



**Fraunhofer**

**IIS**

FRAUNHOFER INSTITUTE FOR INTEGRATED CIRCUITS IIS



**ANNUAL REPORT**

**2011**



Annual Report 2011  
Fraunhofer Institute for  
Integrated Circuits IIS

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# PREFACE

On October 1, 2011, Professor Gerhäuser departed as Executive Director of Fraunhofer IIS, handing the responsibility over to his successor, Professor Albert Heuberger. This momentous day in the history of the institute is well worth a brief look back. Professor Gerhäuser, who has been a member of the collegial board of directors at Fraunhofer IIS since 1993, took over the position of Executive Director from founder director Professor Dieter Seitzer in 1998. At this point in time the institute with its locations in Erlangen, Dresden and Nuremberg counted 220 staff, who worked with an annual budget of about 47 million DM. With more than 720 staff and a 94 million euro budget for 2011, Fraunhofer IIS has now locations in Erlangen, Dresden, Fürth, Nuremberg, Ilmenau, Würzburg and Bamberg.

The period between 1998 and 2011 includes a series of construction initiatives. In July 2002 Fraunhofer IIS celebrated the inauguration of Phase I and in July 2008 Phase II of its new headquarters building in Erlangen-Tennenlohe. In October 2010 the Fraunhofer Linear Accelerator (LINAC) test center in Fürth-Atzenhof was officially opened in a special ceremony. In June 2011 construction of the Test and Demonstration Center L.I.N.K. at the Nuremberg Nordostpark and the laying of the foundation stone for the new Fraunhofer IIS building in Fürth-Atzenhof marked new milestones for Fraunhofer IIS activities. A construction project in Würzburg created the required built-up space for the project group Nano X-ray Systems for Material Characterization. In September 2011 the first shovel of earth was turned at the groundbreaking ceremony for the Fraunhofer Research Campus Waischenfeld. The official launch of the new research platform Sat-Com and the inauguration of the new suite of laboratories and the radio mast for digital radio at the Ilmenau test facility Am Vogelherd highlighted October 2011. It is home to the project group Wireless Distribution Systems / Digital Broadcasting founded by Professor Heuberger in Ilmenau. The total volume of all construction projects is budgeted at about 120 million euros.

Since its founding in 1992, the great success of the Dresden Branch Lab for Design Automation has depended crucially on the dedication of director Professor Günter Elst and his team of scientists. He has been a member of the collegial board of directors at Fraunhofer IIS since October 2006. The long-time director retired in June 2011 and handed the reins over to Dr. Peter Schneider, who will be responsible for the Dresden branch in the interim. As part of the directorial changes, R&D activities will be reorganized in two new departments with focus on the continuation of established R&D activities as well new priorities with view to current demands on the research market. Dr. Schneider will be integrated in the internal management structure and organization at Fraunhofer IIS. He will represent the Dresden Branch Lab externally and will strengthen the ties with universities and colleges in particular Dresden, Chemnitz and Cottbus.

Professor Gerhäuser has been chairman of the board of directors of the Fraunhofer Group for Microelectronics for six years, coordinating the activities of thirteen full member institutes and three associated member institutes. Significant progress was achieved in deepening the cooperation of the microelectronics and micro-integration institutes and the interdisciplinary networking of these institutes throughout Europe. At the end of his second three-year term in 2010 Professor Gerhäuser handed over the chair to his successor Professor Lakner of Fraunhofer IPMS.

In December 2010 Professor Evi Hartmann, Chair of Business Administration / Logistics at Friedrich-Alexander-University Erlangen-Nuremberg, decided to resign as head of the Fraunhofer Center for Applied Research on Supply Chain Services SCS due to fundamental differences of opinion regarding overall strategy and management structure. Under the auspices of Professor Gerhäuser SCS was thereupon reorganized and its R&D program realigned. The loss of key knowledge and employees had to be compensated. An experienced board of advisors was established to help shape and sustain the mission and to ensure close ties with the faculty of law and economics at FAU: Professor Christian Kille (previously SCS), Professor Michael Krupp



Prof. Dr.-Ing. Günter Elst, Prof. Dr.-Ing. Heinz Gerhäuser and Prof. Dr.-Ing. Albert Heuberger (from left)

(previously SCS), Professor Peter Klaus (Emeritus Faculty of Law and Economics and former head of SCS), and Professor Kathrin Möslin (Faculty of Law and Economics). Following his retirement, Professor Gerhäuser takes over as chair of SCS for one year until September 30, 2012.

Professor Randolph Hanke, professor at Würzburg University, continued to expand the growing research team in Würzburg. On October 1, 2011, Alexander Pflaum was appointed professor at the University of Bamberg and will lead the research team established there. After Professor Heuberger's change to Erlangen Dr. Markus Mehnert is acting head of the research team in Ilmenau. Procedures for the appointment of a successor for Professor Heuberger are almost completed.

In a legal dispute concerning proprietary rights, Fraunhofer headquarters and Fraunhofer IIS had to assert their legal position involving considerable outlays in both time and money. The amount in dispute exceeded 50 million euros. An ad-hoc task force comprising experts in contract law and intellectual property rights was coordinated by Fraunhofer headquarters and Fraunhofer IIS. The members traveled to the US several times to talk to witnesses, conduct negotiations and to partake in the one-week arbitration hearing. In January the arbitration award was issued in favor of Fraunhofer for the full amount sought.

Financed with mp3 license revenues, the build-up of the International Audio Laboratories Erlangen (AudioLabs) is making

rapid headway. Three of the six newly established professorships at the Department EEI at the technical faculty of the Friedrich-Alexander-University Erlangen-Nuremberg have been filled and appointment procedures for the remaining three are making good progress. AudioLabs is jointly operated by Fraunhofer IIS and the Friedrich-Alexander-University Erlangen-Nuremberg leading a team of 28 globally renowned scientists.

Professor Gerhäuser: „Looking back at 26 years with Fraunhofer, I would like to say that it was an effort worthwhile! Worthwhile for the technological progress achieved, for our sponsors and clients, for our staff and also for me as a person. I wish my successor the energy, patience, wealth of ideas and intuition to accommodate the often diverse and conflicting interests.“  
Professor Elst: “The launch of the Dresden Branch Lab for Design Automation in 1992 was a great challenge that came with great opportunities. Outstanding scientific contributions in the most diverse fields and the excellent cooperation with our clients, partners and other Fraunhofer institutes but also throughout our own institute are the foundation for a thriving and vibrant future. I wish my colleagues Albert Heuberger and Peter Schneider every success as they assume their new responsibilities along with the continued support and dedication from the staff members.“  
Professor Heuberger: “I am taking over an organization in excellent shape and health, which I will lead according to the principles anchored in our corporate culture.“

Board of Directors, Oktober 2011

Prof. Dr.-Ing. Heinz Gerhäuser

Prof. Dr.-Ing. Günter Elst

Prof. Dr.-Ing. Albert Heuberger

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# THE INSTITUTE IN PROFILE





## Key facts

Under the cooperative direction of Prof. Dr.-Ing. Heinz Gerhäuser, Prof. Dr.-Ing. Albert Heuberger, and (until May 2011) Prof. Dr.-Ing. Günter Elst, the institute develops microelectronic systems and devices as well as the integrated circuits and software needed to accompany them. The Fraunhofer Institute for Integrated Circuits IIS, founded in 1985, has its headquarters in Erlangen and also has premises in Nuremberg, Fürth, Würzburg, Berlin, Dresden, and Ilmenau. It is the largest institute in the Fraunhofer-Gesellschaft.

thereof play an important role here. Fraunhofer IIS is known around the world thanks to its significant contribution to the development of the audio encoding processes mp3 and MPEG-AAC. Further developments such as "mp3 surround" and "MPEG surround" even offer multichannel sound for stereo headphones. In the area of video, DVB-H (Digital Video Broadcasting Handheld) makes it possible to watch television on mobile end devices such as mobile phones or personal digital assistants (PDAs). Another important topic is the technology needed for the digital movie theater of

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# THE FRAUNHOFER INSTITUTE FOR INTEGRATED CIRCUITS IIS CARRIES OUT APPLIED RESEARCH AND DEVELOPMENT FOR INDUSTRIAL FIRMS AND PUBLIC BODIES.

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Our scientists carry out research in the fields of micro-electronics, information processing, telecommunication, audio and multimedia technology, digital broadcasting, digital cinema technology, high-frequency technology, localization and navigation, satellite navigation, medical engineering, and automation in machine and plant construction as well as in the areas of energy management and supply chain services. Wireless communication systems, particularly digital broadcasting systems, are developed up to production-ready prototypes. The encoding of audio and video signals and the international standardization

the future. Image acquisition and recognition are the keys to production quality control in production automation and in medical engineering. To this end, intelligent image sensors, high-speed cameras and industrial X-ray systems are also being developed. Health telematics and communication and sensor solutions for mobile patient monitoring are among the other areas of research within medical engineering. Fraunhofer's "Personal Health" innovation cluster pools skills and its "Medical Technology Test and Demonstration Center METEAN" quickly turns solutions into products and applications. Fraunhofer IIS is also a major participant in the leading cluster "Medical Valley European Metropolitan Region Nuremberg (EMN)" and in the newly founded "Energie Campus Nuremberg (EnCN)". The "Integrated Digital Terminals IDT" and "Communications NUE" departments,



as well as the “Wireless Distribution Systems / Digital Broadcasting DVT” project group, deal with digital broadcasting systems and their application. In the second half of 2010, the Fraunhofer project group “X-ray Systems for Material Characterization” was founded in close cooperation with the new Chair of “Material Characterization Using X-ray Microscopy” at the Faculty of Physics and Astronomy of the Julius Maximilian University of Würzburg.

The focuses of research at Nuremberg’s Forschungsfabrik – “Localization and Communication” and “Energy” in Nuremberg and the Development Center for X-ray Technology in Fuerth – continue systematically to consolidate their position as competence centers. Over the next few years, modern research facilities for these topics will take shape

Research on Supply Chain Services in Nuremberg creates this synergetic connection for clients from industry, services, and public institutions, while the Center for Intelligent Objects ZIO carries out interdisciplinary research into new identification, communication and localization technologies and develops them for practical implementation. Scientists at the Design Automation Division EAS in Dresden develop methods and tools for reliable design of ever more complex electronic and heterogeneous systems. This allows the implementation of product requirements in circuits, devices, or complex sensor systems to be accelerated and optimized. There is close cooperation with the Fraunhofer Institute for Digital Media Technology IDMT in Ilmenau and the “Digital Media Technologies” office of Fraunhofer USA, Inc. in San José, California in the field of audio and multimedia

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## **TOGETHER WITH OUR CLIENTS IN GERMANY AND ABROAD, WE DEVELOP INNOVATIVE CONCEPTS, SOFTWARE, DEVICES AND SYSTEMS WITH THE AIM OF MAINTAINING INTERNATIONAL COMPETITIVENESS.**

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at both locations. Furthermore, in 2009, the department “Process Integrated Test Systems”, which specializes in the examination of the production of devices and cast parts, was started at the location in Fürth. Combining the latest scientific work with field-tested engineering concepts generates innovative solutions for logistics and supply chain management. The Fraunhofer Center for Applied

technologies. Fraunhofer IIS is a member of the Fraunhofer Group for Microelectronics and a guest member of the Fraunhofer Information and Communication Technology Group and Fraunhofer Group for Defense and Security. It is also a member of the Fraunhofer “Vision” and “Digital Cinema” Alliances, the coordination and contact offices of which are located in the institute in Erlangen, as well



as of the Fraunhofer "Adaptronics", "Ambient Assisted Living", "Food Chain Management", "Grid Computing", "Energy", "Numerical Simulation of Products, Processes", "Wind Energy" and "Transport" Alliances. It cooperates closely and diversely with the Friedrich-Alexander-University of Erlangen-Nuremberg. The Chair of Information Technologies with Focus on Communication Electronics is situated in the main building of the Fraunhofer IIS. In addition to this, it also cooperates with a large number of chairs, institutes and facilities. Fraunhofer IIS also cooperates closely with Erlangen's Faculty of Humanities, not forgetting the interdisciplinary seminar "Digital Broadcasting Workshop".

### **Mission**

Together with our clients in Germany and abroad, we develop innovative concepts, software, devices and systems with the aim of maintaining international competitiveness. Our work is customer-oriented and service-oriented. Our most valuable asset – our employees – are supported through targeted further training measures in order to develop their high level of expertise even further. Our productivity can be seen in our scientific publications as well as conference and trade fair presentations. Our inventions are patented nationally and internationally and, where possible, the licenses are not exclusively granted.

### **Research, development and services**

We investigate our clients' problems and demonstrate possible solutions. Our services include, amongst other things, technical consulting and the creation of experts' reports, studies, and concepts. We develop an individual concept for implementation, preferably together with the future users. On their behalf, we execute a project on schedule, based on the agreed aims, for example, the development of the prototype for a product. We offer access to semiconductor manufacturers and cooperation with partners. We offer corresponding services with our X-ray systems and other

test and measuring systems. Dividing our offer of cooperation into independent tasks allows us to deal with each customer requirement individually.

# THE INSTITUTE IN FIGURES

Dr. rer. pol. Peter Dittrich | +49 9131 776-2000 | peter.dittrich@iis.fraunhofer.de

## Human resources, operating and investment budget

The German economy has accomplished a recovery and significantly exceeded the growth forecasts of the leading economic research institutes. Fraunhofer IIS is benefiting from this positive development. While the number of incoming orders from the business sector is increasing again, large-scale government projects also have to be implemented successfully.

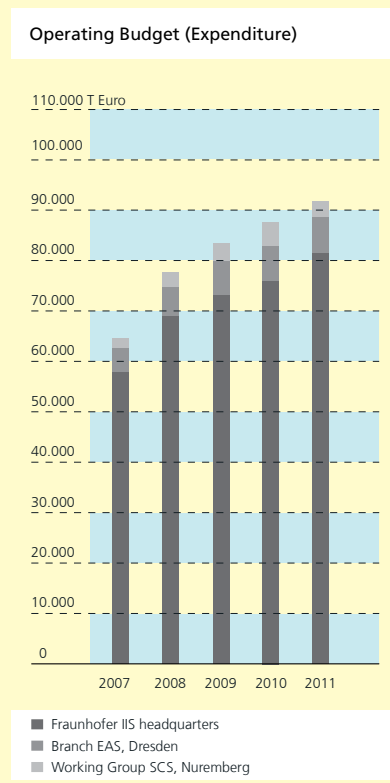
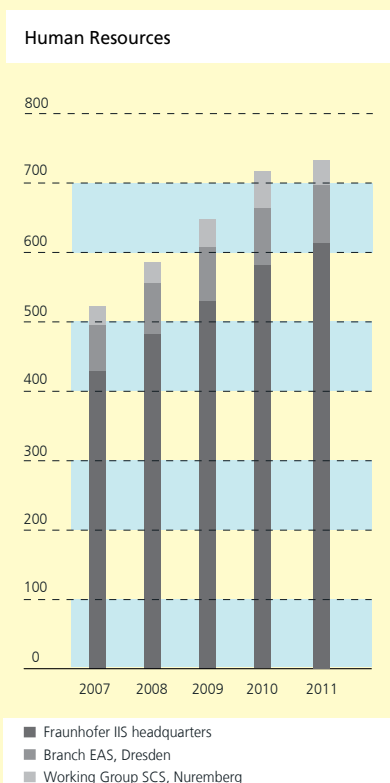
### Human resources

Due to the upturn in Germany, Fraunhofer IIS increasingly competes for highly qualified job candidates against many

other companies. Therefore, the institute is continuously being developed at the locations in Erlangen, Nuremberg, Fürth, Würzburg, Ilmenau and Dresden on a smaller scale than planned. In view of this development, Fraunhofer IIS will further intensify its efforts in the European and international labor market.

### Operating budget

At present, a series of new topics are being integrated into Fraunhofer IIS. Due to the energy transition, already existing IIS topics were boosted additionally. Research projects that are politically relevant have one thing in common: they are

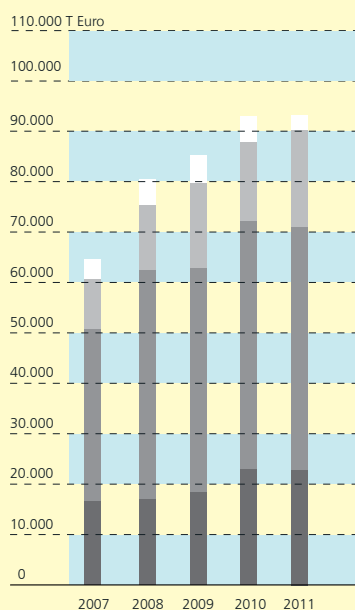


supported by public sector funds in the initial phase. Furthermore, large-scale government projects from the recession years of 2008 and 2009 remain to be completed. This results in a shift in the earnings from industry and economy to public funds. This trend will reverse again the next few years. 24 per cent of the institute's financing comes from basic funding through the Fraunhofer Gesellschaft, 52 per cent from funds from industry and economy and 24 per cent from public and other revenues. The institute expects at least a balanced budget for the 2011 fiscal year.

### Investment budget

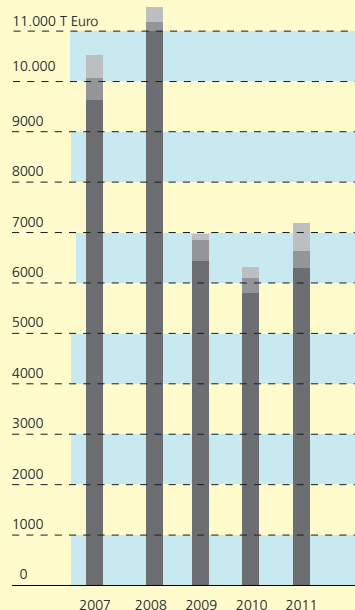
Both qualified staff and continuous investment are necessary in order to sustain one's position against the global competition. In accordance with the profile of the institute, the expenses for computers, software and high-quality design software, in connection with an efficient network, represent the main items of expenditure. The investment budget is comprised of basic funding as well as revenue from projects and licensing. In 2007 and 2008, high initial funding was required as a result of moving into the new building. A considerably higher investment ratio can therefore be registered during these years.

Operating Budget (Financing)



- Basic funding
- Industry projects
- Public projects
- Other projects

Investment Budget



- Fraunhofer IIS headquarters
- Branch EAS, Dresden
- Working Group SCS, Nuremberg



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# ORGANIZATION AND CONTACTS

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## Board of Directors

Prof. Dr.-Ing. Heinz Gerhäuser (Executive Director)  
Prof. Dr.-Ing. Günter Elst (until 31.5.2011)  
Prof. Dr.-Ing. Albert Heuberger (since 1.4.2011)

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## Director Administration

Dr. rer. pol. Peter Dittrich

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## Departments

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### Audio

Dr.-Ing. Bernhard Grill

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### Contactless Test and Measuring Systems

Dr. rer. nat. Peter Schmitt

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### Moving Picture Technologies

Dr.-Ing. Siegfried Föbel

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### Electronic Imaging

Dipl.-Ing. Stephan Gick

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### Image Processing and Medical Engineering

Dipl.-Inf. Christian Weigand

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### Development Center X-Ray Technology

Dr.-Ing. Norman Uhlmann

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### Locating and Communication Systems

Dipl.-Ing. Thomas von der Grün

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### RF and Microwave Design

Dipl.-Ing. Rainer Wansch

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### IC Design – Analog Systems

Dipl.-Ing. Josef Sauerer

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### IC Design – Digital Systems

Dipl.-Ing. Karlheinz Ronge

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### Integrated Digital Terminals

Prof. h. c. Univ. Navarra (UN) Dipl. Ing. Michael Schlicht

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### Communications Networks

Dipl.-Ing. Jürgen Hupp

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### Power Efficient Systems

Dr.-Ing. Günter Rohmer

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### Multimedia Realtime Systems

Dipl.-Ing. Harald Popp

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### Communications

Dipl.-Ing. Ernst Eberlein

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### Process-Integrated Inspection Systems

Dr.-Ing. Thomas Wenzel

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### Supply Chain Technologies

Dr. rer. pol. Alexander Pflaum

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## Project Groups

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### Adaptive System Software

Prof. Dr.-Ing. Wolfgang Schröder-Preikschat  
(University of Erlangen-Nuremberg)

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### Wireless Distribution Systems / Digital Broadcasting

Dr.-Ing. Markus Mehnert (interim)

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### Hardware-Software-Co-Design

Prof. Dr.-Ing. Jürgen Teich  
(University of Erlangen-Nuremberg)

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Net Access Technology  
 Dipl.-Ing. Karlheinz Ronge  
 Dipl.-Ing. Peter Heusinger

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Optical Communications  
 Dipl.-Ing. Josef Sauerer  
 Dr.-Ing. Norbert Weber

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X-Ray Systems for Material Characterization  
 Prof. Dr.-Ing. Randolph Hanke

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Fraunhofer Working Group for Supply Chain Services SCS  
 Prof. Dr.-Ing. Heinz Gerhäuser

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Market  
 Dipl.-Sozialwirt Alexander Nehm

---

Networks  
 Dipl.-Math. Bettina Berning

---

Processes  
 Dipl.-Kaufmann Heiko Wrobel

---

Services  
 Dr. rer. pol. Kai Förstl

---

Center for Intelligent Objects  
 Dr. rer. pol. Alexander Pflaum

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Division Design Automation EAS  
 Dr.-Ing. Peter Schneider

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Heterogeneous Systems  
 Dr.-Ing. Andreas Wilde

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Microelectronic Systems  
 Dr.-Ing. Manfred Dietrich

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**Services**

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Administration  
 Dipl.-Kauffrau Sonja Ludwig

---

IT-Services  
 Dr.-Ing. Roland Plankenbühler

---

Press and Public Relations  
 Dipl.-Sozialwirt Marc Briele

---

Political Communication  
 Dipl.-Designerin Melanie Oßwald MdB a.D.

---

International Business Development  
 Dipl.-Ing. (FH) Martina Spengler MBA

---

Human Resource Development  
 Dipl.-Germ. Katrin Schwendner

---

Quality Management and Organisation Development  
 Dipl.-Math. Christine Mertelmeier

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Vision Alliance  
 Dipl.-Ing. Michael Sackewitz

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Digital Cinema Alliance  
 Dr.-Ing. Siegfried Föbel

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Knowledge Management  
 Ulrich Försterling M.A.

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# ADVISORY COMMITTEE

The Advisory Committee supports the board of directors of the Fraunhofer-Gesellschaft as well as the institute's management concerning strategic developments. The Committee Members provide an interconnective network with industry and local organizations:

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Dr. mult. h. c. Dipl.-Ing. Hermann Franz  
Committee Chairman

---

Dr. Annerose Beck  
Saxon Ministry of Science and Arts

---

Dipl.-Ing. Gerhard Bethscheider  
Vice President, SES ASTRA S.A.

---

Dr. Andreas Goerdeler  
Federal Ministry of Economics and Technology

---

Dr. Gerd-Achim Gruppe  
Member of the Board,  
German Aerospace Center (DLR)

---

Dr. Klaus Heller  
Federal Ministry of Education and Research

---

Markus Löttsch  
Managing Director, Nuremberg Chamber of Commerce and  
Industry

---

Prof. Dr. Marion Merklein  
Dean of the Faculty of Technology,  
University of Erlangen-Nuremberg

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MDirig. Dr. Ronald Mertz  
Bavarian Ministry of Economic Affairs, Infrastructure, Transport  
and Technology

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Dipl.-Ing. Gerhard Schaas  
Chief Technology Officer, Loewe AG

---

Dr.-Ing. Dietmar Schill  
Sony Deutschland GmbH

---

Dr.-Ing. Ernst F. Schröder

---

Prof. Dr. Dr. h. c. Reinhard Schüttler  
Dean of the Faculty of Medicine,  
University of Erlangen-Nuremberg

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MinRat Dipl.-Ing. Norbert Weber  
Federal Ministry of Defence

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# COMPETENCIES

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## Moving Picture Technologies / Electronic Imaging

- Cameras and CMOS image sensors
- 3-D camera technology
- Digital cinema
- Post production tools
- Digital movie archives
- Lightfield/HDR (High Dynamic Range)
- Computational imaging
- Image data compression
- Mobile storage/fieldrecorder
- Embedded imaging
- Cognitive systems
- Face-, persona-, object recognition
- Scene analysis, detailed face analysis and emotion analysis
- 3-D modelling and reconstruction
- Imaging solutions (Time-of-Flight, polarisation, sensorfusion)

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## Image Processing and Medical Engineering

- Real-time systems for pattern recognition and texture analysis
- Knowledge-based image processing
- Computer-assisted microscopy
- Computer-assisted diagnosis for mammography, endoscopy, dermatoscopy, colposcopy, sonography
- Evaluation of macro- and microscopic images from biological samples (cells, textiles) as basis for findings
- Processing and analysis of endoscopic and microscopic images
- Miniaturized sensor systems for vital parameters monitoring
- Signal processing algorithms for vital parameters
- Mobile, wearable systems for health
- Wireless communication and sensor networks
- Clinical trials, health services research
- Validation of medical devices and systems

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## IC Design – Analog Systems

- High speed ASIC design
- RF-ASICs for communication technology
- ASIC prototypes and tested small batch series
- Analog-to-digital converters, complex mixed signal ASICs
- Sensor signal processing for measuring and control technology
- Sensor systems for standard processes (light, magnetic field, electricity)
- Intelligent sensor systems
- Development of magnetic position measuring systems
- Development of vertical Hall Sensors
- Design of optical systems
- Optoelectronic design

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## IC Development – Digital Systems

- System architectures for networked applications
- Networked embedded systems
- Specification and design of System on Chip (SoC) and platform solutions based on microprocessors
- Energy supply and management for electronic components with lowest power consumption
- Intelligent components for measurement and control (energy efficient integrated circuits)
- Energy efficient information- and communication technologies:
  - Intelligent concepts for always-on devices
  - Green embedded systems and energy efficiency management
  - Embedded systems based on Java
- Applications for Smart Grid

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# COMPETENCIES

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## Communications

- System design for communications: high level system simulation, system design and development of algorithms, simulation on hardware-level
- Implementation of communication systems in hard- and software
- Transmitters, receivers, test and measurement as well as fieldtesting for digital broadcasting systems
- Analysis and validation

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## Integrated Digital Terminals

- System specification of digital transmission systems and their terminals (receiver or modem)
- Specification and development of hardware and/or software-based receiver and terminal architectures and their components
- Integration of hardware and software components into receiver and terminals
- Test and qualification of receivers and terminals within qualified test environments
- Development of receiver and terminal reference models for the efficient and smooth mass production
- Support for final product verification

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## Audio

- Coding of audio and video signals
- Multimedia applications, portable and mobile terminals
- Audio and video transmission via ISDN and IP networks, DVB-H
- Signal processing for multimedia applications
- MPEG-4 system solutions
- Surround audio solutions
- Sound quality assessment
- Identification of audio signals
- Intellectual property management and protection
- Broadcast server for digital broadcasting systems

- Modules for digital broadcasting systems, Internet radio
- Semantic audio processing
- Data service for digital broadcasting
- Speech enhancement in hands-free communication

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## Multimedia Realtime Systems

Real-time implementations of audio and video coding schemes (mp3, mp3 Surround, mp3D, MPEG-4 audio/video, high quality voice over IP, Acoustic Echo Control AAC, MPEG Surround, HD-AAC, DAB+, DRM incl. DRM+) for:

- Personal computers
- Smartphones
- Digital signal processors
- Embedded controllers
- Streaming of multimedia content

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## Wireless Distribution Systems / Digital Broadcasting

- Channel modeling and emulation for terrestrial and satellite based communication systems
- Radio channel measurement and modeling for long-wave (stationary -> mobile) and VHF-/ UHF-range (stationary -> mobile, mobile -> mobile)
- System design for mobile satellite communication
- Over-The-Air (OTA) test system for mobile satellite communication in Ku- and Ka-band
- OTA-test system for mobile multiple antenna systems in L- and S-band (e.g. for long term evolution LTE, navigation receivers, Multiple Input Multiple Output (MIMO) communication devices)
- Cognitive-radio test concepts using of the OTA-test system
- Measuring and modeling of vehicle moving profiles e.g. from motorcars in different environments
- Imaged based characterization of land-mobile satellite channels



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### RF and Microwave Design / Locating & Communication Systems

- Simulation and development of RF systems from prototype to product
- Design of miniaturized RF circuits
- Design and linearization of RF power amplifiers
- Simulation and design of antennas
- Simulation of electromagnetic fields
- Wireless positioning systems
- Wireless data transmission, Body Area Network, Sensor networks, RFID

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### Contactless Test and Measuring Systems

- X-ray detectors fully protected against radiation damage, dual energy technologies, contactless weighing, design of scanner systems
- Hardware: HW-based image processing, CCD cameras, low-noise electronics, embedded systems, turn-key industrial test and measuring systems, 3-D CAD
- Sheet-of-light 3-D imaging, optical design for laser scanners
- 3D Color scanning
- High-speed 3-D measurement and classification of bulk foods
- Sensor fusion
- Simulation and design of optical systems
- Spectroscopic imaging
- Distributed Software Systems

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### Development Center for X-ray Technology / Process Integrated Inspection Systems

- X-ray image processing
- Embedded X-ray image processing
- X-ray detectors and sensor systems
- System integration for turn-key industrial systems
- Volume computed tomography

- Digital tomosynthesis
- Laminography
- Metrology using computed tomography
- Nanofocus X-ray systems
- Dual energy X-ray material characterization
- Refractive X-ray imaging
- X-ray microscopy
- Automatic X-ray inspection systems for solder inspection, aluminum wheels, welding inspection, food, plastics, ceramics, cast parts, fiber composites
- Optically or ultrasound excited lock-in thermography for inspection of light-metal cast parts and fiber composite materials
- Automatic ultrasound inspection of semi-finished steel parts, forged parts and fiber composite materials (by inverse phase adaption)
- Mechanized inspection of power plant components
- X-ray simulation
- Industrial image processing systems for manufacturing
- Real-time systems for surface inspection, pattern recognition and texture analysis
- Inspection of bore holes, cavities and pipes
- Error localization in transparent pipes

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### Supply Chain Technologies

Solutions for intelligent objects technologies and applications

- Coaching and advisory service
- Market analysis
- Analysis of logistical processes and optimization
- Technical and economical feasibility studies
- IT-system- and service design
- Hard- and software development
- Development of integration concepts
- Integration of sensors and energy management
- Testing and evaluation
- Implementation support

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# COMPETENCIES

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## Communication Networks

- Longstanding experience in the development of systems and protocols for wireless networks
- Software development for distributed cooperative systems
- Hard- and software development for self-organizing wireless sensor networks
- Development of communication protocols and hardware for wireless communication networks in accordance with the DECT standard and its enhancements
- Software-based solutions for autarkic localization in cellular wireless networks, especially WiFi
- Environment modelling for buildings
- Measurement and monitoring tools for communication networks
- Development of protocols for cooperative and interoperative systems
- Energy-Awareness
- Type approval and preparation of series production of radio modules

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## Power Efficient Systems

- Power/Battery management
- Battery monitoring
- Power supplies
- Wireless energy transmission
- Energy Harvesting
- Voltage converters
- Low power circuit design
- System design and simulation
- Hardware and software components for satellite navigation receivers and localization systems
- High precision satellite navigation receiver
- Supporting Systems for high precision applications (WITRACK-Pseudolites)
- Solutions for indoor navigation systems with inertial sensors

- Seamless indoor and outdoor navigation systems based on inertial sensors
- Seamless navigation systems based on GPS, WLAN and inertial sensors
- Components for digital transceiver architectures
- Reconfigurable and multistandard systems
- Development of system software
- Algorithms for fusion and combination of different sensor data

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## Fraunhofer Center for Applied Research on Supply Chain Services SCS

- Market – Market intelligence for optimal supply chains
- Target market analysis: in-depth evaluation of offer specific customer groups and branches
  - Market potential analysis: identification of possible turnover amounts related to new products and services as well as support for market introduction
  - Market development prognosis: elaboration of future scenarios for strategic decision-making
  - Flow of goods analysis: investigation of transport relations and their source and sink interweaving

- Networks – Optimization of transport networks and systems
- Mathematical MIP-modelling of economic and logistic issues
  - Exact and heuristic optimization procedures
  - Commercial and self-developed software-tool portfolio to support decision-making
  - Geographic information systems (georeferencing, routing, visualization)
  - Process and business models for the logistic services sector (tariffs and costs models for vehicle use, network models, storage models and inventory costs models)

- Processes – Process management and benchmarking
- Benchmarking: neutral assessment of logistic processes by means of scientifically-based databases

- Streamlining: industry and sector comparison to support the implementation of process improvements
- Organization development: development of lean and efficiently structured organizational concepts

Services – Initiation of new services and optimization of existing ones

- Services development
- Complex service supply chains
- Services procurement

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# EQUIPMENT

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## Moving Picture Technologies / Electronic Imaging

- 2-D/3-D digital movie theater
- Video and audio studio
- Post production studio and edit suites
- Camera test laboratory
- Professional cameras for TV, cinema and still image
- Smart cameras, cognitive cameras
- Studio for optical object scans
- Optical sensors for industrial image processing, texture analysis, color image processing
- 3-D imaging sensor
- 3-D recording and playback devices
- Special sensors (polarisation, Time-of-Flight)

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## Medical Engineering

- Medical Technology Test and Demonstration Center METEAN (Located at Erlangen University Hospital)
- Pulse oximeter evaluation system
- ESD evaluation system
- Spectrum analyzer, logic analyzer
- Optical sensors for image processing, texture analysis, color image processing
- Software libraries for image processing and analysis
- Microscopy laboratory with high-end microscopy systems
- Endoscopy laboratory with fiber-optic, rigid and video-endoscopic systems
- 3-D ultrasonic system
- Laser laboratory
- Laboratory for imaging systems for minimally invasive surgery (MIS)

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## IC Design Analog / Digital Systems

- Software for IC Design:
  - Analog simulation: HSpice, Spectre, Spectre RF, HSIM, Ultrasim
  - Digital simulation: Mentor & Synopsys, System-Verilog, VHDL, System-C
  - Logic Synthesis and Test: Synopsys Design-, DfT-Compiler
  - IC layout analog: Cadence Analog Artist, Tanner
  - IC layout digital: Synopsys IC Compiler
  - High-level Synthesis: Mentor
  - IC extraction and STA: Synopsys StarRC, Primitime
  - IC Layout verification: Mentor Calibre, Cadence Assura
  - Design of microwave circuits: ADS
- Emulation systems
- Waferprober Suess, Cascade
- Laser Cutter
- RF and microwave measurement equipment
- ADC characterization system
- IC Bonder
- IC & RF test equipment:
  - Climatic chamber
  - Bit error test equipment
  - Optical spectrum analyzer/optical test equipment
  - Fiber test equipment
- 7-axis method for the characterization of magnetic and positional measurement systems
- Gauss test equipment
- Bonder for Ball/Wedge and Wedge/Wedge
- Pull-Test
- Three-dimensional measurement microscope

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## Communications

- Arbitrary waveform generators
- Transient recorder
- Wideband recording and playback system (14 bit/200 MHz and 500 GByte memory)
- Vector signal analyzer and generators
- Fast time domain measurement equipment
- DVB-SH/DVB-H/ESDR/DRM network
- Van for coverage validation and field trials
- Radio channel simulators
- System simulation software (COSS-AP, SPW, Matlab, System Studio)
- Design systems for digital signal processors
- FPGA design software
- Hardware laboratory
- Thermal imaging camera
- Studio equipment for multi-channel audio
- Loudspeaker-setups surround and 3-D audio
- Multimedia systems
- Workstations for processing of audio and video signals
- Wavefield synthesis cinema
- AV-streaming test environment
- Analog/digital measurement equipment
- Development tools for microcontrollers
- Professional software development tools
- DRM (Digital Radio Mondiale) encoder and decoder chain
- Complete DAB transmission chain and diagnose tools
- GPS reference receiver
- Mobile DAB receiver
- DVB-H modulator
- Audio/video live encoder
- Server platform for own audio/video encoding and DVB-H transmission
- OMA DRM IOP Test Server
- OMA DRM CLIENT Conformance Test Tool
- Car for tests and demos of mobile broadcasting, audio and video applications

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## Integrated Digital Terminals

- Digital simulation: VHDL, System-C, System-Verilog
- Synthesis: Synopsys
- Emulation systems: CHIPit system of Synopsys
- Logic Analyzer: Agilent
- High-level Synthesis: Mentor
- Arbitrary waveform generators: Rohde & Schwarz

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## Audio

- Development and simulation systems for microprocessors and digital signalprocessors
- Systems for the design of complex logical devices
- Sound-proof audio laboratory with equipment for reference-quality playback and sound quality assessment and additional video projection possibility
- Sound studio with well-defined acoustical environment for 5.1-channel surround sound reproduction up to 96 kHz

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## Multimedia Realtime Systems

- Simulation and development systems for microprocessors and digital signal processors (ARM, MIPS, Texas Instruments C6xxx, Motorola 563xx, Analog Devices 21xxx)
- Analog audio/video player/recorder (SVHS, BetacamSP, Laserdisc)
- Digital audio/video player/recorder (hard disk image sequence processor, DV recorder)
- Digital audio/video crossbar with control unit (32 x 32)
- TV reference monitors
- Video measuring instruments (digital component analyzer, analog analyzer, analog/digital signal generator)
- HDTV reference monitor
- HDTV disk recorder
- Prototype HD-radio receiver with MPEG Surround



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# EQUIPMENT

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## Wireless Distribution Systems / Digital Broadcasting

- Modulators for data streams in digital broadcasting systems (100 kHz – 6 GHz)
- Mobile recording devices for RF-signals in frequency ranges between 30 MHz and 3 GHz, particularly for GPS signals
- Playback of broadband signals (Bandwidth up to 80 MHz, frequency up to 3 GHz)
- Simulation of channel properties / signal propagation (30 MHz – 3 GHz)
- Magnetic antennas for 3-D-measurement of magnetic fields (9 kHz – 30 MHz)
- Signal analyzer (frequency range from DC up to 8 GHz)
- Arbitrary-Waveform-Generator for UWB-applications (20 Gs/s)
- 50 meter high antenna tower as a carrier platform for radio and test applications
- Mobile test setup carried by moving motorcars for point-to-point measurements of RF-field strength and delay in the frequency range between 30 MHz and 400 MHz
- Mobile test setup for measuring a 3-D-field strength in a range from 50 kHz up to 200 kHz
- 3-axis motion emulator for test devices with a weight up to 50 kg, a height up to 100 cm and a diameter up to 90 cm (acceleration, max.: 1000°/s<sup>2</sup>, velocity, max.: 300°/s, accuracy: 10 arcsec)
- Shielded anechoic chamber for a frequency range from 1 GHz to 40 GHz
- Laboratory for testing research devices mounted on cars

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## RF and Microwave Design / Locating & Communication Systems

- Simulation software:
  - Microwave circuit simulation: ADS
  - System simulation: ADS, Matlab
  - Electromagnetic field simulation: HFSS, Momentum, CST Microwave Studio, Sonnet, Designer
- Electrodynamic shock tester (500 N)
- Network and spectrum analyzers up to 60 GHz
- Vector signal analyzer (12 Bit/95 MHz, 1.2 GByte)
- Noise and phase-noise measurement unit
- EMC measurements in screened cabin and GTEM cell
- Antenna measurement in a shielded anechoic chamber: farfield/nearfield measurements from 800 MHz up to 40 GHz
- Van with receiving equipment up to 2.7 GHz
- Climatic chamber
- Logic Analyzer up to 800 MHz
- Real Time Locating Systems (RTL5) Measurement Lab
- RFID Measurement Lab

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## Contactless Test and Measuring Systems

- CT capable Minifocus X-ray system, 225 kV/1.6 kW, selectable focal spot size of 0.4/1 mm manipulator system with 9 axis
- X-ray cabin 160 kV/1,6 kW, focal spot size 0,4 or 1 mm
- $\mu$ -focus X-ray system 225 kV, 64/320 W, focal spot size 2  $\mu$ m or 6  $\mu$ m
- X-ray scanner 100 kV, 1.6 kW, focal spot size 3 mm
- Flat panel X-ray detectors, resolution down to 0.03 mm
- TDI X-ray cameras, resolution down to 0.03 mm
- Line lasers
- Specialized cameras for sheet-of-light imaging, 3-D imaging
- Spectroscopic imaging
- Industrial digital color cameras
- Optical simulation tool Zemax

- CAD work station
- Laboratory for electronic engineering

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### **Development Center for X-ray Technology / Process Integrated Inspection Systems**

- Minifocus 3-D CT, 225 kV, voxel size down to 150  $\mu\text{m}$  with KUKA KR 30-3 industrial robot
- Normal focus 3-D CT, 450 kV, voxel size down to 300  $\mu\text{m}$
- $\mu$ -3-D Visualiser: Tomosynthesis system for planar computed tomography, 160 kV, 10  $\mu\text{m}$  spatial resolution within the represented planes
- Sub $\mu$  3-D CT system, focus less than 1  $\mu\text{m}$ , 160 kV, max. 15 W
- Sub- $\mu$  3-D CT system, focus less than 0.5  $\mu\text{m}$ , 100 kV, 15 W
- Fast CT, 160 kV and 225 kV, voxel size down to 200  $\mu\text{m}$
- $\mu$ -focus 3-D CT, 200 kV, voxel size down to 10  $\mu\text{m}$
- $\mu$ -focus 3-D CT, 225 kV, voxel size down to 2  $\mu\text{m}$
- $\mu$ -focus 3-D CT, 225 kV, voxel size down to 1  $\mu\text{m}$
- Portable 3-D CT system 50 kV, voxel size 17  $\mu\text{m}$
- Minifocus 3-D CT, 225 kV, special equipment for dual energy inspection
- Mobile 3-D CT (RoboCT), 160 kV, voxel size down to 100  $\mu\text{m}$
- Refraction setup using Kratky collimator, 60kV
- Tomolibri, multisensor coordinate measurement device, CT and optics, 225 kV, voxel size 10  $\mu\text{m}$   $\geq$  up to 100  $\mu\text{m}$   $\geq$ , achievable accuracy: 10  $\mu\text{m}$  with voxel size 100  $\mu\text{m}$
- Coordinate measuring machine Zeiss Contura G3 800 aktiv, error of indication of size of measurement MPE E =  $1.8+L/300$
- X-Ray Microscope, 40 kV, focus approx. 100 nm
- Keyence digital microscope with measurement function
- Thermography system with optical excitation (5 kW lectr. power) and ultrasound excitation (2.2 kW electr. power)
- Infrared camera equipped with HgCdTe detector for wavelengths from 3.7 to 4.8  $\mu\text{m}$ , with 640 x 512 pixels and 117 Hz read-out rate (full frame)
- Automatic ultrasound inspection system with immersion tank for the automatic inspection of even large parts and electronically controlled xyz manipulator (accuracy < 1  $\mu\text{m}$ ); 16 channel ultrasound inspection electronics suitable for the operation of conventional phased arrays as well as sampling phased arrays in the modes 1 x 16 and 16 x 16, inspection frequency 5 MHz, pulse repetition rate 10000
- Image processing laboratory for industrial image processing
- Laser laboratory
- Software for image processing, surface inspection, bore inspection, texture analysis
- Imaging sensors:
  - high-speed camera
  - polarization camera
  - high-dynamic Linlog camera
  - fast 3-D light sheet sensor
  - monochrome, color, line cameras
- Endoscopy studio with automatic positioning system, various fixed endoscopes and special panorama optics
- 6-axial positioning system for the acquisition of complex components
- 6-axial hexapod robot for precise positioning
- High-power light sources
- Laser light sources up to 200 W pulse power

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# EQUIPMENT

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## Communication Networks

- HF-shielded chamber up to 18 GHz
- Stereo microscopes
- Signal analyzer up to 26 GHz
- Hi-speed 3 GHz oscilloscope
- Mixed signal oscilloscopes
- RF-signal generator up to 6 GHz
- Audio analyzer
- Climatic test cabinet, temperature range from -40°C to +180°C
- RF 4-port network analyzer up to 8 GHz
- Radio communication tester for DECT
- Convection reflow solder machine
- Portable spectrum analyzer up to 7 GHz with wideband measurement antenna for on-site testing
- Calibration software
- Motion Capture Suit (MOVEN)
- Inertial Sensor Data Simulation Tool (test tool for GPS- and inertial data integration)
- Pioneer 3 AT Mobile Robot
- Impedance spectroscopy

*For Competencies and Equipment of the Division EAS see page 115*

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## Power Efficient Systems

- Analog/digital system and circuit-level simulation tools
- Analog/digital measurement equipment
- Development tools for microcontrollers and programmable logic devices
- Battery test system
- Vibration source (shaker)
- Development and verification tools for navigation systems
- GNSS software tool kit
- GPS signal generator (Spirent)
- GALILEO signal generator
- SBAS signal generator
- GPS software receiver
- GNSS antenna platform
- INS signal generator (test tool for integration of GPS and INS signals) (Spirent)
- 2-axis rotary stage for intern and extern inertial sensor calibration







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# RESEARCH RESULTS AND APPLICATIONS

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# IMAGING SYSTEMS BUSINESS FIELD

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The Electronic Imaging and Moving Picture Technologies departments focus their research and development work on the fields of image acquisition, media production and archiving, intelligent systems and image analysis processes. New workflow concepts and systems that cover the entire media production chain and set global standards take center stage.

#### **PRIME@3D – research for realistic 3-D images**

In the PRIME (production and projection technologies for immersive media) research project, both departments demonstrate their core competencies of 3-D camera development and 3-D production systems together with other partners. Staging live productions of “Marina and the Diamonds” and “Fanta4” and the closing presentation at the Berlinale, they convinced both experts and the audience of the quality leap achieved in the area of 3-D production.

#### **Electronic Imaging**

The development of point-of-view cameras form part of the core business of the Electronic Imaging department. The compact micro cameras are particularly suitable for stereo 3-D recording and are used for TV and movie productions. Using an integrated DVB-T transmitter, these micro cameras send high-definition images directly to the broadcasting vehicle via radio. Camera platforms that offer low delay times with image transmission as well as embedded processing and analysis steps will dominate future developments. The camera development portfolio is complemented by polarization cameras and special cameras for medical and security-related applications. In the intelligent systems field, solutions for object and person recognition are being developed, which are applied in science, the media, industry and medicine thanks to their precision and real-time capability.

#### **Moving Picture Technologies**

The Moving Picture Technologies department offers innovative image systems and processes on the basis of high dynamic range (HDR), light field and 3-D recording for the future of the digital media and movie industry. These processes are transformed into practicable encoding and processing systems, which will significantly extend the technical and creative capabilities at the set and in post production for the future. For this purpose, not only the development of devices, such as movie recorders, but also the development of components, e.g. by implementing encoding processes in an ASIC, are being pushed. What has established itself in the industry are the software developments for creating, mastering and controlling digital movie packages. Since these tools have been extended to include new recording methods, such as 3-D or future formats, these works now form part of the key subjects of the department. With the first projects for digital long-term archiving being launched, these software tools find their way into the archiving industry. The international standardization works for professional media formats and the close cooperation with bodies and professional associations for cinema and TV are essential for the department’s developments.

The trend towards 3-D movies continues. While there were only three 3-D cinema productions in 2006, as much as 18 movies are launched in the third dimension in 2011 (as of July 2011). Moviegoers readily pay more in order to make yesterday's "simple" cinema experience an adventure. This new type of entertainment depends on the introduction of digital production and reproduction technologies at more and more movie theaters. The quality of 3-D movies that is indispensable for unrestricted viewing comfort with a feature-length production can only be achieved by means of the latest technology. Additionally, the 3-D trend is also finding its way into the TV and gaming area, raising new technological challenges also in these fields. After all, the production of 3-D contents continues to be very complex, cost-intensive and time-consuming.

The PRIME (production and projection technologies for immersive media) research project sponsored by BMWi pursued the aim to multiply exploit digital contents in the above-mentioned areas of cinema, TV and gaming in an effective way from 2008 to 2011. For this purpose, it was necessary to develop new technological processes for recording, production and post production and for the three-dimensional presentation of contents on different terminals.

Successful examples of the Electronic Imaging department include the digital micro HD camera enhanced in the PRIME project. The special characteristics of this camera of the second generation (micro2): it is very compact and lightweight, offers high image quality and definition (HD format: 1920x1080 pixels) and an exact synchronizability, which is a requirement for 3-D recordings. Equipped with a new CMOS sensor, it provides an even better image quality. Regarding its use in the 3-D TV area, an H.264 encoder was integrated, which allows for high-grade and transmittable compression of the HDTV images in real time.

Thanks to its compact dimensions and low weight, the micro2 camera can also be used on impassable ground or in situations

where a traditional camera cannot be used. For instance, as a so-called point-of-view camera in sports.

Two micro HD cameras are fixed on a special camera superstructure, a so-called side-by-side rig, in a way that they simulate the distance between human eyes. The genlock technique is used to ensure that the cameras record images synchronously. One camera serves as the digital leader. The second one records the scenery with exactly the same settings for calibration, color fidelity and geometry.

The BBC tested this new technology together with KUK, a member of the PRIME consortium. Animal movie specialists recorded the 3-D pilot film "Peregrine", which received a special award for best visual effects at the „Dimension 3 Festival“ in Paris, using the small, handy cameras.

Another highlight: The micro2 cameras allow for making three-dimensional panorama recordings. For this purpose, up to 16 cameras, i.e. eight side-by-side stereo pairs, are arranged in a circle on a specially designed 3-D panorama rig. A special challenge when developing such device for 3-D live-action movie panoramas is the basic conflict between the requirements of a parallax-free panorama generation and the necessary existence of parallaxes for stereo presentation. The solution for this problem consists in the developed camera rig combined with a special geometrical arrangement of the micro2 cameras.

In the course of the complex test productions in the PRIME research project, another existing technology from the Electronic Imaging department was used for recording in super slow motion. These so-called high-speed cameras allow for recording 40 times as many images per second as traditional HDTV cameras. Combined with an appropriate superstructure, two of these high-speed versions thus provide fascinating three-dimensional super slow motions. The much vaunted 3-D filmlet "Summerfeeling" was shot using this technology in cooperation with the partners of the PRIME consortium.



Figure 1: Side-by-side rig

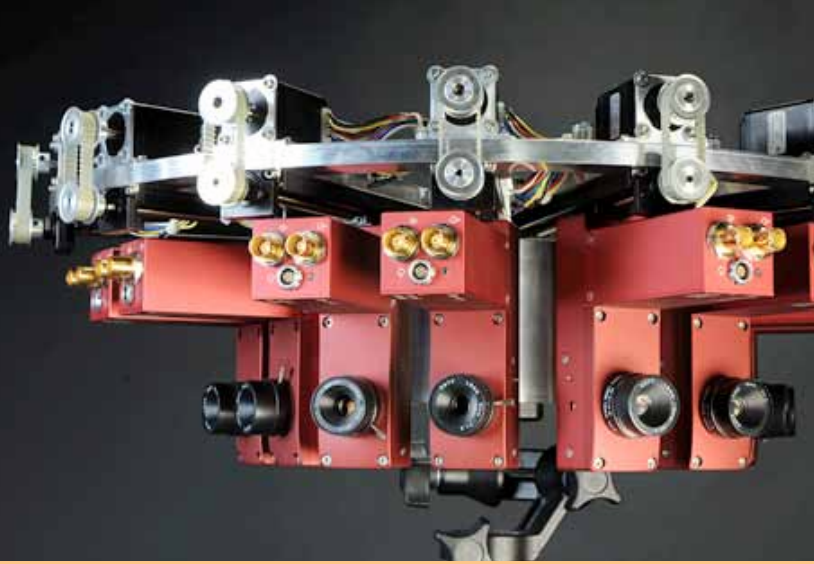


Figure 2: Side-by-side 3-D panorama rig

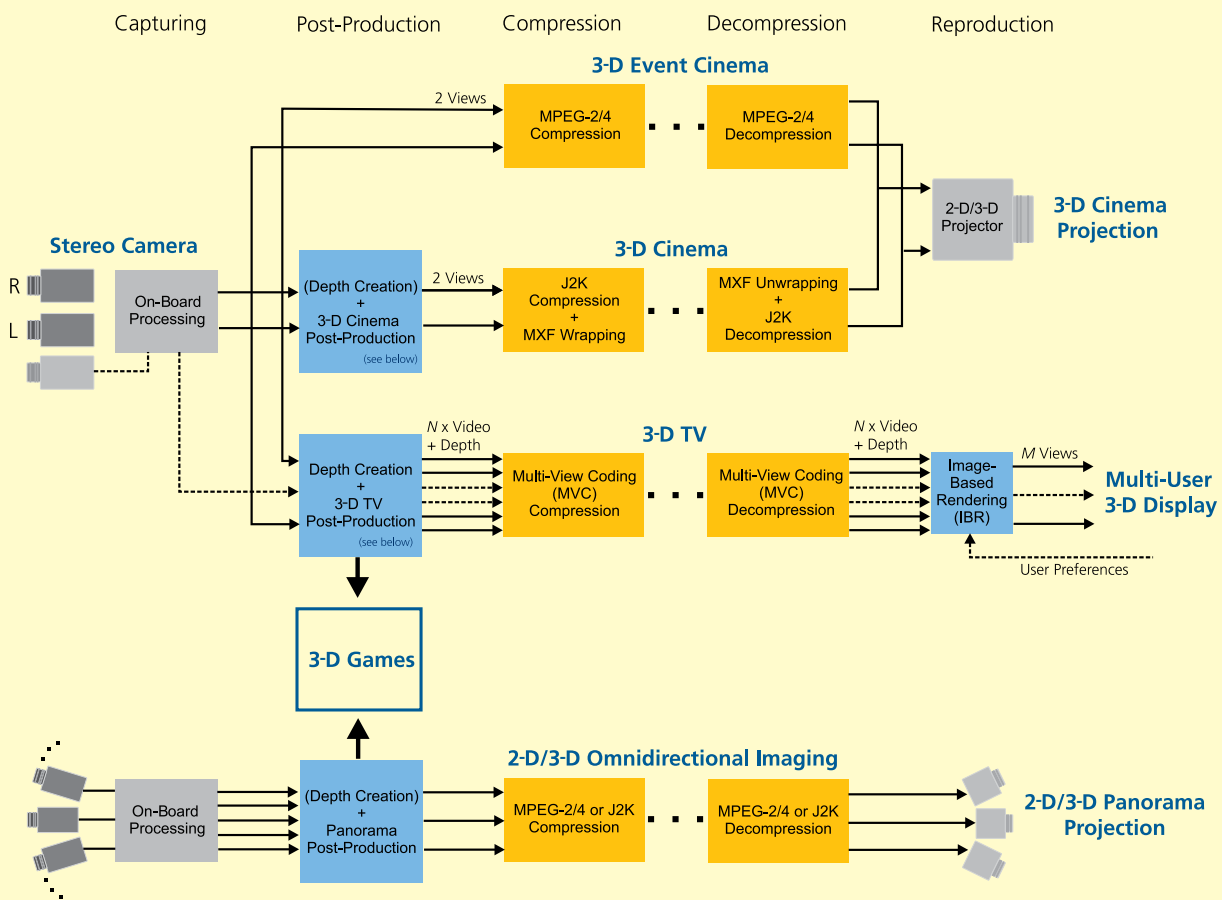


Figure 3: Overview of technologies for stereoscopic contents in 3-D cinema, 3-D TV and 3-D gaming

In order to develop further innovative technologies, the Berlin-based 3-D Innovation Center was founded in 2011. It primarily serves as a presentation platform and work area with focus on 3-D production technologies. More than 30 German companies and research institutions have already declared their interest in accompanying the latest developments.

## Archiving movies digitally

The digital media age is now also finding its way into the movie archiving field. Due to the increasing number of digital movies and contents, archives today primarily receive digital material on hard disks, DVDs or Blu-rays. Furthermore, many archives want to provide materials to their users in a digital format – these were the reasons for developing a format for digital long-term preservation. Fraunhofer IIS developed a concept for a digital format on the basis of JPEG 2000 together with the Fédération Internationale des Archives du Film and designed the so-called CURATOR Archive Suite, by means of which archive packages can be created easily and quickly.

## Fit for the future

The functions of an archive include long-time archiving and the provision of complete original works. Two digital archive profiles were implemented to meet this requirement also in the digital world. These profiles were standardized by the International Organization of Standardization in May 2011 and are based on the technical specifications for digital cinema.

On the basis of these standard profiles, Fraunhofer IIS developed the Master Archive Package (MAP), which contains image and sound data in the highest possible quality available together with technical and descriptive data. Such as the analog master copy, this MAP primarily services for maintenance or can be used for remastering purposes later on. However, MAP is too unhandy for an archivist's daily work due to the large data volume. Therefore, there is a second format, the Intermediate Access Package (IAP), which also contains high-quality image and sound materials but, for example, not all technical and descriptive meta data that are available. Using this IAP, digital cinema packages (DCPs) or broadcast and streaming formats can be created as required in further steps. Thus, the IAP is sufficient as a master for all of today's distribution formats.

## And in practice?

The usual workflow is that the analog format must be scanned and the contents are then packaged into the digital archive format. To ensure that this is carried out in a standard-compliant way, a variety of settings must be observed that require a high degree of expert knowledge. For the archivist to do so without much time and costs, the Moving Picture Technologies department has developed the so-called CURATOR Archive Suite on the basis of its works regarding JPEG 2000 and thanks to its developments for digital cinema. The suite consists of the Creator for creating the digital archive package, the Player, the KDM (key delivery message) Generator for encryption and a JPEG 2000 QuickTime component.

When developing the CURATOR Archive Suite, the scientists attached importance to clarity and easy handling of the software. Data is uploaded, compiled and supplemented by technical and descriptive data in an XML file via an user interface. Technical data are extracted automatically. The number of meta data and their structure is archive independent.

When starting the CURATOR Creator, the user is queried whether an MAP or IAP is to be created. The correct default settings and parameters will then be loaded in the background. Image and sound data as well as subtitle data are loaded into the archive profile and information such as data volume, name of the file, length of the track, etc. is displayed. A QuickTime component that generates JPEG 2000-encoded image files from any "\*.MOV files" had particularly been requested archives. Such component reduces the data amount and therefor improves the creation of an archive package since JPEG 2000 images are already available.

The packaging into the MXF container format (Material Exchange Format) then starts at the push of a button, and the MAP/IAP will be generated. The CURATOR Player serves for checking the finished MAP/IAP. It is a special characteristic of the Player that an MAP or IAP can be displayed on a standard

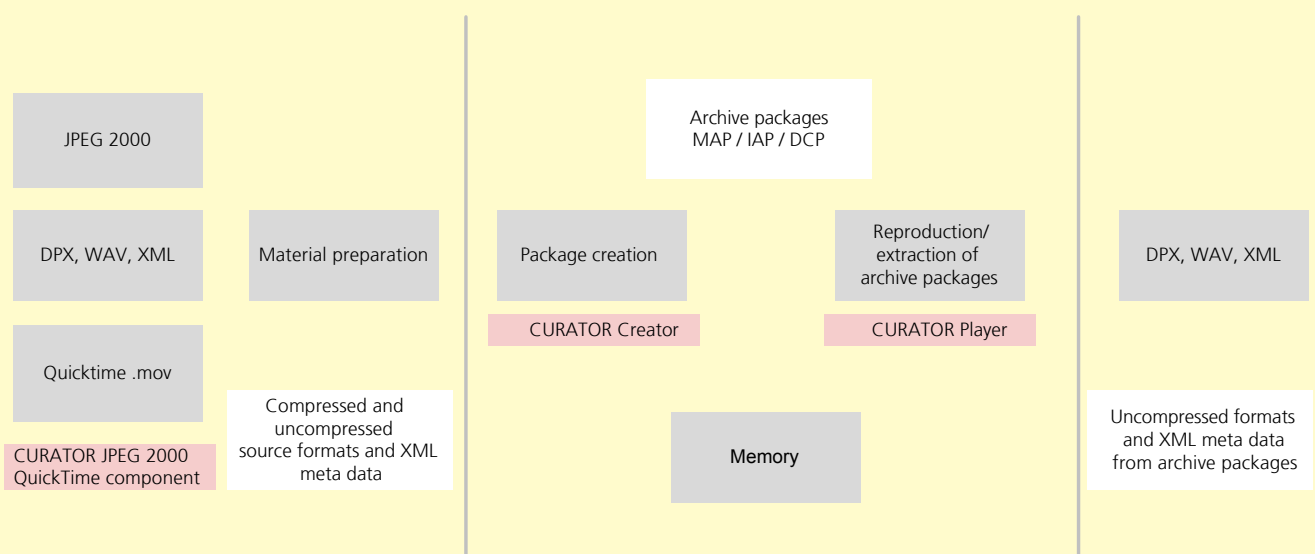


Figure: Workflow description of the CURATOR Archive Suite

PC, i.e. it is decoded in real time, which is usually only possible on a cinema server. This is a comfortable solution to search for IAPs or MAPs particularly for archives.

### Initial projects

The CURATOR Archive Suite has been used by movie archives in Scandinavia and Belgium since April 2011. The increasing work involved in digitalizing existing archive material, the development of new ways of access to the material and the need for archiving digital movie and sound material will further increase the demand for these solutions. It is also

being planned to use the suite for archiving broadcast material and movie footage in relation to movie and TV productions.



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# IMAGE PROCESSING AND MEDICAL TECHNOLOGY

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## Overview

The strengths of the Image Processing and Medical Technology department (BMT) lie in vital sensors and signal processing as well as medical image processing. As a research and development service provider for industry and small and medium-sized businesses, the department supports businesses in the entire chain of the innovation process for medical products. In cooperation with the University Hospital Erlangen, the Medical Technology Test and Demonstration Center METEAN in the BMT department also allows associated examinations and studies to be carried out.

## Vital sensors and signal processing

An example for the successful strategic alignment of the department is its participation in the BMBF leading-edge cluster "Medical Valley Europäische Metropolregion Nuremberg (Medical Valley EMN)". The aim of the cluster is to develop the metropolitan region over the long term into a "model region for optimal health care". The BMT department is a partner in the key project of the "Intelligent sensors" topic. The project "barrier-free health assistance" involves the provision of new services which significantly increase the quality of life with the aid of intelligent sensors and radio-based communication. In this way, for instance, persons suffering from dementia can live in their familiar surroundings for longer as the technical support offers them and their families the greatest possible security.

With the technological orientation towards miniaturized, power-efficient and radio-networked systems, the department continues to pursue the trend of monitoring and assistance systems in order to optimize the constant application in everyday life. The aim is to help every age bracket of the population lead healthy lifestyles using intelligent monitoring systems and digital companions.

## Image processing

The strengths in the field of medical image processing lie in the fields of computer-aided microscopy (CAM), computer-aided diagnosis (CAD) and computer-aided intervention (CAI). The preparation and evaluation of imaging data obtained microscopically and the development of automatic microscopy systems have been a research and development topic for many years. The HemaCAM system for automated microscopic differential blood count analysis was approved as a medical device in cooperation with an industry partner, Horn Imaging GmbH, and is distributed through it in hematology laboratories across Europe.

The main activities in the field of CAD are the areas of endoscopy, dermatoscopy and mammography. The CAD systems offer the doctor image-based decision support with regard to the evaluation. By finding and displaying comparable reference cases already during the examination, the system provides the doctor with an objective "second opinion" and therefore supports a case-based conclusion. Furthermore, processes for the detection of malign tissues, e.g. for bowel cancer screening, are developed that offer the doctor higher sensitivity and security.

The research in the field of computer-aided intervention aims to provide surgeons with new aids and surgical instruments. Examples of these are laser operation instruments for gently opening the skull during brain operations and a surgical instrument for minimal-invasive surgery which helps the surgeon in a maximum way as regards the orientation and execution of an operation by means of image processing technologies.

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# IMAGE PROCESSING AND MEDICAL TECHNOLOGY

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## Laboratory automation by computer-assisted microscopy

Examination and assessment of a blood sample represents an essential source of information in connection with medical diagnostics of numerous disease patterns, such as inflammations, allergies, bacterial infections or various types of blood diseases, such as anemia and leukemia. For such purpose, typically a sample of venous blood is taken and examined by hematology analyzers (flow cytometers). However, depending on the disease pattern, a manual examination must be carried out in up to 40 per cent of all cases. For this purpose, a so-called smear is prepared by applying a drop of blood to a glass slide and dyeing and fixing it. This smear is examined under the microscope and a differential blood count is made that determines the statistical distribution of the leukocytes on the basis of a quantity of approximately 100 to 200 counted cells.

Due to increasing centralization, higher quality requirements and the cost pressure in the health care system, the laboratories are forced to increase automation and use computer-aided solutions. The medical image processing area of Fraunhofer IIS makes an important contribution to this with its work focus on computer-assisted microscopy (CAM) for applications in diagnostics and life sciences.

## Project example and application scenario

The HemaCAM system for making differential blood counts is based on the automatic analysis of digital image data by complex image processing algorithms. It is composed of a high-power microscope with a motorized stage that can be laterally and vertically moved by a computer. An insertable frame allows for simultaneous placement of up to eight slides per round. Such a table and the z-axis allow for moving the slides between the lens with camera and the light source and for automated full recording.

The HemaCAM software can be operated via a graphical user interface, controls all functions of the microscope and finally presents the results of the analysis. For this purpose, the slide is identified by means of a bar code scanner or via character recognition and then the so-called valid area (area with homogeneous cell distribution best suitable for counting) on the slide is identified. Using a 10x slide, an overview of this area is digitalized and a fixed number of leukocytes identified. In the next step, these are recorded individually with a higher-definition 100x slide, detected in the image and pre-classified automatically. Each cell is characterized in the image in terms of its appearance and structure by high-performance algorithms and assigned to the according category by means of a mathematical classifier. Comprehensive algorithm libraries allow for adjustments to other fields of application.

The user interface enables the user to check these classifications at any time and to modify them if required, which is usually only necessary with very few cells. Additional markings regarding particular disease patterns and the morphology also of the erythrocytes can be entered in the user interface interactively. Once a sample has been released by the user, it can be forwarded to a laboratory information system for further processing (e.g. preparation of the report on diagnostic findings) via a data interface.

## Results and outlook

After the approval of the HemaCAM system as an in-vitro diagnostic device in accordance with the applicable directives and provisions of the German Medical Devices Act (MPG) had been completed successfully, the market launch could be started on October 1, 2010. The required specifications, documents and the risk management as well as the design and performance of the legally required performance evaluation study were performed by the leading Medical Technology Test and Demonstration Center (METEAN) of Fraunhofer IIS. In line with the Fraunhofer philosophy, the



Figure 1: HemaCAM consists of a fully automated microscope with a connected camera, computer and graphical user interface and allows for automatically analyzing blood smears and supports the classification of the leukocytes

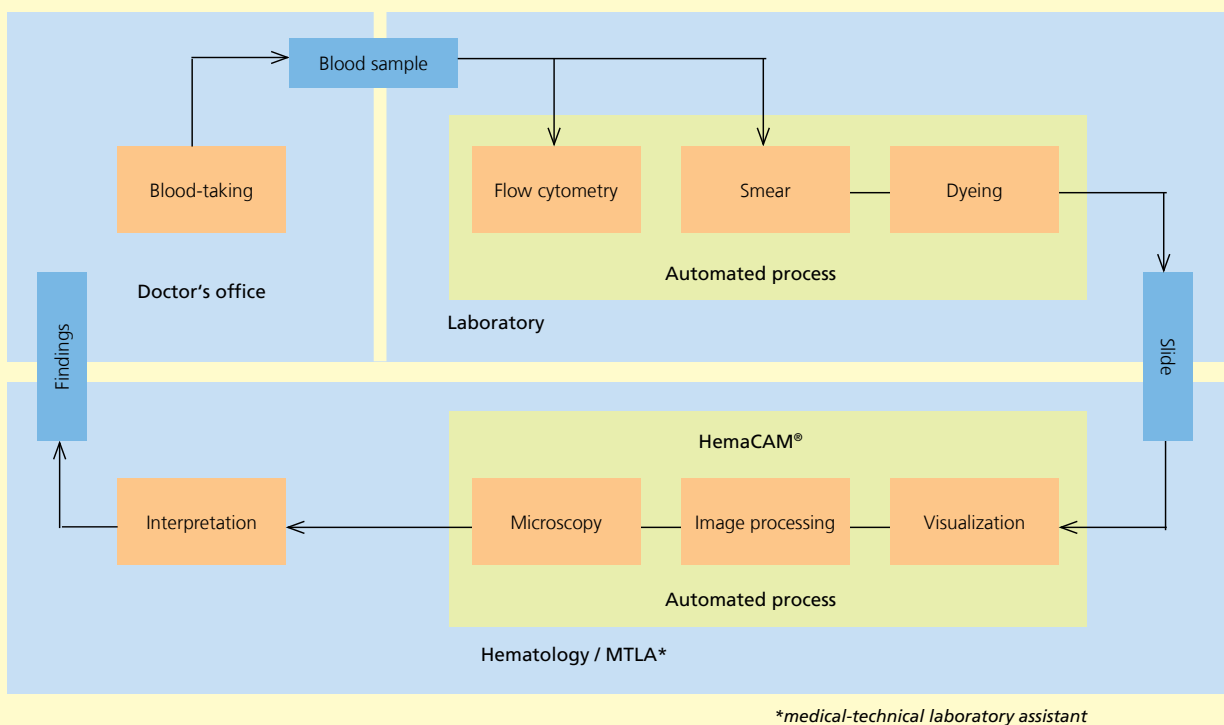


Figure 2: Using computer-assisted microscopy systems such as HemaCAM, laboratory processes can be further automated and made more cost-efficient

highly complex system could thus be prepared for its final approval and placing on the market by Horn Imaging GmbH, our industry partner.

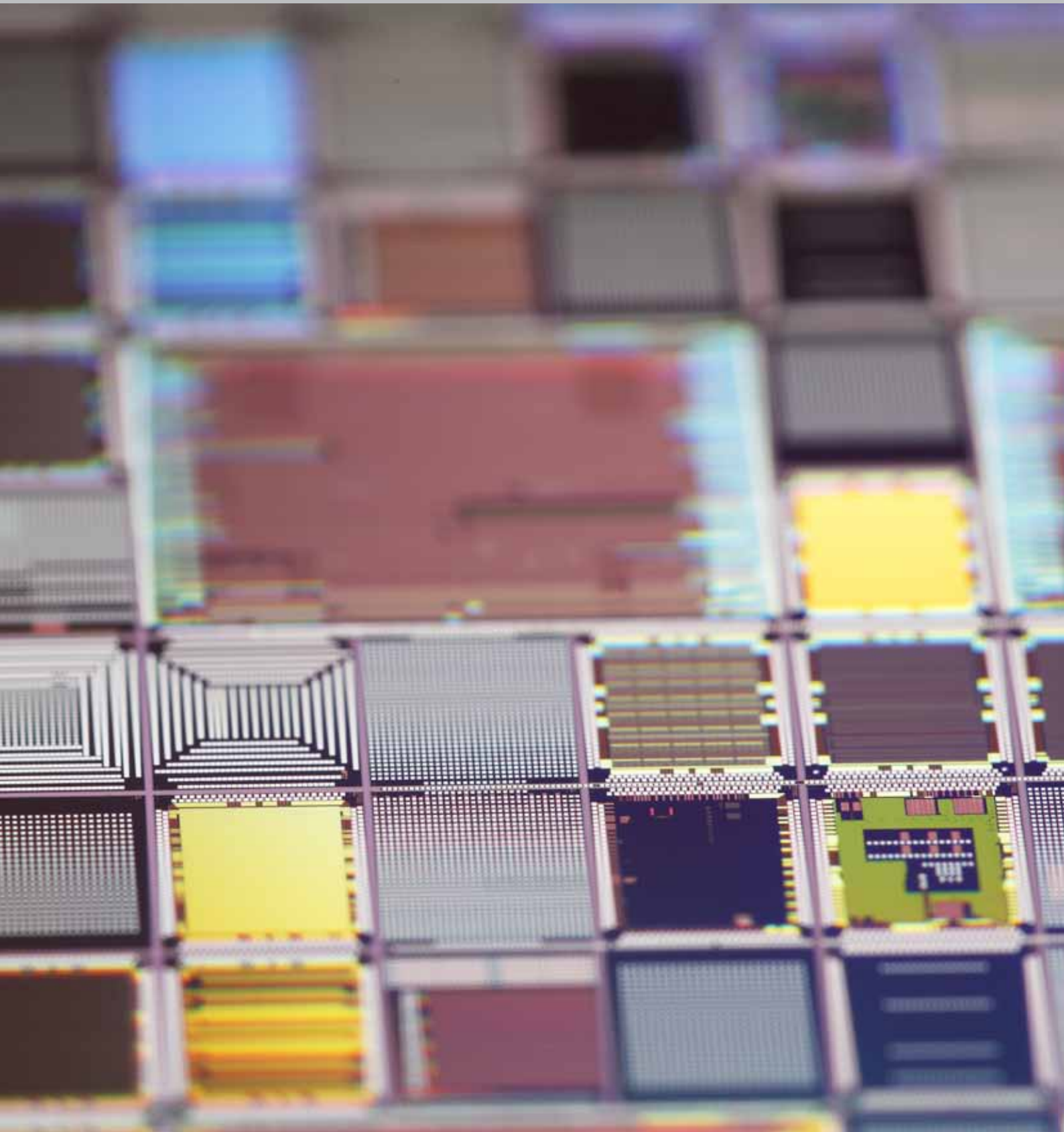
Current research activities deal with the automatic analysis of erythrocytes and bone marrow samples, the detection of malaria viruses and the enhancement of the microscopy platform for large laboratories. This firstly leads to the development of new generations of the HemaCAM system and secondly provides the basis for other fields of application.

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# IC DESIGN – ANALOG SYSTEMS

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## Overview

The design of integrated circuits (ICs), application-specific integrated circuits (ASICs) and functional blocks (IPs) for system-on-chips is one of the core competencies of Fraunhofer IIS. The research and development range already starts with supporting the client with the system development in order to achieve an integration-compatible specification. Starting from the system development, Fraunhofer IIS offers all design services up to the delivery of the mask data to a commercial IC manufacturer and the transition to batch production by such manufacturer. The global cooperation with many reputable semiconductor manufacturers allows for offering a broad range of technologies from 350 nm to 65 nm for the most different applications. Regular multi-project wafer (MPW) runs in the EU-sponsored project EUOPRACTICE give clients access to low-cost ASIC prototypes and low volume batches for pilot or pre-series.

In early 2011, the Digital Design group was affiliated to the department in the course of an internal restructuring in order to accommodate the fact that the majority of the projects have become mixed-signal designs. Furthermore, another group was established in 2011, which focuses on the development of CMOS image sensors. Thus, the cooperation with the departments in the electronic imaging and image processing fields at the institute is intensified.

### Research focus on integrated CMOS sensor systems

The integration of sensors into CMOS technologies offers the benefit that sensors and signal processing are closely coupled. Requirements of modern sensor systems regarding self-monitoring and self-balancing or self-monitoring with security-critical systems can be met at low cost. Furthermore, the transition from operated to controlled sensor systems can be implemented more easily. The focal topics of Fraunhofer IIS

include, amongst others, robust multiple-axis position measuring systems based on the evaluation of magnet field gradients that are recorded by the patented HallinOne sensor technology and interference-proof hall-based current sensors for applications in the performance monitoring field.

Another focus is on CMOS image sensors with special form factors. In a joint research activity with Fraunhofer IOF, image sensors have been developed that do not require a lens anymore, thus allowing for extremely flat cameras. Combining image sensors with nanostructured filters that are realized using the metalization levels leads to completely new applications, such as polarization cameras or multispectral sensors. Following several BMBF and AIF projects implemented during the past few years, the first products that are based on this technology are currently being planned.

### ASIC and IP developments

The IIS researchers develop ASICs for security-critical applications for industry clients from automation technology and aviation. Their key components mostly are analog-to-digital converters. For this purpose, the department evaluates and implements different topologies depending on the requirements and target technology. In the field of digital ASICs, the focus is on the development of SOCs for multimedia applications and satellite navigation. On the basis of the preliminary works carried out in the past few years in the area of quicker wired data transmission, ASICs and IPs for industry clients are primarily developed for use in the automotive field. With the RFICs, the focus continues to be on high energy-efficient transmitter and receiver components for wireless sensor networks and on RFICs for professional applications.



## ULTRA LOW-CURRENT WAKEUP RECEIVERS – operable for many years and always ready for reception

Wake-up receivers are highly power-saving integrated radio receivers that continuously monitor the radio channel and generate a digital control signal when particular wake-up sequences are received. Thus, for instance, a standard radio module can be enabled. In wireless sensor networks, wake-up receivers increase the operating time and reduce response times significantly. Battery-operated sensor nodes can now be designed so that they require low maintenance since service times of several years are achieved. At the ICD-A department, such wake-up receiver was developed in a 180 nm low-cost CMOS technology.

### Integrated channel encoding

The wake-up receiver is able to receive, decode and recognize the transmitted wake-up sequence. The radio transmission of the wake-up sequence is FEC channel-encoded and allows for successful signalization even in case of radio channel interferences.

### Low response time

Unlike cyclically switched-off radio modules, which have response times between a few seconds and minutes, the wake-up receiver has fixed, low response times of less than 40 ms. This is particularly interesting for wireless multi-hop networks.

### Power consumption of only 10 $\mu$ A

The very low power consumption of the wake-up receiver of only 10  $\mu$ A with an operating voltage of 2.5 V to 3.3 V allows for using lithium button cells with low self-discharge. Using the CR2477 lithium button cell, for example, continuous operation with permanent reception for up to ten years can be achieved.

## Batteryless radio reception through energy harvesting

If no batteries at all are to be used, energy harvesting concepts can be used for power supply with certain applications. With a room illumination of 10 lux, the wake-up receiver can already be supplied by silicon solar cells with a size of only 10 cm<sup>2</sup>. A solar-operated dice was built as a demonstrator, which can identify its position and thus the “diced” number by means of acceleration sensors. The wake-up receiver activates it via radio, a microcontroller calculates the position and emits the number as an acoustic signal.

In certain operating environments, thermoelectric generators (TEGs) are also suitable for supplying the low voltage for the wake-up receiver. In general, it is also possible to combine power supply concepts.

### Selective waking

By default, all wake-up receivers in the vicinity of the transmitter without pre-selection are woken, which means that all of them are woken. Many applications require a specific pre-selection, e.g. for certain classes of objects on which the wake-up receiver is installed. However, a selection using IDs, e.g. a serial or inventory number, is also possible. Selective waking prevents unnecessary radio communication and ensures radio availability, which allows for quicker access to movable objects.

### Power-saving radio transmission of sensor data

Apart from the waking functionality, the wake-up receivers also allow for receiving short data packages. These can include an ID or a control demand.

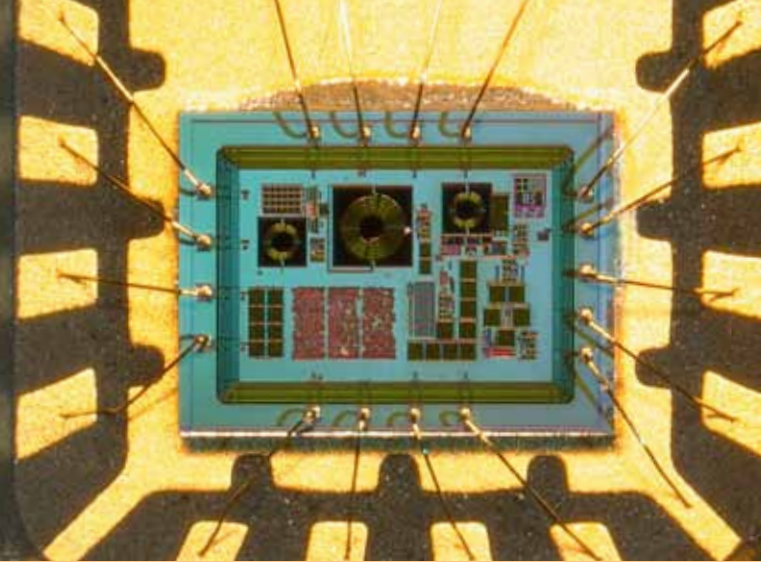


Figure 1: The 2.2 mm x 1.7 mm wake-up receiver chip contained in the QFN16 plastic case (5.0 mm x 5.0 mm)



Figure 2: The solar-operated radio dice can be activated via the wake-up receiver and signals the "diced" number

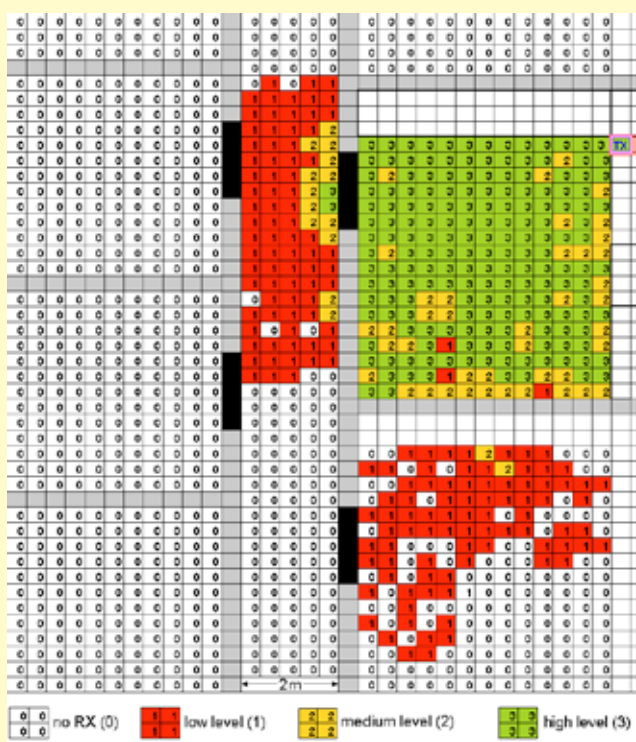


Figure 3: Reception card of a transmitter

## New applications

Due to its very low power consumption, the wake-up receiver is ideal for long-term applications with battery or energy harvesting generators. A variety of radio applications, such as remote maintenance, user authentication, geofencing and localization, can thus be implemented in a low-maintenance and low-cost way.

## Power-saving room-precise localization

When using the wake-up receiver together with a localization system, the high battery operating time is combined with the

room-precise localization capability. For this purpose, a radio transmission scheme was designed that is exactly tailored to the wake-up receiver. The localization system described here consists of a battery-operated transmitter that is positioned in an office or laboratory room and several movable objects, each of which carries a power-saving wake-up receiver. The transmitter (TX) transmits a special radio telegram incl. location information, which can be received by the radio receivers located in its vicinity, at a retransmission rate of, for example, 1 minute. The radio receivers are continuously operated so that they do not miss any radio telegrams and require a current of only 10  $\mu\text{A}$  from a button cell battery or a small solar cell.

Based on the received radio message, a standard microcontroller can identify the number of the room. The microcontroller can be operated at a very low timing pulse frequency below 100 kHz and contributes a power consumption of less than 30  $\mu\text{A}$ . The identification of a room is carried out by every object so that all objects with wake-up receivers are independently able to estimate their current position at a very low power consumption. When using two customary AA batteries as a power supply, operating times of up to 10 years can be achieved in continuous operation. Figure 3 shows the reception card, generated by measurements, of a transmitter (TX) located on the right top in adjoining rooms. The fields are colored depending on their received field strength. Green means very good reception in the direct vicinity of the transmitter. Yellow fields mean a medium received field strength and red fields are locations with moderate reception. The numbers 0 to 3 represent the values of the reception quality received from the microcontroller. Based on an assumed decision rule "minimum reception quality of two", the room where the transmitter is located can be deduced with a probability of 95 per cent.



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# IC DESIGN – DIGITAL SYSTEMS

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### New research topics showing the way to the future

The focus of the department is currently on energy efficiency and embedded systems. The “Design Services” group, which deals with the implementation of digital circuits, was reassigned to the IC Design - Analog Systems department. Thus, this department bundles the strengths for the implementation of integrated circuits from the design up to the layout. These content-related modifications also have been taken as an occasion to change the name of the department to “Networked Systems and Applications”.

### Partner of Energie Campus Nuremberg

The energy efficiency topic has developed to become the central theme of almost all projects of the department. Energie Campus Nuremberg (EnCN) has been started and is intended to be characterized by interdisciplinary cooperation. Under the leadership of ICD-D, Fraunhofer IIS will work there in the NET project “Electrical networks” together with partners of Friedrich-Alexander-University of Erlangen-Nuremberg and Georg-Simon-Ohm University of Applied Sciences Nuremberg. In the course of this project, research will be carried out in the fields of energy flow control in future power networks, interfaces and storage in future energy networks and the pertaining information and communication technology until the end of 2016. The kick-off meeting of the NET project took place in June 2011. The activities within EnCN and the coordination of the NET project, the largest one in Energie Campus Nuremberg by far, will be distinctive of the department in the next few years. They are supposed to almost double the research capacities of Fraunhofer IIS in the field of “energy research”.

### Bundling strengths

Also under the department’s leadership, the “Energy Management” business field is currently being established. Fraunhofer

IIS has been working on that topic for the past several years and is now ready to present and market its research results. Contributions to EnCN and the Energy Management business field are based on the core competencies of the IC Design – Digital Systems department. These include: circuit design, near-hardware software, networked embedded systems also with several processors (multi core) and the application of communication technologies. Thus, the orientation further shifts into the direction of controlling complex, networked systems with application focus on energy management.

### Projects and applications

This focus already becomes obvious through some project examples. For instance, the works on the E-Car Communication Manager, a communication gateway between electric car and charging stations that was developed within the System Research for Electromobility (FSEM), have been completed successfully. This platform serves as a basis for the future integration of (mobile) producers and consumers into the smart grid. In the SmartPM project, the department is working on a smart power supply unit for embedded systems together with the Power Efficient Systems department. The works on a power meter for major consumers together with the IC Design – Analog Systems department and on a gateway for smart demand within the E-Energy project Smart Watts were also continued. To illustrate the ways of how to generate and use regenerative electrical energy, an “energy education house” with chase lights was implemented to demonstrate the energy flow and other elements.

## Smart power management – intelligent power supply unit for embedded systems

As much as necessary, as little as possible – the ideal of economy is increasingly being applied also to the energy supplies of information technology. Today, many computer systems in both the industrial and the private domain use switched-mode power supplies that can only transform the alternate current on the grid-side to a constant direct current. This intermediate voltage circuit is then regulated down individually by so-called point-of-load controllers, which are positioned as close as possible to the consuming components within the computer system to supply an adequate operating voltage to each chip.

### Problem

With this traditional approach, the constant intermediate voltage must be so high that the electric power is sufficient even under the most demanding operating conditions, i.e. with the highest power consumption by the chips and unfavorable ambient conditions. However, this means that under all other operating conditions, electric power is wasted and, for example, converted into exhaust heat in the linear controllers.

### Reducing energy losses

In a European research project under the keyword “smart power management”, the IC Design – Digital Systems department (ICD-D) works on an innovative switched-mode power supply that integrates digital power management functions and provides them to the application software on an embedded system together with the Power Efficient Systems (LOS) department and industrial partners. The power supply unit can reduce the intermediate voltage depending on the operating mode of the embedded system, thus reducing energy losses. Industrial single-board computer,

so-called computers on modules (COM), are the primary field of application. If, for example, a display is activated or a battery is charged through the software control, this significantly influences the energy absorption by the COM.

### Structure of the flyback converter

As shown in the figure, the prototype of the flyback converter intelligently combines the strengths of current analog power electronics and digital control logic. The actual energy withdrawal from the grid to the system is controlled by a power transistor (metal oxide semiconductor field effect transistor, MOSFET). This transistor switches through periodically and supplies electric energy into the transformer. Since the transistor directly works with mains voltage, it must be able to resist voltages of several hundred volts. Therefore, an analog test chip in a newly developed silicon-on-insulator technology (SOI) was designed and manufactured in cooperation with an industrial partner. Using advanced activation techniques, e.g. the switch period or the time for switching on can be controlled more exactly to keep the switch losses of the transistor as low as possible. First measurements made on the test chip have shown very promising results.

### Adjusting the voltage

The digital component of the system consists of a programmable logic in the form of an FPGA or a microcontroller and implements the actual power management functions. In a typical application situation, the software of the COM decides which voltage range is responsible for the current operating mode and writes this value range into the register of the digital component via a simple serial interface (Inter IC Bus, I2C). This range then carries out an algorithm to minimize the input power to the system.

For this purpose, it provides one allowed intermediate volt-

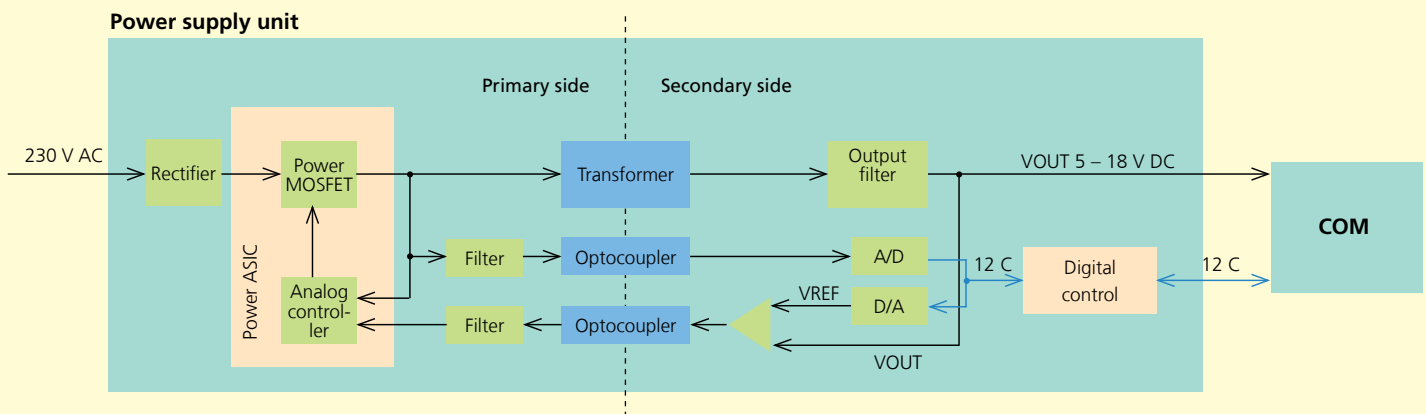


Figure: Prototype of the flyback converter

age value each via a digital-analog converter and waits until the analog component has reached the new voltage. The switching signals of the analog component are digitalized to calculate the current input power to the system, which also includes all losses of components within the COM. After all allowed voltage values have been analyzed, the digital component selects the intermediate voltage value with the lowest input voltage as the new operating point. Thus, the efficiency of the entire system can be optimized

dynamically within a few milliseconds.

This project is sponsored by the Federal Ministry of Education and Research and the European Nanoelectronics Initiative Advisory Council (ENIAC).

# COMMUNICATIONS

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The main activities of the Communications department are the development of satellite-based and terrestrial communication systems with very large ranges. These require robust air interfaces and powerful receiver algorithms. The focus of the satellite-based systems field has been on broadcasting applications for mobile reception during the past few years.

Examples include the successful Sirius XM satellite radio system. The technologies that are now available provide high service quality despite very fluctuating reception conditions (temporary shading, etc.). These concepts also have become the basis of standards such as DVB-SH (Digital Video Broadcasting – Satellite services to Handhelds) and ESDR (ETSI standard satellite digital radio).

Satellite systems are particularly attractive for large-range distribution (unidirectional) of information (data, audio, video). However, systems supporting a bidirectional transmission are also gaining importance. The satellite systems ensure global availability for the “Internet of Things” with M2M (machine-to-machine) communication.

The focus is on systems with at least one of the following characteristics:

- A fully terrestrial infrastructure is uneconomical.
- High redundancy for security-relevant applications.
- Temporary bridging of the failure of terrestrial systems.
- Applications in which the return channel is coupled with a radio-like distribution system (»point-to-multipoint«).

Examples include the MoSaKa project (see 2010 annual report) or the SafeTRIP system (see related technical article). In order to use the scarce resources efficiently particularly within the spectrum and at the required transmission power, innovative concepts for transmitting short messages (status information, measured values, confirmation of receipt, etc.) and RRM (“radio resource management”) are being developed and, for example, tested in large-scale field tests. The results are direct-

ly adopted in commercial applications both in international standards and in cooperation with industry partners.

The Communications department is mainly involved in activities on the physical layer, i.e. digital modulation processes, associated forward error protection, equalization, multiplex and media multiple access concepts. These activities include developing technologies for the L- and S-band (1-3 GHz frequency range) and for the Ku- and Ka-band (10 to 20 GHz). The L- and S-bands are particularly used for terminals with small and low-cost antennae. The Ku- and Ka-bands provide significantly higher band widths, thus also allowing for applications with very high data rates (e.g. 1 Gbit/s).

Increasing the data rate by way of band-width-efficient transmission processes also takes center stage in the research activities for terrestrial systems. In the course of projects such as HDR-HF (high data rate technology for HF communications), technologies are developed that guarantee a direct transmission of high data rates over distances of e.g. 300 km. A fully automated adaptation of the transmission parameters to the properties of the radio channel ensures a continuous and stable connection. In the meantime, the department has developed comprehensive libraries that allow for a quick implementation in real-time prototypes. The flexibility of prototypes based on software-defined radio (SDR) concepts allows for testing different technologies in long-term tests. The figure shows a typical laboratory setup. On the basis of field test results, the conditions are reproduced in the laboratory by high-performance channel simulators, and the systems are optimized in a reproducible environment.

## SafeTRIP – interactive satellite services for automotive applications and road safety

SafeTRIP is a project that is co-funded by the European Union within the 7th Framework Program. SafeTRIP means “Satellite Application for Emergency handling, Traffic alerts, Road safety and Incident Prevention”. 20 partners from seven countries pursue the joint aim to improve road safety, mobility and environment protection for different types of vehicles.

The SafeTRIP system combines satellite broadcasting technologies with complementary communication channels and is intended to provide new bidirectional services across Europe. The system allows for distributing the available transmission capacity between realtime-oriented broadcasting applications (incl. data distribution), so-called “non-linear” distribution for terminals with memory, and addressed individual communication as needed. The focus particularly is on applications from the intelligent transport systems (ITS) field. Potential scenarios for the transport ITS include:

- vehicles that transmit or receive messages to or from roadside infrastructure facilities or a central service center
- vehicles that exchange messages between each other
- connection-oriented, bidirectional communication in real time between vehicles and a central service center

The first two items are required for applications such as vehicle tracking, recognition of the traffic status, traffic alerts, etc. The last scenario is important for emergency call systems such as the European eCall voice communication system.

Currently, commercial ITS applications are based on a terrestrial communication system. The combination with satellite-based systems provides pan-European availability and a variety of contents (e.g. many audio programs).

Compared to satellite systems, which are currently only designed for radio and TV (e.g. SiriusXM), the bidirectional communication allows for new services. In the simplest case, a confirmation of receipt can be sent via the return channel, which e.g. also allows for distributing critical data via broadcasting systems.

The focus of the SafeTRIP project is on testing the core technologies for applications and use scenarios. The demonstrator supports the communication via the Eutelsat W2A satellite, corresponding ground stations and other 3G/4G infrastructures, an on-board unit and end-to-end applications. The performance capability is intended to be evaluated and the benefits to be demonstrated in a trial phase.

## SafeTRIP system architecture

Part of the spectrum in the S-band (2 GHz) has exclusively been reserved for the use of mobile satellite services (MSS) by the EU. The S-band is particularly suitable for terminals that combine 3G/4G technologies with satellite-based applications using small and low-cost antennae. With SafeTRIP, the satellite technology is used for positioning and for distributing information to many or individual users. The return channel is used for transmitting short messages and serves, amongst others, for transmitting requests, acknowledging receipts and collecting information. Apart from package-oriented transmissions, connection-oriented, bidirectional services (e.g. a direct voice connection in emergency situations) are also supported. The SafeTRIP system integrates several communication systems: a satellite-based broadcasting system with extensions for two-way communication and complementary ground components for areas with restricted satellite coverage.

## Satellite communication technology

The architecture of the satellite communication system was mainly developed in projects funded by the European Space





Communication pattern	Air interface Satellite / terminal	Air interface Terminal / satellite	Connection type
Broadcast	DVB-SH	Not applicable	Continuous transmission, one-to-many
Messaging	DVB-SH low latency (LL)	Enhanced spread spectrum Aloha (E-SSA)	Asynchronous bursts, one-to-one
Connection-oriented, bidirectional	DVB-SH-LL	Quasi-synchronous code Division multiple access (QS-CDMA)	Continuous transmission, one-to-one

Table 1: Overview of satellite communication systems in SafeTRIP

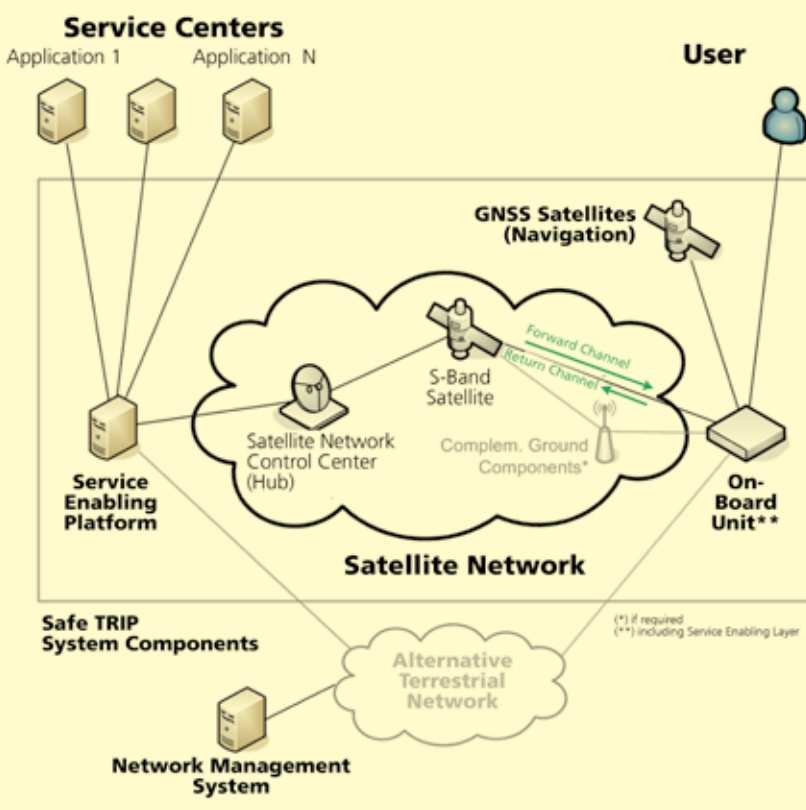


Figure 1: SafeTRIP system concept

Agency (ESA), mainly the DENISE project; furthermore, it is currently undergoing the standardization process with ETSI (European Telecommunications Standards Institute). SafeTRIP includes three communication patterns (table 1). The joint forward link is based on an extended version of DVB-SH [EN 302 583]. This version of the standard allows for the joint transmission of (latency-uncritical) broadcasting applications and time-critical data. The air interface for the

return link forms part of the ETSI standard-ization "S-MIM". All in all, the system is designed for very many (more than one million) users that are virtually active simultaneously, sharing the capacity.

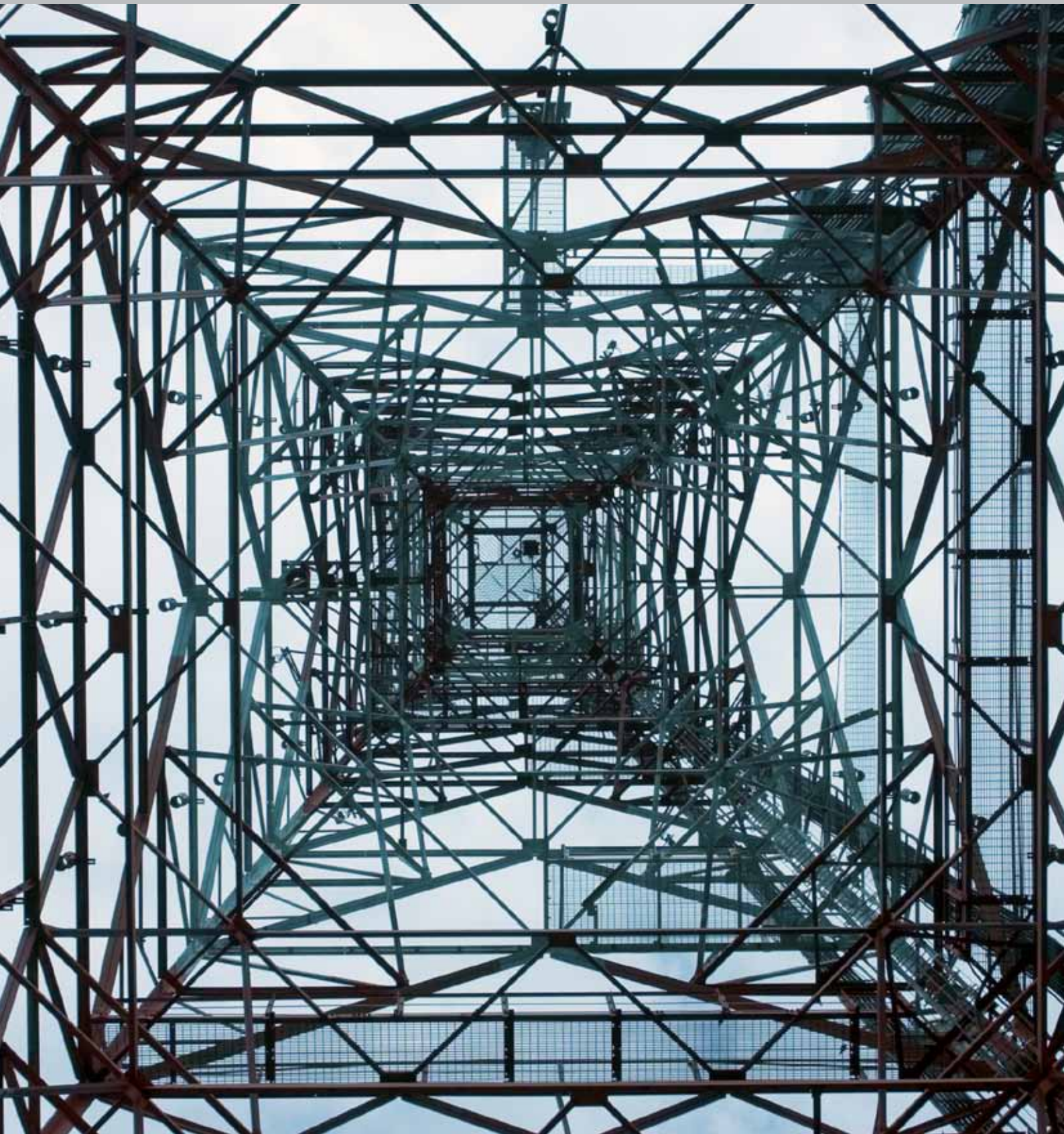


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# INTEGRATED DIGITAL TERMINALS

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### Driving forth media content and services

The introduction of new innovative services and media provisions is at the heart of the "Integrated Digital Terminals" department. The aim is to drive forth media content and services by determining a sustainable concept for a transmission system together with the client. Following this, all system components are realized, validated and integrated. It is only the combination of a clever business idea, customized system architecture and their successful implementation and market launch that determines the economic success of an idea. Based on established or new technologies, the department designs hardware and software-based receiver components and integrates these into a corresponding receiver application. The result of this development process is generally a terminal reference design with the core components "HF component", "baseband processing for modern digital radio and communication systems" (channel decoder) as well as "audio, video and data applications" (service decoder). The range of services of the department therefore ranges from the design and the development of prototypes to the consumer product.

### Along the service chain: from idea to product

The department's work mainly focuses on the further development of existing technologies as well as the discovery of new fields of application and technologies. In this respect, the development of a DAB receiver as a software solution for embedded systems was an important step in the direction of consumer products. A solution for DAB/DMB/DAB+ was developed together with Texas Instruments, which now acts as a reference design for the efficient mass production of a "software defined" multi-standard receiver in the automobile industry and, furthermore, is used as a platform development and implementation of new applications at Fraunhofer IIS.

### Watching TV on cell phones

The transmission standard Digital Video Broadcasting Satellite Service to Handheld Devices (DVB-SH) was the focal point of the establishment of new technologies in the form of a product in the year under report. As a new broadcasting standard, DVB-SH allows television services to be distributed to cell phones and mobile terminals via satellite. A DVB-SH demodulator, one of the key components of terminals, was developed together with the Communications department of Fraunhofer IIS for the actual realization of this idea.

### Partner for the SafeTRIP project

Given the developments in the field of DVB-SH baseband technology, Fraunhofer IIS was chosen as a partner for the European Commission project SafeTRIP (see Communications article). The aim is to design an integrated system platform for a telematic system in vehicles and to offer a new security service for persons and vehicles via satellite connection. The IDT department assumes a decisive role both in the system specification as well as in the design and development of a DVB-SH demodulator.

## Software defined radio – new ways of the radio industry

Software defined radio (SDR) is considered a promising approach of the radio industry to solve the development-specific challenges of new radio platforms. SDR allows for certain flexibility, expandability and the implementation of several radio standards on a hardware platform. Furthermore, an SDR-based solution significantly contributes to reducing the development costs of the hardware platform. Thus, the SDR concept is based on the separation of hardware platform and the matching function elements, which are implemented as software components.

## SDR development – the challenge

The key benefit of the SDR design flow is its flexibility to combine software modules and integrate them into the product family of an SDR platform manufacturer. Since every platform contains different hardware functions and radio applications require real-time processing, the implementation of an SDR development on a manufacturer-specific platform implies a challenge for developers. It is particularly the limited capacities of the internal memory that rule out comprehensive data buffering from the outset. Thus, highly efficient data processing becomes necessary.

Due to the real-time requirement of the software implementation, several tasks and/or applications must run in parallel and the data transfer from and to each processing unit (DSP, hardware accelerator, interface module, etc.) must be ensured at the same time.

Therefore, the challenge for developers is to maintain a balance regarding the capacity utilization in terms of the required data processing and memory accesses to avoid conflicts in the processing steps. Usually the bottleneck is created by the internal bus structures on the SDR platform since all data must be transferred from one module to the next one or to an external memory or interface. With different applications

running on the same device independently from each other, further aspects regarding the function planning must be taken into account and solved. The requested processing power of the different applications regarding the time of arrival can vary strongly. There are phases during which hardly any processing load exists while in another time window, extreme peaks in processing power and memory access can occur. Since the utilization peaks of the different applications are uncorrelated per se, this can easily lead to an overload and, with radio applications, to interruptions. This causes image and sound losses.

To avoid an overload on the platform, all required resources must be monitored by the software implementation. However, it is hardly possible to fully test all combinations since the consideration of all potential test scenarios causes both the test requirements and the verification efforts to skyrocket. Furthermore, independent processes run on the same platform in parallel, thus being a great challenge for planning all bus transfers. Here too, problems regarding the capacity utilization arise and must be solved. To solve these implementation obstacles, it is sensible to set priorities. Thus, the important real-time tasks are separated from subordinate activities. This stabilizes the system, controls the conflict potential arising when accessing internal resources and leaves sufficient capacities for unexpected scenarios.

## SDR implementations – two variants

In principle, there are two application scenarios for SDR implementations: depending on whether different applications are executed in parallel or only alternatively. With applications running in parallel, the performance capability must suffice for all applications that are executed simultaneously. In the case of applications running alternatively, however, the performance requirement is defined by the application with the highest performance demand. This shows that the entire platform costs are determined by the requirements of all applications to be implemented.

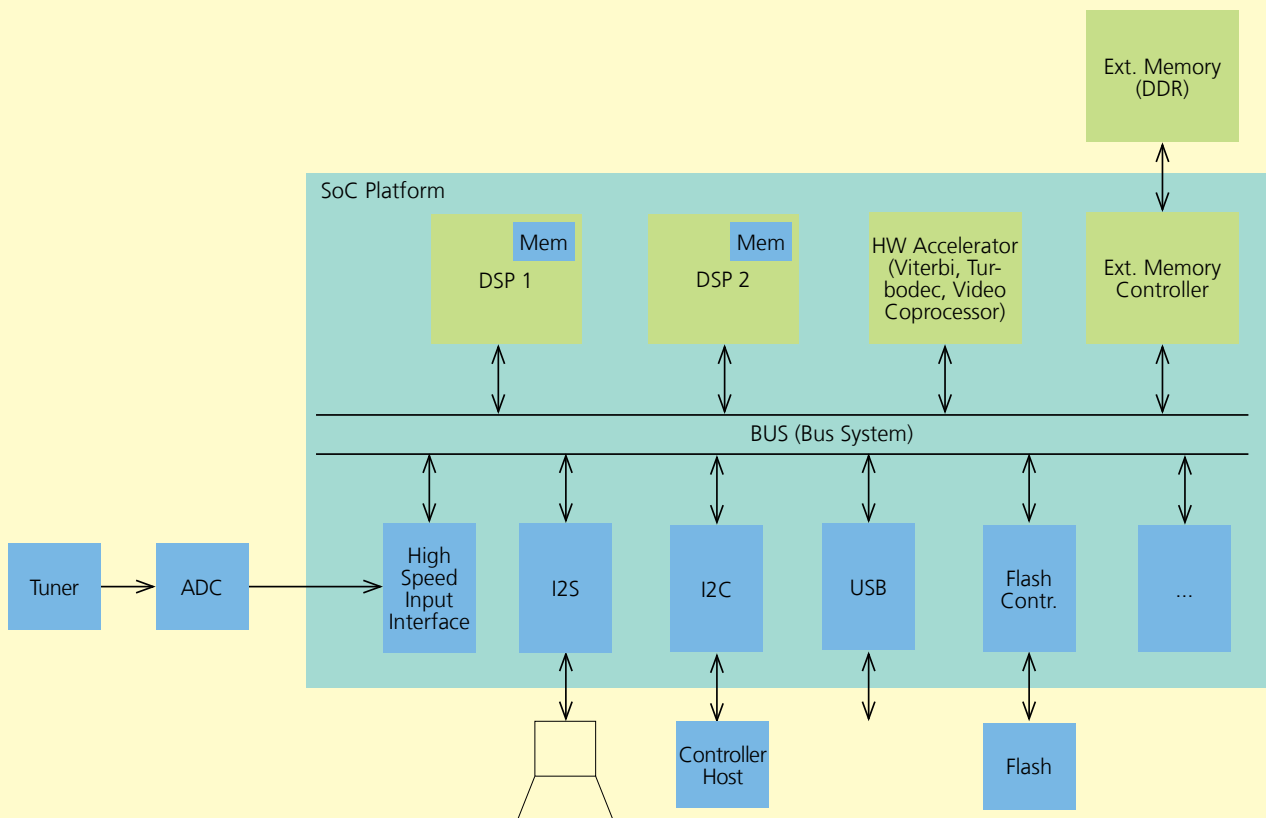


Figure: Block diagram of a typical SoC platform

These finally also define the platform classes that are developed for certain application families. Examples include the application family of digital radio systems. DAB, DAB+, T-DMB, DRM and HD radio, for instance, require similar functions and have similar performance requirements on a radio platform. Alternatively, they can also be mapped on the same DSP class. By contrast, video receivers such as DVB-T, DVB-S, DVB-SH form a second class of broadband radio standards with a higher demand for processing power.

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# AUDIO AND MULTIMEDIA

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The Audio and Multimedia business field of Fraunhofer IIS continues to be the most successful research institution in the audio coding and audio signal processing field worldwide. Last year the business field again grew to some 150 employees from over 20 countries. This strong international focus is reflected by both research and marketing. Last year the employees presented new technologies and solutions at several professional conferences such as ICASSP (International Conference on Acoustics, Speech, and Signal Processing) or AES (Audio Engineering Society), which were well received by science and research. Furthermore, the products of this business field were distributed globally in close cooperation with Fraunhofer colleagues in the US, Japan, Korea, Spain and China. The technologies from Erlangen often form the basis of new business models and set trends for consumer electronics, broadcasting and communication.

## Cloud services vs. physical media

The CD is dead, the DVD is slowly becoming extinct and the Blu-ray will soon meet the same fate. Why put physical media on the shelf when movies and music can be played at any time and in any place on TV sets or cell phones? The developers of the Audio & Multimedia business field became aware of this trend already many years ago and have worked on corresponding technologies. Therefore, all current cloud services with an audio component are either based on mp3 or a codec of the AAC family; all of these are coding processes that were mainly developed at Fraunhofer IIS. The de facto standard for the real-time transmission of music in the Internet is also based on works of Fraunhofer IIS: HE-AACv2 currently is the most powerful audio codec, which transmits music in high quality at very low data rates. Therefore, the German music streaming provider Aupeo, amongst others, licensed an implementation of this codec by Fraunhofer IIS in January 2011. In order to also enable music producers to easily use the Fraunhofer codecs at any time, Fraunhofer IIS and the English company Sonnox presented the Sonnox Fraunhofer Pro-Codec plugin at the

NAMM music product trade show in Anaheim in January 2011. This plugin for music production software enables the users for the first time to directly integrate the MPEG codecs of the mp3 and AAC family into their usual work environment and to monitor the sound quality in real time when mixing a song. The jointly developed plugin can be purchased directly from Sonnox at a price of GBP 295.

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## DIGITAL RADIO IS ALIVE

Finally on air: this now holds true for digital radio in Germany. Following a long dry spell, digital radio had a powerful new start in Germany in August 2011. Since the introduction of the German-wide DAB+ multiplex, it has been possible to receive a total of 13 digital radio stations across the country for the first time. At the same time, the existing DAB radio stations in the various federal states are also being gradually switched to DAB+. Fraunhofer IIS anticipated also this development and has therefore made the technologies required for market success ready for production during the past few years: for example, a design for DAB receivers was developed to allow the cost-efficient introduction of receivers on the market. On the transmitter side, the ContentServer product line can be used for bringing stations on air in a quick and uncomplicated way. At the same time, new services were developed in the Audio and Multimedia business field to make digital radio even more attractive for the end consumer. These include, for example, Journaline as a video text for digital radio or radio in 5.1 surround sound based on MPEG Surround.



*Prof. Hans-Jörg Bullinger, Manfred Lutzky, Markus Schnell and Marc Gayer (from left) at the awards ceremony*

### **Convergence between communication and entertainment electronics**

Whether talking about music, TV or Blu-ray: today we can see and hear top video and audio quality everywhere. HD for the ears and eyes. Only telephone calls continue to be dominated by squawking sounds and jolting images. The developers at Fraunhofer IIS have worked on changing this for several years. Telephone calls and video telephony are supposed to also become a real HD experience in the future. For this purpose, the AAC Enhanced Low Delay (AAC-ELD) codec, amongst others, was developed in the Audio and Multimedia business field. When used in communication systems, AAC-ELD ensures an audio quality that is comparable to that of the CD. Due to the excellent sound, Apple has used the codec developed in Erlangen for its Facetime software for video telephony since 2010.

### **Further strengthening of research competence**

The International Audio Laboratories Erlangen (AudioLabs) have been further expanded last year. Several employees joined the laboratories and three persons have already been appointed to professorships. Prof. Jürgen Herre, Prof. Bernd Edler and Prof. Emanuel Habets have been in charge of the audio coding, audio signal analysis and perception-based spatial audio signal processing fields since autumn 2010. Another three professorships were advertised in mid 2011. The AudioLabs were presented to the scientific community at an event during the AES in London in May 2011.

### **Great success: Fraunhofer prize goes to AMM**

Representing the entire team, graduate engineers Marc Gayer, Manfred Lutzky and Markus Schnell were awarded the 2011 Joseph-von-Fraunhofer prize for the development of the low delay AAC audio codecs. Prof. Hans-Jörg Bullinger, President of Fraunhofer-Gesellschaft, handed over the prize at a festive gala at the Meistersingerhalle in Nuremberg. The Joseph-von-Fraunhofer prize is the highest award of Fraunhofer-Gesellschaft for excellent scientific achievements of employees who solve application-related problems.

The low delay AAC audio codecs significantly improve the quality of telephony and other communication technologies. This is highly necessary since the voice quality of many telephone conversations still is insufficient. Particularly video telephony often unintentionally leads to funny situations since, due to the time delay in transmission, the conversation partners start speaking simultaneously. The reasons for this are high delay times and the bad quality with which such calls have been transmitted to date. Therefore, the aim was to improve the quality and, at the same time, minimize the delay time.

The result is impressive: with Enhanced Low Delay AAC the delay could be reduced to only some 15 milliseconds. During this extremely short time, the algorithm reduces audio data to less than the thirtieth part of their original scope – without significantly deteriorating the sound quality. Due to its enormous performance capability, the coding method has already become accepted in many fields, e.g. in video conference systems, in broadcasting and in relation to mobile video telephony e.g. in the iPhone 4 or the iPad 2.

## Diveemo gets the radio going – the new moving picture service for Digital Radio Mondiale

Diveemo is the new video extension for Digital Radio Mondiale (DRM) and brings action into radio. Using Diveemo, radio stations can also transmit small-format video contents via high distances in addition to the usual radio program and simple data services – via all radio frequencies supported by DRM, including short and medium wave.

Content for Diveemo primarily include news and educational programs. Thus, it is possible, for example, to teach people in isolated regions who would otherwise not get any education due to the great distance from the nearest school.

Diveemo can also be used for providing important information over large areas in the event of disasters. Thus, victims and aiders in earthquake or tornado regions receive information about the current situation in a quick and reliable way. This is due to the fact that with DRM transmission, the population is even provided with news and recommendations on how to behave if the local radio infrastructure, including satellite reception and Internet, is destroyed or not available for other reasons. Particularly in combination with self-sustaining radios (e.g. through a winding mechanism), vital information can thus be given to the people in the disaster area.

This performance and focus distinguishes Diveemo from classical mobile TV solutions. Diveemo makes the benefits of large-area terrestrial radio distribution available for small-format video services on the basis of the DRM digital radio platform. All functions of the digital radio standard continue to be available also for Diveemo services – from automatic frequency switching to Journaline, the video text for digital radio with a multilingual subtitle function.

## Digital Radio Mondiale (DRM)

DRM is an international standardized digital radio system for all radio frequencies up to 230 MHz, including short, medium and long wave, and the VHF bands I, II (FM) and III. DRM comprises two basic operating ranges: “DRM30” is the description of the signal parameters for short, medium and long wave while “DRM+” stands for the new extension to the broadcasting frequencies in the VHF (very high frequency) range, including the known FM band.

## Diveemo functionality

Diveemo has particularly been optimized for very low data rates and typical reception situations of a digital radio standard to allow for simple and low-cost broadcasting of video contents. In its current development status, the service uses today's most efficient MPEG-4 codecs: H.264/AVC for video and HE-AAC v2 for audio data.

Diveemo uses a highly efficient transport format which has especially been developed for this purpose. It transmits the audio and video elements with an individual length avoiding any “scrap” that would waste data rates. Additionally, the default transmission structures of DRM with their fixed temporal reference points are used to ensure a quick synchronization of the receivers both upon the initial switching-on and changing between programs and after potential short reception interruptions. Furthermore, Diveemo supports several audio streams so that educational and information programs can be complemented by multilingual descriptions, if required.

## Diveemo status

Diveemo currently is in the development stage. On September 13, 2010, Fraunhofer IIS, Thomson Broadcast & Multimedia and Chengdu NewStar Electronics presented Diveemo at the International Broadcasting Convention (IBC). On this occasion,



Figure 1: Diveemo-based video program on a UniWave DRM receiver

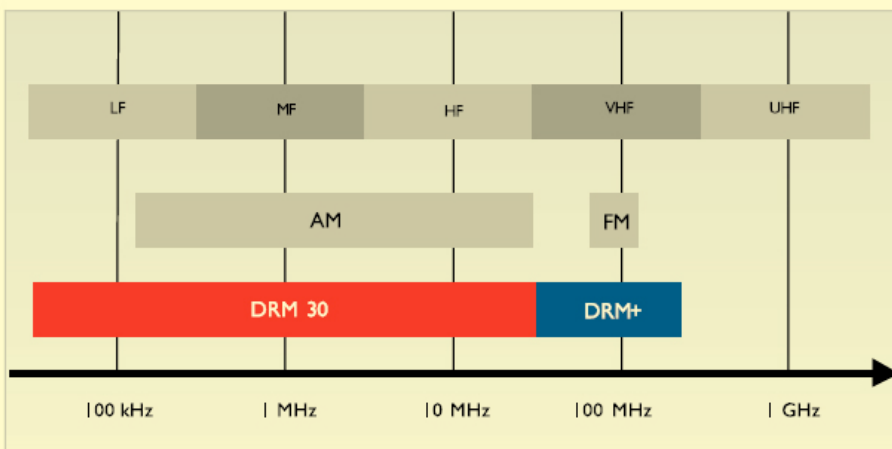


Figure 2: Overview of the radio frequency bands



Diveemo was broadcast live and reproduced on a NewStar DRM receiver during a presentation of the DRM consortium for the first time. The contents for the live transmission from England were provided by the BBC.

Presently, the DRM consortium is working on the final standardization of the information service. Chances are good that Diveemo will be approved as an open standard by the European Telecommunications Standards Institute (ETSI) still

in 2012. Then the way will officially be clear for the area-wide distribution of Diveemo and its global regular operation.



The digitalization of radio and TV has led to many changes in the conventional transmission options, e.g. the enhancement of the potential dynamic range and the introduction of multichannel sound. Although this has significantly improved the audio quality overall, problems can arise in special cases playing back audio material. A very common problem is the difference in volume between individual programs or different stations. One option to solve this problem is to use audio-specific meta data that offer the producer the opportunity to ensure the best reproduction quality possible. The audio meta data used for this purpose are generally known as dialog level, dynamic range control and downmixing.

## Dialog level

The dialog level parameter describes the medium volume level of an audio signal. Since with movies, this level is usually defined by the volume of the dialogs, this parameter is called dialog level accordingly. It normalizes the volume of consecutive programs or different stations when changing on the playing device. Using this parameter ensures a constant volume without disturbing jumps. Thus, one of the most frequent causes of audience complaints is eliminated.

## Dynamic range control

When producing theater movies, differences in volume are used as a creative means. Using modern audio coding techniques, it is possible to transmit this high level of dynamics to the end user. However, this is not an advantage in all listening situations. For example, it is not possible in every living room to play a dynamic range of 70 dB or more at any time of the day. In practice, it is particularly speech intelligibility that is problematic. Low-volume passages such as whispered dialogs can no longer be heard and usually cause the user to turn up the overall volume. In return, however, high-volume passages, such as explosions, also become louder so that the level is disturbing. By transmit-

ting dynamic amplification values, the user is enabled to limit the dynamic range of an audio program if required. These parameters are called dynamic range control or, sometimes, also dynamic range compression or midnight mode.

## Downmixing

Downmixing allows for reproducing surround audio productions on a stereo reproduction system without requiring a parallel transmission of stereo signals. The meta data control the weighting of the rear surround channels and the center channel at any time when mixing the downmix signal. With live broadcasts of a concert, the rear channels often only contain spatial reverberation, which should only be included in the downmix to a low degree. However, with radio plays and movies, essential contents such as dialogs can also take place in the rear channels. In order not to lose any information, these channels must adequately be included in the stereo signal. These differentiations can be defined by the producer by using the downmix parameter.

## HE-AAC and meta data

Today MPEG-4 HE-AAC can be found in many application standards. For example, it is an integral component of the DVB specifications or the Brazilian version of the Japanese ISDB-T standard. The meta data play an important role in reproducing surround sound. Therefore, HE-AAC supports all relevant parameters. To signal the medium volume level of a program, the so-called program reference level exists in HE-AAC. This data field can be used for signaling the medium level in the interval between 0 dB and -31.75 dB (compared to the maximum level) in steps of 0.25 dB. The audio signal is amplified or muted in the decoder by means of this value so that the volume corresponds to the target value during reproduction. Therefore, this parameter works in the same way as the known dialog level. An amplification value in the interval of +/-31.75 dB, also with a definition of

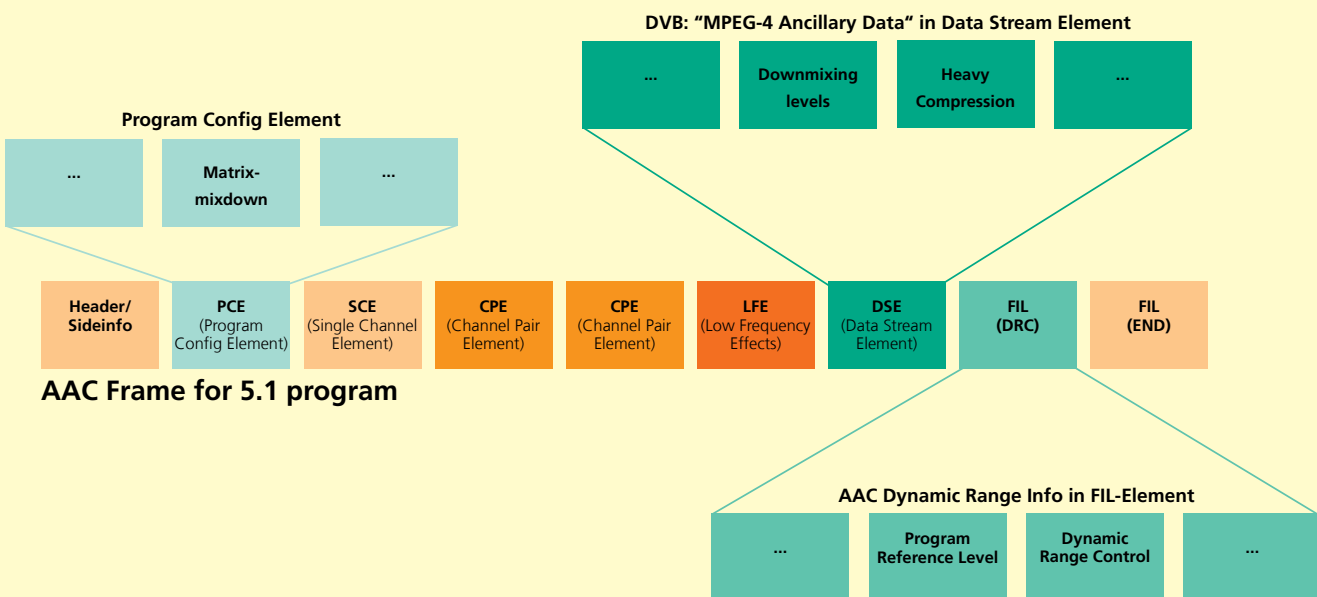


Figure: Overview of the MPEG-4 AAC bitstream

0.25 dB, is provided for the dynamic range compression in AAC. The level of compression can be selected by the end user according to the MPEG specification.

To generate a stereo or mono downmix on the decoder from a 5.1 audio signal, HE-AAC offers the opportunity to define the weighting of the surround channels by means of keyed parameters. Since it is also possible to weight the center channel in the established meta data, an extended and flexible downmix parameter structure was defined on the DVB side which can be embedded in the coded bit stream.

If transcoding becomes necessary when switching over to new techniques, the meta data can be keyed either directly or by simply transcoding in HE-AAC. Additionally, HE-AAC offers the opportunity to include any ancillary data in the bit stream to transmit future, newly defined meta data.

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# WIRELESS DISTRIBUTION SYSTEMS / DIGITAL BROADCASTING

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## IIS research at the Ilmenau location

The Project Group “Wireless Distribution Systems / Digital Broadcasting DVT” in Ilmenau has 11 employees in the period under report. Thanks to its establishment in the Ilmenau University of Technology, the group continues to acquire highly qualified graduates and post-doctoral academics. The main areas of activity are the fields of distributed communication, coverage planning and broadcasting. One focus of the work was the participation in the “Mobile Satellite Communication in Ka Band (MoSaKa)” project sponsored by the German Aerospace Center (DLR). Together with the project partners, the DLR Institute for Communication and Navigation, the company IABG and the Ilmenau University of Technology as well as departments of IIS in Erlangen, a satellite-based communication system is being developed that is supposed to allow for a significantly improved exchange of information between rescuers in conflict areas than is possible today.

In the scope of the project “MILADY”, a project extension was granted which is intended to produce valuable results in the field of channel modeling and coverage prediction in cooperation with the Communications department at IIS. For this purpose, the group managed to get the award for the project “The Mobile Tracking Needs” tendered by the European Space Agency (ESA). The purpose of this project is to define the mechanical requirements on mobile communication terminals, such as vibrations, in more detail.

The infrastructure and technical facilities of the Project Group were further expanded. After an antenna tower

had been constructed on the test facility “Am Vogelherd” in 2009, the laboratory building started in 2010 has now been finished and was delivered for use. The central part is a shielded anechoic chamber on the roof: combined with the antenna tower, it will create a system for dynamic measurements on mobile satellite systems. In addition to this, a system for the synthesis of spatial radio channel models is also integrated in the cabin. With this system the performance of wireless devices with integrated antenna systems (e.g. long term evolution (LTE) user equipment, etc.) can be evaluated under controlled, realistic, and repeatable conditions Over-The-Air (OTA). This is financed by the central strategy fund of the Fraunhofer-Gesellschaft.

The close cooperation with the Technical University of Ilmenau in the DVT research area is a mainstay of quality research and progress in the fields of channel modeling, ripple control systems on long wave as well as OTA testing procedures.

Fraunhofer also has other partnerships with the Ilmenau University of Technology in the field of cognitive radio systems. This involves the adaptive use of currently statistically allocated radio resources which are unused at present and thus allow the limited electro-magnetic spectrum to be utilized more efficiently. The planned OTA system will enable DVT for the experimental verification of research results.

*Start of the broadcasting operation from the test facility “Am Vogelherd”. Prof. Heinz Gerhäuser, Media State Secretary of Thuringia Peter Zimmermann and Prof. Albert Heuberger (from left)*

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# WIRELESS DISTRIBUTION SYSTEMS / DIGITAL BROADCASTING

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Over the air testing – emulation of radio environments for testing communication systems in the range of 800 MHz to 3GHz

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On the Fraunhofer test facility “Am Vogelherd“ in Ilmenau, a system for the synthesis of complex electromagnetic wave fields is being built up in an anechoic chamber in order to define the performance capability of wireless and cognitive communication systems that are equipped with several integrated antennae under controlled conditions (Over-The-Air testing). The structure and functionality of the system will be explained in detail regarding the current state of the art below.

## State of the art

Multiple antennas at transmit and receive side are in favour of beyond 3G communication systems like LTE/LTE-A (Long Term Evolution), WIMAX as well as for WLAN. Furthermore, multiple antennas by means of antenna arrays are used for direction finders as well as for localization systems.

By using several antennae both on the transmitter and on the receiver side (often called Multiple Input Multiple Output, MIMO), the spatial structure and correlation of the wave distribution is utilized. The transmission capacity (through spatial multiplexing) and the reception reliability can be increased through this additional degree of freedom; it also allows for reducing interferences in mobile radio communication (beamforming). An additional degree of freedom results from the variable use of the frequency resource; for example, smart cognitive radio systems can scan for free resources in frequency, space and time. Localization systems evaluate the direction of incidence, thus determining their own position.

It is unimaginable not to use multiple-antennae and multiple-frequency technology in future developments in

these fields. The development of test methods and systems for simulating reality under laboratory conditions for such complex devices is a research focus of the DVT Project Group.

## The OTA testing system

The OTA testing system emulates the spatial-temporal structure of a real radio environment for a device under test by means of a multiple-channel and spatially distributed electromagnetic reproduction system.

The test system is composed of up to 100 dual polarized antennas that are arranged on a circle (two dimensional, 2-D) or a sphere (3-D) surrounding the device under test (DUT). From each antenna, phase coherent signals are radiated to reproduce wave fields with angular and delay characteristics of real environments in a frequency range from 800 MHz to 3 GHz.

## Benefits of the system

Thanks to this system, complex and temporarily variable radio scenarios can be demonstrated emulating realistic multi-path propagation. The costly physical installation of spatially distributed networks becomes obsolete applying this system instead. The shielded OTA test environment is available without limitations and independently from the local radio regulation. Thus, for example, no frequency licenses have to be acquired for any kind of radio equipment tests.

Due to the hybrid design of the test method, it is also possible to test devices that have not yet been fully integrated. Furthermore, the virtual scenario can easily be changed or adapted accelerating the prototype development of complex systems significantly. Finally, the entire measuring process can be repeated very precisely and is thus suitable for comparing different implementations and for certifications.

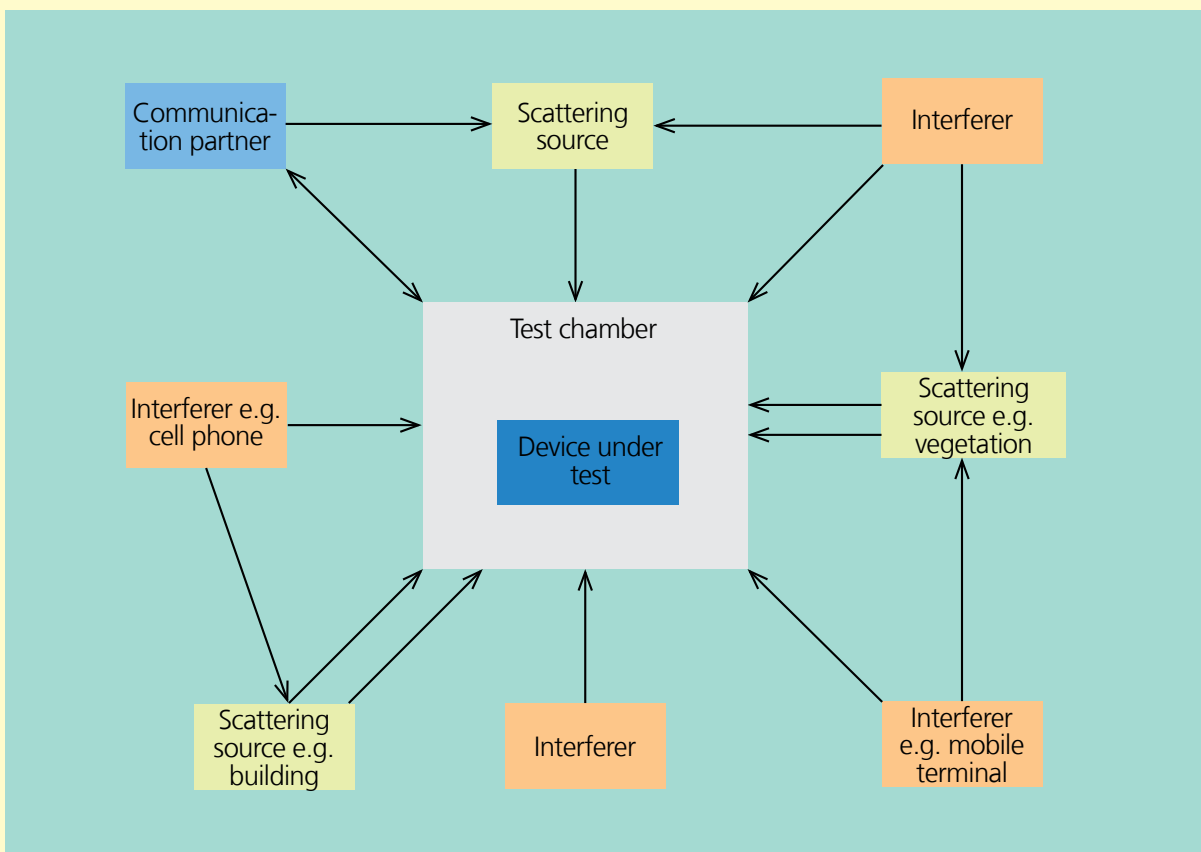


Figure: Diagram illustrating the OTA testing system

The works on Over-The-Air testing are driven together with the Chair "Wireless distribution systems / digital broadcasting" of the Technical University of Ilmenau.



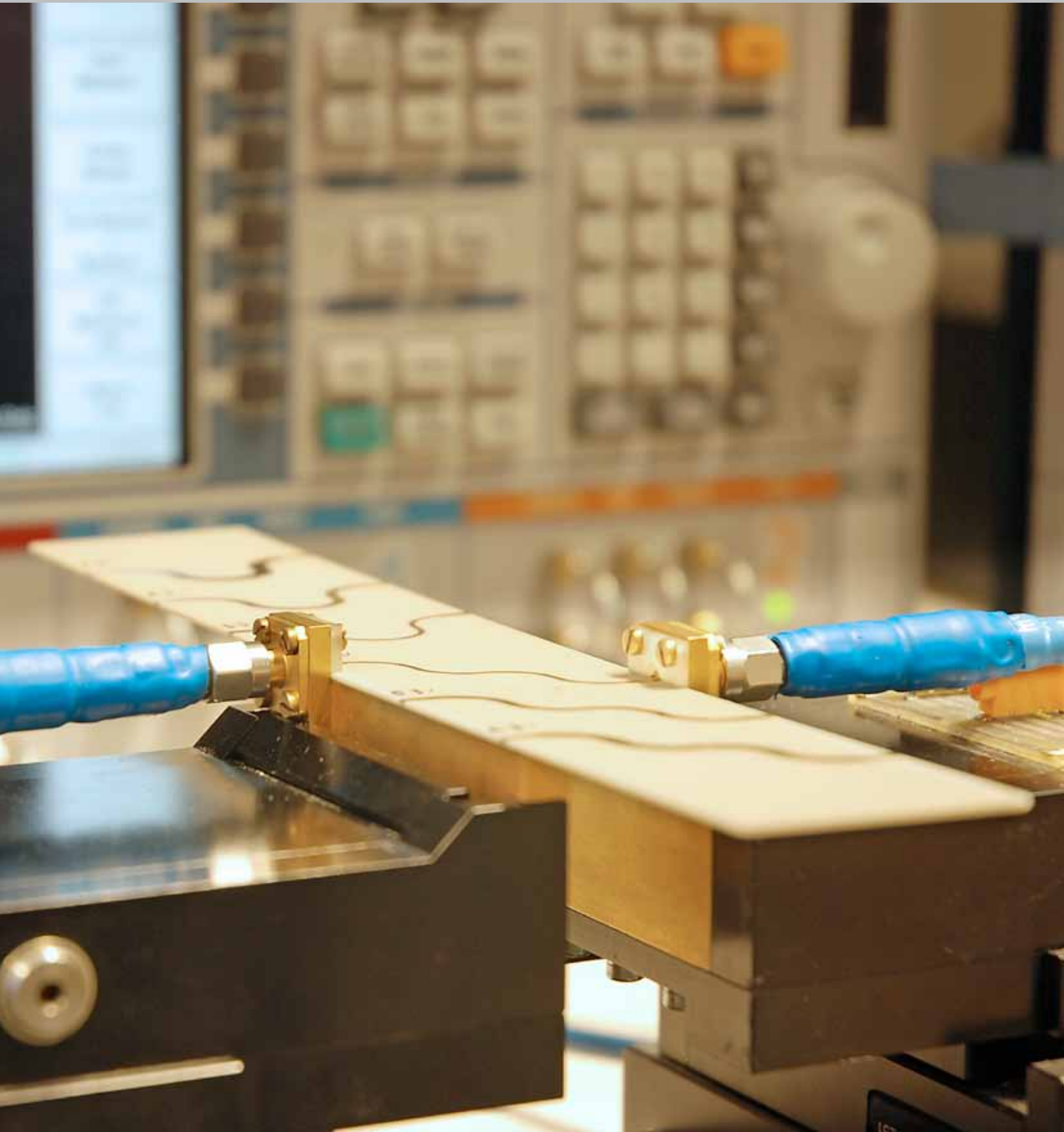
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# DEPARTMENT CLUSTER LOCATING, COMMUNICATION AND RF DESIGN

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The RF and Microwave Design department has existed for some 15 years and has constantly grown in the past few years. This growth and new opportunities at the IIS location in the Nordostpark business park in Nuremberg required reorganization in 2011: the new department "Locating and Communication Systems", which bundles competencies in the field of radio-assisted positioning, emerged from the Radio Positioning group in 2011. Apart from adaptive and time-of-arrival-based radio location systems, its focus includes sensor fusion and event detection. The "RFID and Radio Systems" group focuses on RFID and wireless communication in the close range. Technologies for secure telemetric systems with high ranges play an important role in this context. The RF technology topic is further expanded in Erlangen.

For this purpose, three new groups have been formed. The "Radio Platforms and Algorithms" group creates quick digital hardware and pertaining AD/DA converters, designs and implements signal processing algorithms and firmware and deals with low-power designs and linearization. The "Antennas and RF Circuits" group develops individual antennae for special fields of application, e.g. for energy technology and sophisticated environments. Other key fields of work include the implementation of RF circuits for amplifying and implementing signals. The "Radio Communication Systems" group has many years of experience in FPGA implementation and in analog and digital circuit simulation and works in different fields of application on a project basis.

### **Two departments – one aim**

The Department Cluster Locating, Communication and RF Design cooperates in interdisciplinary projects. The developed technologies, particularly in wireless communication, are driven and marketed jointly. This leads to the three topics of radio communication, radio positioning and antennae.

Radio communication covers a wide range from narrow-band data transmission to digital broadcasting. The focus is on the design and development of radio nodes, radio receivers, modules for satellite communication and software-defined radio. Another focus is on the design and development of customized telemetric solutions with a wide range or high data rate, close-range transmission and RFID systems and their basic technologies (linearization of components, digital signal processing and RF circuit technology).

The Radio Positioning field deals with the design and development of innovative location and localization systems. The different methods around time of arrival and angle of arrival can be used – particularly in combinations – for implementing the most different positioning and localization systems. The applications differ, e.g. the position finding of forklift trucks in warehouses or of soccer players on the field.

As a key element in wireless transmission technology, the antenna is decisive for the realizable performance capability and quality of a radio system. IIS designs tailored high-precision products according to client specifications. Miniaturized and embedded antennae as well as mobile and stationary antennae for satellite broadcasting, integrated mobile communication antennae and adaptive antennae systems are combined and available in a modular system. In this context, the scientists can use their own modern measuring equipment, including the in-house anechoic chamber.

## On-board processor unit for the Heinrich Hertz satellite mission H2Sat

### Aims

As part of the national Heinrich Hertz satellite mission H2Sat, the space agency of the German Aerospace Center (DLR) is planning to develop and operate a German communication satellite. The primary aim is the scientific-technical verification and testing of carrying capacity technologies in space. By choosing the new German SGEO platform, they also pursue the aim to establish system capability in the satellite area.

Fraunhofer IIS participates in the mission by developing an on-board processor – OBP – platform and carries out the following assignments:

- Broadband communication in the Ka band to mobile or at least nomadic terminals. For this purpose, according technologies must be developed and integrated both on the satellite and on ground. The aim of the mission is to test new modulations and wave shapes and to check them for their processability on the satellite. Furthermore, techniques in the on-board switching field up to IP via satellite are intended to be examined experimentally.
- Reconfiguration of the OBP platform to ensure maximum flexibility of the OBP. This offers the opportunity to implement future developments for transmission techniques. The entire digital signal processing can be reconfigured by uploading configuration files.
- Broadband communication in the Ka band to allow for connections via satellite for events of Fraunhofer-Gesellschaft.
- In-orbit verification of a GNSS sensor module and a radiation sensor, based on a memory module.
- Narrow-band communication from user to satellite. The object of investigation again is the application of different procedures for detecting, processing and forwarding signals by means of a satellite that collects them from a large coverage area. Thus, it is also possible to provide a return channel for the first part of the mission.

The central aspect is the demonstration of complete services and applications from the provider down to the end user. The main eligible technologies, parts and components are intended to be created in the course of the H2Sat mission or expanded into this direction.

### Implementation

The OBP of Fraunhofer IIS is integrated into the scientific carrying capacity of the H2Sat via a switching matrix. It can be used for establishing connections to different antenna coverage zones.

The block diagram shows the essential functions of the processor. The processor is connected to the reception paths of the satellite via a down-converter (DOCON). The inputs of the OBP convert signals in the L band to a high intermediate frequency and then scan them. Furthermore, the option of a structure to be realized directly is implemented. Subsequently, the scanned signals are processed by means of four space-suitable field programmable gate arrays (FPGA) that are connected to each other. These FPGAs offer the benefit that they can be reconfigured and thus reprogrammed again and again. They can be used for carrying out many different experiments, ensuring that it will also be possible to examine future transmission techniques. Following the processing in the FPGAs, the signal is implemented from digital to analog and mixed into the L band. This branch exists twice so that two channels are available for transmission. Connection to the satellite is made via up-converter (UPCON).

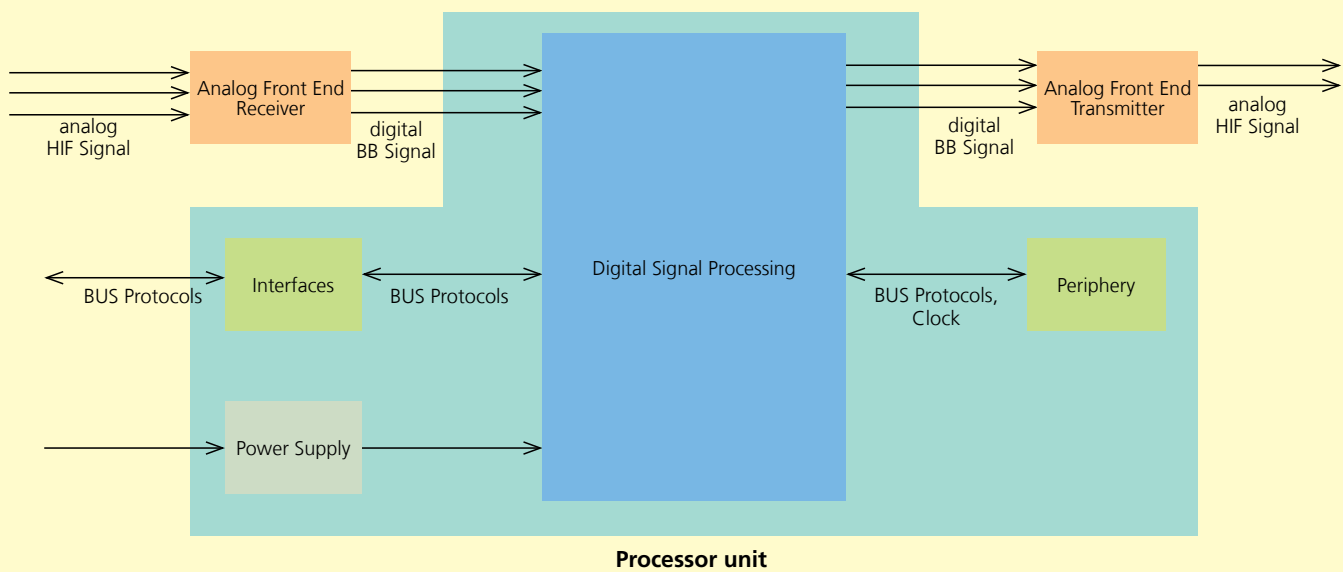


Figure: Block diagram of the on-board processor unit

A TM/TC interface is implemented to the satellite bus for communication and control. An additional interface allows for connection to a GNSS sensor module.

The components selected for the OBP are qualified for aeronautics and ensure a long operating life in space. Thus, the OBP can be used for experiments for many years.

## **RedFIR – real-time positioning technology for training analysis**

Modern athletics have benefited from the use of electronic measuring technologies which, apart from the qualitative and quantitative recording of performance data, particularly allow for objective and individual feedback to athletes for many years. Thus, performance can be experienced more directly, body awareness is raised and the training effect is increased, which are basic requirements to achieve critical changes in movement and reaction.

One of the first technologies was the analysis of the training or match by means of images of a video recording. Another step was to record cataloged events including their occurrence in time. By using these methods and EDP for calculating and visually presenting statistical information, it was possible to make quantitative and qualitative analyses of players, training units and matches. Another step in evolution was the combination of automatic movement tracking by means of image recognition and manual ball tracking and/or manual correction and event recognition. The disadvantages of these systems include fault susceptibility with adverse weather and sight conditions, their relatively low accuracy, subjective evaluations and the additional post-processing. In case of superimpositions or complex match situations, the objects disappear from the focus of video-based systems and can only be returned to tracking by manual correction.

RedFIR stands for an innovative radio-based positioning technology of the next generation that localizes persons and objects in real time with a very high accuracy. The target applications of RedFIR primarily include sports with a high dynamic and complexity; first applications have been implemented in soccer and rugby. The radio-based technology offers a significant benefit over the above-mentioned manual and semi-automatic video-based tracking systems: it can reliably localize objects that are optically hidden in

real time. When tracking information is provided manually, video recordings must be evaluated laboriously.

By switching over to automatic systems, clubs and TV stations will be able to access both more comprehensive and higher-quality databases of service companies much more quickly in the future. Coaches will be able to systematically analyze the potential of a team, specifically develop players, test or virtually integrate new players and simulate moves or entire matches by means of the information tailored to their requirements. Furthermore, players can compare each other on the basis of their performance data and assess themselves objectively within the team.

Apart from providing the technology with its electronic key components, Fraunhofer IIS, in a further step, completed the development of application software for the operation of a training ground in Erlangen. Thus, amongst others, the units of the DFB (German soccer association) test battery tailored to trainees can be recorded fully automatically with a completely new degree of detail. The system automatically analyzes the performance data of the athletes and provides them to the coach in real time as graphical presentation while still on the field.

## **Functionality**

The RedFIR system consists of movable transmitters and a fixed receiver and evaluation infrastructure that receives and processes the signals of the transmitter. The transmitters installed on persons and objects regularly transmit radio signals. Since these spread with a light velocity of almost 300.000 km/s (which corresponds to a "flying time" of 3.33 ns per meter), the position of the respective transmitter is calculated on the basis of the signal, which arrives at several receivers at different points in time.

The times of arrival of the different received signals are determined in the receiver unit. The differences in time of



Figure: Screenshot of the graphical presentation of the DFB test battery

arrival thus calculated are then used to continuously calculate the positions of all transmitters. Due to the selected coding and modulation techniques, the signals of different transmitters are also received and unanimously identified if they overlap in terms of time. Furthermore, the computer network can link the positions of specific actions and derive sport-specific events from them. The system works in the free 2.4 GHz band and can be used internationally without license fees.

The following system components are used with RedFIR:

### Transmitters for players and ball

The used transmitters are miniaturized and can be easily integrated into the clothing of the players or the ball. The transmitters are extremely robust, impact and water-resistant, equipped with sensors and can be programmed specifically to the application. The batteries run for four hours and are charged wirelessly.

### Receivers

The receiver infrastructure consists of several antennae and antenna units that are mounted around the area to be monitored and connected with the receivers that are installed at a central location by means of optical fiber lines. The antennae locations are surveyed when installing the system. All receivers are synchronized in a central computer and the times of arrival are calculated by means of FPGA-based PCI cards. The receiver units are continuously enhanced in terms of cost reduction, increase in flexibility and implementation of new system properties.

### Computer network

The determined data converge in a Linux computer network that consists of Gbit/s-LAN-interconnected standard servers.

The special system software calculates the positions of all transmitters in real time and allows for their direct presentation on a 3-D user interface. For example, when using the system in a soccer match, the positions of players and the ball can be graphically visualized on a virtual soccer field. The computer network including software is continuously optimized with the aim to reduce resources.

### Event recognition

On the basis of the recorded position data, the "event observer" automatically carries out the recognition of certain events that are typical of the application. Many basic events such as possession of the ball, pass, shot on the goal, crosses and physical data such as number of steps, meters run, movement velocities when walking, running or sprinting are recognized by the "event observer" and output via an interface in split seconds. Depending on the requirements of the users, the system can be expanded by any number of additional events. The recorded event data is automatically fed into a database, on the basis of which statistical evaluations are generated.

Using presentation software, the results of RedFIR can be illustrated for users. Thus, the running paths and also the tactical behavior of a team can be presented exactly. It is possible to switch between players or show individual sequences in more detail.

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# CONTACTLESS TEST AND MEASURING SYSTEMS

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### Customized X-ray cameras

The X-ray cameras developed at the Contactless Test and Measuring Systems (BMP) department are based on the optical projection of a viewing screen on several CCD cameras, whose partial images are merged into a single image. The benefit of this concept over conventional X-ray cameras is the fact that all radiation-sensitive components of the camera can be protected against X-rays. This principle of operation has been implemented in area cameras with the XEye series and line scan cameras with the XScan series X-ray cameras.

While traditional X-ray cameras must often be replaced after only a few months due to radiation-caused aging effects from non-stop use in industrial applications, the X-ray cameras developed by the BMP department provide long-term durability in conjunction with high image quality. The first camera of this design has been in use for more than five years by Butting, a pipe manufacturer, for 24/7 testing of welded joints without any noticeable degradation of the image quality. X-ray cameras of this type are also used, for example, in food production, in the production of safety-relevant casting for the automotive industry and in electronics manufacturing.

The most recent application was the upgrade of an existing X-ray system at Borbet, a wheel manufacturer, early this year with an XEye4020, performed in cooperation with the Process-Integrated Test Systems department (PRP). The high dynamic range in combination with its large active area (40 cm x 20 cm) allows for a significant reduction of the number of test positions. Thus, the testing throughput was increased by an average of 30 percent. Thanks to this success, an order for retrofitting of another system has already been placed.

### Optical 3-D test systems

Testing surfaces for small defects such as bulges or cracks using conventional cameras reaches its limits where the defects cannot be imaged with sufficient contrast or the depth or height of the defects has to be measured. The BMP department uses the sheet-of-light method for such testing tasks, using a laser line projected onto an object being recorded by a camera under an angle. The height profile of the object being tested can directly be derived from the shape of the laser line in the image. Using this method, even defects with a height or depth of only a few micrometers can be detected.

Typical fields of application include tire production, where several rubber layers are successively applied to a drum. A defined overlap of the start and end of the individual layers is essential for the safety of the tire since otherwise a weak spot may arise. Since the individual layers are applied at a high velocity and the black rubber provides hardly any contrast, this testing task can only be solved with the sheet-of-light method. The final inspection of tires for bulges and geometry is also performed using this method, which allows for measuring the bulge height and geometry with an accuracy of better than 20  $\mu\text{m}$ . The majority of the testing systems implemented with different partners over the past ten years are in use at tire and automotive manufacturers in Europe and Asia and allow for testing a total of more than 100 million tires per year.

Other fields of application include 3-D scanners for measuring plants. Such scanners are, for example, used by seed breeders for optimizing the seed quality.

*The BMP department developed a portable optical 3-D scanner for agricultural applications for assessment of plant growth*



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# CONTACTLESS TEST AND MEASURING SYSTEMS

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## **FPGA-based system for image pre-processing of X-Ray image data**

In non-destructive material testing, digital X-ray technology has developed to become an elementary component of quality assurance in many industry companies. It is particularly the production of safety-relevant components such as chassis parts for the automotive industry that requires a 100 per cent testing of production in the manufacturing cycle. The turn-over of a fully automated X-ray testing system is determined by the entire processing chain. From component handling to image recording and analysis including the decision whether or not a component is defective. Image pre-processing is a central component comprising functions such as dark and light image matching or averaging of several images for increasing the signal-to-noise ratio, thus preparing the raw data of the X-ray detector for automatic image evaluation.

An FPGA-based hardware platform and a framework for image preparation has been developed in cooperation of a total of six IIS departments (Contactless Test and Measuring Systems, Electronic Imaging, Development Center X-Ray Technology, Digital IC Design, Communications, Process-Integrated Test Systems). Thus, the evaluation computer can be relieved of simple but calculation-intensive algorithms, offering potential for the implementation of high-performance algorithms for image analysis.

The raw data of the X-ray detector are received via a Camera-Link interface (CLink), processed and transmitted to the evaluation computer via another CameraLink interface (figure 1). An adjustment to alternative standard interfaces, such as Gigabit Ethernet (GigE-Vision), is possible due to the modular concept, thus allowing for a flexible response to the most different requirements. The key element of the developed hardware platform is a high-performance FPGA for data processing and a DDR2-SDRAM that serves as an image memory and for providing correction data of the individual algorithms. The system can be cascaded to increase the

computing capacity, for which Gigabit transceivers (Rocket-IO) are used for a quick data exchange. Apart from control activities and the parameterizing of the different algorithms via a SATA interface, an "embedded PC" integrated into the system also is responsible for communication with the evaluation computer via Ethernet. The Linux operating system was used for this purpose.

## **Data rate significantly reduced**

The framework is the actual FPGA-based implementation of the image pre-processing (figure 2). With the aim to integrate the most different algorithms in a basic implementation, an infrastructure was implemented in the VHDL description language, which contains the interfaces, the memory connection and the configuration mechanisms. A short development time for the algorithms for image pre-processing could be achieved by using Catapult-C, a high-level synthesis tool by Mentor, which allows for using the C programming language. Limited by the available resources, several algorithms can be integrated in an FPGA. The structure is characterized by a parallel processing (pipeline structure) of the image data so that a maximum high refresh rate is achieved. Depending on each algorithm, image data must be stored and correction data must be made available. SDRAM memory modules are optimized for linear access, which significantly reduces the data rate in case of random addressing, which is necessary due to the properties of some algorithms.

Therefore, cache controllers with four SRAM-based data buffers each, which can be accessed independently from each other, were implemented for maximizing the data rate. The algorithm is variably assigned to the cache by the framework, with the algorithm initiating the reloading of partial images or correction data.

With a processing velocity of approx. 32 mega-pixels per second, the frame rate achieved by the system is four times

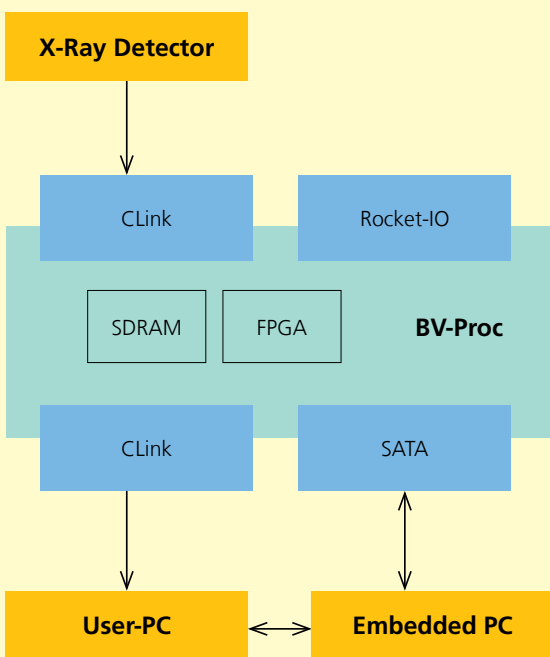


Figure 1: Processing chain consisting of X-Ray detector for image recording, BVProc for image pre-processing and computer for image evaluation

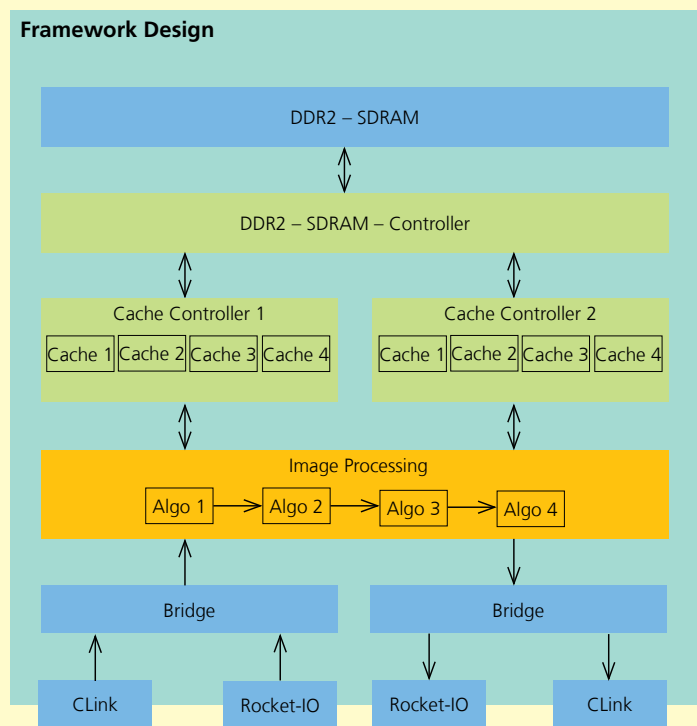


Figure 2: Structure of the framework for FPGA-based image pre-processing

as high than with a parallelized software implementation on a PC (XEON processing unit, 2 GHz, four cores, using SSE).

# FRAUNHOFER IIS IN FUERTH

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## Fuerth – a landmark in the land of ideas

The Development Center X-Ray Technology (EZRT) was successful with its project “Fraunhofer computed tomography from nano to XXL” in this year’s competition “365 places in the land of ideas” and may call itself a “selected place 2011”. The highlight was the awards ceremony at the open house in the test hall at the Fuerth-Atzenhof location on November 8, 2011. The interested public was offered the opportunity to get to know the competencies and works of Fraunhofer EZRT in more detail.

At the IIS Branch Lab in the Uferstadt research and business park in Fuerth, the Development Center X-Ray Technology, Process-Integrated Inspection Systems and Supply Chain Technologies departments research and develop under the umbrella of the Technikum section of the park. The vicinity to the Central Institute of New Materials and Process Technology (ZMP) of the University of Erlangen-Nuremberg and to Neue Materialien Fuerth GmbH allows for interesting cooperations, e.g. in the “Engineering of Advanced Materials (EAM)” excellence cluster, an extension of which has been applied for.

### **New location for non-destructive testing**

New research projects sponsored by the Federal State of Bavaria have also been conducted at the new “Golfpark Fuerth” location in the Atzenhof district in the high-energy test hall for non-destructive X-ray testing of large components inaugurated in 2010 since early 2011. Fields

of application include the recognition of dangerous and smuggled goods, non-destructive testing, quality control and fault analysis in the automotive sector, aviation and aeronautics as well as energy technology.

In May 2011, the excavation works for a new institute building were started next to the test hall. The official start of construction was the laying of the foundation stone on June 30 with Martin Zeil, the Bavarian Minister of Economy, Infrastructure, Transport and Technology, Petra Guttenberger, member of the state parliament, and Dr. Thomas Jung, Mayor of Fuerth. In fall 2013, the researchers will relocate from Uferstadt, the space capacities of which have been exhausted, to the new building.

### **Managing global supply chains**

The Logistics business field of Fraunhofer IIS is represented by the “Supply Chain Technologies” department at the Fuerth location. Today, logistics include much more than just transport, handling or storage. Logistics is the management of global supply chains that provide goods from initial production and production and trade steps to the end customer. Technologies for these supply chains are so-called intelligent object technologies, such as radio frequency identification (RFID) or wireless sensor networks, by means of which the information about the goods in the chain, their environment and history can be recorded, stored and communicated. Supply chains can be controlled more efficiently through the acquired information.

*Laying of the foundation stone for the new institute building in Atzenhof: Prof. Alfred Gossner, Prof. Randolph Hanke, Martin Zeil, Dr. Peter Dittrich, Dr. Thomas Jung, Horst Müller, Petra Guttenberger, Prof. Albert Heuberger and Prof. Heinz Gerhäuser (from left)*



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# DEVELOPMENT CENTER X-RAY TECHNOLOGY

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## Overview

Located in Fuerth, the Fraunhofer Development Center X-Ray Technology (EZRT), a joint department of Fraunhofer IIS and Fraunhofer IZFP in Saarbrücken, is dedicated to new developments in the field of material characterization and testing as well as structural analyses by X-ray technology. It cooperates closely with the "Process Integrated Inspection Systems" and "Contactless Measuring and Test Systems" departments in the field of industrial X-ray technology. The work here primarily focuses on 2-D and 3-D X-ray systems for structural analyses in science, the development of components such as detectors and X-ray tubes, measuring applications in X-ray technology and X-ray processing.

## Cooperation with universities

The EZRT continues to work closely with the central institute of the University of Erlangen-Nuremberg, established in the same location in the Fuerth Technikum, in the Cluster of Excellence "Engineering of Advanced Materials" for the project "Computed tomography for the analysis of cellular and foamed materials and composites".

Furthermore, the establishment of the new Fraunhofer project group Nano X-Ray Systems for Material Characterization, in close cooperation with the new Chair X-ray Microscopy in the faculty of physics and astronomy at the Julius Maximilian University of Würzburg, was started in July 2010. The project group and the chair will move into new facilities at the new Hubland-Nord campus. In relation to this, Katja Hessel, State Secretary of Economy, handed over a sponsoring notification in the amount of 3 million euros in June 2011.

The Fuerth location is also being sponsored for a project for testing light emitting diodes (LEDs). The production of these modern lamps places some demands on quality control. This is the only way to ensure constant quality and a good yield.

Particularly in view of the ban of certain conventional bulbs in the EU, progress in the field of alternative and modern lamps provides important impulses for the technology leadership of Germany in Europe. Therefore, Fraunhofer EZRT will drive the development of new and improved test methods for LEDs with 1.8 million euros until 2013.

In October 2010, the test hall for a 9 MeV linear accelerator (Linac) was inaugurated in Fuerth-Atzenhof. Following the first successful measurements, the further extension of this XXL computed tomography facility is being continued so that it will be possible to examine large objects, e.g. freight containers, still in 2011. Thus, Fraunhofer EZRT can now cover the entire range of X-ray technology from very small (CTportable) to very large (XXL-CT).

## Hugo Geiger award for EZRT researchers

In May 2010, Fraunhofer EZRT presented the computer tomograph CTportable (photograph), which currently is the smallest and most lightweight device in its market segment with approx. 350 x 300 x 230 mm and approx. 20 kg, at the CONTROL trade fair. Stefan Hebele received the Hugo Geiger award for the development of this device at the annual Fraunhofer conference in Nuremberg in May 2011. The Bavarian Ministry of Economy, Infrastructure, Transport and Technology honors three excellent and application-oriented university diplomas or master theses with this award.

This award and the strong industrial demand for the CTportable underline the excellence of Fraunhofer EZRT in the development of laboratory X-ray systems.

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# DEVELOPMENT CENTER X-RAY TECHNOLOGY

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## Characterization of food foams with fast micro computed tomography

Products on foam basis are widely used in the food industry. In order to achieve the desired functionality and properties of a product, the food needs a particular pore structure.

Characterizing the pore structure particularly of sensitive foam systems such as protein foams still is difficult due to lacking reliable test methods. Currently, food technology uses light microscopy images with a subsequent evaluation of 2-D layers for pore analysis. The sensitivity of the foam towards mechanical influences as well as the variability of the material properties aggravate the analysis. A 3-D examination would offer more information and, thus, a more reliable analysis of the pores.

High-definition micro computed tomography  $\mu$ -CT is a very promising method for characterization. This is a contact-free, non-destructive 3-D imaging technology with a resolution in the range of a few micrometers. The precise reconstruction allows for geometrically surveying the complex inner structure so that the pore volume, pore size distribution, porosity, cell wall thickness, etc. of porous objects can be analyzed.

$\mu$ -CT has already been used in the field of food technology for examining the pore structure of dried banana slices, yeast granulate and wheat flour dough and for visualizing the micro-structure of salami and various porous types of food. The examined objects only include stable food since the previous  $\mu$ -CT application has been subject to restrictions in time. High-quality measurements take 10 to 100 minutes. During this period, a large number of projections of the sample are recorded from viewing angles of up to 360°; during this time the sample must not change. A recording time of several minutes is an impediment for 3-D

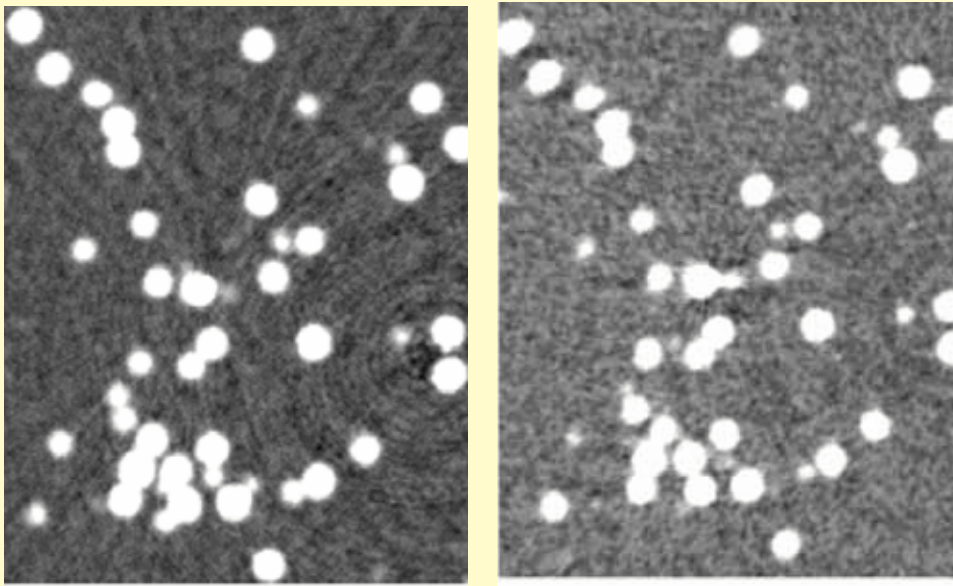
representation particularly with protein foams. The strong influence of ambient conditions such as temperature, micro-climate, positioning, etc. and the quick micro-structural reaction of the foams to these only allow for a 3-D examination with conventional X-ray computer tomographs in special cases in which constant ambient conditions can be maintained. However, the laborious sample handling is not suitable for broad application in the food laboratory.

It is at least equally complicated to achieve a 3-D representation with a reduced measuring time of less than one minute by means of high-energy synchrotron radiation. For example, researchers observed the changes in the cellular structure of bread during production at the European Synchrotron Radiation Facility (ESRF) in Grenoble (France) in 2005.

Broad application in food technology to examine a high number of samples with different free parameters during the production process requires an industry-suitable procedure, such as computed tomography, however with special adjustment to the limited measuring time for applications on non-solidified foams.

Therefore, a  $\mu$ -CT system was established at the Development Center X-Ray Technology by using the latest detector and X-ray technology that meets the special requirements on image quality and measuring time, thus even allowing for analyzing slow dynamic processes with a temporal resolution of up to half a minute.

For this purpose, the performance capability of different imaging components and the influence of the measuring parameters on the image quality were examined. Apart from the properties of the measuring system, the analysis of the 3-D data was verified in order to be able to make statements on the reproducibility of the results and to compare the different recording scenarios with each other. For this purpose,



*Figure: Two cross sectional images of the reference object with different measuring times (14 min/37 s)*

special reference objects with a known pore size were analyzed and examined for their pore size distribution.

The system was already applied to analyze semi-solid foams in the form of different mousse samples.

An adjusted image evaluation algorithmic and a suitable volume data evaluation can be used to describe the structural properties of each pore in the mousse sample quantitatively, from which a pore size distribution can be derived.

Assuming that a further acceleration of the measuring process is possible, it is the aim to develop a »4-D character-

ization« of foams in order to allow, for example, for tracking the structure formation dynamics and the subsequent destabilization phenomena (cell coalescence and occurring flow force).

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# PROCESS-INTEGRATED INSPECTION SYSTEMS

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The Process-Integrated Inspection Systems (PRP) department has specialized on the development of technologies for non-destructive testing during the production process. PRP has the required competencies for all areas of industrial production where 100 per cent quality control through X-ray technology or optical methods is used and cooperates closely with the Development Center X-Ray Technology (EZRT) and the Contactless Test and Measuring Systems (BMP) departments. The focus of activities is on the quality assurance of mass productions in the automotive sector and the aviation and aeronautics industry. Primarily, objects produced by casting methods, such as chassis components and alloy wheels, must be checked 100 percent for inadmissible defects.

For this purpose, the department provides the proven technology of automatic radioscopy. The ISAR (Intelligent System for Automatic Radioscopy) test system, which is currently being delivered in version 7, is constantly setting new standards in this area. Enormous progress could be achieved particularly for testing alloy wheels, which today are predominantly mounted on new vehicles already at the factory, in cooperation with the BMP department. Combining the XEye detector technology of the BMP department with the high-performance evaluation procedure of ISAR allows for testing time savings of up to 50 per cent and, at the same time, an increase in detection performance. Thus, it becomes possible to detect discontinuities that, though they do not lead to a scrap evaluation, allow for an early trend evaluation. The warning generated by the system and the measures subsequently introduced at the casting station prevent scrap before it arises. Thus, an essential contribution to resource-friendly and efficient production is ensured.

This technology, which is currently mainly being used in radioscopic component testing, exclusively uses 2-D projections of the component regions. A section of the PRP department has transferred this procedure to the 3-D world of computed tomography and successfully established it at a foundry. This significantly supplements the benefits for industrial produc-

tion, as they have already been described for the use of ISAR 7. An evaluation of the discontinuities depending on their location, e.g. close to or far from surfaces, allows for a different treatment of tested components. 3-D geometry characteristics of the potential defective spots also allow for conclusions regarding potential causes so that process influences can be derived systematically. The PRP department has the necessary competencies for implementations in industrial environments in the sections involved.

The "mobility" topic is gaining importance for the development of inspection systems. Increasingly large components make the use of stationary systems difficult or even impossible particularly in aircraft construction. Robot-based CT systems, which are e.g. used for maintaining aircrafts, are a focus of PRP. The portfolio is completed by the development of optical test systems. The applications of this method for quality assurance include shining and reflecting surfaces as well as bores that can only be examined by endoscopes.

Scientific services form an integral part of the range of services. Companies are offered the opportunity to evaluate inspection methods and their benefits for their specific problems, to have production start-ups accompanied by test technology or to make use of scientific advice with new test requirements.

Continuous further training ensures the transfer of know-how: training courses are regularly held in Fuerth in close cooperation with the German Association for Non-Destructive Testing (DGZfP). The range was extended by a PRP-designed user course for computed tomography, which meets a very positive response in the industry. The education field was ISO 9001 certified in 2011.



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# PROCESS-INTEGRATED TEST SYSTEMS

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Internal combustion engine pistons made of aluminum are exposed to a temperature of more than 2600° C and a pressure of over 2000 bars during operation of an engine. In order to withstand these forces, internal combustion engine pistons must meet highest demands regarding material quality and dimensional stability. The process-integrated use of non-destructive testing procedures such as ultrasound, eddy current and radiography ensures that each manufactured piston meets these highest quality demands. These procedures used in piston inspection also are the state of the art with other cast parts of a safety-relevant nature.

The disadvantages of these methods, however, are the lack of exact location information of defects and the uncertainties regarding the determination of geometric properties. Therefore, each defect found leads to the piston being rejected for safety reasons since the defect might have a critical size or form at a safety-relevant place in the piston. Thus, even defects that are, for example, located in a piston area that will be removed during post-processing, lead to the piston being eliminated from the production process due to the lack of location information. Even smallest discontinuities with a large distance from the piston surface that influence neither the functionality nor the stability of the piston result in its classification as reject.

By contrast, X-ray computed tomography (CT) offers a complete three-dimensional (3-D) characterization of the object under investigation, thus allowing for the reproduction of exact 3-D information about the size, location and form of structures. With 3-D CT several radiographs, so-called projections, are generated from different perspectives. Unlike with CT devices in the medical field, the object is often fixed on a rotary table and placed between the X-ray tube and the detector in industrial CT systems. The projections are recorded while the object rotates around its own axis. However, since its measuring times usually amount to some minutes, the CT has so far only established itself as a non-destructive testing method for process-accompanying sample testing in the laboratory area.

## **New method finds surface defects**

The Process-Integrated Inspection Systems department at Fraunhofer IIS developed all components of a CT system for process-integrated cast part inspection together with the Development Center X-Ray Technology and the Contactless Test and Measuring Systems department. Besides from an extremely robust detector, which allows for a very low overall measurement time caused by a very short exposure time, innovative and highly efficient algorithms for combining volume calculation and image evaluation were also developed. When using the software solutions that are currently available in the market, particularly defects on the surface of objects cannot be detected in a process-stable way. A new method was developed in the course of the project that can also detect surface defects by comparing the data set of the object under investigation with reference data. The benefit of the new method is that production tolerances on the piston can be taken into consideration when comparing the current data set with reference data. This flexibility is necessary to prevent that pistons utilizing the tolerance to a maximum degree are wrongly classified as scrap. Thanks to these new developments, it is possible for the first time to inspect a casting in a fully automated way by means of 3-D CT within 30 seconds.

The Process-Integrated Inspection Systems department implemented the first prototype system for process-integrated testing of pistons by means of CT together with Mahle GmbH, one of the largest manufacturers of combustion engine pistons worldwide. Apart from the exact characterization of surface defects, this system can also be used to exactly determine the location of the internal cooling gallery.



Figure 1: Combustion engines must meet highest demands in terms of material quality and dimensional stability (source: Mahle)

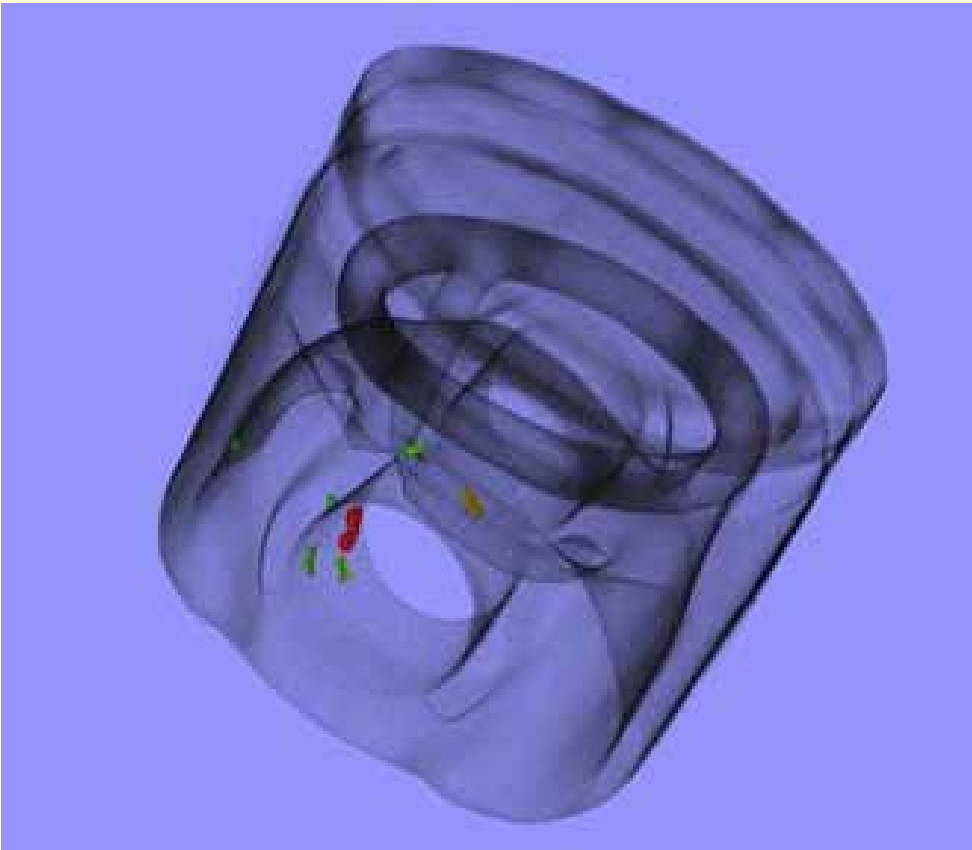


Figure 2: 3-D presentation of the computer tomography data record of a casting with marked surface defects



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# SUPPLY CHAIN TECHNOLOGIES

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### **Managing supply chains – objects with intelligence of their own**

Combining science-based business logistics and engineering innovation has been the aim of the practical research of the Logistics business field at Fraunhofer IIS for 14 years. Today logistics comprise much more than just transport. Logistics today include the management of many-membered international supply chains that provide goods from initial production and production and trade steps to the end customer.

The Supply Chain Technologies (SCT) department develops and researches so-called Intelligent Object Technologies and particularly their use in logistics. These include identification, communication and location technologies such as radio frequency identification (RFID), wireless sensor networks, real-time locating systems (RTLS) and also GPS and WLAN locating. Thus, objects get an intelligence of their own, which allows for storing and communicating information about the object, its environment and history. This information makes all processes of a supply chain more transparent, more recognizable in terms of quantity and controllable in terms of supply chain management.

### **The Center for Intelligent Objects (ZIO)**

The Center for Intelligent Objects (ZIO) directed by Dr. Alexander Pflaum, which forms part of the SCT, ensures close connections with other departments at Fraunhofer IIS that complete the portfolio regarding “intelligent objects and applications”: The Locating and Communications, Power Efficient Systems and Communication Networks departments are primarily responsible for hardware-related developments, while the Fraunhofer Center for Applied Research on Supply Chain Services (SCS) deals with market issues. The ZIO is sponsored by the Bavarian Ministry of Economy, Infrastructure, Transport and Technology with a share of nine million euros for five years.

### **The range of services for different groups of clients:**

- Companies of all sizes and industries are supported by ZIO during the entire development stage of a technology: from the initial idea until roll-out. The researchers neutrally analyze costs and benefits, give advice on possible applications and provide support with the implementation in existing business processes – both in technical and in service-related terms.
- Providers offer the hardware and software for integrated RFID and smart-object-based application systems. ZIO observes the market, makes statements on trends and developments and identifies new target markets. If required, the researchers test and enhance the existing products. ZIO fills technical gaps and integrates sensors or energy management concepts.
- System integrators: ZIO develops integration platforms and solutions for information service providers and telecommunications providers that implement the software-related connection of the technologies to IT systems of users or offer package solutions to enable them to offer innovative technologies. They jointly design prototypes for marketable new package solutions.

## Security and integrity of supply chains – “Aletheia”

The package delivered turns out to be a wrong delivery, the screen of the new LCD TV set remains black, the designer piece purchased at an auction proves to be plagiarism – what is a nuisance for individuals, causes high financial losses for manufacturers and retailers. Today’s supply chains usually are many-membered and international, which implies high complexity and opacity. Integrity violations, such as theft or shrinkage, spoilage and damage or unpunctual deliveries, occur every day.

The solutions for monitoring supply chains that are available in the market, e.g. in form of so-called data loggers, only allow for detecting ex post that an error has occurred somewhere in the process and the goods might be damaged. The Center for Intelligent Objects (ZIO) at Fraunhofer IIS developed within the “Aletheia” research project a system for monitoring the integrity of supply chains that does not only show any deviations at the point in time when they occur but also allows for immediate intervention.

The “Aletheia” system uses wireless sensor networks that belong to the class of so-called smart object technologies. They serve for identification, monitoring by sensors, locating and communication. Thus, objects get their own intelligence, which allows for storing and communicating information about the object, its environment and history. “Aletheia” is based on S3TAG, radio nodes that are based on the s-net technology of Fraunhofer IIS. These wireless sensor nodes are highly energy-efficient and can flexibly be used for monitoring on the container, pallet or even on the single-box level, depending on the application.

The special characteristic of battery-operated sensor nodes is that they interconnect within a package form a network and are able to communicate with each other. For example, if a package is removed from a pallet in an unauthorized way, the sensor nodes recognize this defect and send an alarm message

via the network. Compliance with pre-defined product-specific rules is continuously checked via integrated sensors, e.g. for measuring temperature, humidity or vibrations. Occurring events are stored and can be transmitted as an alarm message immediately via Internet, e.g. to a control center or a smart-phone of the responsible authority.

During development, great importance was attached to an open and integration-capable system. The established standards of the Open Geospatial Consortium (OGC) allow for potentially subscribing to standard-compliant events and data of an “Aletheia” sensor network on any computer and integrating them into any other IT system – another step towards the vision of the “Internet of Things” combined with open web services. The information about the condition of the transported goods is available in real time via the Internet in and without gaps so that the entire supply chain becomes transparent. Thus, the real world and its virtual model in the Internet come closer to each other as intended by the “Internet of Things”.

The “Aletheia” research project was sponsored by the Federal Ministry of Education and Research and implemented together with Deutsche Post DHL, EURO-LOG and Giesecke & Devrient. The Center for Intelligent Objects (ZIO) intensively investigates the vision of fully integer supply chains, the required underlying technologies, applications in logistics and their business models.

*Activation of the so-called black seal, an electronically monitorable “U-lock” for transport containers*







# PROJECT GROUP NANO X-RAY SYSTEMS FOR MATERIAL CHARACTERIZATION

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### **New location of Fraunhofer IIS in Würzburg**

The Project Group Nano X-Ray Systems for Material Characterization, which has existed in Würzburg since 2010, was officially inaugurated with the handover of the sponsoring notification by Katja Hessel, the Bavarian State Secretary of Economy, on 14 June 2011. The federal state of Bavaria will sponsor the research activities at the new location of Fraunhofer Institute for Integrated Circuits IIS with some three million euros in the next five years. Prof. Dr. Randolph Hanke is the head of this Fraunhofer Project Group and the Chair for X-ray Microscopy (LRM) at the Julius Maximilian University and has additionally been responsible for the activities of the Fraunhofer Development Center X-Ray Technology (EZRT) in Fuerth and Saarbrücken as the deputy head of Fraunhofer IIS since December 2010.

### **Research activities**

In close cooperation with the EZRT, the scientists of the project group focus on non-destructive test methods in the micrometer and nanometer range. The main research topics in Würzburg include nano computer tomography, phase contrast radiography, X-ray microscopy and X-ray scattering methods. The focus of the project group is on the development and establishment of new laboratory systems, while the group of university researchers deals with basic research in the field of ultra-high-definition X-ray imaging.

This close cooperation allows for an intensive interconnection of basic research and transfer into the application for non-

destructive imaging nano material characterization. Furthermore, research at the Würzburg location outside the university is strengthened by the new Fraunhofer Project Group, which intends to establish itself also as a cooperation partner primarily for regional industrial companies.

### **Business cooperations**

The cooperation of Fraunhofer IIS with the University of Würzburg began in two specialist fields for both partners already in the first year and has led to mutual added value: the cooperation with the Magnetic Resonance Research, Application & Education Center (MRB) for research and enhancement of magnetic resonance tomography and the pertaining Chair for Magnetic Resonance Tomography enabled both partners to jointly discuss and work on thematically complementary techniques and to give each other a fresh research impetus from the medicine and technology fields of application. Furthermore, cooperation was started with the micro-structure laboratory operated by the Chair for Technical Physics, which particularly deals with nano-structure development for optoelectronic structural elements. The scientists of the Fraunhofer Project Group and the LRM gained new and valuable perspectives for X-ray target production, sample preparation or the manufacturing of micro-structure laboratory reference blocks from the cooperation with this laboratory.

*Katja Hessel, the Bavarian State Secretary of Economy, handed over the sponsoring notification of the federal state of Bavaria, by means of which the activities in Würzburg are financially supported, to Prof. Randolph Hanke*

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# FRAUNHOFER IIS IN NUREMBERG

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### At the Nuremberg location ...

... the scientists of Fraunhofer Institute for Integrated Circuits IIS offer one-stop services with their focus on navigation and location, communication, identification and energy: from market review and project supervision to the design of the latest location and identification technologies and the development of services. Clients and partners benefit from an attractive portfolio. The „Radio Location and Communication“ department of IIS adds to the existing research and development range at the Nuremberg location.

### Towards the future

Under the coordination of Dr. Günter Rohmer, 138 scientists work on location, communication and network access technologies at the Nordostpark business park in Nuremberg. The Center for Intelligent Objects (ZIO) and the Fraunhofer Working Group SCS (Supply Chain Services) complement the range of services at the Nuremberg location by RFID and smart object technologies and developments for supply chains and logistics.

Apart from the ESI Demonstration Center, which deals with the development and use of embedded systems in industrial applications, the work of the Service Factory was also launched in December 2010. It will be responsible for supporting companies with the implementation of innovations in the logistics and service fields.

On June 6, 2011, the activities for a Fraunhofer IIS building in Nuremberg began with the start of construction of the L.I.N.K. (location, identification, navigation and communication) Test and Demonstration Center. With a hall and laboratory area of

1,400 square meters and an open-air ground of 10,000 square meters with many different test tracks, Fraunhofer IIS offers its clients and partners optimum conditions for developing and testing new technologies and services for location, navigation, RFID and smart objects, logistics, communication and energy. New developments can ideally be prepared, evaluated and adjusted for their use within a company under realistic, near-application test conditions and in an optimum technological environment. From the planned opening date in autumn 2012 on, the L.I.N.K. will also be available for companies for their test series.

Together with the European Space Agency (ESA), the Bavarian Ministry of Economy, Sparkasse Nuremberg bank and under the head of the Oberpfaenhofen Demonstration Center, Fraunhofer IIS in Nuremberg will open a Business Incubation Center still in 2011. The ESA BIC will offer founders and spin-offs an appropriate platform for enterprise foundations on topics such as satellite navigation, location and communication systems.

The close interconnection with the Chairs of Information Technology 7 and 8 and the Chair LIKE of the University of Erlangen-Nuremberg and research projects together with the Chair of Information Technology VII of the University of Würzburg and the Universities of Applied Sciences of Nuremberg and Coburg provide access to the latest research results.

The Power Efficient Systems (LOS), Communication Networks (KOM) and Radio Location and Communication (OK) departments research and develop at the Nuremberg location. These are complemented by the Network Access Technology Competence Center (CC-Nat), the ESI Demonstration Center and the Working Group for Supply Chain Services (SCS) as well as the Fraunhofer Service Factory.

*Start of construction of the L.I.N.K. Test and Demonstration Center: Prof. Heinz Gerhäuser, Dr. Georg Ried, Prof. Albert Heuberger, Dr. Roland Fleck and Dr. Günter Rohmer (from left)*

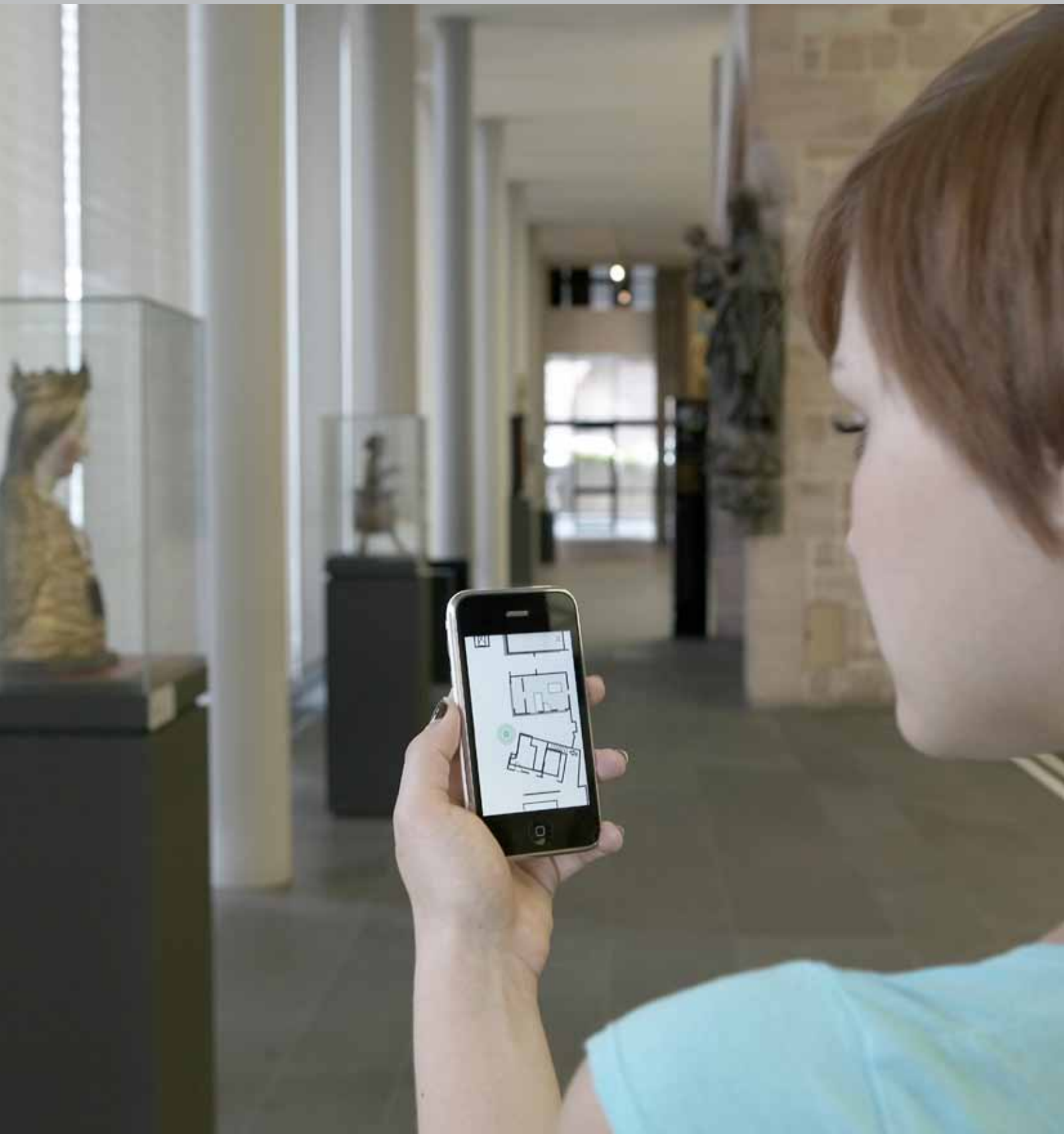
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# COMMUNICATION NETWORKS

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## Overview

As part of the “localization and communication” area of activity, the work in the Communication Networks department focuses on communication and localizing in wireless networks. The three technologies “s-net” for high energy-efficient wireless sensor networks, “awiloc” for self-sustaining localizing in WLAN networks and the ETSI standard “DECT” for professional wireless voice and data networks form the basis of research and development. The Fraunhofer brands s-net and awiloc could be secured internationally and are constantly gaining profile in the market. 24 employees develop communication protocols, network transfers, services, localization techniques, software libraries and hardware modules, amongst others, and employ them in projects.

### Wireless sensor networks with s-net

The s-net technology of the department has offered optimized communication protocols for the realization of high energy-efficient, wireless sensor networks since 2007. Its flexibly adjustable protocol properties provide ideal conditions for individual solutions.

Main fields of application:

- Long-lasting systems for large-scale, distributed data acquisition or data collection: apart from a special development in the metering field, several workshops were carried out together with industry partners. The MoDe research project for the sensor-based optimization of maintenance phases, repairs and truck failures entered the second stage. The internal pilot research project WUR on the topic of power-saving wake-up receivers for sensor networks was completed successfully.
- Smart objects for locating persons and objects and for independent processing of activities: The projects OPAL-Health (a system for wireless localization and environment moni-

toring of medical devices and stored blood) and Aletheia (smart objects that allow for a gapless control of systems and of transport and supply chains as intended by the “Internet of Things”) were completed successfully. The aim of the current Olog-Pat project is to develop a patient localization system as a basis for process optimization.

### WLAN localization with awiloc

In the WLAN localization field, the positive testing of the awiloc technology by the Bavarian State Authority for Data Privacy Supervision confirmed that location-dependent applications can securely be implemented by means of the system. Projects with partners from the awiloc consortium show what that looks like. In November 2010, for example, a location-sensitive, audio-visual museum guide in cellphone format of the art2guide partner started at the Museum of Industry Culture, thus receiving its premiere in Europe. The IT2media partner has offered reference data for the cities of Munich, Berlin, Hamburg, Nuremberg and Erlangen since 2010. The results were jointly presented at the CeBIT and GSMA trade fairs in 2011.

TeleConsult Austria and INDIWAN joined the awiloc consortium as new partners. In the REPKA research project, real-time location information could be provided for improved evacuation planning (see article). At the open house with the Mouse (see p. 138), the department presented a search game, where destinations in buildings can be found on the basis of awiloc. It is easily possible to integrate this functionality in other games or geocaching applications.

### DECT wireless voice/data networks

A wireless audio coupling and synchronization of base stations was developed for professional voice conference systems on the basis of the DECT standard in order to combine several stations to a multiple-cell system with extended area coverage. Thus, mobile conference participants can switch between stations without interruption.



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## Optimized evacuation

In the event of hazards, the quick and reliable evacuation of endangered persons – i.e. the evacuation of affected buildings and regions – has top priority. The sponsored project REPKA focuses on the situation where a large crowd has already left a building and must seek shelter.

## Planning, controlling and adjusting evacuations

The aim of the REPKA (regional evacuation – planning, control and adjustment) project is to be able to better plan and control regional evacuations and adjust them to changed circumstances. For this purpose, new models for mathematical simulation and optimization are developed by partners. To ensure that these are as close to reality as possible and to evaluate the simulation results, the recognition of real-time location information of persons is an essential component. Within the project, it is the responsibility of Fraunhofer IIS to acquire this information.

For a realistic simulation and optimization of the flows of people, recognition must be possible without gaps during the entire evacuation. Using the example of the Fritz Walter stadium in Kaiserslautern, the simulations and scenarios are verified and enhanced in REPKA on the basis of real movement data of persons.

## Locating as a key component

The focus of the research works of the Communication Networks department is on the provision of a robust locating technology for common mobile terminals, such as smartphones with the Android operating system. The position is determined on the terminal by a combination of WLAN location (awiloc), satellite-based location (GPS) and location in mobile radio networks (GSM fingerprinting). Thus, the system is protected against interferences or failures of a single location technology. Several measuring

campaigns, exercises and tests have been carried out at the stadium to acquire the position data.

## Highly exact location data for simulations

The aim of one particular measuring campaign (“Malz-treppe stairs exercise”) was to obtain highly exact position and movement data for simulations. For this purpose, the existing WLAN infrastructure was expanded in the focused stairs area and the obtained position data were re-calculated for the simulation offline on the basis of all sensor data contained in a data record (such as GPS, WLAN, GSM or inertial sensor data). The measurements showed that very exact positions that exceed common satellite-based methods can be calculated by awiloc. The average accuracy achieved was 2 meters.

In an exercise during the soccer match between 1. FC Kaiserslautern and 1. FC Nuremberg in April 2011, the movement data of 70 volunteers were transferred to the REPKA server after they had left the stadium until they arrived at their destinations (e.g. bus terminal, car park, coach). Subsequently, the data were evaluated in detail, processed and also made available for simulation.

## Continuous positioning for guidance systems

To implement a mobile guidance system with sufficient accuracy – as it is also developed in the REPKA project –, the WLAN infrastructure already available in Kaiserslautern is sufficient. Additional access points were only installed at the stadium to improve the WLAN coverage. awiloc ideally complements the GPS location in areas where GPS fails to provide sufficient position data (e.g. in the direct surroundings of the stadium or in tunnels). The balancing of device-specific differences, e.g. offsets of the measured signal values or measuring frequency, required for a mobile guidance system was determined in comprehensive test series in the anechoic chamber at Fraunhofer IIS and was

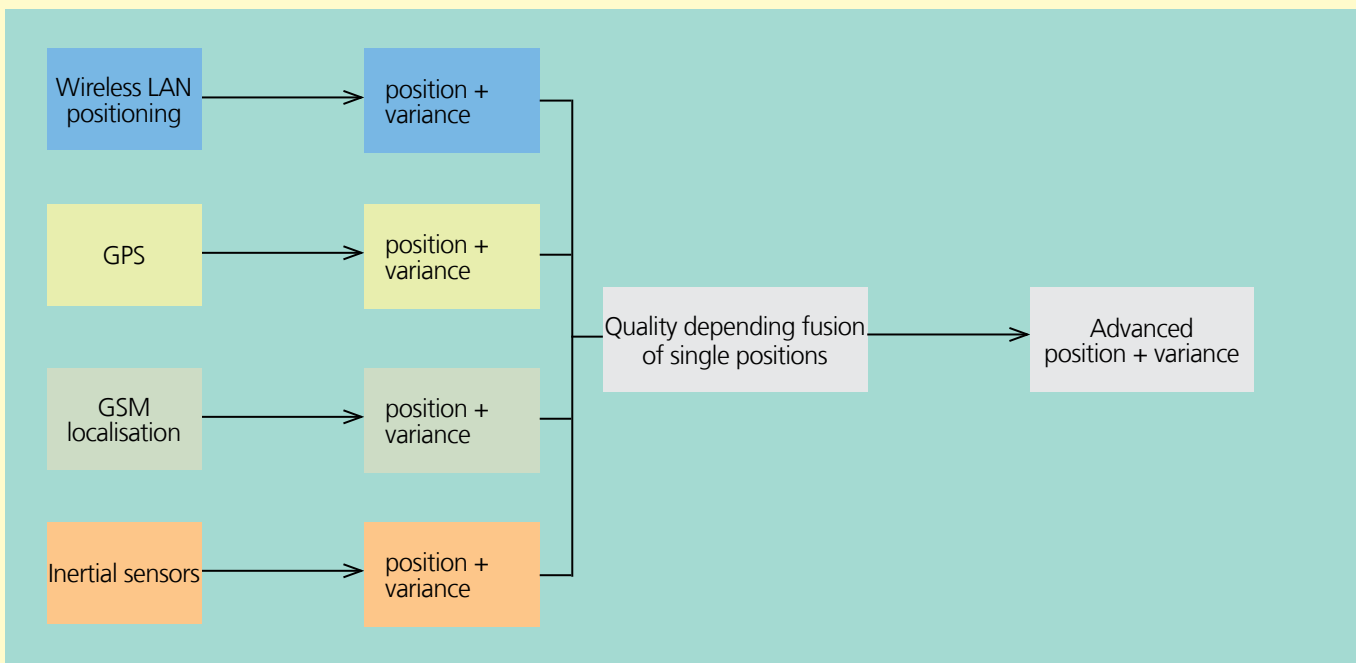


Figure: Fusion of the different position sources for robust and precise locating

incorporated into the positioning algorithm as an adaptive method for automatic device calibration.

### Conclusions

Very precise location data can be obtained for simulations in partial areas. It is possible already today to determine positions for a mobile visitor guidance system on the basis of the existing WLAN infrastructure and awiloc, the self-sustaining WLAN positioning of Fraunhofer IIS, alone.

### Sponsoring

REPKA is sponsored by the Federal Ministry of Education and Research (BMBF) as part of the "Research for Civil Security" program. Apart from IIS, the project partners include the University of Kaiserslautern, the Emergency Management Working Group, IT2 Media and Siemens.

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# POWER EFFICIENT SYSTEMS

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## Overview

The scientists of the Power Efficient Systems department conduct applied research and development with the following core competencies:

- localization and navigation
- sensor data fusion
- battery and power management
- energy harvesting
- adaptive system software

## Navigation

The employees of the Navigation group develop localization systems both for the satellite navigation standards GPS, GLONASS and Galileo as well as for geostationary satellite-based augmentation systems (SBAS), such as EGNOS. They develop, amongst others, integrated hardware components and software solutions, package system solutions and prototypes for applications in the fields of mobile terminals, driver assistance systems, machine controls and precise measuring technology. These system solutions are either discretely integrated on printed circuit boards or in the form of integrated circuits. In addition, software solutions for baseband processing and positioning complement the receiver know-how.

## Multi-sensor systems

The Multi-Sensor Systems group deals with the fusion of various localization technologies for location and navigation. Its focus includes algorithms for sensor data fusion from GPS, WLAN, movement sensors (inertial sensors) or the IIS-proprietary real-time localization system RedFIR. The application requirements can be met within the range from several meters up to a few centimeters. Apart from the required accuracy, the development works aim at improved reliability.

## Integrated energy supplies

Battery and power management, battery monitoring, energy harvesting as well as wireless energy transfer are at the heart of the Integrated Energy Supplies group. One main area of research is the transformation of mechanical and thermal energy into electrical energy. Areas of application are the supply of electronic circuits such as sensors or transceivers. Furthermore, the group works on innovative, future-oriented battery management systems for use in electric and hybrid vehicles as well as small and special vehicles. The focus of work is on circuit design and its miniaturization and ASIC design.

## Adaptive system software

The work here focuses on designing a portable real-time-capable software kit for embedded systems. This allows software modules to be customized to application requirements at a low cost. The services range from drive development, software adaptation to an existing real-time operating system to software infrastructure for component-based systems. An example of an application for the kit system is a flexibly configurable receiver for satellite navigation. Furthermore, the group develops algorithms for signal tracking and positioning in GNSS receivers.

# POWER EFFICIENT SYSTEMS

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## Seamless localization by means of GNSS, WiFi and INS data

### Motivation

WiFi is primarily used for localization within buildings, e.g. for museum or fair guides. Using GNSS (Global Navigation Satellite System), outdoor positions can be determined. But what happens in transition areas where GNSS signals are interfered e.g. by buildings or other objects and WiFi is not continuously available? Previously, location has been shortly interrupted (e.g. also due to manual switching between different localization technologies) so that an accurate position was not constantly available. In order to fill these gaps, Fraunhofer IIS has developed a complete hardware/software platform for testing algorithms for seamless localization in the course of the “Galileo/GPS localization platform for mobile applications” (short: LOK platform) project. This project was funded by the Federal Ministry of Economics and Technology (BMWi).

### Fusion of different localization technologies

The developed hardware/software platform allows for seamless and continuous localization by combining three localization technologies:

- GNSS sensor data (GPS, Galileo, etc.)
- WiFi sensor data
- auxiliary sensor system, consisting of inertial sensors and magnetic field sensors
- other interfaces: RFID reader, radar speed sensor, etc.

The result is a user-oriented package solution that bundles the competencies of Fraunhofer IIS in the fields of satellite navigation, multi-sensor systems and sensor data fusion. The receiver platform for satellite signals from the antenna to the position output ensures high availabilities of an accurate position in the range of a few meters. This is particularly important in the typical environments of mobile applications (rural and inner-

city areas as well as inside buildings). Furthermore, it is possible to access all signals on the various system levels, which facilitates the development and investigation of new algorithms. This has not been possible with commercial components so far.

### Key components

The LOK platform is designed as a development system (laboratory prototype) and mainly consists of GNSS receivers, a WiFi localization system (awiloc), different types of inertial sensors and communication modules such as GSM modem and Bluetooth. The system structure has four key components:

- a complete GPS/EGNOS/Galileo receiver on the basis of an FPGA (field programmable gate array) developed at Fraunhofer IIS – will soon be available as ASIC (application-specific integrated circuit)
- a communication board for correction data
- a sensor board covering the WiFi and INS fields
- other sensors and interfaces via which e.g. a tablet PC can be connected for visualization complement the development platform

The awiloc system of Fraunhofer IIS was used to integrate WiFi signals. This is a location system on the basis of a fingerprinting method with WiFi signal strengths (RSSI, received signal strength indicator) that was fully developed at Fraunhofer IIS.

### Areas of application

Thanks to the combination of GNSS, WiFi and INS data, various areas of application are imaginable:

- location-dependent information systems and location-based services
- people guidance systems (e.g. city tourism, electronic white





Figure 1: Development platform for seamless location by GNSS, WiFi and inertial sensors

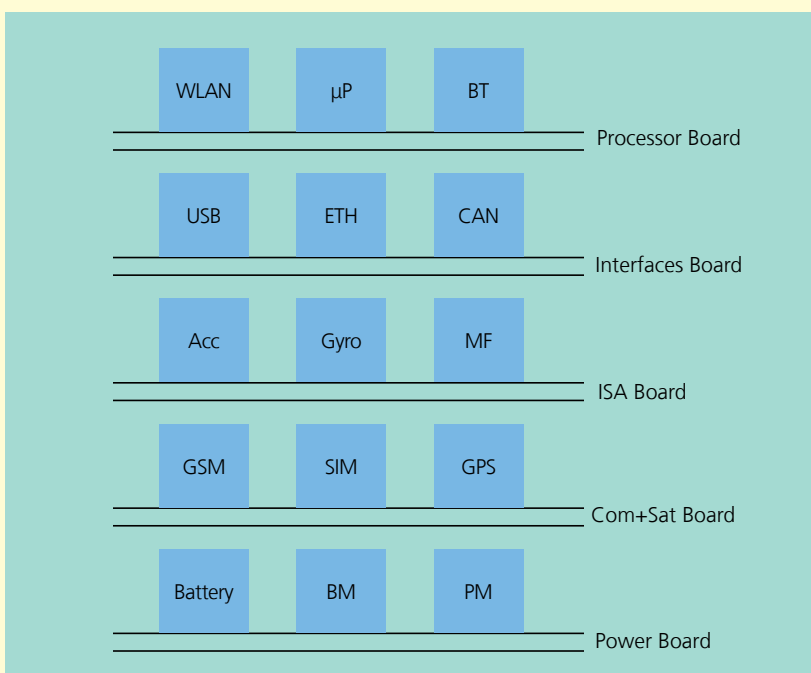


Figure 2: Concept for the modular miniLOK

- sticks)
- systems for transport logistics (e.g. airport, factory trucks)
  - robotics
  - personal safety and location (e.g. for dementia patients)
  - orientation guides for rescuers
  - vehicles supporting elderly persons or persons with limited motor skills

## Outlook

Functionality initially had priority with the existing laboratory prototype. Therefore, an FPGA-based board was used, which offers more design flexibility. Currently, a miniaturized version of the LOK platform (“miniLOK”) with a target size of approximately 5 cm<sup>3</sup> is being implemented in a follow-up project.

Either an IIS-proprietary GPS/Galileo module or a commercial product will be integrated as a GNSS receiver. To ensure that the feasibility of new applications and functions can quickly be tested for clients under real conditions, the “miniLOK” is intended to be designed as a modular rapid prototyping HW/SW set of modules. The following boards of the components (figure 2) have already been implemented: processor, ISA and power board.

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# FRAUNHOFER CENTER FOR APPLIED RESEARCH ON SUPPLY CHAIN SERVICES SCS

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## Services for people

### Supply chains become faster

Millions of goods move around the world every day – in a countless number of networks. Raw materials, food, spare parts, money, people or even knowledge: everything must be transported to its destination in time and, above all, economically. The 36 employees of the Fraunhofer Center for Applied Research on Supply Chain Services SCS have investigated these networks, their markets, processes and services in order to make supply chains not only faster, better, more transparent and profitable but also, above all, more sustainable.

### Trend towards dedicated services

Research on the service aspect in relation to the supply of people will increasingly be in the focus in the future. Generating 70 per cent of the gross value added, the service market is not only the most important economic sector of Germany today. As a high-tech location, Germany also depends on the continuous enhancement of its services in order to remain a pioneer among the growing global competition and to survive in economic terms. Regardless of whether we are talking about new recycling processes, sustainable energy and logistics management, informative food labeling or individual patient information systems: there is a trend towards more, more complex and dedicated services.

### Comprehensive range of services

But: every service is only as good as its implementation and acceptance. Therefore, the Center for Applied Research offers its clients a comprehensive range of services from the development of new, tailored services to the analysis of existing and potential markets or trends and the evaluation

and optimization of logistics networks and processes. Together with Fraunhofer IIS, Fraunhofer SCS combines these services with technologies for people.

The government of the federal state of Bavaria is also aware of this trend-setting development and has invested 11 million euros into the Service Factory Nuremberg, which supports companies in strengthening their service portfolios and initiating innovative services, since December 2010. The Service Factory relies on the service competence acquired by Fraunhofer SCS over many years.

### New head since April

The Center for Applied Research has had a new head since April 2011: Prof. Heinz Gerhäuser took over as director from Prof. Evi Hartmann, who left the Center in early 2011.

### Harold E. Fearon Best Paper Award 2010

Dr. Carsten Reuter and Dr. Kai Förstl received the Harold E. Fearon Best Paper Award 2011 at the annual meeting of the Academy of Management in San Antonio, Texas, on August 13, 2011. The two scientists of Fraunhofer SCS received the award for their publication "Sustainable Global Supplier Management: The Role of Dynamic Capabilities in Achieving Competitive Advantage" in the Journal of Supply Chain Management. The authors answer the question how companies can establish sustainable supplier selection, evaluation and development processes in their value added chain.

The Academy of Management is the largest and most influential association of scientists and practitioners of all management disciplines for the transfer of research findings into practice.

## **Sustainability index for logistics providers – an orientation guide in a non-transparent market**

Transparency is the prerequisite for making a right decision: being able to access all relevant data and information and relate them to each other plausibly is a clear competitive edge. The “Market” business field brings transparency into markets and locations: the researchers investigate the environment and the main parameters influencing their development so that neutral statements regarding condition and trend can be made.

For example, though the topic of sustainability is widely discussed in the logistics industry today, it has hardly been possible to date to compare the actions taken with each other for the lack of homogeneous rules and standards. Fraunhofer SCS is the first institution that has successfully established a method in the logistic services industry that classifies and assesses sustainable action taken by companies.

When selecting their logistics providers, many consignors increasingly take into account the providers’ approach to the sustainability topic already today. But: it is not possible to exactly define the actual sustainability aspect of an action and its implementation. And the question via which channels and media companies report on this has not been answered consistently either. The sustainability index enables consignors to select logistics providers on the basis of sustainable decision criteria. The providers themselves can use the report as an orientation guide for their own positioning. It is the aim of the study to reward companies that are already dealing with the sustainability topic actively.

The study was carried out on the basis of the 150 logistics providers with the highest sales figures of the “Top 100 of Logistics” study. In phase 1, the PR activities of the service providers were looked at in order to make a statement on the transparency of the sustainability communication. In phase 2, information about their sustainable activities were obtained

from all 150 companies in order to examine the measures themselves.

The findings obtained in phase 1 (transparency index) show that only about one third of the companies report about sustainability. Among these, it is particularly the MEP (messenger, express and parcel) providers such as DHL or UPS that report with a transparency that is above average. This can be attributed to the fact that these companies are facing greater public awareness due to their proximity to the end customer and are exposed to strong competition. However, small companies are also able to report about sustainability in a transparent way – this shows that the provision of sustainability information does not depend on the size of a company.

The subsequent phase 2 (sustainability index) focused on the measures themselves. To allow for comparisons between the submitted information despite their heterogeneousness, various criteria were developed by means of which the sustainable activities can be classified. These are structured into the dimensions of “concept” and “measures”. Four different types of logistics providers resulted from this:

“pioneers” are companies with which both dimensions of “concept” and “measures” are very strongly developed. They have dealt with the sustainability topic intensively for a long time. Their measures often go beyond the standard and are highly innovative. This group mainly includes top-selling companies such as DB Schenker or Hellmann. The “doers” focus on the measures. These are mostly very innovative and tailored to the customers’ requirements. By contrast, the “strategists” have a detailed concept, while their measures are rather in the standard range. These two groups also include providers with higher sales figures, e.g. Dachser or Lufthansa Cargo.

Many medium-sized enterprises are from the fourth group – the “observers”. These have not yet progressed in elaborating the concept and measures as much as the other groups but are sustainably active nevertheless. They still differ much from

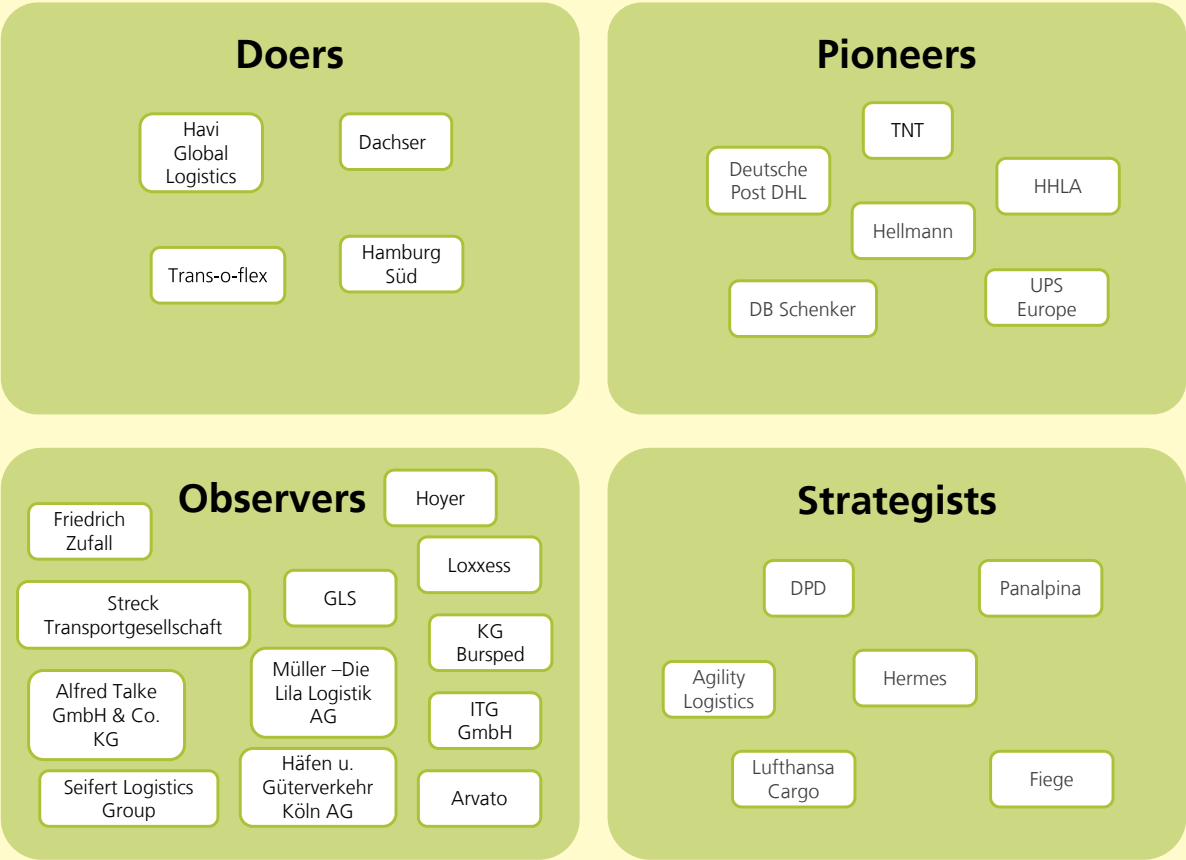


Figure: Classification of companies into types of logistics providers according to the sustainability index

those logistics companies that can hardly demonstrate any activities in the area of sustainability.

The study shows that there are some positive examples of companies that actively deal with the sustainability topic. However, despite the continuing public interest, the topic has not yet been internalized by most logistics providers: far less than half of all companies were able to provide information about sustainable activities.

The report “Sustainability index for logistics providers – an orientation guide in a non-transparent market” will continuously be enhanced in the future.



## SILK – System-based intelligent logistics cooperation

Road-based freight transport is one of the largest sub-markets of the German goods transport industry. In addition to a large number of small businesses, network companies and franchise-style cooperations are also active in this market segment. Ensuring a high utilization of the capacities of trucks, which are an expensive means of production, is a great challenge for such companies – particularly due to the lack of suitable tools for supporting planning activities. A bad utilization of vehicle capacities and an unsatisfactory return freight rate are typical phenomena almost regardless of the size of the business and form the cost drivers in freight transport together with latest developments such as road charges, the lack of drivers and the „digital speedometer“ (the mandatory introduction of electronic driving time monitoring).

However, the main reason for lacking efficiency is the decentralized organization: the local logistics coordinator has good local customer and market knowledge but insufficient network-wide information to build up well utilized turnovers. This information and cooperation barrier is often aggravated by lacking IT support in tour planning and lacking interconnection of the organizational units (OUs).

### Contents of the SILK research project

It was the aim of the SILK research project completed in autumn 2010 to improve this situation by developing innovative cooperation models and scheduling processes, maintaining the benefits of a decentralized organization. The strengths of three principles were intended to be combined in SILK:

1. Local control: each logistics coordinator decides about their scheduling area on their own.
2. Trade and interaction: freights can be exchanged between the OUs.

3. Optimization: orders to be combined are scheduled in an optimum way with the support of computers.

A multi-criteria tour scheduling process for pick-up and delivery problems was developed in SILK for scheduling the orders within an OU. It also allows for realistic, “rolling” scheduling with newly added orders over several days of the week, taking into account the new EU social legislation for driving and working hours regarding the “digital speedometer”.

In the course of the project work, many other sub-problems of practicable logistics were dealt with, e.g. the selection of suitable cooperation and auction models, the return freight problem and its relation to the evaluation and pricing of transport orders (calculation of relation-based return freight ratios), the identification of convenient or unsuitable orders, the selection of a fair distribution key for cooperation profits, etc.

### The SILK scheduling system

Finally, a client-server test system was developed that illustrates the functionality of the SILK approach (figure 1) and by means of which several scheduling calculations could be made. The test client contains a user interface with the optimization module for tour scheduling and a geographical visualization of the scheduling (figure 2); the test server manages the access of all clients to the central order pool.

### Results

The results of the research project confirm that a decentralized organization and an efficient operation are compatible in the freight transport business if the order performance is coordinated in an intelligent, i.e. cooperative, way.

Now the know-how obtained in the project can also be used by other logistics providers to demonstrably achieve an incre-



AuftragID	StartKnotenID	ZielKnotenID
AI_00005	KIS00005	KIZ00005
AI_00007	KIS00007	KIZ00007
AI_02430	KIS02430	KIZ02430
UPLOAD1	KIS00001	KIZ00010

Figure 2: Visualization of transport orders in the SILK test client

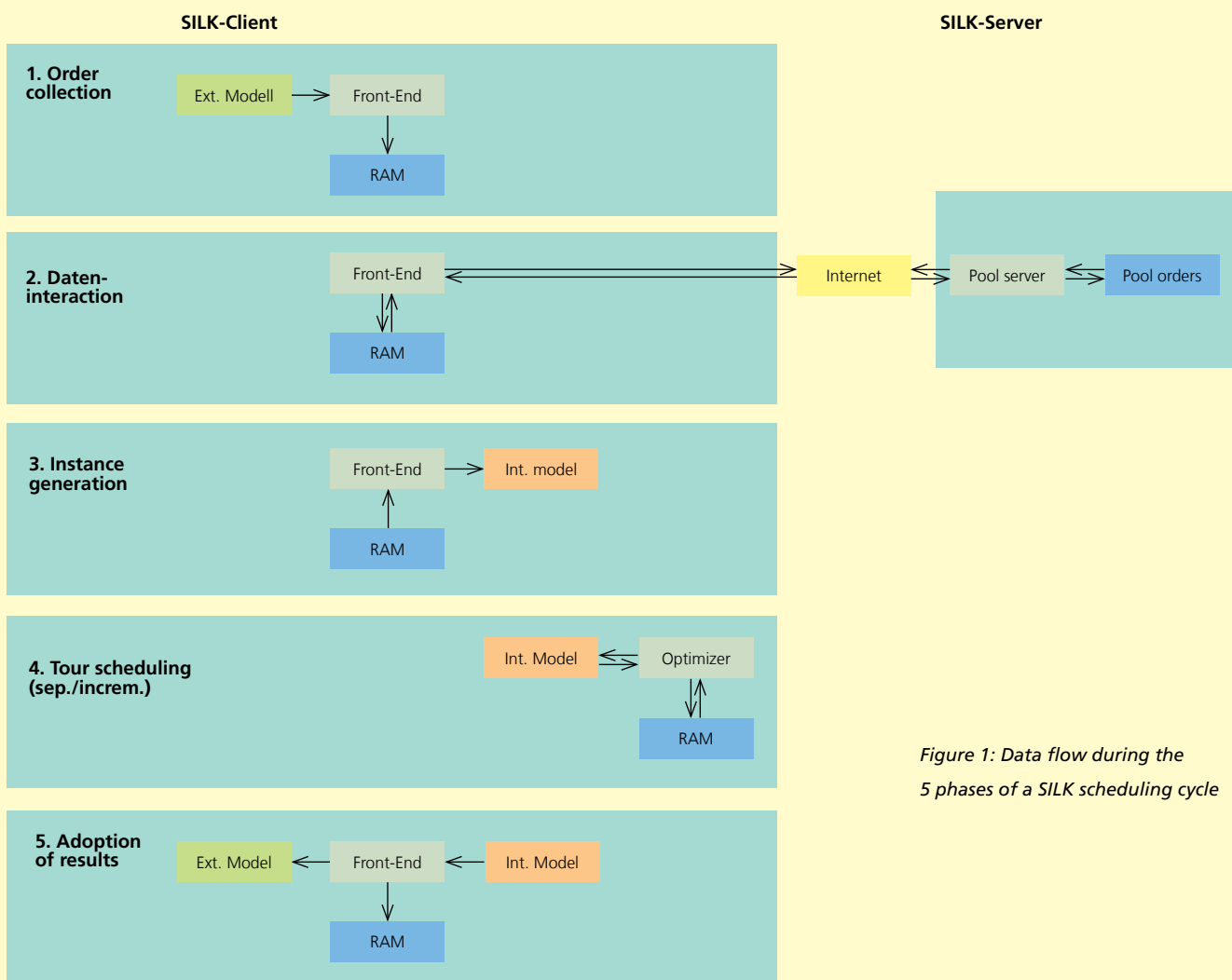


Figure 1: Data flow during the 5 phases of a SILK scheduling cycle

ase in efficiency and cost savings by internal cooperation. Depending on the structure of the company and the scheduling problem, different aspects of the SILK model should be used and adjusted. Any efficiency potentials and the adaptability of SILK to the situation of each company can be examined in advance by means of the SILK system without any risks. The SILK project was sponsored by the Federal Ministry of

Economics and Technology as part of the »Intelligent logistics« main area of sponsoring. It was designed in cooperation with partners from practice, IDS Logistik GmbH and Schenker Deutschland AG.

## Benchmarking study on sales with industrial distributors

Two benchmarking studies on the success factor in sales with industrial distributors had been conducted successfully by Verband Technischer Handel e.V. (VTH, Association of Industrial Distributors) in cooperation with the Fraunhofer Center for Applied Research on Supply Chain Services (SCS) already in 2005 and 2008. More than a total of 40 companies participated in these studies.

## Successful sales management

Apart from getting to know and understand the sales organizations of industrial distributors, the focus of the studies was on performance measuring and the determination of universal cause-and-effect relations for successful sales management. For this purpose, a special sales portfolio was developed for the member companies of VTH that optimally supports a quick classification based on the performance of the sales organizations and the subsequent derivation of standard strategies for increased performance (figure 1).

## Data collection

The contents of the first two studies required a very comprehensive questionnaire to ensure that as many areas of sales as possible were included in the intended best practice collection.

By means of a condensed questionnaire with significantly reduced collection requirements, another 20 member companies of VTH could be won for participation in a new, third sales study by the end of 2010. The following aims took center stage:

- determination of the key quantitative benchmarks in sales, which can now also be identified separately for the individual groups of goods of industrial distributors. These include, for example, the profit contribution per field manager, the

number of serviced clients by ABC criteria or the number of client visits – always in relation to the average values achieved by the best sales organization.

- positioning of the individual sales organizations by means of the determined performance benchmarks in an aggregated overall summary and positioning within the individual main groups of goods.
- supplementation of the quantitative survey by qualitative expert interviews at selected “best in class” companies to achieve an ever deeper understanding of the relevant sales processes and of the “soft” success factors, which cannot be identified by standardized survey methods.

## Best practices in sales

The key findings of all three studies are summarized in a qualification manual (figure 2). This manual is a comprehensive compendium for operational and strategic sales management with industrial distributors. It shows how the best sales organizations of all of the 60 study participants perform and which methods and practices enable them to achieve top performance. Thus, the manual becomes an important reference book and contributes to securing the competitiveness of the sector, which mainly consists of medium-sized businesses.

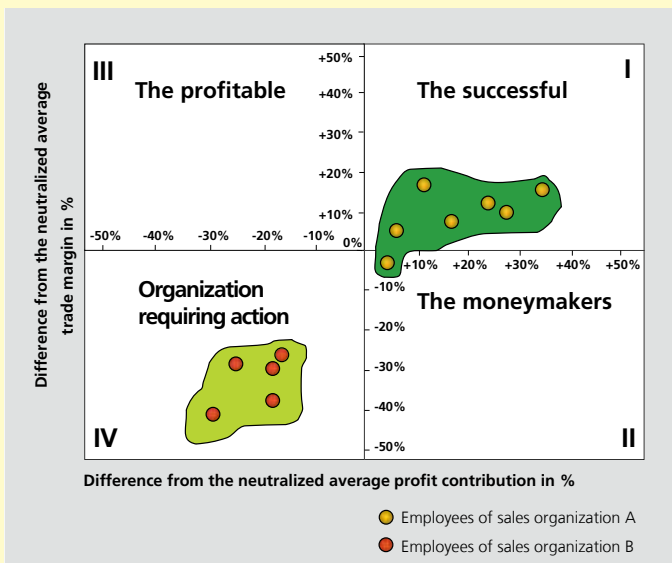


Figure 1: The Nuremberg sales portfolio



Figure 2: Cover of the VTH manual "Best Practices in Sales"

## Patients modify established business models

The pharmaceutical industry and the participants in value added chains are facing drastic changes. New challenges such as declining new approvals and patent expiries of drugs, increasing development costs and times as well as regulations and cost-cutting in the health care system require a reassessment of the traditional business model away from product suppliers towards health service providers. However, the environment for these new product and service concepts is characterized by strict legal and regulatory conditions and high requirements on safety and quality. Three superior aims can be observed in practice in relation to the re-orientation towards health service providers: improving the cost structure, reducing complexity and achieving client loyalty.

Exploring innovative services that can contribute, amongst others, to the third aim forms part of the activities in the “Services” field: the social trend towards more self-determination, individual life planning and an ever stronger health awareness is reflected by changes in patient behavior towards more active participation in therapy and prevention. Patients increasingly inform themselves about their illness and potential therapies, e.g. via the Internet, seek co-determination and, thus, cause a change in the traditional relationship between patient and doctor. The doctor no longer is the “sole decision maker”, e.g. when selecting a drug. Therefore, direct communication with patients is becoming more relevant for pharmaceutical companies.

The trend towards active and responsible patients is also reflected in the area of over-the-counter drugs. An increasing part of the population is willing to assume more self-responsibility and pay for health care services and products on their own. GfK Group found out that in Germany, every adult spends an average of 900 euros annually on health care services in addition to their health insurance contributions.

However, knowing the customers’ wishes is an essential requirement for systematically developing services on the basis of economic aspects. And there is a lot to be caught up in this regard. Vice versa, the patients’ need for information is crucial since, in view of the consumers’ growing cost and quality-consciousness, a systematic supply of information can support differentiation in the market and customer retention. A Swiss biotechnology company has already recognized this potential and supports patients suffering of multiple sclerosis by several free services, such as moderated self-help newsgroups for exchanging experiences in relation to the disease and its consequences for the social environment.

In the future, “Services” will investigate the changed customer needs from a direct and indirect perspective. In the indirect approach, publicly accessible information on customers’ wishes is collected, e.g. by checking blogs and patient newsgroups, and processed and made usable for the relevant company. Additionally, patients are directly involved in the research activities, e.g. by way of panel surveys. Thus, specific needs can be discovered and potential service concepts can be evaluated in advance. Using the results, the business field can systematically develop other knowledge-intensive health care services and, in a second step, directly inform customers about potential new services.



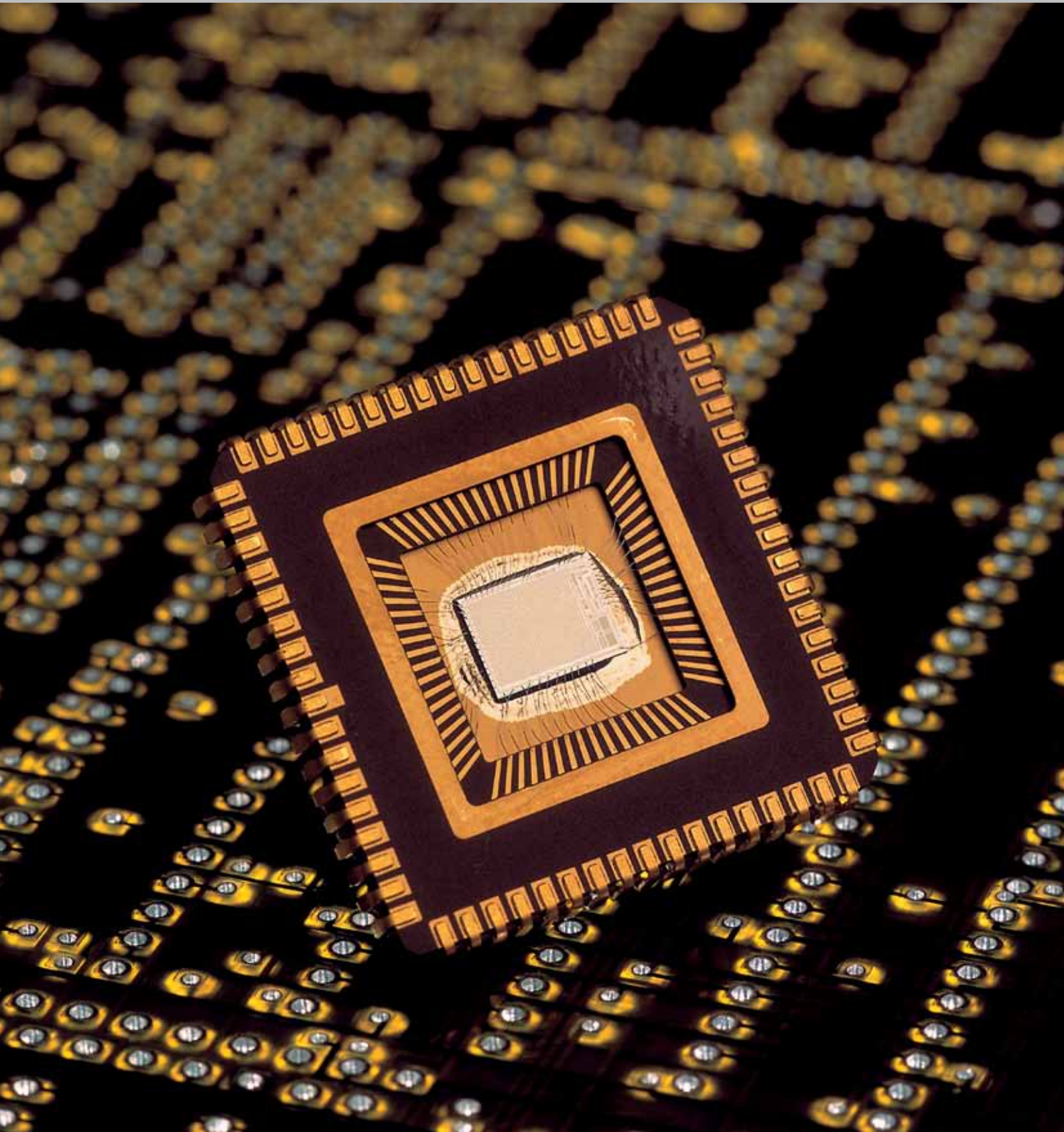


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# DESIGN AUTOMATION DIVISION EAS IN PROFILE

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The Dresden division EAS investigates methods for the computer-aided design of electronic and heterogeneous systems and uses such in the development of hardware/software systems. The developed models, methods and tools serve for the quick implementation of product specifications in circuits, assemblies or devices and complement commercial tools and application-specific design flows. The scientific staff of the division EAS work in the two specialized departments Micro-electronic Systems and Heterogeneous Systems.

The focus continues to be on research and development for the production-oriented design of microelectronic components and systems. The effects of the production technology (materials, structures) and the operating conditions (temperature, vibrations) on the electrical behavior of the components and circuits are measured, amongst others, in the context of the latest integration technologies (system in package and 3-D integration), modeled and finally taken into account in the design. Design methods for minimizing these influences on the entire system behavior then allow for developing circuits and systems with a high functional reliability and estimable life time. Apart from parasitic effects, which e.g. arise from parameter fluctuations during production, electrothermic and electro-magnetic connections as well as aging mechanism for various CMOS technologies are also considered by means of innovative methods. Taking into account realistic operating conditions allows for assessing the system behavior in the development process comprehensively.

Another focus is on mastering the design of systems with a high complexity and heterogeneousness under application-specific constraints. Such include, but are not limited to, high performance, low energy consumption and high functional reliability (robustness). The methods developed for this purpose include model formation and simulation, verification, analysis as well as test and diagnosis. What should be emphasized in this context is the participation in the standardization activities for SystemC AMS, a language for modeling and efficiently simulating software-intensive mixed-signal systems. System components

and parts of circuits can be modeled and interconnected on different abstraction levels. Furthermore, non-electrical correlations, e.g. in sensors and actors, can also be described by SystemC AMS. A development environment implemented by EAS allows, amongst others, for detailed examination of the electric behavior of circuit parts that are modeled very exactly in an overall system that is modeled significantly more abstractly. This connection between different levels of abstraction and the bridge between hardware and software ideally meets requirements and needs of the industrial practice.

System developments for proving the performance capability of design processes and for proving the functionality of new products are increasingly gaining importance. For example, works of EAS support the design of electronic components for integration into textile surface structures. The special properties of conductor structures integrated into the textile are measured and their influence on the energy and information transmission between the electronic components is taken into account. Investigations of new principles of optical image recording by load-based CMOS image sensors led to new findings regarding the achievable resolution and processing speed. Experiments carried out so far suggest that an adequate implementation, on the basis of which optical measuring systems with a high performance capability can be realized, is possible. Further developments relate to magnetic measuring systems with high precision and complexity, robust sensor networks and a new ranging receiver for measuring signal times of arrival based on which the position of TV satellites in the orbit can be determined.

# DESIGN AUTOMATION DIVISION EAS IN FIGURES

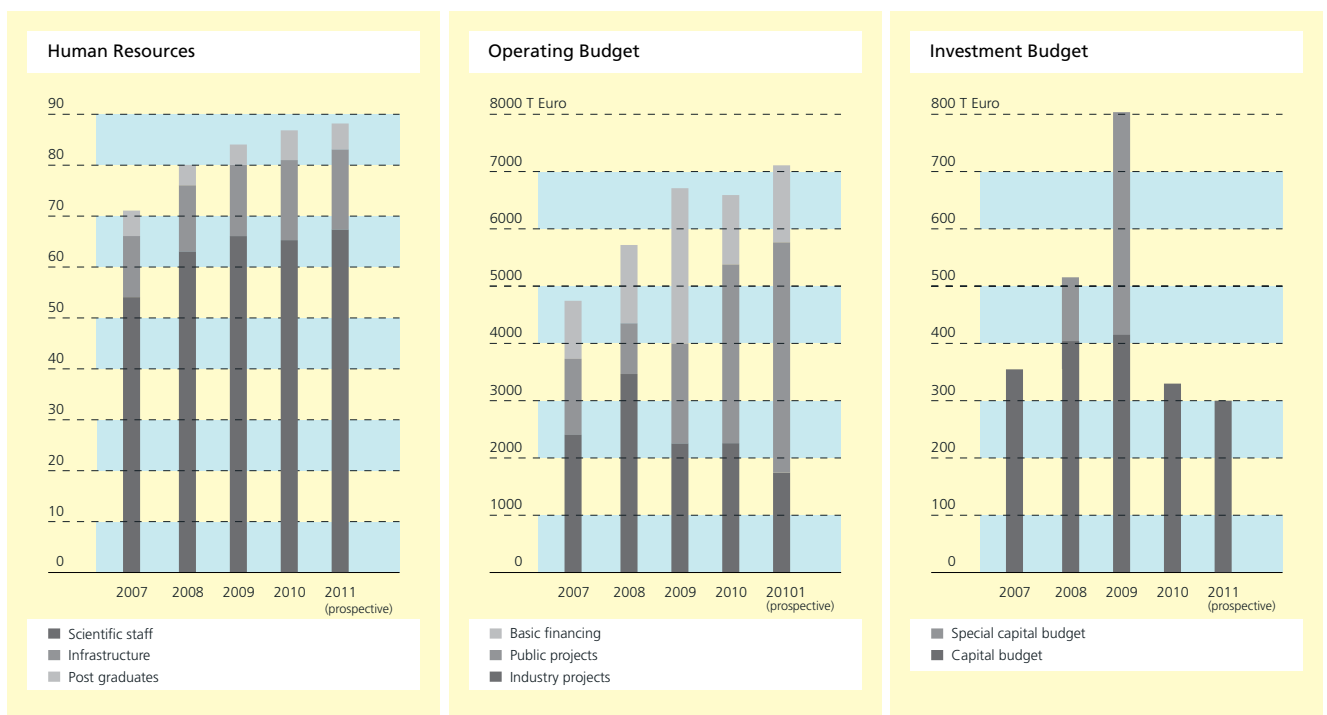
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## Human resources

Changes in the business fields and the associated development of competencies as well as replacements in responsible positions led to a rearrangement of the work structure in the division EAS. The number of employees has stayed the same, the staff composition is shown in figure 1. The highly qualified scientific staff mainly consists of experts with university degrees, primarily in the subjects of electrical engineering and information technology, computer sciences, physics and mathematics. About one third of the scientific employees have a PhD. Currently, four postgraduates and several scientific employees are working on their doctor's theses. Thus, the division supports the scientific qualification of its talented staff and, furthermore, ensures that a relevant part of the necessary basic research is carried out. Two students from the University of Cooperative Education in Dresden are doing the practical part of their diploma studies at the EAS.

## Operating budget

The operating expenses are mainly determined by staff costs. The division EAS benefits from the fact that the segments of most industries using microelectronics grow in the time average and the semi-conductor companies enhance their production technologies. Growth was particularly seen in the area of design processes for mixed-signal systems. However, the consequences of the structural crisis in the semi-conductor industry are also reflected by the share of financing in industry projects (figure 2). A balanced operating budget will be achieved this year due to intensified acquisition activities in public sponsoring programs and with new project partners and clients. The massive efforts to win new clients from among the industries using microelectronics have already led to an increased number of industry projects, on the basis of which the division is now working on further increasing the industry revenue. Additionally to this, the increasing development



of EAS product prototypes at the division and the positive development in industry-support, the positive economic development, which can be expected to continue.

### Investment budget

Investments in the extension and renewal of the highly available and high-performance computer technology and the tools for developing hardware and software are indispensable to ensure that competitiveness can be maintained and the employees can be relieved of routine works or complicated calculations. In the year under report, this applied to expansions in the IT field, special file, terminal and high-performance computer servers and network technology. Further funds were used for special laboratory equipment, e.g. for investigating innovative high-precision image sensors and optical and magnetic measuring systems. Due to the relatively high investment volume of the past few years, the device equipment could be completed with a small volume this year. The third diagram shows the annual investment volume of the past five years, indicating the amount of special investment funds.

### Competencies

- computer-assisted methods, processes and tools for simulation, analysis, synthesis, optimization, verification, test generation and diagnosis
- modeling methods, model generation, model reduction, development of behavior and circuit models for electrical systems and of behavior and structure models for heterogeneous systems, e.g. sensor/actor systems
- strategies for the verification of complex system designs consisting of simulative and formal methods
- coupling between design tools (e.g. of different simulators) and between tools (models) and hardware
- development of innovative hardware/software systems, e.g. in the fields of digital broadcasting, automotive and ambient assisted living
- development of design platforms for sensor systems, sensor networks, industrial circuits and communication systems
- multi-physical (mechanical, thermal, optical, magnetic, fluidal) modeling and simulating under functional and reliability aspects
- development of innovative image sensors and optical measuring systems, magnet-based position sensors and condition monitoring systems

### Equipment

- high-performance computer infrastructure with modern workstation computers, high-availability file servers, high-performance computer servers and virtualization clusters and two parallel computers (grid cluster)
- commercial IC design systems by CADENCE, MENTOR, SYNOPSYS, XILINX, etc.
- simulators such as ANSYS, COMSOL, CST Microwave Studio, COSSAP, HSPICE, SimulationX, Dymola, MATLAB/SIMULINK, SABER
- proprietary developments for simulation, synthesis, analysis and verification, e.g. SystemC-AMS-based system development environment, analog fault simulator
- laboratory workstations for installing, commissioning and measuring electronic components of systems
- opto-mechanical measuring setup for characterizing optical sensors
- industry robots for the application design of sensor systems on the basis of magnetic sensors
- measuring technology for characterizing textile conductor patterns
- high-velocity camera and infrared thermography system



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# DESIGN AUTOMATION / HETEROGENEOUS SYSTEMS

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## Energy saving in buildings through intelligent management

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### Overview

Buildings still account for more than 40 per cent of primary energy consumption. Apart from production buildings, residential buildings with the key components of HVAC (Heating, Ventilating and Air Conditioning), water heating, lighting and home electronics are the major consumers. Reducing the required energy solely by additional passive measures, such as insulation solutions, has no benefits in terms of total energy consumption when correlating the savings with the production expenditure.

Therefore, future concepts for energy-optimized buildings must be based on a holistic integrated energy management. This means that the installed energy sources, storage devices and consumers must be adjusted individually to the intended use. Apart from minimizing energy consumption, this will also increase quality of life, comfort and safety. The following principle applies: "Only use as much energy as is absolutely necessary (in terms of space and time)".

Implementing this basic concept makes completely new demands on the degree of automation. Market analyses show the current obstacles for the implementation of this aim. The largest ones include lacking communication opportunities beyond trade borders, unclear or lacking configuration options for the overall system, lacking holistic cross-trade optimization and control strategies and the interface management. Furthermore, there are significant deficits in the provision of design, test and commissioning environments for energy minimization, which are indispensable for the changeover in building automation.

### Optimal building solutions by integrated energy management

Future concepts of buildings with minimized energy consumption require an integrated consideration of the automation-based overall solution that includes all installed components. This is the only way to develop an individual and optimal overall solution that fully utilizes the energy-saving potential of building technology. Together with German and European automation and construction companies, the division EAS meets the challenge to support the building energy management system (BEMS) by means of a suitable design method. Concepts and tools for the holistic and energy-minimizing planning and implementation of building control and automation are being developed in close cooperation.

The core of the model-based approach pursued is a holistic simulation model that comprises both the specified behavior of the BEMS as an automation system and the structural-physical behavior of the building structure. This model forms the basis of several subsequent development steps:

- execution of operating scenarios that include the behavior of the building components, thus supporting the early detection of algorithmic errors within the energy management
- calculation and optimization of energy consumption already at the planning stage and execution of variant examinations
- review of the overall system behavior in the event of exceptions and errors
- automatic generation of BEMS functional blocks from the BEMS model
- virtual pre-commissioning of the automation-based overall solution for increasing the robustness and maturity of the energy management system



Figure 1: Energy-optimized office building on the basis of a holistic integrated energy management concept / © FASA AG ENERGETIKhaus100 office

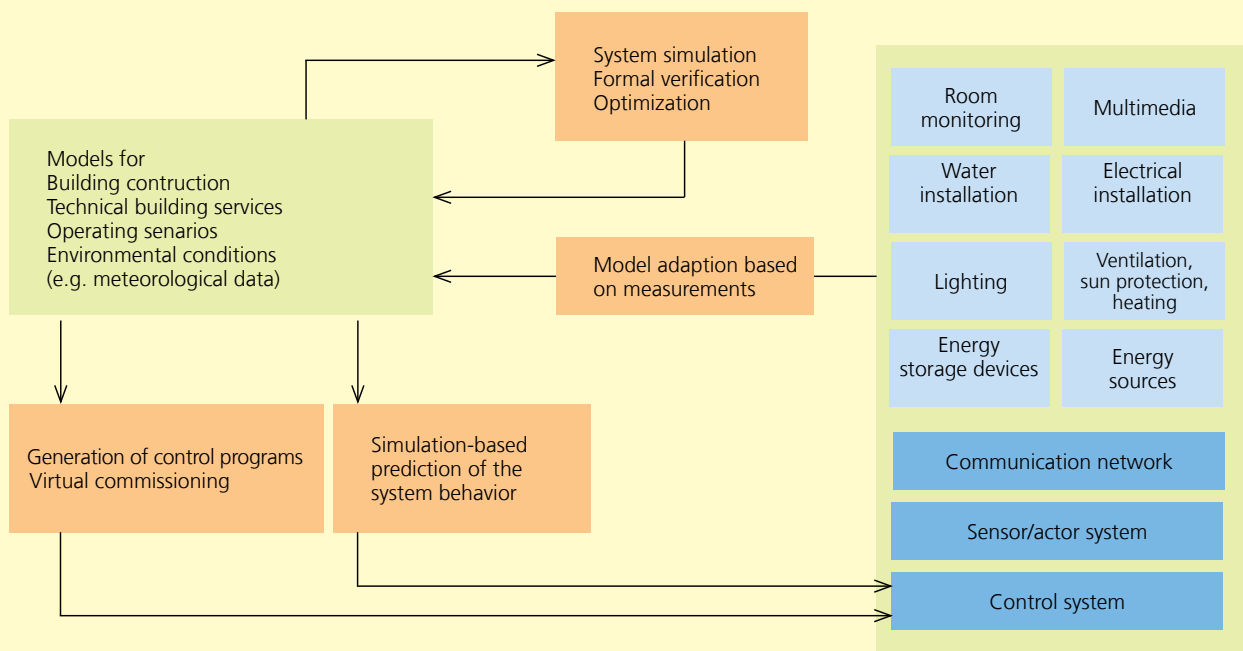


Figure 2: Model-based design of buildings with an optimized energy flow

## Effects

The use of an integrated cross-trade energy management in buildings is expected to lead to energy savings of up to 50 per cent for the building sector. Apart from these savings, the costs for planning, optimization, commissioning and operation of the complex energy management systems will also be reduced significantly. Thus, the obstacles for their economical marketing and application will finally be noticeably reduced both for the manufacturer and the user.

The use of model-based tools in the development, configuration and commissioning guarantees a robust automation system that is optimized depending on the relevant application scenario (building size and structure, intended use, acquisition and operating costs). Thus, the dissemination of integrated energy management systems is supported by reducing the total costs of ownership. This leads to sustainable energy savings in building operation.

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# DESIGN AUTOMATION / MIXED-SIGNAL SYSTEMS

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## Textile-based network and its applications

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### Overview

Smart products with an innovative functionality are created by integrating electronic components into textile structures. Such products include clothing that monitors individual health data and interacts with the wearer and the environment. Energy and information are transmitted in such smart textiles via conductive textile structures that form complex, heterogeneous networks together with the electronic components. The areas of application for smart textiles include age-based assistance systems (ambient assisted living), medical technology, work and leisure wear as well as additional functions such as bags or tarpaulins.

### Textile-based network

The sensors integrated into the textiles record parameter values, such as temperature, humidity or acceleration, which are then transmitted to specially developed processor nodes (TexNodes) for further processing. A dedicated bus system (TexBUS) with a high-efficiency bus protocol has been developed for secure, low-energy transmission even of high data rates. The data can be further transmitted to external computers or stored externally via commercial interfaces (e.g. ZigBee, Bluetooth, cell phone). The focus in the field of smart textiles is on the development of textile-based networks and appropriate methods for their efficient design. Such network consists of processor nodes that process signals from sensors. Depending on this evaluation, they trigger actions or forward corresponding data for external processing (figure 1).

Such textile-based networks allow for very robust and fail-safe solutions for smart textiles, due to the digital recording and processing of the data on site by the processor nodes

and their interconnection. The processing capacity of the overall system can be adjusted to the existing requirements by adding processor nodes.

The bus system used in the network of the division EAS and the pertaining bus protocols allow for easily and quickly integrating new sensors and processor nodes into an existing network. The nodes are optimized for low energy consumption. Furthermore, the number of lines of the bus systems is minimized. Thus, the complicated technological processes of the textile line integration and the contacting of electronic components can be reduced. The software for the processor nodes takes into account the high requirements on system robustness and the special characteristics of the textile structures. Currently, a verification strategy is being developed that is intended to ensure a zero-error design rate for such networks, taking into account realistic conditions of use.

### Initial applications

Initial application examples illustrate the range of potential uses: EASyCONTROL is a wrist bandage via which, for example, household appliances can be switched on and off contactlessly by moving one's hand (figure 2). EASyJACKET is a smart jacket for recording simple personal parameters for monitoring activities of the wearer. Furthermore, fluorescent strips are activated on the back of the jacket when it is dark. EASyTENT triggers an alarm upon attempted burglaries, e.g. in a tent or bag (figure 3). When the zipper is opened, an alarm starts on an activated cell phone.



Figure 3: Cell phone alarm upon opening a zipper

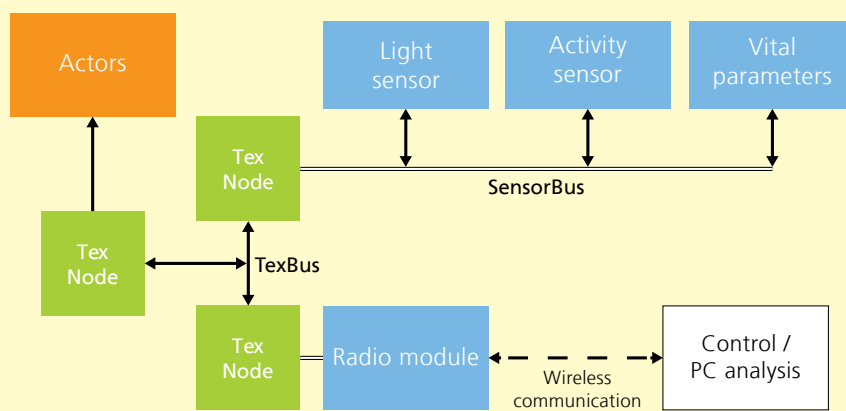


Figure 1: Textile-based network

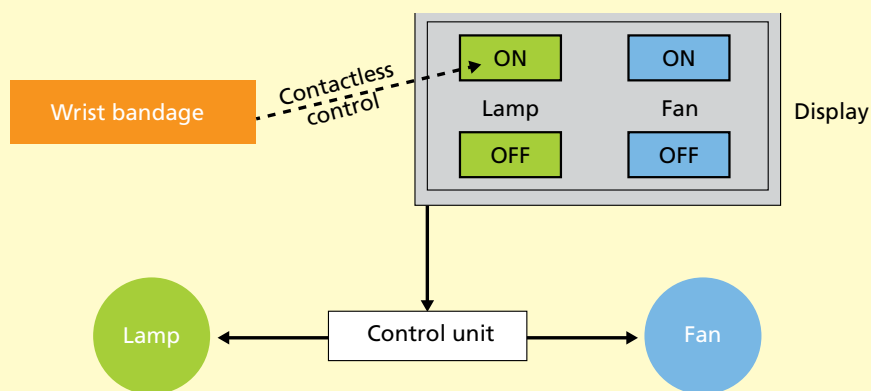


Figure 2: EASyCONTROL – contactless device control





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# **FRAUNHOFER-GESELLSCHAFT, GROUPS, ALLIANCES AND COOPERATIONS**



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 more than 80 research units in Germany, including 60 Fraunhofer Institutes. The majority of the more than 18,000 staff are qualified scientists and engineers, who work with an annual research budget of €1.66 billion. Of this sum, more than €1.4 billion 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.

Affiliated international research centers and representative offices provide contact with the regions of greatest importance to present and future scientific progress and economic development.

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

of new technologies, and helping to train the urgently needed future generation of scientists and engineers.

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

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

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# FRAUNHOFER GROUP FOR MICROELECTRONICS

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The Fraunhofer Group for Microelectronics (V $\mu$ E) has coordinated the activities of all Fraunhofer institutes that operate in the fields of microelectronics and micro-integration since 1996: these include 13 institutes (and three guest institutes) with approximately 2,700 employees. Their annual budget amounts to some 307 million euros. The responsibilities of Fraunhofer V $\mu$ E include the early recognition of new trends and their consideration in the strategic development of the institutes of the group. Other functions include joint marketing and PR activities. In 2011, Prof. Hubert Lakner took over the chair of the group from Prof. Heinz Gerhäuser.

Other fields of work include the development of joint topics and projects. Thus, the group is able to offer future-oriented research and application-oriented developments particularly to innovative medium-sized businesses and to significantly contribute to their competitiveness. The core competencies of the member institutes are bundled in the following

cross-sectional business areas:

- Technology – from CMOS to Smart System Integration
- Communication Technologies

and application-oriented business areas:

- Light
- Safety and Security
- Energy Efficient Systems and eMobility
- Ambient Assisted Living
- Entertainment

The office of the Fraunhofer Group for Microelectronics is the central coordination office. It forms the link between science, industry and politics in close cooperation with the institutes.

The members of the group include the Fraunhofer Institutes for:

- Applied Solid State Physics (IAF)
- Digital Media Technology (IDMT) (guest)
- Electronic Nano Systems (ENAS)
- High Frequency Physics and Radar Techniques (FHR)
- Integrated Circuits (IIS)
- Integrated Systems and Device Technology (IISB)
- Microelectronic Circuits and Systems (IMS)
- Communication Technology, Heinrich Hertz Institute (HHI)
- Open Communication Systems FOKUS (guest)
- Photonic Microsystems (IPMS)
- Silicon Technology (ISIT)
- Institute for Non-Destructive Test Methods (IZFP) (guest)
- Reliability and Microintegration (IZM)

the Fraunhofer research institutions for

- Modular Solid State Technologies (EMFT)
- Communication Systems (ESK)

and the

- Fraunhofer Center Nanoelectronic Technologies (CNT)



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**Fraunhofer**  
MIKROELEKTRONIK



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# FRAUNHOFER INFORMATION AND COMMUNICATION TECHNOLOGY GROUP

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Our modern living and working environments cannot be imagined without information and communication technology. Fast-paced developments and short innovation cycles characterise the IT industry. Consequently, and even more than in other branches, competitiveness hinges on innovation speed and efficiency. Moreover, software systems are becoming increasingly complex. Society and companies need to be able to react to those rapid changes and upcoming challenges. The knowledge required to keep up with these developments evolves with equal speed. Experts need to keep up to date with industry events and research findings. In all these cases, the Fraunhofer Information and Communication Technology (ICT) Group is the direct contact for companies and users alike.

With its 19 member institutes, the Fraunhofer ICT Group provides applied R&D in almost all IT sectors and for a broad range of industries. The combined expertise of the Fraunhofer ICT Group's institutes allows for industry-specific, comprehensive and customised IT solutions and competent technological consulting for businesses, authorities and the media.

Our approximately 4,500 researchers and engineers provide R&D services in the following business areas:

- Medicine
- Automotive
- Production
- Digital Media
- Sustainability
- Financial Sector
- Security
- E-Business
- E-Government
- Information and Communication Technologies

The members of the ICT Group include the Fraunhofer Institutes and Organisations for:

- Algorithms and Scientific Computing SCAI
- Applied Information Technology FIT
- Applied and Integrated Security AISEC
- Industrial Engineering IAO
- Medical Image Computing MEVIS
- Digital Media Technology IDMT
- Experimental Software Engineering IESE
- Computer Graphics Research IGD
- Intelligent Analysis and Information Systems IAIS
- Communication, Information Processing and Ergonomics FKIE
- Open Communication Systems FOKUS
- Optronics, System Technologies and Image Exploitation IOSB
- Computer Architecture and Software Technology FIRST
- Secure Information Technology SIT
- Software and Systems Engineering ISST
- Industrial Mathematics ITWM
- Integrated Circuits IIS
- Telecommunications, Heinrich Hertz Institute HHI
- Communication Systems ESK

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# FRAUNHOFER GROUP FOR DEFENSE AND SECURITY VVS

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The VVS has proven itself as a center of scientific excellence within the German defence and security research community. For the first time, the Fraunhofer security conference “Future Security” was held at the representative premises of the state of Baden-Württemberg in Berlin.

## **The societal commitment of the Fraunhofer-Gesellschaft**

In accordance with the Fraunhofer-Gesellschaft’s self-conception, it supports the industrial sector but it also addresses itself to tasks which are related to society as a whole. Since its establishment, the Fraunhofer-Gesellschaft has partly been financed by and dutybound to the German Ministry of Education and Research (BMBF) as well as to the Federal Ministry of Defence (BMVg). Fraunhofer’s wide range of competences covers most of the institutional research of the BMVg. New security threats and their political consequences created novel security challenges in a national and international context. Today’s modern industrial societies which are interlinked with highly complex private and public infrastructure networks are much more vulnerable to a multifaceted set of risks and threats. Thus and in order to protect their citizens, there is an increased demand for innovative security solutions.

## **Additions to the group successfully mastered**

Today, the group is comprised of nine member institutes. In accordance with the BMVg’s long-term plans – the concentration of the department’s research capacities which are funded by general grants, as well as the plan to create new opportunities in the civil security market for the institutes which are solely dealing with defense research – the three institutes of the former Research Establishment for Applied Sciences (FGAN) were integrated into the Fraunhofer-Gesellschaft. The new members of the VVS group are: the Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR, the Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE as well as the Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB in

Ettlingen, which merged with the Fraunhofer IITB in Karlsruhe into the new Fraunhofer IOSB on January 1, 2010. As a further guest institute, the Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institute, HHI, joined the group in 2010.

## **The leading position in security research strengthened**

Especially in the field of civil security research, the group can look back on a very eventful year 2010. Fraunhofer, led by the VVS, has established itself as the most active and the most successful player in the BMBF-financed national security research program, as well as in the “security” theme of the European Union’s 7th Framework Programme (FP7). Furthermore, the VVS is significantly involved in the organization and design of both programs. With regard to the continuation of the German security research program from 2010 onwards, Professor Klaus Thoma handed over a position paper to the BMBF already in February 2010. This paper is called “Memorandum of the Fraunhofer-Gesellschaft Concerning the Continuation of the National Security Research”. In addition, the members of the VVS directorate participated in all salient national and European conferences which were dealing with the organization and design of future security research. Significantly, Professor Thoma delivered a keynote speech at the SRC 2010, the central conference of the European Commission regarding the field of security research.

## **A distinct public profile could be emphasized**

In 2010, the VVS held its annual security conference “Future Security” at the representative premises of the state of Baden-Württemberg for the first time in Berlin. Its being placed in the vicinity of national policy makers as well as a high-quality and detailed agenda – among others, results of several German-Israeli project partnerships were introduced – contributed to a very successful event. In 2011, the “Future Security” will again be held in Berlin, this time however, it will take place on the representative premises of the state of Nordrhein-Westfalen. The invitation of the VVS to the Army Science Conference (ASC)



in Orlando, Florida, USA, can be regarded as another successful event in 2010. Leading representatives of politics, industry and research showed deep interest in the research activities of the VVS, which was the only European participant in the conference. With the promising positioning of the group within the US-American research community, an important cornerstone for potential further research cooperation could be established.

The members of the group include the Fraunhofer Institutes for:

- High-Speed Dynamics, Ernst-Mach-Institut, EMI
- Applied Solid State Physics IAF
- Chemical Technology ICT
- Technological Trend Analysis INT
- High Frequency Physics and Radar Techniques FHR
- Communication, Information Processing and Ergonomics FKIE
- Optronics, System Technologies and Image Exploitation IOSB (former FOM and IITB merged into IOSB on January 1, 2010)
- Integrated Circuits IIS (guest institute)
- Telecommunications, Heinrich-Hertz-Institut, HHI (guest institute)

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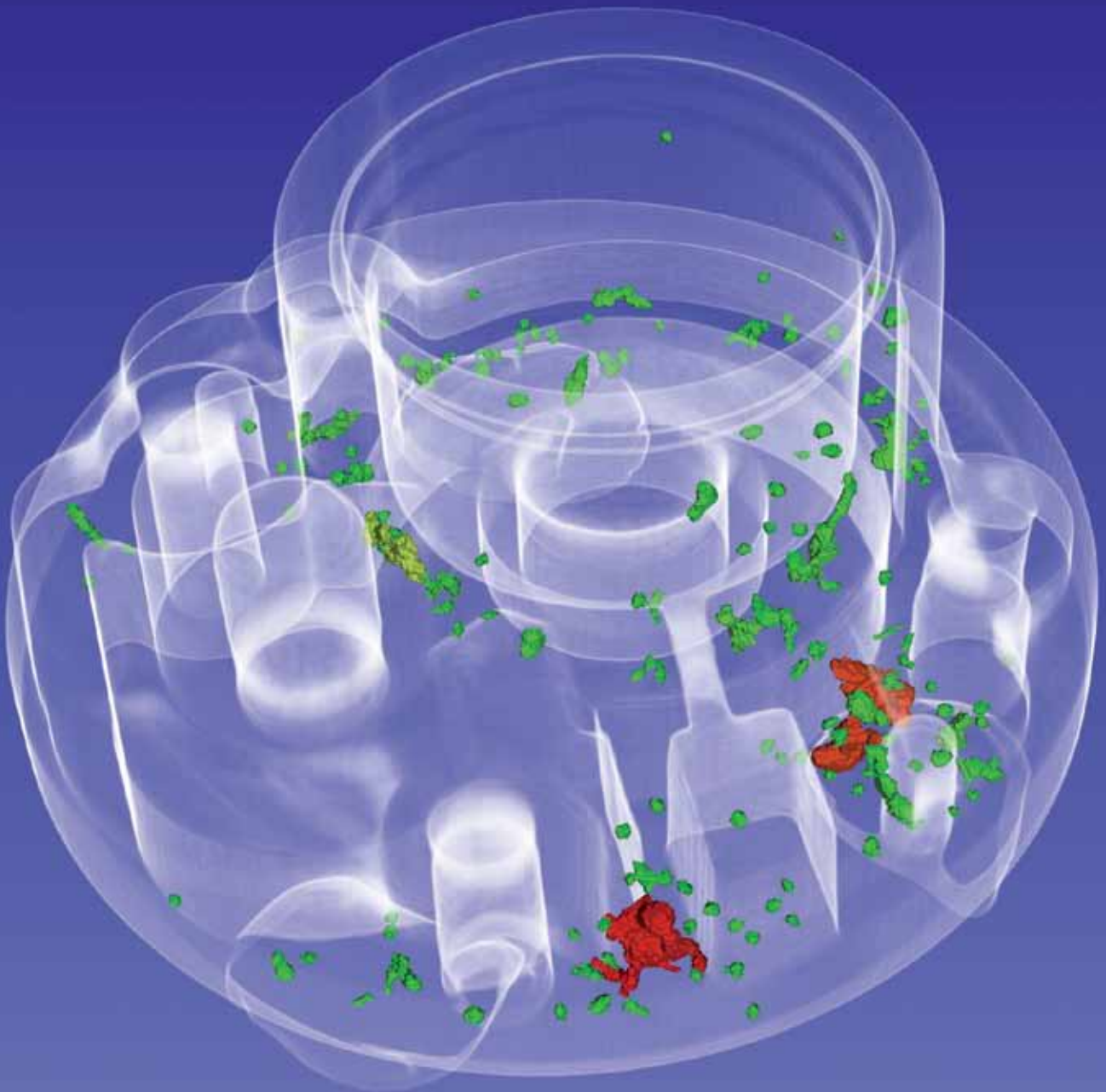
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# FRAUNHOFER VISION ALLIANCE

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## Fraunhofer Vision Alliance – solutions for machine vision

### Non-destructive testing with image processing – guideline series by Fraunhofer Vision Alliance

#### Overview

The trend towards higher productivity and quality in production leads to a very dynamic development regarding the production and automation technologies, where image processing plays an important role. Within the Fraunhofer-Gesellschaft, 16 of all 60 institutes deal with different aspects of machine vision. To facilitate access for potential clients and use the synergies of the broad scientific bases in an optimum way, the central office of Fraunhofer Vision Alliance was set up as a contact point at Fraunhofer IIS in Erlangen. From here, inquiries can be forwarded to the optimal partner in terms of specialization and location. If necessary, challenging developments can be carried out by cross-institute project teams and, if possible, using sponsoring funds.

#### Imparting knowledge through publications

In its guideline series, Fraunhofer Vision Alliance makes annual publications on practically relevant topics of industrial image processing. The illustrative and generally understandable presentation of current knowledge enables potential users to become acquainted with this complex field. Apart from the state of the art, the versatile potential uses of optical measuring and testing technology for industrial production and quality assurance are described by way of examples.

Thus, readers get a realistic idea of the opportunities and limits of the technology regarding their own test requirements.

The guideline series of Fraunhofer Vision Alliance already consists of 12 volumes. Each volume addresses a special topic and includes theoretical and practical articles by applied science and industrial research.

#### Opening markets through publications

Apart from their significance as a sought-after source of information and acknowledged reference book, the “Vision guideline series” is an effective marketing instrument for the participating institutes and development partners from industry – with a wide range and a high level of attention from the relevant user groups and specialist media.

The latest example is volume 12 on heat flow thermography, which was published in May 2011 continuing the success of its predecessor, which dealt with the topic of industrial X-ray technology. The bases, principles and modern procedures of heat flow thermography as a powerful tool for non-destructive testing are explained on some 100 pages. The range of topics includes the hardware as well as triggering, optical reproduction, detection, evaluation algorithms and cross-industry application examples from industrial practice. Spectral-resolution thermography and the combination with complementary test methods provide interesting outlooks to the future.

All volumes of the guideline series can be ordered either directly from Fraunhofer Vision Allianz or via book shops.

*X-ray testing of a casting – X-ray technology is the topic of the Fraunhofer Vision guideline 11*

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# FRAUNHOFER ALLIANCE DIGITAL CINEMA

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### Research and development for the cinema of the future

The most important topics for the enhancement of digital cinema and the digital media in the past year were new technologies and trends around 3-D. Furthermore, it becomes more and more important for a successful and cost-efficient workflow to use a process that couples production data from the set directly with new systems for post production and archiving. This means that the hype around 3-D enters the stage of practical implementation for movies, broadcasting and home applications. The Fraunhofer institutes of the Digital Cinema Alliance offer new developments for optimizing production and projection technology and show innovative trends for the future in joint sponsoring projects with industry partners. The interlocking of systems and formats in the overall work process of production, the internationally acknowledged achievements in standardization and the scientific know-how of the Fraunhofer institutes are important contributions to the success of innovations in a highly competitive market for clients. Dr. Siegfried Föbel of Fraunhofer IIS has been the new spokesman of the Fraunhofer Alliance Digital Cinema since 2011.

### Activities around the Berlinale

Again this year, the institutes have been involved in the international film festival Berlinale supplying project topics and services. Fraunhofer IIS and HHI presented results and productions from the PRIME (production and projection technologies for immersive media) project together with other research and industry partners. More than 250 guests from the film industry, the media, science and research organizations and further industrial companies were impressed by the high-quality program including 3-D animation and games, documentations and movies – shot and produced with Fraunhofer technology.

At the initiative of the Alliance institutes Fraunhofer IIS and HHI and together with the KUK film production, the new image film "Dimensionen der Forschung" (Dimensions of

research) was produced on behalf of the Fraunhofer-Gesellschaft. Fraunhofer is the first research organization to use the opportunities of 3-D technology to present its technologies and the projects to a broad audience as a realistic experience.

### 3-D Innovation Center in Berlin

The 3-D Innovation Center is another platform that allows for combining new technologies and products through the synergy of scientific expertise and practical knowledge all along the 3-D production chain. The partners of the 3-D Innovation Center have a forum to exchange opinions, discuss special requirements and experience or carry out tests and demonstrations prior to development and market launch. The 3-D Innovation Center is supported, amongst others, by the Federal Ministry of Economics and Technology and directed by Fraunhofer HHI. The Fraunhofer Alliance Digital Cinema is a partner of the Innovation Center. With this initiative, Fraunhofer Alliance Digital Cinema now has presentation and innovation centers at all four locations: the TimeLab Berlin (HHI, IDMT), the dome projection technology in Berlin-Adlershof (FIRST, IDMT), the sound laboratory in Ilmenau (IDMT) and the Fraunhofer IIS digital cinema with 3-D equipment and IOSONO sound system (IIS, IDMT) in Erlangen.

Some of these developments were presented to visitors at the joint trade fair stands of the Alliance institutes at the NAB (National Association of Broadcasters) in April 2011. The joint stand at the IBC (International Broadcasters Convention) was an important fixed point in the acquisition and PR activities also in 2011.

### Members of the Fraunhofer Alliance Digital Cinema:

Fraunhofer IIS (coordination and spokesman), Fraunhofer FIRST, Fraunhofer HHI, Fraunhofer IDMT.

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# FRAUNHOFER INSTITUTE FOR DIGITAL MEDIA TECHNOLOGY (IDMT)

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There were many new developments at Fraunhofer IDMT in 2010 and 2011 that caused a stir also in the press. For example, the Eyetracker system for fatigue monitoring in vehicles was presented at the SID-ME and Vision trade fairs in autumn 2010. Two cameras that are installed in the cockpit of the vehicle and connected with an FPGA chip monitor the driver's eye movements and identify the number of lid movements. Thus, it calculates whether there is a risk of microsleep and the driver should have a break. The system is computer-independent and calibration-free. This new development is supposed to guarantee much more safety on the road in the future.

One of the most famous German nightclubs, the P1 in Munich, opened its doors again after a comprehensive reconstruction in autumn 2010. Since then, one of the absolute highlights at the club has been the new sound system, which was created in cooperation between Fraunhofer IDMT and Bose GmbH and with which the Munich club sets new standards in disco sounding. A total of 18 high-tech loudspeakers and four sub-woofers were installed around the dance floor, controlled by the Fraunhofer spatial sound wave system for three-dimensional sound effects. The light and video system of the club is also connected to the new sound system in a multimedia-based way so that the guests can also experience the beats and rhythms visually. In the future, it will not only be possible to use the system in the club and event area but also in planetariums and theme parks, for live sounding, product presentations or three-dimensional audio-visual simulations.

Audio experts from all over the world met at the 42th International Conference of the Audio Engineering Society (AES) on the "Semantic Audio" topic in Ilmenau in summer 2011. More than 50 scientists from the fields of media technology, information technology, signal processing and musicology reported and discussed about current research findings and technical developments regarding the analysis and processing of digital music and voice recordings. This conference of three days was organized by Fraunhofer IDMT in cooperation with the Audio Engineering Society, the global association for professional

audio technology, the Queen Mary University of London and the Technical University of Ilmenau. Scientists from all over the world gave a current overview of technologies and processes for analyzing, for example, the structure or harmony of music pieces. Thus, it is possible to conveniently sort archives at radio stations or in a private music collection and to search them for songs with certain properties. The conference was culturally enriched by a Jazz concert at the Ilmenau student club BC and ended with a joint excursion of the participants to the famous Bach museum in Eisenach on Sunday afternoon.

## Profile

The Fraunhofer Institute for Digital Media Technology (IDMT) in Ilmenau (Thuringia) is active in applied research in the field of digital audio-visual applications.

Apart from solutions for virtual acoustics for private and professional users (e.g. the wave field synthesis technology), it also develops software technologies for analyzing and characterizing multimedia contents and audio-visual applications for medical technology. Furthermore, the research portfolio includes the planning of interactive application scenarios for entertainment and knowledge management and the design of architectures for digital online selling. In cooperation with its partners and clients from business, culture and education, the Ilmenau institute transforms future-oriented scientific findings into package solutions and prototypes that are suitable for daily use and tailored to the specific challenges of the users and the requirements of the market.

*Tests with mini cameras show that an easy integration of the Eye-tracking solution into displays will be possible in the future*





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# FRAUNHOFER USA DIGITAL MEDIA TECHNOLOGIES

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*Dipl.-Medienwiss. Jan Nordmann | +1 408 573-9902 | [jan.nordmann@dmf.fraunhofer.org](mailto:jan.nordmann@dmf.fraunhofer.org)*



Fraunhofer USA Digital Media Technologies provides Marketing and Distribution Support for Fraunhofer IIS Audio and Multimedia Technologies at International Exhibitions and other Occasions:

**CEATEC, Tokyo**

October 5 – 9, 2010

Support with the introduction of MPEG Surround for consumer electronic devices.

**129th AES Convention, San Francisco**

November 5 – 7, 2010

Support with the introduction of new MPEG audio technologies.

**Inter Bee, Tokyo**

November 17 – 19, 2010

Support with the distribution of MPEG Surround for digital broadcasting systems.

**2011 International CES, Las Vegas**

January 6 – 9, 2011

Market launch support: Sonnox Fraunhofer Pro-Codec Plug-In

**Mobile World Congress, Barcelona**

February 14 – 17, 2011

Support with the introduction of the Fraunhofer communication technologies for 4G networks.

**NAB, Las Vegas**

April 11 – 14, 2011

Sales support for MPEG Surround for digital broadcasting systems.

The Audio and Multimedia Office of Fraunhofer USA, Inc. "Digital Media Technologies" (DMT) continued its dynamic growth in 2009 by taking on new staff and exploring market opportunities for new technologies like Voice over IP (VoIP).

In close collaboration with Fraunhofer IIS in Erlangen the team in San José, CA, introduced new audio formats to the American market. Examples are lossless HD-AAC and MPEG Surround – both developed to improve the sound experience of consumers for content purchased through music and video download services. The new audio codecs and related technologies enabled a far more realistic and improved quality of teleconferencing applications.

With the initiation of U.S. business deals, Fraunhofer USA significantly stimulated Fraunhofer software licensing. What is more, Fraunhofer DMT played a strategic role in the product planning process, hosted the semi-annual meeting of the executive board of Fraunhofer USA in San Francisco, and trained Fraunhofer IIS members in North-American corporate culture.

*Fraunhofer USA Digital Media Technologies, a division of Fraunhofer USA, Inc., promotes and supports the products of Fraunhofer IIS in the U.S.*

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# FRAUNHOFER IIS CELEBRATES THE KIDS' PROGRAM "DIE SENDUNG MIT DER MAUS"

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© I. Schmitt-Menzel/TrickStudio Lutterbeck GmbH/Die Sendung mit der Maus@WDR

On the occasion of the 40th birthday of the “Sendung mit der Maus” TV program for children, the WDR TV channel organized a German-wide open house, and Fraunhofer IIS exclusively joined the celebration as a premium partner in Southern Germany.

More than 10,000 little and grown-up fans of the Mouse visited the laboratories. At many stations, they were even allowed to test the latest developments themselves. For example, the guests could take part in a 3-D film production as actors or learned on a treasure hunt how GPS and other

locating systems work. Furthermore, the scientists in Erlangen demonstrated how it is possible to talk to each other over long distance as if you were at the same place using the latest technology and whether your own body can be a natural power station.

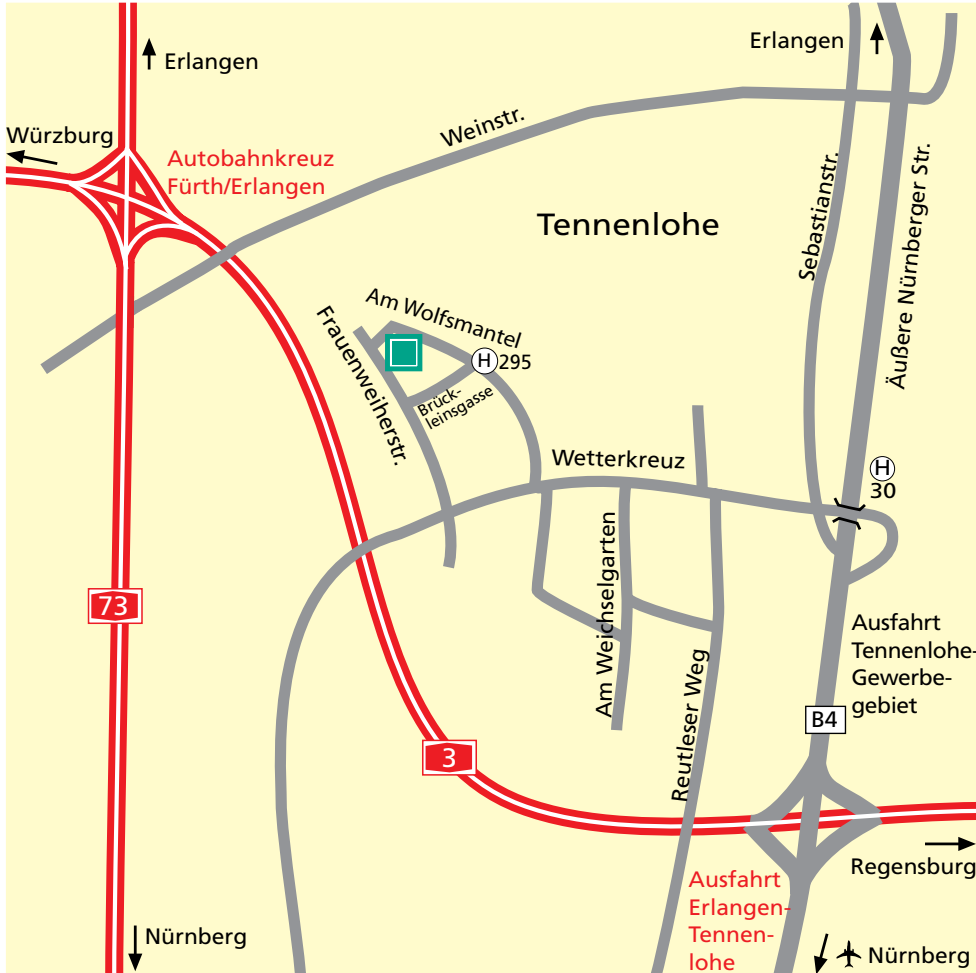
Of course, the Mouse did not miss this extraordinary family party: it was a special guest at the institute in Erlangen. It demonstrated its show talent on the stage and met its fans for souvenir photos.





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## HOW TO FIND US



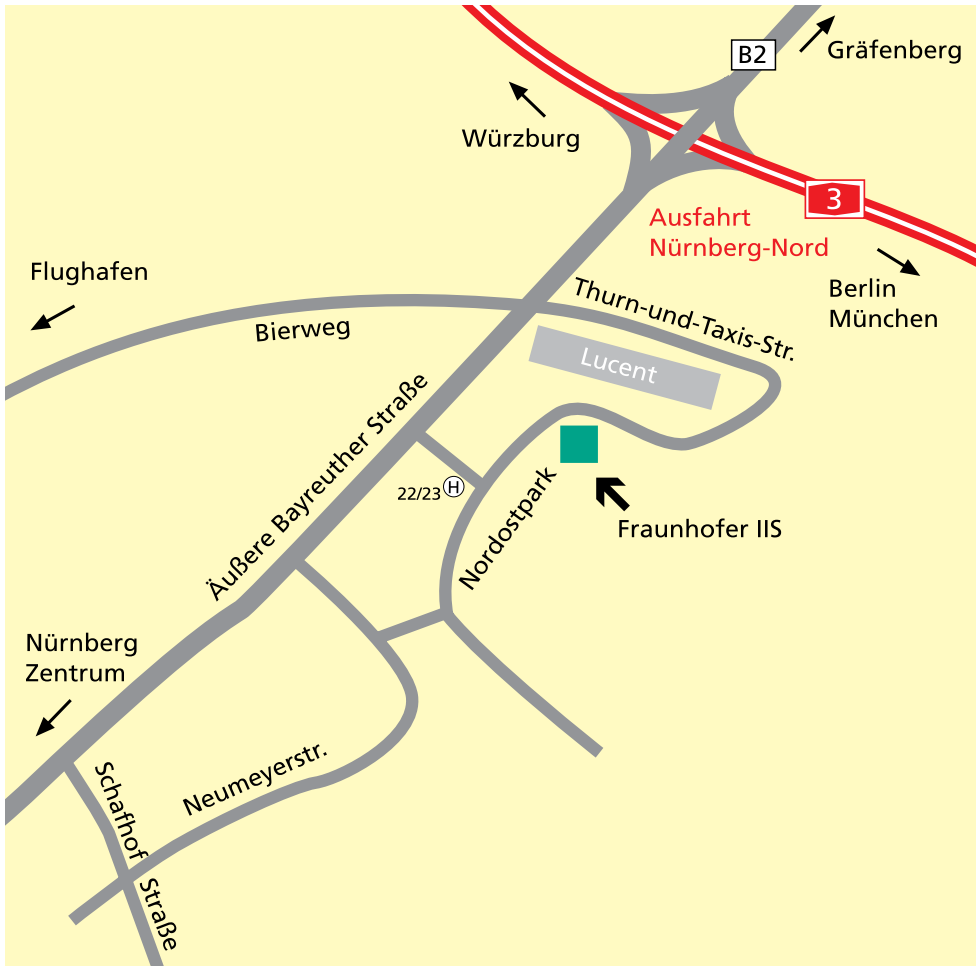
Fraunhofer IIS headquarters with  
antenna tower

**By car:** Fraunhofer IIS is located near the Nuremberg airport at the intersection of highway B4 Nuremberg-Erlangen and free-way A3 Regensburg-Frankfurt. Follow A3 until exit Erlangen-Tennenlohe, then follow B4 heading for Erlangen and take exit Erlangen-Tennenlohe following signs to Erlangen and continue on highway B4 until exit Tennenlohe-Gewerbegebiet, Wetterkreuz. At the traffic lights go straight for two blocks, before hotel Tennenloher Hof turn right onto Am Wolfsmantel. After 500 m you will see Fraunhofer IIS on your left. Visitor car parking is available in front of the building.

**By plane:** The taxi ride from the airport takes approximately 20 minutes.

**By train:** Take bus no. 295 with destination Tennenlohe leaving in front of the Erlangen main station. After a ride of about 25 min exit at bus stop Brückleinsgasse right in front of Fraunhofer IIS.

Fraunhofer IIS  
Location Nuremberg  
Nordostpark 93  
90411 Nuremberg



- Location Nuremberg
- Fraunhofer Center for Applied Research on Supply Chain Services SCS
- Department Power Efficient Systems LOS
- Department Communication Networks KOM
- Project Group Net Access Technology
- Wireless Location Group

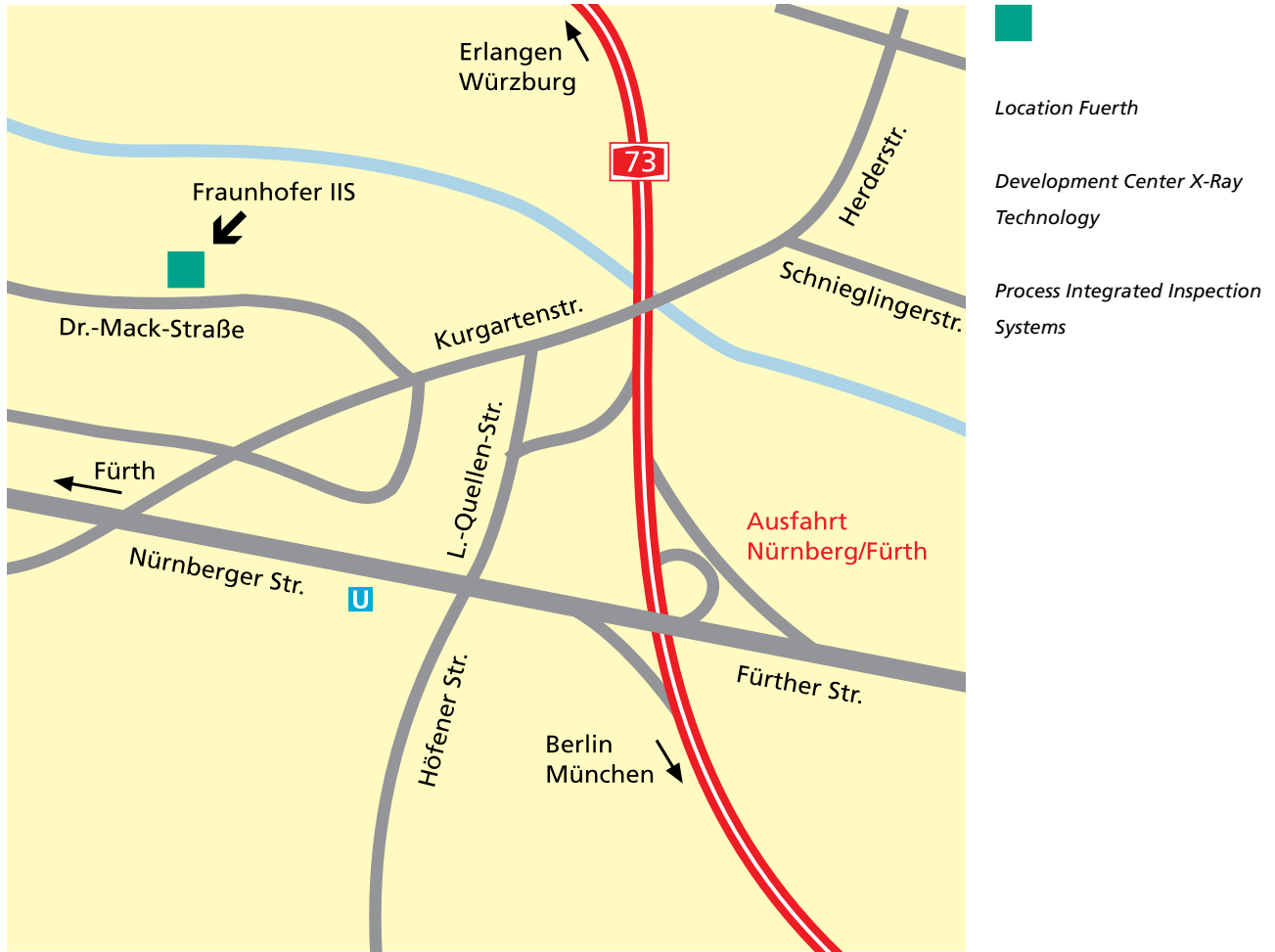
**By car:** Nordostpark is located directly at highway B2, at the Nuremberg city limit, within two minutes driving distance from freeway A3. Exit freeway A3 at Nürnberg-Nord and follow B2 in the direction Nuremberg. You will enter Nuremberg on Äußere Bayreuther Straße. After 400 m turn left following the signs into Nordostpark. Proceed for 100 m, turn left and follow the street to the first gateway to the right. Please contact the Fraunhofer IIS reception at Nordostpark 93.

**By train:** Arriving at main station take subway U2, direction Flughafen (airport). Exit the subway at station Herrnhütte and

take bus no. 22 or 23 heading for Nordostpark. Exit the bus at Nordostpark-Mitte.

**By plane:** Enter Subway U2, direction Röthenbach and exit at subway station Herrnhütte. Take bus no. 22 or 23 heading for Nordostpark-Mitte. A taxi ride from the airport takes approximately 15 minutes.

Fraunhofer IIS  
 Location Fuerth  
 Dr.-Mack-Straße 81  
 90762 Fuerth



**By car:** From the north: Follow freeway A3 until intersection Fürth-Erlangen. Change to freeway A73 heading for Nuremberg. Exit the freeway at Nürnberg-Fürth. Turn right onto Ludwig-Quellen-Straße and, at its end, turn left onto Kurgartenstraße. Turn right at the next intersection onto Dr.-Mack-Straße. After 200 m you will find us on the right-hand side.

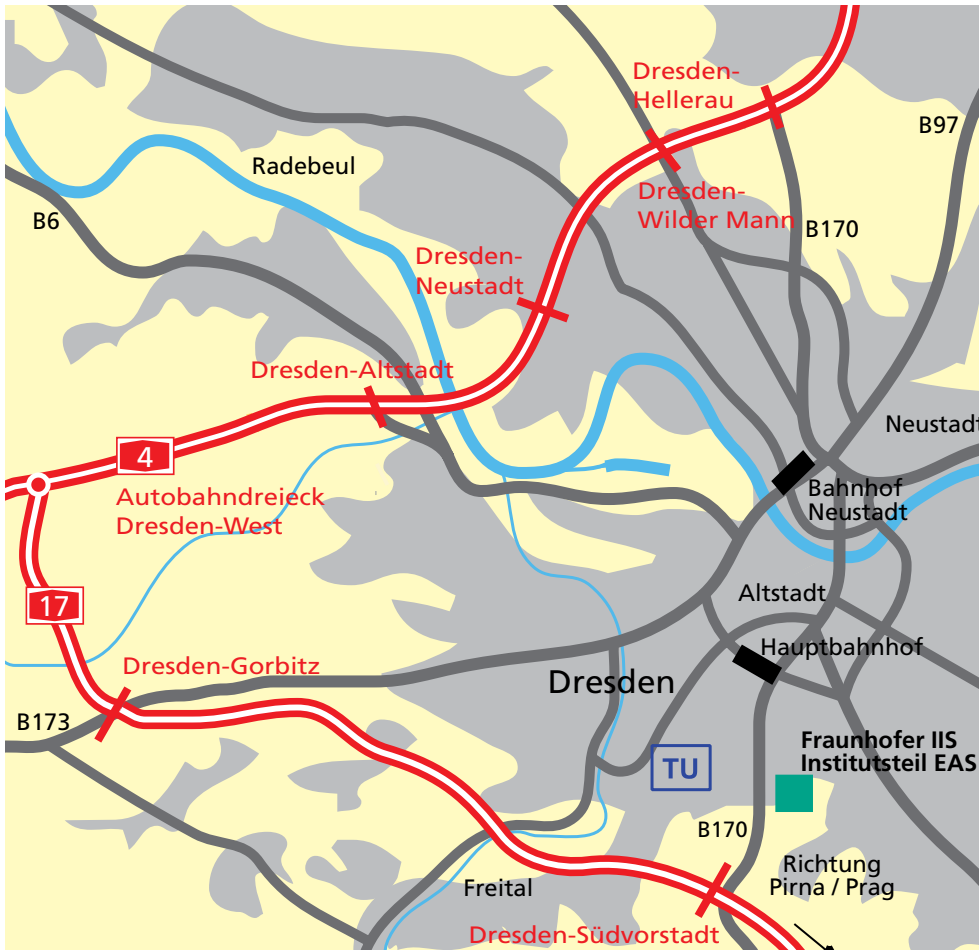
From the south: Taking freeway A6 or A9, change to freeway A73 at intersection Nürnberg-Süd respectively Nürnberg-Feucht in the direction Bamberg (Nürnberg-Centrum). At exit Nürnberg-Fürth turn right onto Nürnbergger Straße. At the next intersection turn right onto Ludwig-Quellen-Straße. For further directions see: "From the north".

**By train:** Arriving at Fuerth main station or Nuremberg main station take subway U1 to station Stadtgrenze. Exit

the subway station and cross Nürnbergger Straße. At the Aral gas station turn right onto Kurgartenstraße. At the second intersection turn left onto Dr.-Mack-Straße. We are located on the right in "Uferstadt" (approx. 7 minutes walking distance).

**By plane:** Arriving at Nuremberg airport take subway U2 heading for Röthenbach. At station Plärrer change to subway U1, direction Fürth Stadthalle. Exit the subway at station Stadtgrenze. For further walking directions see: "By train". A taxi ride takes approximately 20 minutes.

Fraunhofer IIS  
Division Design Automation EAS  
Zeunerstraße 38  
01069 Dresden



 Fraunhofer IIS  
Division Design Automation EAS

**By car:** Take the A4 freeway and continue until you reach the "Autobahndreieck Dresden-West" freeway junction. Turn onto the newly-built A17 freeway, heading towards Pirna/Prag. At the "Dresden-Südvorstadt" exit, drive onto the B170, following the "Dresden Zentrum" signs. Stay on this road (Innsbrucker Straße, then Bergstraße) for 2.8 km. At the intersection of Bergstraße and Zeunerstraße, turn right onto Zeunerstraße. After 300 meters, you will arrive at Zeunerstraße 38.

**By train:** Arriving at Dresden train station exit at east side and go to bus traffic junction "Am Hauptbahnhof". Take bus no. 72 destination Coschütz or bus no. 76 destination Mockritz. Get off at third stop at Mommenstraße (about 5 minutes). Cross Bergstraße B710 and turn onto Zeunerstraße. To reach Fraunhofer IIS at Zeunerstraße 38 is a five-minute walk from the bus stop. Alternative: Take a taxi, the Branch lab is located about 2 km from the main station.

**By plane:** Arriving at Dresden airport take a taxi or the S-Bahn (suburban commuter railway system) for the 15 km to Fraunhofer IIS. Take the commuter railways until Dresden Hauptbahnhof (main station). For further directions please see "Arriving at Dresden train station".



## Editorial Notes

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