Fraunhofer IIS

Fraunhofer IIS locations

Dresden

Ilmenau

Coburg

Bamberg

Würzburg

Waischenfeld

Erlangen

Fürth

Nürnberg

Deggendorf

FRAUNHOFER INSTITUTE FOR INTEGRATED CIRCUITS IIS | HIGHLIGHTS 2014 ANNUAL REPORT

JOSEPHS®
DIE SERVICE-MANUFAKTUR

INNOVATIV
KOMMUNIKATIV
KOOPERATIV

ENTDECKE
DEINEN CUBE

WERKSTATT
DENKFABRIK
GADGETSHOP

DIENSTLEIS-
TUNGEN &
SERVICES
LÖSUNGEN

OFFEN
KREATIV
INTERAKTIV

HIGHLIGHTS
2014
ANNUAL REPORT

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ANNUAL REPORT

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C O N T E N T S

»As an institution devoted to applied research, we are at the forefront of technological innovation, striving to be a catalyst for tomorrow's technologies and applications.«

Excerpt from the Fraunhofer IIS mission statement

YOUR COMPANIONS ON A NEW JOURNEY

Ladies and gentlemen,

It should come as no surprise that being innovative is a top priority for a research institution such as the Fraunhofer Institute for Integrated Circuits IIS. We strive to go further because we shape tomorrow – today. Let us accompany you on this new journey.

In the course of our work in 2014, we once again met with new challenges, new partners, new projects and new successes.

One special event in 2014 was the opening of JOSEPHS®, a new service outlet that we have established in the city center of Nuremberg. It is a place where companies can test the acceptance of their products and services even before they are launched on the market, thus enabling customer requirements to be taken into account at the development stage.

Our research campus in Waischenfeld, which was established at the end of 2014 and will be officially inaugurated in 2015, is another example of our innovative approach to collaborative research. It provides an environment where our researchers can continue working with customers and project partners, and also serves as a place where our research teams can spend a few days concentrating on specific projects.

Despite all these changes, progress and new openings, I still believe that the way forward for our institute is to build on our core competencies as one of the world's leading applied research organizations for system solutions and services in microelectronics and IT. This will enable us to continue offering sustainable solutions based on sophisticated technology that our customers can use to their advantage in both national and international markets.

I invite you to join us as we continue to explore all avenues that allow us to exercise our strengths in this endeavor – several are described in this Annual Report for 2014.

Yours sincerely,

Prof. Dr. Albert Heuberger, Director of Fraunhofer IIS

FACTS AND FIGURES

THE GLOBAL FRAUNHOFER NETWORK

Glasgo
Dubli

Porte

Boston

East Lansing

Plymouth

Storrs

San Jose

Newark

Boulder
Creek

College Park

*Fraunhofer's locations
around the world*

São Paulo

Santiago

ON-SITE WO

Gothenburg

ow
n

Munich

Brussels Vienna

Bolzano Graz

o

Beijing Seoul Tokyo

Osaka

Cairo

Dubai

Bangalore Selangor

Jakarta

RLDWIDE

FRAUNHOFER IN GERMANY

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

At present, the Fraunhofer-Gesellschaft maintains 66 institutes and research units. The majority of the nearly 24,000 staff are qualified scientists and engineers, who work with an annual research budget of more than 2 billion euros. Of this sum, around 1.7 billion euros is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 percent is contributed by the German federal and Länder governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

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

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies, and helping to train the urgently needed future generation of scientists and engineers.
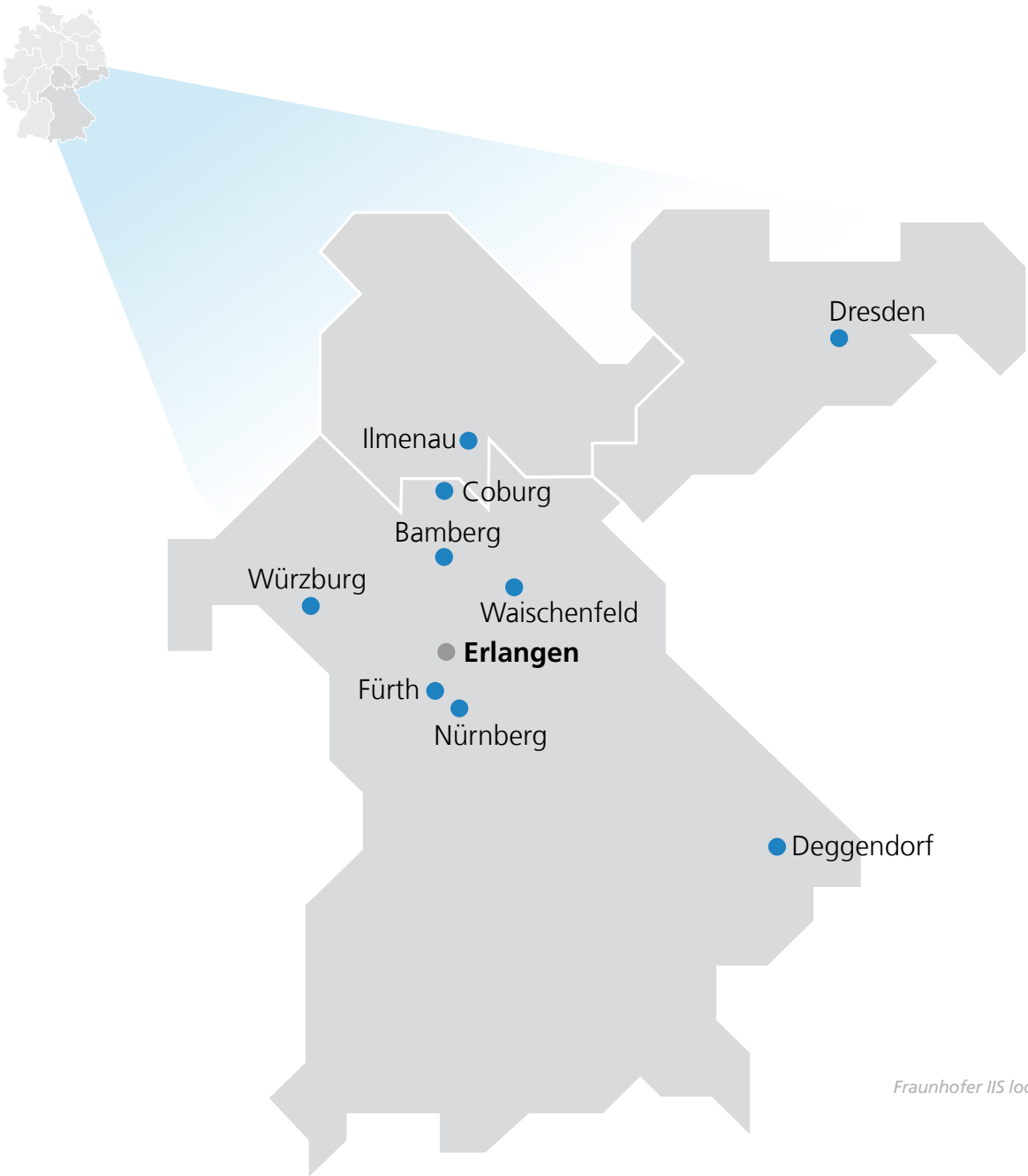
As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry and in society. Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

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

www.fraunhofer.de

Main locations ●
Other locations ○

Itzehoe ●
Rostock ○
Lübeck ●
Stade ○
Bremerhaven ●
Hamburg ○
Oldenburg ○
Bremen ●

Wolfsburg ○
Berlin ●
Hannover ●
Potsdam ● Teltow ● Wildau ○
Braunschweig ●
Lemgo ○
Magdeburg ●
Goslar ○
Cottbus ○
Gelsenkirchen ○ Münster ○ Paderborn ○
Halle ●
Schwarz-heide ○
Oberhausen ● Dortmund ● Göttingen ○
Schkopau ○
Leipzig ●
Duisburg ● Schmallenberg ●
Leuna ○
Willich ○ Kassel ●
Dresden ● Zittau ○
Köln ○
Jena ●
Freiberg ○
Aachen ● Sankt Augustin ●
Erfurt ○ Hermsdorf ●
Chemnitz ●
Euskirchen ● Gießen ○
Ilmenau ●
Wachtberg ●
Remagen ○ Frankfurt ○ Hanau ○
Alzenau ○ Coburg ○
Mainz ○ Aschaffenburg ○
Darmstadt ● Sulzbach ○
Bamberg ○ Bayreuth ○
Kaiserslautern ● Wertheim ○
Würzburg ● Erlangen ●
St. Ingbert ● Mannheim ○
Fürth ○ Sulzbach-Rosenberg ○
Saarbrücken ● Nürnberg ○
Karlsruhe ● Pfinztal ●
Regensburg ○ Straubing ○
Ettlingen ● Esslingen ○
Stuttgart ●
Deggendorf ○
Augsburg ○ Freising ●
Garching ●
München ●
Freiburg ●
Weßling ○ Rosenheim ○
Kandern ○
Holzkirchen ● Prien ○
Efringen-Kirchen

The Fraunhofer-Gesellschaft currently operates 66 institutes and research units in Germany.

EARCH OF
CTICAL UTILITY

14

Dresden

Ilmenau

Coburg

Bamberg

Würzburg

Waischenfeld

Erlangen

Fürth

Nürnberg

Deggendorf

Fraunhofer IIS locations.

FRAUNHOFER IIS
IN PROFILE

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 66 institutes and research units at locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of nearly 24,000, who work with an annual research budget totaling more than 2 billion euros.

The Fraunhofer Institute for Integrated Circuits IIS is one of the world's leading application-oriented research institutions for microelectronic and IT system solutions and services. It ranks first among all Fraunhofer Institutes. With the creation of mp3 and the co-development of AAC, Fraunhofer IIS has reached worldwide recognition.

In close cooperation with partners and clients the Institute provides research and development services in the following areas: Audio & Multimedia, Imaging Systems, Energy Management, IC Design and Design Automation, Communication Systems, Positioning, Medical Technology, Sensor Systems, Safety and Security Technology, Supply Chain Management and Non-destructive Testing.

About 880 employees conduct contract research for industry, the service sector and public authorities. Founded in 1985 in Erlangen, Fraunhofer IIS has now 13 locations in 10 cities: Erlangen (headquaters), Nuremberg, Fürth, Dresden, further in Bamberg, Waischenfeld, Coburg, Würzburg, Ilmenau and Deggendorf. The budget of 120 million euros is mainly financed by projects. 23 percent of the budget is subsidized by federal and state funds.

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Range of services

RESEARCH AND DEVELOPMENT

LICENSING OF TECHNOLOGIES AND SYSTEMS

CONSULTING AND PROJECT SUPPORT

MARKET STUDIES

FRAUNHOFER IIS – WORKING FOR YOUR FUTURE!

FRAUNHOFER IIS – YOUR PARTNER

Range of Services

We develop, implement and optimize processes, products and equipment until they are ready for use and for the market. Flexible interlinking of expertise and capacities enables us to meet extremely broad project requirements and complex system solutions.

Service which Meets Requirements

Companies of all sizes in the industrial and service sectors benefit from contract research. Fraunhofer IIS represents an important source of know-how for small and medium-sized companies that do not maintain their own R&D departments. For our customers in industry we develop and optimize technologies, processes and products right up to the production of prototypes and small batch series.

Technology and System Licensing

We make the results of our research activities available to industry, either as patents or licenses.

Achieving Success Together

We collaborate with our customers to get their projects off the ground and support them during implementation. You can come to us for advice on technology questions, to help you improve individual work processes or to commission us to develop your product from start to finish. We assess your requirements, select the suitable technology and carry out commercial and technical feasibility studies. Based on the overall results, we offer you guidance to help you make investment decisions. In addition, we support you in implementing the new technology and help you to successfully realize your applications.

Studies

With Fraunhofer IIS you can determine the potential, the application areas and the challenges for your project or your new technology. In the run-up to any research collaboration, we advise our customers on custom-designed studies, feasibility and acceptance studies, market observations, trend analyses, and profitability calculations.

KEY FIGURES

Despite crises in Europe and around the world, 2014 was a very successful year for the German economy. The positive economic situation was also reflected in companies' willingness to innovate, which meant that 2014 was also a successful one for Fraunhofer IIS: The number of job positions rose by more than 6 percent to 830 and the operating budget rose by over 7 percent to approximately 116 million euros.
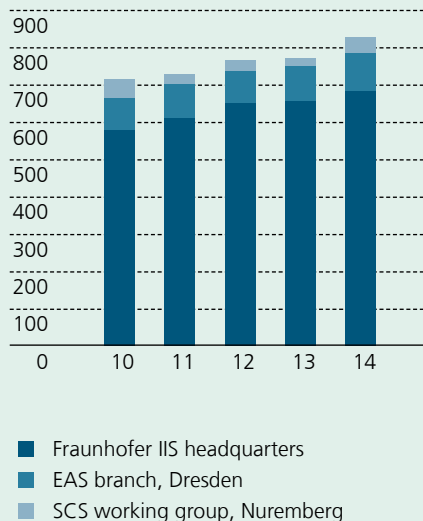
Human resources

In 2014, Fraunhofer IIS had 830 positions (full-time equivalents) on the payroll. Since numerous employees held part-time positions and there were a great many student interns, the actual number of employees was much higher. As an employer, the institute has to contend with fierce competition from industry to attract highly qualified scientists and managers. Fraunhofer IIS has the advantage of having an excellent reputation – the Fraunhofer-Gesellschaft regularly performs very well in surveys of European employees. In addition, Fraunhofer IIS provides a superb range of opportunities for further training and ways for employees to achieve a successful work-life balance.

Take the "Mit-Kind-Büro" that was introduced in 2014; this makes it possible for employees to bring their children with them to work should arranged childcare fall through.
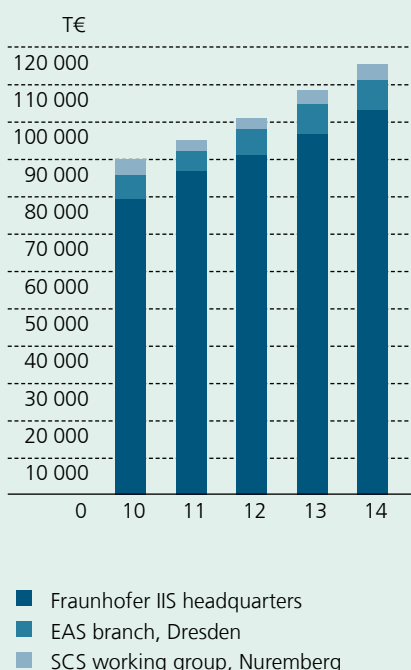
Operating budget

The operating budget rose by more than 7 percent to over 116 million euros in 2014, with the Working Group on Supply Chain Services (SCS) experiencing particularly strong growth. The main reason for this was the reintegration of the Fraunhofer IIS SCT department into the working group. Some growth can be attributed to the opening in May of the new JOSEPHS® service manufactory in Nuremberg.

Human resources 2010–2014

- ■ Fraunhofer IIS headquarters
- ■ EAS branch, Dresden
- ■ SCS working group, Nuremberg

Operating budget 2010–2014

- ■ Fraunhofer IIS headquarters
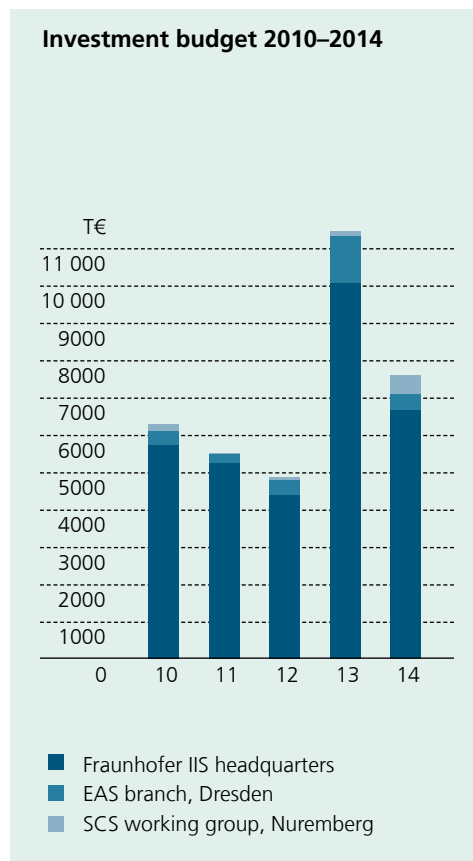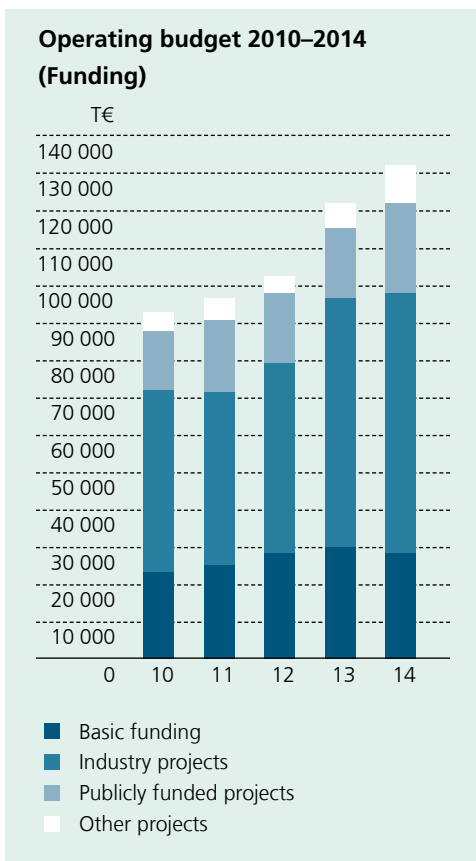- ■ EAS branch, Dresden
- ■ SCS working group, Nuremberg

A significant portion of the investment in JOSEPHS® was made in 2014 and getting the project off the ground resulted in higher personnel and rent costs. Conversely, there was a rise in revenue thanks to companies using JOSEPHS® as a service platform.

The institute's overall funding in financial year 2014 was based on the Fraunhofer model and can be broken down as follows: 23 percent from the Fraunhofer-Gesellschaft's basic funding, 58 percent from revenues from commercial and industrial projects, and 19 percent from public and other sources. Given the present volume of contracts, Fraunhofer IIS expects to balance its operating budget for 2015, as in previous years.

Investment budget

Capital expenditure of over 11 million euros made 2013 an exceptional year. However, the approximately 7.6 million euros of funding in 2014 was still above average compared with recent years. In addition to the aforementioned investment in JOSEPHS®, Fraunhofer IIS is in the process of constructing a combined laboratory and office building at its Nuremberg location as well as the Fraunhofer Research Campus Waischenfeld. As the institute grows (presently 10 locations), so do the expenditures for IT security, computers, software and top-quality design software in conjunction with a powerful network.

Operating budget 2010–2014 (Funding)

T€

- Basic funding
- Industry projects
- Publicly funded projects
- Other projects

Investment budget 2010–2014

T€

- Fraunhofer IIS headquarters
- EAS branch, Dresden
- SCS working group, Nuremberg

ADVISORY BOARD

The Advisory Board supports the administrative bodies of the Fraunhofer-Gesellschaft and the institute directors, and helps to forge contacts with industry and related organizations.

Members of the Fraunhofer IIS Advisory Board

From left:

Dr. Bernhard Grill

Frank Treppe

Dr. Keith Ulrich

Dr. Alexander Tettenborn

Dr. Peter Schneider

Jürgen Beuthner

Dr. Ronald Mertz

Dr. Beate Rauscher

Prof. Dr. Albert Heuberger

Jürgen Weyer

Dr. Dietmar Schill

Prof. Franz Kraus

Dr. Marc Steckling

HIGHLIGHTS

AT YOUR SERVICE

Services can be the key to success – online and offline. You just have to know how. At JOSEPHS® – the Service Manufactory, small and medium-sized companies in particular have been testing co-creation products and multichannel sales avenues for new marketing and service concepts since May 2014.

Let's imagine for a minute that you've got an idea for a new service, or you've almost finished your proto- type and are looking for the best and fastest way to bring it to market. Where do you start? Are you going to carry out or commission a market study? Are you going to open your own online shop? Or rent a bricks-and-mortar store? These days, such options are available to successfully develop complex com- binations of products and services. Many users and buyers have become "prosumers" professional con- sumers who expect certain services when buying a product – services like consulting, customer support, getting to co-create unique and distinctive products. So how do you know what it is exactly that your customers want?

Many online businesses possess a wealth of detailed information about their customer base. They involve their customers in developing or designing their offerings. Offline companies, too, are reporting that introducing new production and marketing models can be a successful move. Using combi- nations of online-offline offers, concept stores and special sales events, stores are becoming places where people like to go to meet others and experience something new. They buy from such stores because they feel comfortable there.

A hybrid approach for bridging the offline-online divide

Many of today's successful business concepts take a hybrid approach. They provide services that fit the product while simultaneously pooling the strengths of the offline world and the Internet. While a growing number of online companies are encouraging their users and customers to join virtual communities or idea competitions to take part in develop- ment, there is a shortage of real places that enable collabora- tion at an early stage.

JOSEPHS® is one of these rare places where users and customers are free to co-create. Opened in May 2014, this store in the center of Nuremberg is named after Joseph von Fraunhofer, who achieved equal measures of success as a scientist, an in- ventor and an entrepreneur. He would surely have approved of a place where companies could test their products and services in new ways.

"Short development cycles are standard at many companies. But when it comes to services, or combinations of products and services, these kinds of development processes are much harder to design. Since users and customers are factors in whatever service you're planning to offer, it's essential to do as much as possible to incorporate social and human aspects into development," says Frank Danzinger, deputy managing director of the Fraunhofer IIS Center for Applied Research on Supply Chain Services SCS.

JOSEPHS® is a unique place for co-creative market research and solution development

JOSEPHS® provides an environment in which research find- ings related to open innovation and co-creation can be tried out in practice. The most unusual feature of this initiative is that developments are not tested in the laboratory and cus- tomer needs are no longer blindly incorporated into products without first being filtered.

The JOSEPHS® project is managed by the Fraunhofer IIS Center for Applied Research on Supply Chain Services SCS in collaboration with the Friedrich-Alexander University of Erlangen-Nuremberg. In alternating three-month test cycles, guest participants have the opportunity to help shape the de- velopment, launch and marketing of the concepts. Based on these findings, and with the support of advanced Fraunhofer technologies and methods (such as awiloc® and SHORE™), companies can obtain direct feedback from users and poten- tial customers as early in the process as possible. This data- based method limits the risk to existing markets and stores.

Danzinger comments: "We know that many new products fail to find a market – and the success rate of product-service bundles or pure service packages is even lower.

The service sector is a particular challenge because in this case user preferences and customer experience have a direct impact on sales. This makes it difficult to develop products solely in experiments and closed laboratory environments. It is precisely for this reason that the JOSEPHS® project was launched. It has since received two awards, including the FAMAB Award 2014 for "Best Store Design" in November 2014 and the high-tech service know-how transfer prize in the "economic policy concepts" category on December 1, 2014.

WANT TO KNOW MORE ABOUT JOSEPHS®? FIND THE ANSWERS HERE.

What does JOSEPHS® offer for me?

You will be allocated space in an open workshop that allows you to test your products and services for a period of three months. Beforehand, IIS experts will help you define what you need in terms of customers and solutions, and design a suitable environment in JOSEPHS®. This includes access to the entire infrastructure including the emotion detection system SHORE™, awiloc® location technology, and the support and monitoring skills of our on-site personnel. Moreover, you will be able to draw attention to your services by participating in think tank events. At the end of the three-month period, you will receive an analysis of your data accompanied by suggestions for improvements.

What is meant by an interaction island?

An interaction island is a research environment at JOSEPHS® where you can work on your questions and solutions. Measuring between 10 and 30 square meters, it can be used in various scenarios. In addition to the appropriate furniture, an interaction island also includes multimedia devices and a multi-client cash register system.

What is the purpose of the think tank?

The think tank provides a space for workshops and other events where, for instance, you can invite members of the public to discuss specific subjects or hold workshops to present your ideas. In addition, the think tank organizes "Open Think Tank," a series of free public lectures. This gives people an opportunity to learn about some of its exciting new ideas, which might serve as inspiration for future developments.

How are ideas evaluated?

Ideas are evaluated in light of the questions you are exploring in your particular development process. On a quantitative level, this involves analyzing the data collected using awiloc® and SHORE™ technologies. You will also receive data logged by our staff, who accompany the visitors, ask them questions and observe their behavior right up to the purchase decision. Visitors to the islands can also use feedback or voting boards or questionnaires to provide their own comments and suggestions. The relevant tools are applied in accordance with the R&D subject in question. In this way, you can be assured of receiving data that has been systematically collected and prepared with the evolution of your services in mind.

What is the benefit for me?

By using JOSEPHS®, you can directly involve your customers in your development and testing processes. The resulting data are rich in information because they are derived from direct and intensive interaction with your products, services and solutions. JOSEPHS® offers an environment that corresponds closely to real-life operating scenarios, which distinguishes it from the more conventional market survey approach. Moreover, the JOSEPHS® approach limits the risks normally associated with development projects, reducing the probability of failure when the product is commercialized as well as increasing market acceptance of the developed solutions and services. This is of particular advantage to small and medium-sized businesses, as JOSEPHS® can provide them with greater visibility and facilitate access to users and potential customers.

Why should I join the JOSEPHS® community?

There are many reasons for choosing JOSEPHS® as a development environment. Perhaps you want to test ideas for a concept store to serve as a retail outlet for personalized lifestyle products or prototypes of new products. Or maybe you are looking for a risk-free way of deciding whether your online site can be converted into a bricks-and-mortar business, and you need reliable data to negotiate with investors. Or then again, you might want to review your product portfolio on the basis of feedback from employees and customers, in order to identify potential areas for improvement. This type of feedback analysis can also be used to test the subjective response to products, packaging and services prior to their market launch. You can also invite customers to provide input on issues affecting your future business objectives; for instance, modular cell-phone design or quadcopter delivery. The platform also allows you to build up communities of interest and expand your media exposure. Experience has shown that it is beneficial to involve end users at an early stage in innovation and design processes, when you need to collect information on their requirements, but also in later phases where the emphasis is on fine-tuning solutions or adding supplementary features.

What makes JOSEPHS® so special?

JOSEPHS® is a laboratory that doesn't feel like a laboratory at all – a place for exploring customer behavior and acceptance in a co-creation approach. JOSEPHS® addresses all types of customers, who can visit during usual shopping hours from Monday to Saturday. Specific panels or focus groups are needed only in special cases. As far as possible, we avoid the use of obtrusive technical gadgets such as eye trackers because their presence can distort visitors' natural behavior when trying out the offered services and products. Starting in spring 2015, JOSEPHS® will offer a way to involve a more widely based online community to take part in its studies, thus extending the reach of the development environment.

In what way do the researchers support this project?

As a participant in the JOSEPHS® initiative, you become part of a research and development project. Before being allocated space in the store, we meet with your experts to identify the driving forces behind the issues that your company wishes to explore and reproduce them in the appropriate environment or interaction island for testing. Throughout your residency in our store, and in the months that follow, we will analyze the collected data and observations. Our findings will be evaluated with respect to the original purpose of the project, taking into account any additional issues identified during the test phase, such as process improvements. These results will be communicated in the form of recommended actions, such as modifications to the product design or suggested areas in which technological support might be relevant.

In what way have other companies benefited from this support?

Thomas Fickert, CEO and founder of the DEXPERIO Group: "We develop solutions and products to help bricks-and-mortar companies compete successfully against rivals in e-commerce. But people need to actually see them working and gain hands-on experience in order to find out how they function. In this respect, JOSEPHS® is precisely the right presentation platform for us. It allows us to gather feedback – both from potential customers in the retail sector and from consumers – without having to invest a great deal of time and effort."

Thomas Harmes, managing director of mifitto GmbH: "It has already exceeded my expectations. I'm delighted that the facilities and services offered by JOSEPHS® have proved to be so popular. We have already used some of the findings to make our product even more user-friendly."

Sabine Linz, from online jewelry store amoonic: "JOSEPHS® has provided us with plenty of information that we can use to imagine what future jewelry stores might look like, how to

organize our offering online and offline, and how to meet our customers' personal jewelry requirements."

What is the benefit for Fraunhofer IIS?

JOSEPHS® is operated by the Fraunhofer IIS Center for Applied Research on Supply Chain Services SCS, part of the Fraunhofer Institute for Integrated Circuits IIS, in collaboration with the Institute of Information Systems at Friedrich-Alexander University of Erlangen-Nuremberg. Its purpose is to research new services to optimize the value chain, test the technical and commercial viability of ideas for services, and help established companies and start-ups to implement their new services.

The collaboration serves to answer questions concerning the systematic development of innovative services and solutions, and investigate issues such as prototyping, productivity and professionalization. Special emphasis is given to the use of modern information and communication technologies in the service sector. The main focus of this research lies on the innovation process for combinations of products and services, or so-called hybrid solutions.

Over the medium and long term, JOSEPHS® itself is pursuing a clearly defined business strategy and orientation. In its current status as a publicly funded prototype, the declared aim is to refine the concept in order to assure its economic viability in the medium term, and to consolidate its presence as a feature of the Nuremberg city center. ▪

1 *The think tank at JOSEPHS® – a customizable space for creativity in downtown Nuremberg.*

2 *Frank Danzinger, deputy managing director of the Fraunhofer IIS Center for Applied Research on Supply Chain Services SCS , demonstrates the options for applying technologies in JOSEPHS®.*

SHORT FACTS

How does SHORE™ work?
SHORE™ is a Fraunhofer technology for face recognition and emotion detection. This technology is available for use at JOSEPHS® in connection with certain types of research. SHORE™ makes it possible, for example, to tell whether someone is sad, surprised or happy, and can also determine a person's age and sex. The technology processes and edits the data, providing you with a means of evaluating the emotional response to your solutions.
www.iis.fraunhofer.de/shore

How does awiloc® work?
awiloc® is a location system developed by Fraunhofer IIS that enables mobile devices to determine their position in indoor environments using WLAN signals. Handheld devices equipped with awiloc® are handed out to people who visit JOSEPHS®, providing them with information about the companies it hosts. While serving as a guide, these devices also record the route the visitor takes, enabling data such as the time spent at different booths to be collected (see page 48).
www.awiloc.de

Where can I find more information about JOSEPHS®?
JOSEPHS® has its own website, providing information, a list of contacts and a schedule of current events at JOSEPHS®.
www.josephs-service-manufaktur.de

For more information about supply chain research, please go to: **www.iis.fraunhofer.de/supplychain**

CONTACT

Dr. Frank Danzinger, deputy managing director Fraunhofer IIS Center for Applied Research on Supply Chain Services SCS , Phone +49 911 58061-9527
frank.danzinger@scs.fraunhofer.de

SIMPLE SOLUTIONS FOR BETTER-QUALITY TELEPHONY

The speech quality of telephone calls has hardly improved in over 150 years. Telephone conversations frequently sound muffled and are often difficult to understand. New audio technologies co-developed by Fraunhofer IIS promise significantly improved sound quality for voice and video calls.

"Horses don't eat cucumber salad." A memorable sentence, uttered in Frankfurt in 1861 by Johann Philipp Reis as he demonstrated the world's first functioning electromagnetic device capable of transmitting speech over distance. He named his prototype a "telephone" and sold the device in large quantities all around the world as a scientific demonstrator. What began with cucumber salad has developed into a business worth billions. The telephone is an integral part of our modern, information-driven society. Yet speech quality has hardly improved in over 150 years. Telephone conversations still frequently sound muffled and are often hard to understand, making phone calls a tiresome experience. Hopefully this will soon be a thing of the past, as new audio technologies co-developed by Fraunhofer IIS promise significantly improved sound quality for voice and video calls.

HD everywhere

Today, we are surrounded by HD content: TV in full HD, and internet videos streamed in premium video and audio quality. Consuming HD content on smartphone high definition displays and over sound optimized headphones is something many consumers take for granted. But we seem just as ready to use our smartphones to make calls where the quality has more in common with the gramophone records of yore than it does with a 21st-century HD media experience. When you're confronted with loud background noise, foreign languages or unfamiliar accents, phone calls quickly become an ordeal. We have powerful smartphones that can record video in HD quality with CD like audio and the ability to play back more premium audio than a single person could listen to in their entire lifetime, but those same smartphones fail to recreate the sort of clarity in a conversation that will make you think you are in the same room as the person on the other end of the line.

The evolution of speech coding

The poor sound quality of telephone conversations is due to the use of speech codecs to relay the human voice. Speech codecs provide a compact representation of speech signals and are used today in almost every form of telephone communications, including mobile, internet and telephony. While audio codecs such as mp3 or AAC mimic how we hear, speech codecs model human speech, making it possible to efficiently store speech information and relay human voices while maintaining relatively good quality.

However, speech codecs do not have the ability to handle background noise, other people talking or music playing, which is why in these scenarios, the signals transmitted are heavily distorted or even incomprehensible.

One way to differentiate speech codecs is by audio bandwidth: Narrowband, wideband or super wideband. The most common is narrowband, which transmits signals at a maximum bandwidth of 4 kilohertz – in line with the original channel capacity of wired telephone lines, which was between 300 and 3400 hertz. Dependent on the age of the individual, humans are capable of hearing sounds ranging from 20 hertz to 20 kilohertz. Human speech contains signal fragments that go well beyond 10 kilohertz. Since more than three quarters of the audible spectrum of sound cannot be transmitted using narrowband techniques, telephone calls are often muffled resulting in poor quality. This makes it difficult to distinguish between certain consonants, for instance "f" and "s." Both consonants display a similar profile within the frequency spectrum, but the "s" phoneme is characterized by significant energy around the 10 kilohertz mark. Since this is not transmitted by the speech codec, distinguishing the sound can be challenging.

On the other hand, wideband can normally transmit signals of up to 7 kilohertz. Wideband is used primarily in the HD voice services and was most recently introduced by a selection of telephony providers. Doubling the audio bandwidth has a noticeable effect on speech quality, however, less than half of the audible spectrum is transmitted.

That's why there are now novel techniques capable of transmitting signals at 14 kilohertz and above. Super wideband – or fullband – is vital to achieving Full-HD Voice, where telephone calls attain the same level of quality we have come to expect from today's other digital services. It's not a quality you can guarantee with a simple speech codec, which is why Full-HD Voice solutions are either audio codecs optimized for communications systems or hybrid solutions that unite the worlds of audio and speech encoding in a single system.
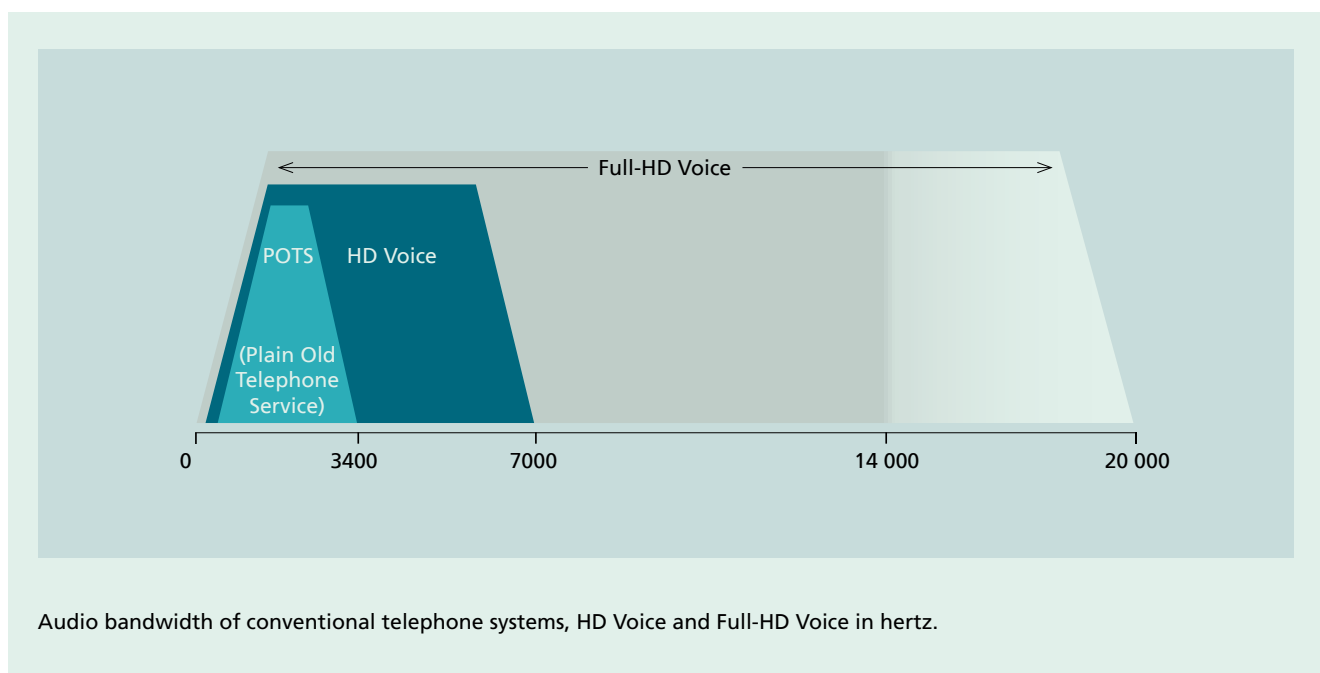
Full-HD Voice with AAC-ELD

IP-based telecommunication services already offer Full-HD Voice quality. To achieve Full-HD Voice quality, these services utilize the AAC-ELD codec, which is an open MPEG standard, and Fraunhofer IIS played an important role in its development. Thanks to the extremely low coding delay, low data rate and excellent sound quality, numerous providers have already opted to use AAC-ELD. For example, Apple uses AAC-ELD in its video telephony service FaceTime. FaceTime is available on virtually all Apple devices, including: iPhone, iPad and Mac.

AAC-ELD is also natively integrated in leading mobile operating systems iOS and Android. This gives other providers of video telephony services easy access to the audio codec as well.

Premium sound quality is expected in a business setting, therefore, providers of videoconferencing and telepresence systems are adopting Full-HD Voice where systems are employed. The majority of products are based on the TIP standard, which ensures interoperability among devices from different manufacturers. The TIP standard utilizes AAC-LD as the codec for relaying speech. AAC-LD is a member of the AAC-ELD family and offers a similarly high quality of sound given the bit rates employed.

Full-HD Voice and AAC-ELD play a critical role in radio, relaying phoned-in reports from journalists in the field to broadcast studios. Using these techniques makes it possible to broadcast reports live without a perceptible deterioration in sound quality, even if reports are received over poor-quality internet connections.

Audio bandwidth of conventional telephone systems, HD Voice and Full-HD Voice in hertz.

In other words, Full-HD Voice and AAC-(E)LD are already widespread, with hundreds of millions of calls already being made using software and systems that support these standards. That said, it is vital to make note that the most important area of telecommunications remains conspicuously absent: conventional mobile telephony.

Enhanced voice services for mobile telephony

Over-the-top (OTT) providers such as Skype and FaceTime, which offer telephony services via internet protocol (IP) without going through a local telecommunications provider, pose an increasing threat to the already established mobile telephony providers. Admittedly, these services are not as reliable as a regular telephone connection and often run into stability issues given the capacity of today's mobile data networks. However, these services are often free and offer significantly better speech quality. With the capacity of mobile data networks increasing in leaps and bounds, we can expect such services to become significantly more reliable. This has prompted a rush in the mobile telecommunications industry to catch up in terms of sound quality.

With the introduction of the fourth generation of cell-phone technology in the form of LTE, operators are reorganizing their networks for IP-based transmission. While solutions already exist for transmitting voice calls over the LTE data network (VoLTE, voice over LTE), it will be the first time that regular cell-phone calls are delivered via IP connection, which is already often the case with landline telephone services. In order for standard cell phone conversations to offer speech quality comparable to over-the-top services, leading companies developed the Enhanced Voice Services (EVS) codec, which is set to revolutionize mobile telephony thanks to significantly improved speech and audio quality.

Twelve leading companies from the mobile telecommunications sector joined forces to develop the EVS codec, under 3GPP, the international organization for the development of mobile telecommunications standards. As a member of this consortium, Fraunhofer IIS was instrumental in the development of EVS. At the end of 2014, work was completed and presented as a new 3GPP standard. EVS is the first 3GPP codec with the ability to transmit the full audio bandwidth of 20 kilohertz perceptible by the human ear. EVS was developed specifically for packet-based systems such as VoLTE (voice over LTE) or VoWiFi (voice over WiFi).

"EVS WILL REVOLUTIONIZE MOBILE COMMUNICATIONS BY SIGNIFICANTLY IMPROVING SPEECH AND AUDIO QUALITY"

Numerous EVS functions were developed with this purpose in mind, including an integrated speech and audio codec, a source-based variable bit rate mode, automatic speech detection, an error masking mechanism, a special operating mode for degraded network conditions and powerful jitter buffer management technology. These functions make EVS extremely resilient to transmission errors such as jitter or packet loss, in addition to significantly boosting speech quality in mobile telephony.

The EVS codec also paves the way for new applications. For example, the improved sound quality could allow radio presenters to broadcast in radio quality from any location using their smartphones, without needing expensive and conventional studio technology. Cell phone users can benefit from the improved sound quality made possible by EVS to share experiences via cell phone, such as a concert performance, grandchildren singing happy birthday, or the chimes of Big Ben from the heart of London, all as if you were really there.

The future of telephony

You might say the future of telephony has only just begun. Soon we can expect cellphone calls to have the same feel as a conversation with someone in the same room. This is possible thanks to a revolution in the sound quality of telephone audio codecs, that Fraunhofer IIS has served an instrumental role in developing. In the future, mobile devices will be equipped with worldwide standards beyond mp3 and AAC that also have roots in Erlangen. The new standards will bring about critical improvements in sound quality. There is no doubt that Johann Philipp Reis would be thrilled, and perhaps amazed, to see and hear the advances of his "telephone" since the now famous comment about cucumber salad. ∎

HIGH-SPEED DATA TRANSFER OVER COPPER WIRES

A new high-speed link allows data to be transmitted using a ten-meter copper wire at a rate of 10 Gbit/s in real time. The electronic component is ideal for use in high-bit-rate data streaming applications such as driver assistance systems, high-resolution cameras, and multimedia applications in vehicles.
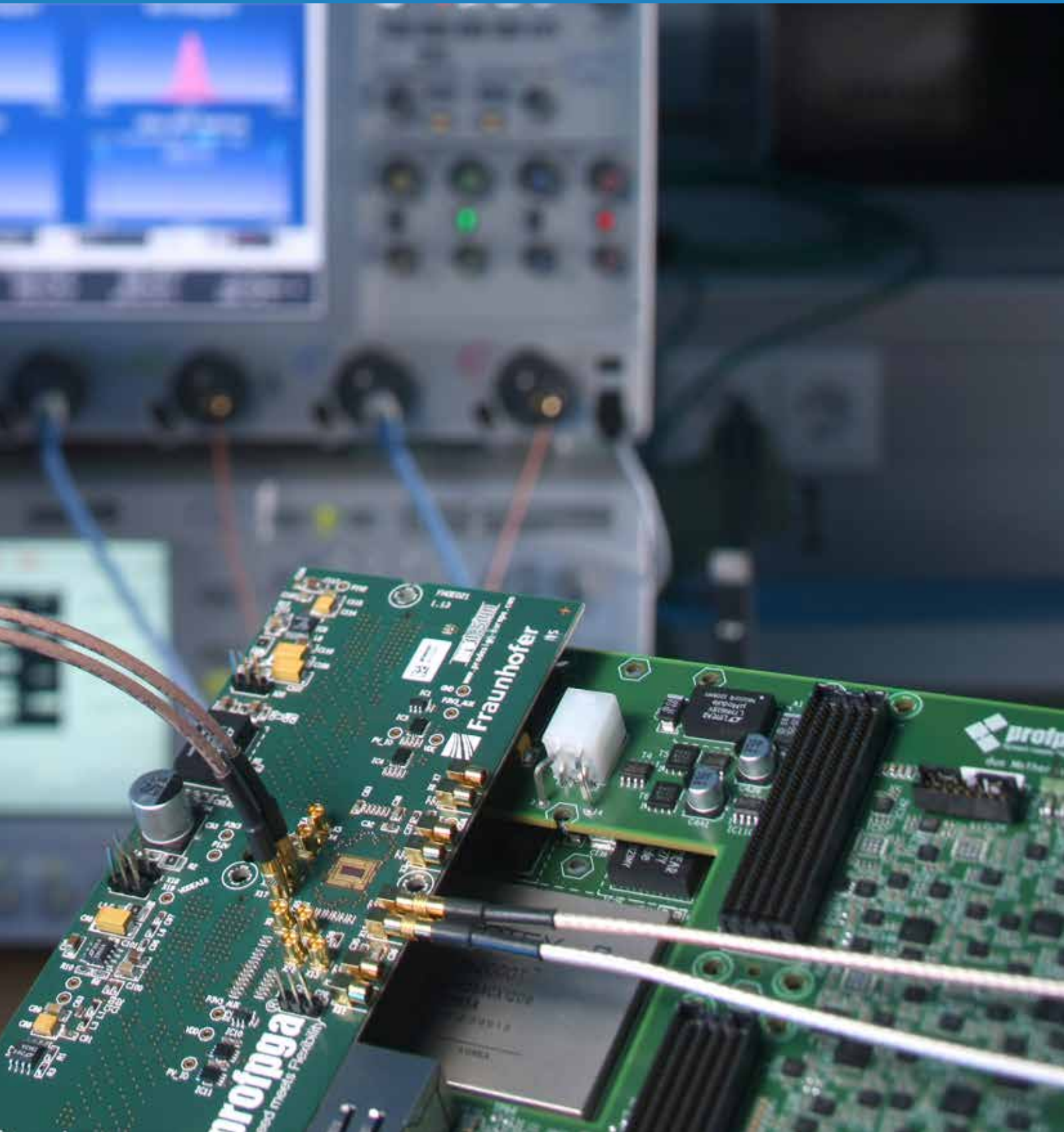
Driving has become simpler and safer: Navigation systems help us find our way; head-up displays project the tachometer or speedometer straight onto the windshield; driver assistance systems featuring multiple cameras help ensure safe and reliable transportation; and real-time image transmission enables drivers to spot dangerous situations in good time and react immediately.

Now driving can be made even easier. Imagine the driver relaxing while the car uses its camera-based assistance system to navigate through commuter traffic, while the passengers watch a sporting event live via Internet TV. Tomorrow's rolling sports studio will broadcast 4K images from every conceivable angle. And if you happen to have missed your favorite program, a recording will be streamed straight to the vehicle from the compact and energy-efficient data center. It all sounds simple, but presents developers with a significant challenge since such applications rely on reliable and high-speed data transfer.

10+ Gbit/s data link speeds up data transfer via cable

Infotainment and security-relevant control data are transferred concurrently and independently of each other over one and the same connection. These parallel applications call for a high data throughput over a simple and low-cost copper wiring harness that combines the advantages of low weight, minimal power consumption and short delays in data transmission.

"HIGH DATA THROUGHPUT WITH A SIMPLE AND COST-EFFECTIVE COPPER CABLE"

It's a challenge that Dr. Norbert Weber and his team eagerly accepted, developing a new broadband transmission system for high-bit-rate data streaming. A new high-speed link allows for data rates of 10 Gbit/s via twisted-pair copper cables. The system uses a twisted-pair cable of between

10 and 15 meters in length and consumes less than 1 watt per transmitter/receiver pair. What's more, the minimal time required to process the signals enables real-time video data for human-machine interaction. The development's universal design makes it possible to concurrently transmit a range of content with varying requirements, thereby merging connections that previously ran in parallel in a single data transfer cable.

The researchers can draw on years of broadband data transfer experience. Back in 2004, they teamed up with German semiconductor manufacturer Inova Semiconductors to develop systems that enable point-to-point data transfer at data rates of up to 1 Gbit/s via copper cable. This technology is branded as APIX (automotive pixel link) and has been successfully employed in series production for some years now by various automotive manufacturers. In 2009 this was followed by APIX2, featuring a data transfer rate of 3 Gbit/s – a technology now integrated in all of BMW's current models. Even so, constantly increasing data rates made it necessary to develop a 10+ Gbit/s data link, an undertaking begun in 2011 as part of a funding project under the leadership of Norbert Weber. "Already we can see the magic 10 Gbit/s on the horizon," said Roland Neumann at the time, as the head of development at Inova Semiconductors considered the needs of the automotive industry. But how is it that such quantities of data can be transferred over a single copper cable?

Equalizers compensate for the drawbacks of cable networks

If you're looking to transmit high-bit-rate signals over a simple twisted-pair cable, you soon run into the problem that these signals extend over an extremely wide range of fre-

quencies. However, twisted-pair cables are of only limited use for high frequencies, since attenuation soars with increasing frequency. The upshot is that the high-frequency portions of the signal are suppressed and that data bits sent along the cable are heavily distorted and subject to time spreading. By the end of the cable, all you have is a worn-out signal. There is also a significant spread of time delays, which ultimately results in transmission errors (bit errors).

To compensate for the poor transmission characteristics of the cable, analog equalizers and special filter circuits in the transmitter and receiver combine to generate an inverse property in the cable so that the final signal exhibits an extremely flat frequency curve. This allows the decision logic in the receiver to clearly reconstruct the signal transmitted. In practical terms, this means that a 3 Gbit/s signal such as that required by the APIX2 standard can be effectively transmitted using a 10-meter cable.
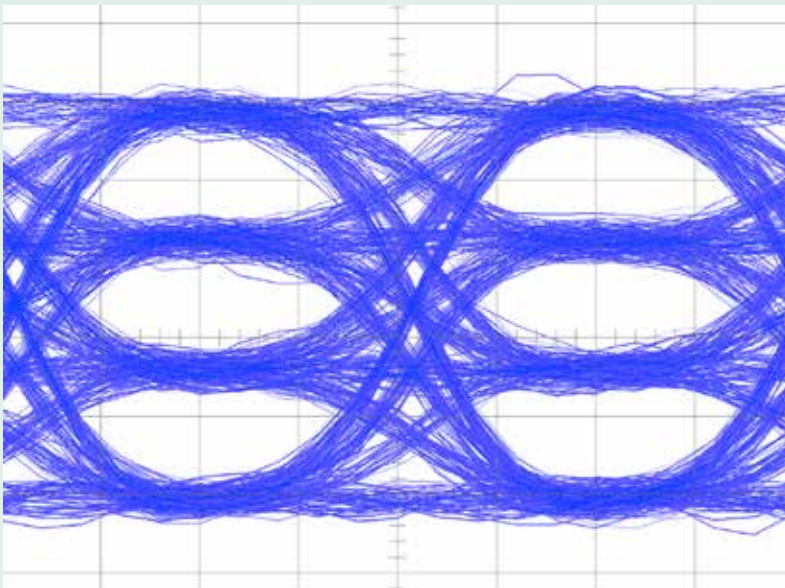
An eye diagram of the data transmission format employed, PAM4

How broadband data transfer works

At the heart of the technology is PAM4 modulation, whereby two bits rather than one are transmitted in a given time slot. This means that only half the bandwidth is required, allowing developers to keep using the same standard cable as before. To further improve the performance of the equalizers, the decision was also made to install digital-analog converters in the transmitter and analog-digital converters in the receiver. Equalization is now done digitally and can also be modified via the FPGA test platform.

10 Gbit/s calls for paradigm shift in technology

Many common twisted-pair cables have other undesirable features. Owing to the way the cable is made, there is a slump in the frequency response around the 3 gigahertz mark – i.e. a point at which there is a very high level of attenuation. A high-bandwidth signal can no longer be transmitted along such a cable. In order to transmit signals with a bandwidth of 10 Gbit/s, the scientists had to find another way (see page 39). In collaboration with IC designers, the Communications department at Fraunhofer IIS developed a waveform that takes up less bandwidth than the signal form used previously. The signal also has manageable requirements as regards CMOS technology – ultimately the entire circuit is meant to fit on as small a chip as possible and consume as little power as possible so that it can be used in a series product.

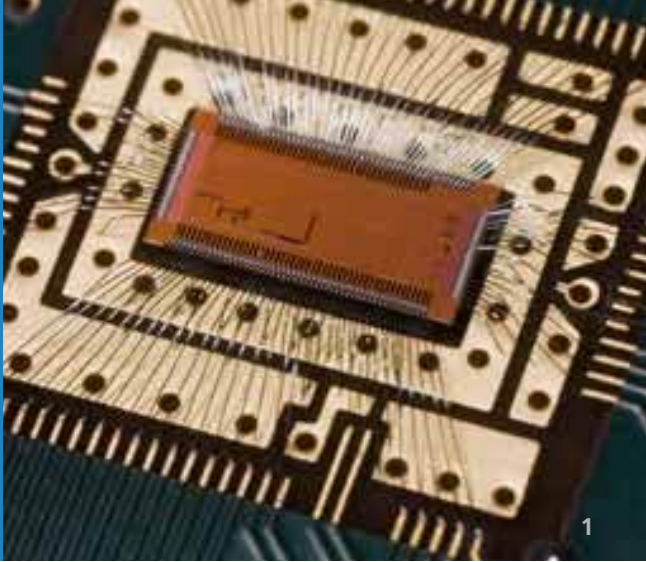**Diverse areas of application for 10 Gbit/s technology**

While relaying video signals has provided the main impetus for high data rates, other areas also have to deal with ever increasing amounts of data. At some point, every computer could have a 10 Gbit/s data interface – a project on which Apple has already embarked with its Thunderbolt interface. But to get from the computer to the local network, you have to bridge much more than the three meters that Thunderbolt currently offers. The same applies to networking server racks, an application which currently makes use of optical connections. An electrical copper-cable connection would be a significantly more flexible and cost-effective option.

Another potential application lies in the relay of broadband antenna signals from what the automotive industry calls smart antennas. This way, data no longer has to be transferred in analog mode – which is prone to errors – but can be converted into a digital signal directly at the antenna.
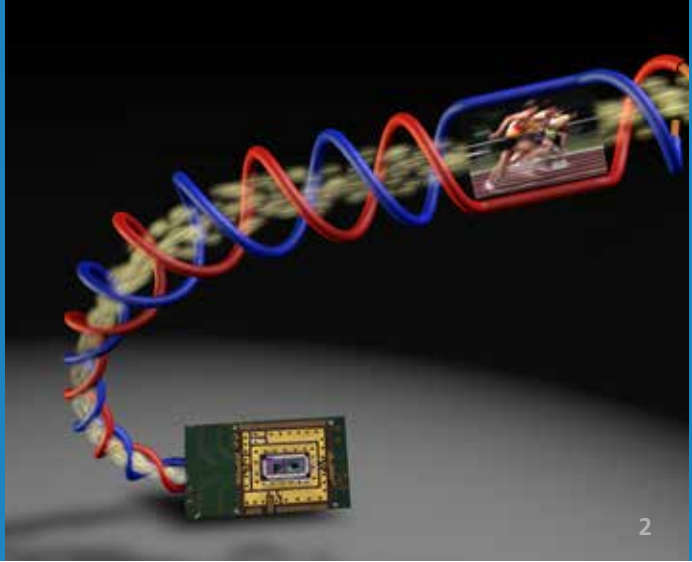
Medical technology has similar data transfer requirements. Take for instance an x-ray computer tomograph. Here, the high-definition x-ray images have to be transferred from the x-ray camera that revolves around the patient to a storage unit within the device. This means data rates of 10 Gbit/s and more. Professional camera systems also generate signals with extremely high bit rates since they operate in HD mode or at high speeds – sometimes both. As a result, camera interfaces also demand data rates over 10 Gbit/s.

Data rates of 12 Gbit/s and more in view

High-definition cameras and displays will drive up data rates far beyond those currently used in automotive applications. Accordingly, there are plans to achieve data rates of up to 12 Gbit/s in future applications, as the automotive industry is now demanding. Fraunhofer IIS is already working on the task. ∎

THE 10+ GBIT/S PHYSICAL LAYER

Features

– Transfer over twisted-pair copper cable
– Takes up less than three gigahertz bandwidth thanks to PAM4
  modulation
– Power dissipation for transmitter/receiver pair less than 1 watt
– Range of 10–15 meters

Areas of application

– Transmission of video signals for 4K displays
– Networking of server racks
– Signal transmission via smart antennas
– X-ray computed tomography

For more information on IC Design and Design Automation at
Fraunhofer IIS, please visit:
www.iis.fraunhofer.de/icdea

1 *IC with integrated sensor and
receiver electronics.*

2 *Efficient 10+ Gbit/s high-speed
physical layer for the next genera-
tion of video transmission.*

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MAKING THE INVISIBLE VISIBLE

Polarization is a quality of light that is imperceptible to the human eye – but not to a camera developed by Fraunhofer IIS: POLKA, a polarization camera, unlocks completely new possibilities for industrial quality control. The machine eye opens up a new dimension.
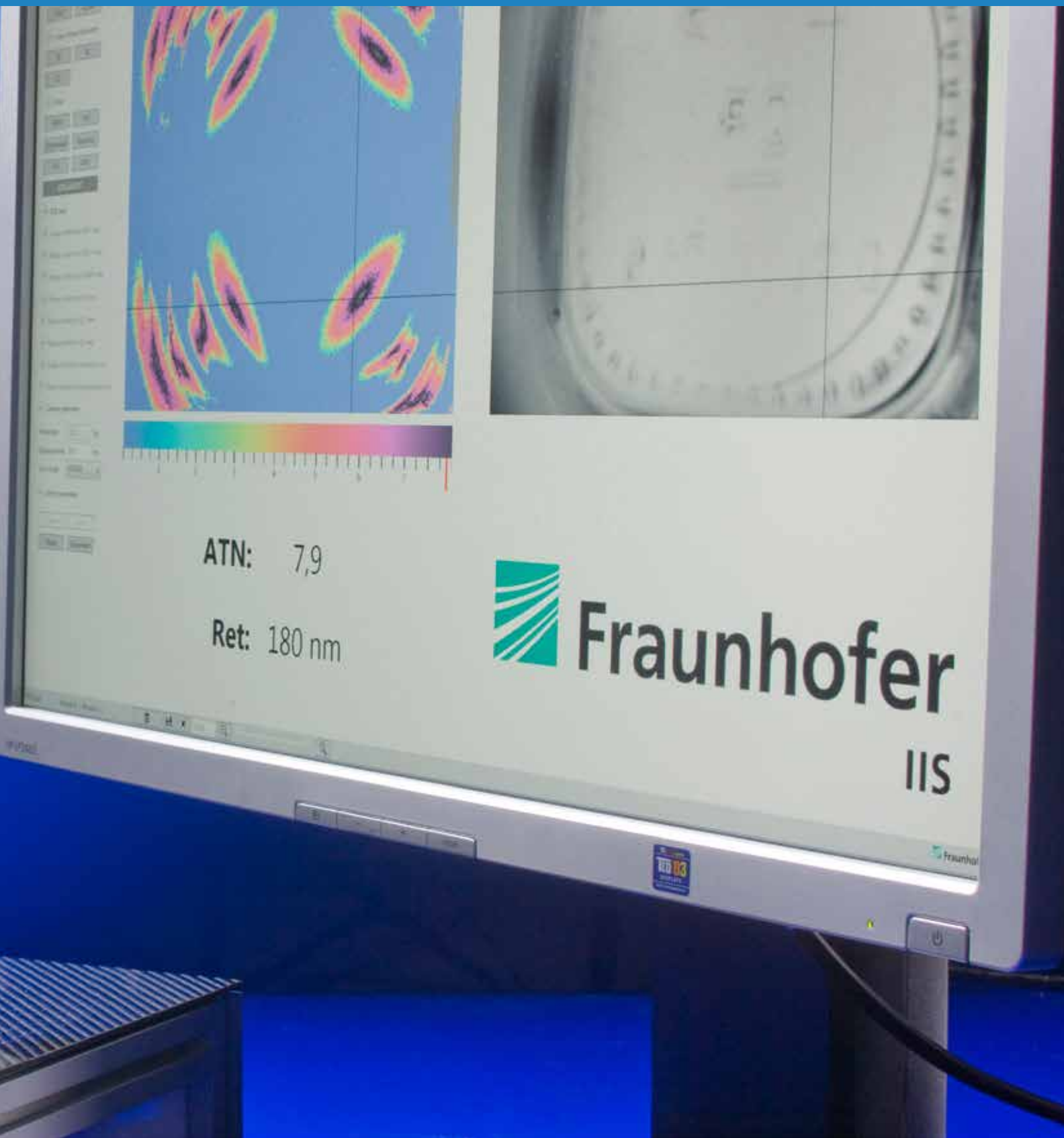
Clear glass appears transparent to the human eye, irregularities in plastics go unnoticed – but POLKA, the polarization camera developed at Fraunhofer IIS, sees it all. It uses polarization to uncover the invisible – which is just as well, since during the manufacture of glass products or bottles, residual stresses may remain in the glass containers. During the filling process or on the way to the consumer, they might then break due to the high stress. For other materials, for instance plastics, defects may creep in during production, making the material instable. What could previously only be examined through random checks can now be integrated into the manufacturing process using POLKA. It reliably detects stresses in glass in real time and can be used for quality control for many other materials. POLKA significantly cuts production costs by reducing the number of production rejects, saving energy in the process. POLKA also enables customers to see the fiber orientation within light construction materials such as carbon-fiber reinforced plastics, which is important because the fibers must be correctly aligned to create a stable end product. Together with his team, Arne Nowak, head of the Imaging Solutions Group, has developed the camera and is working on further refinements.

What is POLKA exactly?

Arne Nowak: POLKA is a polarization camera with which you can measure the polarization state of light pixel by pixel. Other methods require a series of images to evaluate an object. POLKA's sensor accomplishes the task in a single shot, because it obtains all of the necessary information at the same time from the filters distributed locally within the camera. Our Integrated Circuits and Systems colleagues worked with us on this.

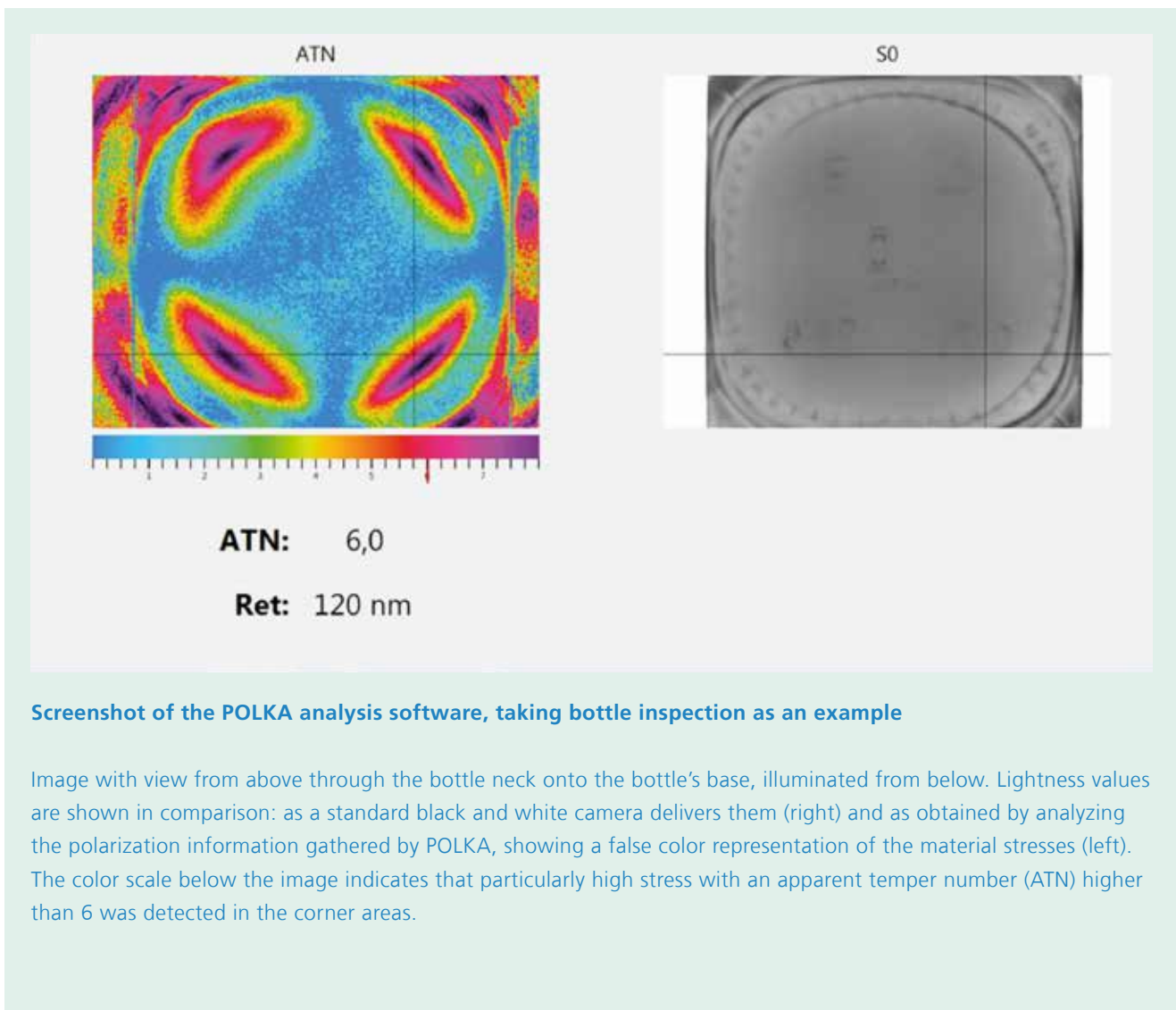**How does POLKA make polarization visible?**

Arne Nowak: The ingenious thing is in the image sensor. Basically, POLKA is built the same way as a normal camera – light passes through the lens onto the image sensor which then converts the light into electrical signals. These signals are then digitized, processed by the electronics and further processed or analyzed with software on the PC. The key difference with POLKA is the nanostructure of polarization filters mounted before each individual pixel, so that every pixel has its own filter. Four pixels form a pixel group, which contains polarization filters with four different orientations. Using algorithms to process this raw image, we can calculate the polarization state for each individual pixel. Currently, POLKA is designed for PC software to perform this analysis, that is, outside the camera. That keeps the camera flexible,

especially in the development phase. It would be possible to integrate the analysis directly into the camera of course, but it depends on the application area. That decision should be made according to the customer's requirements.

What sets POLKA apart?

Arne Nowak: Our polarization camera is very robust. It is designed for heavy-duty industrial applications, so it holds up well, especially against vibration. The image sensor principle is what makes this possible: with conventional constructions, there's a chance that the filter calibration may slip. POLKA's polarization filter is integrated directly into the image sensor, which means that, with respect to polarization, the camera is and remains perfectly calibrated.

Another decisive factor is that POLKA delivers data in real time. This means we can also record and measure moving objects without difficulty. As an example: during bottle inspection, the bottles travel continuously along the conveyor belt. POLKA is the perfect solution for this because stopping the belt would interrupt production and incur additional costs. We also made sure integrating POLKA into an existing system was as easy as possible. For image processing, for instance, commercially available accessories for conventional industry cameras also work with POLKA, such as a standard C-mount lens.

Screenshot of the POLKA analysis software, taking bottle inspection as an example

Image with view from above through the bottle neck onto the bottle's base, illuminated from below. Lightness values are shown in comparison: as a standard black and white camera delivers them (right) and as obtained by analyzing the polarization information gathered by POLKA, showing a false color representation of the material stresses (left). The color scale below the image indicates that particularly high stress with an apparent temper number (ATN) higher than 6 was detected in the corner areas.

So quality control in the glass processing industry is just one of the potential applications?

Arne Nowak: POLKA offers significant advantages for quality control in the glass processing industry in particular because glass cools inconsistently, especially for glass with large wall thicknesses, extreme curvature or fast cooling speeds. For this reason it's important to examine residual stress in glass.

Until now, inspection took place randomly. With POLKA, this test can now be integrated directly into the production line. This means every single bottle can be analyzed, so glass manufacturers can identify and respond to irregularities in the production process as quickly as possible. As a result, companies produce far fewer rejects and improve the quality of delivered products. And if the production chain is adjusted correctly, especially the lehr, the company also saves on energy.
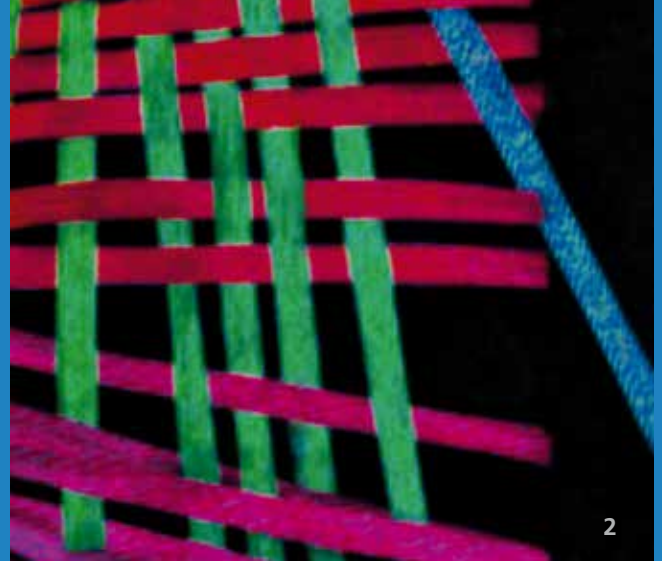
Identifying whether a product meets quality standards is an automatic process. Threshold stress values that may not be exceeded are set in advance. Then POLKA measures the residual stress in every single bottle, and the system weeds out any bottles that surpass the established values.

When it came to glass inspection, we had a reliable partner. Optical Inspection Systems Dr. Günther in Meerane, Germany, which markets optical inspection systems for glass bottles, has integrated POLKA into its machines. This is of course advantageous for us because we have an industrial production environment to use for testing. So we can develop outside of the lab too, in a specific industrial application that allows us to refine the system even more.

Are there other potential application areas for POLKA besides glass inspection?

Arne Nowak: In theory, POLKA could be used anywhere where products are subjected to quality control and where faults could be made visible using polarized light. Glass inspection is just one of many potential application areas. For instance, our camera is ideally suited for inspecting carbon-fiber reinforced plastics (CFRP components). The carbon-fiber layers are usually arranged crosswise over each other and laminated. An extremely stable component can be made from this wonderfully light woven fabric.

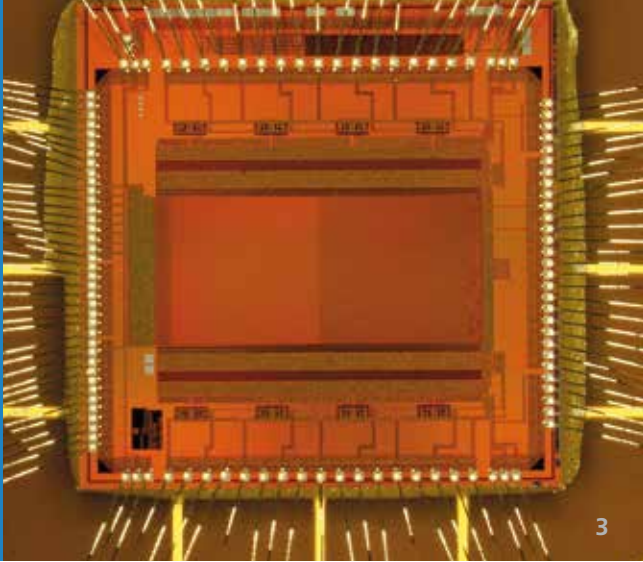## "AT POLKA'S CORE IS THE IMAGE SENSOR WITH ITS INTEGRATED POLARIZATION FILTERS"

Right now for instance, automakers are using CFRP components in electric vehicles because it's important to use components that are as light and stable as possible. The problem is that if the arrangement of the carbon fibers isn't up to par, component

stability is compromised. With POLKA, we can make the fiber orientation visible, and measure it too: by illuminating the woven fabric of carbon fibers, the light is reflected and the reflected light is polarized. POLKA lets us assess the fiber's orientation so we can determine the direction of the polarization. This gives companies the assurance that they really are producing high-quality components.

The medical industry is another potential application area. You could make different kinds of tissue visible using polarized light, for instance. Or you could identify foreign objects. Right now, we're researching how to use polarized light 3D imaging to measure drill holes by means of endoscopy. And there are possibilities for metalworking, too, such as examining metal surfaces for thin layers of oil or dirt.

My team and I are very hopeful that we will discover even more possible applications. Especially with the wide range of research topics that Fraunhofer IIS and the other Fraunhofer Institutes cover, the possibilities seem endless. ∎

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4

POLKA: MEASURING AND ANALYZING POLARIZED LIGHT

POLKA, the prototype polarization camera developed by Fraunhofer IIS, is a special camera designed to capture and measure the polarization state of light, pixel by pixel. Polarization is a quality of light that is imperceptible to the human eye.

Suitable for industrial use, the prototype polarization camera offers optimized control and special algorithms for analyzing sensor signals. The dedicated software controls the camera and visualizes the results. The hardware design can be modified to suit customer wishes and software can be enhanced to include task-specific image processing and evaluation algorithms for specific requirements.

POLKA offers the glass and plastics processing industry new possibilities for quality control and stress detection in transparent materials. It enables customers to see the fiber orientation within light construction materials such as carbon-fiber reinforced plastics, an important property affecting component rigidity. Other applications might include reflection suppression on non-metallic work pieces, tissue analysis for medical purposes and materials differentiation in general.

Find further information about the Imaging Systems research area here: **www.iis.fraunhofer.de/image**

1 Arne Nowak, head of the Imaging Solutions Group, developed the POLKA camera together with his team.

2 The angle at which CFRP fibers are arranged is made visible through the false-color representation of the reflected light's direction of polarization.

3 At the heart of POLKA is the image sensor with its integrated polarization filter.

4 POLKA: A special camera for imaging measurement using polarized light.

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MUSEUM APP 2.0

With awiloc®, site-specific services can be made available everywhere, whether inside or outside. Because awiloc® self-sufficiently locates mobile devices without having to exchange data with a central server, awiloc® enables an approved use of position information in line with data protection legislation. Mobile applications – known as apps – use awiloc® to navigate, inform and help users worldwide in cities, buildings and museums.
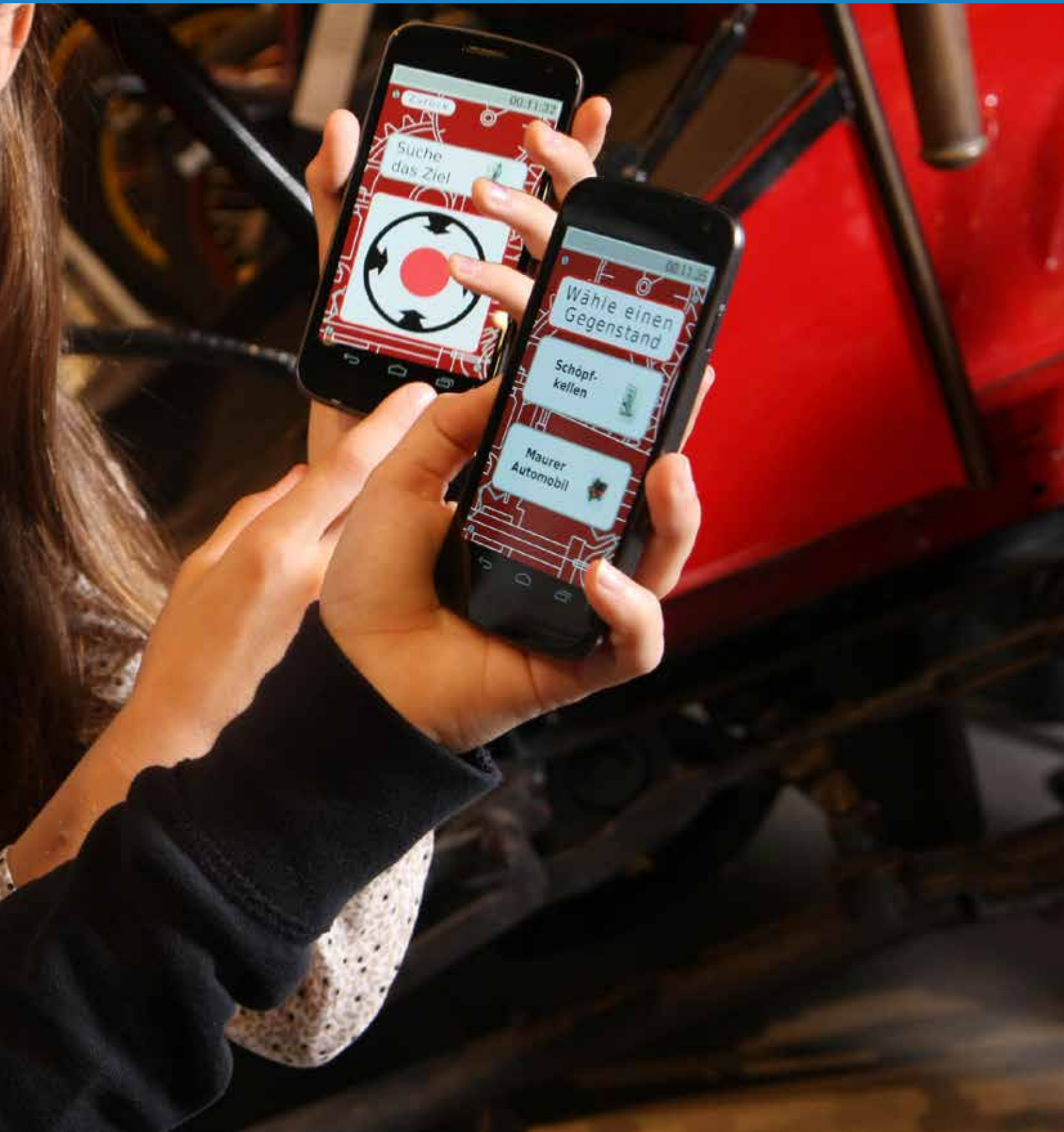
Aside from numerous apps for city navigation and public transportation, location-based services have also become an important part of the museum experience. Multimedia guides with awiloc® positioning add a whole new dimension to museum visits – offering visitors exactly the additional content they want in a direct and uncomplicated manner, just like a personal guide. This raises the bar for experiencing art, culture, technology and history. Inconvenient pushing of numbers or buttons is a thing of the past.

On the go with your own personal museum guide

In Germany and around the globe, more and more museums and app developers are relying on awiloc®. The Museum for Industrial Culture in Nuremberg, released the first multimedia guide with awiloc® in 2010. Since then, more than 20 international museums have adopted this positioning technology, including well known museums such as the National Maritime Museum in London, the Perot Museum of Nature and Science in Dallas or the State Museum of Egyptian Art in Munich. Their museum guides whisk visitors away into a virtual 3D world, thanks to Fraunhofer IIS and its partners, e. g. NOUS Wissensmanagement GmbH.

Access location-based services everywhere

In our mobile society, the availability of location-based services is becoming increasingly important to users. We expect GPS to show us the way when we're on the go, not only displaying estimated driving time and arrival time, but also indicating various points of interest, such as the next gas station or attraction. But the positioning capabilities of established GPS systems hit a road block in urban areas and in buildings because the signal is blocked by street canyons and concrete walls. Still, much of our mobile life takes place there and users expect to be kept informed with pinpoint accuracy. In order to track down interesting places in a city, it is often necessary to sign in to multiple web portals or service pages using your personal data, or to fall back on other devices. For many of these services, the goal is not to assist users, but to glean information about users. To ensure that uncomplicated, simple and mobile navigation and information doesn't end at a building's front door, there's a need for localization technology that functions both indoors and out and guarantees the user's data privacy. awiloc® makes that possible.

Safe and continuous positioning for commercially available smartphones and wearables

With awiloc® technology, Fraunhofer IIS has developed the perfect complement to GPS. The great advantage: data privacy regulators have approved awiloc®'s self-contained method of determining locations on a mobile device, meaning that no data is exchanged with a central server to calculate positions. Device independent, awiloc® works with commercially available smartphones and wearables (such as watches or glasses). What's more, there's no need for individual infrastructure. Installation is simple and inexpensive. The positioning algorithm is independent of the wireless technology used and is based on a refined received signal strength (RSS) method known as fingerprinting. Wireless networks from the highly popular family of IEEE 802.11 wireless standards offer an ideal base. Also suitable are other kinds of radio networks, for instance Bluetooth Low Energy (BLE), GSM or UMTS.

The fingerprinting method works on the assumption that a location or position can be uniquely characterized by the strengths of the wireless signals received from multiple wireless base stations. The positioning benefits from a high level of accuracy provided by a wide range of signal patterns at the various positions and is therefore accurate to within a few meters. The more complex the environment's structure, the more accurately awiloc® can determine locations. Using directional antennas, it is possible to generate an extremely compact view of the progression of drops in signal strength in specific areas, further boosting accuracy. In addition, targeted installation of radio transmitters in specific building structures can be used to achieve characteristic signal propagation (such as placing a transmitter in back corners or in

wall openings). Based on these field-strength measurements, mobile devices can determine their own position using the awiloc® technology.

For practical use, novel methods were developed for positioning in variable environments and to better compensate for various device properties. Furthermore, methods and tools were developed and integrated for easy start-up as well as to provide simple site descriptions and allow effective implementation on a range of device platforms. During development, special emphasis was placed on legal compliance in consultation with the supervisory authorities responsible for data protection. The Bavarian State Office for Data Protection Inspectorate (Bayerische Landesamt für Datenschutzaufsicht) confirmed the app's best possible data economy and level of data protection.

Self-sufficient localization

Among signal-strength-based methods, awiloc® offers the only autonomous method for calculating a device's position without establishing a server connection. This creates opportunities for new applications: localization is possible even when no connection or only limited data connection exists, such as in

the subway, in underground buildings, on ships, or wherever data connection would be too expensive. Carrying out self-sufficient positioning requires special algorithmic methods as well as particularly efficient implementation to protect the resources on the user's device. Under these general conditions, it is particularly challenging to establish an initial position from the large number of reference points. Unlike other technologies, awiloc® calculates a continuous position with motion vectors for direction and speed. The device's acceleration data is also considered. This is not possible with conventional methods that rely on a server because the amount of data and data frequency is too high. Errors in individual position can be identified and corrected, positioning is more stable, and lag time is minimized. As a result, new location-based services for mobile users in urban areas and buildings can be easily, simply and safely realized.

Day to day application of awiloc® technology

The mobile awiloc® applications offered by our partners make it easy to navigate through unfamiliar environments and gather information about your surroundings. awiloc® helps you get your bearings in many situations in which people

With the awiloc® ToolChain, it's easy to develop your own services.
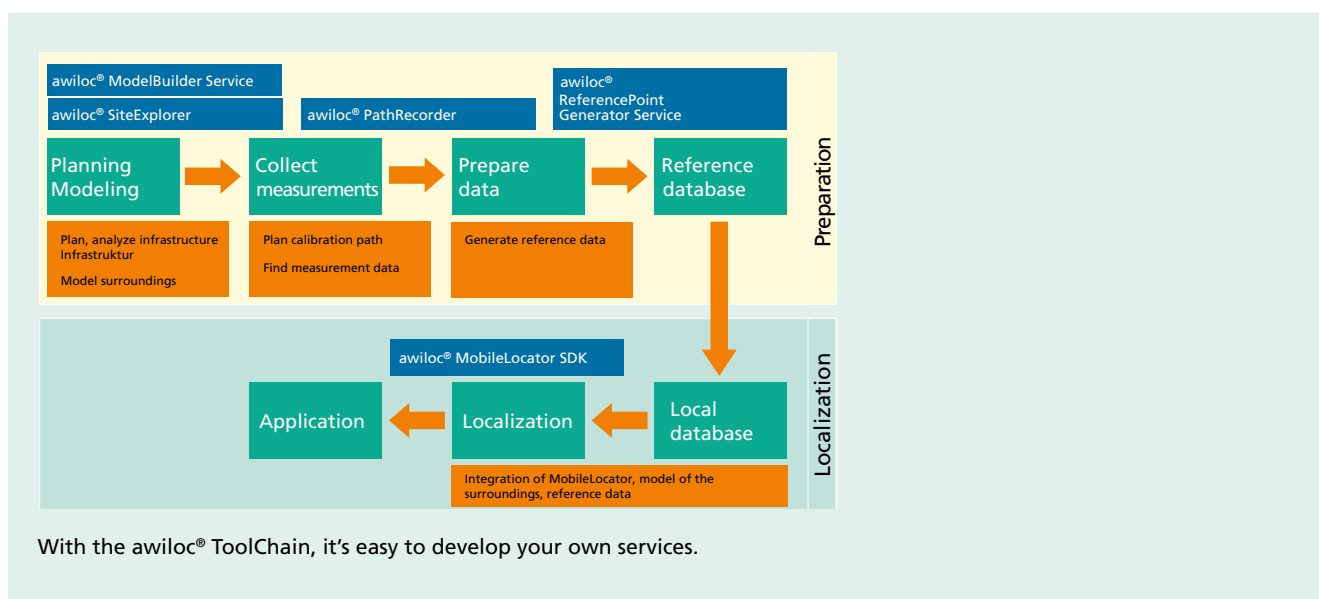
were previously left to fend for themselves, such as finding the right platform, providing museum visitors with precise location-based information or safeguarding people working alone on large sites. awiloc® offers the perfect basis for applications designed to support people's mobility needs and keeps them informed in everyday situations.

Today's active seniors are increasingly using mobile devices. In order to remain independent during day-to-day shopping trips or while traveling despite age and the associated impairments to mobility, awiloc® facilitates mobile smartphone applications that offer individualized, barrier-free navigation. Families with strollers and wheelchair users also benefit. This sample application was the object of ACCESS, a BMBF research project, for which Fraunhofer IIS supplied the awiloc® positioning technology.

awiloc® alliance – the next steps

To facilitate new projects and cooperations among users, companies and research partners concerning positioning in public areas and buildings, as well as to build up location-based services, Fraunhofer IIS founded a partner network in 2008.

In the awiloc® alliance, users present problems and potential applications, and application and system developers contribute system modules. These are then fit together to create a complete solution. This is how the experts at Fraunhofer IIS help develop new applications and address gaps in the technology. The awiloc® partner meetings take place regularly and serve as a platform for exchange and an opportunity for partner networking. Partners have the opportunity to play an active part during presentations about issues such as product innovations, development projects or problems to solve. For developing and evaluating real applications, Fraunhofer IIS runs awiloc® test environments in several German cities (including Nuremberg). These provide a functional platform for positioning in urban areas and in buildings, and enable

rapid development of location-based services. They offer an environment in which ideally attuned technologies and applications can be developed and tested.

awiloc® positioning can be used to come up with solutions for many scenarios and applications, with target-group-oriented navigation in cities and buildings holding particular potential for location-based services. In the retail industry, location-dependent information and advertising is an increasingly important topic. Taking awiloc® as a base, it would be easy and inexpensive to develop applications for shopping centers, for instance. In downtown areas, awiloc® technology could be used to improve GPS. Fraunhofer IIS is currently working on various research projects with the aim of simplifying and improving navigation in downtown areas. For instance, most conventional navigation systems turn out to be somewhat useless once the entrance to the parking garage has been reached.

Fraunhofer IIS is working up parking garage solutions in the GeMo research project by fusing awiloc® with GPS, inertial sensor data and motion models. Integrating all of the existing location and motion information compensates for the disadvantages of the individual positioning technologies, and even makes positioning within a parking garage possible. By providing end-to-end navigation, awiloc® also simplifies local and distance travel. awiloc® provides seamless support through multiple transportation modes, navigates train and subway stations, and effortlessly finds the right stop, the right platform and even the right train car and seat. Regarding safety, mobile information systems incorporating awiloc® can help create a safer environment in the run up to major events or improve planning for regional evacuations and adapt to changing conditions. Research projects focusing on ambient assisted living have shown that awiloc® technology can also provide discreet support to the elderly and people with disabilities in specific situations, for example by determining the poistion of affected individuals within their own homes. This support is not limited to those directly

affected, but also explicitly extends to caregivers, doctors and family members.

BENEFITS OF AWILOC® TECHNOLOGY

– Constant positioning in multistory buildings, underground sites, entire city districts
– Data privacy regulator approved – only the user sees the localization data
– On device only – no data communication, no central server
– Context-aware localization enables logical positioning, e.g. floor, room
– Customer-specific reference data facilitates exclusive service offers

Mobile devices that can independently determine position:
– increases security
– enables new business processes
– streamlines performance
– improves orientation
– enables systems that act autonomously
– promotes new services
– continuously delivers positioning values
– doesn't generate any provider costs

Find further information on awiloc® here:
www.awiloc.com

For more information on Localization at Fraunhofer IIS,
please visit: **www.iis.fraunhofer.de/positioning**

1 *Together with awiloc®, smart glasses or smart watches build the foundation for indoor navigation systems.*

2 *Treasure hunt with awiloc® In the Museum for Industrial Culture in Nuremberg.*

CONTACT

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NEWS IN BRIEF

WHAT YOU SHOULD KNOW

2014 JOSEPH VON FRAUNHOFER PRIZE GOES TO easyDCP

On May 23, 2014, Heiko Sparenberg and Dr. Siegfried Foessel were awarded the renowned Joseph von Fraunhofer Prize for their work in developing easyDCP, a software solution for creating digital cinema packages (DCPs). Now an internationally recognized product, the easyDCP post-production software evolved from important research conducted as part of compliance test plan development commissioned by Digital Cinema Initiatives (DCI). The DCI is an organization of the six Hollywood studios and requested that standards for digital cinema be developed; these were then adapted and made available to the German and European film industries.

By creating the software and rigorously adapting it to suit the requirements and working conditions of studios and film productions, Fraunhofer IIS scientists were able to successfully turn their development into a product that is today valued and used by over 1000 post-production companies worldwide.

The software allows even smaller, independent producers and filmmakers to create their own DCPs. With its comprehensive range of functions, the program is a real boon for post-production companies, film producers, distributors and film festival organizers. These functions include the easy production of subtitles and audio tracks in different languages, or supporting 3D film formatting and 4K resolution. One of the places the software is used for bringing every DCP to the the big screen is at the Berlinale.

Heiko Sparenberg, head of the Digital Cinema Group
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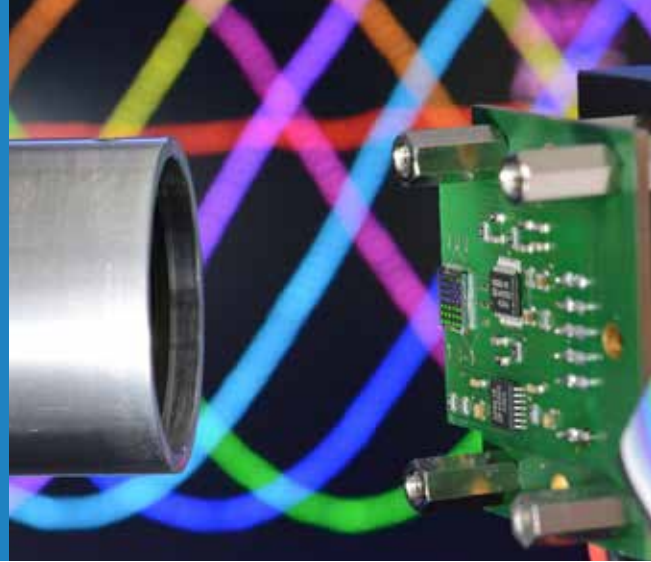
FINDING THE RIGHT SIZE WHEN BUYING SHOES ONLINE

E-commerce has its challenges, one of which is product returns. Much of the footwear ordered online is sent back because the shoes don't fit, or because people order a second pair in another size, to make sure, and then return the pair they don't need. All this is set to change. In 2014, the Fraunhofer Development Center for X-ray Technology EZRT, part of Fraunhofer IIS, developed a new technology for mifitto GmbH, a retail and mail-order service provider for shoes and textiles. Founded in 2012 and based in Duisburg, Germany, the start-up wants to match shoe and foot measurements to provide customers with more accurate size recommendations. Using X-ray technology, the shoes are precisely measured and then compared to the size and shape of customers' feet – dimensions calculated based on photos sent in by the customer themselves. mifitto GmbH currently offers the world's first online size guide for shoes. Should the system prove successful, they also plan to use it for fitting articles of clothing.

Markus Eberhorn, head of the Computed Tomography Systems Group, markus.eberhorn@iis.fraunhofer.de

GETTING THE RIGHT SPIN

Special sensors are used to determine the exact position of goods being moved via conveyor belt, or in engine feedback systems in vehicles. There are currently two types of such rotation angle sensors on the market, working according to either magnetic or optical measuring principles. Magnetic sensors are very durable and are ideal for use in harsh environments. They are, however, not as precise as optical sensors. Optical sensors, in turn, are not very flexible to use since they must be precisely mounted in a fixed position on the object being measured.

Researchers at the Fraunhofer Institute for Integrated Circuits IIS in Erlangen have developed a new rotational angle sensor that combines the advantages of both solutions into one. It makes use of the polarization effect, that is to say the direction in which light oscillates. The researchers attach a polarization film to the test object – the drive shaft, for example – and direct a light beam at it. Polarized light is produced on the reverse side of the film. Should the drive shaft now rotate, the polarization vector rotates with it, thus serving as a kind of direction indicator. Fraunhofer IIS scientists showcased a demonstrator of the sensor at the SENSOR + TEST trade fair in Nuremberg, Germany, in June 2014.

Dr. Norbert Weber, head of the Optical Sensors and Communications Technology Group, norbert.weber@iis. fraunhofer.de

DRAGONFLY CAN TEST CAST PARTS IN HALF THE TIME

Developed by the Fraunhofer Development Center for X-ray Technology EZRT, a division of Fraunhofer IIS, the new DRAGON-FLY technology reduces testing time for cast parts by up to 50 percent compared to the start-stop methods used to date.

During the X-ray imaging process, a robot moves larger items such as cast parts between the X-ray source and the detector. Until now, the robot had to keep stopping and holding the component still so that the X-ray images could be acquired. In combination with high-performance X-ray tubes made by Siemens AG, the DRAGONFLY technology developed at Fraunhofer EZRT allows now to reduce the exposure time for each position to 5 milliseconds, thereby allowing high-resolution X-ray images to be taken from different angles while the component is in motion.

As part of fully automated 100-percent X-ray testing processes, the DRAGONFLY technology has the potential to replace existing testing setups used to assure the quality of safety-relevant cast components. Until now, operators had to line up several testing stations back-to-back along the production line, requiring considerable maintenance and generating significant energy and labor costs. DRAGONFLY saves time, thereby making it possible to reduce the number of testing stations.

Thomas Kondziolka, Marketing and Communication, Non-destructive Testing, thomas.kondziolka@ iis.fraunhofer.de

BlueTEG, THE SENSOR WRIST-BAND THAT POWERS ITSELF

In 2014, Fraunhofer IIS scientists developed and launched the first Bluetooth Low Energy wristband with a thermoelectric power supply. The BlueTEG sensor wristband measures sensor values such as ambient temperature or acceleration rates and sends these via Bluetooth to a smartphone or tablet app. BlueTEG's USP is its Energy Harvesting technology. Integrated into a wristband, BlueTEG can use even small differences in temperature between the wearer's skin and the surrounding environment to generate electrical energy to power the electronics. The technology uses a state-of-the-art thermogenerator and a special voltage converter developed at Fraunhofer IIS. Unlike conventional devices, BlueTEG requires no power supply cords or batteries that have to be recharged or replaced. Possible application areas for the sensor wristband include all kinds of body sensor and radio sensor technology, where it can ensure a self-sufficient power supply. As such, BlueTEG could be integrated into products like multi-functional and GPS watches, or medical sensors.

Dr. Peter Spies, head of the Group for Integrated Energy Supply, peter.spies@iis.fraunhofer.de

DR. SIEGFRIED FOESSEL NAMED NEW FKTG CHAIRMAN

At the start of 2014, Dr. Siegfried Foessel, head of the Moving Picture Technologies department at Fraunhofer IIS, was named chairman of the Fernseh- und Kinotechnische Gesellschaft FKTG, a German association for television and film professionals. This new position follows Dr. Siegfried Foessel's previous role as university liaison officer for the FKTG, in which he was responsible for communication with universities and colleges.

His objectives as chairman include strengthening networks with international organizations, navigating the changes taking place in media usage and accommodating new formats and new production techniques to firmly establish these within the FKTG's topic portfolio. At the association's annual conference on May 6, 2014 in Cologne, he highlighted the need to reinforce the FKTG's importance and appeal in the media industry, and in particular among members at university and those entering employment.

Dr. Siegfried Foessel, head of the Moving Picture Technologies department, siegfried.foessel@iis.fraunhofer.de

CT SCAN OF THE INSIDE OF A FERRARI

In 2014, X-ray artist Nick Veasey and the Fraunhofer Development Center for X-ray Technology EZRT, a division of Fraunhofer IIS, collaborated to show us something that had never been seen before: X-ray images of the inside of a Ferrari. A dream come true for fans, car enthusiasts and technology geeks – thanks to Fraunhofer expertise. The artist will use one-of-a-kind XXL computed tomography technology to scan a total of ten Ferrari racing cars of the past 50 years.

October 2014 marked the official launch of this art project at Fraunhofer's location in Fürth, Germany, when British artist Veasey and Fraunhofer EZRT X-rayed a Ferrari 365 GTB/4 Daytona. Press invited to the event were treated to an explanation of the unique X-ray system in the 400-square-meter test hall in Fürth and how the art project was going to be carried out. Veasey will use the radiography results to continue his work on the project. A first for the artist was having the ability to X-ray large objects in one piece, sparing him the need to laboriously take them apart. Plans for scanning the remaining Ferraris in the series are already under way.

Thomas Kondziolka, Marketing and Communication, Non-destructive Testing, thomas.kondziolka@ iis.fraunhofer.de

SPATIAL-AV: TECHNOLOGIES FOR IMMERSIVE FILM AND MEDIA EXPERIENCES

Movies often call for 3D special effects. How to bring more creativity into 3D film productions and what new directions will be available to film and media productions in the future is the focus of Fraunhofer Digital Cinema Alliance's Spatial AV project. This project was launched three years ago by four Fraunhofer Institutes: IIS, HHI, IDMT and FOKUS. Using a range of production scenarios, the researchers are able to show what can be integrated into the production process, both today and in the future.

Complex 3D productions are easier with new intelligent software, as it synchronizes and calibrates stereo cameras automatically. For more elaborate productions, the researchers have developed a kind of light-field or multi camera system consisting of 16 cameras, which be added to as needed. The key to the light field image system is the software. It can create as many views as desired so that virtual camera movements can be produced without having to move the actual device, for instance.

Object-oriented audio technologies match sound and image optimally and complete the near reality experience. New TV involvement allows viewers to use panorama images to navigate interactively and act as their own cameraman. The project is supported by a pool of companies from the film and media industry. Currently, many developments are being put to use in test productions.

Dr. Siegfried Foessel, head of the Moving Picture Technologies department, siegfried.foessel@iis.fraunhofer.de

IN THE FAST LANE WITH FRAUNHOFER SYMPHORIA

Fraunhofer's Symphoria technology creates an unmatched in-vehicle sound experience with 3D surround sound. As the first automaker to deploy the technology, Audi is offering Symphoria in the latest generation of the TT and Q7 models, providing a unique listening experience to every passenger.

Symphoria creates impressive worlds of sound within the vehicle, turning the car into a rolling sound sensation. Fraunhofer technology lends the car unbelievable acoustics with dimensions of tone that provide more depth, width and height of sound to create the sense of actually being in a concert hall or at a live performance. Symphoria semantically analyzes relevant sound elements in the audio signal and intelligently distributes them to speakers integrated into the vehicle.

Symphoria is capable of adapting to the special conditions inside the automobile and provides outstanding sound regardless of the audio source from the built-in sound system or the type, location and number of integrated speakers. Symphoria also replays music in excellent quality, and infuses the sound with more volume and a sense of spaciousness.

Matthias Rose, head of Marketing Communications, Audio & Multimedia, matthias.rose@iis.fraunhofer.de

FRAUNHOFER CINGO®
FOR SAMSUNG GEAR VR

The Samsung Gear VR virtual reality headset is the first device to incorporate the new 3D capability of Cingo mobile surround sound technology from Fraunhofer IIS. Cingo allows users of the Samsung Gear VR headset a completely immersive audio experience in the world of virtual reality.

With Cingo, Samsung Gear VR users can perceive sound elements from the left or right, but also in front, behind, above or below. Users are immersed in the virtual world of sound that truly feels like a reality. For example, if watching a movie, users feel as if they are truly part of the action.

It not only improves the quality of sound delivered via loudspeakers or over headphones, Cingo enhances stereo contents natural timbre and intelligibility to be on par with today's theater systems. An integrated loudness optimization function delivers clear and natural sound even in noisy environments. What's more, media content can also be experienced in 3D with Cingo. Thanks to the intelligent combination of new audio technologies, Cingo delivers an unsurpassed level of sound quality, providing a unique experience for today's mobile users.

Matthias Rose, head of Marketing Communications, Audio & Multimedia, matthias.rose@iis.fraunhofer.de

NOTABLE EVENTS
OF THE YEAR

FRAUNHOFER INVESTS IN THURINGIA

In Ilmenau, the Fraunhofer-Gesellschaft will be building a new building for researchers at the Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB and the Fraunhofer Institute for Integrated Circuits IIS. Estimated cost will be around 25 million euros. Construction is scheduled to begin in summer 2016, with completion and handover expected at the end of 2018.

IOSB's Advanced System Technology branch has been located in Ilmenau since 1995. Fraunhofer IIS and the Ilmenau University of Technology have been collaborating at the site as a research group since 2008, working closely together on projects and sharing personnel. The aim of the partnership is to translate university research directly into industrial project and product related developments.

Because both facilities have limited space, development is also limited. In 2014, the Land of Thuringia and the Fraunhofer-Gesellschaft have agreed on the financing for a building expansion. Thuringia and the Fraunhofer-Gesellschaft will each assume 30 percent of the costs, and the remaining 40 percent will be covered by funds from the European Regional Development Fund.

Franziska Schüler, Project Group for Wireless Distribution Systems, franziska.schueler@iis.fraunhofer.de

EMEA FREESCALE CUP IN GERMANY FOR THE FIRST TIME

Taking place in Germany for the first time, the EMEA (Europe Middle East Africa) Freescale Final Cup Challenge was held in April 2014. As a cooperation partner of the competition, Fraunhofer IIS also hosted the event. The Freescale Cup, organized by Freescale Semiconductor, is an international competition for students to build and program a fully autonomous model car. The winning team was the one that could successfully negotiate the obstacle packed racetrack the fastest.

Teams from more than 100 universities throughout EMEA compete for the Freescale Cup. Each one receives the same standard car kit consisting of a chassis, a camera and a Freescale 32-bit microcontroller set. The teams then have the task of equipping a battery-powered car so that it can autonomously negotiate an obstacle course studded with speed bumps, hills, chicanes and intersections. Any kind of remote control, or any alternations to the engine or chassis, are of course against the rules. In fall 2015, the world finals will be held in Germany, another first – hosted once again by Fraunhofer IIS in Erlangen.

Susanne Ruhland, event management,
susanne.ruhland@iis.fraunhofer.de

YOUNG SCIENTISTS EXPERIENCE APPLIED RESEARCH

How does science work? What is applied research? And what exactly do scientists do? Future scientists can find answers to these questions at events offered by the Fraunhofer-Gesellschaft. Fraunhofer IIS held two such opportunities in 2014.

The Fraunhofer Talent School is a program for gifted high school students in grades 10 through 13 with an interest in technology. The students get the chance to explore current approaches to scientific problems in a series of workshops. In 2014, Fraunhofer IIS conducted the talent program at the research campus in Waischenfeld for the first time.

Talent Take Off is a university studies orientation program for high schoolers and university students interested in technology who want to learn more about MINT subjects and careers (mathematics, information technology, natural sciences and technology). In total, 17 university students had the opportunity to shadow Fraunhofer IIS researchers as part of the Talent Take Off program in September 2014. The students were invited to the institute's new research campus in Waischenfeld by Femtec GmbH together with the Fraunhofer-Gesellschaft and Fraunhofer IIS.

Ann-Kathrin Räth, HR Recruiting,
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CITY OF INNSBRUCK PROJECT WINS "ALPINEN SCHUTZWALD-PREIS"

In January 2015, Fraunhofer IIS and the city of Innsbruck recei-ved the renowned Alpinen Schutzwaldpreis (Alpine Protection Forest Award) for their RFID-based localization solution. The solution won in the category for protection forest partnerships and innovations.

Downhill mountain biking has a long tradition in Innsbruck and the surrounding area. Even so, riding off-road in forested areas creates conflicts among various forest users and causes soil erosion. In collaboration with the city of Innsbruck, Fraunhofer IIS investigated the technical and economic feasibility of an RFID-based solution for examining compliance with the prescribed routes. Such a solution would be based on RFID technology used to determine the cyclist's position. To implement the solution, an RFID transponder is affixed to the bicycle. This is where the many years of expertise in RFID and locating systems as well as RFID performance, long-term testing and field testing comes in.

The award, which honors outstanding projects in alpine forests, is presented by the forest associations of alpine countries, specifically Liechtenstein, South Tyrol in Italy, St. Gallen and Graubünden in Switzerland, Carinthia, Vorarlberg and Tyrol in Austria, and Bavaria in Germany. It recognizes exemplary ideas for conserving and improving protection forests and raises awareness about related issues.

René Dünkler, marketing for Locating and Communica-tion Systems, rene.duenkler@iis.fraunhofer.de

CLOSING EVENT FOR THE BMBF FUNDING PROGRAM "ON THE GO IN OLD AGE"

Practitioners and experts came together on October 23, 2014 at Fraunhofer IIS's Test and Application Center L.I.N.K. (Localization, Identification, Navigation and Communication) to exchange ideas and see current research findings in practice firsthand. These findings are the result of the funding program called "On the go in old age – seamless mobility chains for eliminating, bypassing and overcoming barriers," sponsored by the German Federal Ministry of Education and Research (BMBF). On L.I.N.K.'s 1400 square meters, the 14 projects offered many real-life examples and presented new ways for people to experience countries, cities and buildings independently. One such project is ACCESS, with which Fraunhofer IIS researchers demonstrated a mobile navigation and information system for accessible tourism. The solution simplifies the planning steps for the next trip or city sightseeing tour, guiding the user on a personalized barrier-free route. Obstacles or problems that have not yet been recorded can be noted and added by any user or qualified agency. At the heart of this development is awiloc®, a privacy-approved tech-nology available for licensing, which users can employ to set up customized navigation and information services based on existing infrastructures such as WLAN, Bluetooth, low energy, and GPS.

Karin Loidl, marketing for the Communication Networks department, karin.loidl@iis.fraunhofer.de

10th ANNIVERSARY OF THE FRAUNHOFER DIGITAL CINEMA ALLIANCE

In 2004 – the year the Fraunhofer Digital Cinema Alliance was founded – cinema and many media areas were not yet fully digitized. When it came to picture quality and flexibility, Internet-based and digital formats seemed to have left film behind: there were no high-quality digital movie cameras, post-production tools, transmission standards or audio technologies, to name but a few examples. To close the technological gaps with new developments and standards, four Fraunhofer Institutes – IIS, HHI, IDMT and FOKUS – came together to form the Digital Cinema Alliance. With this central point of contact, the institutes could offer new technologies and projects for the film industry, film productions, filmmakers and media producers. The institutes are particularly keen to maintain an overview of the total workflow process, from production to screen, distribution or archiving. In ten years, the Alliance has made a name for itself with many achievements, including: ARRI D20/D21, one of the world's first digital film-style cameras; the DCI test plan for Hollywood studios; easyDCP software, used to make digital cinema packets; the OmniCam for capturing live panorama images; and 3D audio technology.

With centers in Berlin, Ilmenau and Erlangen as well as the 3D Innovation Center and a digital cinema, the researchers offer a professional environment in which to test and present new developments under real conditions.

Angela Raguse, communication for Fraunhofer
Digital Cinema Alliance, alliance-dc@iis.fraunhofer.de

NAMES, EVENTS, PUBLICATIONS

NAMES, EVENTS, PUBLICATIONS

To meet financial reporting requirements, a presentation of facts and figures is provided in a separate section. This can be found online at

Fraunhofer
IIS

NAMEN, EREIGNISSE, VERÖFFENTLICHUNGEN
NAMES, EVENTS, PUBLICATIONS

2014
JAHRESBERICHT
ANNUAL REPORT
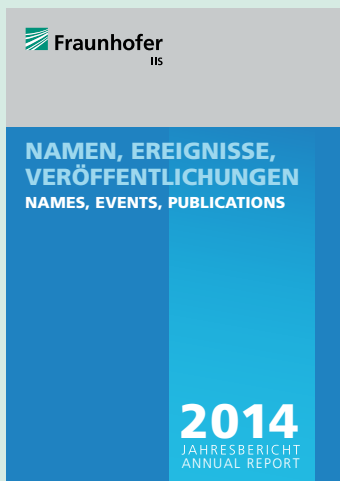
Contents

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www.iis.fraunhofer.de/jahresbericht

ORGANIZATION CHART

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Electronic Imaging Stephan Gick **E R**	**Audio for Embedded Systems** Marc Gayer **E R**	**Contactless Test and Measuring Systems** Dr. Peter Schmitt **F Ü**	**Radio Communication Systems** Gerd Kilian **E R**
Image Processing and Medical Engineering Christian Weigand **E R**	**Audio for Communications** Manfred Lutzky **E R**	**Process-integrated Inspection Systems** Dr. Steven Oeckl (Komm.) **F Ü**	**RF and SatCom Systems** Rainer Wansch **E R**
Integrated Circuits and Systems Josef Sauerer **E R**	**Business** Harald Popp **E R**	**Project Group NanoCT Systems** Dr. Simon Zabler **W Ü**	**Project Group Wireless Distribution Systems** Prof. Dr. Giovanni Del Galdo **I L**
Center for Applied Research on Supply Chain Services Roland Fischer (Managing Director) **N**	**Audiolabs IIS** Dr. Frederik Nagel **E R**	**Application Center for CT in Metrology** Prof. Dr. Jochen Hiller **D E G**	
Project Group Information Services for the Digital World Prof. Dr. Alexander Pflaum **B A**	**Multimedia Applications** Dr. Nikolaus Färber **E R**		
	Patents and Licensing Stefan Geyersberger **E R**		
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Administration Dresden
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Human Resources
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