

52° Nord

Fraunhofer IFF's Magazine about Manufacturing of the Future.

#1





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Ready for the Unknown

The unknown is our constant companion in research and development. Every new technology, every new discovery challenges us, making us ask, "What's next?"

It is precisely this question that is leading us to our next big step in industrial manufacturing: transformation to a new era of manufacturing. We are entering an age in which humans and machines are interacting in a completely new way and artificial intelligence is not just be a tool but also a partner helping us transition into the unknown.

The opening of our Elbfabrik manifests our commitment to the unknown too. It is far more than a research center.

It is our "engine room" and the heart of our work. It is where we show what the future of manufacturing might look like and demonstrate our innovations to you.

You, our partners from industry and business, are the most important drivers of the practical implementation of our research findings. Together, we will be able to create a future shaped by sustainability and efficiency in which technology and innovation play a key role.

**Your
Julia Arlinghaus**

6

From E-Waste to Zero Waste: Disassembling and Recycling Electronics Intelligently

10

The Elbfabrik: Where the Manufacturing of Tomorrow Becomes Reality

14

Hands-on Research: Interview with Christian Richter

16

Sensortional: Sensor-Based Process Monitoring in Real Time with the AirBOX

18

Open, Connected, Collaborative: Our IoT Platform for Seamless Connectivity in the Smart Factory

20

Optimal Forest Road Development: Ina Ehrhardt Talks about One of Her Favorite Projects

22

One Plan It: Fusing Two Planning Worlds

24

Suggested Reading: Rural Hydrogen Infrastructure Development

26

An Upgrade for Industry 4.0

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Smart all the way under the floor – part of our demonstration factory equipped with a smart industrial floor from Bosch Rexroth. This flooring makes the factory floor itself flexible and adjusts to manufacturing. Sensors, LEDs and other components make permanent marking in manufacturing environments unnecessary.



From E-Waste to Zero Waste

Disassembling and Recycling Electronics Intelligently

The speed at which technological progress now renders electronic devices obsolete begs the question: How can we ensure sustainable consumption of such devices? The exponential growth of electronic waste is alarming. Millions of tons of discarded electronics threaten our environment every year. At the same time, discarded devices are a treasure trove of unused resources just waiting to be recycled.

A glimmer of hope in this scenario is offered by disassembling electronics intelligently so that every electronic device – no matter how obsolete it is – is given a new lease on life and can reenter the innovation cycle.

Our growing dependence on electronic devices is not without consequences. Statistics show that the problem is urgent. Fifty-four million tons of electronic waste – from broken smartphones to discarded household appliances – were produced worldwide in the year 2019 alone. If current trends go unchecked, we will produce an incredible seventy-four million tons of electronic waste by 2030.

A substantial part of discarded electrical and electronic waste – estimated to be over eighty percent in some studies – is not officially recycled. Instead, it is either landfilled or incinerated, squandering a treasure trove of resources: The discarded devices are rich in precious metals, such as gold, silver and palladium, and a variety of rare earths essential for the manufacture of many modern technologies.

The economic loss is just one aspect of this challenge, though. The environmental toll is just as devastating. Improper disposal of electronic waste, especially incineration, releases a cocktail of hazardous chemicals and toxins. These harmful substances can pollute the air, seep into the soil and ultimately reach water sources, creating a serious health hazard for people and animals. The global community urgently needs to reassess its treatment of electronic waste and transition to sustainable practices.

We have to adopt the principles of the circular economy to consume sustainably: We have to ensure that we prevent waste, use products longer and regenerate our natural systems. Fraunhofer IFF's iDEAR project embodies these principles and is concentrating on the efficient disassembly of electronics and the recovery of resources.

Sustainable Electronics through Intelligent Disassembly

Electronic products keep developing at unprecedented speed, growing more complicated and more customized with every iteration. As a result, their materials vary widely and the sheer quantity of product models becomes overwhelming.

The challenge lies not only in the devices' complexity, however, but also in their wear, which causes other complications when they are disassembled. Rusted

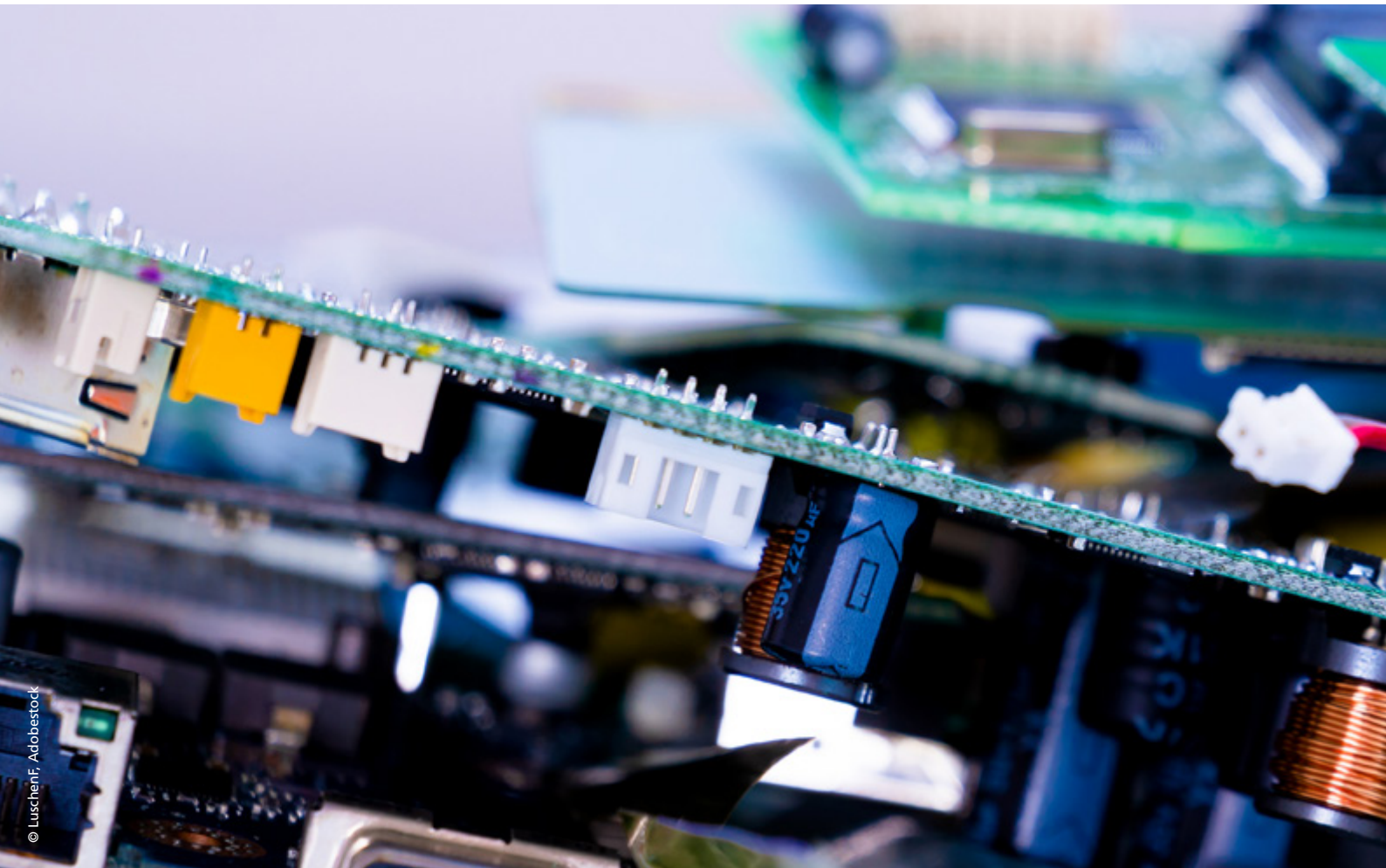
screws, worn components, deformation and missing parts make manual disassembly labor-intensive, inefficient and less and less practicable.

The project Intelligent Disassembly of Electronics for Remanufacturing and Recycling iDEAR is intended to pave the way for more sustainable consumption of electronic devices by concentrating on two main components: remanufacturing and recycling.

Automation in E-Waste Management

To date; only a few specialized systems are capable of disassembling a limited number of products automatically. The immense technical complexity required to program robots is a major obstacle.

The iDEAR project is concentrating on improving the electronics recycling process by harnessing the synergy between materials science, metrology, robotics and



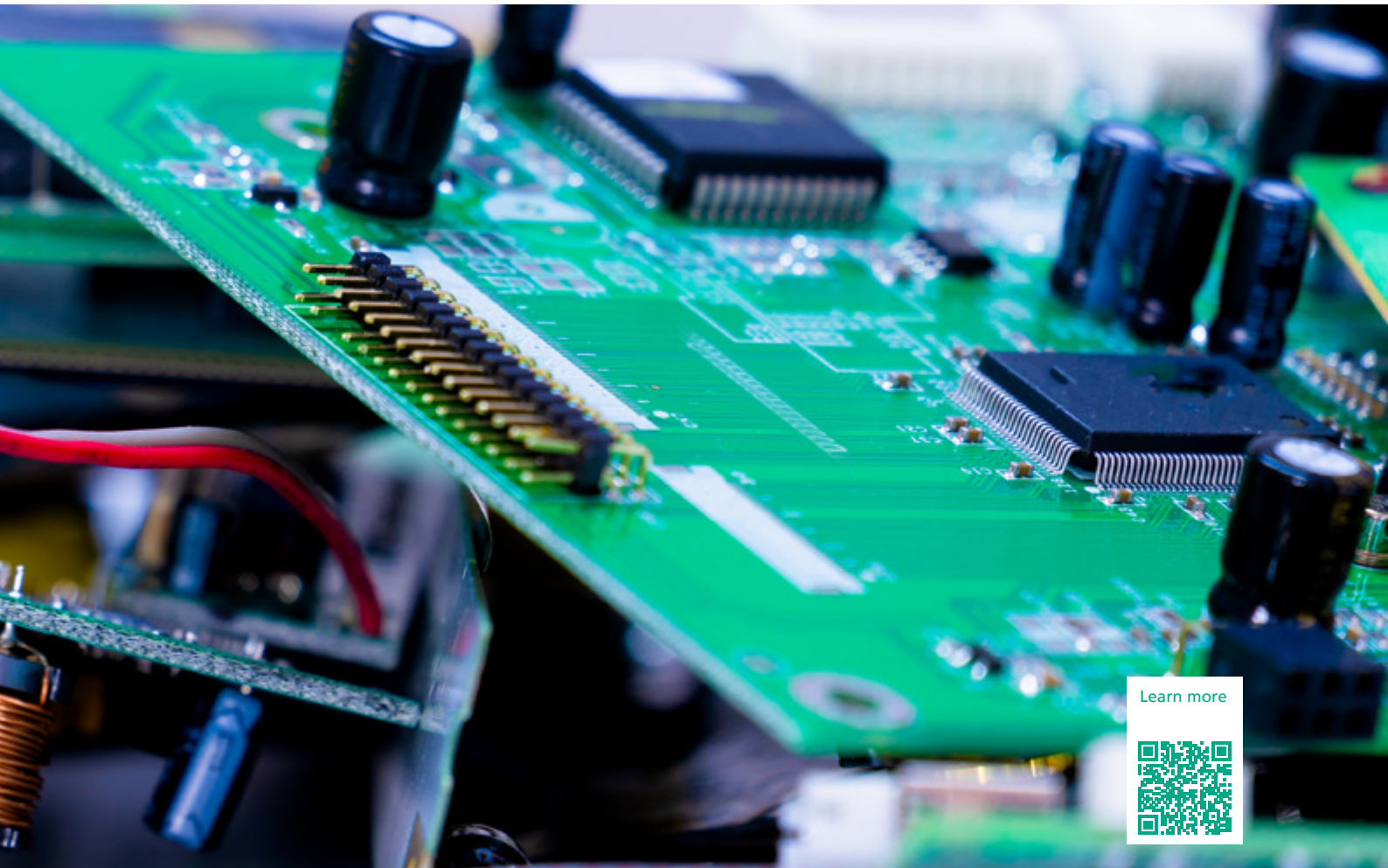
artificial intelligence. The goal is to create an integrated intelligent system that enables automated and nondestructive disassembly processes – the basis for a certified and complete waste management system.

Automation helps identify and sort parts precisely and recover materials more cleanly and more efficiently. The project additionally aims to streamline the disassembly process by integrating advanced robotics, thus saving time, money and resources. Another priority is understanding the energy impacts of recycling to ensure that energy is efficiently recovered from materials that cannot be recycled.

The iDEAR project will thus ensure that valuable resources remain in circulation longer. The overarching vision is to advance a circular economy that is a mainstay of sustainable consumption wholly consonant with the United Nations' Sustainable Development Goals, especially SDG 12 (Responsible consumption and produc-

tion) and SDG 8 (Decent work and economic growth), and is a demonstration of proactive action.

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The Elbfabrik will open its doors in Magdeburg's Port of Science on September 14, 2023. It is where manufacturing of tomorrow becomes reality and the distinctions between virtual product development and real manufacturing blur. Equipped with the latest technology, the Elbfabrik not only serves as a research and testing facility but also as a collaboration platform for partners and companies.

The Elbfabrik: Where the Manufacturing of Tomorrow Becomes Reality



A glimpse into the future of the connected, automated and human-centered factory

The Elbfabrik unites different stand-alone solutions in one complete package on altogether 800 square meters of testing space, 80 square meters of creative space and 140 square meters of coworking space, showing what a unified design of the factory of the future can look like. Rather than just scrutinizing the actual production process, the Elbfabrik already starts in the planning process, analyzing data-driven business models and capabilities to create value from connected data. The design is modular to meet industrial companies' individual needs. At the Elbfabrik, virtually every industry will be able to see the added value the digital twin provides in real operation and the ways data-driven planning and control of the entire process flow make efficient and sustainable manufacturing possible.

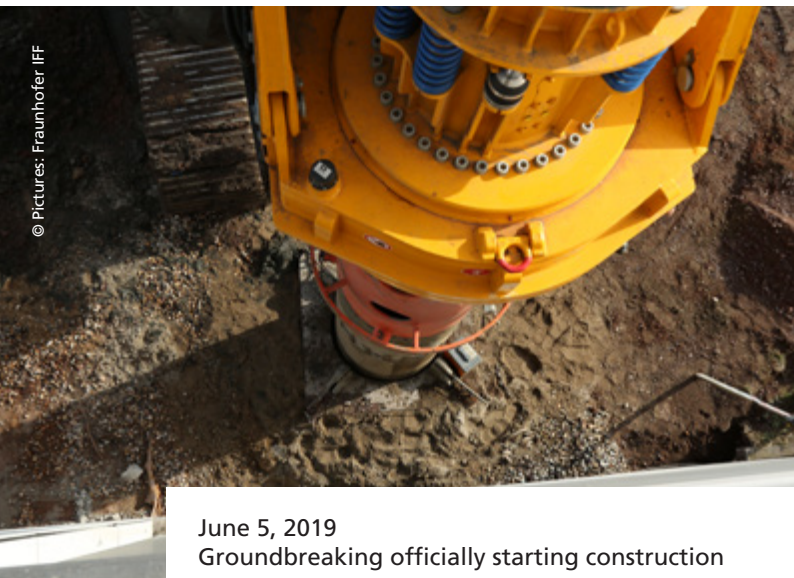
The Elbfabrik's main issue is protecting value creation through digitalization and automation. A realistic manufacturing scenario presents different challenging processes in assembly, logistics and quality assurance. The Elbfabrik's demonstrators explain how automation or assistance systems that support worker can be used to design such processes to be just as cost effective as sustainable.

The Elbfabrik relies on a systemic approach to design processes sustainably and resiliently. Automated solutions, such as automated guided vehicles (AGV), and an intelligent crane are used to integrate the move-

ment of parts, for instance. The Elbfabrik additionally presents solutions for all other typical steps in assembly processes. Thought is given to the digital level from the very start. Physical and digital process are already running synchronously the moment a custom product is configured. This creates the digital twin of the real product generated during planning. This twin's data are added to at every point in the assembly process and synchronized in real time. The digital twin reproduces a product's complete life cycle and provides a valid, detailed dataset at all times to ensure efficient and sustainable manufacturing. This makes supply chains and assembly processes transparent and even efficient recycling possible in the first place. Until now, digital twins have primarily been used in design. The Elbfabrik demonstrates that it is possible and expedient to display them throughout the entire production process as integrated datasets and to give thought to new data-driven business models from the outset.

The Human Factor of Production

People will play a significant role in the manufacturing of tomorrow. They have valuable skills. Their flexibility, problem-solving skills and creativity are unsurpassed. The research scientists at Fraunhofer IFF are researching to assist people with their work and adapt their skills to changing requirements. This is being done with intelligent digital assistance systems, among other things. They draw directly on current data from the digital twin, while providing an interface to keep the twin up to date on employees' flexible activities during manufacturing. They also automatically feed data back into



the system without interrupting people's actual work. People's skills are reinforced and used optimally. At the same time, these assistance systems help minimize defects, a major benefit in quality assurance and resource efficiency.

Connected Manufacturing

The intelligent floor in the demonstration and research factory is also directly connected to the digital twin. It comprises 543 very differently outfitted panels installed on altogether 210 square meters. The individual segments house force sensors. Others supply power inductively or have technologies for human-machine interaction. The components have multiple functions that make manufacturing more flexible. Equipment and systems on the floor can be recombined and reconnected over and over again without interfering in the underlying infrastructure or compromising the complete system's safety to make adjustments in the assembly process..

All of the Elbfabrik's systems are connected to a specially developed IoT platform. It is the central system that enables all the demonstrators to be fully connected and exchange data. This platform is compatible with every common interface, i.e., machines and equipment can be combined easily and simply into one complete system, thus minimizing the labor required to integrate different systems. The platform enables flexible interoperability through the Elbfabrik's infrastructure without having to interfere in the production system's component systems. This makes it easy to connect all

processes and to exchange data between integrated systems rapidly and reliably.

This is just the first step. In the future, it will be possible to coordinate other research factories outside the Elbfabrik and exchange data with them, for instance. The future of manufacturing lies in integrated value chains connected beyond facilities and the confines of companies. The Elbfabrik is prepared for and actively creating this future with its partners.

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Hands-on Research

Interview with Christian Richter

Christian Richter, born in Lutherstadt Wittenberg, has a doctorate in mechanical engineering, specializing in automation in manufacturing. He has been managing the Elbfabrik project since March 2022.



You've been the Elbfabrik project manager since 2022. What's that mean specifically?

As project manager, I'm responsible for the planning, coordination and management of the project, ensuring that we achieve our objectives within the specified time and budget and with the available resources. This also includes coordinating some twenty-five parties involved in the project from all the institute's units. Judgment of character and diplomacy are definitely valuable skills for this. The most important thing for me personally is being passionate about the job and motivating everyone else.

What really excites you about the project?

Above all, the project's dimensions. Upon earning my doctorate, project management was the next step for me. The Elbfabrik project is far bigger than my previous position in terms of the capital budget and the number of project partners involved. The variety of work and especially the challenges I face daily motivate me. Moving the project along and being so close its completion spurs me on.

What is your workday like?

Every day is different. Structure is very important to me. That's why there is a certain order to my workday, which, of course, nevertheless permits the flexibility necessary in such a project. A typical day begins with a discussion about current work. Consultations to resolve specific issues and regular meetings follow. I spend my afternoon on creative work, such as writing articles or preparing talks or interviews. Later, I often go into the testing facility to work on specific technical issues together with others involved in the project. I always try to contribute something during the technical implementation to offset my work at my desk.

What do you do to relax after work?

I leave work behind me on the way home. I'm a volunteer fireman in my free time. Along with calls, there are also regularly scheduled activities, such as evening shifts and training days. The volunteer fire department in my hometown frequently prepares and hosts weekend events too.

What have been your biggest challenges and lessons during the project?

Requesting bids for and contracting goods and services is a very complex process in publicly funded projects. Every challenge means growth too. Personally, I have been able to develop greatly personally since, rather than being just part of a small group of researchers, I have taken on the coordination of the complete project with over twenty demonstrators and their presentation as project manager.

What is your personal highlight at the Elbfabrik?

My personal highlight is the intelligent floor. I'm fascinated by its tremendous capabilities in terms of flexibility, tracking and tracing and safety, as an infrastructure shared by the machinery and equipment installed it. This flooring additionally opens many upgrade options, for instance, for electrical grids, and constitutes a paradigm change in internal logistics. It creates many new opportunities for development both in individual domains, such as multiple-factory manufacturing and the concomitant value networks, and for our research at the institute.

What is your personal vision of the Elbfabrik?

For me, the Elbfabrik is hands-on research. My vision is to present the Fraunhofer Institute for Factory Operation and Automation's portfolio of services to interested project partners and to give them the opportunity to experience it first-hand there.

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Sensortional: Sensor-Based Process Monitoring in Real Time with the AirBOX

Receive an SMS with a factory building's PM values on your smartphone in the morning at breakfast? Record a ceramic blank's temperature distribution? Easily test what a new sensor can do without undertaking complex integration? Integrating and processing a wide variety of sensor solutions and measurement principles in one place? No problem with the AirBOX.

Our portable AirBOX can collect sensor data specifically wherever they are generated. The requisite equipment can be installed flexibly on the spot. By connecting sensors into one network and inferring events needed to monitor processes from the data, the multisensor AirBOX helps companies organize and control their smart factories in real time.

Olaf Poenicke | olaf.poenicke@iff.fraunhofer.de



Real-time data



Plug and Sense (with a wide range of 50 sensors and actuators)



Compact and robust for industrial environments (762 g, 120 x 120 x 70 mm; temperature range of 0–60 °C)



Available as a standard product (already in use in various industrial use cases)

Learn more



Open, Connected, Collaborative: Our IoT Platform for Seamless Connectivity in the Smart Factory

Now more than ever, companies need to optimize and design their processes more efficiently. Rapid technological change and the introduction of newer and newer facilities, systems and equipment is confronting many with the complex challenge of integrating and interconnecting these components in their manufacturing. This is not only a matter of technical integration but also of a smooth data stream and the elimination of format incompatibilities. An incorrectly integrated new machine or absent or inconsistent data in manufacturing can cause costly errors and delays that affect a company's productivity and profitability adversely.

In theory, intelligent workpieces in smart factories seek the most efficient path along the factory floor themselves. The use of individual machines, systems or equipment is factored in fully automatically. This only works, though, when the individual components in manufacturing are connected seamlessly and can exchange sensor data and communicate with each other.

In practice, manufacturing systems' complex interfaces and individual machines' proprietary systems or different communication protocols impede genuine digitalization in a company.

This is where our IoT platform comes into play. It not only provides a solution to such technical challenges but also serves as a link between different stand-alone systems. It enables manufacturers, especially discrete manufacturers, medium-sized and large logistics companies and equipment component manufacturers to ensure the seamless integration of and communication between facilities, systems and equipment, thus fully maximizing the benefits of digitalization.



© Fraunhofer IFF, Andreas Lander



Our IoT platform features universal protocol support, i.e., it supports every common IoT protocol. A central transformation component converts between different data formats and structures, establishing a seamless bidirectional data flow to and from facilities and equipment.

Another of the platform's outstanding features is its flexibility and scalability. It was developed from the ground up to be easily upgraded and adapted to specific requirements. Theoretically, the number of devices or systems that can be connected is unlimited. Moreover, the platform is cloud-based, i.e., all data are stored securely in the cloud, guaranteeing high availability.

Our IoT platform also enables users to install their own applications. What is more, data can be (pre-) processed, something that is especially useful when connecting individual systems and equipment.

Easy integration using standard interfaces ensures that systems can be connected without great effort and time-consuming employee training.

Fraunhofer IFF's IoT platform is the answer to the growing demands of Industry 4.0. It provides companies an efficient, flexible and cost-effective solution for integrating and interconnecting their systems and technologies.

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Optimal Forest Road Development

Ina Ehrhardt Talks about One of Her Favorite Projects

Project synopsis

What's the name?

Gasse 2.0

What is it?

A design support tool

What's it for?

Developing forest roads for later use by equipment

How?

The design tool calculates feasible road routes based on mathematical models and algorithms

How long?

2017–2019

With whom?

Forstbetrieb Oberharz in Saxony-Anhalt

What makes this project your passion project?

We were subsequently able to develop a product and generate a follow-up project from this project. This will enable us to keep developing the idea.

Being able to establish a licensing model for use in forestry through our work and our team's dedication spurs me on in my ongoing work. Apart from that, we have succeeded in getting the first clients from the solar industry, who are facing quite similar challenges, excited about our developments. Individual colleagues' development throughout the project was especially rewarding to me. I was able to witness how they grew with the challenges and talked about the project and their work enthusiastically. Our development as a team and the valuable ideas from professional colleagues were instrumental in moving the project forward.

What role does collaboration with your partner play?

The respectful and constructive collaboration with our partner was very motivating in the project. Our open and professional dialogue, mutual understanding and well-thought-out solution to the problem, earned us respect and recognition. We were particularly pleased by the presence of the managing director, who personally presented the solution at the final presentation, showing us his appreciation and making a powerful public impact in the industry and the network. I am particularly pleased at how we made our partner happy and are able to help them in their everyday work with our solution.

Learn more





What were the challenges in this project and how did you deal with them?

Reducing the very different practical problems to simple rules to turn them into algorithms and programs was certainly one of the biggest challenges. At the start, our work consisted of identifying the actual problem and figuring out how we can solve it with IT. We repeatedly scrutinized how roads were laid out in the past and what skills and knowledge the users who will be working with our solution have. That was essential to the success of the project. That was just as fascinating as instructive. Listening, asking the right questions, repeatedly scrutinizing and discussing the different approaches with my teammates rather than drawing any premature conclusions – that was the key to success.

What did you learn from this project and what insights did you gain for your work?

Persistence and perseverance definitely paid off. We intentionally took time to establish the foundations

and understand the heart of the problem before we concentrated on developing the solution. We repeatedly stepped back and verified that we were on the right path. That paid off in the end. The partner's needs were always our priority. A practicable and robust solution does not have to be the high-end option. Often, many of the partner's processes or equipment are not even ready yet. Then we run the danger of our development outpacing practice.

Particularly exciting for me was that we succeeded in breaking down the antithesis between economics and ecology. It was important to give the whole thing a measurable dimension to enable the users to make a decision. Variability and flexibility result in employees' expertise being used to respond to individual cases outdoors.

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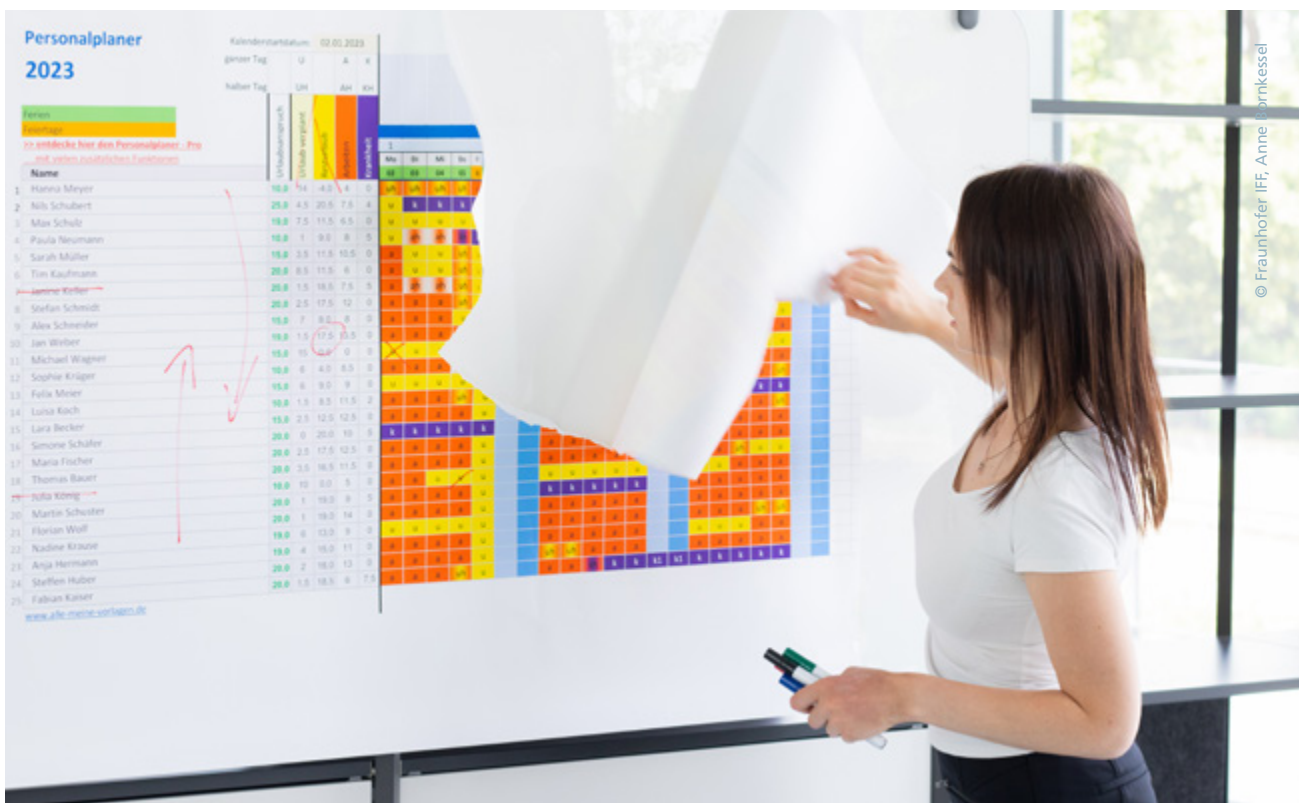
One plan it

Fusing two planning worlds

Between frustration and paperwork

In the world of build-to-order manufacturing, perfect coordination of production planning and staff scheduling is crucial to smooth manufacturing operations and thus a company's success. The complex products manufactured and the highly qualified employees managed make this an extremely demanding job.

Sudden disruptions, such as machine failure, employee illness or schedule and order changes from customers, make it important to have a system that enables users to adapt quickly and simultaneously to ensure that qualified employees are being used optimally. Tools such as Excel, pencil and paper and even printed tables quickly reach their limits in such situations.





The solution is One plan it

Our tool seamlessly combines production planning and staff scheduling on one user-friendly platform. It employs efficient algorithms to support production planning and staff scheduling intelligently. At the same time, One plan it factors in employees' skills. This not only ensures that manufacturing operations run smoothly but also that employees are used optimally.

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Learn more



and access the free
demo version





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Suggested Reading

Rural Hydrogen Infrastructure Development

Hot off the presses: Our study of rural hydrogen structure development!

A team of Fraunhofer IFF research scientists report in this study on a model project for the transportation sector in less developed regions as exemplified by Salzland County in Saxony-Anhalt. The energy experts examined relevant technologies and existing energy facilities and storage as well as transportation capabilities and ascertained the hydrogen demand for transportation. They additionally developed a three-phased model up to 2050 and calculated the economic efficiency for municipal operations and the county transportation authority.

In this study, the research scientists arrived at the conclusion that a hydrogen infrastructure in rural regions is entirely feasible and economically expedient.

The study is available in German only.

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[Learn more](#)



Imagine a manufacturing landscape in which human intelligence works seamlessly together with the latest technology, revolutionizing the way products are manufactured. Welcome to the manufacturing of the future in which the merging of human expertise and advanced automation propels manufacturing into undreamed-of dimensions of productivity, customization and innovation.

An Upgrade for Industry 4.0

Even as most companies are still in the midst of the “digitalization” project, the concept of Industry 4.0 is already being upgraded with an essential component: The manufacturing landscape of the future will be more highly geared toward people, more sustainable and more resilient. How can digital transformation be geared toward people and organized sustainably to maximize the benefits of Industry 4.0 fully?

Between Steam and Data

From the steam engine that drove the First Industrial Revolution at the end of the eighteenth century to the mass production lines of the Second Industrial Revolution through the emergence of IT and automation during the Third Industrial Revolution – every era has ushered in a change of manufacturing operations. Then, Industry 4.0 brought the digitalization of industrial manufacturing, combining physical and cyber systems in an unprecedented way. Dominated by intelligent factories in which the Internet of Things (IoT), artificial intelligence (AI) and cloud computing play the leading role, Industry 4.0 is an era of technology-driven metamorphosis. Although companies are still in the process of integrating such cyber-physical systems, assessing their experiences with them and perfecting them, the groundwork has been laid for the next transition.



MANUALS



Production Capacity: 400/day

Uptime: 99%

Energy State: Active

Pressure: 420

Auto

Errors: 0



LOCATION

ONLINE-LAB--359



CONNECTED

MAXData



RULES

- Enable automation using supporting systems.
- Report critical safety conditions immediately.
- Use appropriate when working in hot areas to lab.
- Remember to use safety glasses, long hair and jewelry.
- Stay out of safety zone, unless you are operating the machine.

Whereas Industry 4.0 has primarily explored the limits of technology, the concept is now being logically upgraded to harmonize this advancement with humans. Human innovation is being combined with machine precision and the symbiosis of human creativity and technological progress is being harnessed to raise productivity, customization and innovation to an even higher level.

The combination of human skills and digital efficiency, which will not only change manufacturing but also the entire corporate landscape, is the quintessence of a new customized, collaborative and sustainable Industry 4.0.

Manufacturing Dream Team

Rather than viewing humans and machines as competitors in the manufacturing of the future, we picture a world in which both collaborate in perfect harmony. Humans will take center stage. Robots and AI systems will act as capable assistants. This collaboration will make it possible to complete work more precisely, more quickly and more efficiently and thus to manufacture highly customized products that meet customers' needs perfectly.

This is a paradigm change from pure automation to a collaborative model that revolves around "empathetic manufacturing". This means manufacturing processes will be more personal, individual and values-based and guided by human knowledge, intuition and value judgments.

The New Technology Superstars

As we delve deeper into the heart of the matter, it becomes clear that this era of manufacturing will be driven by an ensemble of high tech.

Robots, especially cobots, will be the workers in the manufacturing of the future. Cobots are intended to assist humans, not replace them. Their high precision, repeat accuracy and indefatigability augment human skills and boost safety in manufacturing environments.

Artificial intelligence and machine learning (ML) are at the forefront whenever predictive analysis and advanced pattern recognition are employed to expedite decision making. These technologies enable companies to recognize trends and make sound decisions for the near future with unprecedented speed and accuracy.



Augmented reality (AR) and virtual reality (VR) link the digital and physical world. They enable human-machine interaction, facilitate collaboration regardless of the distance and provide employees immersive training experiences.

The backbone of this upgraded vision of Industry 4.0 is the Internet of Things. With its network of interconnected devices, sensors and systems, the IoT makes it possible to collect and exchange data in real time. This connectivity establishes a new level of transparency and control over operations. It facilitates predictive maintenance, energy efficiency and quality control.

The Obstacles along the Way

This steady development of Industry 4.0 is not without challenges, though. The cybersecurity risk concomitant with the growing connectivity of and dependence on digital technologies is a major problem. Companies have to invest in robust security measures to protect their operations and sensitive data.

Another problem is the potential shortage of skilled labor. Since demand for technical specialists is growing, companies have to invest in education and training to

provide their employees needed skills, such as data, programming and systems analysis skills. It is just as important to foster soft skills, such as creativity, problem solving and emotional intelligence, since these human traits are the crux of personalized, sustainable and resilient manufacturing.

The Golden Mean

Companies' success is ultimately contingent on the right balance between technological progress and human thought. It is a matter of creating a workspace where technology and humans coexist harmoniously to develop new capabilities for innovation, productivity and sustainability. And it is a matter of taking responsibility for employees, customers and society.



From E-Waste to Zero Waste: Disassembling and Recycling Electronics Intelligently

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Hands-on Research: Interview with Christian Richter

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Sensortional: Sensor-Base Process Monitoring in Real Time with the AirBOX

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Open, Connected, Collaborative: Our IoT Platform for Seamless Connectivity in the Smart Factory

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Optimal Forest Road Development: Ina Ehrhardt Talks about One of Her Favorite Projects

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One plan it: Fusing Two Planning Worlds

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Suggested Reading: Rural Hydrogen Structure Development

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