenbach-Alsenborn
- Hilite, Nürtingen
- Hospitals: Frankfurt/M., Essen
- Hubert Stüken GmbH & Co. KG, Rinteln
- Human Solution, Kaiserslautern
- IBS FILTRAN GmbH, Morsbach-Lichtenberg
- Inergy, Brüssel
- Institut für Textiltechnik (ITA), Aachen
- IPConcept und DZ-Bank , Luxemburg (L)
- John Deere, Mannheim, Kaiserslautern
- Johns Manville Europe GmbH, Bobingen
- KITE China, Beijing (CHN)
- Kronos, Leverkusen
- KTM-Sportmotorcycle AG, Mattighofen (A)
- Landesbank Baden-Württemberg, Stuttgart
- Liebherr, Kirchdorf, Colmar (F)
- LONZA Group AG, Basel (CH)

- Lufthansa A. G., Frankfurt
- MAN Truck & Bus Deutschland GmbH, München
- Mann+Hummel GmbH, Ludwigsburg
- Marathon Oil, Houston (USA)
- Massachusetts General Hospital (MGH)/Harvard Medical School, Boston (USA)
- Math2Market GmbH, Kaiserslautern
- Merck KGaA, Darmstadt
- mfd Diagnostics GmbH, Wendelsheim
- Miebach Consulting GmbH, Frankfurt/M.
- MTU Aero Engines GmbH, München
- Nissan, Kanagawa (J)
- NOGRID GmbH, Mainz
- Odenwaldwerke, Amorbach
- Paul Wild OHG, Kirschweiler
- Pfalzwerke AG, Ludwigshafen
- Porsche AG, Weissach
- proALPHA Software AG, Weilerbach
- Procter & Gamble, Cincinnati (USA), Schwalbach, Euskirchen
- Progress Rail Inspection & Information Systems, Bad Dürkheim
- PSA Peugeot Citroën, Velizy-Villacoublay Cedex (F)
- R+V Versicherung, Wiesbaden
- RaySearch Laboratories AB, Stockholm (S)
- Repsol, Houston (USA)
- RJL Micro & Analytic GmbH, Karlsdorf-Neuthard
- Robert Bosch GmbH, Stuttgart
- Rolls-Royce Deutschland Ltd & Co KG, Oberursel
- Scania CV AB, Södertälje (S)
- Schleifring und Apparatebau GmbH, Fürstenfeldbruck
- Schott, Mainz
- Seismic Imaging Processing SIP, Aberdeen (GB)
- Sharp Reflections, Stavanger (N), Kaiserslautern
- SIEDA GmbH, Kaiserslautern
- Siemens AG, Erlangen
- Skytron Energy GmbH, Berlin
- Solvay GmbH, Hannover
- Statoil ASA, Stavanger (N), Trondheim (N), Oslo (N)
- Stryker GmbH & Co KG, Freiburg
- Superon GmbH, Dernbach
- SWK Stadtwerke Kaiserslautern GmbH, Kaiserslautern
- Technische Werke Ludwigshafen, Ludwigshafen
- Teckpro AG, Kaiserslautern
- ThinkParQ, Kaiserslautern
- Uhde Inventa-Fischer, Berlin
- Universities: Bordeaux (F), Bremen, Chemnitz, Freiberg, Freiburg, Heidelberg, Kaiserslautern, Karlsruhe, Kassel, Mainz, Münster, Nancy (F), Paris/Fontainebleau (F), Saarbrücken, Thuwal (KSA), Ulm, Zürich (CH)
- Universities of applied sciences: Berlin, Birkenfeld, Darmstadt, Kaiserslautern, Lübeck, Mainz, Mannheim, Saarbrücken
- Voith Hydro, Heidenheim
- Volkswagen AG, Wolfsburg
- Volvo CE, Konz, Göteborg (S)
- Webasto SE, Stockdorf
- Woltz, Wertheim

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- Dr. Mattias Schmidt, Procter & Gamble Service GmbH
- Prof. Dr. Wolfgang Wahlster, DFKI GmbH
- Dr. Carola Zimmermann, Ministry for Education, Science, Further Education, and Culture in Rhineland-Palatinate

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 Automobile Production Alliance
- Fraunhofer Battery Alliance
- Fraunhofer Big Data Alliance
- Fraunhofer Cloud Computing Alliance
- Fraunhofer Lightweight Structures Alliance
- Fraunhofer Simulation Alliance
- Fraunhofer Traffic and Transportation Alliance
- Fraunhofer Vision Alliance (Image Processing)
- Fraunhofer Innovation Cluster "Digital Commercial Vehicle Technology"

Further cooperations

- Innovation Center "Applied System Modeling"
  The Fraunhofer Institutes IESE, ITWM, IPM (Department Materials Characterization and Testing) as well as the departments of Computer Science and Mathematics at TU Kaiserslautern work in close cooperation at ASM to bring high tech products to market quickly.
- 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 in Kaiserslautern

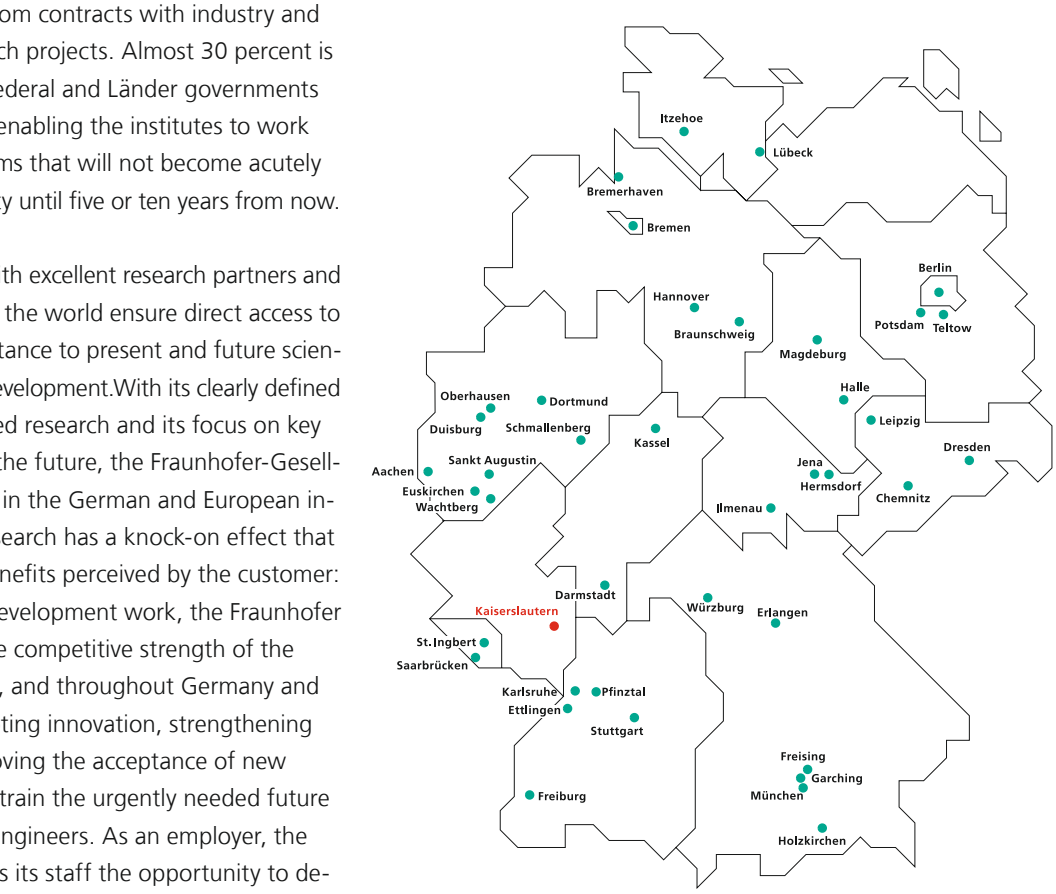
THE FRAUNHOFER-GESELLSCHAFT AT A GLANCE

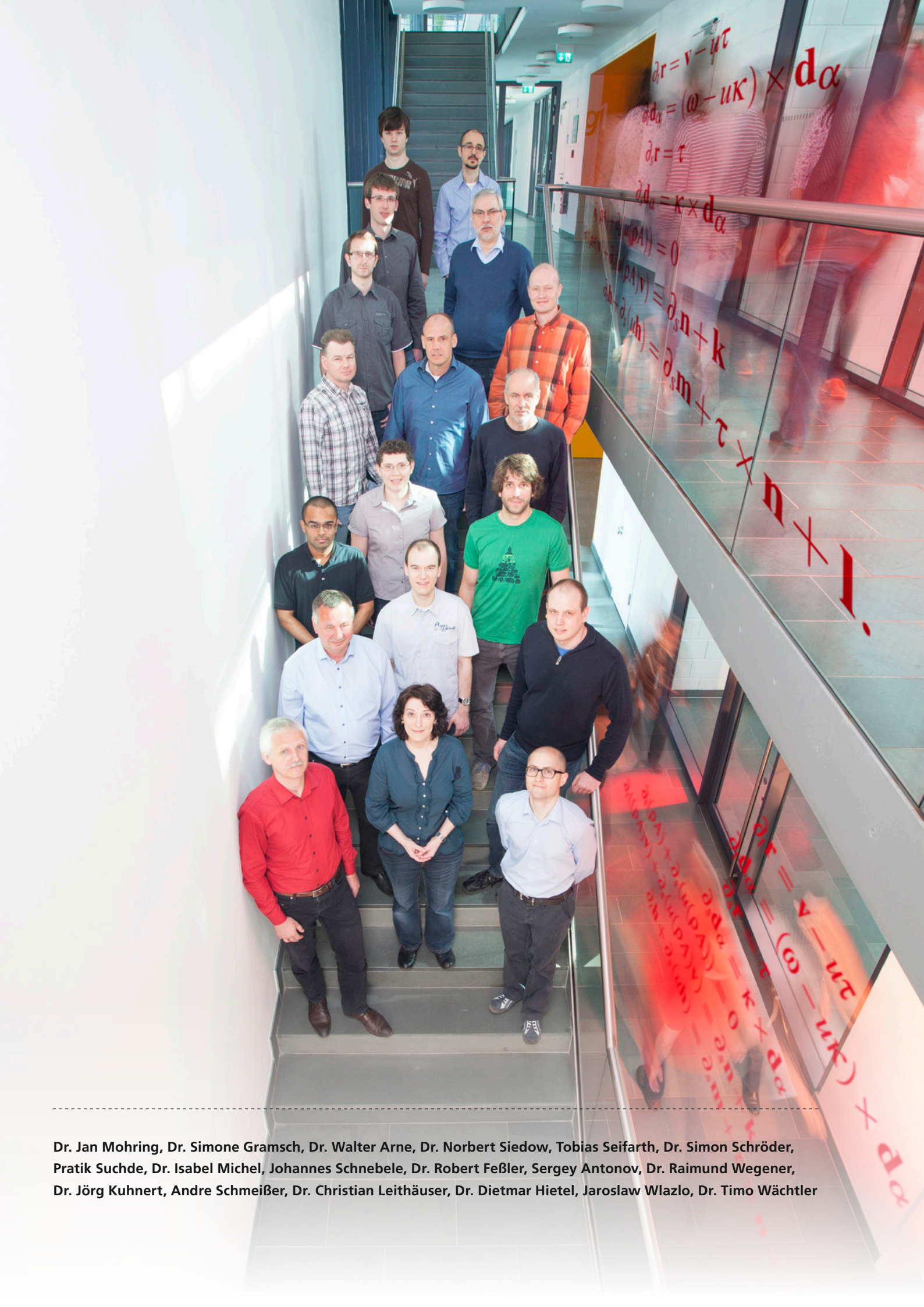
Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual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

At present, the Fraunhofer-Gesellschaft maintains 66 institutes and research units. The majority of the nearly 24,000 staff are qualified scientists and engineers, who work with an annual research budget of more than 2 billion euros. Of this sum, around 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.





Dr. Jan Mohring, Dr. Simone Gramsch, Dr. Walter Arne, Dr. Norbert Siedow, Tobias Seifarth, Dr. Simon Schröder, Pratik Suchde, Dr. Isabel Michel, Johannes Schnebele, Dr. Robert Feßler, Sergey Antonov, Dr. Raimund Wegener, Dr. Jörg Kuhnert, Andre Schmeißer, Dr. Christian Leithäuser, Dr. Dietmar Hietel, Jaroslaw Wlazlo, Dr. Timo Wächtler

TRANSPORT PROCESSES

▪ FLEXIBLE STRUCTURES

Modeling and numerical simulation of flexible structures in turbulent flows, especially fiber dynamics

▪ FLUID DYNAMICS

Simulation and optimization of flows, fluid-structure coupling

▪ GRID-FREE METHODS

Finite Pointset Method (FPM) for simulation of fluid and continuum mechanical problems

▪ OPTICS, RADIATION, HEAT

Design of freeform lenses, heat transfer, diffusion

▪ MODEL REDUCTION

Transfer of huge finite element models to parametric reduced state space models

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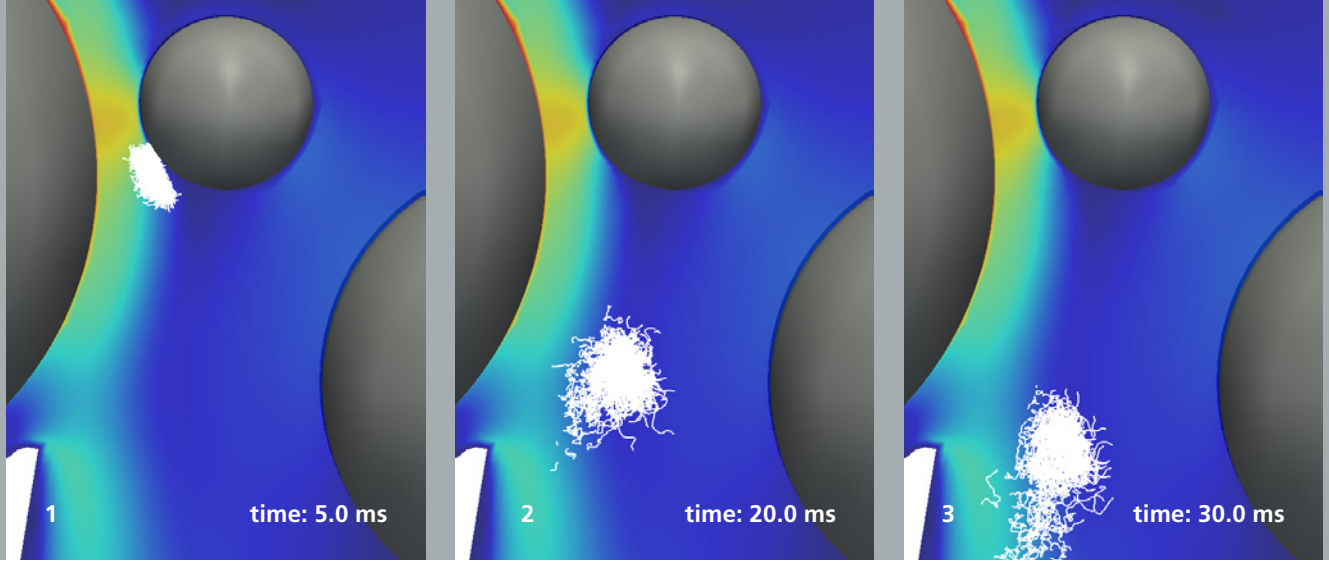
DR. RAIMUND WEGENER
HEAD OF DEPARTMENT

The core competence of the Transport Processes department is mathematical modeling of complex manufacturing problems and the development of efficient algorithms for numerical solutions (simulation). The problems are primarily found in the context of the technical scientific field (fluid dynamics, radiative transport, optics, acoustics, structural mechanics, etc.). They are in terms of mathematics, modeled by differential equations that can be mainly characterized as transport equations. Our customers in the industries are primarily interested in optimization or the technical design of production processes and products. The department provides collaborative research projects with the engineering-oriented R&D divisions of the partner firms, studies that include design and optimization proposals, and concept development as well as software programs from components to complete tools.

2014 was a highly successful business year for the department in the area of contract research. The share of contract research has significantly increased in comparison to previous years. However, acquisition was less successful in the area of public projects and revenues dropped below target expectations. The department acknowledged this as a challenge and applied for new research projects, which has already resulted in the first successes. Consequently, the expectations in this area for next year are very optimistic. Fortunately, publication and conference participation has remained at satisfactory levels in the scientific subjects.

In the last annual report, the focus of the department's contribution was on software development in various subject areas. The main software tools FIDYST (Fiber Dynamics Simulation Tool), as a simulator for filament dynamics, and FPM (Finite Pointset Method) as a meshfree solver for a wide range of problems in continuum mechanics are highlighted once again here, however, with a new focus on continuous development while citing some respective individual applications. This section is supplemented by a research project in the area of medical technology.



FIDYST FOR SIMULATION OF AERODYNAMIC WEB FORMING

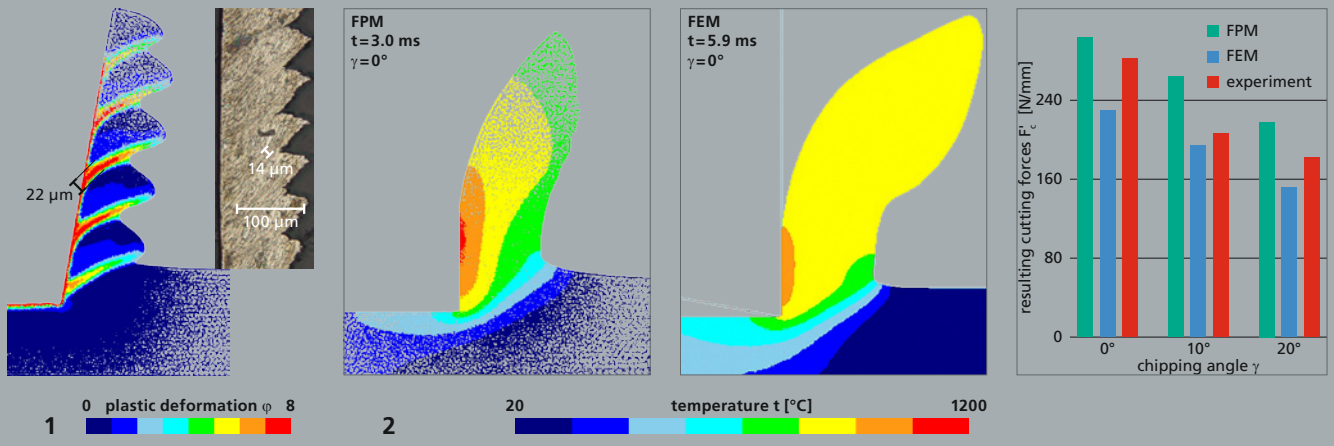
1–3 *Simulation results of the Airlay process K12 (Autefa Solutions)*

What do cosmetic pads, nonwovens sound insulation, and painter's drop cloths all have in common? These are all Airlay products. The applications of nonwoven fabrics are continuously increasing, especially, in the automotive industry. Hence, the demand for the production equipment to manufacture aerodynamic random webs has also increased – and so, also the demand for so called Airlay units from the nonwoven fabrics producers is growing.

An Airlay unit works based on the following principle: First, the supplied raw material, for example, fiber mats made from renewable raw materials or recycled plastic fibers, are pre-opened. Then, the fibers are detached from the rotating cord cylinder and transported in an air stream. The air fiber mixture lands on a conveyor belt where it is compressed by suction. The goal of the nonwoven manufacturers is to produce nonwovens with the greatest volume with the least raw material. Additionally, energy consumption needs to be minimized.

In the BMBF Project OPAL, in close cooperation with machinery manufacturer Autefa Solutions and nonwoven producer Ideal Automotive, Fraunhofer ITWM has simulated the K12 process for an optimal design of the Airlay processes. This involved first simulating the unloaded air flow and then validating these flow simulations by direct comparison measurements at the K12 unit. In parallel with these activities, Fraunhofer ITWM extended the fiber dynamics simulation tool (FIDYST) with a new module for the simulation of staple fibers. To simulate a representative number of fibers, it was necessary to parallelize the fiber dynamics simulations. In addition, Fraunhofer ITWM developed a cluster version of FIDYST to perform and evaluate thousands of fiber simulations on their own in house computer cluster, locally known as the "Beehive". The simulation study with 6,000 fibers with various material parameters took place in Fall 2014, after Ideal Automotive had specified a reference scenario. The first simulation results already provide indications of the fiber distribution on the belt and the homogeneity of the web structure. The investigation of three dimensional web structures regarding homogeneity and the validation of results with CT imaging of the nonwoven produced are the tasks of the OPAL project partners and are presently ongoing.

FIDYST represents a new simulation tool to simulate and optimize an extended range of production processes for technical textiles.



GRID-FREE SIMULATION OF THE CUTTING PRODUCTION PROCESS

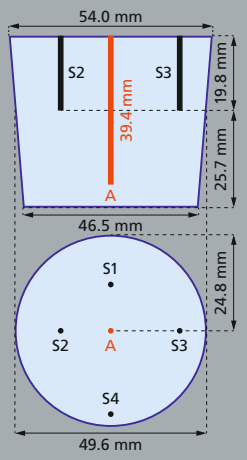
1 *Segment formation through partial material failure (local shear zones)*

2 *Comparison of chip formation in FPM and FEM simulation and experiment*

Cutting processes are used in the manufacturing of almost all mechanically engineered products. Consequently, there is a large potential for optimization. The interesting issues concern both process characteristics (e. g., cutting loads, chip shape, wear and tear on the tools, etc.) as well as product properties (e. g., residual stress after machining, surface finish, microstructure, edges, etc.). The criteria listed here are mostly empirically adapted in everyday industrial situations. Currently, the simulation of machining operations is used mainly in technical research environments.

A simulation-based optimization on an industrial scale would offer great advantages, as it would expose all machining processes to the smallest detail (plastic deformation, material failure, chip/edge formation, thermal strain, internal stresses, etc.) and would lead to very effective optimization of the machining processes. This implies the need for a high capacity computer model. As part of the DFG project "Use of the Finite Pointset Method (FPM) in the simulation of chip formation" and in cooperation with the Institute for Machine Tools and Plant Operations (IWF) at TU Berlin, ITWM has developed a simulation method for the chipping production processes that satisfies the requirements mentioned above better than any previous tool. The numerical basis for such a simulation is the so called Finite Pointset Method, a grid-free method in continuum mechanics developed at ITWM that has already achieved successes in the areas of airbag inflation, glass forming, tank/silo filling, vehicle design, and turbine design.

Efforts in the area of machining have concentrated on adapting the FPM solver for dynamic behavior in metallic materials and integrating a liquid coolant or lubricant phase in the simulation. The focus of the next development phase will be on coupling the machining with the so called minimum quantity coolant or lubricant. Here, a spray of liquid droplets is used instead of a compact liquid for the cooling phase. This forms a film on the work piece surface or on the chip. Cooling effects occur mainly through evaporation in conjunction with conventional heat transfer. This creates new challenges for mesh-free FPM simulations. In addition to the work piece and the tooling stage, we now have to model the surrounding air and spray as a 3D phase. Furthermore, the resulting film must be modeled with all effects (heat transfer and evaporation) as further phases (2D manifold). Ultimately, all five phases will be numerically coupled with each other.



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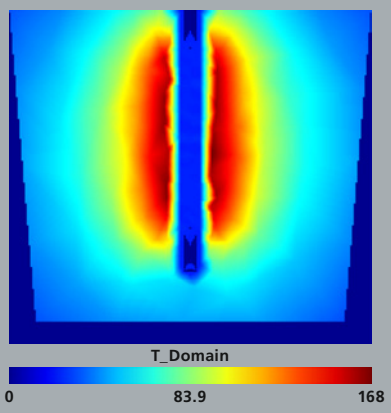

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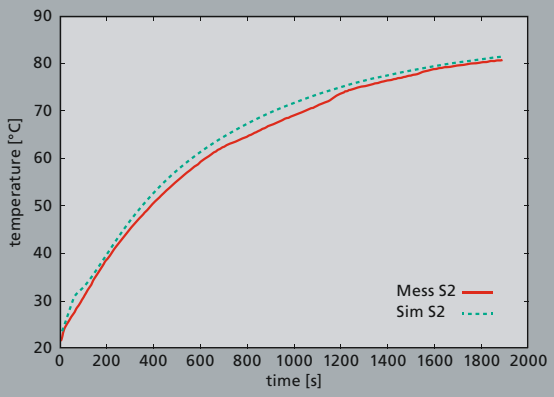

3

LASER INDUCED THERMOTHERAPY

The magnetic resonance controlled, laser induced, interstitial thermotherapy (LITT) is an established procedure for the minimally invasive ablation of various tumors. In LITT, laser energy is directly introduced through optical fibers directly into tumor and destroys the tissue through denaturation of the proteins. In order to control coagulation in the tumors and the application of energy during the therapy, a visualization of the temperature curve during the therapy is essential. Magnetic resonance thermometry and computer simulation can be used to plan, control, and regulate the LITT.

In collaboration with the radiology department of the University Hospital Frankfurt/Main, the DFG project "In vitro temperature determination and computer simulation of temperature distribution for the optimal planning and control of laser induced thermotherapy" uses a mathematical model that reflects the practical approach of LITT. The energy input of the laser into the tissue is modeled by coupling radiation transport and heat conduction equations. The MR compatible laser applicator is water cooled, to prevent excessive tissue temperatures close to the applicator, which permits the treatment of much larger tumors. The cooling effect is mathematically implemented by the boundery conditions of the heat transfer equation. The goal of the dynamic simulation is to localize the time for the destruction of tissue by the heat energy generated by the laser. The destruction of the tissue cells is a chemical process that converts tumor tissue into coagulated tissue while taking the thermal history into account. The damage function is described by activation energy and a frequency factor in the Arrhenius equation. The solution of the coupled radiative heat transfer system requires efficient numerical methods. This is even more important for the inverse problem of parameter identification, where the direct problem has to be solved many times for different parameters.

Software for the efficient dynamic simulation was developed in the project. A Finite Element-program provides the basis whereby the key areas around the applicator can be dissolved much finer than the more distant areas. Large blood vessels are taken into account by a Robin boundary condition. The simulation software also accounts for the fact that more applicators are used in the effective treatment of tumors in clinical trials. Comparisons of the temperature values between simulation and the measurements on a phantom are in good agreement.

1 *Phantom design (A: Applicator, S1-S4: Temperature sensors)*

2 *Temperature simulation*

3 *Temperature comparison of simulation and sensor 2 readings*

Prof. Dr. Oleg Iliev, Dr. Aivars Zemitis, Dr. Torben Prill, Dr. Stefan Rief, Inga Shklyar, Dr. Sarah Staub, Dr. Matthias Kabel, Dr. Ralf Kirsch, Christine Roth, Jonathan Köbler, Dr. Sebastian Rau, Dr. Konrad Steiner, Tobias Hofmann, Dr. Dariusz Niedziela, Dominik Gilberg, Dr. Heiko Andrae, Dr. Sebastian Schmidt, Dr. Jochen Zausch, Dr. Katherine Leonard, Alexander Leichner, Maxim Taralov, Vassilena Taralova, Dr. Sven Linden, Simone da Vita, Dr. Rolf Westerteiger, Sebastian Osterroth, Ruturaj Deshpande, Dr. Petr Zakharov, Dimitar Iliev

FLOW AND MATERIAL SIMULATION

▪ MICROSTRUCTURE SIMULATION AND VIRTUAL MATERIAL DESIGN

Structure-property-relationship and design of porous media and composites

▪ HYDRODYNAMICS AND CFD

Numerical simulation of flow through porous media on multiple scales

▪ COMPLEX FLUIDS

Computational fluid dynamics of complex fluids: fluid and bulk material handling in process technology

▪ MECHANICS OF MATERIALS

Multi-scale simulation of composites: Calculation and optimization of deformation, stiffness, compressibility and resilience

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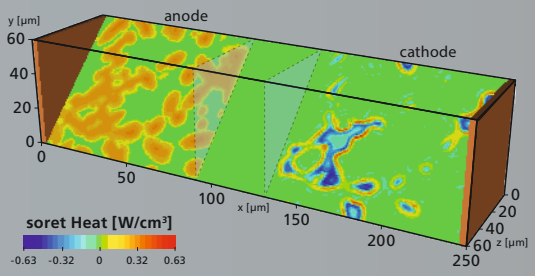
DR. KONRAD STEINER
HEAD OF DEPARTMENT

The Flow and Material Simulation Department works on multiscale modeling and the development of efficient and robust simulation methods as well as software tools for the integration of virtual material design in product development and process design by means of microstructure simulation. This department's strength lies in the development, provision, and specific use of multiscale and multiphysics methods and customer-specific software solutions suitable for industrial application.

Modeling and simulation of the production processes (mixing, dispersing, injection, filtering, coating) of complex composites or hybrid materials are being integrated more and more into the virtual design process. The simulation challenge of the mutual influences of manufacturing processes and restrictions with the multifunctional, local material properties of complete components when under dynamic strain are typical for many applications. The department's ongoing integration and combination of microstructure simulation technology with conventional manufacturing and system simulations for complete components or instruments employ multi-scale approaches. This opens up a variety of application projects, specifically in the design of technical filters or, for process engineering equipment and machinery in general, from innovative batteries or fuel cell systems to the functional design of fiber and particle reinforced, lightweight construction materials.

The Flow and Material Simulation Department completed several major research projects and five doctorates as well acquiring many follow-on industrial projects in 2014. New BMBF and AiF projects have been started in the subject area of optimization of porous material structure, for example, batteries and fuel cells as well as in the area of lightweight construction with fiber-reinforced plastics and natural fibers. The large number of follow-on projects in the area of industrial contract research has resulted in a high order backlog and the high expectations that 2015 will be another very successful year. Scientific cooperation in Kaiserslautern has been significantly intensified by the launch of the second phase of the Innovation Center for Applied System Modeling and the continuation of the Research Center $(CM)^2$ at TU Kaiserslautern, specifically with the Chairs of the Mathematics and Mechanical and Process Engineering Departments. Additionally, there are also agreements for joint contract work with industry.



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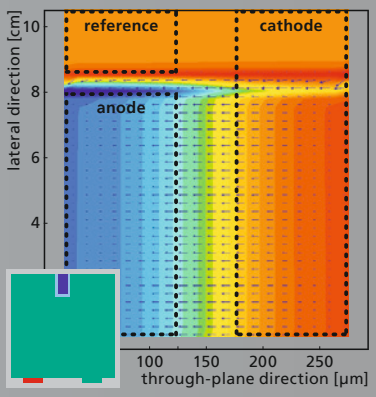

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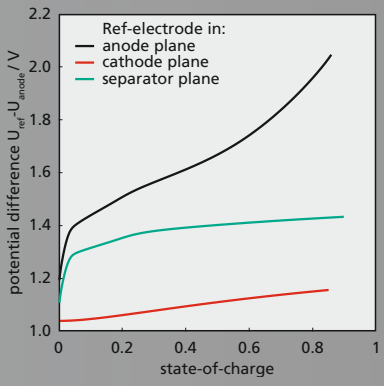

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BATTERY CELLS WITH INTEGRATED SENSOR SYSTEMS: SIMULATION AIDED CONCEPT DEVELOPMENT

The strong increase of electromobility demands the continued development and improvement of the key component of an electric car: the electrical energy storage. The main effort is currently focused on the lithium ion accumulator technology. While these batteries provide high specific power and energy densities, the automobile sector, in particular, demands high standards of safety and durability. Consequently, a good thermal and electrical battery management system (BMS) is necessary. The more precisely the status of individual cells within a battery pack is known, the better the BMS can ensure the safe and continuous operation of the pack. One aspect of the collaborative "TopBat" project ("Temperature optimized battery component with instrumented cells") is concept development and testing of cells that are individually equipped with voltage and temperature sensors. The aim is a sensor integration with the least possible impact on battery performance.

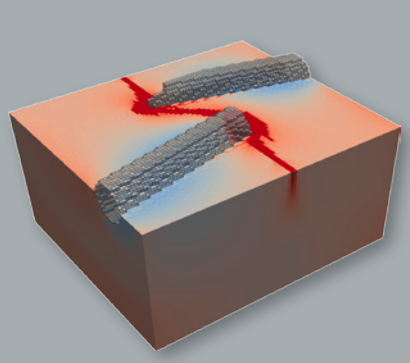
Electrical potential measurements help to evaluate the so called plating risk – a degradation process, in which metallic lithium is deposited that lead to a dangerous short circuit within the cell. In addition to the two battery electrodes (anode and cathode), a reference electrode is introduced in the cell through which no current flows and which serves the sole purpose of measuring the electrical potential. It is the idea of project partner Fraunhofer ISIT to manufacture this reference as porous electrode similar to anode and cathode. This ensures an easy integration into existing manufacturing processes. The aim of this project is to use computer simulations to study what the geometry of such an enhanced cell must look like (position and size of the reference electrode) in order to provide useful measurement results. Accordingly, the ITWM simulation software BEST (Battery and Electrochemistry Simulation Tool) was expanded and used for the corresponding simulation studies. BEST is based on a set of partial differential equations that describe the processes within a lithium ion battery. These are solved three dimensionally for a realistic cell. This allows to calculate the reference potentials and to assess in detail how they relate to the plating risk.

The computation of heat generation and its interaction with the battery performance is another major focus of the project. This is why a thermal-electrochemical battery model has been integrated in BEST, to allow for the determination of the local temperature distribution. This is of great value e. g. for the interpretation of cell-internal temperature measurements.

1 *Cut through an electrode's microstructure showing an inhomogeneous heat distribution.*

2 *Cross section of a pouch cell showing the electrolyte's lithium ion concentration (arrows indicate ion flux). Inset: top view of the cell.*

3 *Computed potential difference between reference electrode and anode for different positions of the reference within the cell's foil stack.*



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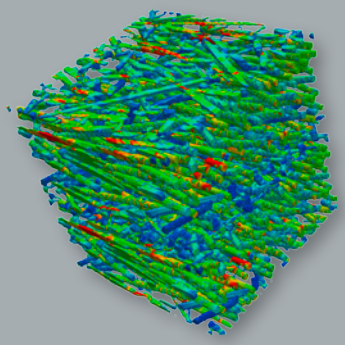

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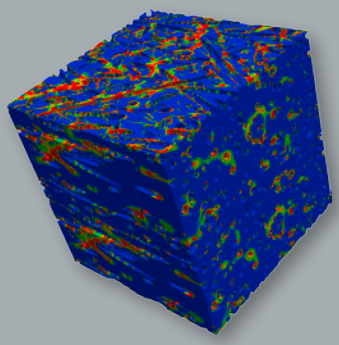

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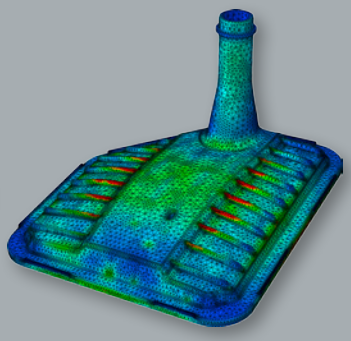


4

ADAPTIVE APPROXIMATION METHOD FOR MULTI-SCALE SIMULATION OF NONLINEAR BEHAVIOR OF COMPOSITES

1 *Simulation of local damage, matrix damage consisting of micro cracks, red zones high damage, blue zones low damage*

2 *Virtual microstructure of short fiber reinforced plastics generated with GeoDict software; mass fraction of glass fibers 30%, stress distribution in fibers*

3 *Matrix damage, red zones high damage, blue zones low damage*

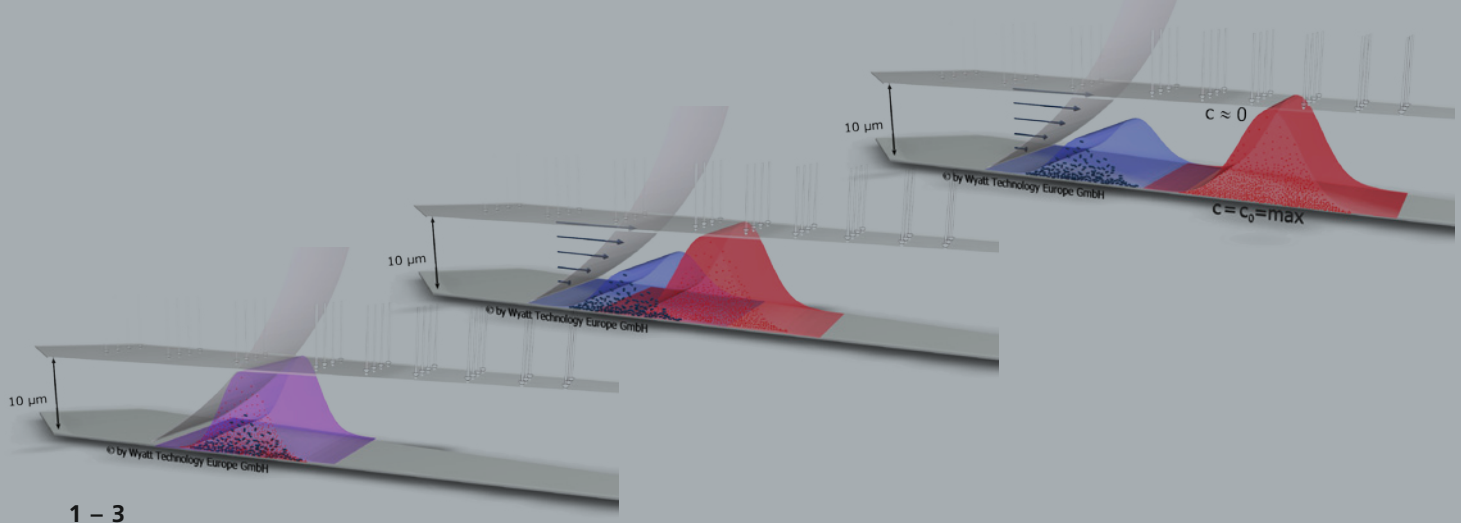
4 *Stress distribution in filter housing of Filtran company under internal pressure, red zones high equivalent stress, blue zones low equivalent stress*

In lightweight construction – as well as in the automotive and consumer segments (e. g., drill housings) – fiber reinforced plastics are increasingly replacing metals as the work material. Predicting the strength and damage effects of these components regarding the directional dependency of the mechanical material characteristics is complicated. Therefore, complex multiscale simulations are required for accurate predictions. The computational time (CPU time) and the computer memory requirements are very high for these multiscale simulations.

At ITWM, we are working on methods to reduce these high computational efforts on the basis of so-called configurational forces. With these forces, macroscopic indicators can be defined, that will allow to take into account the microstructure precisely only in necessary subdomains of the component.

Standard forces describe the external factors that act to deform a fixed object. The configurational forces, in contrast, capture the effect of the microstructural inhomogeneity on the deformation. We use simple and fast homogenization methods for subdomains of the component where the influence of the microstructure is insignificant, whereas, in areas where the microstructure has a greater influence on the strength, more expensive and more accurate methods are required. Depending on the subdomain, these may include: boundary element methods, finite element methods, or the Fast Fourier Transformation of the Lippmann-Schwinger equation. Having this adaptive choice of microstructural solvers, a very high accuracy can be achieved with lower requirements for memory and CPU.

Together with the Chair of Applied Mechanics at TU Kaiserslautern, Fraunhofer ITWM is developing indicators for the selection of a micro solver based on configurational forces and, also, an interface for the scale coupling. ITWM is developing a fast microstructure solver called “Feelmath” for use with areas that require the high resolution of a complex microstructure. BMBF is the sponsor of MuSiKo, a collaborative research project involving the Institute for Applied Mathematics and the Chair of Applied Mechanics at Saarland University, as well as the Institute for Applied and Numerical Mathematics at Karlsruhe Institute of Technology. Additional support for the project is provided by industrial partners Robert Bosch GmbH and Siemens PLM Software.



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MODELING AND SIMULATION OF FIELD-FLOW FRACTIONATION

Asymmetrical Flow Field-Flow Fractionation, AFFFF, and Electrical Field-Flow Fractionation, EFFF, are simple, efficient and robust approaches for separation of nano- and micron-size particles in solutions and dispersions.

AFFFF technology is well developed and widely used by industry and academia. It exploits the interplay between diffusion and flow filed for particles with different hydrodynamic radii. A leading product in this area is ECLIPSE from Wyatt Technology Europe GmbH. The design of ECLIPSE is based on a careful analytical study of fluid flow and of separation in a microchannel. .

Further improvement in the design and the performance of the fractionation devices can be achieved via mathematical modeling and computer simulation. Three dimensional flow simulations allow for obtaining a detailed view on the flow within the spacer, as well as on the particles transport there. Compared to the analytical considerations, the CFD (Computational Fluid Dynamics) simulations provide more detailed information in the case of complicated geometry, or complicated flow control. This information supplements the analytical considerations in optimizing the flow regimes and in further improving the design and the performance of the device. In particular, simulations with different size and/or location of the injection pipe, with different number and size of the outlet pipes, allow for analyzing the influence of these parameters on the important components of the process, such as the size and shape of the focusing area, symmetry, magnitude and separation of the peaks in the fractogram, etc. CFD simulations allow for precise location of the focusing zone for each reasonable flow rate distribution for any selected shape and size of the spacer. It is well known that the size and the shape of the focusing area influences significantly the particles separation during the elution stage, and therefore its study is important in further improving the design of the fractionation device. Furthermore, the simulation, combined with properly optimized flow control, allows for optimizing the density of the sample in the focusing zone, what is especially important in the case of hollow fiber where the small focusing area can result in high sample concentration, and thus undesirable agglomeration of particles/moleculae.

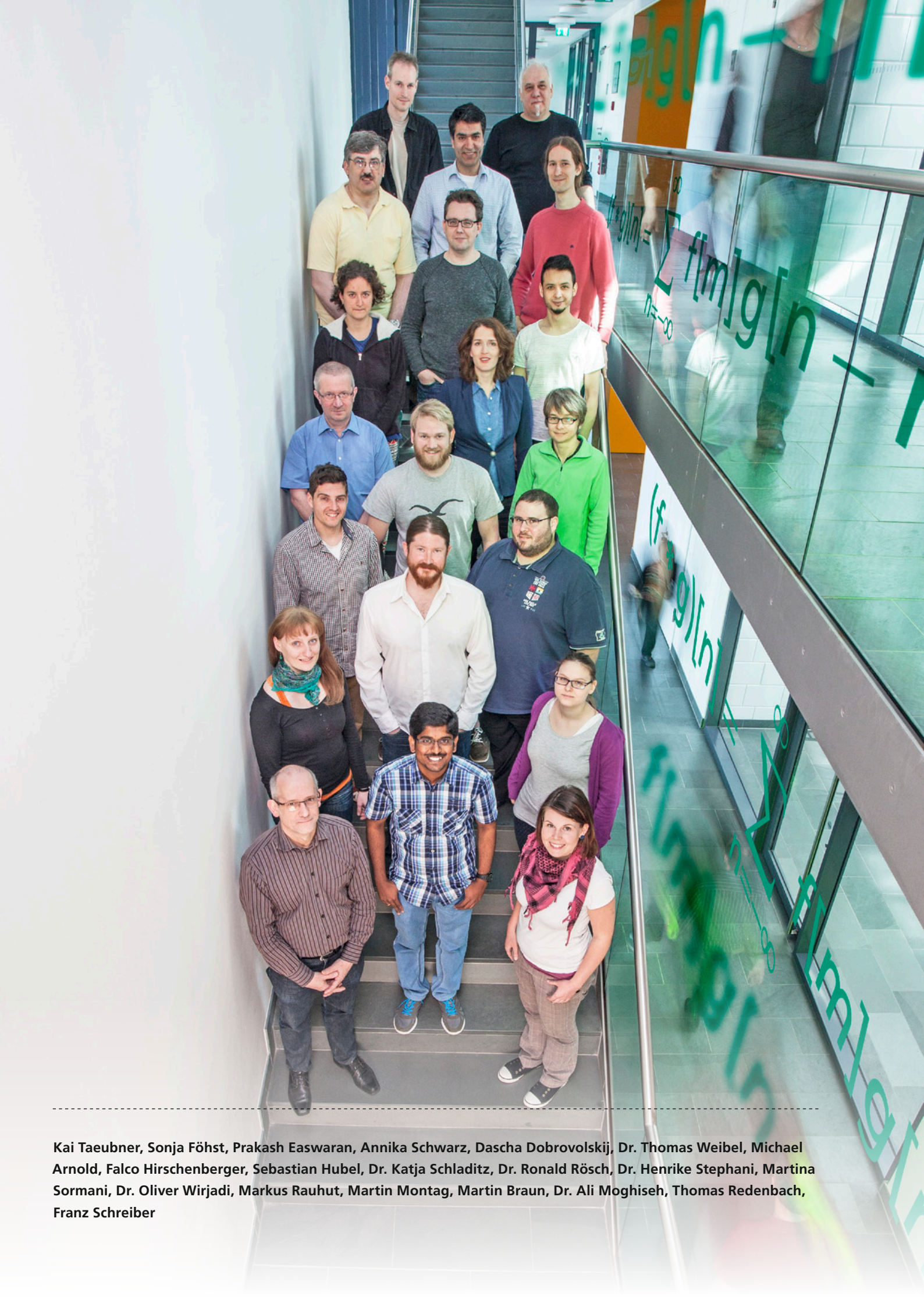
EFFF technology is very useful for separating particles with the same size (which can not be therefore separated by AFFFF), but with different electrical properties. A combined EFFF and AFFFF approach allows to separate broader class of particles and to reduce the number of devices used in a Lab. To summarize, CFD simulation is a powerful approach for evaluation and pre-selection of designs and flow control, without building expensive prototypes.

Schematic representation of the AFFFF process: Particles having different hydrodynamic radius and thus different diffusion are separated based on the interaction between a horizontal parabolic flow and the interplay between the diffusion and a vertical cross flow.

1 *Initial stage: The different size particles are mixed, the particle distribution functions overlap.*

2 *The distribution functions for the different size particles start to separate with the time because the smaller particles have larger diffusion coefficient which lifts them in the area of higher horizontal velocity.*

3 *The goal is achieved, when the two types of particles are separated.*



Kai Taeubner, Sonja Föhst, Prakash Easwaran, Annika Schwarz, Dascha Dobrovolskij, Dr. Thomas Weibel, Michael Arnold, Falco Hirschenberger, Sebastian Hubel, Dr. Katja Schladitz, Dr. Ronald Rösch, Dr. Henrike Stephani, Martina Sormani, Dr. Oliver Wirjadi, Markus Rauhut, Martin Montag, Martin Braun, Dr. Ali Moghiseh, Thomas Redenbach, Franz Schreiber

IMAGE PROCESSING

▪ SURFACE INSPECTION

Online-evaluation of the optical appearance of industrial products

▪ MICROSTRUCTURE ANALYSIS

Characterization and stochastic modeling of microstructures based on 3D image data

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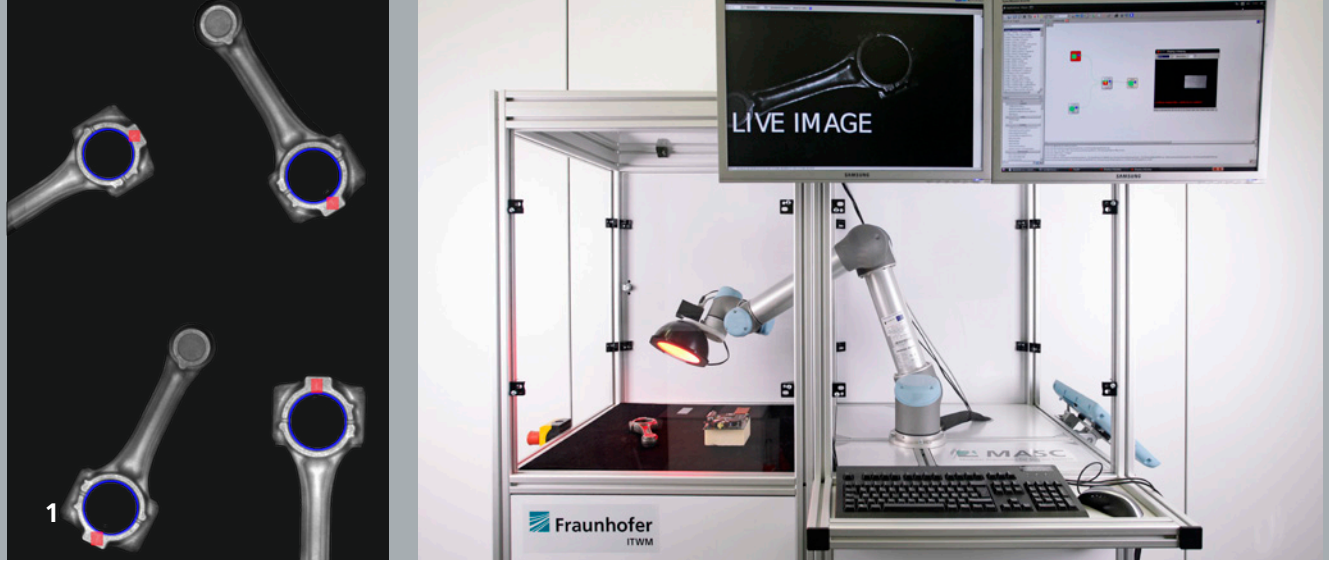
MARKUS RAUHUT
HEAD OF DEPARTMENT

Image processing has become an important element of industrial production. For several years now, inspection systems have been a direct part of the planning for a production line, as opposed to a retrofitted installation. One of the most important quality assurance measures now, in particular, is the surface inspection, or the checking of the optical appearance of a product. The faults detected may be either functional or aesthetic. It is especially difficult, with aesthetic "errors" to represent a subjective feeling as a mathematical model. Last year, the department was able to carry out many such projects, which indicates the strong growth in the areas of quality assurance and optimization.

The department continued to develop surface inspection systems, ultrasonic inspection systems, as well as simulation software for use in these areas, for example, for determining the POD (Probability of Detection) and in 2014, again successfully introduced them into operations. The aim of the associated projects was always to achieve 100 % control of production, this means inline detection of defects and continuous monitoring of the process stability. Another focus field is surface and material characterization. The micro and nano structure of modern materials substantially determines their macroscopic material properties. The division develops algorithms for the characterization and stochastic modeling of such micro structures on the basis of 3D image data. Analysis of the spatial geometry and structural characteristics of materials opens up new possibilities for the optimization of material properties through virtual material design. Specific projects completed included the microanalysis of fiber reinforced composites, the particle analysis in the micro-injection process, and 3D reconstruction of porous materials using FIB-SEM tomograms (Focused-Ion-Beam/Scanning Electron Microscopy). Recently, the department has been working on the issues of image understanding and scene analysis. Broadly speaking, this involves the automated understanding of image content. Specifically, the department has performed the following projects: locating visually similar and identical content in the videos from a database and, the detection of objects in camera images stored in a database, for example, from smart phones; and, the collection and analysis of camera images of urban areas, for example, the recognition of road signs and street names.

In summary, the department once again closed out the year successfully after close cooperation with partners in industry and research in the development and implementation of custom solutions in the field of image/signal processing and ultrasonic imaging. The two image processing software packages – MAVI and ToolIP – continued to have many customers in industry and research.



AUTOMATIC INSPECTION OF NON-LAMBERTIAN SURFACES WITH 4D LIGHT FIELDS

The optical inspection of components with non-Lambertian surfaces represents a major challenge. As the geometric complexity of the parts increases and the specularity of the surface rises, so too grow the requirements for a capable inspection system. Figure 1 shows how the surface of an object, depending on the viewing angle, may sometimes have a strong specular or a diffused reflection.

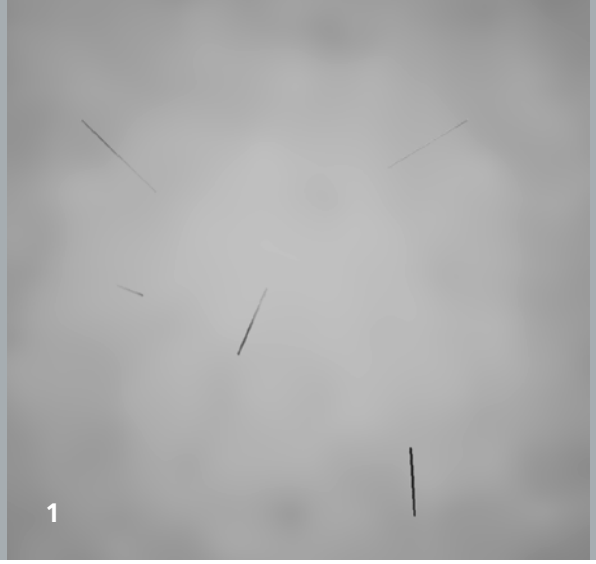
A new approach being developed by the department enables robust fault detection on complex surfaces, even with an unknown translation and rotation of the part. The images from four dimensional light fields enable the capture of the reflection intensities at each pixel on the image plane depending on the viewing angle. Figure 2 shows a maximum projection from the 2D sub-space of the reflections in the usual 2D image plane. This is independent of position and orientation of the image space constant and, in many cases, allows simple, but robust fault detection. Similarly, a 4D illumination field contains implicit 3D object geometry. Using innovative reconstruction algorithms, a robust 3D surface can then be calculated where traditional stereo algorithms would fail because of surface specularity.

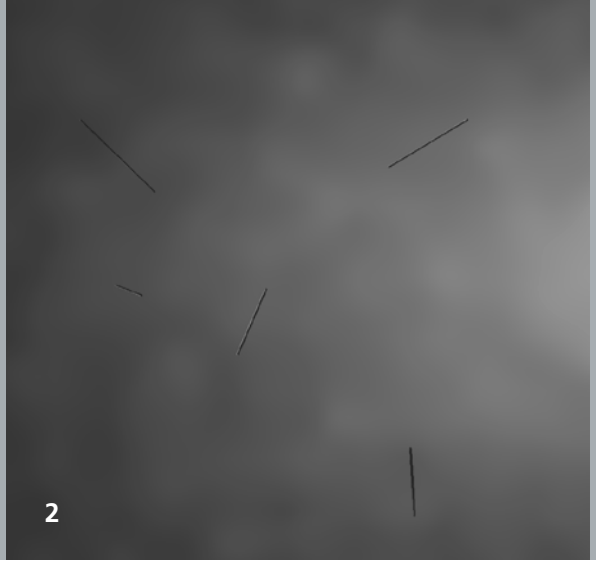
So called light field cameras that capture the light fields have been available on the market for quite some time. They use various arrays of micro lenses near the camera chip. The incident light beams which map onto an image point from different directions can then be distributed over several pixels. In this way, a 4D light field can be reconstructed in the camera plane. A disadvantage of this approach, however, is that both the measurement range and the resolution of the angle of incidence are restricted by the optical structure. This explains why the ITWM approach is different: we use a virtual light field camera. In this case, prior knowledge is required (for example, CAD data) about the object to be inspected, in order to calibrate a virtual camera plane for the object surface. A traditional camera and a diffused light source are then guided around the object using a robot. The 4D light field is then calculated using the captured 2D images.

Now the defects can be seen in this light field based on differences in texture, reflective properties, or 3D geometry. It is possible to use local features or statistical methods for this step. As these evaluations, depending on the properties, always take place in different, but always two dimensional sub-spaces of a 4D light field, conventional methods of 2D image processing can be applied.

1 *Examples of non-Lambertian surfaces: Depending on the positioning of camera and lighting, defects are sometimes poorly and sometimes well detected.*

2 *Design of a system to measure 4D surface light fields: The robot moves the standard components around the test object. The 4D light field can then be calculated using the individual shots.*





SIMULATION OF SURFACE DEFECTS BY MEANS OF RAY TRACING TO DETERMINE THE PROBABILITY OF FAULT DETECTION (POD)

1 *Virtual image produced by bright field imaging; cracks are difficult to see with the naked eye.*

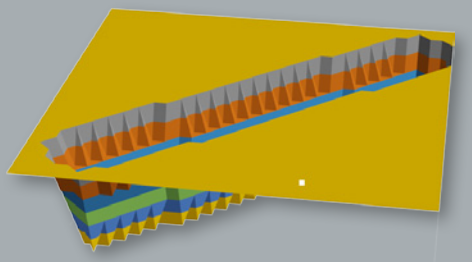
2 *Virtual image produced by dark field imaging; cracks are much easier to see than in figure 1*

The capability of achieving the detection rate and probability as defined by the end user is what decides whether the optical inspection system will ever be used in practice. One of the ways to quantitatively define this parameter is provided by the â versus a analyses, which give the probability of fault detection (POD). A POD analysis facilitates the quantitative calculation of a safe minimum detectable fault size. One method of evaluating POD analysis for optical systems is to create a test piece with target faults incorporated, for example, channels or grooves to describe cracks and fissures. However, because of the huge diversity, this method is able to cover only a small portion of the possible defects. To account for this, we have developed a process that uses ray tracing for a realistic simulation of surface defects. The images generated in this way allow a POD analysis on the basis of a large number of defects. POD analysis is an important tool for generating quantitative statements, for example, "This inspection system is guaranteed to detect faults down to 0.1 mm."

We applied the internationally accepted approach to POD analysis as it is defined in a manual published by the US Department of Defense (MIL-HDBK-1823). It is based on the assumption of a standard normal distribution of measured values. This assumes a linear dependence of the response signal on the fault size and a constant spread/variance of the measured values.

The implementation of a virtual simulation requires a toolbox that includes the following elements:

- A two camera model for entocentric and telecentric lenses (objective)
- A process to prepare virtual images of materials, i. e., ray tracing; in ray tracing, the rays originating from a (virtual) camera are tracked in a 3D scene. The 3D scene is composed of triangular meshes. One ray is constructed for each image pixel and its intersection with the triangular mesh is calculated. A ray from the intersection point is then calculated to each light source in the scene, which permits a calculation of the brightness of this pixel. We have used the open source "PovRay" as our ray tracer.
- An algorithm to generate virtual defects in the material surface as described by the triangular mesh (our ground truth); we have developed a process to create cracks, which implies that other types of defect are not covered. The algorithm provides elevation maps that are rendered by the ray tracer.
- An algorithm to detect defects in the virtually generated image data; this is a classic detection method. The position of the defect is not known in advance.



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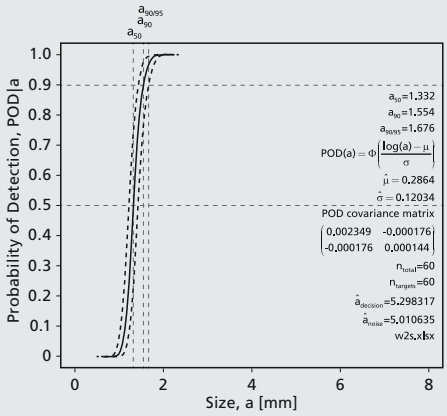

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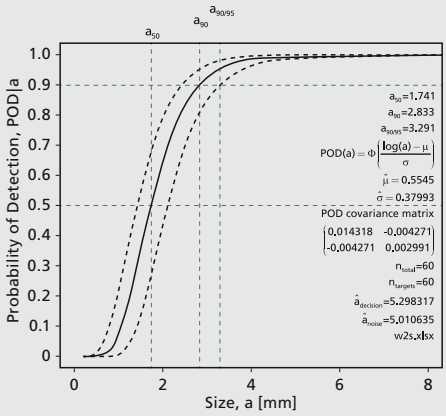

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The detection capability/quality of an image processing system is greatly affected by the illumination design. Variation in the recording angle between camera and lighting makes certain types of defects on the surface more conspicuous and facilitates detection. In simple terms, there are two ways to set the angle between camera and light source: If the light comes from the direction of the camera and is reflected by the test object back in the direction of the observer, it is called a bright field image. This produces an evenly bright, well contrasted image. A dark field image results from the light passing over the optical system; only the diffusion caused by a defect on the surface is visible in the camera image, i. e., the defect appears brighter.

If the simulation is physically correct, different recorded scenes should produce different image qualities. As a rule, cracks are always detected in a dark field image because they are highlighted by this kind of illumination. In comparison to a bright field image, this is usually even visible to the naked eye. Similarly, a quantitative evaluation (e. g., from the POD) should also show better detection rates with dark fields than with bright fields.

Using our toolbox, we have generated 480 datasets with different crack widths and crack depths. The crack depth ranges from 0.01 mm to 0.08 mm (randomly generated). The virtual images were each rendered with a bright and a dark field by the ray tracer. After finding that visual detection of the cracks is better in the dark field than in a bright field, the POD values were calculated. The POD defines the size above which a fault can be reliably detected:

image/width in mm	0,15	0,25	0,35	0,45
dark field/POD in mm	1,67	1,04	0,8	0,62
bright field/POD in mm	3,29	1,56	1,38	1,05

The findings indicate that the POD for the virtually generated dark field images is significantly better, i. e., much smaller defects can be reliably detected.

The first toolbox for virtual image processing has been created and the results correspond to practical experience acquired in the field. Ray tracing is an effective means of generating the virtual camera shots and POD calculations facilitate the quantitative assessment of inspection tasks.

3 *Virtual crack produced as a triangular mesh; elevation map rendered by the ray tracer.*

4 *POD curve of a dark field image at a crack width of 0.15 mm; the figure shows a POD of 1.67 mm.*

5 *POD curve of a bright field image at a crack width of 0.15 mm; compared to figure 4, the POD is much lower at 3.29 mm.*

Dr. Julia Orlik, Tjorben Groß, Dr. Jan Hauth, Hans Trinkaus, Andreas Barthlen, Dr. Patrick Lang, Dr. Andreas Wirsen, Dr. Christian Salzig, Dr. Alex Sarishvili, Anastasia Migunova, Ferdinand Küsters

SYSTEM ANALYSIS, PROGNOSIS AND CONTROL

▪ SYSTEM ANALYSIS AND CONTROL

Development of model based monitoring systems and control strategies as well as their hardware integration

▪ DATA MINING AND DECISION SUPPORT

Development of data based prognosis tools and technology for visual analytics

▪ MULTISCALE STRUCTURE MECHANICS

Numerical algorithms for computing the effective mechanical properties of multiscale materials

www.itwm.fraunhofer.de/en/sys

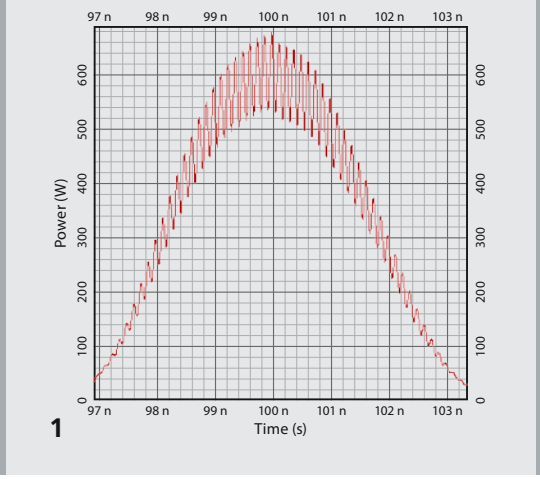
DR. PATRICK LANG
HEAD OF DEPARTMENT

The focus of the System Analysis, Prognosis, and Control department is on products and processes that defy modeling on a purely physical basis because of their complexity and often have to be partially described on the basis of measurement data and expert knowledge. The department relies on its core competencies in system and control theory, data mining, and multivariante statistics as well as in multi-scale analysis methods.

Areas of application are energy systems, projects that deal with the monitoring and stabilization of power generation and transmission, and efforts to increase the energy efficiency in manufacturing. Other significant application areas include: the analysis and verification of the behaviors of electronic control units (in the context of "hardware-in-the-loop") and highly integrated electronic components, often in connection with mechanical components during the design phase. In the Life Sciences group, the analysis and assessment of omics data related to clinical trials play a major role in the diagnosis and prognosis of disease progression, and in assessing the efficiency of a given therapy. The analysis and optimization of manufacturing chains and business processes in terms of quality, error sources, or energy efficiency are another focus of the department. The Material and Product Design group develops models for the prediction, classification, and simulation of product and material behaviors, which are then used as a basis for design decisions. Industrial textiles represent a special focus, where the effective material properties are calculated and optimized on the basis of mathematical homogenization methods.

In each priority application, the department provides consulting services and customer-specific software development as well as specific products. Although during the reporting year, the anticipated volume of public funding was not acquired, the industrial income did increase. With newly acquired contacts in the industrial community as well as the new proposal initiatives that were introduced, a significantly better environment is anticipated for 2015.

The selected projects represent a cross section of the application fields of the department; details are presented concerning the analysis and optimization of a complex electro-optical measurement system, the multi-scale modeling of woven structures, and the consulting support processes.



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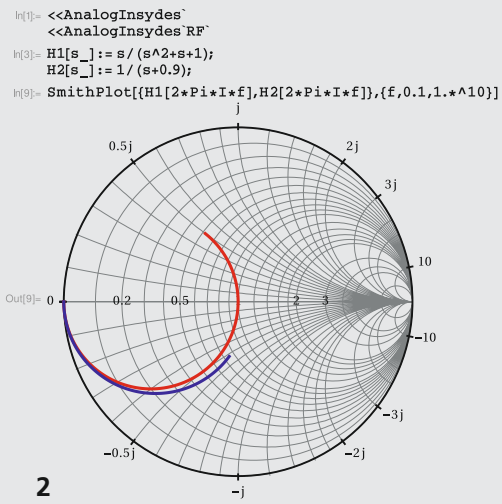


2

SIMULATION OF ELECTRO-OPTICAL SYSTEMS

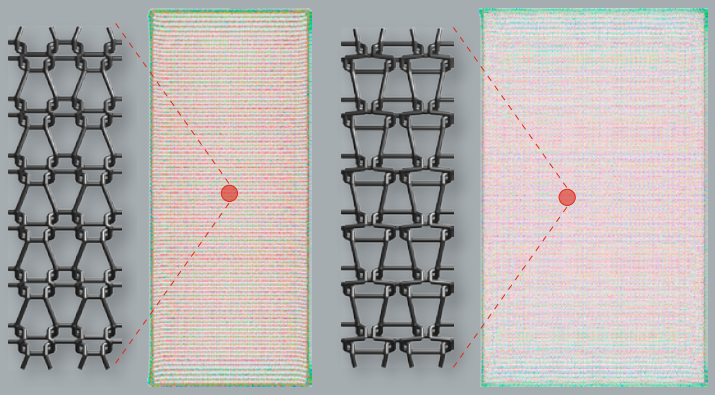
Conventional measurement and analysis methods are limited for high frequency radio signals. Meanwhile, the use of extremely high frequency signals (EHF, millimeter wave) promises new and significant technical potential such as greater transmission rates. Consequently, there is much interest in finding alternative means of measurement and, in this way, supporting the development of new components to generate, transmit, and process ultra-fast signals.

The Fraunhofer Institutes participating in the OptoScope project are extending optical technologies that have been well researched in a variety of projects over the years. The aim is to develop oscilloscopes consisting of electrical and optical components to measure electrical signals in the range over 100GHz and to characterize the transfer behavior of the components operating in this frequency band. For this purpose, an optical pulse is first modulated with the electrical signal to be measured using a recently developed electro-optical modulator. Subsequent to this, the modulated optical signal is time stretched by means of a dispersive component. A Raman amplifier is used to keep the performance of the extended signal above the noise level of the system. The resulting signal now amplified and stretched in time, can be electrified by means of photo-diodes so that it can be recorded using conventional measuring approaches. In a final processing step, the electrical signal measured in this way, can be projected to the high frequency radio signal at the modulator.

The task of Fraunhofer ITWM in this project is to provide the modeling and simulation of both electrical and optical sub-components as well as critical overall system support to Fraunhofer IPM in the design of the prototype. Before the hardware implementation, the functionality of the prototype will be analyzed by means of a simulation. Finally, all parts of the integrated system will be optimized by simulation, so that the first hardware prototype will deliver a good performance right from the start and, hopefully, none of the cost intensive components will have to be exchanged afterwards. In addition to the development of the electro-optical system as a whole, a software package was developed at Fraunhofer ITWM for the EDA tool “Analog Insydes”, which includes the required analytical functions for extremely high frequency radio signals.

1 *Modulated optical pulse; shown with “Optical Time Domain Visualizer”*

2 *SmithPlot of the Analog Insydes packet for the analysis of RF signals*



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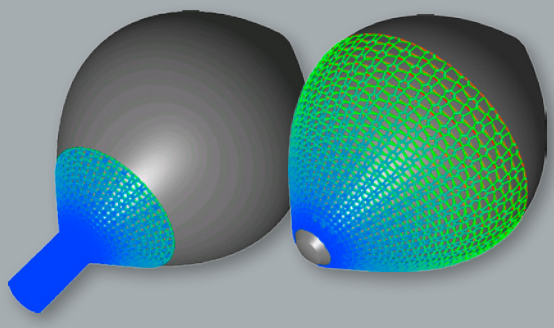


2

MODELING, SIMULATION, AND OPTIMIZATION OF THE MECHANICS OF WOVEN STRUCTURES

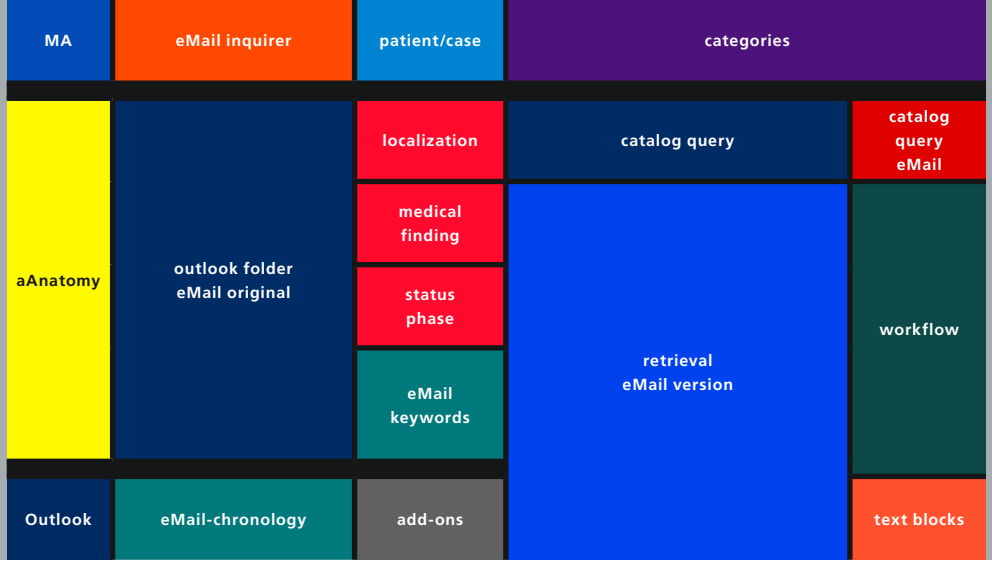
1 *Optimization of the knit geometry relative to the Poisson ratio*

2 *Application of the fabric*

The aim of this joint DFG project with the department of Applied Mechanics at FAU Erlangen is to create simulations to optimize the structure of woven or knitted fabrics, 3D knitwear, and fiber materials with heterogeneous microstructures – with a special focus on the contacts between individual threads or fibers. The consideration of contact leads to a non-linear problem and the different geometric length scales make direct numerical simulation extremely complex. This is why a multi-scale approach has been chosen to facilitate dimension reduction of the problem.

The problem has two small parameters: the first is the relationship between periodic or representative patterns in the fabrics and the overall fabric dimensions; the second is the relationship between fiber (or yarn) diameter and its length. Mathematically asymptotic methods are named homogenization or dimension reduction relative to the first or second small parameter. In homogenization, the aim is a scale separation on the basis of auxiliary problems using a periodicity or representative structural unit cell to facilitate the derivation of the overall effective material behavior of the fabric. A dimension reduction (asymptotic in terms of the fiber thickness) reduces the fabric to a beam network, where the total displacement can be computed as a superposition of the stretch, bending, and torsion of one-dimensional beams. The mechanical contact between the beams must be explicitly taken into account.

The computational algorithms corresponding to the contact problem are implemented using a beam Finite Element Method expanded with beam elements. In addition, besides the calculation of the effective mechanical material properties for various existing woven and knitted fabrics for industrial and medical applications, the approach also has the potential in the targeted design of new fabrics with predefined mechanical property profiles. For example, the goal may be to achieve a certain stress profile while optimizing the local fabric structure for a deformed woven or knitted fabric. In a two-step iterative process based on the initial fabric design, the effective macroscopic stress distribution is calculated and compared to the desired profile, and the differences are minimized by a gradient algorithm. The result is a set of parameters that describe the optimal fabric structure for the intended purpose. Additionally, various finishes can be simulated and analyzed for the fabric finishing processes. This allows the quality of the resulting fabric finish to be assessed in advance and, ultimately, prevents the formation of wrinkles and other optical inhomogeneities.



1

INTERAKTIVE WORKFLOW SUPPORT IN E-MAIL-SERVICE

1 *Graphical User Interface, based on a wide screen*

The old telephone switchboard – whether located in a business, in government offices, in a hotel, etc. – has been transformed over the years from a pure telephone connection center to become a multimedia contact center, where incoming telephone, e-Mail, fax, or internet inquiries are all handled on an equal basis. Besides the information requirements of the requester, the variety and complexity of the tasks in the call centers have steadily increased, so that the "agents" have a growing need for access to a knowledge management system to support them in their work.

A rapidly growing share of the inquiries from customers or citizens is arriving now as an e-Mail; the information seekers expect to receive a comprehensive written response as soon as possible – and, one tailored to their individual questions and needs. To do this, the respective e-Mail service references information stored in internal databases, their own websites as well as the links placed there to other sources. An essential part of the response is a direct reference to the sources used, in particular, to the information provided in the Internet regarding the issues related to the subject. All work steps are accompanied by quality assurance methods. A current project is working to implement the software support for these workflows, the interactive provision of appropriate documents, and the automated retrieval of the relevant key terms, especially, those characteristic of the e-Mail processing operations. The project is also exploring modern interactive means on the part of the user.

Many consulting centers now use extensive lists of key terms (also compound words), for example in searching for the appropriate documents or to manage the workflow. The set comprising these key terms is the result of a growing base of knowledge acquired over many years. The great potential for applying this knowledge provided the impetus for the expansion of content and the development of a new interactive semantic catalog that can be used to access synonyms, alternative spellings, related English terms, and associated categorizations. All stations in the e-Mail workflow combined with a variety of access options to the semantic catalog are found in the GUI, oriented on a wide screen display. Smaller or supplemental screens may also be used based on the modular design of the GUI, users may interact by touch, mouse, and keyboard. The integration of telephones, fax, and chat services is also included in the overall concept.

Dr. Volker Maag, Dr. Michael Bortz, Dr. Maksym Berezhnyi, Jasmin Kirchner, Dr. Alexander Scherrer, Esther Bonacker, Diana Ackermann, Dr. Tino Fleuren, Anna Hoffmann, Neil Jami, Dr. Rico Walter, Gregor Foltin, Prof. Dr. Karl-Heinz Küfer, Grete Kaffenberger, Dr. Neele Leithäuser, Dr. Peter Klein, Dr. Michael Schröder, Bastian Bludau, Dr. Heiner Ackermann, Dr. Kai Plociennik, Andreas Dinges, Dr. Jan Schwientek, Dr. Sebastian Velten, Rasmus Schroeder

OPTIMIZATION

▪ MEDICAL THERAPY PLANNING

Development of new methods for clinical therapy planning based on multicriteria optimization

▪ OPTIMIZATION IN VIRTUAL ENGINEERING

Physically and technically based models and their simulation in algorithmic software (virtual engineering)

▪ OPTIMIZATION OF ENTERPRISE STRUCTURES AND PROCESSES

Modeling of planning systems for logistics and organizational tasks and development of specialized software applications

▪ MODELING, SIMULATION, AND OPTIMIZATION IN PROCESS ENGINEERING

Customized development of software components from conceptual chemical engineering through process- and aggregate-design to control and feedback control issues

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PROF. DR. KARL-HEINZ KÜFER
HEAD OF DEPARTMENT

The central focus of the department is to develop custom solutions for planning and decision making problems encountered in the logistic, engineering, and life sciences in close cooperation with partners in research and industry. The work methods are characterized by tight integration of simulation, optimization, and decision support. Simulation in this context refers to the construction of mathematical models while taking into account the design parameters, restrictions, and the optimization of quality and cost. The core competencies of the department are the development and implementation of applications and customer-specific optimization methods for calculating the best possible design solutions for processes and products. A distinguishing characteristic in the development and implementation of interactive decision support tools is the close integration of simulation and optimization algorithms, while giving special consideration to a multiple criteria approach. Overall, optimization is viewed not so much as a mathematical problem to be solved, but rather as a continuous process supported by the department by the development of suitable tools. The major research focus is on the following:

Optimization of enterprise structures and processes

The portfolio includes consulting and support for the modeling of logistical and organizational planning systems and the development of individual software components. Decision support solutions are created in customized software tools using optimization methods that provide the best compromise between the competing planning goals "minimizing costs" versus "maximizing quality of service". Based on discrete event simulation and combinational optimization, the activities in this department are concerned with efficient strategies for transport logistics, design problems, the planning and control of production and R&D processes, and with models and algorithms for the planning and disposition of process activities in hospitals and healthcare systems.

Optimization of medical therapy planning

The trade-off between the prospect of a cure for a serious illness and the prevention of side effects routinely poses a difficult planning challenge to doctors in therapy planning. The focus of interactive therapy planning is the development of new methods for planning clinical therapies on the basis of multiple criteria optimization. The group develops innovative planning modules for ionizing radiation therapy, ultrasonic therapy, radio frequency ablation, and the systemic therapy of senology, which gives medical doctors and the attending physicians a rather simple way to balance the chances and risks of individual treatments.

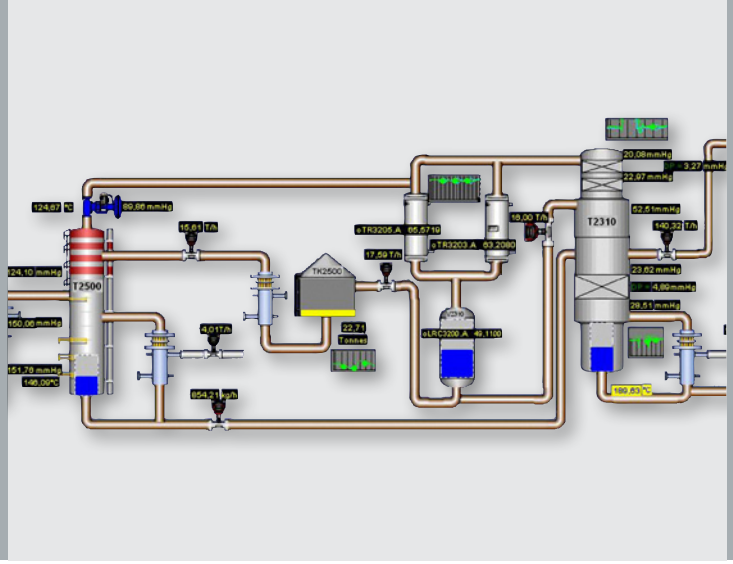
Optimization in virtual engineering as well as modeling, optimization, and simulation in process engineering

The use of mathematical optimization methods in the engineering disciplines relies on the modeling of physical relationships and technical processes and mapping them in computer programs (Virtual Engineering). Optimization assists engineers to ensure quality and cost targets are satisfied to the maximum extent possible in the design of products and processes. The projects aim to create software components for simulation supported optimization, which solve high dimensional problems by using specially developed integration techniques for simulation and optimization algorithms. Multi-criteria optimized product and process layouts are presented in interactive decision support tools to the decision makers for evaluation and selection.

The year 2014 was an outstanding one for the department, one characterized by growth and great economic success. Special highlights include:

- Start of the R&D project "HyDisC" for the conceptual process design to account for crystallization processes on behalf of BASF SE.
- Start of the collaborative project "H_2OPT" funded by BMBF for the energy efficient design and control of pumps in the drinking water supply systems.
- Completion of the "RescueAnalyzer", a strategic analysis and simulation software for the site structures of emergency medical service systems on behalf of the state of Rhineland-Palatinate.
- Start of the research cooperation with Merck KGaA in Darmstadt for the end-to-end simulation of the value chains in the production of drugs.

In the scientific spotlight, besides our three completed doctorates, the approval by BMBF of the "H_2OPT" project is certainly one of the major accomplishments.



INES – INTERFACE BETWEEN EXPERIMENTS AND SIMULATION

1 *Chemical production plant in Ludwigshafen*

2 *Screenshot of a process control system with data at tags*

The goal of INES (Interface between experiments and simulation) is the development of software tools to facilitate the data-supported modeling and simulation of chemical plants. The simulation environment is the BASF in-house flowsheet simulator CHEMASIM; however, the methods developed in this project are independent of this application. The aim is to obtain optimally parameterized models. Therefore, reliable data should be selected from an existing database in order to realize meaningful model adjustments. This adjusted model then is available for optimizing the process design.

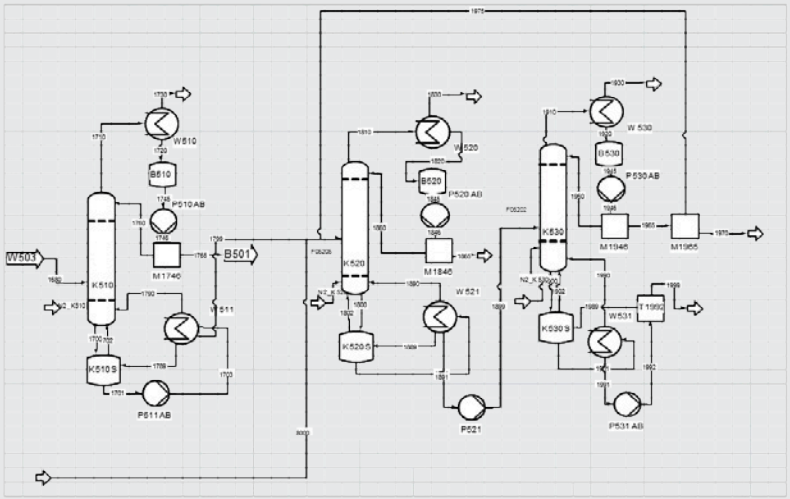
Reliability of data is judged according to three criteria in this project:

- no outliers
- stationary intervals
- mass balances satisfied

Removal of outliers is done interactively by defining a window around the median of a data series proportional to the median absolute deviation. This allows the user to define an outlier-detection according to the working context (accuracy of the instrumentation, known errors). Stationary intervals are found by a heuristic segmentation of the data series. In this approach, break points are set such the averages between neighbouring time-intervals differ significantly. For these intervals, a statistical analysis for stationarity can be realized.

Mass balances are checked by an interactive configuration of a data reconciliation. For control volumes defined by the user, mass balances are calculated if data redundancy is given; furthermore, a componentwise data reconciliation is done. In the case of non-redundant data, the software makes suggestions which quantities have to be measured in order to achieve redundancy. The results of the data reconciliation are used to detect possible gross errors in the data.

On the basis of these criteria, different time-intervals can be compared and analyzed. This comparison is supported by simple methods of data mining to detect correlations between aggregated quantities like means or standard deviations. These are also exported in a format compatible with the process simulator.



3 *Model of a chemical plant in a stationary flowsheet simulator*

The process simulator can then be used for a model adjustment. The adjusted model can then be used for optimizing the process design. In this project, a measure for robustness with respect to uncertainties in model parameters has been developed. Therefore, a sensitivity analysis is coupled with a multicriteria optimization. Within the sensitivity analysis, the user can choose between deterministic or quasi-random methods to calculate the impact of uncertainties in model parameters on output functions of the simulation.

Finally, process parameters can be chosen such that these sensitivities are maximized or minimized, according to the context at hand. Maximizing the sensitivity is desired for the optimal design of experiments. On the other hand, minimal sensitivities shall be achieved for process designs that are robust with respect to uncertainties in model parameters. The practical experience shows that minimizing or maximizing these sensitivities is only one of many objectives. Therefore, it is realized within a multicriteria setting, allowing the user to quantify the trade-off between, e. g., decreasing sensitivity other objectives like high product quality or low operating costs.

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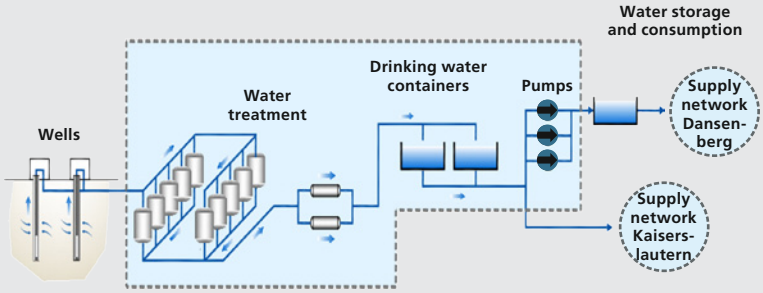


2

H_2OPT: ENERGY EFFICIENCY IN THE WATER SUPPLY MANAGEMENT

1 *Transportation pumps of the EWR in the waterworks Bürstadt*

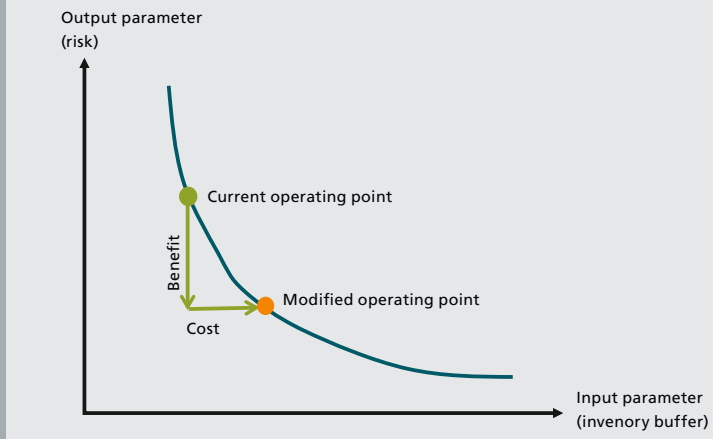
2 *Model of the waterworks network Rote Hohl Kaiserslautern*

The municipal electricity expenditures for the supply of drinking water represent a significant investment. It is assumed that a proper use of pumps based on the information about the drinking water consumption could reduce running costs and thus imply savings in the double-digit percentage range. In cooperation with the faculty of mechanical engineering SAM at the University of Kaiserslautern and in direct contact with water supply companies SWK and EWR and the consultancy Obermeyer, it is the goal of ITWM to exploit these untapped savings potentials in the project H_2Opt which is financially supported by BMBF.

The role of the optimisation department is to develop a software prototype that assists the water supply companies to design and operate their facilities in a more cost-efficient way. The workflow of the software is divided into three parts. In the first part, the planner assembles a customisable model of the water network that takes into consideration the laws of fluid mechanics. The configuration is adaptive and interactive. Then, the planner creates a consumption profile corresponding to the day in question. This process depends on additional information such as being a working day, a school day or a holyday as well as humidity, the time of the year or social events. Finally, desirable solutions are displayed and the planner is assisted to find the one solution that fits his needs.

The core idea to increase energy efficiency lies in the consistent use of characteristic curves of the water network and the pumps. The characteristic curves of the water network assign flow rates to the corresponding delivery heads, which represent the water pressure inside the network. Both flow rate and delivery head define the operating state of a pump. Each operating state is as efficient as a pump allows it to be. Ideally, a pump is chosen with efficiency at its maximum.

Databases consisting of typical consumption profiles and pumps available on the market can be used to generate a variety of solutions, which gives the planner an overview of appropriate and inappropriate pump choices. Furthermore, the pump schedules can be used as degrees of freedom. These are displayed in the software on hourly basis taking into account the availability and the size of supply containers. In a first application with our project partners at Worms, pump schedules could be improved with significant energy savings. One of our next steps is to assist SWK at the selection of new pumps for Brunnengebiet Ost.



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SIMULATION AND PROGNOSIS IN SUPPLY CHAIN RISK MANAGEMENT

Companies are increasingly reducing their share of value adding activities and instead, are performing more specialized tasks for a variety of products. This trend, combined with the networking of businesses on all continents, leads to ever more complex global networks and consequently, supply chains that are ever more susceptible to interruption. It is clear today that not only a local natural disaster can have a global impact, but also raw material shortages, operational disruptions at a basic resource supplier, or political unrest along the transport routes can all have significant implications for the production capabilities of companies. In a study titled "Supply Chain Resilience 2014" (The Business Continuity Institute), 81 % of the surveyed companies reported at least one incident that resulted in production losses. The need for active management of such risks is great and companies have shown willingness to make substantial investments to minimize the risk along their supply chains.

Because of the complexity and stochastics of supply chains, mathematical models play a great role in Supply Chain Risk Management (SCRM). Supply chains are complex networked structures and there are risks everywhere: at regions, suppliers, transport routes, and various individual transport nodes. Infrequent catastrophic events and everyday risks occur at different spatial and temporal scales. Proactive not reactive handling of these risks requires qualitative and quantitative risk assessments. From a mathematical point of view, different tools are used depending on the application. Situations that are subject to a certain regularity, can be examined using Markov chains, Markov decision processes, and Monte-Carlo simulations, etc. The risk can be assessed and the impacts of various countermeasures can be forecasted. The very rare major loss events are addressed using scenario analysis.

ITWM contributes to the development of models and decision oriented visualization of logistic processes in the BMWi project VILOMA (Visual Logistics Management), a consortium under the lead management of VW. In the future, logistical weather maps and characteristic logistics curves will help to identify impending problems at an early stage and to determine the optimal operating point in supply chains to balance risks and SCRM costs, for instance by inventory buffers. The aim of an ongoing project with Procter & Gamble is to study rare major loss events at suppliers as well as regular, short duration supply shortages. The random occurrence of the latter can be well described by stochastic distributions. The initial task is the quantification of this risk. This may then lead to recommendations for action concerning the size and positioning of material safety stocks. The project primarily addresses strategic and tactical planning horizons.

1 *Logistics curves used to find the optimal operating point in a supply chain in the conflict between risks and SCRM costs (e.g., of inventory buffers)*

2 *The method structure in the Procter & Gamble project*

Dr. Christina Erlwein-Sayer, Stefanie Grimm, Dr. Tilman Sayer, Dr. Jörg Wenzel, Sarah Grün, Prof. Dr. Ralf Korn, Sema Coskun, Dr. Roman Horsky, Dr. Johannes Leitner, Dr. Gerald Kroisandt

FINANCIAL MATHEMATICS

▪ OPTION PRICING

Valuation formulae and pricing algorithms

▪ CREDIT RISK AND STATISTICS

Validation and enhancement of rating procedures

▪ PORTFOLIO OPTIMIZATION

Calculation of risk measures and risk management of large portfolios

▪ INTEREST RATE MODELS

Development of interest rate models with particular emphasis on low interest rate periods

▪ ACTUARIAL MATHEMATICS

Simulation and optimization of ALM strategies

▪ PENSION PROVISION

Modelling of interest and inflation risks, longevity models, product development

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PROF. DR. RALF KORN
HEAD OF DEPARTMENT

The Financial Mathematics Department offers modern solutions to all kind of problems in development, analysis and numerical implementation of mathematical models for the finance and insurance industry. Our approach is based on most recent research in finance and statistics to develop concepts, algorithms, models, and software platforms for finance and insurance companies.

Strategically, we focus on insurance and pension companies, because we offer a range of innovative solutions in modelling (longevity, inflation and interest rate risk, risk management) as well as in the area of simulation of capital and population dynamics.

In particular, together with Fraunhofer SCAI, we started the WISA project "Stochastic modelling and numerical simulation for the risk management of insurance companies". In this project, among other things, we develop a new interest rate model based on regime switching, which is supposed to model the currently low interest rates more realistically than common interest rate models.

In the past year we could gain two new project partners, Frankfurt-Trust Investment-Gesellschaft mbH and a big German insurance company. In joint projects we were again able to prove our increased knowledge in portfolio optimization and pension provision.

Together with Landesbank Baden-Württemberg the new version 4.0 of "Derivatekalkulator Pro" was certified and put into operation in the second half of 2014.

Several publicly sponsored projects continued as planned. This concerns the BMU project "Quantifying the geothermal success risk" (GEOFÜND) in geothermal drilling as well as the BMBF project "Energy efficient acceleration of simulation methods for risk measurement and management" (ESR) on energy efficient simulation speed-up. Jointly with TU Kaiserslautern we worked on the DFG project "Regime-Switching Models in Finance: Statistics and Optimization". These projects document well the wide range of knowledge of our department.

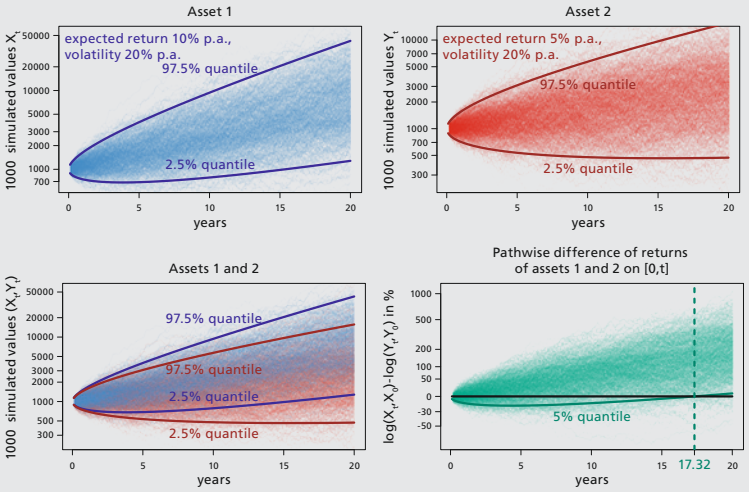
VALUATION OF COMPLEX STRUCTURED PRODUCTS

In the current low interest rate environment live insurance companies are forced to achieve high interest yields in order to generate the interest rate guaranteed by law. Therefore, besides plain bonds, also structured products are used as an investment. The seller of such a product can possibly reach a higher yield than by investing in the riskless interest rate. The buyer on the other hand gets an insurance against various financial risks such as exchange or interest rate fluctuations.

A Range Accrual e.g. pays an interest rate at the end of each period (usually yearly) depending on the number of days the underlying instrument is fixed within a given range. The underlying is usually taken to be a reference interest rate such as LIBOR. To hedge an exchange rate sensitive deal or just to realize own expectations, also an exchange rate can be used as underlying. The resulting product is a so called FX Range Accrual. For example, a 3 % interest rate can be agreed upon. This interest rate is multiplied by the number of days in the corresponding year, on which the USD/EUR exchange rate is fixed at 1.50 USD/EUR or below. Here the lower end of the range is tacitly assumed to be 0.0 USD/EUR.

For the seller, this Range Accrual will earn above average, as long as no unexpected turbulences in the FX market occur. If however the USD/EUR FX rate rises above 1.50, the product might even yield no interest at all. The buyer in this case has to pay less interest on her funding and in this way gets protection against rising FX rates. By construction negative yield is excluded. Also, the nominal has to be refunded at the end. The value of such a product obviously depends on at least two factors: the EUR interest rate market – rising interest rates make the product less valuable for the seller, since she can get higher interest on the market. On the other hand the yield depends directly on the FX rate. Rising FX rates decrease the yield and such the value of the product for the seller.

For risk neutral valuation we hence need an interest rate model and a correlated FX rate model. The valuation becomes more complex, if additional early exercise options or a minimum yield are part of the deal. In an industry project we implemented a model that allows to simulate both factors and their joint development. This allows to valuate the product together with the mentioned additional agreements.



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RISK-BASED PORTFOLIO ALLOCATION

1 *Illustration of the difficulty to precisely estimate the expected rate of returns*

With interests being at their current low levels already for a substantial time, investing into stocks becomes increasingly attractive even for investors with a longer investment horizon. Classical portfolio theory (Markowitz, Merton) offers precise specifications on how to invest one's money such that the expected terminal value is optimal.

Still, these approaches suffer from the fact that they need a specification of the expected rate of return of the investment alternatives. Estimating these rates of return from historical data is a notorically difficult problem. For instance, to separate at significance level 95 % an expected (annual) rate of return of 10 % from an expected (annual) rate of return of 5 % if both have an (annual) volatility of 20 % and are correlated at level 0.8, you need more than 17 years of observations (see the illustrating figure).

In this context it is well known that under realistic conditions it is very difficult to out-perform an "equal-weights" strategy which invests the same proportion of wealth into each asset. In the last few years this gave rise to new types of strategies which abstain from considering (hard-to-quantify) expected rates of return. Instead strategies for given investment alternatives are developed that distribute the risk equally onto the components. Alternatively prescribed levels of risk are matched. Of course for this to be reasonable, each alternative should still have an (unknown) positive expected rate of return. These approaches can be subsumed under "Risk Parity" and "Risk Budgeting", respectively, and well allow for different ways to quantify risk.

In a joint project with (and for) FRANKFURT-TRUST Investment-Gesellschaft mbH in Frankfurt, we have generalized extant approaches, which so far have all been considering the one-period setup of Markowitz only, to the time-continuous, dynamic Merton setting. This framework in pariticular applies to pension plans.

1

MORE PASSION FOR PENSION – MATHEMATICAL ASPECTS

1 *EI-QFM Board of Trustees met at Fraunhofer ITWM*

The term longevity risk refers to the pleasant fact that in Germany during the last decades the average life span per person increased steadily. Due to continuing decline in governmental pension payments this results in the need for increasing private pension activities. In 2014 the financial mathematics department worked in several areas related to this topic.

The basis of retirement pension consultancy is a reliable calculation of the income of a customer, the customer's entitled subsidies and the amount of required (additional) pension. This is done using software, so called provision calculators. Together with the European Institute for Quality Management of Financial Products and Processes (EI-QFM) in Kaiserslautern the department of financial mathematics checked and certified several commercial provision calculators.

To give the customer an indication of the relation between the potential of a pension plan to generate a good yield and its associated costs, the German Ministry of Finance launched a corresponding research study. It contains the recommendation to use the so called reduction in yield as a cost indicator. This reduction equals the percentage yield which is used up by the costs of the pension plan. In a project study for the Kaiserslautern based software company teckpro AG the ITWM could hint at some flaws in this study and suggested reasonable improvements and additional aspects.

While a lot of research on retirement products in theory and application is concerned with the aim to provide the customer ideal products with respect to the risk-return relation, the actual period of retirement is not considered. Moreover, payments in this period of using the accumulated capital are typically designed in a classical way. I.e. the accumulated capital is invested in a very conservative, low-risk portfolio and the customer receives a life-long payment from it.

Although in this setting the customer can still benefit from extra gains generated by this portfolio, the nowadays long time of retirement calls for a more flexible investment of the customer's capital that can provide a higher return potential. In 2014, ITWM consulted a big German insurance company to suggest possibilities of an innovative investment of the customer's capital during the retirement phase. Further, the product ideas of the insurer were analyzed via stochastic market scenarios.

Dietmar Weber, Christoph Mühlbach, Christine Biedinger, Dr. Sascha Feth, Michael Kleer, Dr.-Ing. Joachim Linn, Eduardo Pena Vina, Fabio Schneider, René Reinhard, Dr. Andrey Gizatullin, Thomas Halfmann, Dr. Michael Burger, Dr. Klaus Dreßler, Christine Rauch, Tim Rothmann, Dr. Stefan Steidel, Björn Wagner, Michael Lübke, Axel Gallrein, Marius Obentheuer, Dr. Michael Speckert, Thomas Stephan, Thorsten Weyh, Johannes Krebs, Dr. Clément Zémerli

MATHEMATICAL METHODS IN DYNAMICS AND DURABILITY

▪ MODELING AND SIMULATION OF USAGE VARIABILITY AND RELIABILITY

Design targets for durability and optimization of highly variable design attributes like reliability and energy efficiency

▪ SYSTEM SIMULATION IN VEHICLE ENGINEERING

Tire, soil, and driver models

▪ NON-LINEAR STRUCTURAL MECHANICS

Simulation of highly deformable components and structures such as tires, rubber bushings, hydro-bushings, air-springs, hoses and wiring harnesses

www.itwm.fraunhofer.de/en/mdf

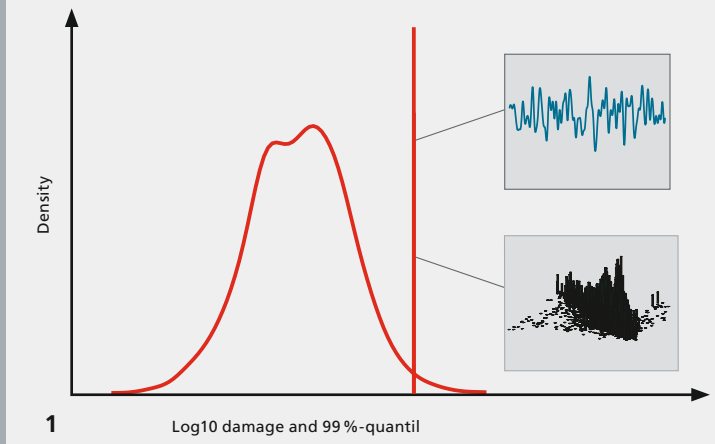
DR. KLAUS DRESSLER
HEAD OF DEPARTMENT

The department MDF is dedicated to the development and deployment of new technologies for simulation and modelling of usage variability, durability and energy efficiency. Statistics and simulation methods are used to deal with the broad range of product usage and applications. Multi-body simulation (MBS) and finite element methods (FEM) are deployed for system and component analysis. In our projects with vehicle industry we deal with reliability, durability, structural dynamics and system dynamics.

The department takes a lead in the activities of the Fraunhofer Innovation Cluster Digital Commercial Vehicle Technology (www.nutzfahrzeugcluster.de) and works with the industrial partners Bosch, BPW, Daimler, John Deere, Liebherr, Schmitz Cargobull and Volvo on the projects "usage variability", "energy efficiency", "ground interaction simulation", "tire simulation", "on-board simulation" and "simulation of cables and hoses". Our long term goal is to advance system level virtual product development by integrating the interaction of the vehicle with the rest of the world (tire, gound and usage simulation) and the driver into the scope of system simulation.

A big step on this way has been made with the launch of our geo-referenced system "Virtual Measurement Campaign (VMC®)". The VMC software provides a framework for the systematic analysis of usage variability of vehicles with a unique combination of geo-referenced data, statistics and simulation methods. This enables new paradigms for durability engineering and for the optimization of energy efficiency.

On the system simulation side a big challenge is the integration of assistance systems and of the driver into the virtual product development process. Here we work on new technology for hybrid and interactive simulation. Furthermore, we are developing and applying methods and software for invariant system excitation, tire simulation (CDTire), soil and material simulation and for the simulation of cables and hoses (IPS Cable Simulation). The integration of the driver into the virtual product development process is our main focus in the ongoing projects with our own interactive driving simulator RODOS®. The system is currently used for the development of driver models, for the improvement of the human-vehicle interface and for the qualification of assistance systems.



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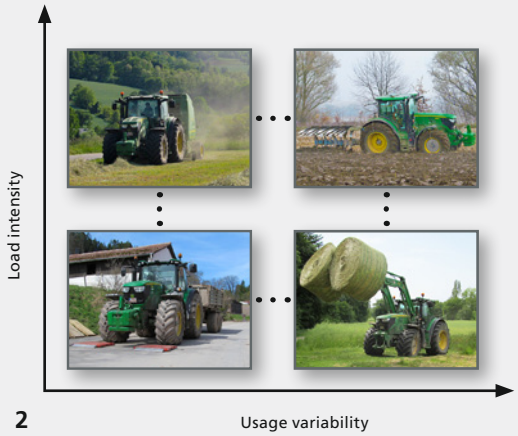


2

U·SIM – MODELING AND SIMULATION OF USAGE VARIABILITY FOR VEHICLE ENGINEERING

U·Sim

1 *Load distribution*

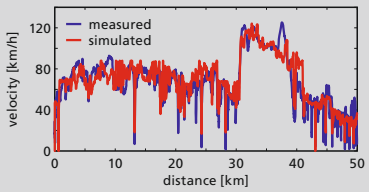
2 *Usage variability vs. load intensity for tractors*

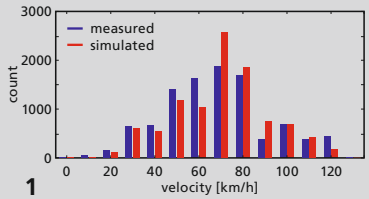
Vehicle design has to strike a compromise between durability and reliability on one hand, as well as cost and energy efficiency on the other hand. An ideal design target for a component introduces only moderate overdesign as a safety margin. To obtain such a target, it is necessary to understand actual vehicle usage on public roads by different customer groups over the entire design life. For this purpose, most vehicle manufacturers nowadays conduct extensive measurement campaigns on public roads. To derive a qualified design target, they need to answer the questions of what and where to measure and how to extrapolate the results to a certain target mileage. Customers are usually very different and hence it is not sufficient if a measurement campaign replicates one particular customer. Instead, a measurement campaign should ensure that in particular all corner cases and extreme situations are covered, even if they are only experienced by a small fraction of the customer base.

The software U·Sim was developed at Fraunhofer ITWM to simulate the usage variability of many (virtual) customers representing a vehicle's entire design life based on selective measurements on public roads. The key to the solution is to separate between the exploration of the different operating states by appropriate measurements ("What can occur?") and the recombination of these states based on a usage model ("How often something occurs?").

U·Sim generates a large number of customers with different mission profiles by recombining the atoms (measurement segments) using Monte-Carlo simulation. Each customer is represented by a multi-channel load collective – rainflow matrices for measured forces, torques, accelerations, etc. – consisting of a selection of atoms with repetition factors. Using pseudo-damage numbers, quantile customers for each load channel (e. g. 99 % customer) can be identified. Together with safety margins and special maneuvers (e. g. curbstone crossing), these customers define a design target that is explicitly related to public road conditions.

U·Sim is already used by several manufactures. During an ongoing project including a PhD thesis with John Deere, the process is currently implemented for tractor development. In agricultural engineering the requirements to efficiency, emissions and lightweight design are raising as well. Therefore, conventional product development becomes more and more inefficient. Due to extreme high variability in usage and load intensity, deriving suitable usage models is particularly important. The U·Sim process supports our partners in this respect and increases transparency, process reliability as well as reproducibility and improves documentation of results and decisions.





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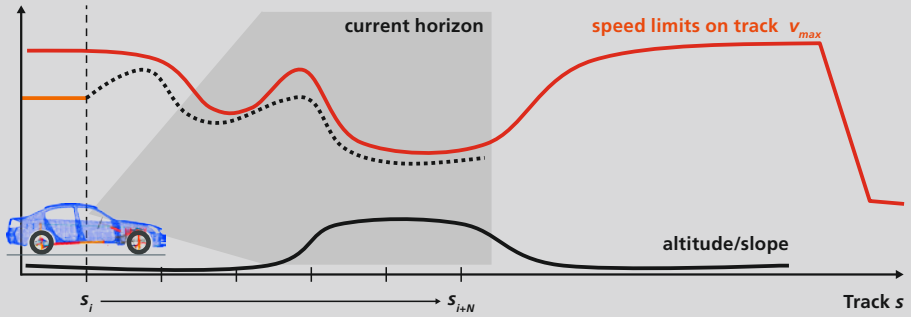


2

SPEED PROFILE GENERATION WITH VMC

1 *Speed profile: Comparison fo measurement (blue) and simulation (red) top: speed over distance bottom: time at level for speed*

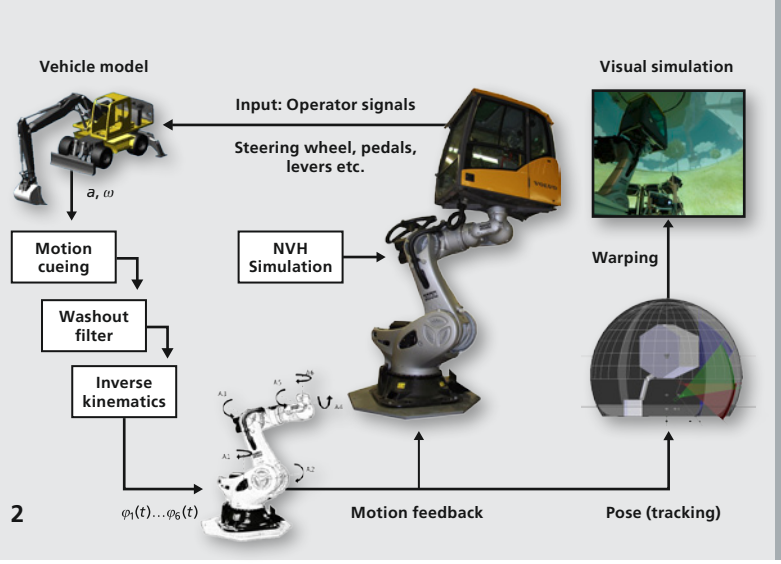
2 *Moving-horizon approach in optimum control methods for speed profile generation*

Speed profiles are an important and characteristic factor concerning dynamic loads of a vehicle as well as energy and resource efficiency. Thus, it is obvious to aim for speed profile generation by simulation, based on specified route data and driver and vehicle characteristics, in order to analyze and to evaluate the mentioned criteria early in the development process. To this end, the software package Virtual Measurement (VMC) that has been developed in the past years at ITWM provides the necessary data and numerical methods.

For the speed profile generation, one has to take into account basically three main influence factors: The first factor contains the so-called route data for a given route. This includes topographic data (slope, curvature) as well as information about traffic-lights, traffic and legal speed restrictions. Second, the driver behavior is playing a crucial role; it can be described mathematically, e.g., by maximal tolerable accelerations or by driving goals and tasks. The third factor is the vehicle. Here, models for longitudinal dynamics of different complexity may be used. For instance, characteristic quantities such as mass, maximal driving and braking power are sufficient to calculate a speed profile. In case of availability, more sophisticated data, such as engine characteristic maps or gearbox characteristics, can be integrated to generate results of higher quality. Additionally, consumption maps can be used to perform analyses concerning fuel consumption and energy efficiency; it is also possible to generate a speed profile that is optimal in terms of fuel consumption.

Mathematically, an optimal control problem is formulated. That is, the given route shall be driven under the corresponding boundary conditions, respecting the longitudinal dynamics as well as driver characteristics and goals. The longitudinal dynamics model constitutes the dynamical system. The route data and the driver properties are considered as constraints. The resulting problem is numerically solved by an optimal control algorithm combined with a moving-horizon scheme, in which overlapping segments from a moving preview horizon are taken into account for computation.

The speed profile generated in that way can be used for further analyses within the VMC software package. It can, however, also be used as input for a more complex full-vehicle multibody system model, with which more advanced studies and investigations can be carried out.



INTERAKTIVE DRIVING AND OPERATION SIMULATION WITH RODOS®

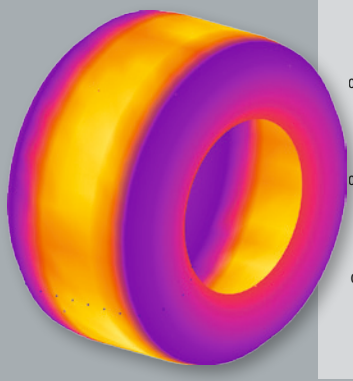
Driving simulators help to optimize product development attributes like energy efficiency, productivity, durability and reliability, especially in the early stages of development. For that purpose, all external influences acting on the vehicle as well as the actions of the operator must be considered. The use of prototypes in early development stages is often not affordable. In addition, field measurements on prototypes are often not reproduceable, whereas in a simulator one can observe and control all the parameters. A second problem when working with actual prototypes is the time gap between prototype tests. The driver must be able to evaluate and compare stages of development that could be several weeks apart.

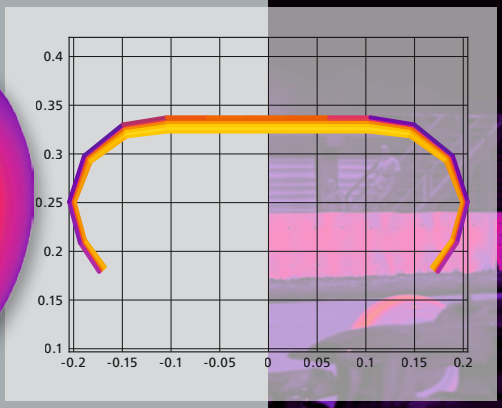
This is a non-issue in an interactive simulator. Here, complex scenarios and the interactions with the driver can be rigorously studied and reproduced under laboratory conditions. Multiple tests can be easily carried out by adjusting parameters, so the time between iterations can be dramatically reduced. For this purpose RODOS® was conceived and developed at Fraunhofer ITWM in the past few years. It features a 6-axis robot with payloads up to 1000 kg. At this moment RODOS® is proving its capabilities in the construction equipment and agricultural machinery domain. Together with experts, advanced driver assistance and safety systems are being designed and optimally tuned. In this way, new operational modes, human-machine interfaces, information systems and machine configurations can be tested and improved with a virtual vehicle model, even before the first prototype exists.

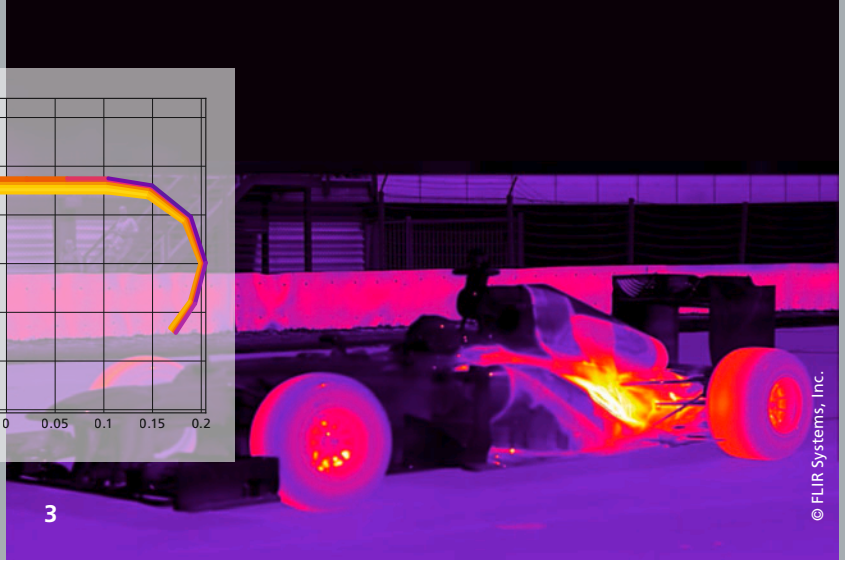
Major changes to the design of a new machine as weell as new functionalities can be safely tested. Since all the modeled system states can be observed and manipulated at runtime slight variations can be tested. The assessment of a configuration is not merely limited to the evaluation of measurement curves; an expert is able to literally feel the new configuration with all its senses by controlling the machine. Even though RODOS® is not intended as a complete replacement for tests in actual prototypes, it allows those tests to be highly realistic. All algorithms and core components of RODOS® have been developed at the Fraunhofer Gesellschaft, thereby retaining full flexibility in the source code to face new challenges in the future. It is also possible to integrate commercial solutions in any stage of the simulation. This flexibility permits to work with the proprietary models of our partners and customers in the simulator, something that is routinely carried out.

1 *Interaktive Simulation with RODOS®*

2 *RODOS®: Hardware Set-up*







1 2 3

CDTire – INTERFACING THE STRUCTURAL TIRE MODEL WITH A DETAILED THERMO-DYNAMICAL MODEL

1 *Breaking scenario with CDTire/3D and CDTire/Thermal*

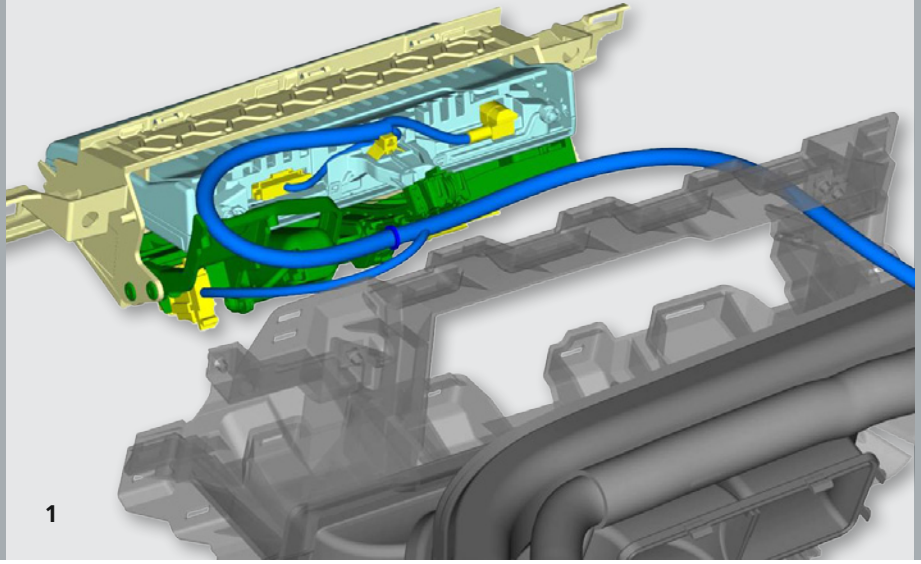
2 *Temperature distribution in tire cross section*

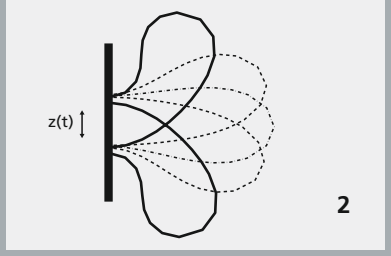
3 *Temperature distribution of a F1 racing car, obtained by a FLIR thermos camera*

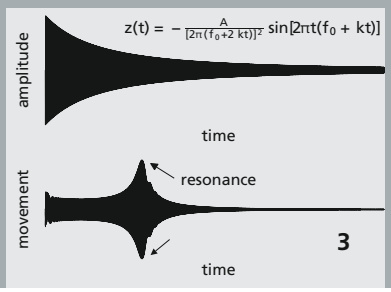
In the last years ITWM developed the tire model CDTire/3D, a shell-based bead-to-bead model with materialized modeling of sidewalls and belt. All functional layers of a tire (inner liner, carcass, belt and cap plies and the tread) are modeled as separate entities accessible in pre-processing and condensed into one geometric shell representation. The structural properties of each layer can be parameterized separately and may vary with local cross section position. This modeling yields an optimal compromise between computational effort and solution accuracy, allowing for full vehicle simulation scenarios with all typical application attributes to assess and optimize vehicle suspension, structure and dynamics with more than reasonable simulation times.

In the past, temperature dependency of tire properties was neglected due to the lack of appropriate models and options. But recently, manufacturers of premium sports cars realize that the temperature dependency cannot be neglected when analyzing vehicle dynamics performance into the stability limit. The same is true for predicting the rolling resistance of a tire, temperature dependency also plays an influential role here. For this reason, ITWM developed in 2014 a thermo-dynamical model of the tire (CDTire/Thermal) with a dedicated interface that allows the coupling to the structural tire model CDTire/3D – and also to all other models in the CDTire model family.

The thermo-dynamical model CDTire/Thermal is based on a finite volume formulation of the 3-dimensional heat equation with conductive heat transfer within the tire as well as to the inflation gas, the rim and the road and additionally the convective heat exchange with external air. This heat exchange is modeled with the approach of Nusselt, utilizing a velocity and tire geometry dependent Nusselt number. The finite volume discretization is freely selectable in all 3 (circumferential, cross section and thickness) directions. In thickness direction, a non-equidistant resolution can be used. Heat sources into the thermo-dynamical model from the tire are all dissipative structural energy losses as well as the sliding friction power. To feed these sources, as well as to pass the temperature field, a dedicated software interface was developed, allowing for coupling to all tire models that can feed this interface sensibly. The model was developed in cooperation with Goodyear for rolling resistance predictions for truck tires and was validated in cooperation with the Sauber F1 team.







CABLE DYNAMICS SIMULATION IN VIRTUAL ASSEMBLY PLANNING FOR AUTOMOTIVE INDUSTRY

Because of the presence of more and more electrical components and new safety systems, modern vehicles have to be designed for an ever increasing number of cables and hoses. Studies made by the automobile industry show that approximately 25 percent of all quality problems are related to flexible components. In collaboration with the MDF department, FCC has developed IPS Cable Simulation, an innovative and user friendly simulation software for assembly and design optimization of flexible components. This software has been optimized during collaboration with key-partners for being used efficiently in the industry. IPS is based on an exact geometric beam model for a physically correct simulation of the deformation of cables and hoses, which enables precise simulations in real time.

In general, practical tasks involve slow movements and deformations, which are represented very well in IPS by the sequential computation of quasi static states of equilibrium. However, the vibration of the chassis, motor and powertrain during driving, as well as the introduction of external dynamic loads from the road surface over the tires and chassis add a dynamic load input on all of the cables and hoses in the vehicle, which leads to vibrations with frequency variance and different amplitudes. Accounting for such dynamic effects is increasingly important in assembly design planning. This was the main motivation for the IPS team for expanding the beam model to include dynamic effects. The dynamic model accounts for the geometric nonlinearity implied by large spatial displacements and rotations as well as for the inertial effects and the damping properties of cables. A time integration process adapted to the application ensures a very efficient and stable simulation. To identify the critical zones of the simulated cables or hoses, we developed an analysis tool, which calculates the spatial distribution of stress from the forces and moments of the beam model. The accumulated stress on a cable or a hose under dynamic loads is then determined using a cutting plane algorithm.

In the ongoing BMBF project MusiKa, we are testing this new technology with our industrial partners AUDI and STIHL. One important application is to simulate an experimental set up in order to identify resonance frequencies and to estimate the service life of the cables. Another application is the dynamic simulation under controlled and measured engine excitation. This facilitates engineering decisions already in the pre-development phases, e.g. for finding an optimal cable assembly by considering the dynamic behavior of flexible components under driving conditions.

IPS CABLE SIMULATION

1 *Cable layout and analysis in IPS*

2 *Cable mounting loop with sine sweep applied at both end points*

3 *Sine sweep signal, movement of the center point and resonance*

Tina Hill, Frauke Santacruz, Dr.-Ing. Janis Keuper, Dr. Abel Amirbekyan, Clemens Koch, Sven Breuner, Delger Lhamsuren, Dr. Mirko Rahn, Matthias Deller, Dr. Alexander Klauer, Christian Mohrbacher, Dr. Rui Màrio da Silva Machado, Dr. Franz-Josef Pfreundt, Bernd Lietzow, Frank Kautz, Matthias Klein, Dr. Matthias Balzer, Bernd Lörwald, Dr. Daniel Grünewald, Ely Wagner Aguiar de Oliveira, Valentin Fütterling, Lukas Ristau, Dr. Martin Kühn, Dr. Dimitar Stoyanov, Dr. Tiberiu Rotaru

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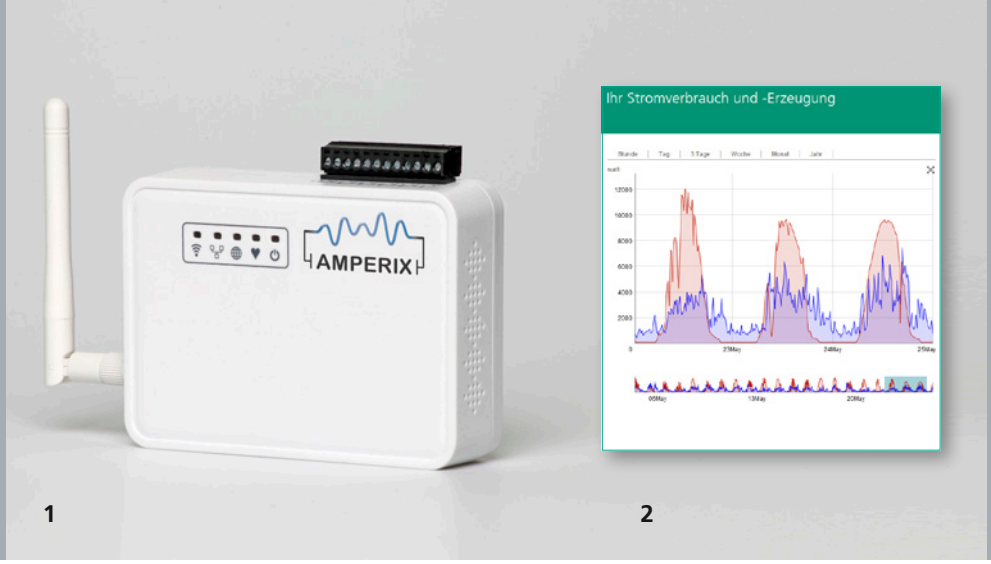
DR. FRANZ-JOSEF PFREUNDT
HEAD OF DEPARTMENT

High Performance Computing (HPC) – is indispensable for research and economic competitiveness. Basic research in the fields of energy, the material and life sciences, or even climate research is unthinkable today without detailed simulations. This is also true for key areas of the German economy: Whether electronic devices, autos, airplanes, modern medicines, or innovative operational processes – they all have their basis in simulations. High Performance Computing opens the way for new applications in the simulation of complex social phenomena or more demanding tasks in logistics.

At the same time, the increasing complexity of the underlying HPC architectures and their efficient use poses great challenges for industrial users: Programs today have to work in parallel and account for both locally stored data as well as content from storage that can be accessed only via a network. The additional possibilities opened through the use of specialized hardware like graphic processors, further increase the complexity of these programs. In close cooperation with industrial and academic partners, the Competence Center for High Performance Computing develops solutions to the question of how the increasingly complex processors and parallel computers can be used efficiently. In addition to developing tools for the management of supercomputers, it also produces integrated software solutions.

One of these tools is the Global Address Space Programming Interface (GPI), which enables the programming of scalable, tightly coupled software, that is, software that on the one hand, enables the exchange of small data packets at a high frequency, and on the other hand, solves problems in the provision of more resources much faster. Whereas, GPI assumes an explicit formulation of the communication patterns of the application, the GPI-Space tool goes further and automates the parallelization and fault tolerance as well as the storage management. These tools and the world's leading parallel file system BeeGFS (also developed at CC HPC), are successfully deployed in complex client-specific applications. Last but not least, CC HPC is working on the management of the energy revolution and the associated fluctuation in the generation of alternative energies. All aspects of the issue are being studied: temporal decoupling of energy production and consumption, consumption forecasting and shifting, optimization of power consumption as well as the use of net services to manage distributed battery systems. Comprehensive knowledge in the design and control of complex IT systems is being applied to achieve the goal of a safe, environmentally-sound, and economic energy supply. The concept of "Green by IT" has become a significant business segment.



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SMART METER: BETTER INDOOR CLIMATE, LOWER ELECTRICAL BILLS

The provisions of EEG 2014 stipulate a cost efficient increase in the percentage of electrical power generated from alternative energy sources to at least 80 percent of the total power consumption by 2050. At the same time, energy costs are rising steadily. The aim of the mySmartGrid and EMOS projects is to counteract this trend by identifying opportunities for individual cost savings.

In mySmartGrid, intelligent measurement and control systems are developed to adjust the levels of energy consumption to energy production. Approximately 300 test homes have been equipped with appropriate hardware to measure the electricity consumption. The measurement values are transmitted via an Internet connection to the central mySmartGrid website. Participants (subscribers) can access the usage and production data for their PV unit, which is displayed in the form of a graphic, through an account on the website. The subscribers can analyze their own power use and identify the "power guzzlers". Another component of the website is the forum, an exchange platform where the subscribers as well as the project team can meet and discuss ideas and solve problems together. Subscribers who have a PV unit can install a power inverter independent PV system monitor and, through the individual yield forecasts, increase their own consumption. A key component of the project is the HexaBus system: Communication must be established with the device before the automated control of household appliances can be implemented. The HexaBus as an IPv6-based wireless system does this and more: New appliances can use the system in order to implement any number of additional functions. A washing machine, for example, can wait for a remote start signal from the user.

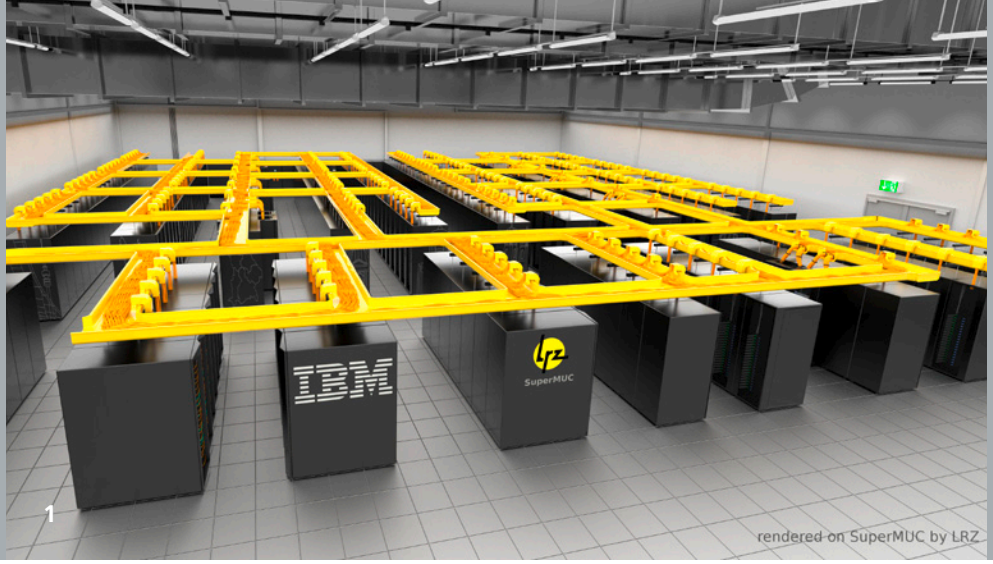
Building on mySmartGrid, since 2013 the energy management project (EMOS) is studying how to achieve the optimum indoor climate for rental properties with open-source smart meters. Achieving the optimum indoor climate means energy savings and a reduction in harmful CO_2 emissions. This not only is good for the environment, it also contributes to individual own well-being. A comfortable living climate, controlled by efficient, energy saving heating and ventilation is the goal. Based on our HexaBus home automation system, devices are being developed that can measure the temperature and humidity and provide recommendations to the residents. Subscribers can compare the recorded values as visualized presentations on the mySmartGrid website. Feedback about their power consumption and the indoor climate in their homes helps to reduce energy use and, as a result, heating and electrical bills are lower.

All results from these projects are freely accessible and are based on open source components.

1 *Amperix – a flexible internet-enabled energy meter*

2 *mySmartGrid-website: Graphic presentations aid in understanding home energy consumption. Users can zoom into the graphic.*

3 *Mobile mySmartGrid website: Display with intuitive icons when accessing from mobile phone or tablet*



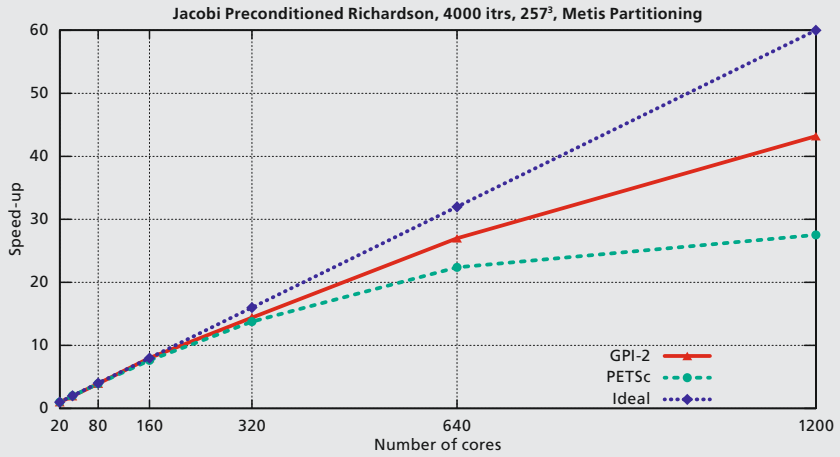
DEEP-ER, EPIGRAM AND EXA2CT: EU PROJECTS

1 *The Petascale System SuperMUC at the Leibniz supercomputing center in Munich*

The European Technology Platform ETP4HPC has recognized the strategic nature of High-Performance Computing as a crucial asset for the EU's innovation capacity and has developed an agenda, to take the European High Performance Computing technology to world-leadership. The HPC group of Fraunhofer ITWM, which is a member of the ETP4HPC platform, has provided important contributions related to the communication of massively parallel programs and highly-scalable I/O systems. Together with the European Commission the strategy proposed by ETP4HPC will be implemented in the current research framework program Horizon2020. The primary goal is to establish exascale computing systems by the year 2020. Exascale computing systems perform 10^{18} operations per second. These new systems pose numerous challenges. For instance the energy consumption of the computing components needs to be reduced significantly, to be able to run a computer with exascale capabilities economically. This calls for radical innovations regarding the architecture of future supercomputers and the deployment of computing elements with low electrical consumption. In addition the development of scalable software for future systems with millions of compute cores requires a paradigm shift concerning the system software and the programming models.

In the scope of the European DEEP project as well as the successor project DEEP-ER such an architecture is designed and deployed prototypically. The architecture is a so-called cluster-booster architecture, which consists of a cluster of compute nodes with many cores and a booster. This combination offers a maximum of data throughput and scalability of the booster. The booster part of the system can be used for the part of the programs, which is highly scalable, whereas the traditional cluster can be used for programs, which control the data throughput and have dependencies to other data. It turned out in the DEEP project, that the growing gap between I/O bandwidth and compute speed is a relevant challenge for the DEEP architecture, which is being addressed in the successor project DEEP-ER. DEEP-ER extends the computer architecture based on various computing elements with a highly-scalable I/O system. DEEP-ER will provide a prototype with Intel Xeon Phi processors, a uniform high-speed network for the compute node, non-volatile memory (NVM) on the compute nodes and network-attached memory (NAM), to support high-speed accesses of the storage. In the scope of the project the HPC group will adapt the highly-scalable, efficient, parallel I/O-system based on the parallel file system BeeGFS to the DEEP-ER architecture. Extension of the Posix I/O standards will allow the applications to use the different levels of the storage system efficiently.

Using more cores on the same problem size (i. e. strong scaling) means that the computation time for each core declines, while the communication overhead stays constant or rises which

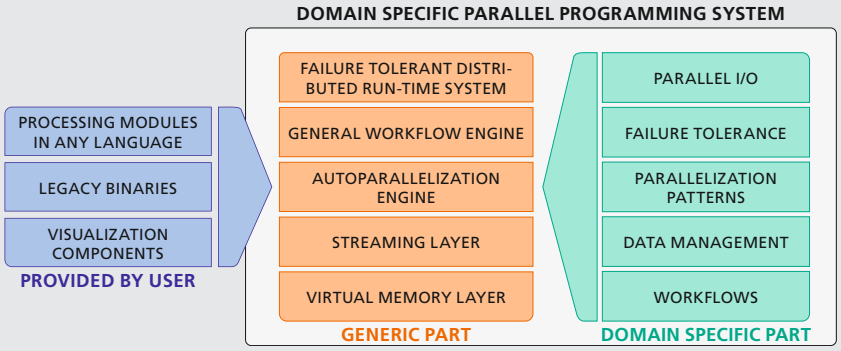


2 *Scaling a matrix-vector-based operation in comparison*

implies that the time-to-solution is dominated by the communication costs. This gives rise to asynchronous, non-blocking communication models which allow the communication to start at the earliest possible stage in the execution of the program and the data to arrive in a timely manner, when it is really needed. Moreover, the increasing number of computing components demands more concurrency and the ability to communicate in a finer grained manner. The CC-HPC provides such a system: GPI. The Global Address Space Programming Interface (GPI) was designed with scalability of parallel applications in mind, enabling efficient multi-threaded communication with low latency and high bandwidth, with no load on the processing units and avoiding temporary' copies of data. GPI is currently one of the main programming models for two EU projects, namely EPiGRAM and EXA2CT.

The aim of the EPiGRAM project is to prepare communication programming models for exascale systems by fundamentally addressing their main current limitations. EPiGRAM introduces new disruptive concepts to fill the technological gap of exascale programming models. EPiGRAM analyses the philosophies between diverse communication programming models and tries to combine the best features of communication programming models. An important point is the interoperability between different communication models. GPI is used in the two applications of the EPiGRAM project: NEK5000, a computational fluid dynamics and IPIC3D, a code for the simulation of space and fusion plasmas.

The EXA2CT project brings together experts at the cutting edge of the development of numerical solvers and HPC software architects for programming models. The advancement of simulation as a discipline relies on increasingly compute intensive models that require more computational resources to run. Due to limits in single processor performance, exascale machines will rely on massive parallelism. In the scope of the project CC HPC supports the partners using the GPI programming model and the development of mathematical software libraries. The main goal is that it becomes easier for the application developers. During the project, prototype applications are being developed which can be used as a blueprint for larger application codes.



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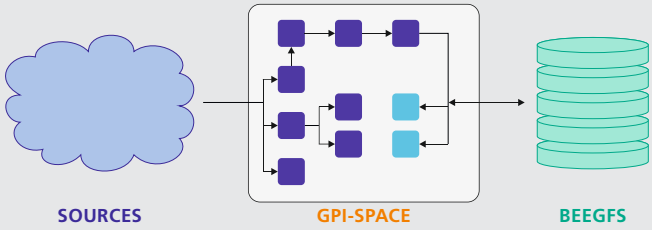
BIG DATA: COMPETENCES AND PROJECTS

1 *Overview of the core components of GPI-Space as well as application and domain specific HPC components.*

In recent years, Big Data has become an important application for supercomputers besides the traditional applications such as simulations and others. Overall performance and data throughput are more and more becoming a critical factor in data processing for companies and users from all industries. Being able to analyze huge amounts of data not only brought forward new business models for industry, but enables new discoveries by researchers based on advanced technologies. New challenges are introduced lately by real-time streaming data processing. Among the key words are: personalized industries, identification of disease markers, genome analysis for all, or process monitoring for individual components. The CC-HPC has focused its research in the past years on new approaches and ideas as alternatives to today's quasi standard solutions in Big Data, and has developed powerful and flexible tools that not only outperform those standards, but are also fit for future hardware architectures.

Based on GPI and taking into account the advanced development of paradigms from the cloud environment, CC-HPC has created GPI-SPACE, a development platform and runtime environment. It is a tool that considerably simplifies the development and fault tolerant execution of parallel software programs and is perfect for working with Big Data applications. GPI-Space is thus solving two of the most important and still open issues in the processing of extremely large data volumes: 1) a programming model for the respective applications and 2) the execution environment. One of the main characteristics of GPI-Space is the separation of domain and HPC expert knowledge. GPI-Space frees a domain developer from the burden of parallelization and all its potential traps and enables him to use his expert knowledge to focus on the solution of his application specific problem. HPC experts can – at the same time – start to solve the specific parallelization problems for this domain like I/O, partition patterns, failure tolerance, data management, and workflows. GPI-Space brings together those components, the HPC specific part on the one hand and the application specific part on the other and allows failure tolerant, dynamic and parallel execution even of existing sequential legacy programs. In addition to the traditional analysis of data from a fast parallel file system, a streaming layer is now part of GPI-Space which allows data processing right from the source (e. g. sensors, cameras …) without the need to put the data on a disk, first. This allows new real-time big data applications, just like the one described further down.

The virtual storage device used in GPI-Space is based on the fast, internal main memory and not on slower external disk storage as in other Big Data solutions. By this alone, the response times are significantly reduced, especially, if the same data is used by multiple resources. The virtual memory is also independent of specific applications and makes it possible to connect



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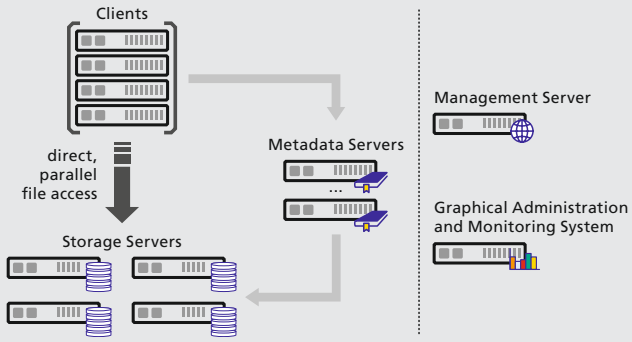

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them in a simple and direct way. The GPI-Space operating environment is not only fault tolerant, but also fully interactive and allows to change the size and structure of the machine used during the runtime of an algorithm, or to use the optimal topology for the different phases. That is another big advantage over existing solutions which usually have to keep as many resources on hand during the entire run time as required by the most resource demanding part of the application.

BeeGFS – formerly known as FhGFS – started at CC HPC as a high-performance parallel file system, dedicated to the HPC community and is used today in HPC centers of universities, research centers and industry worldwide. It was developed from scratch, making scalability, maximum performance, flexibility and ease of use the corner stones of the development. Until today, its superior performance and scalability and the user friendly operation make it popular to an ever growing global user base. To stay on this track, one focus of development in 2014 was on internal optimizations in the storage servers. New features like support for quotas, authentication, BeeGFS-on-demand, etc. have also been added and made the software even more user friendly. To take BeeGFS to the next level, ThinkParQ was founded as a spin-off from Fraunhofer and is now responsible for BeeGFS sales and support. CC HPC, however, is continuing as driving force behind the development and just recently put its "Scalability Lab" into operation. The purpose of this multi-node cluster is to make BeeGFS and its components fit for the challenges of future exascale environments.

The goal of an initiative by Fraunhofer ITWM and some of its industry partners is, to build a real-time monitoring system for smart meters in large building complexes, such as hospitals, hotels, universities, office buildings etc. Live data from smart meters, attached to key distribution boxes in the building, is fed into GPI-Space where advanced algorithms evaluate the data for specific patterns. With non-intrusive appliance load monitoring, individual consumers are identified without the need for direct metering. Live data analysis as well as analysis of historic data in storage are used to optimize a building's energy consumption.

Using data mining on the smart meter data, valuable information can be extracted, to make a prediction of future energy consumption, based on previous years, months, weeks and days and use this energy consumption forecast to optimize the use of renewable energy sources in the building, such as solar panels. In addition to this planning purpose, individual devices with high energy consumption can be easily monitored to implement auto-off or fault-detection.

2 *Using the straming layer, GPI-Space is capable of processing data directly and in real-time from the source (sensor etc.) as well as from disk.*

3 *The BeeGFS hardware architecture; number and physical location of storage server, metadata server and client processes is completely variable and provides maximum flexibility to the user.*

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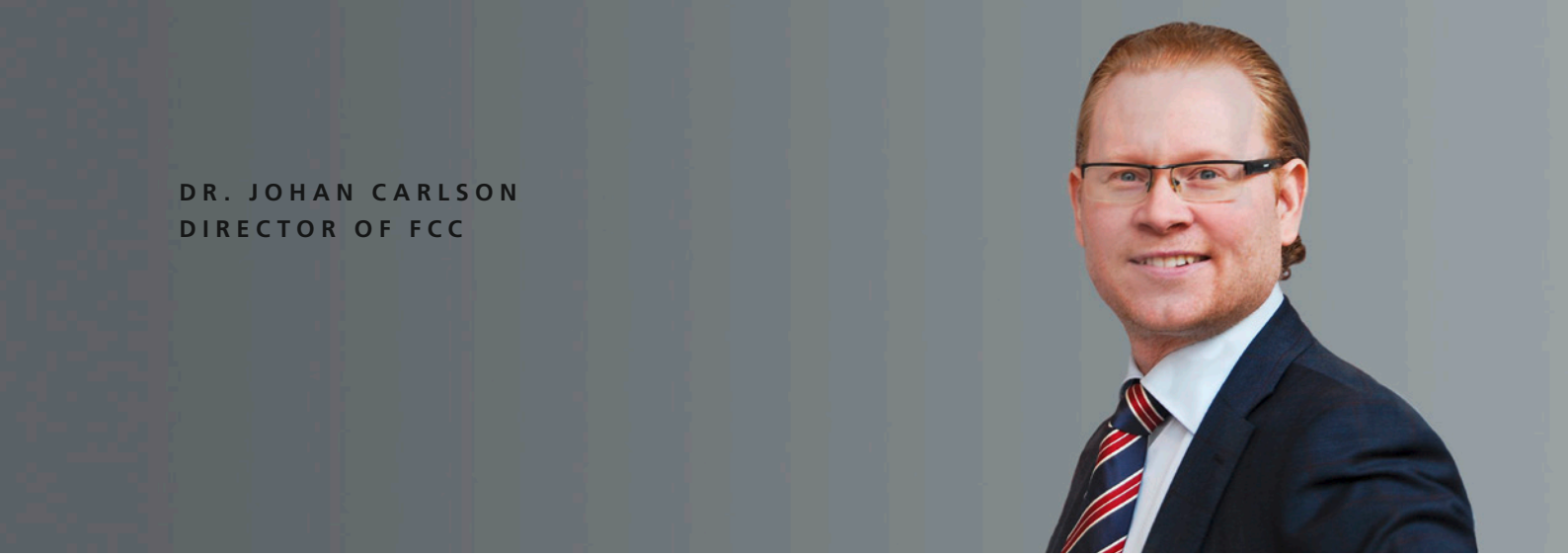


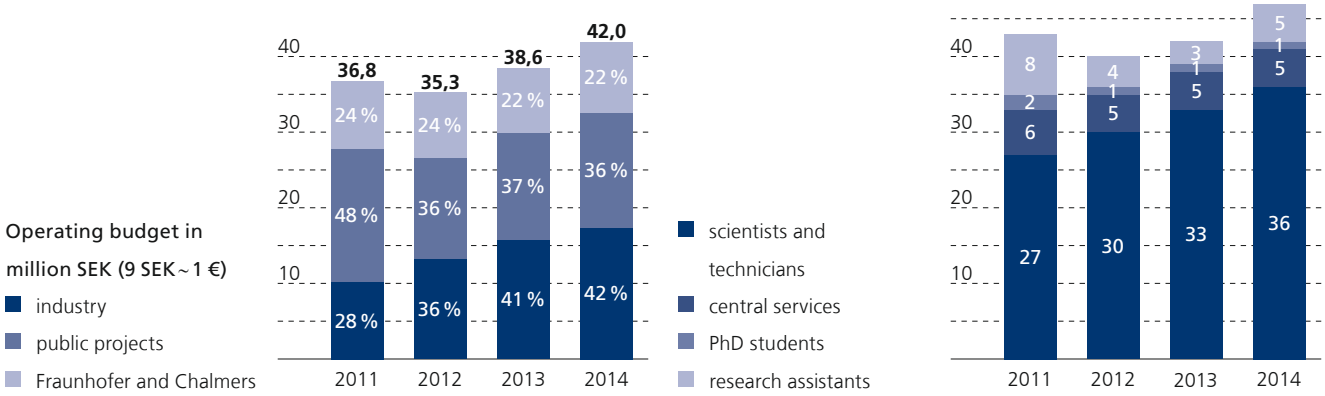
DR. JOHAN CARLSON
DIRECTOR OF FCC

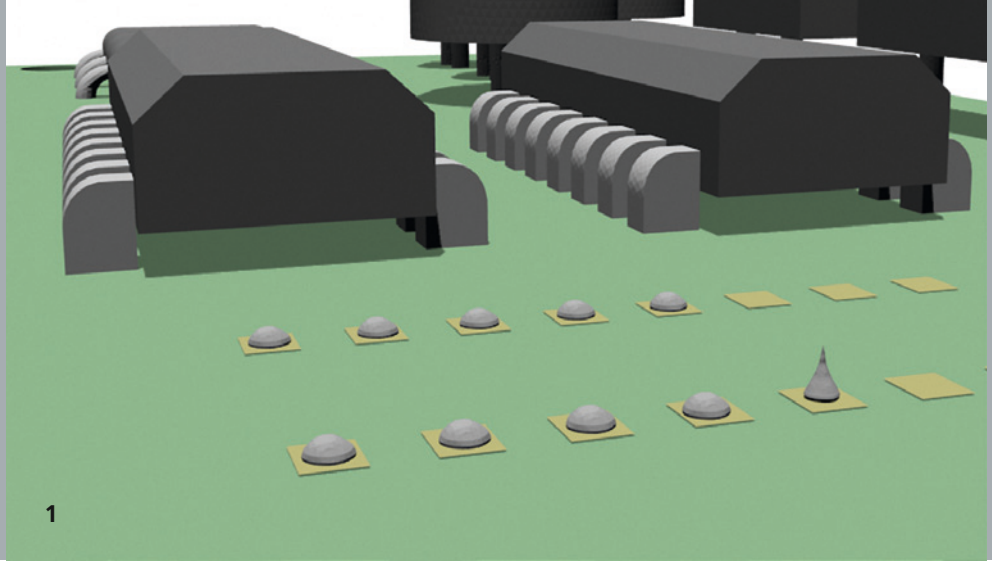
FCC is offering contract research, services, algorithms and software based on advanced mathematics within Modeling, Simulation and Optimization (MSO). MSO provides a significant leading edge in industrial innovation of products and production systems. In 2014, we have successfully proved this together with clients from the automotive and vehicle, metrology, pharmaceutical, wood and paper, and electronics industries. Examples include simulation and optimization of robotized sealing stations, simulation of assembly ergonomics, modeling and simulation of drug compound distribution and effect, off-line programming of white light sensors, and edge wicking of paperboards. During 2014, we have performed over fifty projects for our industrial clients and twenty public projects financed by public research agencies such as SSF, VINNOVA and the EU. The revenue shows a satisfying growth of almost 10 percent since last year, an industrial income of 41 percent and a positive net result. Our work and technologies have helped clients mainly in Sweden, but also in Germany, US, Finland, Denmark, Japan, Israel, Korea, and Great Britain. However, the full potential of using advanced mathematics in industry is far from reached and new technologies together with increased efforts in marketing and sales will hopefully continue our growth in 2015 and beyond.

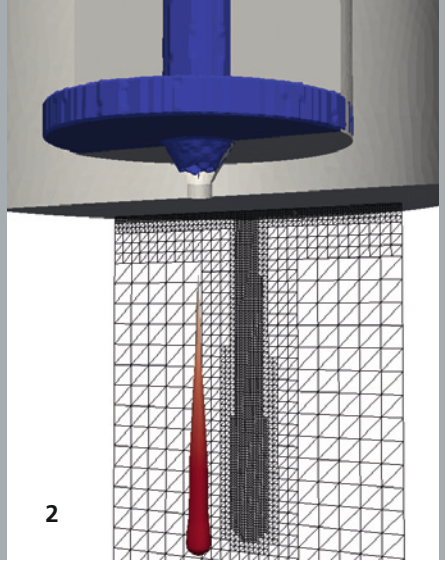
The cooperation and exchange of projects with ITWM during 2014 have involved a variety of subjects such as metrology, biomechanics, the simulation of flexibles, virtual paint, position tracking systems, product configuration optimization, continuous production, the simulation of ultra-fast electronics, and big data analytics.

A special thanks goes to our Vice Chairman Professor Helmut Neunzert, now retiring from the FCC board after 13 years. He successfully brought Fraunhofer to Sweden by initiating the discussions and negotiations resulting in the start of FCC in 2001. As a true and enthusiastic friend of FCC, he has been a driving spirit for building a successful Swedish centre in industrial mathematics following the Fraunhofer model with a high level of contracted research boosted by pre-competitive research funded by Fraunhofer and Chalmers.

Dr. Johan Carlson
Director of FCC







SIMULATION OF JET PRINTING OF SOLDER PASTE ONTO A PRINTED CIRCUIT BOARD

In close collaboration with the company Mycronic AB, Fraunhofer-Chalmers Centre is developing a novel software for simulation of the jet printing process used in the manufacturing of printed circuit boards. The software makes it possible for Mycronic to strengthen their knowledge of the complex jetting process and is supporting their product development of the next generation of jet printers.

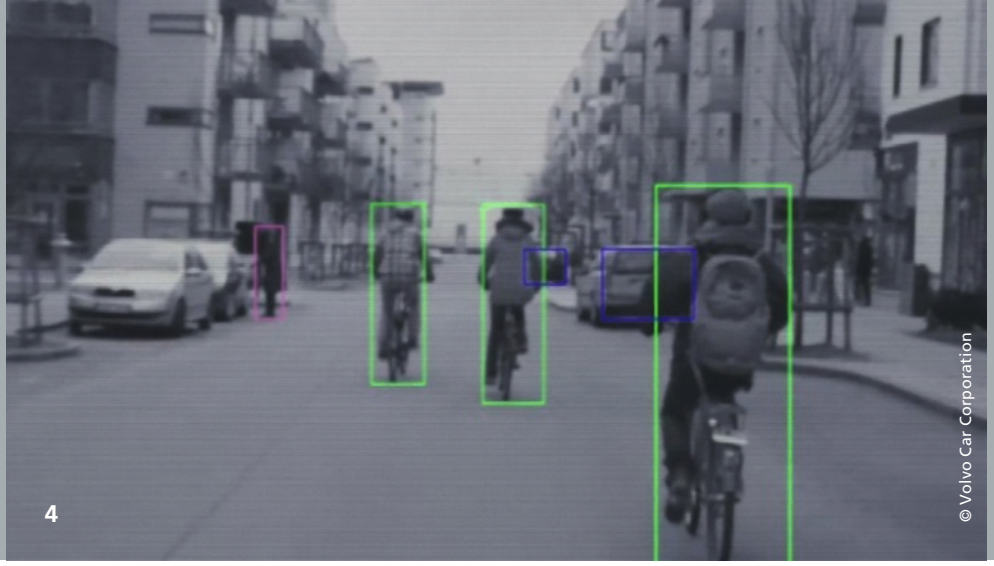
The driving force in the jet printer is a Piezo element that expands rapidly when subjected to an electrical signal and cause a piston to accelerate. The movement of the piston results in a sudden increase of the pressure in the chamber containing the solder paste forcing the fluid to squeeze through the printing head nozzle. When the signal is cut off the Piezo element retracts and the pressure decreases again. At this point the momentum of the fluid is large enough to form a droplet that will travel through the air and impact on the PCB. Due to the complexity of the solder paste, consisting of a mixture of solid granules and flux, and the small time and spatial scales of the process it is difficult to acquire experimental data of the jetting sequence. To perform simulations instead is also very challenging due to the large acceleration of the piston and strong fluid-structure interaction between the piston and the solder paste.

The simulations of the ejection and formation of the solder paste droplet are successfully performed with our in-house software IBOFlow (Immersed Boundary Octree Flow solver) coupled with LaStFEM (Large Strain FEM solver). The immersed boundary techniques and adaptive octree grids simplify the simulation setup and are perfectly suited for handling the complex fluid-structure interaction. The solder paste is modeled as a generalized Newtonian fluid with a time dependent Carreau model that takes both the visco-elastic and shear thinning behavior into account.

Simulations show that the jet printing process is sensitive to material parameters such as surface tension and viscosity. In particular, the viscosity at high shear rates is important in the early jetting sequence while the surface tension is more important for the droplet formation after the actual jetting event. Different Piezo signals affect not only the droplet velocity and size but also the filament breakup and forming of satellite droplets. The software's ability to capture that is very promising since it is crucial for the quality of the solder joint. The detailed modeling and short simulation times make it possible for Mycronic to use the software to gain better knowledge of the jetting process and in their development of the next generation of jet printers.

1 *Close up of jet printing simulation on a PCB. The solder paste is ejected on the PCB in a certain pattern. In the next step of the process these droplets will form the solder joint between the electric component and the PCB circuit.*

2 *Jetting simulation of solder paste showing the droplet and the adaptive octree mesh together with parts of the computational domain. The steady solder paste inside the chamber is depicted in blue and the moving ejected droplet in red. The gray parts are the jetting head and the moving piston.*



REAL-TIME VIDEO ENHANCEMENT FOR AUTOMOTIVE APPLICATIONS

1 *Image captured using the headlights as light source during night; the animals are barely visible.*

2 *Using an infrared flash helps a little; dark areas are improved, but instead other areas are just white.*

3 *The output from the video enhancing algorithm is dramatically better.*

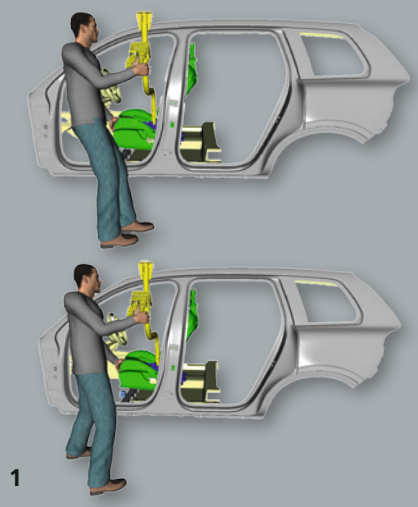
4 *Automatically detected cars, cyclists and pedestrians*

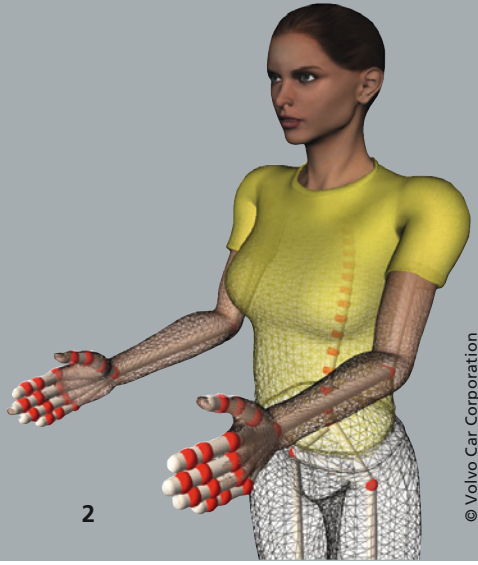
In a project carried out in cooperation with Volvo Car Corporation, Epsilon Embedded, and Chalmers University of Technology, FCC has developed an automatic algorithm for real time video enhancement based on fusion of regular and infrared video signals. The improvement is dramatic and makes it possible for the driver to get an enhanced view of both the road and its surroundings, even given very poor conditions in complex environments. The algorithm can handle changing conditions and automatically combines improved image quality in dark areas and in areas flooded with bright light.

The video enhancement algorithm consists of a combination of local adaptive contrast enhancement, noise reduction, light normalization, and fusion of video streams with and without infrared flash. Several state of the art algorithms were initially evaluated but the resulting videos were found to be of insufficient quality. This called for a novel approach, using a combination of available methods and custom developed algorithms. Key components include Contrast Limited Adaptive Histogram Equalization (CLAHE), Video Block Matching 3D (VBM3D), and tone-mapping. Histogram Equalization is a well-established contrast enhancement technique. CLAHE is a version of this technique that is local in nature with less amplification of noise.

When amplifying dark video and enhancing contrast, noise is also amplified, and noise reduction is necessary. Here VBM3D was used, which works by identifying similar small parts of an image from the current or neighboring frames of the video, building a 3D structure of those image parts and then performing a transform based noise reduction. Using an infrared flash gives better image information in dark areas but well lit areas will actually become worse. Therefore the method utilizes two video streams, one with flash and one without. The two streams are combined by using a continuously updated weight map of what parts of the image are bright and what parts are dark. Finally, object contrast is enhanced, making dangers visible, and artificial light-condition-objects are removed (for example the bright oval cast by the headlights). In order to do this, light patterns that are stable as the car moves are calculated and the image is then normalize based on these light patterns. This removes the oval cast by the headlights but preserves real objects.

The results have been presented both internally at Volvo Car Corporation and in different forums like Vehicle ICT Arena's Innovation Bazaar and at Transportforum, the main Nordic conference for the transportation sector, and have been very well received by the automotive industry.





IMMA – INTELLIGENTLY MOVING MANIKINS

Better ergonomics in assembly plants reduce work related injuries, improve quality and productivity, and reduce cost. Motivated by this, new methods, algorithms and software tools for fast and easy evaluation of assembly ergonomics considering human diversity have been developed in the IMMA project. The IMMA project has successfully combined advanced mathematics, ergonomics, and virtual product realization. The project was part of the SSF ProViking Program and involved researchers from FCC, Wingquist Laboratory and Virtual Ergonomic Centre, in close collaboration with our industrial partners Volvo Cars, Scania, AB Volvo, and Virtual Manufacturing.

The ergonomics in assembly operations are an important factor to keep workers healthy and to avoid injuries and maintain productivity and production quality. A bad layout of an assembly station, a poor product design or badly chosen assembly sequences are all common sources that are known to result in awkward and uncomfortable assembly motions. In industry today, ergonomic studies of assembly operations are conducted. However, the full potential is far from reached due to limited software support lacking easy creation of realistic assembly motions considering the intended population. As a consequence, the ergonomic studies are time consuming and are mostly done with only a few manikins in static positions, instead of studying the full assembly motion with a set of manikins that with high confidence represent the intended work force. To resolve these shortcomings, a digital human modeling tool, IMMA, has been developed in close collaboration with the Swedish vehicle industry. The main results of the project is a fast and easy software tool that automatically finds a collision free assembly motion with as low biomechanical load as possible, considers human diversity, can be controlled with a high level instruction language, and uses industrial ergonomic assessment methods.

To automatically create manual assembly motions, a detailed modeling of human body kinematics is needed. The biomechanical model of the IMMA manikin is built as a simplified human skeleton and consists of 82 bone segments. The joints in the biomechanical model have in total 162 degrees of freedom to represent the mobility of a human body. A comfort function is defined to determine which positions of the manikin that are ergonomically sound. The comfort is based on ergonomic criteria of the biomechanical model and has been formalized to fit the mathematical framework of IMMA. The framework creates a tight coupling between powerful algorithms for collision-free path planning and the biomechanical model. In this way, kinematic constraints, balance, contact forces, collision avoidance and comfort are taken into account in the generated assembly motions.

1 *A position where the manikin has a stable balance and a position without balance*

2 *The biomechanical skeleton with manikin meshes from Poser®.*

TALKS

Andersen, Olaf; Schladitz, Katja; Rösch, Ronald
Standardized characterization of cellular materials using computed tomography
CellMat, Dresden, September

Andrä, Heiko; Kabel, Matthias; Müller, Ralf; Spahn, Johannes
Multiscale damage simulation of composites by using the Lippmann-Schwinger integral equations
Workshop "Multiscale Simulations", Univ. des Saarlandes, January

Andrä, Heiko; Spahn, Johannes; Kabel, Matthias
The Lippmann-Schwinger-type integral equation for progressive damage in composites
27th International Workshop Research in Mechanics of Composites, Bad Herrenalb, December

Annibale, E. S.; Steidel, S.; Dreßler, K.
Nichtlineare Modellreduktion
Aachen, November

Annibale, E. S.; Dreßler, K.; Hermanns, O.; Linn, J.; Zemerli, C.
Virtual Design and Dynamical Simulation of Flexible Cables, Hoses, and Wires
São Paulo (BR), September

Annibale, E. S.; Zemerli, C.; Dreßler, K.; Hermanns, O.; Edelvik, F.; Mark, A.
Efficient Numerical Simulation of Spray Painting Processes in Automotive Manufacturing
São Paulo (BR), September

Barthlen, Andreas
Stable Parametric Model Order Reduction using Matrix Interpolation
Reduced Basis Summer School Münster, August

Bauchau, O.; Lao, Z.; Lyu, M.; Brändle, S.; Linn, J.
Formulations of Viscoelastic Constitutive Laws for Beams in Flexible Multibody Dynamics
Busan (ROK), June

Berger, Martin
Ökonomische und logistische Aspekte des Projektes SUSI TD
Science Alliance, Kaiserslautern, April

Bortz, Michael
An Interface between Experiments and Simulation: Data Selection, Model Adjustment and Decision Support
Jahrestreffen der ProcessNet-Fachgemeinschaft „Prozess-, Apparate- und Anlagentechnik", Lüneburg, November

Bortz, Michael
Decision Support by Multicriteria Optimization
Young Scientist Workshops, Fraunhofer ICT-IMM, Mainz, September

Burger, M.
System Load Derivation in Vehicle Engineering by Solving an Inverse DAE Control Problem
Friedrich-Alexander Universität Erlangen-Nürnberg, March

Burger, M.; Bäcker, M.; Gallrein, A.; Kleer, M.
Full-Vehicle Real-Time Simulation with an Advanced Flexible Tire Model on Fraunhofer's Driving Simulator
Augsburg, October

Calabrese, F.; Bäcker, M.; Gallrein, A.
Advanced Handling Applications with New Tire Model Utilizing 3D Thermo-Dynamics
Augsburg, October

Carmelo, Vicari; Khozoei, Mohammed Ali
Statistical Variation Aware ANN and SVM Model Generation for Digital Standard Cells
ECMI 2014, Taormina (I), June

Dick, Veronika
Molecular dynamics study of water transport through hydrophilized PVDF membranes
NANO4WATER: 4th dissemination workshop of the nano4water cluster, Stockholm (S), April

Dick, Veronika
NANOPUR – WP4: Membrane performance testing and modeling
NANOPUR metting M24, Venedig (I), Mai und NANOPUR metting M30, Berlin, November

Dobrovolskij, Dascha; Spies, Martin
Ultraschall-Simulation für komplexe Bauteile mittels ABCD-Methodologie
DGZfP-Jahrestagung 2014, Potsdam, May

Dreßler, K.
IPS Cable Simulation – bridging the gap between physics based simulation and VR
Karlsruhe, October

Dreßler, K.
Simulation der Nutzungsvariabilität zur Bemessung gegen variable Betriebslasten in der Fahrzeugentwicklung
Stuttgart, January

Dreßler, K.
Simulationsbasierte Konstruktion, Montage und Absicherung von Kabeln, Leitungssträngen und Schläuchen
Osnabrück, March

Dreßler, K.; Bäcker, M., Burger, M.; Speckert, M.; Wolf, B.
Simulation von hochauflösenden Reifenmodellen für Lenkkapazitätsanalysen am Ackerschlepper
Mannheim, February

Dreßler, K.; Bäcker, M.; Gallrein, A.
Reifenmodellierung in der Fahrzeugentwicklung
Essen, June

Dreßler, K.; Linn, J.
Simulation for assembly-oriented design and digital validation of cables and hoses
Berlin, May

Dreßler, K.; Speckert, M.
Methoden der Last- und Beanspruchungsanalyse und Statistik für Betriebsfestigkeitsanwendungen
Ingolstadt, October

Dreßler, K.; Speckert, M.
Simulation der Nutzungsvariabilität für Betriebsfestigkeit und Energieeffizienz unter Verwendung georeferenzierter Daten
Baden-Baden, November

Dreßler, K.; Speckert, M.
Statistical modelling of usage variability and the VMC-concept
Paris (F), April

Dugan, Sandra; Wagner, Sabine; Dillhöfer, Alexander; Rieder, Hans; Spies, Martin
Detection and Sizing of Stress Corrosion Cracks in Austenitic Components Using Ultrasonic Testing and Synthetic Aperture Focusing Technique
40th MPA-Seminar, Stuttgart, October

Dugan, Sandra; Wagner, Sabine; Dillhöfer, Alexander; Rieder, Hans; Spies, Martin
Nachweis und Größenbestimmung realistischer Testfehler in austenitischen Werkstoffen mittels Ultraschall und die Grenzen bei der Prüfung durch die Schweißnaht
DGZfP-Jahrestagung 2014, Potsdam, May

Easwaran, Prakash; Redenbach, Claudia; Wirjadi, Oliver; Prill, Torben; Schladitz, Katja; Lehmann, Martin
Modeling of interacting fibers based on 2D images for fibrous filter media simulation
Chicago (USA), October

Eckstein, C.; Pirro, P.; Speckert, M.
Erstellung anwendungsspezifischer Lastkollektive als Eingangsgröße der numerische Simulation
Mannheim, February

Eckstein, C.; Pirro, P.; Speckert, M.; Streit, A.
Determination of test scenarios for durability verification of tractors under consideration of their usage variability
Kaiserslautern, March

Edelvik, F.; Mark, A.; Zemerli, C.; Hermanns, O.
Efficient numerical simulation of spray painting
Kaiserslautern, March

Filla, R.; Obermayr, M.; Frank, B.
A study to compare trajectory generation algorithms for automatic bucket filling in wheel loaders
Kaiserslautern, March

Föhst, Sonja
A tree-like model for airways in mice lungs
Kaiserslautern, October

Föhst, Sonja
Geometric analysis of compensatory lung growth in mice via image analysis
Ulm, March

Gallrein, A.; Bäcker, M.; Burger, M.; Gizatullin, A.
An Advanced Flexible Realtime Tire Model and its Integration Into Fraunhofer's Driving Simulator
Detroit (USA), April

Gerwalin, Elmar
Wollen Anwender eigentlich Green IT?
8. Controlling Tagung, Sankt Augustin, March

Gibali, Aviv
Projection methods – a powerful tool for real-world problems and combinatorial games
Group Seminar SS 2014, Mathematics of Computation, Institut für Numerische Simulation, Bonn, May

Gramsch, Simone
Erfolgreich arbeiten am Fraunhofer ITWM
Femtec, Kaiserslautern, September

Gramsch, Simone
Simulation of Fiber Dynamics for Nonwoven Processes
Index14, Genf (CH), April

Gramsch, Simone; Hietel, Dietmar; Leithäuser, Christian; Wegener, Raimund
Innovative Simulation Techniques and Tools for Nonwoven Production Processes
Index14, Genf (CH), April

Grimm, Stefanie
Modelling asset prices within a hidden Markov model - investment strategies including assets and bonds
Stochastik Tage Ulm, March

Groß, Tjorben; Trenn, Stephan; Wirsen, Andreas
Topological solvability and index characterizations for a common DAE power system model
2014 IEEE Multi-Conference on Systems and Control (MSC 2014), Antibes (F), October

Hermanns, O.
Echtzeitsimulation zur montagegerechten Auslegung und digitalen Absicherung von Kabeln und Schläuchen
Bad Nauheim, February

Hietel, D.; Feßler, R.; Leithäuser, C.
Design of Polymer - Faster from Polymer to Fibers
53nd Dornbirn Man-made Fibers Congress, Dornbirn (A), September

Hietel, Dietmar; Arne, Walter; Leithäuser, Christian; Wegener, Raimund
Improvement of Fiber Spinning and Nonwoven Processes
Index14, Genf (CH), April

Hietel, Dietmar; Gramsch, Simone; Wegener, Raimund
Simulation von Vliesstoffprozessen für Filtermedien: Zufällige Determiniertheit oder determinierte Zufälligkeit
12. Symposium Textile Filter, Chemnitz, March

Horcicka, M.; Arnold, M.; Burger, M.; Simeon, B.
Zustandsbeobachtung von Mehrkörpersystemen mit dem DAE-Beobachteransatz
Anif, Salzburg (A), September

Hubel, Sebastian; Spies, Martin; Bamberg, Joachim; Götz, Joshua; Hessert, Roland
Bestimmung von oberflächennahen Spannungszuständen in randzonenverfestigten Triebwerkswerkstoffen mittels Rayleigh-Wellen
DGZfP-Jahrestagung 2014, Potsdam, May

Iliev, Oleg; Efendiev, Yalchin; Latz, Arnulf; Taralova, Vassilena; Taralov, Maxim; Zausch, Jochen; Zhang, Shiquan
On computer simulation of multiscale processes in porous electrodes of Li-ion batteries
Seminar on Scientific Computing in Lawrence Livermore National Lab; Livermore (USA), October und Seminar on Numerical Methods for PDEs, Dept of Mathematics, PennState University; State College (USA), October

Iliev, Oleg; Kirsch,Ralf; Osterroth, Sebastian
The simulation of filter cake build-up for spherical particle mixtures
FPS, European conference on fluid-particle separation, Lyon (F), October

Iliev, Oleg; Lakdawala, Zahra; Printsypar, Galina; Leonard, Katharina
Computer Simulation of Filtration and Osmosis Processes
Invited lecture at Summer School on Innovative Membrane Systems, Cetraro (I), October

Iliev, Oleg; Lakdawala, Zahra; Printsypar, Galina; Vutov; Yavor; Taralova, Vassilena; Taralov, Maxim
Reactive flow in deformable porous media
Workshop on reactive flow in porous media, Oberwolfach, September

Iliev, Oleg; Maday, Yvon; Taralova, Vassilena; Schmidt, Sebastian; Zausch, Jochen; Zhang, Shiquan
POD-EIM and RB MOR for simulation of processes in Li-ion batteries
Workshop on Model Reduction; Paris (F), January

Iliev, Oleg; Steiner, Konrad; Zemitis, Aivars; Klein-Hessling, Walter; Sonnenkalb, Martin; Freitag, Martin
Towards a coupled CFD/LP code approach for containment simulations
CFD4NRS-5, Experimental Validation and Application of CFD and CMFD Codes in Nuclear Reactor Technology, Zürich (CH), September

Iliev, Oleg; Calo, Victor; Iliev, Dimitar; Kirsch, Ralf; Mikelöic, Andro
Modeling and simulation of filter media deformation in connection with filtration problems
Spring Conf. American Filtration Society, Houston (USA), March

Iliev,Oleg; Lakdawala,Zahra; Printsypar, Galina; Vutov; Yavor
Multiscale simulation of filtration and separation processes
Numerical Methods for Scientific Computations and Advanced Applications, Bansko (BG), Mai und Annual Meeting of International Society for Porous Media, Milwaukee (USA), May

Jami, Neil
Dynamics in Logistics
4th International Conference on Dynamics in Logistics (LDIC 2014), Bremen, February

Kabel, Matthias
Computer Aided Material Characterization
Opel Innovation Conference, Rüsselsheim, November

Kabel, Matthias
FFT-based homogenization of elasticity at large deformations
27th International Workshop Research in Mechanics of Composites, Bad Herrenalb, December

Kabel, Matthias
Microscopic Simulation of Thermally-Induced 2nd Order Eigenstresses in AlSi-Alloys
2nd Seminar on the Mechanics of Multifunctional Materials, Bad Honnef, May

Kabel, Matthias
The FeelMath Structural Mechanics Solver on 3D Images
GeoDict User Meeting, Kaiserslautern, October

Khozoei, Mohammed Ali
Waveform modelling in order to speed up transient SPICE simulations
ECMI 2014, Taormina (I), June

Khozoei, Mohammed Ali; Lang, Patrick; Hauser, Matthias
The usage of Symbolic Model Order Reduction techniques for reducing the complexity of a system of differential-algebraic equations describing the behaviour of an integrated circuit, thus reducing drastically the simulation time
ECMI 2014, Taormina (I), June

Kleer, M.; Gizatullin, A.; Pena Viña, E.; Dreßler, K.
Interactive real-time driving simulation with the Fraunhofer robot based driving and operation simulator
Pollenzo-Bra (I), April

Kleer, M.; Gizatullin, A.; Pena Viña, E.; Dreßler, K.
The Fraunhofer Robot-Based Driving and Operation Simulator: A simulation platform for commercial vehicles – Current development status
Kaiserslautern, March

Klein, Matthias
myPowerGrid – Netzdienlichkeit von PV-Heimspeichern
Perspektiven der Entwicklung des Stromnetzes und der Stromspeicherung in der Metropolregion Rhein-Neckar, StoREgio, Energieagentur Rheinland-Pfalz, Ludwigshafen, May

Kleinert, J.; Simeon, B.
A Conical Interior Point Method for Nonsmooth Rigid Body Dynamics
Rhodes (GR), September

Kohl, Matthias; Ruckdeschel, Peter
Convergence of Robust Models
Workshop und Meeting der Projektgruppen „Robust Risk Estimation" and "Robuste Analyse hydrol. Zeitreihen", Bochum, February

Korn, Ralf
Aspekte der Zinsmodellierung und ihrer praktischen Anwendung (4 Lectures)
Deutsche Bundesbank, Frankfurt, January

Korn, Ralf
Computational Problems in Pricing, Risk and Asset Management in Banks and Insurance Companies
24th International Conference on Field Programmable Logic and Applications München, September

Korn, Ralf
Der Zufall, Dein Feind und Helfer
ITWM, April

Korn, Ralf
Grundlagen der Finanzmathematik (5 Lectures)
Deutsche Bundesbank, Frankfurt, January

Korn, Ralf
Lebensversicherungsmathematik: Anfänge, Garantieprodukte, Langlebigkeit
TU Dortmund, December

Korn, Ralf
Monte Carlo Methods in Finance: Basic Methods and Recent Advances (5 Lectures)
Commerzbank, Frankfurt, July

Korn, Ralf
Save for Bad Times or Consume as Long as You Have? Worst-Case Portfolio Optimization: Concept and Recent Results
Belg. Actuarial and Financial Mathematics Conference, Brussel (B), January und University Liverpool(GB), February

Korn, Ralf
Sparen für schlechte Zeiten oder verjubeln, solange noch was da ist? Worst-Case optimaler Konsum
Universität Augsburg, January und Universität Bayreuth, July

Kühn, Martin
Anisotropic Diffusion Filtering Terabytes of Seismic Data in seconds: The Power of the GPI-2 One-sided Communication Approach
28th International Conference on Supercomputing, München, June

Kuhnert, Jörg
Meshfree Numerical Scheme for Time Dependent Industrial Problems in Fluid and Continuum Mechanics
International Conference on Mathematical Modeling and Computer Simulation, IIT Madras, Chennai (IND), December

Leithäuser, Christian; Hietel, Dietmar
Optimized Distribution of Polymer Melts and Solutions
Index14, Genf (CH), April

Linden, Sven; Hagen, Hans; Wiegmann, Andreas
The LIR-approach to Simulating Single Phase Flow on CT Images
Interpore, Milwaukee (USA) May

Linden, Sven; Wiegmann, Andreas
Efficient Prediction of Permeability based on 3d Images of Core-samples
EAGE, Amsterdam (NL), June

Losch, Katharina
Stochastic modeling of engineering materials for predictions of spatial mechanical characteristics
Ulm, March

Maag, Volker
A dimension reduction approach for the nondominated set approximation
20th Conference of the International Federation of Operational Research Societies (IFORS2014), Barcelona (E)

Malten, Rebekka
Blick über den Tellerrand der klassischen Oberflächeninspektion
Fraunhofer IOSB, Karlsruhe, December

Marquardt, A.; Obermayr, M.
Optimizing test rig configurations and excitations for excavator booms
Kaiserslautern, March

Mohring, Jan
Parametric Reduction of FE Models with Variable Mesh Topology
85th Annual Meeting of the International Association of Applied Mathematics and Mechanics, Erlangen-Nürnberg, March

Mohring, Jan
ROMI – Root cause analysis of Measurement Issues
Kronion eMMA, User Meeting and Symposium 3D-Messtechnik, Landau, November

Neunzert, Helmut
Mathematik am Fraunhofer-Institut: problemgetrieben – modellbasiert - lösungsorientiert
Universität Graz (A), September

Neunzert, Helmut
The tasks ahead – Reflexions on the future of mathematics
Conference "Numerical Methods for Scientific Computations and Advanced Applications, Bansko (BG), May and Conference „Future Mathematics", Danish Technical University, Kopenhagen (DK), May

Neunzert, Helmut
Von Ursache zu Wirkung: Warum Künstler und Naturwissenschaftler die Blickrichtung manchmal umkehren
ADA-Seminar, Meiningen, March

Neusius, David; Schmidt, Sebastian; Klar, Axel
On boundary approximation for simulation of granular flow
FVCA7 - The International Symposium of Finite Volumes for Complex Applications VII, Berlin, June

Neusius, David; Schmidt, Sebastian; Klar, Axel
On boundary approximation for solving continuum granular flow equations
IWH Symposium "Simulation and Optimization of Extreme Fluids", Internationales Wissenschaftsforum Heidelberg, November

Neusius, David; Schmidt, Sebastian; Klar, Axel
On boundary approximation for voxel-based simulation of granular flow
6th European Conference on Computational Fluid Dynamics (ECFD VI), Barcelona (E), July

Niedziela, Dariusz; Rogowski, Andreas; Schmidt; Sebastian; Steiner, Konrad;
Instationäre, räumlich aufgelöste Simulation von Feststoffströmungen in Silos mittels GRAIN
Thyssen-Krupp Seminar der PLM / CAx Community, Lorch am Rhein, May

Niedziela, Dariusz; Schmidt; Sebastian; Steiner, Konrad; Zemerli, Clement;
From dilute granular flow to solid-like behavior, a hydrodynamic view
MGMAS Conference, Faculté de Médecine, Montpellier (F), July

Niedziela, Dariusz; Schmidt; Sebastian; Steiner, Konrad; Zemerli, Clement
Unified approach of hydrodynamic modeling and numerical simulation of dilute and dense granular flows for industrial applications

11. World Congress on Computational Mechanics (WCCM XI) & 6th. European Conference on Computational Fluid Dynamics (ECFD VI), Barcelona (E), July

Nowak, Dimitri
A ray tracing technique for the Pareto set navigation
20th Conference of the International Federation of Operational Research Societies (IFORS2014), Barcelona (E), July

Oden, Lena
Energy-Efficient Collective Reduce and Allreduce Operations on Distributed GPUs
International Symposium on Cluster, Cloud and Grid Computing, Chicago (USA), May

Oden, Lena
Energy-efficient Stencil Computations on Distributed GPUs using Dynamic Parallelism and GPU-controlled Communication
International Workshop on Energy Efficient Supercomputing, Lousianna (USA), November

Oden, Lena
GASP/GPI2 for GPUs: A PGAS Framework for Efficient Communication in GPU Systems
GPU Technology Conference, San Jose (USA), March

Oden, Lena
GPI2, GPI on GPU and GGAS - Communication Alternatives For Heterogeneous Clusters
Argonne National Labatatory, Lemont (USA), May

Oden, Lena
Infiniband-Verbs on GPU: A case study of controlling an Infiniband network device from the GPU
International Workshop on Accelerators and Hybrid Exascale Systems, Phoenix (USA), May

Orlik, Julia
Homogenization in contact problems with Coulomb friction on the microstructure
Staatliche Universität Moskau, Lehrstuhl PDE, Lecture, October

Orlik, Julia
Simulation und Optimierung technischer Textilien
Universität Stuttgart, Institut für Materialprüfung, Werkstoffkunde und Festigkeitslehre (IMWF), Lecture, November

Orlik, Julia; Shiryaev, Vladimir
Evolutional contact with Coulomb's friction on a periodic Microstructure
IMSE 2014, Karlsruhe, July

Orlik, Julia; Shiryaev, Vladimir
Homogenization of multiscale contact problems
GAMM-Seminar on Microstructures, Universität Bochum, January

Orth, Thomas; Chichkov, Nikolai; Schmitte, Till; Spies, Martin
Ultrasonic Pipe Inspection with Conventional Transducers or Phased-Arrays? A Comparison Based on POD-Analysis Can Help
DGZfP-Jahrestagung 2014, Potsdam, May and 11th ECNDT, Prag (CZ), October

Pfreundt, Franz-Josef
BeeGFS – High Performance Filesystems for HPC and the Big Data World
HP-CAST 23, New Orleans (USA), November

Pfreundt, Franz-Josef
HPC and Big Data Storage- and Innovative Parallel Filesystems The Fraunhofer Parallel Filesystem
HP-CAST 22, Leipzig, June

Pfreundt, Franz-Josef
Prognose der Leistung fluktuierender Energieerzeuger – Methoden und Bedeutung
Fachtagung Smart Grids und Virtuelle Kraftwerke, Nieder-Olm, March

Pfreundt, Franz-Josef
The Fraunhofer File System and Big Data Moving forward with a new name: BeeGFS
13th HLRS/hww Workshop on Scalable Global Parallel File System, Stuttgart, May

Prill, Torben; Wieser, Christian; Schladitz, Katja; Jeulin, Dominique
Multi-Scale Simulation Study to Asses the Impact of a Nanoporous Additive to Battery Performance
ModVal 11, Winterthur (CH), March

Pupashenko, Daria; Ruckdeschel, Peter
Smoothness for dynamic GLM's with error distributions from Extreme Value Theory
Workshop and Meeting „Robust Risk Estimation" and "Robuste Analyse hydrol. Zeitreihen …", Bochum, February

Rauhut, Markus
Bildverarbeitungssoftware: Anforderungen, Qualitätskriterien & Standardbibliotheken
56. Heidelberger Bildverarbeitungsforum, Heidelberg, October

Rauhut, Markus; Spies, Martin
Optical Techniques for NDT
Short Course QNDE–WFNDEC 'Imaging NDE Methods', Boise, ID (USA), July

Rauhut, Markus; Spies, Martin
Simulation von Oberflächendefekten mittels Raytracing zur Bestimmung der Fehlerauffindwahrscheinlichkeit
DGZfP-Jahrestagung 2014, Potsdam, May

Rieder, Hans; Dillhöfer, Alexander; Spies, Martin; Bamberg, Joachim; Hess, Thomas
Online-Prozessüberwachung mittels Ultraschall bei der generativen Fertigung
DGZfP-Jahrestagung 2014, Potsdam, May

Rösch, Ronald
Fehlerdetektion in texturierten Oberflächen im praktischen Einsatz
7. Fraunhofer Vision Technologietag, München, October

Ruckdeschel, Peter
Optimally Robust Covariances (Also Covering Weighted Observations)
Stochastik Tage, Ulm, March und ICORS 2014, Halle, August

Ruckdeschel, Peter
Robustness Approaches for State Space Models And Regime Switching
Sondierungsmeeting MIKMOD-ITWM, St. Augustin, September

Ruckdeschel, Peter; Desmettre, Sascha; Pupashenko, Daria; Spangl, Bernhard
Statistical Models for Extreme Value Processess
Meeting „Robust Risk Estimation" and "Robuste Analyse hydrol. Zeitreihen", Wien, September and ERCIM, Pisa (I), December

Ruckdeschel, Peter; Korn, Ralf, Kohl, Matthias, Spangl, Bernhard
Project Overview "Robust Risk Estimation"
Workshop and Meeting „Robust Risk Estimation" und "Robuste Analyse hydrol. Zeitreihen", Bochum, February

Ruckdeschel, Peter; Spangl, Bernhard
Robust Filtering and Extreme Value Statistics for Hydrological Data
Workshop and Meeting „Robust Risk Estimation" and "Robuste Analyse hydrol. Zeitreihen", Bochum, February

Ruckdeschel, Peter; Spangl, Bernhard
Robust Filtering and Extreme Value Statistics for Hydrological Data
Abschluss- / Statussymposion VW-Stiftung Hannover, October

Schladitz, Katja
3D-Bildanalyse der Mikrostruktur komplexer Materialien
7. Fraunhofer Vision Technologietag, München, October

Schneider, F.
A general approach for efficient embedding of flexible structures in multibody dynamics
Rhodes (GR), September

Schulz-Reese, Marion
Emerging Trends in Talent Management
IIT Madras, Chennai (IND), January

Schulz-Reese, Marion
Human Resource Management at Fraunhofer ITWM
IIT Madras, Chennai (IND), January

Schulz-Reese, Marion
Industrial Mathematics – Path Travelled by Kaiserslautern
IIT Madras, Chennai (IND), February

Schwientek, Jan
Optimale Verwertung von (Farb-)Edelsteinen – Mathematische Optimierung in Projekten des Fraunhofer ITWM
Lecture Series Mathematik in der Praxis, Technische Universität, Ilmenau, April

Schwientek, Jan; Nowak, Dimitri
Chebyshev approximation and semi-infinite programming
Group Seminar SoSe 2014, Mathematics of Computation, Institut für Numerische Simulation, Bonn, May

Seebich, H.-P.; Spraul, M.; Speckert, M.; Feth, S.; Streit, A.
Planung und Analyse von Stichproben zur Abschätzung der Zuverlässigkeit von Steuergeräten im Feld
Freiburg, February

Spahn, Johannes; Andrä, Heiko; Kabel, Matthias
Multiscale modeling of progressive damage in elasto-plastic composite materials
WCCM-ECCM-ECFD 2014, Barcelona (E), July

Speckert, M.
Einige statistische Aspekte bei der Erfassung von Lastdaten in der Fahrzeugentwicklung
Ludwigsburg, November

Speckert, M.; Dreßler, K.; Ruf, N.; Halfmann, T.; Polanski, S.
The Virtual Measurement Campaign concept - A methodology for geo-referenced description and evaluation of environmental conditions for vehicle loads and energy efficiency
Kaiserslautern, March

Speckert, M.; Dreßler, K.
Die virtuelle Messkampagne – ein geo-referenziertes System für die Fahrzeugauslegung hinsichtlich Beanspruchung und Energieeffizienz
Ingolstadt, October

Spies, Martin
Simulation und Optimierung der Ultraschallprüfung von Composite-Bauteilen – Ein Anwendungsbeispiel
Workshop "+composites SAAR", Saarbrücken, May

Spies, Martin; Dillhöfer, Alexander; Rieder, Hans
AVG-Diagramme für die Ultraschall-Prüfung von Leichtbaukomponenten
DGZfP-Jahrestagung 2014, Potsdam, May

Spies, Martin; Dillhöfer, Alexander; Rieder, Hans; Rauhut, Markus
Validierte Verfahren zur zerstörungsfreien Prüfung von Kupfermaterialien
11. Kupfersymposium, Frankfurt, November

Spies, Martin; Dillhöfer, Alexander; Rieder, Hans; Rauhut, Markus
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FA-Sitzung Kupfergusswerkstoffe, Düsseldorf, October

Spies, Martin; Rieder, Hans; Dillhöfer, Alexander
Experimentelle und Modell-basierte POD-Bestimmung für Volumenfehler in gegossenen Bronze-Bauteilen unterschiedlicher Gefügestruktur
266. Sitzung DGZfP-AK München, March

Spies, Martin; Rieder, Hans; Dillhöfer, Alexander
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Spies, Martin; Rieder, Hans; Dillhöfer, Alexander
Experimentelle und simulationsbasierte POD-Ermittlung am Beispiel schwerprüfbarer Komponenten
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Workshop "Microstructural Characterization and Quality Assurance", Saarland University, Saarbrücken, April

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UT Imaging with Phased Arrays and the Synthetic Aperture Focusing Technique SAFT
Short Course QNDE–WFNDEC 'Imaging NDE Methods', Boise, ID (USA), July

Staub, Sarah
Micro-Scale Simulation of Nonlinear Deformation of Thin Porous Media
Interpore, Milwaukee (USA), May

Staub, Sarah
Microscopic Simulation of Thermally-Induced 2nd Order Eigenstresses in AlSi-Alloys
GAMM Jahrestagung, Erlangen, March

Steiner, Konrad
Kontinuumsmechanische Multiskalen-Modellierung und -Simulation von Partikel- und Suspensionsströmungen
Verfahrenstechnisches Seminar, University of Kaiserslautern, June

Stephani, Henrike
Typischer Aufbau und Beispiele für Algorithmen von Oberflächeninspektionssystemen
Fraunhofer IOSB Karlsruhe, December

Süss, Philipp
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Tilman Sayer
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Velten, Sebastian
Assistenz im Ausfallmanagement
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Wirjadi, Oliver
Characterization and Modeling of Fiber-Reinforced Polymers
Frankfurt, September

Wirjadi, Oliver
Geometric and Mechanical Modeling of Fiber-Reinforced Composites
Annecy (F), July

TEACHING ACTIVITIES

Zausch, Jochen
Electrochemical Simulations on 3D-Microstructures for Lithium-Ion-Batteries
GeoDict User-Meeting, Kaiserslautern, October

Zausch, Jochen; Latz, Arnulf
Thermal Modeling of Lithium Ion Batteries on Micro and Macro Scale
ModVal 11, Winterthur (CH), March

Zémerli, C.
An integrated design, assembly and validation process combining human simulation with path planning and flexible components
Guyancourt (F), September

Zémerli, C.
Recent progress on the modeling and simulation of coating processes in automotive industry
Shanghai (CHN), April

Zémerli, C.; Niedziela, D.; Schmidt, S.; Steiner, K.
From dilute granular flow to solid-like behavior: a continuum view
Montpellier (F), July

Andrä, Heiko
Einführung in die Boundary-Element-Methode
University of Kaiserslautern, Summer term 2014

Andrä, Heiko
Kontaktmechanik
University of Kaiserslautern, Winter term 2013/2014

Bitsch, Gerd
Professur für Mechatronik, Robotik und CAE-Simulation
University of Applied Sciences Kaiserslautern, Dept. of Applied Engineering Sciences

Burger, Michael
Differential-Algebraic Equations
University of Kaiserslautern, Summer term 2014

Burger, Michael
Dynamics of Mechanical Multibody Systems
University of Kaiserslautern, Winter term 2013/2014

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Dreßler, Klaus
Durability Load Data Analysis
University of Kaiserslautern, Summer term 2014

Kleer, Michael
Robotik 1
University of Applied Sciences Kaiserslautern, Summer term 2014

Korn, Ralf
Professur für Stochastische Steuerung und Finanzmathematik
University of Kaiserslautern, Dept. of Mathematics

Küfer, Karl-Heinz
Probability and Algorithms
University of Kaiserslautern, Dept. of Mathematics, Winter term 2014/15

Küfer, Karl-Heinz
Theory of Scheduling Problems
University of Kaiserslautern, Dept. of Mathematics, Summer term 2014

Nowak, Dimitri
Mathematical Models in Supply Chain Management
University of Kaiserslautern, Dept. of Mathematics, Winter term 2014/15

Orlik, Julia
Professur für Modellierung, Partielle Differentialgleichungen, Kontinuumsmechanik
Hochschule Rhein-Main, Dept. of Architecture and Civil Engineering, Wiesbaden

Pfeffer, Markus
Grundlagen des internationalen Controlling – Internationale Erfolgsbeurteilung und wertorientierte Steuerung
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Prätzel-Wolters, Dieter
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Freiburg, February, Lecture

41. DVM-Arbeitskreis Betriebsfestigkeit
Ingolstadt, October, Exhibitor, Lecture

EAGE 2014
Amsterdam (NL), June, Exhibitor, Lecture

EngineExpo 2014
Stuttgart, June

EURO PhD School on MCDM
Madrid (E), February

European Conference on Mathematics for Industry
Taormina (I), June, Lectures

11th European Conference on NDT
Prag (CZ), October, Lecture

Fluid Particle Seperation
Lyon (F), October, Exhibitor, Lecture

7. Fraunhofer Vision Technologietag
München, October, Exhibitor

GAMM – 85th Annual Meeting
Erlangen, March, Lecture

GAMM FA Dynamik und Regelungstheorie
Salzburg (A), September, Lecture

GeoDict User Meeting
Kaiserslautern, October, Lecture

11th German Probability and Statistics Days
Ulm, March, Lecture

Gesellschaft der Informatik Jahrestagung
Stuttgart, September, Exhibitor

Hannover Messe
Hannover, April, Exhibitor

29. Hofer Vliesstofftage
Hof, November, Exhibitor, Lecture

HP-CAST 22
Leipzig, June, Lecture

HP-CAST 23
New Orleans (USA), November, Lecture

ICNAAM 2014
Rhodes (GR), September, Lecture

ICORS 2014
Halle, August, Lecture

INDEX14
Genf (CH), April, Exhibitor, Lecture

6. Industriearbeitskreis Virtuelles Nutzfahrzeug - CVC
Kaiserslautern, March

6. Innovationstag der SmartFactoryKL
Kaiserslautern, September

Inter Solar Europe
München, June

24th International Conference on Field Programmable Logic and Applications München
München, September, Lecture

2nd International Congress on 3D Materials Science (3DMS)
Annecy (F), June, Lecture, Poster

International VDI Conference EUROTYRE 2014
Brüssel (B), November

Interpore
Milwaukee (USA), May, Exhibitor, Lecture, Poster

ISC – International Supercomputing Conference 2014
Leipzig, June, Exhibitor

IST-Anwenderkonferenz
Aachen, November, Lecture

93. jährliches Treffen der DPG (Deutsche Physiologische Gesellschaft)
Mainz, March, Poster

LDIC-2014
Bremen, February

Maintain 2014
München, June

MATRIX – Mathematics Awareness, Training, Resource, & Information Exchange
Dresden, September, Exhibitor

MEORGA
Frankfurt a. M., March and Ludwigshafen, September

MessTec & Sensor Masters 2014
Stuttgart, March

Modeling Granular Media Across Scales
Montpellier (F), July, Lecture

ModVal 11
Winterthur (CH), March, Lecture

MoLaS Technology Workshop
Freiburg, November

40th MPA-Seminar
Stuttgart, October, Lecture, Poster

mtech
Chemnitz, May, Exhibitor

OR2014
Aachen, September, Lecture

PowerGen Europe 2014
Köln, June

PowTech
Nürnberg, October, Exhibitor

Präsentationstag am Lifecycle Engineering Solutions Center (LESC): Virtual Reality für Forschung und Industrie TechViz
Karlsruhe, October, Lecture

ProcessNet Jahrestagung 2014
Aachen, September, Poster

SAE International Congress
Detroit (USA), April

SC – Supercomputing 2014
New Orleans (USA), November, Exhibitor

SEG 14
Denver (USA), October, Exhibitor, Poster

Seminar »Inspektion und Charakterisierung von Oberflächen mit Bildverarbeitung«
Karlsruhe, December, Exhibitor, Lecture

Sensor + Test
Nürnberg, June

SIMPACK User Meeting 2014
Augsburg, October, Exhibitor, Lecture

Simulation 2014-Automotive Circle International
Guyancourt (F), September, Lecture

SIMVEC - Simulation und Erprobung in der Fahrzeugentwicklung
Baden-Baden, November, Exhibitor, Lecture

Stuttgarter Produktionsakademie
Stuttgart, October

SURCAR
Shanghai (CHN), April, Lecture

29. Symposium Photovoltaische Solarenergie
Bad Staffelstein, March, Exhibitor, Lecture, Poster

12. Symposium Textile Filter
Chemnitz, March, Exhibitor, Lecture

Tag der Mathematik
Kaiserslautern, July, Exhibitor

Technologietag AUDI
Ingolstadt, November

Thermodynamik-Kolloquium 2014
Stuttgart, September, Poster

treffpunkt-Firmenkontaktmesse
Kaiserslautern, May, Exhibitor

VI-grade 2014 International Users Conference
Pollenzo-Bra (I), April, Exhibitor, Lecture

AWADRS AND PRICES

OWN EVENTS

Vision 2014
Stuttgart, November, Exhibitor, Lecture, Poster

WiMa14 – Firmenkontaktmesse
Ulm, November, Poster

Workshop »+compositesSAAR«
Saarbrücken, May, Lecture

Workshop »Microstructural Characterization and Quality Assurance«
Saarbrücken, April, Lecture

Workshop MSO-Tools 2014
Berlin, September, Lecture

Asprion, Norbert; Bortz, Michael; Burger, Jakob; Welke, Richard
IChemE Awards 2014: Core Chemical Engineering Award
Institution of Chemical Engineers (IChemE), November

Hubel, Sebastian; Dillhöfer, Alexander; Rieder, Hans; Spies, Martin
1. Platz Posterwettbewerb der Jahrestagung 2014 für »Bestimmung von oberflächennahen Spannungszuständen in randzonenverfestigten Triebwerkswerkstoffen mittels Rayleigh-Wellen«
Deutsche Gesellschaft für Zerstörungsfreie Prüfung (DGZfP), May

CFD Workshop for the Filtration Group
Kaiserslautern, May

3rd Commercial Vehicle Technology Symposium Kaiserslautern – CVT 2014
Kaiserslautern, March

Deutsch-französischer Workshop »Mathematical Image Analysis«
Kaiserslautern, October

Einweihungsfeier des Erweiterungsbaus der Kindertagesstätte Klammer@ffchen
Kaiserslautern, July

Felix-Klein-Herbstschule 2014
Kaiserslautern, October

Femtec-Exkursion
Kaiserslautern, September

Fotoausstellung Sabine Hartert »Im Lichte Indiens«
Kaiserslautern, October/November

27th International Workshop "Research in Mechanics of Composites"
Bad Herrenalb, December

Nacht, die Wissen schafft
Kaiserslautern, March

Nutzer- und Entwicklungsworkshop für INES-Prototypen
Annweiler, September

Seminar »Lastdaten – Analyse, Bemessung und Simulation«
Kaiserslautern, May

Seminar »Statistische Methoden in der Betriebsfestigkeit«
Kaiserslautern, July

69. Sitzung der Fachgruppe IT-Controlling der Gesellschaft für Informatik
Kaiserslautern, November

Technologietag »Jurojin – Statistik für Versuche zur Betriebsfestigkeit«
Kaiserslautern, October

Technology-Day »CDTire: Scalable Tire Model for Full Vehicle Simulation«
Kaiserslautern, November

Technology-Day »Usage Variability and Virtual Measurement Campaign®«
Kaiserslautern, November

Lecturesreihe »Blick über den Tellerrand«
Kaiserslautern

- Abele-Brehm, Andrea, Universität Erlangen-Nürnberg
  Vom Examen zum Superjob – Berufsverläufe von Mathematikerinnen und Mathematikern in den ersten 10 Jahren der Erwerbstätigkeit
  January
- Weichel, Klaus
  Kaiserslautern
  Arm, aber attraktiv? – Stadtentwicklung in Zeiten des Mangels
  February
- Heieck, Jörg
  Kaiserslautern
  Zwischen den Welten – Kunst und Physik
  March
- Lengauer, Thomas
  Saarbrücken
  Life Ascending – eine biologische Schöpfungsgeschichte
  April
- Hirschi, Caspar
  Universität St. Gallen, Schweiz
  Wie organisiert man Innovation? Antworten aus der Geschichte
  June
- Wehn, Norbert
  University of Kaiserslautern
  Die University of Kaiserslautern im Spannungsfeld zwischen Exzellenzinitiative, demografischem Wandel und Schuldenbremse
  September
- Krattenthaler, Christian
  Universität Wien
  Musik und Mathematik? Persönliche Ansichten zu einer

GUESTS

schwierigen Beziehung
October

- Schlegel, Wolfgang
  Deutsches Krebsforschungszentrum, Heidelberg
  Mit Strahlen gegen Krebs: Was Physik und Technik zur Tumortherapie beitragen können
  November
- Reuter, Andreas
  HITS gGmbH, Heidelberg
  Profilbildung – Was hat das mit Bildung zu tun?
  December

Lecturesreihe des Arbeitskreises »Bildanalyse und Mustererkennung Kaiserslautern« (BAMEK)
Kaiserslautern, January - December

Workshop: Fraunhofer RODOS® Interactive Driving and Operation Simulator
Kaiserslautern, March

Al-Issawi, Jumana
Fraunhofer MEVIS, Bremen
UX & Useability
February

Arnold, Martin
Martin-Luther-Universität Halle-Wittenberg
Numerik für Mehrkörpersysteme
February

Bauchau, Olivier
Hong Kong University of Science and Technology (HK)
Flexible multibody dynamics
March

Ciegis, Raimondas
Vilnius Gediminas Technical University (LT)
Numerical simulation of heat transfer in underground electrical cables
November

Diebels, Stefan
Saarland University
Technische Mechanik
August

Dudas, Catarina
FCC, Göteborg (S)
Continuous production
October

Kohl, Matthias
Hochschule Furtwangen
R-Pakete zu Robuster Statistik
February

Kutyniok, Gitta
TU Berlin
Compressed Sensing: Theory and Applications
October

Leyendecker, Siegrid
Friedrich-Alexander-Universität Erlangen-Nürnberg
Applied dynamics
August

Niedziela, Maciek
University Zielona Gora (PL)
Viscoelastic materials
February, August

Nikitin, Sergey
Arizona State University, Tempe (USA)
Control theory
May, June

Ospald, Felix
TU Chemnitz
Numerical simulation of injection molding using OpenFOAM and CoRheoS FLUID
March

Panasenko, Grigory
Université St. Etienne (F)
Asymptotische Methoden in PDEs
July/August

Peters, Bernhard
Université du Luxembourg (L)
Die Extended Discret Element Method (XDEM) als Simulationsplattform für multiphysikalische Anwendungen
May

Pupashenko, Daria
Hochschule Furtwangen
Robuste Statistik
January-October

Ritter, Klaus
University of Kaiserslautern
Quasi Monte Carlo Methods
October

Sanz-Solé, Marta
Universitat de Barcelona (E)
An introduction to the European Mathematical Society
February

Scheichl, Robert
University of Bath (UK)
Petascale multigrid performance and beyond applications in the earth sciences
June

Spangl, Bernhard
BOKU Wien (A)
R-Pakete zu Robuster Statistik; Robust filtering and extreme value statistics for hydrological data
February, April

Struckmeier, Jens
Universität Hamburg
Particle methods in numerical mathematics
October

Zhang, Siquan
Sichuan University (CHN)
Model order reduction for micro-scale lithium ion battery model
July

COLLABORATION IN BOARDS, EDITORSHIPS

Andrä, Heiko
- Mathematical Reviews (Reviewer)

Dreßler, Klaus
- Proceedings of the 3rd Commercial Vehicle Technology Symposium (CVT 2014) (Editor, with Berns, K.; Schindler, C.; Jörg, B.; Kalmar, R.; Zolynski, G.)

Gerwalin, Elmar
- IT-Strategiekreis der Fraunhofer-Gesellschaft
- Fachgremium IT-Geschäftsprozessunterstützung (Fraunhofer-Gesellschaft)
- Fachgruppe IT-Controlling der Ges. f. Informatik (Deputy Speaker)

Gramsch, Simone
- Wissenschaftlicher Beirat KOMMS (Kompetenzzentrum für Mathematische Modellierung in MINT-Projekten in der Schule)

Henrike Stephani
- International Conference on Pattern Recognition (ICPR, Reviewer)

Iliev, Oleg
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Korn, Ralf
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- Felix-Klein-Zentrum für Mathematik e.V. (Chairman)
- Wissenschaftlicher Beirat DISC, University of Kaiserslautern (Member)
- European Actuarial Journal (Co-Editor)
- Mathematik im Fokus (Editor)

Küfer, Karl-Heinz
- Arbeitsgruppe »OR im Gesundheitswesen« der GOR (Chairman)

- Mathematics of Operations Research (Reviewer)
- Medical Physics (Reviewer)
- ORSpektrum (Guest Editor)
- Zentralblatt für Mathematik (Reviewer)
- Mathematical Programming (Reviewer)

Kuhnert, Jörg
- Scientific Committee, ESI Group, Paris (F) (Reviewer)
- Geotechnik (Reviewer)
- Applied Mathematics and Computation (Reviewer)

Maasland, Mark
- Fraunhofer-Allianz Vision (Member)

Neunzert, Helmut
- Fraunhofer-Chalmers Research Centre for Industrial Mathematics FCC (Vice Chairman of Advisory Board)
- ECMI-Series „Mathematics in Industry" (Editor)
- Buch: Mathematik im Fraunhofer-Institut – Problemgetrieben – Modellbezogen – Lösungsorientiert, Springer Spektrum Verlag (Editor)

Ostermann, Isabel
- International Journal on Geomathematics (Reviewer)

Prätzel-Wolters, Dieter
- Applied Mathematics Committee (AMC) of the European Mathematical Society (Member)
- European Research Centres on Mathematics, ERCOM (Member)
- Forschungszentrum Center of Mathematical and Computational Modeling CM² der Technischen Universität Kaiserslautern (Member)
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- Buch: Mathematik im Fraunhofer-Institut – Problemgetrieben – Modellbezogen – Lösungsorientiert, Springer Spektrum Verlag (Editor)

Rieder, Hans
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- DGZfP Fachausschuss Ultraschallprüfung (Member)
- DGZfP Unterausschuss ‚Phased Array' im Fachausschuss Ultraschallprüfung (Chairman)
- VDE/VDI-Fachausschuss Nichtlineare Systeme (Member)

Rösch, Ronald
- Image Processing On-Line (Editor)
- Fraunhofer-Allianz Vision (Coordination Board)
- Fraunhofer-Allianz Leichtbau (Member)
- Heidelberger Bildverarbeitungsforum (Boardmember)
- Deutsche Gesellschaft für Materialkunde e. V. (DGM, Member)
- DGM-Arbeitskreis Tomographie (Member)
- DGM-Fachausschuss Strahllinien (Member)
- Deutsche Gesellschaft für Zerstörungsfreie Prüfung e. V. (DGZfP, Member)

Ruckdeschel, Peter
- Statistics (Reviewer)
- Computational Statistics and Data Analysis (Reviewer)
- Computational Statistics (Reviewer)
- Statistical Papers (Reviewer)
- Sensors (Reviewer)
- IEEE Signal Processing Letters (Reviewer)
- Advances in Statistical Analysis (Reviewer)
- R Journal (Reviewer)
- Journal of Banking and Finance (Reviewer)

Schladitz, Katja
- Leichtbau-Cluster (Member)
- International Society for Stereology (Vice-President for Europe)
- Journal of Microscopy (Reviewer)
- Image Analysis & Stereology (Editorial Board, Reviewer)
- Computers (Reviewer)
- Nanomaterials (Reviewer)
- Materials letters (Reviewer)

Schulz-Reese, Marion
- Österreichisches Bundesministerium für Wissenschaft und Forschung (Reviewer)
- Wissenschaftlicher Beirat KOMMS (Kompetenzzentrum für Mathematische Modellierung in MINT-Projekten in der Schule)

Siedow, Norbert
- DFG (Reviewer)

Spies, Martin
- 19th World Conference on Non-Destructive Testing WCNDT 2016, München (Vice President, Scientific Committee)
- Deutsche Gesellschaft für Zerstörungsfreie Prüfung e. V. (DGZfP, Boardmember)
- DGZfP Fachausschuss Ultraschallprüfung (Member)
- DGZfP Fachausschuss Hochschullehrer (Member)
- DGZfP Unterausschuss ‚Modellierung und Bildgebung' im Fachausschuss Ultraschallprüfung (Chairman)
- DGZfP Unterausschuss ‚Ausbildung' im Fachausschuss Ultraschallprüfung (Member)
- DGZfP Unterausschuss ‚Phased Array' im Fachausschuss Ultraschallprüfung (Member)
- IEEE Transactions on Ultrasonics, Ferroelectrics & Frequency Control (Reviewer)
- Journal of the Acoustical Society of America (Reviewer)
- Journal of Computational Acoustics (Reviewer)
- Materials Evaluation (Reviewer)
- NDT&E International (Reviewer)
- Wave Motion (Reviewer)
- Ultrasonics (Reviewer)
- Acustica (Reviewer)

Vecchio, Irene
- Bernoulli Society (Student Member)
- Deutsche Gesellschaft für Materialkunde e.V. (DGM, Member)

PATENTS

Velasco-Forero, Santiago
- IEEE-Transactions on Image Processing (Reviewer)
- Journal of Mathematical Imaging and Vision (Reviewer)
- IEEE-Transactions on Signal Processing (Reviewer)
- IEEE-Transactions on Geoscience and Remote Sensing (Reviewer)
- IEEE-Special Topics in Remote Sensing (Reviewer)
- Pattern Recognition Letters (Reviewer)
- International Journal of Remote Sensing (Reviewer)
- Image Analysis and Stereology (Reviewer)

Wenzel, Jörg
- Mathematical Reviews (Reviewer)
- Zentralblatt der Mathematik (Reviewer)

Wirjadi, Oliver
- SPIE Optical Engineering (Reviewer)

Schröder, Michael, Küfer, Karl-Heinz; Polityko, Dmitry-David
Entwurfswerkzeug für Art und Form einer Schaltungsrealisierung
US Patent 8,645,900 B2; Veröffentlichung 2014

EDITORIAL NOTES

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Adress	Fraunhofer-Platz 1 67663 Kaiserslautern Germany
Phoen	+49 (0) 6 31/3 16 00-0
Fax	+49 (0) 6 31/3 16 00-10 99
E-mail	info@itwm.fraunhofer.de E-mail of our employees is <surname>@itwm.fraunhofer.de
Internet	www.itwm.fraunhofer.de