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IFFOCUS

DIGITAL IS GETTING SMART

INDUSTRIE 4.0
New Business Models in Process Manufacturing

SMART FARMING
How Digitization Is Transforming Farming

THE FUTURE OF MANUFACTURING IN A DIGITAL WORLD
How Digital Assistance Systems Are Assisting Manufacturing Workers

Fraunhofer

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FRAUNHOFER INSTITUTE FOR FACTORY OPERATION AND AUTOMATION IFF, MAGDEBURG

» It takes little imagination to foresee that the need for assistance systems such as robots or digital assistants will grow in the future. «

Prof. Michael Schenk, Director of the Fraunhofer Institute for Factory Operation and Automation IFF in Magdeburg.

Editorial

The economy has been in a state of flux for years. Digital transformation, Industrie 4.0, the Internet of Things, automation and assistive robotic systems – all these are elements of a development that is changing companies and the way they manufacture. Not only major corporations are transitioning to digitized manufacturing. Small and medium-sized companies and even microenterprises will not be able to get around this – nor can they afford to . And I would wager,that your company has also already taken actions to transform itself digitally. After all, smart digital transformation means greater productivity, responsiveness and quality. In short, it improves a company's chances of remaining competitive globally and regionally. And it readies companies to meet coming challenges.

Take just demographic change. Just a few years ago, corporate executives shook their heads skeptically and did not believe that it would soon be a genuine problem. Today, we can experience it on a daily basis. A growing number of industries have recruitment problems. That applies not only to high-tech companies and OEM. Skilled trades and the healthcare industry are particularly struggling with labor shortages, too. Fewer and fewer young people are willing to work wherever the job is hard and "dirty", is quickly fatiguing, and its image is no longer "sexy" enough. We nevertheless still need the work of such professions, whether they be masons, bakers or nurses. It takes little imagination to foresee that the need for assistance systems such as robotic or digital assistants will grow in these professions in the future. Apart from lightening workers' workload, the could have a nice side effect of also burnishing the outdated image of one profession or another again.

Of course, digital transformation also makes work easier in more highly engineered domains such as in engineering, industrial maintenance and, not to be forgotten, advanced farming. Provided, however, that digital transformation is implemented intelligently rather than simply at any cost, that is, smart solutions are created. This is the only way you will all be able to profit from it. This not only includes integrated use of digital data on as many levels of a company as possible but also pertains to new business models, for instance. After all, future products also include data generated by industrial digital infrastructures. This opens prospects for entirely new businesses, which give rise to interesting thoughts about how companies will be able to earn money in the future.
For exactly twenty-five years now, the Fraunhofer IFF has been working on technical systems and visions, which help companies overcome these and other problems and challenges and to better maximize their commercial potential. In this issue, we report on some of this research work once again. Enjoy reading.

Your Michael Schenk

Industrie 4.0

New Business Models in Process Manufacturing

Industrie 4.0 has primarily meant the development of requisite technologies. The next step is about converting ensuing technologies into smart, profitable solutions. The prospects are good since digital transformation will open up new business models that were inconceivable earlier. This could soon fundamentally change the relationship between manufacturers and customers to their mutual benefit. This is also true for process manufacturing, which has profited very little from Industrie 4.0 so far.

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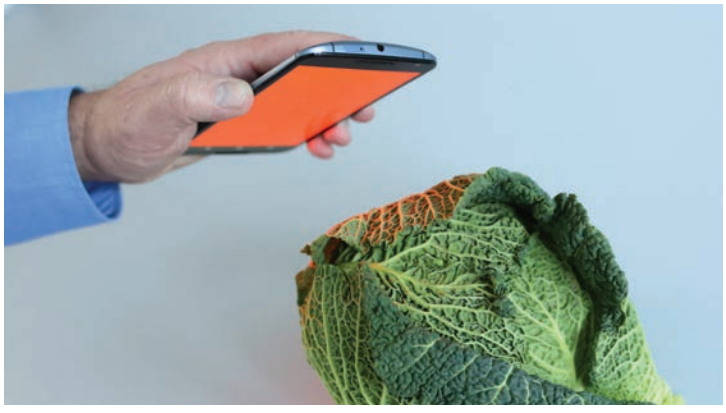

Smart Farming

Die Digitalisierung erobert auch die Agrarwirtschaft. Hyperspektrale Kameratechnik macht Unsichtbares sichtbar, verbessert damit Ernteergebnisse und eröffnet den Landwirten neue Geschäftsfelder.

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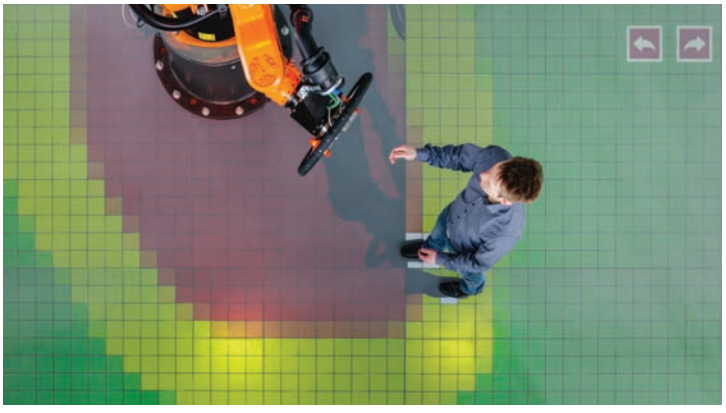

Humans and Robots Are Getting Closer

Digital transformation and automation go hand in hand in manufacturing. This is producing smart assistance systems that enable humans to collaborate directly with robots efficiently and safely.

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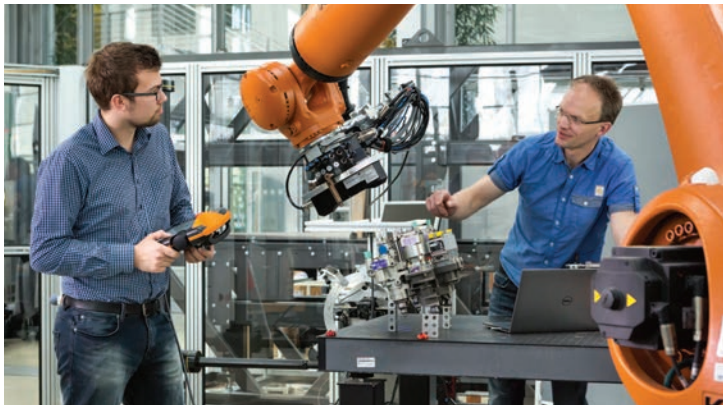

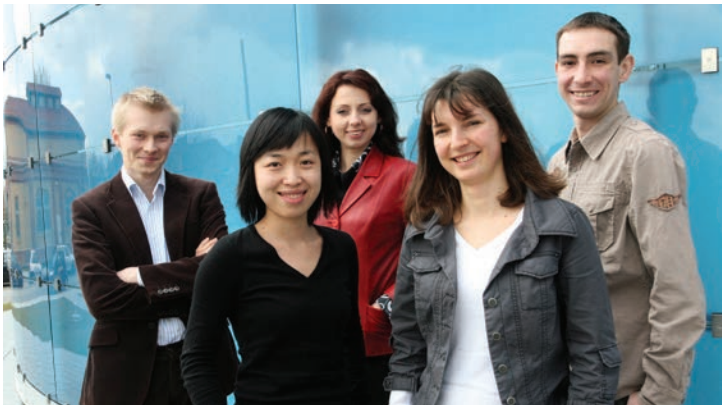

The Future of Manufacturing in a Digital World

In the future, humans will be able to resort more heavily to automated and digital assistance systems in manufacturing. They will lighten their workload and ensure efficiency and flexibility. This will move the digital and real world closer together.

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Sharp Minds

Doctorates, awards and collaborative research partnerships: Learn more here about the people and the research networks at the Fraunhofer IFF.

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Tactile Handle for More Safety and Effectiveness in Warehouses

Vehicles in logistics centers will be more intuitive to steer in the future, thus making work easier and safer. "Tactile handles" are making this possible. They employ pressure sensors to detect the direction in which a user is pushing or pulling the cart. "Users steer carts merely with hand pressure," explains Prof. Klaus Richter, expert group manager at the Fraunhofer IFF. "Whereas steering used to require effort, our handle has a kind of power steering that makes movement easy." Commands are transmitted to motors, like those used for electric bikes, which execute the movement. Vehicles are interconnected much like vehicle to vehicle communication and have proximity detectors. In the event of a risk of collision with another cart, they stop immediately. The system will be as simple as possible. "We intend to minimize the components in order to keep the price down," explains Richter. "Tactile handle" is being developed in the FAST Realtime research project funded by the Federal Ministry of Education and Research's program "2020 – Partnership for Innovation" . ■

Tactile handles make moving and cumbersome order picking carts child's play. Photos: Fraunhofer IFF, Uwe Völkner

Forty Ambassadors Visit the Fraunhofer IFF

At the invitation of Günter Nooke, the German Chancellor's Personal Representative for Africa and the Federal Ministry of Economic Cooperation and Development's Commissioner for Africa, forty ambassadors of African countries visited the capital city of Magdeburg in the summer of 2016. A major item on the trip agenda was a visit to the Fraunhofer IFF embodying Germany as a center of technology.

The ambassadors learned about new technologies for smart and sustainable energy production, virtual siting and digital analysis systems for farming and the food industry. ■

Photos: Fraunhofer IFF, Viktoria Kühne

State-of-the-Art VR Technology in Magdeburg

The future of virtual reality is being shaped significantly in Magdeburg: The state is funding the upgrade and renovation of the "Elbe Dom" at the Fraunhofer IFF's Virtual Development and Training Centre VDTC. Opened in 2006, the Elbe Dom is one of Germany's largest facilities for virtual reality for business and research organizations. Renovating the facility is essential to keep pace with rapid technical developments and respond to current and especially future demands, .

Minister of Economic Affairs Jörg Felgner and Landesinvestitionsbank President Manfred Maas presented a letter confirming funding of over € 2.2 million from EU and state funds to Director Michael Schenk on November 7, 2016. Felgner stressed, "we will be launching a new dimension of virtual reality use in Magdeburg once the VDTC is upgraded. The Fraunhofer IFF is a leader in this field nationally and internationally. So that this stays that way, not only the researchers but also the technical infrastructure have to be top."

Altogether € 2.5 million are being invested in renovation and upgrade of the system. The mixed reality laboratory will have an extra floor projection system in the future for realistic 3D VR simulations, touch sensors in the floor, optical positioning and motion capture systems and much more. It will enable users to move freely in and interact intuitively with surrounding virtual environments.

The "old" Elbe Dom with a 360-degree projection screen, a diameter of 16 meters and a height of 6.5 meters was one of the largest visualization systems for virtual interactive applications for business and research in Germany. Photo: Thomas Ernsting

Then-Minister of Economic Affairs Felgner (r.) and IB President Maas (l.) present the funding confirmation letter to Prof. Michael Schenk, Director of the Fraunhofer IFF. Photo: Fraunhofer IFF, Viktoria Kühne

Director Michael Schenk is thrilled: "At the new Elbedome 2.0, we will also be able to work on important future challenges of research such as developing technologies for future work environments and for Business 4.0. Its expanded capabilities will also make a space for digital planning and experience available to research partners and companies." ■

Award-Winning Innovations Made in Saxony-Anhalt

Fraunhofer award winners with representatives of partner companies at the 2016 Hugo Junkers Award ceremony. Photo: Andreas Lander

Saxony-Anhalt macht starke Forschung. Companies and research organizations in the state regularly produce fantastic technical innovations. The state recognizes and raises public awareness of these achievement every year with its Hugo Junkers Award. The best contributions in five categories receive awards.

Digital Assistance System for Process Manufacturing

"The eighty-nine submissions impressively mirror the ingenuity and entrepreneurship of our industry and research in Saxony-Anhalt," according to Minister of Economic Affairs Armin Willingmann, who presented the awards. The Fraunhofer IFF won three awards in 2016. The R&D project "CPPSprocessAssist" placed third in the category "Most Innovative Alliance". A consortium of companies and research organizations lead managed by the Fraunhofer IFF developed an assistance system for digitized maintenance and servicing of chemical plants. The only project of it s kind funded by the Federal Ministry of Research and Education is transferring principles of Industrie 4.0 to process manufacturing. The new digital assistance system will reduce time and labor for the maintenance of process equipment in operation and facilitate automatic documentation of servicing and maintenance.

The "Netzwerk InDiWa: Metaalliance for the Development and Marketing of Innovations for Automated Rotor Blade Inspection" took second place in the category "Most Innovative Alliance". The Fraunhofer IFF is one of several partners in the network lead managed by the ZPVP GmbH / Experimentelle Fabrik. It is interdisciplinarily researching and developing innovative products, systems and services for nondestructive and automated inspection, diagnostics and maintenance of wind turbines.

App Reveals Constituents

Second place in the category "Most Innovative Product Development" also went to the Fraunhofer IFF. Together with Strube Research GmbH, researchers in Magdeburg developed a noninvasive real-time scanner that detects plant diseases. A hand scanner, specially developed software and a smartphone app will enable farmers and plant breeders to minimize the time and labor required to inspect plants in the future. Hyperspectral analysis measures metabolic changes in leaves in the field, which are an immune response to pathogen infestation and invisible to the human eye. The scanner "sees" whether a plant is healthy or diseased within one second. ■

Innovative Research Presented in Brussels

The Fraunhofer IFF was represented at the State Representation's summer party with the theme "Saxony-Anhalt: State of Engineers meets Europe" in Brussels on June 23, 2016. Building bridges between research and industry, the researchers presented the Fraunhofer IFF's latest developments for the logistics industry. These included a "Tactile Handle" for easy and intuitive control of order picking carts and an RFID wristband used to automatically identify objects in work and picking processes. Both technologies make work safer and more efficient. Minister-President Reiner Haseloff and the Presidents of the Saxony-Anhalt Chamber of Engineers had invited them to the Representation of Saxony-Anhalt to the European Union, Jörg Herrmann. ■

State Secretary in the Federal Ministry of Transport and Digital Infrastructure Rainer Bomba (m.) also marveled at the innovativeness of the technology presented. Photo: Alexander Louvet

Institute Expansion: New Center for Cognitive Autonomous Work Systems at the Fraunhofer IFF

Frontal view of the Fraunhofer IFF's addition in Magdeburg's Port of Science. Graphic: Fraunhofer IFF

The Fraunhofer IFF is growing. The Senate of the Fraunhofer-Gesellschaft backs the institute's plans and approved the construction of a "Center for Cognitive Autonomous Work Systems". This new part of the institute will be built in Magdeburg's Port of Science. The Fraunhofer IFF is thus responding to the steadily changing world of work and the attendant challenges for every industry.

Technological developments, aging society and ongoing immigration of foreign labor will change the world of business and work in Saxony-Anhalt, Germany and the European Union fundamentally. It will diversify in terms of educational opportunities, cultural background, employment rate, and employee age and health. Trends such as customization and digital transformation of products, manufacturing and business concomitantly create increasingly more complex and more flexible worlds of work and life. Complex and constantly new work requirements are frequently offset by recurring, monotonous and, in part, physically and mentally strenuous work. Future work systems will have to meet these demands. This will entail new forms of work organization, work systems design, learning and technical support.

The Fraunhofer IFF is intensively working with its interdisciplinary approach to research in its research field "Smart Work Systems" on new technologies that meet these challenges. It is especially concentrating on refining technical systems increasingly cognitive and autonomous capabilities. The institute intends to add capabilities, infrastructure and equipment needed to respond to the growing importance of such research. Among other things, the researchers intend to develop next-generation machines in the laboratories and testing facilities of the future Center for Cognitive Autonomous Work Systems. Top priority will be given to flexible and partly autonomous assistance systems for manufacturing and services, for instance, robots or inspection assistants with which workers closely collaborate or new sensor-assisted assistance systems for complex assembly jobs. They will automatically detect the need for assistance, provide it, and optimize it by constantly monitoring variations in products or processes.

"The Center for Cognitive Autonomous Work Systems is an important component of the State of Saxony-Anhalt's Digital Agenda," emphasizes Prof. Michael Schenk, Director of the Fraunhofer IFF. "It will enable Saxony-Anhalt to establish a reputation as a state piloting smart work systems." ■

AR-LEAN: Joint Project Will Combine RFID Wristband and Data Glasses

Testing the integrated system with RFID Wristband and Smart Glasses. Photo: Fraunhofer IFF

Worker assistance system, also technical assistance systems that help workers on the job, e.g. industrial assembly, warehousing, installation and repair, are increasingly finding their way into business. Especially digital and wireless assistance systems for warehouse and manufacturing jobs, e.g. part and product identification with RFID (radio frequency identification) or smart glasses for mobile augmented reality solutions, are well on the way to becoming established. RFID systems help identification items and facilitate documentation of picking processes. Warehouse workers thhat use them can always be sure they have picked the right item. Smart glasses, on the other hand, project specific information such as order details or other contextual information on a product directly in their wearer's field of view. Together with Ubimax GmbH, the Fraunhofer IFF has developed an integrate system that combines the RFID Wristband developed by the engineers in Magdeburg and smart glasses from Ubimax.

Specialized in state-of-the-art RFID systems, the Fraunhofer IFF has long been a partner to manufacturers and retailers intent on digitally transforming supply chain operations, thus making them more reliable and more efficient.

Ubimax numbers among the world's pioneers in smart glasses use and the development of AR applications manufacturing and supply chains. The rapidly growing SME is the only Google partner in Europe that uses Google Glass in industrial applications.

The Fraunhofer IFF and Ubimax are now working in the AR-LEAN project funded by the Federal Ministry for Economic Affairs and Energy on combining the wearable assistance systems they have each developed. They intend to refined the RFID Wristband and smart glasses or even a smart watch to be an ergonomic and mobile complete wearable for the manufacturing and supply chain sector. A new software platform will furnish the basis for integrating the widest variety of endpoints later and simply creating new assistance applications. The project will conclude in early 2018. ■

Prof. Michael Schenk Heads the Group for Production Once Again

The Senate of the Fraunhofer-Gesellschaft confirmed Director of the Fraunhofer IFF Michael Schenk's chairmanship of the

Fraunhofer Group for Production for another three years. Prof. Schenk has head the group successfully since 2014.

His second term will run until September 30, 2019. Group for Production's central office headed by Dr. Fabian Behrendt will thus remain at the Fraunhofer IFF until 2019 am. The central office coordinates the member institutes' joint activities and launches flagship issues such as Industrie 4.0 or Production as well as strategic investments. Schenk's confirmation as chairman underscores both the group's positive development and the significance of the institutes in the eastern states and their research to develop Germany as a center of manufacturing.

Established in 1998, the Fraunhofer-Gesellschaft's Fraunhofer Group for Produc-

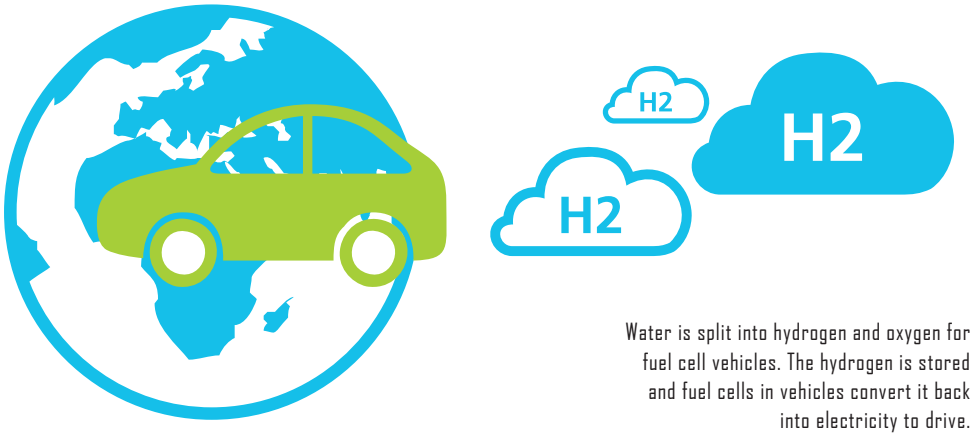
tion is a research and development partner to every manufacturing industry. Its eleven manufacturing-driven institutes with some 1,400 employees pool their expertise for the manufacturing industry. Its research priorities are Industrie 4.0, resource-efficient manufacturing, adaptive manufacturing, biochemical manufacturing, factory workplace of the future, urbane manufacturing, lightweight manufacturing technologies, manufacturing for energy systems and additive manufac-

State Secretary Armin Willingmann (l.), now Saxony-Anhalt Minister of Economic Affairs, and Prof. Michael Schenk at the 19th IFF Science Days in Magdeburg. Photo: Fraunhofer IFF, Viktoria Kühne

turing systems. Thanks to its close ties to universities and universities of applied sciences on the one hand and industry partners on the other hand, the group interconnects research and industry closely and interdisciplinarily. This enables the group to provide comprehensive and complete service for the entire industrial value chain an. The aim is to prepare companies for manufacturing of the future and to provide them support during their successful transition. ■

www.produktion.fraunhofer.de

Hydrogen Vehicles for Saxony-Anhalt



Water is split into hydrogen and oxygen for fuel cell vehicles. The hydrogen is stored and fuel cells in vehicles convert it back into electricity to drive.

The future of drivetrains will be diverse. It ought to be clear at the latest since the Bundesrat's initiative to no longer zulassen motor vehicles with combustion engines as of 2030 that we will no longer power our cars with diesel and gasoline in the future. An alternative will be fuel cell vehicles powered with hydrogen.

Whereas such green vehicles will be commercially available to private customers or buses in mass transit, only a few ideas have existed for commercial applications. This is why the Fraunhofer IFF is establishing hydrogen-powered transporter or forklift fleets in industrial and commercial parks in joint projects together with such partners as Abo Wind AG in Saxony-Anhalt. The companies are testing the benefits of hydrogen fuel cell vehicles in business, industry and internal supply chains. Abo Wind will supply this fleet with hydrogen produced sustainably from renewable energy. Interested companies can participate in the projects anytime.

Fuel Cells for Vehicles

Many experts see vehicles with hydrogen fuel cell drivetrains playing an important role in future transportation. When the hydrogen is produced cost effective, they are even considered a better alternative to combustion engine that current battery-powered drivetrains. Hydrogen is easily made. The batteries in fuel cell vehicles are significantly smaller and lighter. Just as with a combustion engine, tanking lasts just a few minutes. They also have a significantly better ecological footprint than conventional drivetrains. Along with zero emission vehicles, hydrogen will primarily be used to store renewable energy. Electricity from sun and wind is used to split water into hydrogen and oxygen. The hydrogen is stored and fuel cells in vehicles convert it back into electricity to drive. Fuel cell vehicles's range of 300 to 600 kilometers is already many times higher than of most battery-powered vehicles. ■

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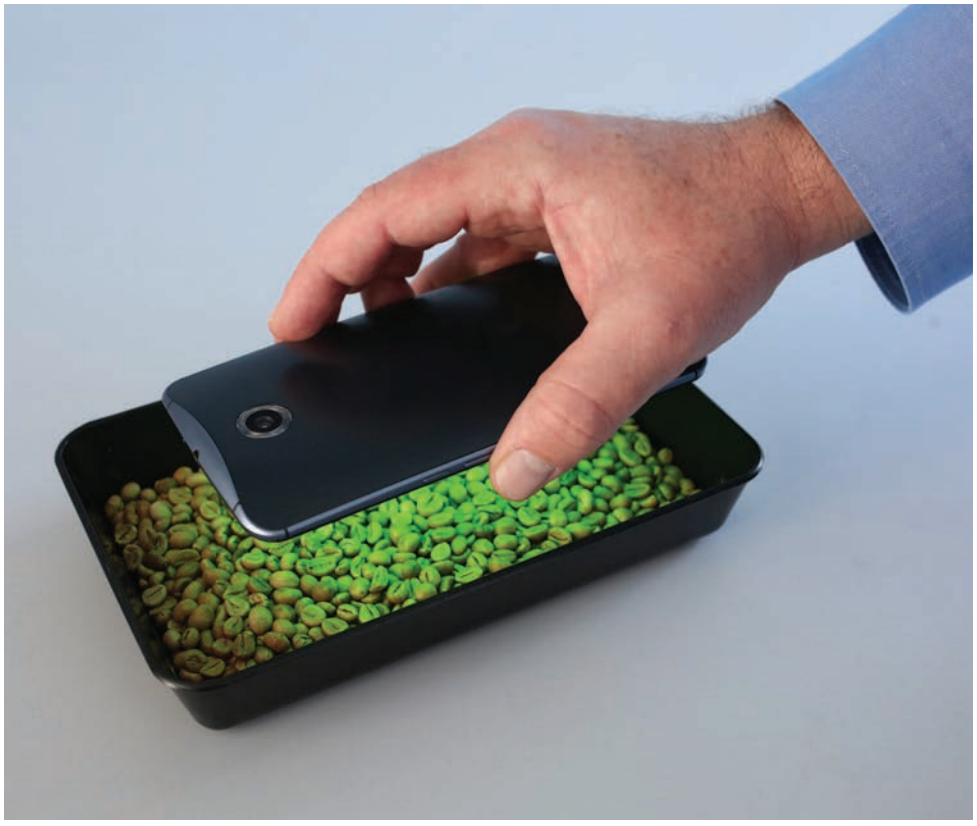
App Reveals Constituents

Researchers at the Fraunhofer IFF have developed an app that displays the specific constituents of objects. It has numerous uses such as inspecting food quality, crop condition or cosmetics.



Researchers at the Fraunhofer IFF worked with different raw coffees to develop the App HawkSpex® mobile prototype. The app detects exactly whether beans are Arabica or Robusta. Photo: Fraunhofer IFF, Viktoria Kühne

Customers cannot be certain that non-organic apples might not have gotten mixed into a supermarket's display of organic apples. If a seller's description is to be believed, a car has never been in an accident. Unverifiable information has to be accepted in many situations. The "HawkSpex® mobile" from the Fraunhofer IFF will enable consumers to verify such information in the future. The principle: Take out your smartphone, open the app, aim it at the object to be scanned, such as the dream car's fender, and get the desired information, for instance, whether paint has been touched up and the car may have been involved in an accident.

No Hyperspectral Camera Required

Such scans usually require a special hyperspectral camera: It adjusts to different colored light each time and ascertains how much of a color's light is reflected by the object, thus generating a complete spectral fingerprint of the object. The researchers use a mathematical model to extract just about any information on an object, e.g. its constituents, from its spectral fingerprint. "Since hyperspectral cameras aren't integrated in smartphones, we simply reversed this principle," explains Prof. Seiffert, expert group manager at the Fraunhofer IFF. "The camera gives us a broadband three-channel sensor, that is, one that scans every wavelength and illuminates an object with different colored light. This means that, instead of the camera measuring luminous intensity in different colors, the display successively illuminates the object with a series of different colors for fractions of a second. Intelligent analysis algorithms enable the app to make do with a smartphone's limited computing performance and compensate the limited performance of the camera and display."

The first laboratory version of the app for which a patent has been filed is finished. The researchers are developing a variety of initial applications together with companies before it can be released to private users, though. The system first has to be taught with reference scans how to analyze whether apples contain pesticides, for instance.

The app has extremely interesting commercial potential, too, and can be used to develop sectors that would not really benefit from high precision scanners. Examples include quality control of foods, the effectiveness of cosmetic products or even agriculture. Farmers, for instance, could easily obtain information on whether their crops are sufficiently supplied with nutrients or need fertilizer.

Seiffert, hopes the "HawkSpex® mobile" app could be launched on the market around the end of 2017.

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20 YEARS OF THE LOGISTICS GUEST LECTURE SERIES : DEVELOPMENT, PROSPECTS AND TRENDS

JUNE 20, 2017 | 6 P.M.
AT THE FRAUNHOFER IFF MAGDEBURG

2016
IFF Science Days

Photos: Fraunhofer IFF, Viktoria Kühne

The Internet of Things Needs New Systems

Interview with Markus Jenisch,

Senior Solution Architect, Nokia

Digital transformation in industry and society, smart interconnectivity of increasingly larger domains in industry as well as our daily life, is steadily advancing. Whereas growing bit rates, which allow us to exchange increasingly larger data packets, are especially needed for personal use, industry requires even more. New telecommunications technologies are needed if machines, robots or systems are to be interconnected worldwide and communicate with each other in real time. This will be done by the coming 5G system and specific solutions for industry such as the Narrowband Internet of Things (NB-IoT), which is primarily intended to enable transmitting small volumes of data for business applications in regions with limited network coverage.

The introduction of more effective telecommunications systems is essential to Industrie 4.0 and the Internet of Things (IoT) ultimately functioning. What effect will 5G have?

Industrie 4.0 and the Internet of Things are generating entirely new demands on systems. On the one hand, even more bandwidth is needed to transmit high resolution videos such as 4k/8k or 360-degree videos. On the other hand, small mobile sensors and actuators require very energy-efficient transmission systems so that they can operate several years without battery replacement. 5G provides not only higher bit rates but also better spectral efficiency, shorter delays and higher energy efficiency. Nokia is playing a significant role in 5G research and standardization.

The multitude of different system technologies is a challenge for the industry. How can systems be made interoperable, that is, made to cooperate smoothly?

Various access points in the licensed and unlicensed spectrum will satisfy future systems' requirements of bandwidth, coverage, availability or delay. Services will largely be provided disconnected from the underlying infrastructure. Software-defined networking (SDN) and virtualized system functions will facilitate this development. Since they make it possible to vary quality of service (QoS) as required, standard wireless solutions are ideal for critical industry applications' requirements. The common wireless practice of defining global standards will ensure generally good interoperability.

Malfunctions or even an outage of telecommunications systems are worst case scenarios for Industrie 4.0. What is being done to prevent data losses in manufacturing when malfunctions occur?

Several approaches basically ensure high system availability. Network nodes such as a wireless cell's base stations located near users are increasingly connected to the core network by redundant paths. In the future, network functions will also be executed distributedly by virtualization, thus enhancing reliability. Small cell solutions increase wireless coverage inside and outside buildings, thus minimizing dead zones. The introduction of Mobile Edge Computing is another factor that is particularly important for applications with rapid system response times of a few milliseconds. This relocates data processing close to users, thus eliminating long distances when transmitting data.

Not least, the logistics industry needs energy-saving and low-cost wireless communication in which interconnected inexpensive sensors have to function five years. LPWAN systems such as the Narrowband Internet of Things NB-IoT are supposed to provide this. When will NB-IoT arrive and how will this technology develop internationally?

3GPP IoT solutions were standardized in 2016. Standard systems such as LTE Cat. M1, also known as eMTC are commercially available, too. NB IoT solutions designed and classified for cost-sensitive mass applications and classified as LTE Cat. NB1 are expected this year. Nokia presented such a Narrowband IoT solution at the Mobile World Congress 2017.

» Industrie 4.0 and the Internet of Things are generating entirely new demands on systems. «

Markus Jenisch, Senior Solution Architect, Nokia
Photo: Renz Fotografie

Logistics requires ubiquitous connectivity. Is NB-IoT the solution here, too?

Improvements have put NB-IoT within reach and its energy consumption have made it a solution whenever only low volumes of data have to be transmitted and expenditures for sensors have to be kept low. This is the case, for instance, when containers on port premises transmit their current location or when streetlights or buildings "register" passing cars. Since we expect future systems will make even higher bit rates possible and be expanded even more across the board, different technologies – copper, coaxial or optical fiber cables as well as LTE or later 5G – will be employed in wireless systems. NB-IoT will also be instrumental in comprehensive connectivity unrestricted by any technology.

What will manufacturers and logistics providers have to do to prepare properly for the new system and thus take advantage of the attendant opportunities?

Interconnecting different things and transmitting information are but one part of the changes that digital transformation entails. Interconnectivity makes it possible to collect and store information from the widest variety of domains of sensor technology. Only smart processing of all available data will result in the optimization of business processes, though. What is more, companies can assess the opportunities provided by new innovative services. One such service is "air to ground", a version of LTE specifically for aviation, which will facilitate real-time and ultra-wideband communication in aircraft in the future and could also take logistics a step further in E2E cargo monitoring.

BRIEF BIOGRAPHY

Markus Jenisch

- Diplom degree in telecommunications engineering from Stuttgart University of Cooperative Education
- Development of communication system components at Alcatel
- Manager of System Planning and Optimization
- Senior Consultant for Digital System Architectures at Alcatel-Lucent
- Senior Solution Architect of Future System Solutions for System Operators at Nokia

Markus Jenisch has also been teaching at Baden-Württemberg Cooperative State University for many years and supports the German government's National IT Summit with contributions.

Smart Farming

How Digital Transformation Is Changing Agriculture

Janine von Ackeren

Numerous domains of agriculture have already been digitally transformed. Agricultural machinery, for instance, frequently drives over fields autonomously. Digital transformation of plant nutrition and health is still pending, though. Testing plant health and nutrient content normally entails mailing plant samples to a laboratory. A system will enable farmers to obtain such results immediately and comprehensively on the spot in the future. This system will also open up new business models for food and feed producers.

The days in which farming was manual labor are long gone. It has been digitally transformed in many domains, instead. Tractors drive over fields autonomously, and seed drills know by GPS where they have already sown, thus avoiding sowing seeds twice on one spot. Digital transformation of plant health and nutrition has not been around all too long, though. Farmers usually test their plants by picking a few leaves from select plants and mailing them to a wet chemistry lab where they are analyzed for iron, zinc, phosphorus and nitrogen. This approach has drawbacks, though. On the one hand, comprehensive testing cannot be done. A farmer can only collect samples of individual plants. The more samples a farmer collects, the more exact the results are. This costs more, too, though. On the other hand, since this method is not real-time capable, it takes about two days until the results are available.

Hyperspectral data structure of a leaf: Two-dimensional location information is available in a multitude of spectral channels. Graphic: Fraunhofer IFF

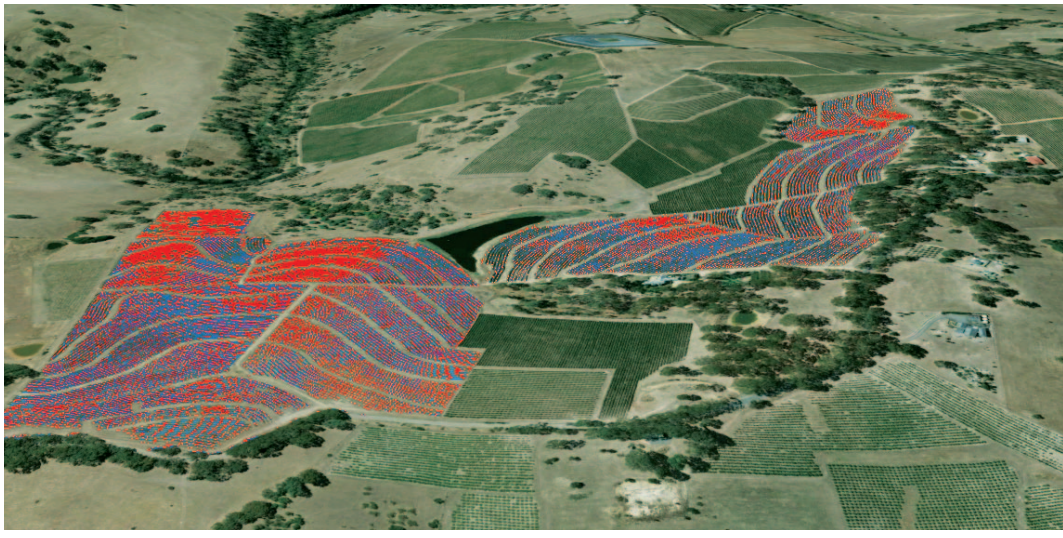
A "Wet Lab" in the Field: Analyzing Every Plant in Real Time

Researchers at the Fraunhofer IFF are digitally transforming plant analysis. "We have brought a wet lab's capabilities to fields in real time," says Prof. Udo Seiffert, Expert Group Manager at the Fraunhofer IFF. "Instead of just samples as in the past, our technology can also analyze a complete field, every single plant on it." This enables the farmer to apply fertilizer and pesticide systematically wherever they are needed. First, that saves money. Second, it increases harvests. Third, it protects the environment. One potential scenario might entail a farmer mounting the new sensor on a tractor, which scans plants' condition as it drives. Do they need fertilizer? If so, what kind? A fertilizer sprayer attached a few meters farther back on the tractor's trailer sprays the right quantity of the optimal fertilizer directly on the spot in the field. Or the farmer flies over her or his fields with a special camera that operates based on the same measuring principle and obtains a complete supply map that shows where fertilizer or pesticide are needed. Such sensors and cameras are based on hyperspectral analysis and see more than the visible light captured by ordinary cameras to analyze frequencies beyond blue, red and green, i.e. infrared and UV radiation. A mathematical algorithm extrapolates plants' nutrient content or diseases infecting them from the light spectrum they emit.

» JUST AS DIGITAL TRANSFORMATION MEANS GREATER CUSTOMIZATION IN INDUSTRIE 4.0, THE HYPERSPECTRAL SENSORS' DATA ENABLE MAKING YIELD-SPECIFIC DECISIONS IN AGRICULTURE. «

Digital Alternative for Smaller Farms

Since such a purchase may not pay off for smaller farms, though, the researchers at the Fraunhofer IFF have developed another solution that tests single plants digitally, an app that looks directly inside plants and displays specific constituents such as nutrient content. A farmer needs nothing more than a smartphone for this. "We simply reversed the principle for the app," explains Seiffert. "Instead of the camera measuring luminous intensity in different colors, the display successively illuminates the object with a series of different colors for fractions of a second. Intelligent analysis algorithms enable the app to make do with a smartphone's limited computing performance and compensate the limited performance of the camera and display. Since this app can hardly analyze an entire field, though, samples still have to be taken, but at no cost and in real time.



Aerial photographs of fields: A hyperspectral camera reveals a plant's nutrient supply. Optical sensors and artificial intelligence are helping make fields machine readable digitally. Image: Fraunhofer IFF

Combining Different Data Sources Adds Value

The intention is to generate recommendations for action from the data obtained from the hyperspectral cameras and sensors. For instance, plants in an area are infected by disease XY and have to be treated with such and such a pesticide. First, the giant mountain of data amassed by the sensors and cameras has to be analyzed. This is also called big data. "Numerous algorithms from Industrie

A hyperspectral camera's operating principle is simply reversed with a smartphone and the "HawkSpex® mobile" app. The results can be used for an initial individual analysis, e.g. to scan a plant's condition. Photo: Fraunhofer IFF

Artificial intelligence requires extensive, representative digital data sets collected under realistic conditions, e.g. during traditional vegetable farming. Here, Fraunhofer IFF researchers are scanning lettuce with a hyperspectral camera system. Photo: Fraunhofer IFF

4.0 can be modified for big data issues in agriculture," explains Dr. Christian Teutsch, who is researching Industrie 4.0 at the Fraunhofer IFF. "The problem lies less in the evaluation of data itself than in the collection of data from different sources, regardless of whether this is about digital transformation in industry or agriculture." Taking full advantage of the capabilities of digital transformation requires compiling data from different sources. For agriculture, this means that data generated by a seed drill, for instance, could be combined with data from hyperspectral sensors; or with meteorological data: What were the weather conditions under which plant diseases increased in the past? What can be extrapolated from the current weather? "Generating such value added requires finding out what data is stored where together with the client and especially ascertaining which data are needed for which applications," says Teutsch.

Digital Transformation Makes New Business Models Possible

The researchers at the Fraunhofer IFF are developing the entire chain, starting with the sensors through the software module to data evaluation up through the Internet platform or app for users. Naturally, this includes having an eye on different business models that emerge during digital transformation. "An agricultural equipment manufacture looks at the data differently than an agricultural consultant, and, in turn, a plant breeder," explains Seiffert. That is why the researchers at the Fraunhofer IFF provide the different stakeholders different approaches and business models for large farms or for disseminators such as consultants, agricultural equipment manufactures and plant breeders. They are now implementing the basic technology in concrete solutions together with users.

One solution is custom marketing. "Just as digital transformation means greater customization in Industrie 4.0, the hyperspectral sensors' data enable making yield-specific decisions in agriculture," says Teutsch. An agricultural consultant could ascertain some plants' nutritional state with a sensor and then deliver appropriate, optimized fertilizer the very next morning. Plant breeders, on the other hand, have a different focus. They are interested in the properties of certain crossbreeds and their response to different fertilizer situations or weather conditions. This too can be clarified quickly and easily with the new sensor and smart data analysis.

Digital transformation also opens up other new business models beyond hyperspectral sensors, e.g. harvester maintenance. "At manufacturing facilities, for instance, it is commonplace for manufacturers to make money primarily from options and service customized for customers" explains Teutsch. "This is conceivable for harvesters, too. A manufacturer could collect and analyze data from integrated sensors and ascertain a certain probability of failure for the coming days from them. The manufacturer could forewarn and ask the farmer to come in for servicing in good time beforehand." Costly and nerve-racking machine downtimes would be a thing of the past.

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Industrie 4.0

New Business Models in Process Manufacturing

Dr. Nico Zobel

Industrie 4.0 has primarily meant the development of requisite technologies. In the next step, the focus is now on completely new business models ensuing from this development. In the future, customers might pay for use rather than for the product.

Without a car, heading off to a lake in the mountains or going on an excursion away from the city and into the countryside is often entails a lot of fuss. City dwellers, on the other hand usually reach their destinations faster and with less hassle by subway, commuter train and bus. Rather than relying on a car of their own, many people chiefly use mass transit or even car sharing services. In the latter case, this means that they save money on purchases and constant upkeep, i.e. taxes, insurance and possible expenses for a garage or parking space, and pay a low monthly fee and for the kilometers ridden instead. Such business models already exist in

industry, too. Some paint manufacturers now sell their product by the auto bodies painted rather than by the liter. Companies that need process steam for manufacturing usually built their own generating station. Now there are suppliers that build such generating stations at customers' facilities at their own expense and provide the needed process steam directly as a service. Customers are billed for consumption.

Industry 4.0 Goes Hand in Hand with New Business Models

Since such a business model has been an emerging trend for years, it will logically continue in the future, too. After all, whereas the first phase of Industrie 4.0 was primarily about its technical dimension, i.e. smart facilities and communication, the second phase is focusing instead on turning technical capabilities into new business models. This is opening up entirely new business opportunities. That is why we at the Fraunhofer IFF are working with different industry partners on technically implementing and testing these capabilities. Industrial filters provide a prime example of the potential behind this. Instead of purchasing industrial filters themselves, customers could use them for a fee. That brings customers numerous benefits. On the one hand, the financial risk shifts from them to the supplier. Rather than having to pay the high price themselves, customers now let the manufacturer pay for filters. On the other hand, customers only pay when they use the filters. This is also the main difference from renting or leasing. Whereas a set price is paid for a rental, even when the rented object is gathering dust unused in a corner, the new business model only charges a fee (apart from a low base rental fee) when the object is used.

So far, so good. Why should suppliers do that and pay the purchase price themselves though.

» OFFERING NEW SERVICES IS HIGHLY POPULAR AT THIS TIME «

The chemical industry has profited little from Industrie 4.0 so far. This will soon change if the researchers at the Fraunhofer IFF have their way. Photo: Industrieblick, Fotolia

Such a business model brings suppliers man benefits, too. Consider a € 50,000 industrial filter. When the customer buys this filter, it amortizes after a certain time, say ten years. Now, the filter has a service life of twenty years, though. Although it bears the financial risk, a supplier that bills by the new business model would earn money over the filter's entire service life. The supplier would also be paid in another currency: It continuously receives data on the filter. Whereas users now know much more about the filters and their performance in real operations than the manufacturers, this would change to the manufacturers' advantage. Such data can be turned into cash and create a major competitive edge. The data received by the filter could be used to keep a better eye on maintenance, thus reducing operating costs. The manufacturer that knows its equipment or filters best, works most effectively and can therefore afford to set fees lower, thus gaining a tremendous edge over the competition.

Suppliers can, in turn, pass part of the financial risk onto their suppliers. Suppliers of larger components are also customers in a certain sense. They also purchase filters, boilers, conveyor belts and the like. Shifting the purchase costs to the suppliers of individual components spreads the financial risk. Financial risk will probably be increasingly passed along to manufacturers of individual components in the coming years. There might even be completely new market participants such as investors that establish ties between manufacturers and customers by assuming the capital expenditures and operating the different equipment at customers' facilities as a service.

Simulating Business Models Exactly

This market model will most certainly establish itself in segments of industry. It is the logical next step and rather than whether it will be taken, the question is more who will take it first. Once it has been taken, customers will benefit. Other suppliers will have to follow suit. That is why we at the Fraunhofer IFF intend to study what such a business model might look like exactly with some partners. How high does the base fee have to be? How high do user fees have to be? To clarify such and similar questions, we are attaching meters to a specified number of components, on ten filters, if we stick with our example. We

Digital transformation will also change maintenance in process manufacturing. Photo: Fraunhofer IFF, Dirk Mahler

are using the data collected on a central server and the data already on hand in the company to compute different billing models. We are thus scrutinizing every parameter. It is essential to incorporate expedient cross subsidization. While one filter runs nearly thirty years, others are used only ten percent of the time. All of that has to be factored in. The individual filters' service life also has to be factored in. Then, we formulate maintenance forecasts from the data obtained. A seal, previously replaced routinely every half a year, might only need to be replaced every nine months then.

This, however, is but one new business model that might become established based on Industrie 4.0. A dozen other business models exist. Many are based on centrally collected operating data that have been stored in isolation on individual computers or servers. Data could be combined beyond one particular production facility, and services based on them could be offered. Issued warnings might be an example: Caution, the following equipment is running inefficiently. There is still a bit to do until such new data-based business models become established. Offering new services is highly popular at this time.

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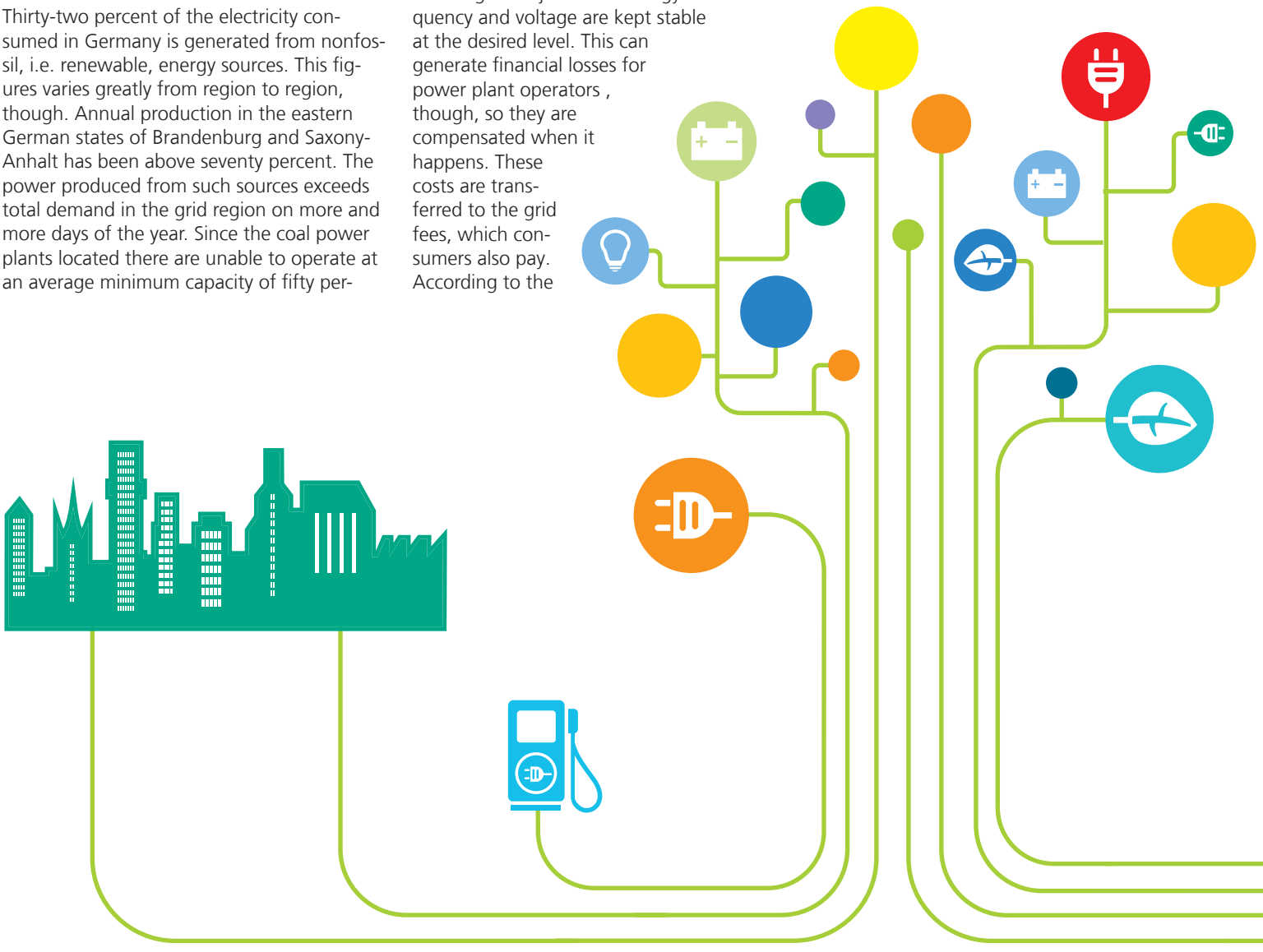
WindNODE Is Bringing Energy Demand and Supply Together

Janine van Ackeren

The production of electricity from renewables has been the most important and most visible part of the energy transition in Germany. Now, the priority is to harmonize the fluctuating green power supply, grid stability, conventional energy sources and demand.

Thirty-two percent of the electricity consumed in Germany is generated from nonfossil, i.e. renewable, energy sources. This figures varies greatly from region to region, though. Annual production in the eastern German states of Brandenburg and Saxony-Anhalt has been above seventy percent. The power produced from such sources exceeds total demand in the grid region on more and more days of the year. Since the coal power plants located there are unable to operate at an average minimum capacity of fifty percent, the only option is to transport the excess power through available extra high voltage lines to other consumption regions. The last resort when these line capacities have also been exhausted is "redispatching": Grid operators take actions in power production, reducing the injection of energy until frequency and voltage are kept stable at the desired level. This can generate financial losses for power plant operators , though, so they are compensated when it happens. These costs are transferred to the grid fees, which consumers also pay. According to the Federal Network Agency, the costs of such grid and system stability actions in Germany totaled around one billion euros in 2015. This makes it hardly surprising that solutions that close the gap between supply and demand,



which is influenced by heavily fluctuating production as well as daily and annual peak demand, are being sought intensively.

A Major Research Project

Preparations for the commencement of the major research project WindNODE in early December 2016 took around one and a half years. Lead managed by the transmission system operator 50Hertz Transmission, industry and research partners will spend four years studying how to integrate fluctuating quantities of power produced from renewable and non-renewable resources in grids most reliably and most effectively. They will be concentrating on the eastern states and Berlin.

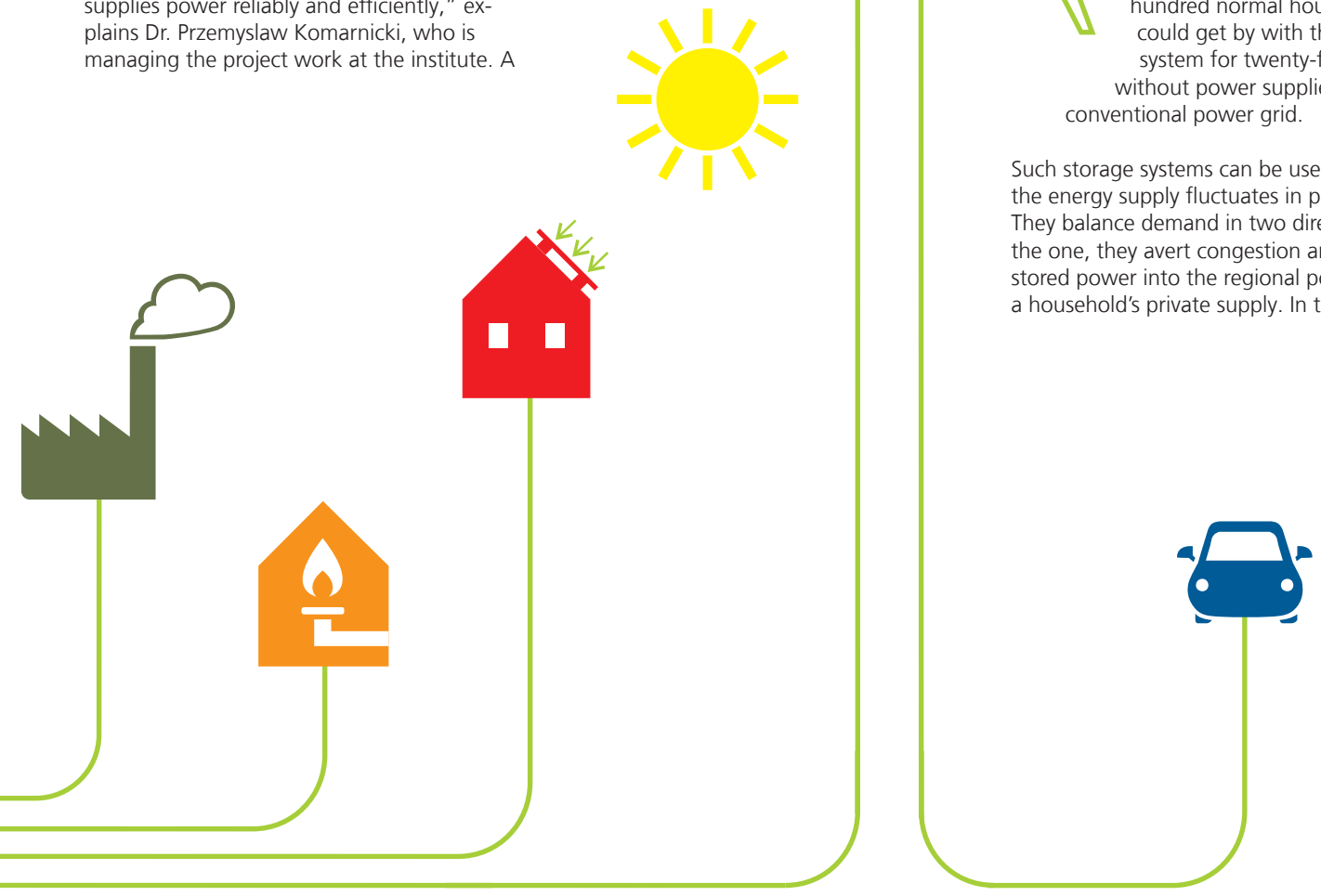
The Fraunhofer Institute for Factory Operation and Automation IFF in Magdeburg also has an important role in the project. For years, it has been working intensively on systems that reliably manage power grids. "In WindNODE, together with our partners, we at the Fraunhofer IFF will be researching which technology for networking producers, consumers and infrastructure most effectively supplies power reliably and efficiently," explains Dr. Przemyslaw Komarnicki, who is managing the project work at the institute. A technical demonstrator will be built at the institute by 2018.

The idea behind WindNODE is best described as optimized load transfers in industry and the public and private sector. These consumers will be enabled to adjust their electricity consumption better to its regional and temporary availability, while transmission and distribution grids and distributed energy storage systems will provide an additional buffer whenever availability fluctuates.

Large Batteries Stabilize Power Grids

The researchers from the Fraunhofer IFF demonstrate its impact strikingly. The Fraunhofer IFF's Virtual Development and Training Centre VDTC is located in Magdeburg's Port of Science directly on the Elbe. A transportable large battery with one megawatt of power is located right next to the building. It contains eight lithium-ion battery lines with five thousand battery cells. The battery can either be supplied with power from the grid or from the institute's own photovoltaic system. The researchers can use it and a smart energy management system they developed to supply power to their facility housing as many as one hundred employees, offices and different laboratories for several hours. Alternatively, some one hundred normal households could get by with the storage system for twenty-four hours without power supplied from the conventional power grid.

Such storage systems can be used whenever the energy supply fluctuates in power grids. They balance demand in two directions. In the one, they avert congestion and inject stored power into the regional power grid or a household's private supply. In the other,



» IN WINDNODE, TOGETHER WITH OUR PARTNERS, WE AT THE FRAUNHOFER IFF WILL BE RESEARCHING WHICH TECHNOLOGY FOR NETWORKING PRODUCERS, CONSUMERS AND INFRASTRUCTURE MOST EFFECTIVELY SUPPLIES POWERRELIABLY AND EFFICIENTLY. «

they absorb oversupplies of power and stabilize overloaded grids.

The cells each supply 3.7 volts and are series-connected. Dr. Komarnicki shows visitors a circuit diagram during a test. Power is going from the photovoltaic cells to the institute's roof. The batteries are nearly full. Two electric cars are parked at the charging stations. "We will now disconnect the institute from the grid," he says and throws a switch. This is unnoticeable in the rooms. Computers keep running. Even employees in the testing facility where some robots are swinging their arms are unaware that the power flow has changed. The battery becomes a power supplier for a few minutes and could help stabilize the local grid during congestion. Naturally, this all works the other way around, too: Whenever there is too much power in the grid, all of the storage systems are charged. Some additional loads such as air compressors, electric heaters or air conditioners may even be connected.

Controlled by Smart Energy Management Systems

Sophisticated software is needed for all of this to function. The Fraunhofer IFF researchers' smart energy management system controls the balance of power supply and demand. In the future, the Fraunhofer IFF's software will compute ordinary management functions, too. Bypassing an available electric vehicle during congestion and injecting the power stored in its batteries back into the grid, instead, may well be economically expedient in the future. "Using a taxi in such situations may be more cost effective – naturally, this has to be computed as a function of the distance driven – because power is very expensive at such a time and sales revenue from the injection of power is very lucrative," says Dr. Komarnicki, citing an example for private users. All of this can be scaled for industry of course, thus taking on quite significant dimensions with economic relevance for business, too.

The use of large battery energy storage systems and interruptible loads in industry not only stabilizes grids and cuts expenditures to upgrade grids but also reduces costs and even generates business models of interest to companies. Industry's interest in the WindNODE project is correspondingly large. Project partners include Siemens and Infraleuna GmbH, the largest service and supply company that supplies Leuna chemical facilities in Saxony-Anhalt with all necessary media.

Naturally, far more components have to be incorporated into such highly complex industrial systems to optimize the control of demand. Some companies even have their own

The Fraunhofer IFF's mobile energy storage system. Five thousand battery cells are in the container. (See the photo on page 26). Photos: Fraunhofer IFF, Daniela Martin

supply systems, and their business models differ, too. The control algorithms are nevertheless similar and have to be modified and, when necessary, upgraded for exactly the particular case being analyzed. Energy production forecasting will be added. Dr. Komarnicki is convinced, "the market signals for the price of electricity will play a crucial role in the control of such systems."

Potential New Business Models

The capabilities are substantial: Whereas WindNODE defines minimum dispatchable loads as 1.5 to 2 megawatts, they are frequently ten time larger in industry. Drive units or pumps have high connected loads. Some run continuously. Others do not. "At times, not starting two of a plant's large compressors fully synchronously is already enough to cut peak loads," says Dr. Komarnicki. WindNODE's mission extends far beyond such relatively simple stand-alone solutions, though.

WindNODE is intended to bring another significant advance over the energy management system developed at the institute earlier. Not only the electricity sector alone but also other sectors such as heat, gas and compressed air will be analyzed. The new demonstrator at the institute will therefore additionally have power-to-gas and power-to-heat systems that produce hydrogen and heat from excess electricity. This can be reconverted in future energy systems, e.g. fuel cells, or used to generate heat. This will give the complete system significantly more storage capacity than current battery energy storage systems. Alternatively, electricity and heat could either be used internally or sold then, something that could be an interesting business model for more than just industrial parks.

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Connectivity

for Smart Logistics Zones

Prof. Klaus Richter

The logistics hub of Leipzig-Halle Airport. Photo: Fraunhofer IFF, Dirk Mahler

» LPWAN WILL BECOME ESTABLISHED AS THE NEW BASIC TECHNOLOGY FOR DESIGNING INNOVATIVE DATA HUBS AND THUS NEW BUSINESS MODELS. «

The Smart Logistics Zone

Logistik 4.0 is seen as an integrator for every industrial application in our gigabit society. Like Industrie 4.0, Logistik 4.0 encompasses digitized processes and systems based on continuous data exchange among human actors and technical assets. Logistik 4.0 defines a smart logistics zone as the ecosystem of a systemically definable structure space with its logistical operations and the individuals involved in it, the mobile and infrastructural logistical components, and the requisite IT ambient intelligence. This logistically motivated spatial category enables actors from logistics and telecommunications to specify, standardize, and provide communications services collectively for new Logistik 4.0 business models regionally and globally. The new 5G wireless system generation will satisfy the smart logistics zone's requirement of integrated connectivity through its convergence of communications systems for the first time ever.

Logistics Connectivity

Logistics requires connectivity, albeit with low bit rates, to communicate without interruption throughout the entire global supply chain to the assembly lines of manufacturers or private end customers in rural areas.

The telecommunications industry has not been able to satisfy the demands on such a low-power wide-area network (LPWAN) for low capital expenditures and communications costs, long life and wider availability.

Already being used for decentralized x-ray screening, video-based situation analysis at logistics hubs or among private end customers, broadband communication links may also be interesting in the future for crosschecking multispectral cargo fingerprints in international supply chains.

LPWAN gateway on one of the Fraunhofer IFF's buildings. Photo: Fraunhofer IFF

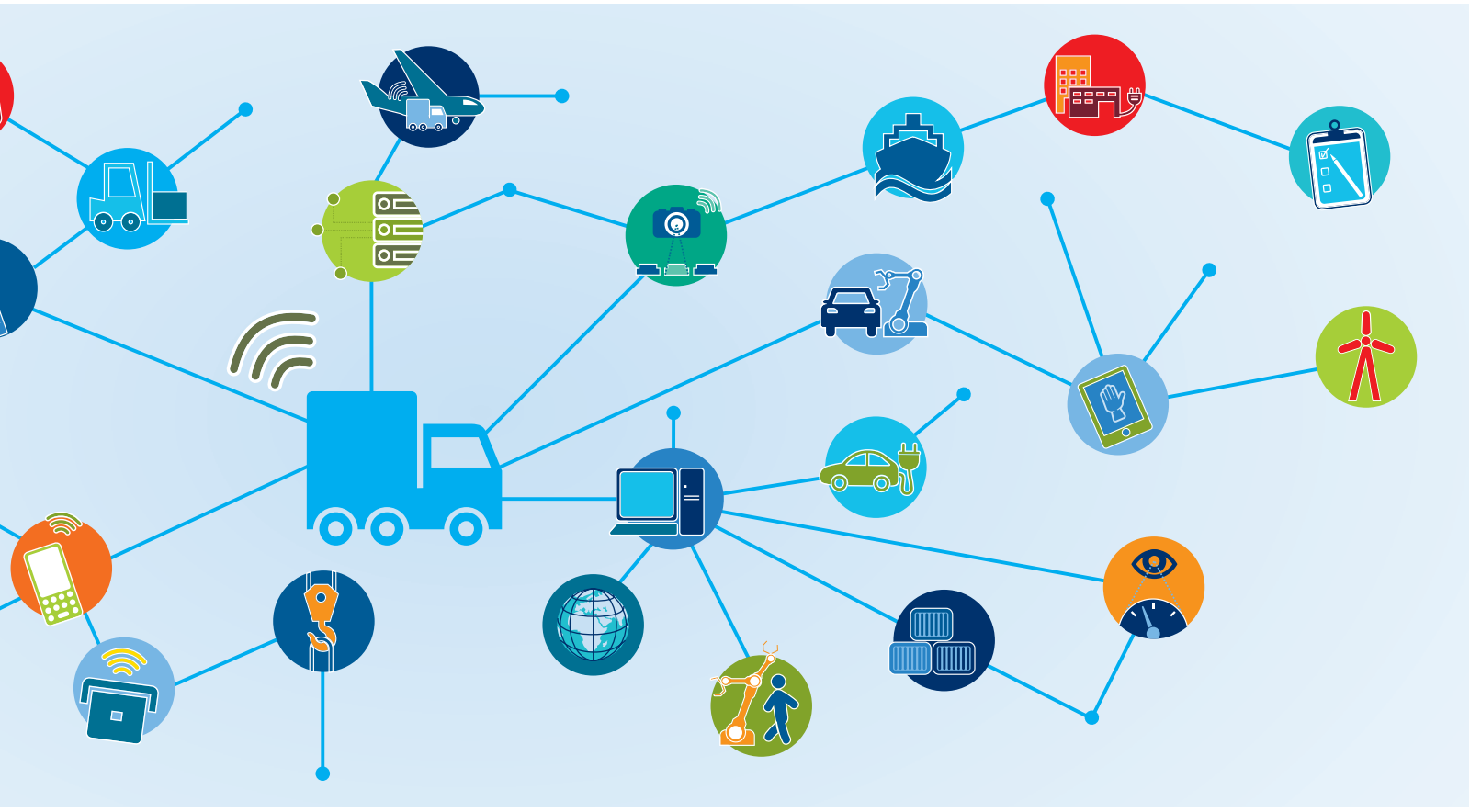
This imposes two demands for connectivity on the logistics industry, extensively using mobile broadband links for near real-time assessment of cargo handling to transfer risk between two stakeholders and integrating low-power wide-area networks with low data volume to integrate connectivity in logistics operations. This will further establish applications in short-distance wireless networks (WPAN) that eliminate cabling in communication between personal endpoints and radio nodes on an object.

Logistics Connectivity as a Telecommunications Industry Service

Logistics connectivity requires telecommunications industry services to use networks' convergence to provide communication access to logistical assets, equipment or human actors in a smart logistics zone as needed and without established borders. Shipments and shipping equipment are in transit internationally and require connectivity across regions and borders. Uninterrupted connectivity also means connectivity on the means of transportation, whether that be a plane or ship. Customs and security agencies have to be enabled to access information efficiently. Regulations have to allow nondiscriminatory roaming among different internet providers. In keeping with the brevity of contract logistics (network slicing), Internet and telecommunications services will have to be dynamically adaptable and provide supply chain connectivity down to assembly lines in factories. At the same time, communication links ought to enable the tracking of logistical assets once approval has been given to ascertain this information. International logistics means compliance with international rules and regulations on public security throughout the entire transport chain. Network neutrality may not counteract these demands.

LPWAN: New Basic Connectivity for Logistics

The road maps for Industrie 4.0, Industrial Internet and Internet of Things are currently spurring the development of new wireless technologies. The telecommunications industry is finally competing with services for the market segment of low-power wide-area networks. LPWAN technologies are communications systems used by mobile or stationary radio nodes to establish communication with a network server either over unlicensed frequencies in an ISM-Band (LoRaWAN, Sigfox, etc.) or licensed wireless frequencies (NB-IoT, NB-LTE, etc.). LPWAN technologies are highly interesting for logistics in order to have constant access to battery-powered sensors (temperature sensors in plastic pallets for the food industry), ensure access to sensors without personal short-distance wireless devices (unaccompanied shipment of pallets) or to read



New communications technologies will enhance logistic's performance. Graphic: Fraunhofer IFF

a large number of devices in one zone simultaneously (all shipping equipment at one logistics hub).

The main focus of rollouts of LPWAN technology is currently on smart metering and smart parking. Logistics applications' transportation of radio nodes, thus defining additional demands on roaming and tracking, makes them different.

LPWAN will become established as the new basic technology for designing innovative data hubs and thus new business models, which use smart data interfaces and analysis to support logistical decision making automatically. Standard data interfaces and clearly specified privacy policies are the foundation for proper handling of customer data. Part of the Internet of Things, digital logistics data present a company's performance and therefore have to be protected from unauthorized access. New services will be created for different spatial categories of smart logistics zones, which will adaptively ensure communication through an international supply chain or hotspots at logistics hubs by utilizing the convergence of 5G communications systems.

Conclusion

Although it is seen as both the driver and the basis of Industrie 4.0 scenarios, Logistik 4.0 has been unable to meet expectations because integrated connectivity along the supply chain has been unavailable at acceptable prices. LPWAN technologies will make smart logistics zone a reality in widely varying spatial categories of logistics. The Fraunhofer IFF's access to this technology at this early stage, enables it to help its research and development partners and clients select the right connectivity to develop innovative logistics services.

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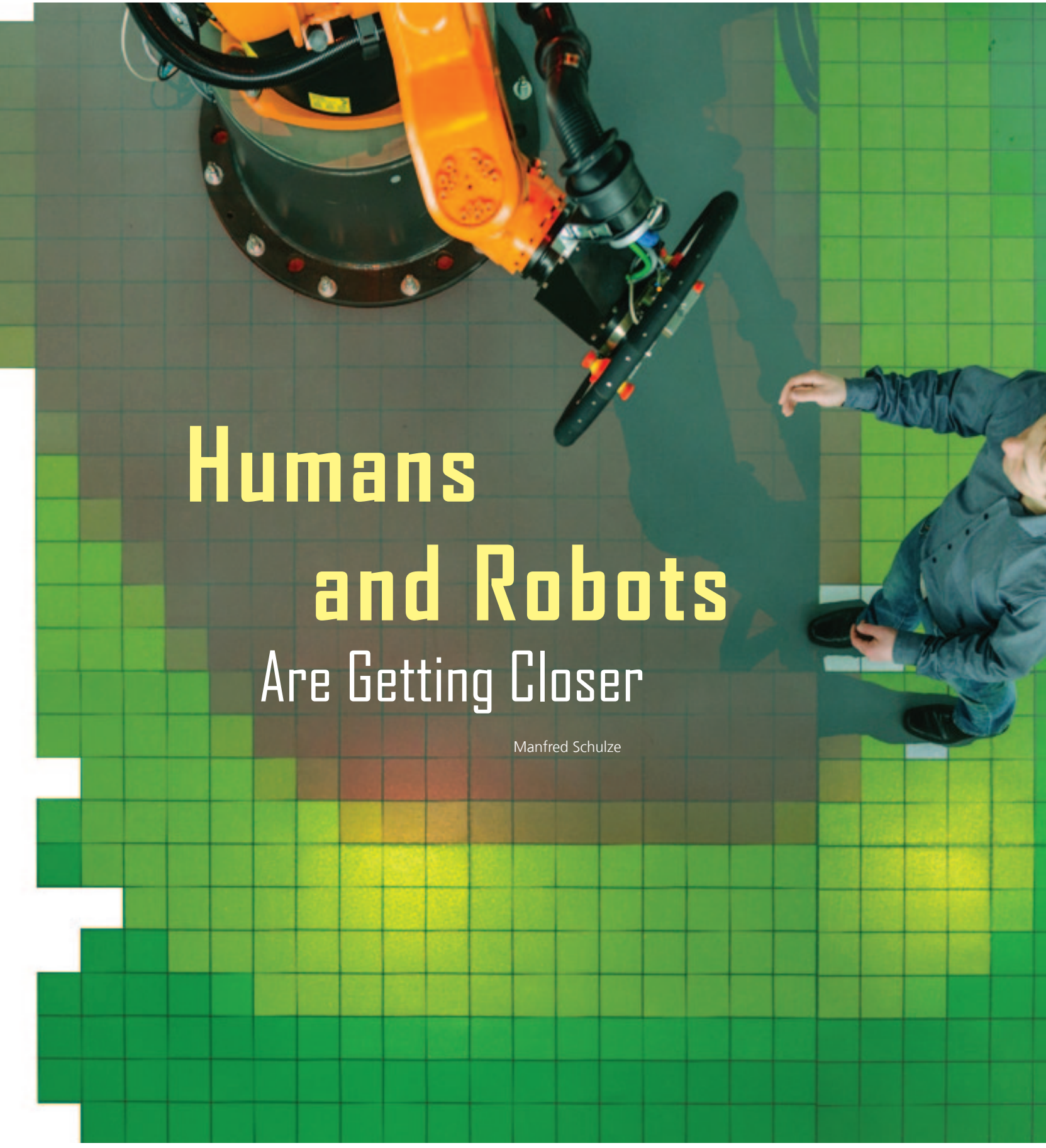


Humans and Robots

Are Getting Closer

Manfred Schulze

Digital transformation and automation go hand in hand in manufacturing. Among other things, the researchers at the Fraunhofer IFF employ tactile sensors, cameras and augmented reality technologies as well as novel combinations of them to make human and robot collaboration safe. They are developing smart assistance systems that enable humans to collaborate directly with robots efficiently and safely.

A look in one of BMW, Volkswagen, Opel or Mercedes's plants where robots are welding body parts together in a shower of sparks normally reveals hardly a human worker. This view of practically fully automated manufacturing was generally considered the shape of the future for a few years. After all, machines do not make any mistakes, do not need any vacation, and do not tire even when they have already worked two shifts.

Not every step of work is suited for full automation, though. Staying with carmaking, being able to combine humans' dexterity and five senses with robotic arms' strength and speed in final assembly would be far more important.

Such collaboration between humans and robots faces a major hurdle of weight and speed. Collisions between the two that would cause humans pain or injury have to be an impossibility. Humans can be a problem, too, though. Although they may see a robot, they often have no idea how their steel colleague intends to move next. Moreover, humans are by nature not careful enough to keep from landing in a danger zone unintentionally.

This is why robots' immediate work spaces are normally off limits to factory workers. Human-robot collaboration, however, is the current global trend in robotics. Strict separation of humans and robots is supposed to be abolished in order to let humans and robots each do the jobs they do best, for instance, in final assembly in carmaking – and to do so close to, next to or even with each other. Keeping robots from injuring humans is top priority. Thresholds for the onset of pain or even risk of injury in the event of contact between a robot and human often necessitate reducing robot speed greatly. That diminishes the productivity and cost effectiveness of process automation. How are human-robot collaboration and the cost effectiveness of manufacturing operations to be reconciled?

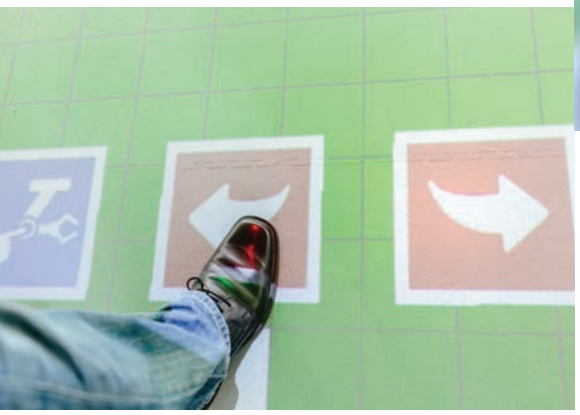
New Technologies for Safe Human-Robot Collaboration

For some years now, researchers at the Fraunhofer Institute for Factory Operation and Automation IFF in Magdeburg have been collaborating with industry partners on solutions that make human-robot collaboration safe and cost effective.

"We've developed two novel systems that close precisely this gap," explains Prof. Dr. Norbert Elkmann, Manager of the Robotic Systems Business Unit at the Fraunhofer IFF. "On the one hand, the Fraunhofer IFF has developed a camera and projection system that monitors work spaces dynamically. Since this system

Tactile enabling device for manual robot guidance.

Additional information and interactive surfaces projected on tactile flooring. Operators tap their feet on virtual buttons to give a robot simple commands.



even detects a human's hand, minimum distances between humans and robots can now be implemented. What is more, we have developed spatially resolved flooring that covers the robot's work space. This system detects a human's location in a work space at all times. The robot slows or stops when it is approached. This renders large separate work spaces for robots obsolete."

Spatially Resolved Flooring with Visualized Dynamic Danger and Safety Zones

The institute's testing facility houses a roughly thirty-square-meter testing area where an ordinary industrial robot's soft droning indicates its readiness to activate its gripper on command. A projector projects a red field on the floor, which tightly encircles the robot when it stops. This shows workers where safety and danger zones begin and end. In order to make it even easier for humans to move near the robot, the researchers have divided its surroundings into more zones, which they project on the floor in color with the projector. Red indicates the immediate danger zone, yellow the adjacent warning zone, and green the safety zone.

A researcher enters a few commands in his tablet and the facility comes alive. The approximately three-meter-high robot moves as programmed and grasps a part. The red zone on the floor constantly follows the robot wherever it moves. The robot controller communicates with the projector, which thus knows whether the steel arm will move left or right in the next moment and how far it will extend. Since that alone does not suffice to be a safety solution, the researchers have installed spatially resolved flooring around the robot as well. It detects the movements of humans in the robot's vicinity and transmits this information to the robot controller. If a human approaches and enters the zone despite the warning, the robot stops immediately. The two technologies together form a complete system that detects both humans and robots' movements all the time and adjusts the robot's actions to them.

Camera and Projector System that Monitors Work Spaces Dynamically

Since the "Camera and Projection System that Monitors Work Spaces Dynamically" reliably detects humans' hands, thus making minimum safety zones around robots feasible, its principle enables humans and robots to coexist optimally and safely. It also employs sensors and smart software that analyze recorded data to subsequently feed them back them into the real world as assistance and safety instructions.

Here too, the researchers are relying on a dynamic light curtain that draws a visible boundary around a robot and follows its every movement. Here, however, the curtain itself signals the robot to stop in the event it is breached by a human. "The location of cameras and projectors installed around a robot and the 3D environment data around the work space are known and calibrated to each other. We use this as the basis for computing an expected image for each camera, which is compared with the real camera image," explains Norbert Elkmann. If the light curtain drawn around the robot by the projectors is breached by an arm reaching toward the robot, for instance, the projected line is not displayed in the camera image as computed in the expected image. The breach of the safety zone is detected immediately and the robot stops.

A robot stops immediately whenever the dynamically projected safety zone around it is breached.

Simple command input for a mobile assistance robot. Photos: Fraunhofer IFF

Norbert Elkmann shows what that could look like concretely in practice on a model of an automotive plant's assembly line that has known practically only the either/or solution of robot or human. Robots could certainly also assist with different manual assembly tasks such as the installation of relatively heavy door elements. This would enable humans and robots to collaborate beneficially, guaranteeing safety.

To demonstrate how quickly the system responds, the robotics expert simply sticks out his arm, breaching the red line. The actively working robot stops instantaneously. "Computing the image situation defined as hazardous requires just a few milliseconds. The robot's braking takes the longest," explains Prof. Elkmann. This is primarily contingent on its range and weight. The robot would have responded exactly the same if a foot had entered the red zone or a person had suddenly bent her head into the zone. The height of the breach of the zone does not matter. Even a single finger is enough to trigger the robot's emergency stop.

Reliable Solutions

Such complex system control is only possible because of the recent rapid development of three-dimensional data models, which now dominate industrial process planning and control. "We incorporated the camera's imaging system in such a system, thus finding a reliable solution that functions flawlessly even under the real conditions of large-scale manufacturing," explains the Fraunhofer expert, who expects its use will not remain limited to the automotive industry.

The camera and projection system that monitors robot work spaces dynamically is the first in the world to comply with the specifications of speed and separation monitoring in ISO 10218 and TS 15066 on human-robot collaboration. This approach to solving problems of human-robot collaboration is just one of several being studied in Magdeburg. A tactile sensor system that detects robot collisions is also very advanced. The robotics community and industrial users are also following the world's first live subject tests of onset of pain or injury from contact between humans and robots at the Fraunhofer IFF with great interest. The researchers in Magdeburg have been contracted by the Berufsgenossenschaft Holz und Metall, Daimler, KUKA and others to conduct these tests. The findings of the live subject tests will enter into standards. New research projects building upon these studies and enabling early-stage planning of human-robot collaboration applications that incorporate safety standards are in preparation.

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The Future of Manufacturing in a Digital World

Dr. Dirk Berndt

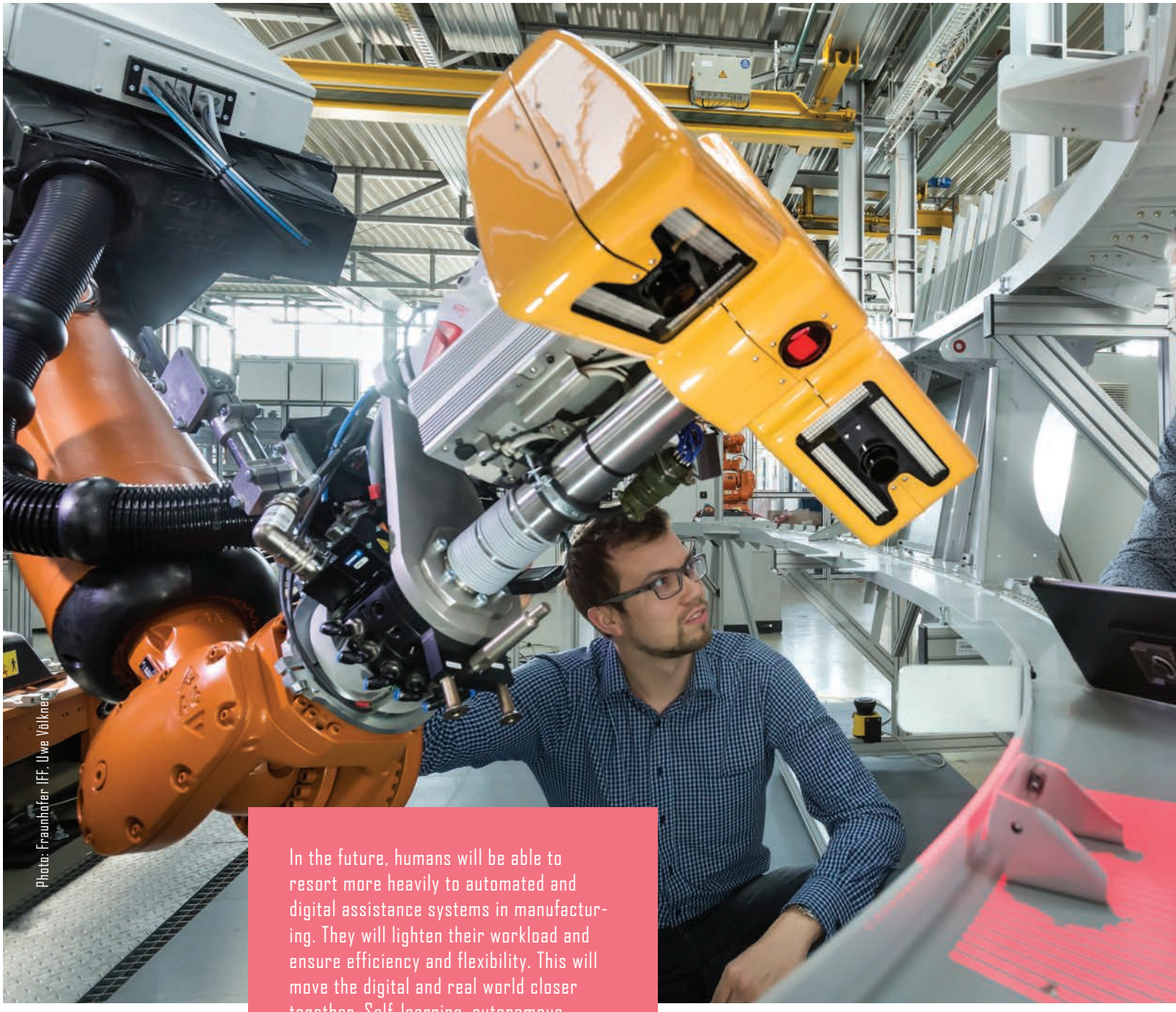
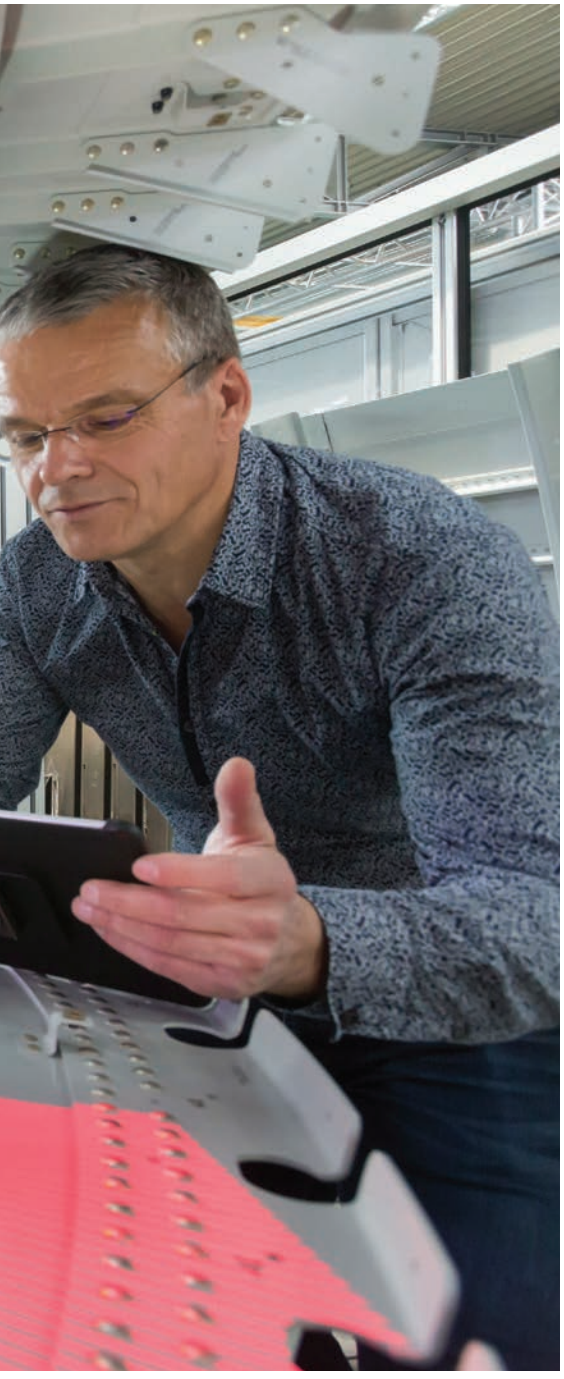


Photo: Fraunhofer IFF, Uwe Völkner

In the future, humans will be able to resort more heavily to automated and digital assistance systems in manufacturing. They will lighten their workload and ensure efficiency and flexibility. This will move the digital and real world closer together. Self-learning, autonomous systems are making this possible: They provide workers necessary information, help with the inspection of parts, and perform heavy physical labor.

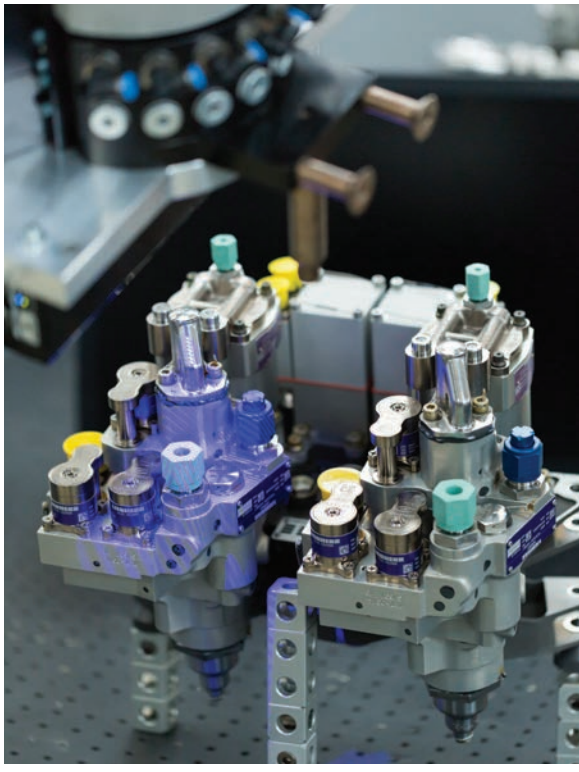


Imagine we are looking at an automotive assembly line. One worker is mounting steering wheels, one is bolting wheels on the body, and another is installing windshields, always with an eye on cycle times. The range of models is quite large. Customers can select the seats, navigation systems, paint colors, steering wheels and other options they want.

This range of models is expected to grow in other domains as well in the future because customization is highly popular. Many people use custom products to accentuate their individuality. A large number are surely also willing to dig a little deeper in their pockets for this. This has its limits, though. Ultimately, no one wants to pay three times more for a custom product. This raises the question of how to manufacture custom products cost effectively? After all, automated systems such as robots and inspection systems have only been practical when the same movements have to be performed repeatedly. Just as with smaller-quantity products, automation makes responding flexibly and, in extreme cases, manufacturing one item difficult.

That is why we at the Fraunhofer IFF are relying on hybrid assembly, i.e. a mix of automated, technically assisted and manual labor. In other words, humans and machines work hand in hand. After all, they both have their advantages: Humans have cognitive and motor skills and know-how and react flexibly. This also enables them to complete work that have previously stymied machines. Technical systems, on the other hand, perform consistently. They never get tired, bored or stressed, no matter how long the workday is.

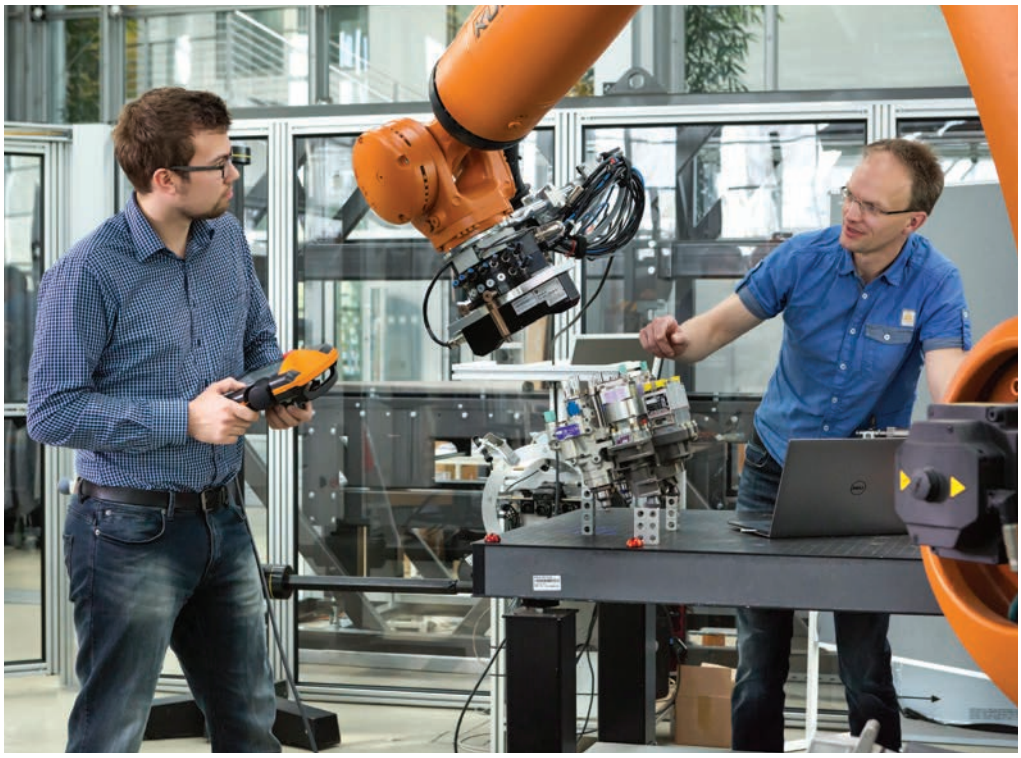
We have a vision: While a robot performs heavy physical labor and routine jobs, humans complete work subject to extreme changes. To do this, they naturally have to know which part goes where without having to spend time consulting technical drawings first. Assistance systems can help humans in three ways here, specifically with information, testing and physical assistance. Once technical systems attain cognitive skills, hybrid assembly systems in which humans and machines collaborate as equals are feasible.



A module being scanned optically to inspect the correctness of assembly. The software compares the real parts with the digital planning data. Deviations are detected immediately. Photo: Fraunhofer IFF, Uwe Völkner

Information, Testing and Physical Assistance

Which part goes where? This question is not easily answered for customized products by any means. Ultimately, there is a different an-



Research engineers at the Fraunhofer IFF commissioning a robot-guided 3D sensor for optical assembly inspection. Photo: Fraunhofer IFF, Uwe Völkner

Mobile assistance systems make complex equipment easier to control and expedite individual procedures tremendously. Photo: Fraunhofer IFF, Uwe Völkner

swer for every single product. Questions about the tools and aid needed becomes more complex, too. That is why we are developing assistance systems that guide people through the assembly process. They are based on augmented reality, i.e. digital overlays on special glasses, a tablet or a output screen in the real field of view.

Take glasses as an example. Workers looking through them see their work space and individual parts. They additionally see information shown in their field of view at exactly the right spot. This may be the parts to be used or the location where a part is to be mounted.

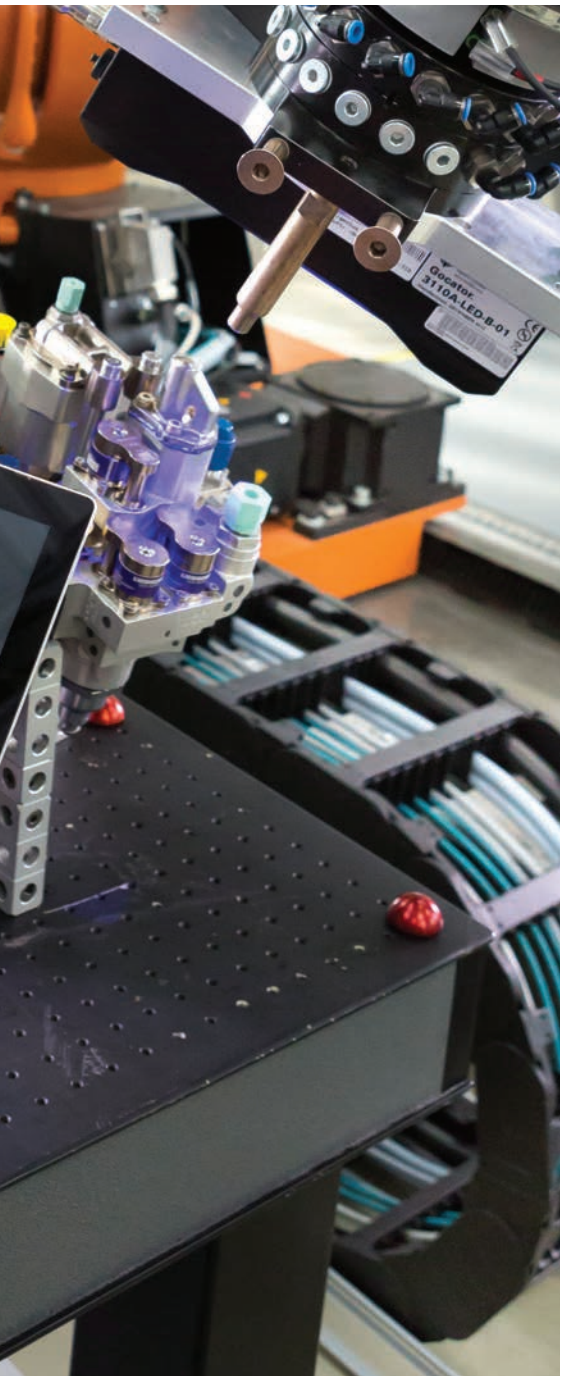
Is the part installed in the right spot? Is it aligned correctly? This used to be inspected manually. In the future, sensors will inspect products unobtrusively in the background and notify workers only in the event of an error. Data from continuous analysis of the progress of manufacturing can be used to generate a digital twin of any individual product, i.e. an always current digital copy of the product.

Not every part is easily manageable. Lifting dashboards everyday can cause back pain over time. We at the Fraunhofer IFF are relying on robots to lighten human workers physical workload in such situations. Various assistance scenarios are conceivable. A robot might perform the entire job or a person might move the part while the robot lifts it. At any rate, the person interacts with and guides the robot. When it notices that a worker is straining his or her back, the system might propose squatting when lifting or help lift the part.

The Basis: An Integrated Digital Model

Digital models, more precisely CAD data and mathematical and physical models of a product and the manufacturing equipment, constitute the basis of such assistance systems. We use them to ascertain the necessary assistance function flexibly and to plan production. We therefore speak of an integrated digital product model, from development to the customer order to the product and even beyond.

We intend to add more virtually all-inclusive mathematical and physical models to this model in the future. A concrete bridge provides a good explanation of what this means. Although the CAD data reproduce the bridge's design exactly, the weight of the reinforced concrete parts would cause them to sag and the bridge to bend a bit when cars drive over it. We are therefore working adapting the digital model further to reality



A "digital assistant" helps a worker assemble parts in a complex assembly such as the electrical enclosure here. The system shows the worker on a monitor how to assemble the part or whether there is an error. Photo: Kolbus GmbH & Co. KG

bit by bit by using physical simulations and reproducing features under specific environmental conditions.

An Autonomous Self-Regulating System

The system learns continuously over time. To do so, it records all possible data first and compares it with prior condition data and events. Is it more expedient for the worker to preprocess data into one version or into another? How many errors typically occur during a selected procedure? The system learns in two ways. First, it responds to environmental changes, e.g. the first time a new part is installed. Second, it conforms to humans' needs. Every worker requires a different level of assistance. Stressed, tired or new workers receive more assistance than "old hands". The system detects when a person completing an assembly grows uncertain and provides assistance.

Another factor that is likely to change in the future is workers' flexibility. Whereas the sequence of a product's assembly is rigidly specified at this time, people will be able to start assembling a component on the right, left or in the center in the future. Inertial sensors, i.e. combinations of accelerometers and angular rate sensors, make this possible. They could be installed in a wristband, for instance, and record that individual's movements. Does the individual reach into a box? Does she move her arm? We intend to use such motion data to determine the step with which a worker is occupied automatically and to provide appropriate information.

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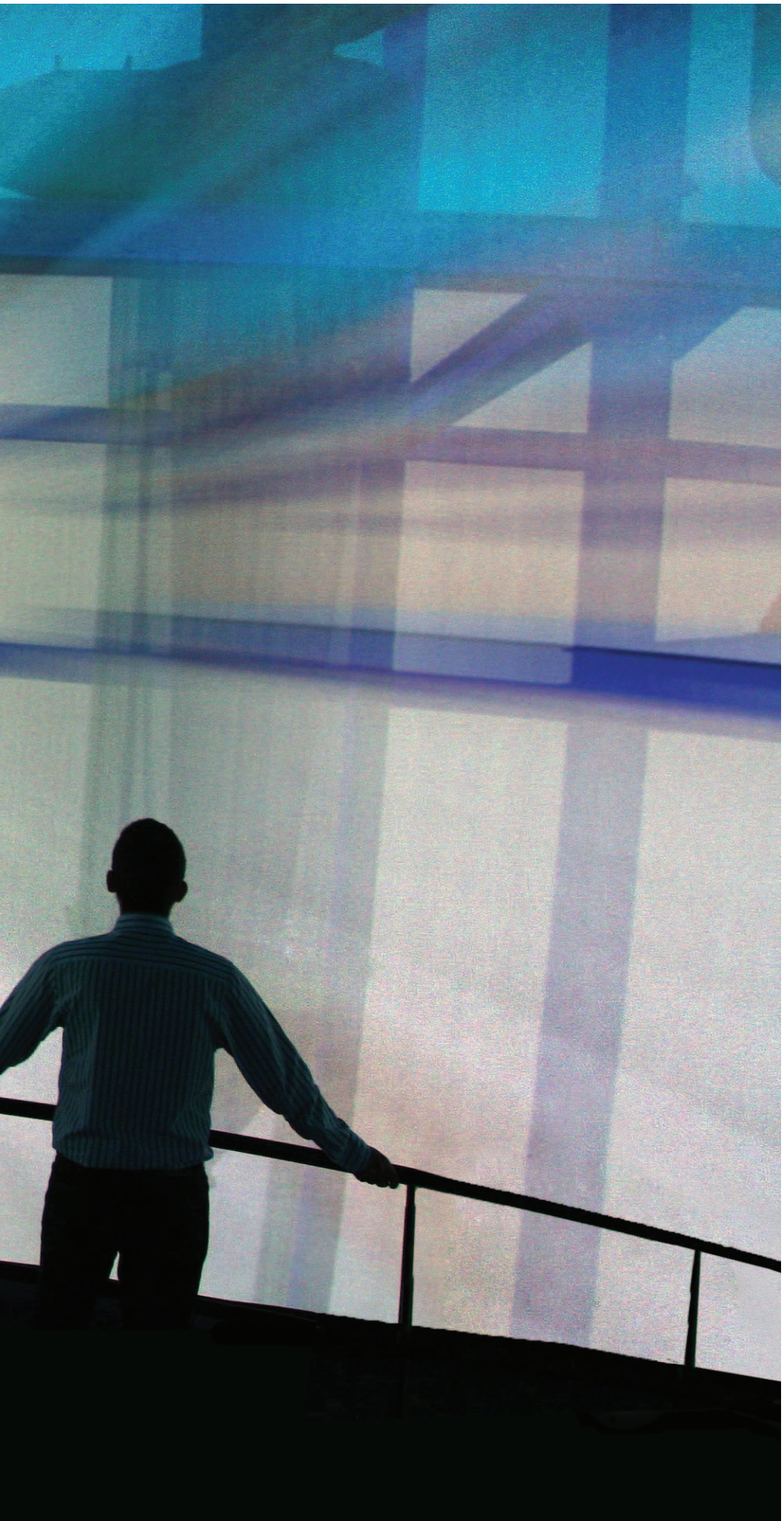
Factories Are Becoming Digital from Design through Control

Manfred Schulze and Stefanie Kabelitz

Photo: Fraunhofer IFF, Dirk Mahler



A very real look into the factory of tomorrow can definitely be digital: A 3D model of a chemical plant is floating across a large screen in the foyer of the Fraunhofer Institute for Factory Operation and Automation IFF. The demonstration video shifts to different perspectives of the plant's highly complex design. Additional color information is added and blends with pipelines, building contours and symbolized control elements.

What initially merely looks like a quite ordinary facility designed on a computer is really another not so small revolution on the long road to the digital factory. This model could boost the importance of the concept of Industrie 4.0 significantly. Holger Seidel is convinced of this at any rate. The manager of the institute's Logistics and Factory Systems Business Unit is coordinating a major, interdisciplinary research project in which mathematicians, civil engineers, facilities engineers, architects, process automation specialists and many more experts from academia and industry are collaborating.

"We intend to turn the previous idea of a digital factory, which was actually always only based on manufacturing operations, into a complete concept finally," says the logistician, describing the project. Using an automatable design system, not only future manufacturing process planning but also the facility's design, floor plan, setup, and, of course, highly complex phases of construction will also be developed based on this approach. Database-supported building design and process planning for the future manufacturing facility and will already be consolidated in an early phase of the complete project. This is the real progressive approach of the researchers in Magdeburg.

Although building design with computerized design tools but ultimately from a mix of digital data and human action is common standard practice, one single person has difficulty coordinating material deliveries, the workforce required from individual subcontractors, quality control and many other details perfectly even in relatively small projects such as the construction of a single-family home. This is doubly true for large projects such as the

construction of a new factory. The complexity of such large construction sites ultimately stretch human capabilities to their limits. This is why humans are the most frequent cause of problems there. "Although creativity is also always important somehow at any construction site, laying a pipeline differently than planned or sizing a wall opening differently can entail expensive additional work. In the worst case, later restrictions on use must even accepted," explains Eyk Flechtner, specialist in factory design at the Fraunhofer IFF. This is why so-called "Building Information Modeling" (BIM) is increasingly being employed, especially for major capital expenditures. New design tools that build upon this can reduce shutdowns, communication problems and errors significantly.

BIM uses interconnected database-supported tools including integrated design development and construction drawings for a building. This also includes every construction phase, order and delivery date. "The advantage of such a system is that everyone in a position of responsibility at a construction site can always exactly track the steps being taken right at any moment and the consequences ensuing from changes," explains Flechtner.

"The quantities of data are no longer a problem for BIM," adds Stefanie Kabelitz. The mathematician has been working for several years at the Fraunhofer IFF on software for multiple project planning. "Conventional microcomputers and dashboards can now be easily used to retrieve necessary data and detail views at a construction site," she explains. Complex data models, on the other hand, are stored in a cloud, for instance. This still primarily pertains to pure building design.

Holger Seidel considers this just a partial step, though. He is eying the major project combining digital process planning and building design and talking about the "two worlds, unfortunately still clearly separated," which he would like to integrate in the future. "Facility design for many major projects is fully digitized now. Work is done with 3D models, which ultimately yield a digital twin of the real manufacturing facility," according to the research scientist.

Yet a real interface between manufacturing operations and digital factory design like what is possible with BIM is lacking. Anyone intending to build a genuinely smart factory, though, has to harmonize the two to the greatest extent possible. The vision is of constant interaction among everyone in charge of process planning and factory design based on data during the entire design and construction phase.

The expert considers continued management of digital models after commissioning one of the major challenges. This is already difficult for process data and becomes even more challenging when data from the model of a

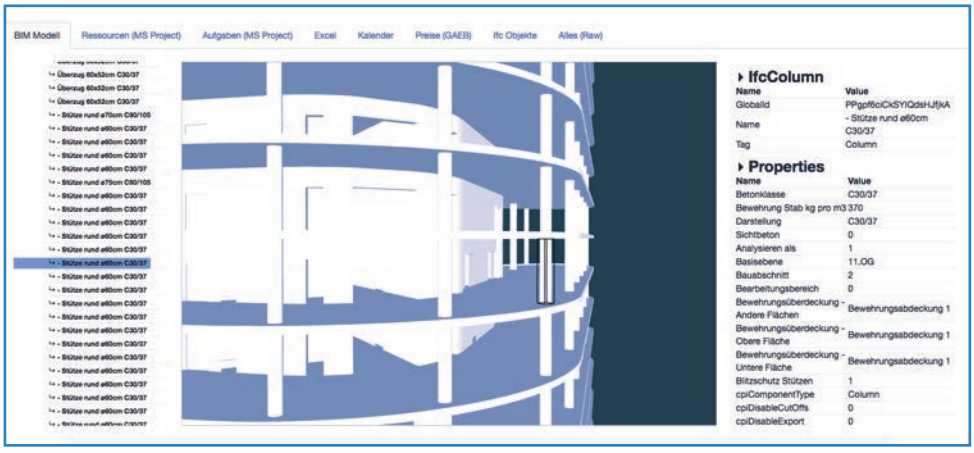
Virtual interactive inspection of planned construction projects conveys a very realistic impression of a future building. This is based on 3D data of a building. This makes it possible to review and assess options and alterations swiftly. Photo: Fraunhofer IFF

building are added as well, especially since cycles of building use and manufacturing operations are not identical. A factory usually exists significantly longer than its assembly line. In order to be able to draw on the existing data and benefit from the integrative smart factory quickly in the event of changes, digital twins have to be kept as close to their real counterparts as possible. Otherwise, the benefits of digital design models for maintenance, forecasting or even just rapid access when remodeling are forfeited. The researchers already have an idea of how to meet this challenge, though. "We are thinking of using the base of data for an assistance system, possibly even an automatic update. But that is a vision for the near future," says Holger Seidel.

A few other issues have to be resolved first, and this has top priority, too. One issue is legal guidelines such as Germany's official scale of fees for building design, which regulates specific sequences of service and billing. Another issue is the organization of process planning and control for real-time data acquisition, while building design tools have entirely different priorities, e.g. a maximum of degrees of freedom for changes. Both have to be brought together if factories that operate smartly, in real time and flexibly are truly to become reality.

Although some of the challenges are huge, numerous researchers and engineers are tackling them nonetheless because great potential value added beckons. Once the challenges have been surmounted, radically new opportunity will open up for designers and operators. One is integrated use of augmented reality (AR) and virtual reality (VR) technologies for integrated real-time planning of phases of construction and manufacturing operations. Use of head-mounted displays in conjunction with BIM models, for instance, will open up new opportunities for interactive VR building inspection and design options.

Andreas Höpfner is working on smartly transferring BIM models from engineers' design systems to VR. He intends to enable users to use directly interactive technologies to manipulate architectural elements and their properties interactively in VR environments. The software will simulate the impacts of any changes made by a user in a virtual 3D design world on ensuing processes in the background and in real time. It will analyze a change's potential impacts on the processes or even the building design and visualize



Designing a building with a BIM model. Image: Fraunhofer IFF

them for the user. Technical factors (construction budgets, workmanship) relevant to decision making are also incorporated by linking geometries and corresponding object variables. Andreas Höpfner qualifies this somewhat, however. Time-efficient implementation and thus the practicality of this technological approach are heavily dependent on the quality of the CAD data and the "model hygiene" of the BIM data set. When their quality is consistently high, nothing more stands in the way of immersion in virtual interactive factory design.

Holger Seidel likes to point anyone not convinced that this is all feasible or concerned that too much digital transformation is more than employees might be able handle to the last ten years of developments in the automotive industry. Growing numbers of individual electronic components were installed at first, which only provide assistance when combined in a convenient user-centric interface. Drivers have no direct dealings with ECU, ABS or even a navigation system's exact operating principle. Yet these systems exist all the same, ensuring that we get from A to B safer. The current trend toward integrated design in conformance with BIM has recently gained significant momentum in architectural engineering, thus establishing the conditions for the use of immersive virtual reality technologies, too. "The integration of a wide variety of systems in smart factories as well will be necessary and possible in the medium-term," assures Holger Seidel.

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Photo: Fraunhofer IFF, Dirk Mahler

Resource efficiency is steadily growing in importance in industry. More than just the demand for heat and power is crucial. Cleaning and painting operations, for instance, require larger and larger quantities of water. The Fraunhofer IFF advises companies and helps them develop more energy and resource efficient systems and manufacturing processes.

Thresholds for safe human-robot collaboration: Since humans and robots will collaborate with increasing frequency in the future and share a common work space, safety is a priority issue.

How strongly may a robot touch a person without injuring that person seriously? The Fraunhofer IFF has developed the first ever tester approved by the cognizant ethics commission that tests collision on human subjects to ascertain thresholds.

Photo: Fraunhofer IFF, Uwe Völkner

Dual Degree Program with Thammasat University in Thailand Finalized

Dual master's degree for szudents. Prof. Chalie Charoenlarpnopparut, Vice-President of Thammasat University (l.), and Prof. Jens Strackeljan, President of Otto von Guericke University Magdeburg, signing the cooperation agreement. Photo: OVGU

A cooperation agreement with Sirindhorn International Institute of Technology (SIIT) of Thammasat University in Pathum Thani, Thailand, is expanding Otto von Guericke University Magdeburg's ties with Southeast Asia and strengthening Magdeburg as a center of research and academia. The agreement finalizes the dual master's degree program in "Digital Engineering" overseen by the Center for Digital Engineering, Management and Operations (cedemo) in the School of Computer Science in collaboration with the School of Mechanical Engineering and the School of Electrical Engineering and Information Systems.

Both universities aspire to collaborate closely in teaching and research. This will enable students from Thailand and Magdeburg to complete part of the program at their respective partner university. They attend the partner university for at least one semester and take the appropriate exams there. In the end, students receive a dual degree, one master's degree from both universities.

President of Otto von Guericke University Magdeburg Jens Strackeljan, was visibly very pleased about the cooperation: "The prestigious academic and research institution Sirindhorn International Institute of Technology is an ideal partner for us. With the agreement, we are taking an important step in international collaboration with Otto von Guericke University Magdeburg." ■

Career with Fraunhofer

With Fraunhofer IFF Deputy Director Gerhard Müller (l.), her then-boss and dissertation adviser Dr. Matthias Gohla (2nd from l..), among others, the Fraunhofer IFF was well represented at Ling He's (m.) doctoral defense in Hamburg. Private photo

Dr. Ling He was a research scientist at the Fraunhofer IFF from 2007 to 2014. The specialist for sustainable energy generation in fluidized bed systems worked in the Process and Plant Engineering Business Unit. At the same time, she completed her dissertation on "Fuel Gas Generation from Biomass Gasification in Fluidized Beds" under Prof. Stefan Heinrich at Hamburg University of Technology. Ling He was awarded her doctorate with "magna cum laude" in December of 2016. ■

Fraunhofer IFF Players on the Winners' Podium

The Fraunhofer-Gesellschaft has not only outstanding researchers in its ranks but also plenty of passionate soccer players. They compete for the trophy of best team at the Fraunhofer institutes' annual soccer tournament. Twenty-eight teams totaling over 300 players met up in Halle an der Saale in 2016, too. The Fraunhofer IFF's team played well and took third place. Only the defending champion Fraunhofer IMWS in Halle and second-place Fraunhofer IWU in Chemnitz bested the team from Magdeburg. Since even the high temperatures far above thirty degree Celsius had no effect on the players on this day, all of the teams are looking forward to the next tournament at the defending champion's Halle an der Saale in the summer of 2017. ■

18th IFF Research Colloquium

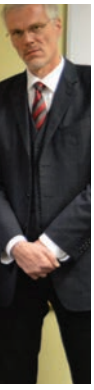
The development of resource efficient and green systems and technologies for industry now plays a major role in young engineers' education. Use of available resources is not just an environmental issue, though. It is just as important for companies, especially in economically turbulent times, to establish distinctive features and enhance their competitiveness by using advanced technologies. That is why te Fraunhofer IFF and Otto von Guericke University Magdeburg emphasize these priorities for young engineers.

Tom Assmann, graduate assistant at Otto von Guericke University's Institute of Logistics and Material Handling Systems ILM, presenting his work on "Defining a City's Urban Logistics Systems" at the 18th Research Colloquium. Photo: Fraunhofer IFF, Daniela Martin

Eleven young researchers from the Fraunhofer IFF and Otto von Guericke University Magdeburg's Institute of Logistics and Material Handling Systems ILM and their joinnt cneeters of excellence presented their work on "Resource-Efficient Manufacturing and Supply Chains", the theme of the 18th of the research colloquiums held at the Fraunhofer IFF every year. Their presentations emphasized the significance of digital transformation for the future of industry. All the speakers are building upon digital methods and technologies to improve industrial manufacturing, maintenance and supply chain operations. Topics ranged from a new "Development Methodology Based on Virtual Engineering Programs" to "Visual Docking for Safe Visual Inspection of Wind Turbines with Multicopters".

Young researchers gladly take advantage of thecolloquium. It offers them an opportunity to present their research, dissertation or project work to an audience of researchers, engineers and students from various disciplines and to test their own theses. Constructive dialogue with the professional audience is intended to help them refine their work effectively. ■

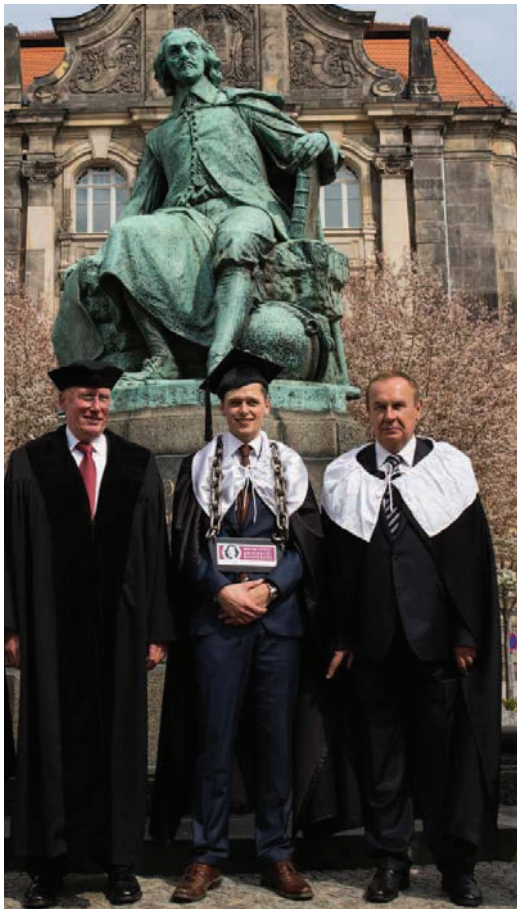
Excellent Dissertation



Otto von Guericke University Magdeburg recognized excellent scholars at St. John's Church in Magdeburg on the 414th birthday of its namesake at its Academic Ceremony, the school's most important event in the academic year. In keeping with tradition, the best young scholars from schools with dissertation awards were recognized in the presence of Saxony-Anhalt Minister of Economic Affairs, Science and Digital Transformation Armin Willingmann and other representatives of the state's government, business, research, academia and culture. One of the best was Dr. Fabian Behrendt, employee of the Fraunhofer IFF and manager of the head office of the Fraunhofer Group for Production.

Dr. Behrendt completed his Diplom degree in logistics engineering management at Otto von Guericke University in Magdeburg in September of 2011. Afterward, he worked as the assistant to the chairman of the Federal and State Commission "Future of Transportation Infrastructure Funding" (Daehre Commission) as well as a graduate assistant and doctoral candidate at Otto von Guericke University's Institute of Logistics and Material Handling Systems. Fabian Behrendt also worked as a research scientist at the Fraunhofer IFF from August 2012 to September 2013.

He started as manager of the head office of the Fraunhofer Group for Production in October of 2013. He completed his doctorate with "summa cum laude"with his dissertation "Process Model for the Analysis of Multidimensional Impacts on Freight Transportation Systems" in 2016. ■



Dr. Fabian Behrend (center) in a photo traditionally taken by doctors' from Otto von Guericke University Magdeburg before the monument to its namesake Otto von Guericke. Private photo

Young Researchers Visit the Fraunhofer IFF

Dr Tina Haase (back) at digital "Pong" with a young attendee of "Future Day". What looks like a game has a scientific background since both are wearing the input devices on their hands: They are sensor-equipped gloves developed at the Fraunhofer IFF, which can be used, for instance, to measure and then easily design factory assemblers's workplaces ergonomically.

Seventeen school students visited the Fraunhofer IFF on national Future Day on April 27, 2017, which the institute took as an opportunity to put together a small program for boys and girls in fifth grade and above with an interest in science and engineering. The program for potential future researchers was diverse. Along with two workshops in which the young and especially female attendees learned about sensor-based assistance systems for workers in manufacturing, small experiments in geometry and physics were performed. A science talk also provided an opportunity to ask Fraunhofer researchers questions about professions and career opportunities.

The Fraunhofer-Gesellschaft is systematically developing new talent in engineering and science. Since women need to be recruited more heavily for technical professions, Future Day is intended to appeal to girls in particular. Since the institute's program has been extremely well received, Future Day will certainly be held in the coming year, too. ■

Fraunhofer Supports Female Research Scientists

The Fraunhofer-Gesellschaft is intent attracting more women for applied research and raising the percentage of female executives in its own ranks. That is why it launched the TALENTA program, which is intended to provide young and experienced female professionals goal-driven assistance with their personal development, among other things through financial assistance to institutes and a number of systematic development programs. Two young researchers, Alinde Keller and Marlene Eisenträger at the Fraunhofer IFF have been part of TALENTA start since 2016, a development track that specifically supports participants finding their direction at the start of their careers. While Alinde Keller is researching learning and experience transfer in workplaces conducive to learning in the Measurement and Testing Technology Business Unit, Marlene Eisenträger is not only writing her dissertation on the implementation of virtual engineering in companies but also advising master's students writing their theses. Both especially appreciate the TALENTA program for the time it allows them for their own professional development. The program also includes intensive advising by a personal adviser and the setting and completion of milestones. "The program enables you to make many valuable new contacts, which are very important for your further research career," explains Alinde Keller. Each development program lasts two years. ■

Marlene Eisenträger (l.) and Alinde Keller (r.) are participating the Fraunhofer-Gesellschaft's TALENTA program. Photo: Fraunhofer IFF, Daniela Martin

Prof. Peer Witten Inducted in the Logistics Hall of Fame

The inductees in the Logistics Hall of Fame were introduced at a ceremony at the Federal Ministry of Transport and Digital Infrastructure in Berlin on November 29, 2016. State Secretary Dorothee Bär was the host. Honorary President of the BVL and former member of the Supervisory Board of the Otto Group Prof. Peer Witten, a pioneer and visionary of e-commerce and the resultant express shipping service, was inducted in the Logistics Hall of Fame. The jury recognized-Witten for having foreseeing the e-commerce boom's boost of the shipping and supply chain sector and laid the proper foundations decades ago. From the mid-1980s onward, Prof. Witten, Director of Logistics at Otto Group, not only turned Hermes into a successful parcel distribution organization but also initiated a number of innovations that set market standards and later served as the benchmark for online shopping. Along with the early introduction of virtual information and service platforms and environmental management systems in warehousing, this chiefly included new delivery services such as delivery on every workday, twenty-four-hour service or selectable time periods. Hans-Otto Schrader, CEO of the Otto Group, delivered the speech honoring Witten, a member of the Fraunhofer IFF Advisory Board since 2000 .

Hans-Otto Schrader (r.), CEO of Otto Group, presenting the Hall of Fame certificate to Peer Witten (l.), VPresident of teh Advisory Board and spokesperson of the Logistik-Initiative Hamburg.
Photo: Logistics Hall of Fame / Gabsch

Die Logistics Hall of Fame recognizes individuals from all over the world, who have made exceptional contributions to logistics and supply chain management. It additionally documents outstanding achievements in logistics and encourages innovations. This is intended to raise awareness of the innovativeness of logistics and to boost the logistics industry's image. ■

Dr. Behrendt (r.) accepting his certificate from Prof. Georg Rosenfeld, member of the Fraunhofer Executive Board, at the festivities. Photo: Marc Müller

Fraunhofer Research Manager

Since 2015, the Fraunhofer Academy has been offering a form of strategic skills development in the utilization of research findings unique to the German research system: the "Fraunhofer Research Manager" honors programs. The course teaches skills not only for executives but also at the interface of research and industry and aims to enhance attendees business skills.

Dr. Fabian Behrendt represented the Fraunhofer IFF in this exclusive training program. The thirty-two-year-old is both an employee at the institute in Magdeburg and the manager of the head office of the Fraunhofer Group for Production. This job has brought him extensive practical experience managing the Group for Production's strategic research – surely one reason he completed the continuing education program with honors.

Teaching strategic knowledge is just part of the program's additional value, though. The network of Fraunhofer-Gesellschaft institutes its advances is just as important, stressed Prof. Georg Rosenfeld, Executive Vice-President for Technology Marketing and Business Models, who presented the certificates of completion at a ceremony on March 8, 2017.

Other courses have been planned to follow up this year's program. Among other things, a "Fraunhofer-Research Manager" expertise network is supposed to be established, which will facilitate strategic collaboration among Fraunhofer institutes. ■

Best Paper Award for the Fraunhofer IFF's Robotics Experts

Three researchers from the Fraunhofer IFF received the Best Paper Award at the 2016 International Conference on Emerging Technologies and Factory Automation (ETFA) in Berlin. Magnus Hanses, Roland Behrens and Prof. Norbert Elkmann won with their paper "Hand-Guiding Robots along Predefined Geometric Paths under Hard Joint Constraints". Their paper and presentation were based on their work in the STIMULATE Medical Research Campus, a research cluster in which Otto von Guericke University Magdeburg, Siemens Healthcare and the Fraunhofer IFF are some of the members.

In STIMULATE, researchers fro the Fraunhofer IFF are developing a robot intended to assist physicians image-guided minimally invasive procedures by means of guided movements. The focus was on improving radiation protection, ergonomics and precision over conventional procedures. Rather than being specialized for one specific procedure the robots are able to perform different procedures.

The EFTA conference is cosponsored by the Institute of Electrical and Electronics Engineers IEEE, since 2014 the largest professional association in the world with over 430,000 members in over 160 countries. ETFA's mission is to bring industry and academic researchers and professionals together to enable them to report on the most recent advances and developments in new domains of technology. ■

In the STIMULATE research project, researchers from the Fraunhofer IFF are developing a hand-guided assistive robots for minimally invasive procedures. Photo: Fraunhofer IFF, Uwe Völkner

Upcoming Events

Meet up with researchers from the Fraunhofer Institute for Factory Operation and Automation IFF at these events.

May 20, 2017
Long Night of Science,
Magdeburg

May 29, 2017
Science at City Hall,
Magdeburg

June 20 – 22, 2017
20th IFF Science Days at the Fraunhofer IFF,
Magdeburg

June 21 – 22, 2017
VDI / VDEh Maintenance Forum,
Salzgitter

October 25 – 27, 2017
34th International Supply Chain Conference,
Berlin

November 14 – 15, 2017
14th Factory Planning Conference
Ludwigsburg

November 27, 2017
Science at City Hall,
Magdeburg

November 28 – 30, 2017
sps ipc drives,
Nuremberg

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20TH IFF SCIENCE DAYS IN 2017

JUNE 20 TO 22, 2017

Conference sessions in 2017 will examine major issues of research in digital engineering and human-robot collaboration.

Presentations, personal dialogue and the accompanying exhibition give attendees of the IFF Science Days insights into current research projects being completed jointly by our researchers and their industry partners.

Take advantage of the conference to learn about current trends and prospects in your professional field. We look forward to seeing you at the IFF Science Days in Magdeburg from June 20 to 22, 2017!

www.wissenschaftstage.iff.fraunhofer.de