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Sustainable digitalization

Annual Report 2018

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2018

Dear readers,

“The future does not result from the vagaries of fortune but from the decisions that we make today” – Franz Alt, Journalist. You don’t need a crystal ball to know that digitalization will determine the way we work and live our lives in the future. This digital revolution certainly opens up a lot of new business opportunities, the ultimate goal cannot simply be ‘higher, faster and further’. The decisions that we make today have direct consequences – the climate and our future society being two key areas affected. But how can we turn sustainability goals into success criteria for digitalization? Even if digital sustainability isn’t (yet) the prime concern, there’s every chance of us being able to design it with this in mind. In fact, we can go further than that: digitalization actually helps us to protect the environment and to make our planet a livable place for future generations – a world of social justice, where everyone has equal access to education. Sustainability doesn’t have to be seen as an obstacle to business development but – as in the case of renewable energy – can offer new opportunities for entrepreneurs. Accordingly, the digital transformation doesn’t need to imply greater resource consumption and higher levels of pollution but can offer us powerful tools for achieving our sustainability targets. In November 2018, for example, the German Government launched 50 digital flagship projects for environmental and climate protection. The selection of Fraunhofer FOKUS projects that we present to you in this annual report focusing on “Sustainable Digitalization” also clearly shows how digital transformation and sustainability can be combined to work together.

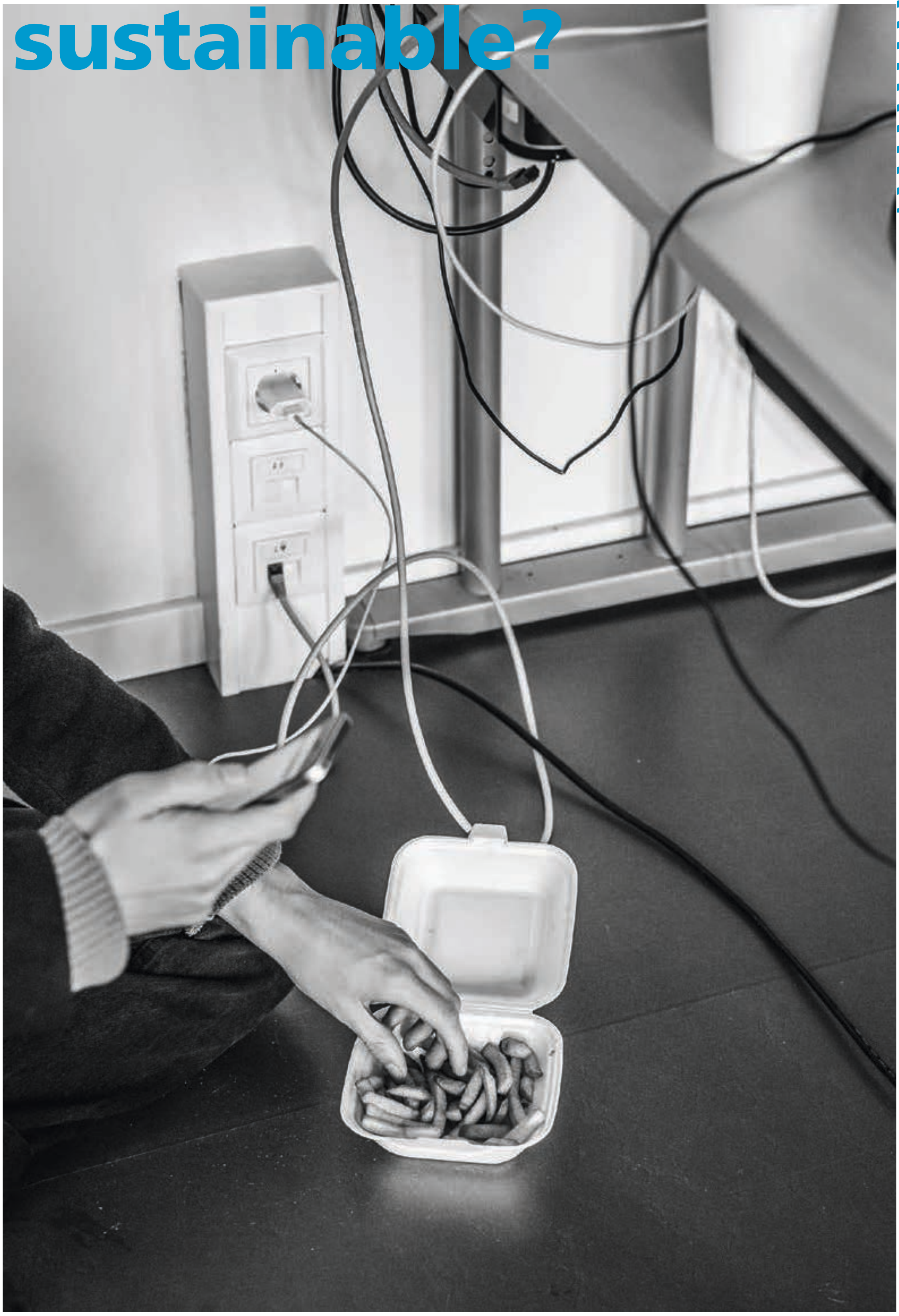
On the following pages, we show you how it’s possible to use bits and bytes in a way that ensures that digitalization and sustainability are not mutually exclusive subjects. Fraunhofer FOKUS is developing smart mobility applications to help road users save energy, for example. Find out why the shortest route is not always the best one (p. 12) and how failsafe software makes a big difference in terms of sustainability. We’ve also been working with our partners to develop Internet of Things “testware” that offers manufacturers a cost-efficient way to evaluate their software-based systems (p. 14). We show how the consumption of electricity from renewable energy sources can be synchronized with its generation (p. 20). And data doesn’t have to be stored and processed in energy-intensive cloud data centers, but can be managed instead by using edge computing (p. 21). All of these individual examples highlight how Fraunhofer FOKUS, as an institute for digital networking, is looking to the future and working with its partners to create sustainable digitalization.

We wish you an enjoyable read!

Prof. Dr. Manfred Hauswirth
Executive Director FOKUS

Prof. Dr.-Ing. Ina Schieferdecker
Director FOKUS

Can digitalization be sustainable?



When we talk about digitalization today, the primary focus is not on conserving resources and achieving climate goals – on sustainability, in other words. But to make the digital transformation sustainable, in addition to thinking about financial aspects we need to look at the ecological and social components.

In the interest of intergenerational equity, it's necessary to consider the needs not only of the current generation but of future generations as well. This is how the UN formulated it in 2015 in its 17 Sustainable Development Goals that will serve as a guideline for all states until the year 2030.[1] With this in mind, it is important to raise awareness. A lot of things happen in digitalization without us being aware of the resources used. What does it mean to "just quickly Google something"? Which resources and how much energy are required for this? Around 3.8 million searches were carried out every minute worldwide in 2018.[2] A user's monthly searches consume roughly as much energy as a 60-watt bulb uses in three hours.[3]

Powerful computer infrastructures are also needed as connectivity grows. Server farms run on huge amounts of resources and materials and require enormous energy. According to the Federal Government, in 2016, German data centers needed a total of 12.4 billion kWh of energy. This means data centers are responsible for two percent of the country's energy consumption[4] – and 30 to 50 percent of this is for cooling alone.[5] Many companies have therefore either relocated their servers to cooler regions or are employing combined heat and power within a kind of "cogeneration plant" to cool their computers (heat exchangers), using the heat produced by the cooling process for district heating or energy generation. If the Internet were a country, it would be the fifth-largest energy consumer in the world, according to a Greenpeace study.[6] The infrastructure of devices, data centers and communication networks needs a total of around 900 TWh every year and thus consumes about four percent of the world's electricity.[7] In Germany alone, the entire Internet infrastructure uses roughly 55 TWh of energy per year[8] and generates as much CO_2 as all domestic flights in Germany annually.[9] If IT applications were networked intelligently, this could make a major contribution to environmental protection. Up to 190 million tons of CO_2 could be saved per year in Germany alone, according to the German Government.[10] Traffic control systems not only optimize traffic, they can also save a great deal of energy. Optimized routing can cut fuel consumption by ten percent,[11] while car-to-car communication can reduce it by around 20 percent.[12] Resources can also be saved by intelligently connecting various mobility services such as car sharing, local public transportation and (electric) rental bicycles. But one thing is clear: Cutting CO_2 alone isn't enough to develop a sustainable society. When it comes to sustainability, the resources consumed in production also play a critical role. Another problem is that manufacturers have to supply the market with new products in order to survive financially. This problem is intensified by increasingly short technology cycles, which mean that products are replaced faster. Longevity or alternative revenue streams are currently receiving very little attention on a macroeconomic level. Software is no longer updated, batteries are permanently installed for design reasons, and expensive replacement parts make repairs cost-prohibitive. The inability to repair devices leads to increased demand and thus more production. The demand for raw materials such as metals and rare-earth elements is growing. Because of this people and the environment are often ruthlessly exploited in developing and emerging countries. Strengthening the circular economy with the support of digitalization can help solve this problem. Systematic quality management, including early and extensive software tests and updates, can prevent the failure of devices and infrastructures. According to industry estimates, software errors in German companies alone result in losses of around 84.4 billion euros annually.[13]

The digitalization of industrial and agricultural processes can not only save energy, but lead to higher productivity and efficiency as well. In farming, for example, fertilizer and water use could be reduced to achieve more environmentally sustainable agriculture.[14] In computer technology processes are being reconsidered, as well: Not all data has to be stored in the energy-intensive cloud. Decentralized data processing is a promising alternative with significant energy-saving potential, because less data needs to be transported and stored. Data portals like those for urban data spaces can help reduce the redundant collection of data.[15] But what good is this data if it cannot be interconnected? Therefore, the lack of interoperability is a serious and pressing issue. Standards-based digitalization can help eliminate the patchwork of often incompatible solutions. It also offers a great opportunity to simplify access to education, promote lifelong learning for everyone, and support the economy and administration. These are just a few examples of how the Sustainability Development Goals (SDGs) are being addressed through intelligent, resource-efficient digitalization solutions.[16]

However, sustainable digitalization can only succeed on a wide scale if we change our way of thinking in all spheres of society, increase our awareness of sustainable development and take action. Fraunhofer FOKUS is creating the technological conditions for this purpose and is demonstrating potential solutions.

Streaming is a major competitor for video stores. Whether it contributes to sustainability is debatable however – because it often leads to higher consumption.

A throwaway mentality is one reason for increased resource use. Some devices could get a second lease on life.

The intelligent connection of various modes of transport, such as car sharing, local public transportation and (electric) rental bicycles, can contribute a lot to sustainability.

"Sustainability must be considered right from the outset"

Ulf Hoffmann talks to the FOKUS Directors Prof. Dr.-Ing. Ina Schieferdecker and Prof. Dr. Manfred Hauswirth about the need for sustainable digitalization.

Can digitalization be sustainable?
Ina Schieferdecker: Not only can it be, it must be inherently sustainable and designed to be sustainable. Sustainability must be considered right from the outset, as is the case with IT security or usability. This requires agreement at national and international level on how to deploy the digital transformation so that it's aligned with and achieves the UN's sustainable development goals.

How can Fraunhofer FOKUS contribute to sustainability?
Manfred Hauswirth: There are obvious areas of digitalization that can be sustainable and we are active in these. I had an eye-opening experience as a result of my involvement with industrial water. A steel mill had to be shut down because they hadn't been given sufficient warning about the rise in temperature and level of the Rhine. At the time, they received their data by fax. You can't shut a steelworks down like a computer; it takes several days. The loss of production then added up to a significant amount of several millions. Although this figure only reflects the commercial consequences of the shutdown, it's useful because one of the ways of overcoming defensive attitudes towards sustainability is to show its potential economic benefits.
I. S.: We need to make sure that digitalization offers solutions that are future-proof, interoperable and compatible with our existing infrastructure. We certainly don't need to keep reinventing the wheel. One of the significant contributions of FOKUS over the past 30 years has been its collaboration on international open standards and licenses, and the co-development of an interoperable, standards-based infrastructure with open interfaces and formats in the public domain, in administration and in business. Here's another example: the energy transition can only succeed if it makes use of digitalization to manage the volatility and flexibility that renewables are subject to. I believe that, sooner or later, a carbon tax or a general resource tax will be introduced – facilitated by digital monitoring and tracing, made possible by digitalization.
M. H.: For me this is a classic conflict of goals, because we work with a simple cause-effect relationship. Let's say, for example, we would like to reduce carbon emissions by increasing electromobility. However, current battery technology is not sustainable or environmentally friendly and it's also heavily reliant on rare-earth elements, which in turn creates new dependencies.
I. S.: Yes, life cycle management is definitely a key element in achieving sustainability goals and digitalization is one of its most important tools. A carbon tax should not be based just on emissions, but calculated over the entire life cycle. FOKUS has already been involved in a number of carbon footprint projects. For this to work we would have to integrate a completely new mechanism in the product cycle.

How do we benefit from digitalization? By being able to apply for a passport or register our car online?
M. H.: Those are good examples. But here in Germany we can't do any of that. As a high-tech nation, we ought to be ashamed at the level of paper bureaucracy that still exists here. If I don't have a postal address in Germany, I don't exist.
I. S.: That is the basic discussion we are having. Digitalization can make many things more efficient, more convenient, more reliable and also more secure – as long as we design and protect the digital solutions in accordance with our guidelines.

But you have to persuade people to go along with you, because society as a whole is afraid of digitalization.
I. S.: Why is that? We should be more afraid of failing the digitalization.

Many people are afraid they might lose their jobs, that work will change dramatically, or that their data could end up anywhere.
M. H.: But it's already happening. I find it incongruous that we readily provide our data – movement data, voice data and biodata – to Internet companies, yet when someone suggests the creation of a register of personal data in Germany, people protest in the strongest terms. I don't understand it. I hope that I can trust my own government more than an American Internet company.
I. S.: The fact that digitalization is a huge and powerful tool isn't the problem; what we do with it is. This is why we need to talk about the direction in which social and economic systems are heading.

How important are open data portals for sustainable development?
I. S.: In addition to providing transparency and encouraging participation, the added value of open data lies in its capacity to deliver new or enhanced business opportunities that will strengthen the economy. Open data is the basis for smart cities and thus a prerequisite for sustainable development. And if I know that the data has already been collected, this can also save resources. Meanwhile, however, we take it further: as well as open data, the availability of broad-based, urban digital data is important because it allows us to create opportunities for optimization and added value while preserving the (data) sovereignty of the municipalities.

Can 5G boost sustainability?
M. H.: There are techniques used in 5G that can provide seeds for sustainability. 5G virtualizes the network – something we have already experienced with the cloud. So far, communication processing and information processing have remained separate. With 5G serving as a virtualization platform, they can now converge. 5G offers greater opportunities for communication and information sharing. As a result, no one maintains a cluster of specialist applications any more, but purchases it as software. This can contribute to sustainability because it reuses existing resources. On the other hand, information processing can be integrated into the network or carried out locally (edge cloud computing). This means that data is no longer "sent to the USA", thereby counteracting the formation of monopolies and strengthening national data sovereignty.

Will we see the dismantling of giant data centers?
I. S.: No, because even more data will be produced. At the moment, cloud offerings cost almost nothing. That's wrong, but it will take time to change.

Is the flat rate the death blow for sustainability?
M. H.: No. We have undertaken some important telephony projects. Consider the VoIP protocol, for example, in which FOKUS was involved and which played a vital role in making flat rates possible. From the end user's point of view, there is nothing better than flat rates. But in a B2B context we need to move away from flat rates.

Back when people used phone booths, there was a saying: "keep it short!"
I. S.: Indeed. That was because the resource was scarce. Data centers are expected to consume 11 percent of global energy in 2030. And there is a lot of data junk using up valuable resources. However, if we succeed in moving away from cloud computing and if we develop more sensible, resource-saving applications with fog and edge computing, then we will have taken an important step forward.

Thank you very much for this interview.

Networking against poor air quality

There are many elements contributing to sustainable mobility in cities. A well-developed public transport system is as much a part of this as modern cycle routes. Digital and networked (electric) mobility can make a further contribution in enabling traffic to be more environmentally friendly while at the same time considering individual needs.

We have to improve the air in our cities. From free local transport to driving bans on cars, major European cities have already tested many initiatives in an attempt to ensure sustainable mobility. But they are still either unfinished or are too slow to take effect, as the May 2018 EU lawsuit against Germany and five other countries demonstrates.[1] Digital, networked mobility offers a number of opportunities for reducing pollutant emissions over the short term.

You can think of networked vehicles as objects traveling in the Internet of Things. Because they are equipped with a large number of sensors, they are able to generate data – on road construction or heavy rainfall, for example – and exchange it at any time via wireless networks with the road infrastructure and other road users. This data can then be linked to weather and air data to produce short-term emission simulations for individual streets or the entire city. Based on environmentally conscious, city-wide traffic scenarios, individual recommendations are then displayed on the driver's smartphone or in the car – or executed directly by highly automated cars.

Better air and individual needs are not a contradiction

If drivers are given precise instructions and positive feedback, they are prepared to make detours that will add a few minutes to their journey – if they believe it will benefit people and the environment. This was demonstrated by the TEAM[2] European research project on collaborative mobility led by FOKUS researchers. The 30 km/h zone on Leipziger Strasse in Berlin recently introduced to improve air quality confirms this readiness to help: most drivers voluntarily observe the speed limit.

In contrast to introducing city congestion charges or banning cars from cities entirely, digital mobility has the advantage of being able to cater to individual needs, such as the weekly shopping trip, while still managing to optimize pollutant and traffic volumes throughout the city. Measurements of vehicles under real driving conditions show that pollutant emissions are strongly dependent on driving styles – a factor that also affects the battery range of electric vehicles. Braking and start-up in particular, consume a lot of energy and release high levels of pollutants. This can be avoided, for example, by approaching traffic lights just as they turn to green. The Fraunhofer FOKUS TEAM project put this into practice by having the networked traffic lights transmit their sequence timings wirelessly directly to the vehicle. The driver is instructed to maintain a specific optimum speed, based on the current sequence timings, while the highly automated car adjusts its speed autonomously. The next step in maintaining smooth traffic flows involves communication between vehicles driving cooperatively behind each other in order to avoid the need for sudden braking. Apart from offering an improved driving experience, dynamic route guidance also helps drivers to avoid heavily congested areas and encourages them to switch over to electric power. Fraunhofer FOKUS has developed an app for this purpose. When using a highly polluted route, for example, the app will advise drivers of plug-in hybrid vehicles to switch over to electric drive. It can also provide drivers of diesel vehicles with timely information about how best to circumnavigate heavily polluted areas. Since NO_x – which is the sum of the pollutants nitric oxide (NO) and nitrogen dioxide (NO_2) – degrades relatively quickly, these behavioral changes can quickly improve air quality and help to meet emission limits. To get as many people as possible to use applications that reduce the burden on the environment, researchers from the Smart Mobility business unit are also helping start-ups to make a successful market entry– one example being Rydies, which networks mobility solutions for bicycles with other modes of transport.

Prof. Dr.-Ing. Thomas Weber, acatech, Vice President

Does automated, connected mobility reduce traffic levels?

"The most important thing is to make sure that the mobility of the future meets people's basic mobility needs better than it has in the past. Automated connected vehicles should therefore not simply replace current vehicles. We expect the need for mobility itself to increase rather than decrease both regionally and globally. It is therefore vital that we develop vehicle concepts that integrate seamlessly with the major trends in mobility technology: connectivity, electrification as well as automation, and carsharing/ridepooling. This will relieve the pressure on the entire integrated transport system and make it safer, more environmentally friendly and more user-centered."

Software for keeping people safe

We put our faith in the assumption that software programs will do what they were written to do. While there is no such thing as the perfect application, we expect a certain level of quality from software-based systems. These standards are needed to minimize the risk of attacks or failure of the system itself.

Software now forms an indispensable part of the safety-critical systems used in aerospace or the energy supply sector, for example, as well as in automotive manufacturing and our increasingly digitalized cities. More and more things are now being networked together with the aim of making life easier and resource usage more efficient. Smart home applications offer one example where the central heating thermostat or lights in the apartment can be controlled remotely with a smartphone app. What works in the "smart" home also offers business clients a way to manage entire building complexes via the Industrial Internet of Things – to increase efficiency, save energy and make general savings on costs.

In these contexts, software security has a key role to play. What happens when this security is not fit for purpose was recently shown by the Mirai botnet. In 2016, it used the Internet of Things (IoT) as a vector to attack everyday devices like routers or TVs and infect them with malware. Worldwide, around half a million compromised IoT devices were then used by Mirai to attack websites using a "distributed denial of service" (DDoS) attack, which tries to take servers offline by forcing them to handle a huge number of requests. This caused major disruption and actual periods of outage at service providers like Amazon, Twitter and Netflix.[1] An attack of this kind against a key industrial complex or utility would have had fatal consequences.

Software quality control and certification

Guarding against attacks like Mirai depends on developing the right quality controls and certification for the device software, whose capabilities must be tested for functionality, interoperability, robustness, security and trustworthiness. While some testing tools are available for IoT applications, these are often incomplete or have not been consistently improved and enhanced.

In its IoT-T project, a joint undertaking with business partners and funded by the German Federal Ministry for Economic Affairs and Energy, Fraunhofer FOKUS is developing IoT testware that aims to offer IoT product manufacturers a low-cost way to test and certify their systems. This testware is based on the open-source programming tool Eclipse and standards from the European Telecommunications Standards Institute (ETSI). For the project's test suites, which can be executed automatically, proven and standardized technologies like TTCN-3 are being used – an established standard that is a particular favorite for protocol testing. This IoT testware is the first platform to offer TTCN-3 test suites for conformity testing against the CoAP (Constrained Application Protocol) and MQTT (Message Queue Telemetry Transport) protocols that form the basis for communication between IoT devices. These conformity tests not only target the robustness, reliability and dynamic nature of open environments but will also be entirely open source to ensure that they can be extended by third parties and easily integrated with other tools. The developers in the IoT-T project aim to offer their IoT testware as an efficient way of closing existing gaps in the quality assurance of IoT devices while also enabling their certification.

Safe software for people

There are many ways in which software helps to make our lives and our environment safer. One example is offered by the technologies behind networked public safety. In Germany, one of these tools that save lives in emergencies and critical situations is the KATRETTER volunteer system. This app-based system helps rescue workers to better integrate help offered by volunteers into their emergency and disaster relief activities. In such a situation, an operations center run by a fire service (for example) uses geolocation to pop up a message on the phones of helpers who are close to the emergency. If someone suffers a cardiac arrest, for example, a person registered in KATRETTER as a first responder with the relevant expertise can be directed straight to this individual to start providing first aid as quickly as possible. This approach avoids wasting valuable time until the emergency medical team arrives. Even people without specific know-how can register – and help out with piling sandbags in the event of a flood, for example. Privacy is of course a very important issue here, because the app handles information about volunteers and people affected by the emergency. Accordingly, Fraunhofer FOKUS involved data protection experts at an early stage to ensure development followed "privacy by design" principles. The resulting app not only integrates first responders and volunteers while complying with the law but also ensures efficient user management by minimizing the data handled.

Sustainable digitalization in everyday life

60 % energy savings

Smart buildings could reduce energy requirements for lighting on business premises by over 50 %[15]

21.5 TWh of electricity

Information and communication technology (ICT) uses around 17 % of power in private households – more than double the amount consumed by lighting[14]

4 terabytes of data

A self-driving car generates as much data[12] in one day as the Hubble Space Telescope does in five months[13]

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60 kinds of raw materials

Making a smartphone requires 30 kinds of metals and 30 other materials[1]

2 gigatonnes of CO_2

Using smart agriculture[2] worldwide would be equivalent to shutting down 500 coal-fired power plants[3]

46 million books

Every year, people in Germany buy 30 million ebooks[4] and 16 million audio books[5], saving around 14,000 tonnes of paper[6, 7]

60 million tonnes

The global tonnage of e-waste[9] weighs roughly the same as all of the passenger vehicles in Germany[10, 11]

8 hours a week

Over half of all 3- to 5-year-olds are active online – for roughly half the time they spend watching TV[8]

Ensuring sustainability in media evolution

Digitalization has led to serious changes in media use. Sustainability has not always played a role in this. But there are paths that could lead to sustainable development.

Media is typically collectively defined as a delivery systems for transmitting information, such as the press, radio and television.[1] Digitalization has also changed electronic mass media such as broadcasting and online media outlets. In its FAME (Future Applications and Media) and VISCOM (Visual Computing) business units, Fraunhofer FOKUS deals with various technologies to visualize images and for the television of the future. Television use in particular has changed rapidly in recent years.

Increasing media consumption

While entire households would gather around just a few neighborhood devices in the 1950s, the trend now is toward two or even three devices in a single household. In 2018, around 236 million televisions were sold worldwide.[2] In Germany, 97.8 percent of all households now have a television.[3] And that's not all: around 37 percent of all households in Germany actually have two televisions.[4] Because television is no longer viewed only in a linear or "classic" way, i.e., by watching whatever program is currently being broadcast on a TV set, devices such as smartphones, tablets and mobile computers are also being used to consume media. Streaming makes media permanently available. The only requirement is for these devices to have an Internet connection with the necessary bandwidth. All of this leads first and foremost to increased media consumption. After all, who can resist when an affordable, convenient and wide selection of moving images is available to watch? At first glance, the increase in devices and rise in media consumption through streaming would not seem to speak in favor of sustainable development. Along with the cost of the devices for playing videos, it is necessary to take the additional data centers and their energy consumption into account.[5]

This stands in contrast to "classic" television consumption. Who can forget the days when children were allowed to watch one last bedtime show before going to sleep? After the children had fallen asleep, many parents settled down in front of the TV just in time for the 8 o'clock news and the Sunday evening drama afterwards. Then they would often play a DVD they had rented from the video store. Energy was consumed here, too. First, both the appropriate televisions and DVD players had to be manufactured. Then there was the trip to the video store, which was often made by car. When we compare the CO_2 emissions of streaming a 90-minute film and renting a DVD from a store, this trip makes all the difference. If it is longer than 17 kilometers and is made by car, streaming wins the race. But if a DVD is sent through the mail, then streaming and rental have identical emissions.[5] In the end, therefore, digitalization will probably become an environmental zero-sum game when it comes to media.[5]

Sustainable development through digitalization

The solutions developed by the Future Applications and Media (FAME) business unit of Fraunhofer FOKUS show how digitalization and new technologies might still contribute to saving resources in media consumption in the future. Among other things, the scientists here are trying to make it possible to process and display 360° video content on low-performance devices such as TVs or HDMI sticks. Right now, such devices are not capable of directly displaying the actual video data for 360° films – on account of the amount of data (UHD is the lowest quality level for 360° films) and how it has to be processed or converted (perspective calculation). The platform developed by FAME will enable the high-quality streaming of 360° videos without latency by rendering only the viewing area selected by the viewer. The system thus works on existing smart TVs, HbbTV devices and mobile devices, as well as in normal web browsers. It may therefore prevent the need to continually acquire new devices. The Visual Computing (VISCOM) business unit of FOKUS offers another example of sustainable media and media use. These scientists are using their projector autoalignment not only in driving simulators for the development of new car models and autonomous driving, but also in virtual reality studios such as the one at the Zuse Institute Berlin. With this technology, intelligent and highly efficient algorithms ensure that the partial images from the individual projectors are rectified and adapted to the projection screen to produce a high-resolution, seamless overall image. At the points where the partial images from the projectors overlap, they are automatically and precisely aligned with one another. If the projector's position and thus its image changes, the calibration process is restarted and the image is automatically reintegrated into the overall projection. The Zuse Institute Berlin uses its virtual reality studio to display 3D visualizations of complex data and processes. One example of such an application is the 3D depiction of surgical procedures, which can be supplemented with additional data such as ultrasound, CT and MRI images. Media are thus helping to make operations safer and giving doctors access to all the information they need during procedures.

Data flows in water management

If Lake Constance was suddenly Europe's only source of fresh water, it would be drained within six months.[1] Yet private households account for only a tenth of our total consumption.[2] Most of the resource is used for industrial production and by the water industry itself.[3]

Water is crucial to many sectors of industry, e.g. as a coolant, solvent, reagent or product component. Although some regions in Germany have an abundance of water, this is not true everywhere. Nevertheless, too little is being done to use this precious resource more economically. Industrial water management has not yet fully exploited the benefits of digitalization, although doing so would contribute substantially to our ability to meet the United Nations' sustainable development goals on water management.[4] In its position paper "Industrial Water 4.0", which Fraunhofer FOKUS helped prepare, the DECHEMA association explains how the industrial water cycle could be digitalized. The concept combines Industry 4.0 with Water 4.0 and highlights three main areas: the digitalization of industrial water management, the relationship with industrial production and the integration with municipal (waste) water management. In practice, the proposed solutions could make many sectors of industry more productive, more dynamic and more sustainable and would create enormous potential for more efficient use of industrial water.

Digitalization instead of wasting resources

Imagine a situation in which a chemical producer using a networked plant could minimize the usage of energy and additives by implementing precise measuring methods to treat waste water, thereby saving on costs and reducing environmental pollution. A digital twin – a virtual image of all of the production plant's processes and operations – analyzes stress scenarios and recommends any action that may be required. Based on this information, plant workers can flexibly adapt production to make the best use of the fresh water or the wastewater treatment plant. Communicating with the local suppliers can also prevent bottlenecks in the water supply and complications with the disposal of sewage.

Any communication network in a critical infrastructure must be secure and interoperable. Researchers at the FOKUS Industrial IoT Center recommend gradually replacing hardware production engineering with software and standards-based information and communication technology. The standards of the IEEE Working Group TSN (Time Sensitive Networking) and OPC UA – a machine-to-machine communication software – serve as key components. They enable the establishment of a vendor-independent communication network that also provides the basis for applications in the field of artificial intelligence, such as the condition monitoring of machines. For improved security and speed, the FOKUS team offers edge computing technologies that process industrial plant data locally to avoid sending it to a central cloud.

Load shifting for a stable power network

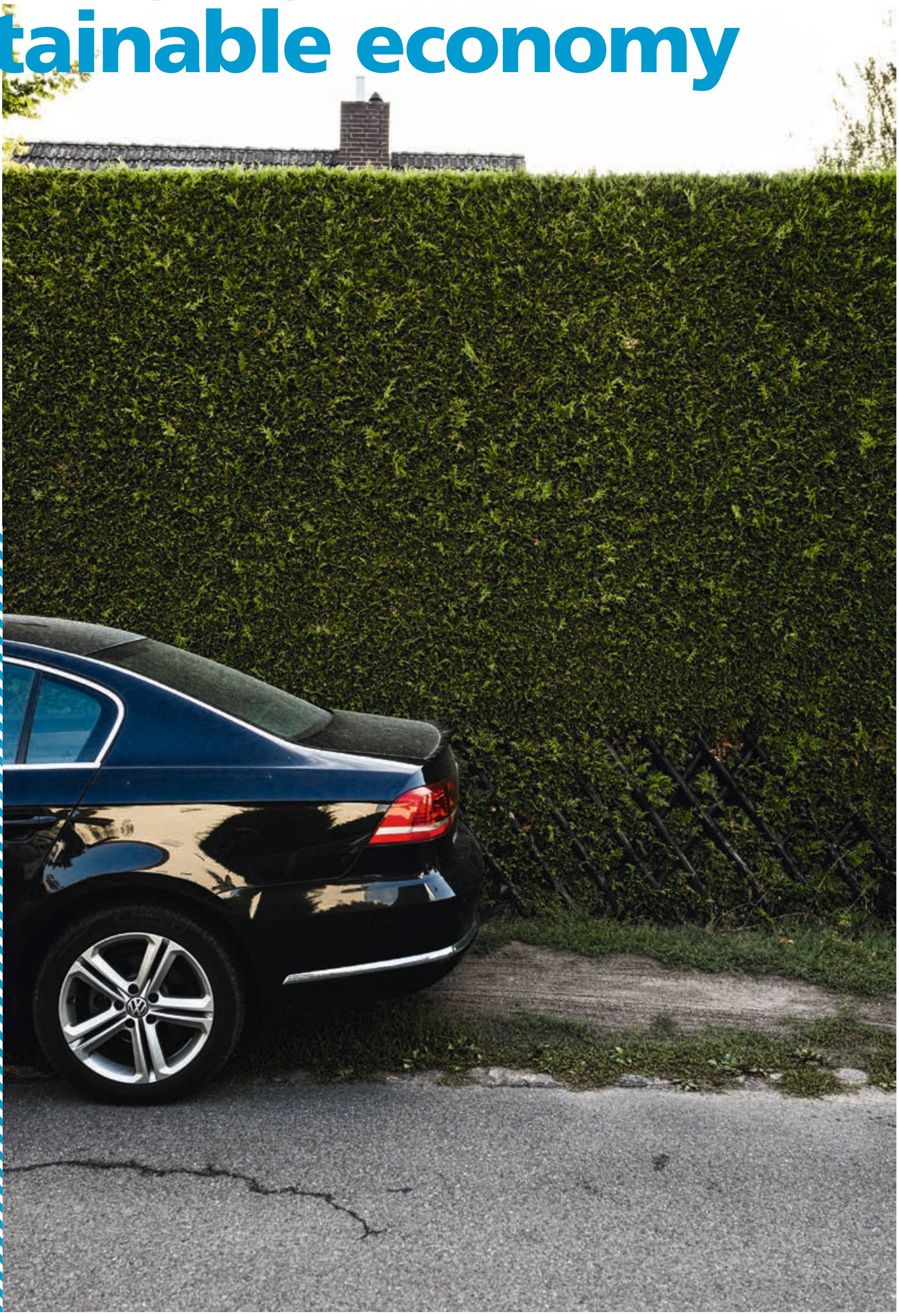
In addition to water, electricity is essential for industrial production. Today, the dedicated use of renewable energy is rarely possible, mainly because of wide fluctuations in supply. Digitalization can help, however, by improving flexibility and efficiency. For example, Fraunhofer FOKUS and its partners in the WindNODE project in northeastern Germany are investigating the load shifting options available to industrial energy users. During planning, production processes are adapted to the available energy supply. This means avoiding peak loads and systematically forecasting electricity costs in order to benefit from low energy tariffs. Here too, models and algorithms are deployed to help analyze electricity flows and – to complete the cycle – to optimize water management. Now, all that remains to be done is to ensure the flow of data.

Michael Kläring,
Plant Manager, Siemens Messgerätewerk

How green is Industry 4.0?

"Siemens AG's Messgerätewerk in Berlin produces protection and automation devices for electricity grids. Digitalization at the plant facilitates the provision of data in real time and allows processes to be optimized for sustainable and economical production. Power quality devices based on the MindSphere IoT platform monitor power quality, minimize production downtime and reveal potential energy saving opportunities. Tablets and hand-held scanners in production and logistics reduce paper consumption and provide digital time-optimized production sequences. The improved efficiency of the production lines reduces both energy consumption and waste."

Leveraging data for the sustainable economy



As digitalization gathers pace, it generates and processes huge volumes of data, with the pool of digital data available worldwide increasing every day. All of which raises the question of how data platforms and the services that run on them can help make the digital transformation sustainable.

In business, companies can apply the principle of platform economy to boost competitiveness and enhance value. Yet how can this intelligent combination of data and services also be used for sustainable business practice?

The Industrial Internet of Things

The aim here isn't merely to network sensors, machinery, processes and company data intelligently, while guaranteeing high levels of data protection and data security. There's also a need to record and analyze machine data in real time, and ensure the robust and real-time synchronous control of machine pools. One solution that Fraunhofer FOKUS is working on for large-scale manufacturing applications is in edge computing, where data is processed and analyzed near to its sources and control systems rather than in cloud-based systems. This reduces both the duration and distance of the data transfers necessary. Processing on the edge of the network enables faster response times, since latency (the time needed to transfer data) is reduced. This also works to increase data security, because the data is processed at their source and saved only locally – rather than being uploaded into a remote cloud infrastructure. This type of data processing is a key element of the Industry 4.0, and the Industrial IoT research group at Fraunhofer FOKUS led by Dr. Florian Schreiner and Dr. Alexander Willner has been developing demo models and toolkits to showcase the potential offered by this technology. Edge intelligence is being combined with time-sensitive networking (TSN) and real-time communication protocols to produce a networked, real-time production environment.[1]

Open Government Data

Data platforms are also used widely in the public sector – an approach termed Open Government Data. The German State of Berlin launched its Open Data Portal back in 2011, while the nationwide GovData portal was piloted in 2013 (and started regular operations in 2015), and the European data portal went into service in early 2016 after a three-month beta phase. Fraunhofer FOKUS was a key technical planning and implementation partner for all three platforms. Open data not only drives transparency and participation but also boosts the economy, strengthening it by opening up new and advanced business opportunities. In the context of smart cities and communities, another key aspect is that local government is also embracing open data to help develop e-government solutions, for example. In this way, public institutions are brought on board to support the digital transformation.

Data provisioning and exchange in the urban space

How can data exchange and collaboration work successfully in the urban space? This was the question addressed in the "Urban Data Space" study funded by the German Federal Ministry of Education and Research, which was published jointly with Fraunhofer IML and Fraunhofer IAIS in summer 2018.[2] Led by FOKUS research scientist Silke Cuno, the project team first conducted surveys to assess the current data situation in selected German municipalities, which included Bonn, Dortmund, Emden and Cologne. Particular attention was devoted to the topics of data quality, data security and data protection in relation to various sectors. In its findings, the study recommends that urban data platforms should be built on open standards, offer open interfaces and formats, and foster pilot projects based on core scenarios. In this way, the identification of areas of common interest can be used to drive the creation or reuse of exchangeable and generic IT components with broad deployment options. All cities and municipalities would then stand to benefit from their use.

A team at Fraunhofer FOKUS led by Dr. Yury Glikman and Dr. Jens Klessmann has now developed "Piveau Data Technologies" – a set of reusable tools for preparing administrative data. These tools help public authorities and companies alike in the collection, evaluation, aggregation, quality control, and publication (as appropriate) of their data and metadata, as has been recommended by the German Government's 2014 "National Action Plan to Implement the G8 Open Data Charta":

1. A clear sense of direction for public data in Germany.
2. Publication of datasets.
3. Publication of data on a national portal.
4. Measures for consultation, engagement and knowledge sharing.

Many of these milestones have already been achieved. In the future, too, the need for responsible digitalization of many areas of our lives will require us to construct a data and services ecosystem in which businesses, local government and the civil society can derive mutual benefit from a high-quality data repository in order to offer services that are not just innovative but which are oriented on the sustainable development goals of the United Nations.

Bringing together sustainability and digital transformations

Prof. Dr. Dirk Messner, Director of UNU-EHS (United Nations University – Institute for Environment and Human Security), Co-chairman of the German Advisory Council on Global Change (WBGU)

Sustainability research shows that the transformation toward sustainability must be accomplished by around the middle of this century in order to avoid tipping points in the Earth system – such as the melting of the Greenland ice sheet, the collapse of the monsoon system or the Amazonian rainforest, and irreversible changes to the climate that could trigger a new "hot age." In essence, the focus is on decoupling growing prosperity and socio-economic development from greenhouse gas emissions in the next three to four decades, using resources in circular economies, and radically reducing the pressure on ecosystems. These are big challenges, and they have to be tackled in a narrow time frame. If we take the Agenda 2030 with its comprehensive sustainability goals seriously, not only must we reduce the man-made risks from the dynamics of the changing Earth system, we also have to eliminate extreme poverty and reduce the inequalities that threaten the social cohesion and stability of many societies.

In early 2019, the German Advisory Council on Global Change (WBGU) – in the context of which I have the pleasure of working alongside Prof. Dr.-Ing. Ina Schieferdecker – will publish a comprehensive report on "Sustainability Transformations in the Digital Age." Our core question is: Can digitalization help humanity achieve these tasks necessary for sustainable development? For this to be possible, digital innovations would have to be tied to and merged with the transformation toward sustainability – something that politics, business, society and science are not yet prepared for.

Our hypothesis is that the digital age and technological advances relating to machine intelligence are opening the door to a new era of human civilization. Major organizational tasks are involved in bringing the digital revolution together with the necessary transformation toward sustainability, i.e., the development of prosperity, security and democracy for what will soon be ten billion people within the limits of the Earth system. Many governments feel overwhelmed by the speed of the technological changes. But governments are not the only ones under pressure to adapt. To promptly tackle these organizational tasks for sustainability and the digital transformation, scientists must also quickly take steps to arrange research that could contribute to the development paths leading to future digital sustainability societies. It is clear that research into digitalization and the opportunities and risks of machine intelligence must be more closely intertwined with the sustainability sciences. So far, however, there have hardly been any systematic points of contact between them. A good 30 years ago, climate and Earth system researchers learned how to cooperate with social scientists and economists, spawning the well-established sustainability sciences that illuminate the interactions between human

societies and the dynamics of the Earth system – and now the time has come to explore human development within the limits of the Earth system in the digital age. To achieve this, new networks must be established between digitalization and sustainability research.

It is certainly possible for a digitalized sustainable society to succeed. All of its energy would come from renewable resources. Precision farming could use sensors, robots and autonomous systems to optimally nurture plants and animals while simultaneously protecting the environment. Intelligent design, repairability and automated deconstruction at the end of a product's life span could significantly reduce the demand for new raw materials and pave the way for a global circular economy. Global communication platforms and virtual networking could promote universal awareness of the responsibility of every individual for overarching issues of sustainability and humanity – just as the printing press triggered educational revolutions and formed the basis of the Enlightenment. In virtual rooms, polycentric networks could become the point of departure for new models of global governance. Global minimum tax rates and global competition law would prevent world companies from pitting states and societies against one another. The relationship between data use and the private sphere could be arranged to guarantee digital self-determination. Digital technologies promise great advances in personalized diagnostics and the treatment of diseases.

All of this would require technological innovations to be linked to social and institutional ones. After all, it does not take much imagination to describe how the vision of the digital sustainable society could all too easily fail: it is easy to picture more inequality, the concentration of economic and political power, growing resource consumption, data abuse and people being controlled by private companies or states. Digitalization thus entails tremendous organizational tasks for all societies, and it demands that we scientists establish new research alliances.

From research to practice

Leistungszentrum Digitale Vernetzung

The Berlin Center for Digital Transformation pools the expertise of the four Berlin-based institutes Fraunhofer FOKUS, Fraunhofer HHI, Fraunhofer IPK and Fraunhofer IZM in the fields of information and communications technology (ICT), data processing, production systems and microelectronics. Business partners and public organizations are also offered the opportunity to cooperate on research projects run by participating individual Fraunhofer institutes. These Center partners benefit from both the latest enabling and cross-sectional technologies as well as from extensive options for transferring the results of the project directly into practice. The participating institutes have set up Transfer Centers specifically for this purpose, in which solutions for the four application areas are developed and put to the test. The Berlin Center for Digital Transformation receives funding from the Senate Chancellery for Higher Education and Research within the Berlin State Government and the European Regional Development Fund (ERDF).

Kompetenzzentrum Öffentliche IT

The Competence Center Public IT (ÖFIT) at Fraunhofer FOKUS has been set up as a point of contact and think tank for questions relating to public IT, with a particular focus on social trends and the action areas that these generate for government and administration. At ÖFIT, Fraunhofer FOKUS is developing practicable models, ideas for digital policy, and scenarios for interdisciplinary cooperation between actors in public administration, civil society and business. Information technology (IT) is becoming an increasingly important part of public life, as information technologies start to have a lasting impact on the environments in which citizens live and work. The Competence Center therefore investigates current topics in digital policy and the digital society with the aim of supporting proactive design efforts in the era of digitalization. This is also why ÖFIT takes an interdisciplinary approach to research and development work in public IT. The Competence Center Public IT is funded by the Federal Ministry of the Interior, Building and Community.

weizenbaum institut

The Weizenbaum Institute for the Networked Society was formed in September 2017 with the aim of investigating the current changes in our society that are occurring in response to digitalization, and to develop forward-looking technical, social, economic and political strategies to address these changes. Coordinated by the WZB Berlin Social Science Center (WZB), the Berlin-Brandenburger Consortium is funded by the German Federal Ministry of Education and Research (BMBF). Aside from the WZB itself, its members include Berlin's four universities – Freie Universität Berlin, Humboldt-Universität zu Berlin, TU Berlin and the Berlin University of the Arts – as well as the University of Potsdam and Fraunhofer FOKUS. One of the three founding directors is FOKUS Institute Director Prof. Dr.-Ing. Ina Schieferdecker, who is also a Principal Investigator. FOKUS Institute Executive Director Prof. Dr. Manfred Hauswirth is also a Principal Investigator. Manfred Hauswirth formed Research Group 11, "Digitalization and Scientific Value Creation" and Research Group 19, "Digitalization and Networked Security". Ina Schieferdecker heads Research Group 6, "Responsibility and the Internet of Things" and Research Group 20, "Criticality of AI-Based Systems".

Fraunhofer FOKUS | Akademie

The FOKUS Academy offers further training in the fields of technology and innovation, with the aim of transferring ICT know-how from research into business or government practice. The Academy offers ICT courses for ICT decision-makers, developers, project managers and management staff from small and mid-sized companies, the manufacturing sector and public administration. The online training courses and hands-on workshops are organized and hosted by researchers working at Fraunhofer FOKUS. CPD courses offered by the FOKUS Academy include training for management, subject specialists and end users, as well as in-house training and certification. Courses at the FOKUS Academy are organized as "blended learning", i.e. as a mix of interactive online courses and face-to-face sessions. A curriculum consisting of self-study videos, interactive tests, exercises and homework is supplemented by workshops and seminars where participants come together to broaden their expertise in a classroom setting with their course tutors. Courses are offered in German and English. Another CPD program is the Cybersecurity Learning Lab, where Fraunhofer FOKUS is a member. At the Lab, courses focused on the very latest developments in cybersecurity are taught by experts from Fraunhofer and selected technical colleges.

Hands-on research

Fraunhofer FOKUS has a large number of laboratories and showrooms that offer a variety of hands-on ways to gain insights into our applied research. For business clients, they offer many windows into the expertise FOKUS can contribute to joint projects.

Industrial IoT Lab

To keep things running smoothly in the factories of the future, Fraunhofer FOKUS is using data analysis tools with real-time capabilities for plant monitoring and predictive maintenance, as well as locally networked, intelligent nodes (fog/ edge computing nodes) to ensure networks are secure, reliable and fast. With its Time-Sensitive Networking (TSN) + OPC Unified Architecture (OPC UA) test environment, the Industrial IoT Lab offers a standardized, real time-ready communication infrastructure for manufacturing and control applications. The lab lets manufacturers, end users and other interested visitors learn all about IoT systems and applications.

Common Criteria Certification Lab – CertLab

In 2010, faced with a growing volume of certification work for IT security products, the German Federal Office for Information Security (BSI) decided to outsource some of its work monitoring evaluation facilities during evaluation procedures to Fraunhofer FOKUS. CertLab handles the monitoring of testing facilities during the evaluation of software and hardware products, and is the only organization that performs this all-important role outside of the BSI itself. The certification procedure remains under the authority of the BSI at all times.

E-Health Lab

The E-Health Lab develops interoperable solutions for medical data communications as well as the necessary security architectures needed for access and rights management, for example. Alongside electronic patient records that enable the exchange of medical data between physicians and patients using a number of technical protocols, work at the Telehealth Technologies Innovation Center also focuses on the EFA electronic health record specification and data portal access solutions. In addition to developing digital integration solutions and cooperative platforms for regional healthcare networks, researchers are also investigating patient-oriented applications – to supplement treatment programs with the help of telemedicine and telerehabilitation, for example.

Conformance and Interoperability Lab

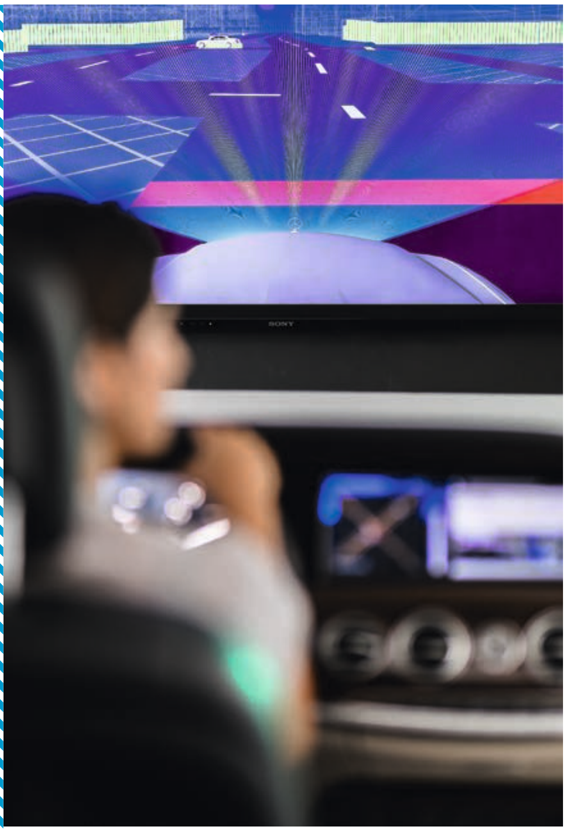
The Conformance and Interoperability Lab run by Fraunhofer FOKUS offers a powerful test environment for evaluating and enhancing the quality of mobile devices and networked systems. Apart from testing device/ system performance and security, work at the Lab focuses on validating their conformity and interoperability against relevant standards from a number of bodies, including ETSI, ITU, OMG, AUTOSAR and OMA. One key feature of the Lab is its tool-based, automated test methods for evaluating and securing the systems and their system components. These methods enable efficient test suite creation as well as the automated documentation and traceability of test runs.

Smart Media Lab

The Smart Media Lab showcases the latest developments and technologies from the Future Applications and Media (FAME) business unit. Alongside technology for cloud-based 360° video playout, interactive 360° streaming and non-linear video (NLV), the lab also offers applications that drive end user and device interaction – such as for HbbTV, for example. All of this enables the creation of prototypes, demo models and proof-of-concept solutions that comply with the latest technical standards.

Safety Lab

The Safety Lab in the ESPRI business unit offers its partners collaborative real-world testing for networked technologies and public safety solutions. The Lab's research and development work focuses on models and solutions for improving hazard control, and for the networking of existing safety solutions. Hazards such as pandemics, extensive or prolonged power outages, terrorist attacks or extreme weather events strike at the heart of the technology-dependent societies of the 21st century. Developing the right technical and organizational countermeasures to these dangers requires a rethink of approaches to networked safety. The Safety Lab simulates a range of hazard scenarios while showcasing potential safety solutions to stimulate debate and discussion.



Smart Mobility Lab

The Smart Mobility Lab offers its visitors a vision of the self-driving vehicles of the future. A 1:1-scale cockpit enables the simulation of a wide range of driving scenarios. As with a real autonomous vehicle, the steering wheel in the simulator turns all by itself while passengers experience a virtual journey through a 3D world that is projected onto a large video screen. Dangerous tailgating, system errors or hacker attacks can also be accurately reproduced. Fraunhofer FOKUS has long experience in the fields of secure vehicle-to-vehicle and vehicle-to-infrastructure communication. An integrated approach is followed here, which extends from the realistic simulation of vehicle-to-X-based applications and the integration of infotainment products in fleets of research vehicles through to trials conducted in a wide range of test environments.

Berlin 5G Playground

The Berlin 5G Playground is an open-access testbed that enables early testing of innovative product prototypes in a realistic, end-to-end 5G environment. The test platform offers both indoor and outdoor field testing for a mixture of radio access technologies and supports ultra-reliable, low-latency communication. Together, these components make up the first inner-city 5G testbed in any European capital that is available for use with collaborative research and development projects. The software-based and 3GPP-based 5G core network (Open5GCore) developed by Fraunhofer FOKUS is now being used to set up 5G test networks and innovative 5G applications worldwide.

eGovernment-Labor

Established in 2004, the eGovernment Lab offers a neutral and independent forum for collaboration between public actors and the private sector. Over 60 lab partners now work with Fraunhofer FOKUS to develop and integrate innovative models, applications and best-practice solutions. The Lab is a workshop, a competence hub and “storefront” for e-government, offering a hands-on approach to incorporating the latest technologies into real-world application scenarios for the future of public administration. The portfolio ranges from the modernization of technical IT methods and manufacturer-neutral IT infrastructures to the implementation of electronic recordkeeping and the trialing of innovative technologies such as AI and blockchain. Research at the eGovernment Lab focuses on user orientation and interoperability, working to interconnect current topics of debate and challenges with upcoming technological and social trends.

TV Lab

The TV lab offers an extensive, manufacturer- and provider-neutral test and development environment for the latest hybrid TV technologies, TV devices, media formats, interactive content and multi-screen applications. We help our business partners implement complex TV and streaming solutions based on technologies such as HbbTV, MPEG-DASH, Dynamic Ad Insertion (DAI) and Server-Side Ad Insertion (SSAI), 360° video streaming, addressable TV, digital rights management (DRM) and content protection. Our portfolio extends from design, implementation and validation through to the development and evaluation of comprehensive tests on real-world devices.

Automotive Interoperability Lab

The Automotive Interoperability Lab offers research and development services for the development and quality assurance of software-intensive vehicle electronics systems. Our target market is the vehicle manufacturer and supplier sector. The laboratory offers test benches for the automated testing of applications in the car-to-X environment, for infotainment and for safety-critical driver assistance systems. The goal of this R&D work is to develop methods to enhance efficiency and reduce costs in quality assurance, as well as methods and processes for improving and maintaining IT security – all of which are now decisive factors in the specification and development of onboard software and automotive electronics.

Graphic Lab

The Graphic Lab develops and tests innovative technologies for visualization. Multiple visualization surfaces – including a vertical dome and curved projection screens – are used for prototyping and optimizing the calibration software developed by Fraunhofer FOKUS for high-resolution 3D stereoscopic image materials. Several human-machine interface (HMI) technologies are also available for conducting research on the architectures and methods used in X Reality application scenarios. The Graphic Lab is a meeting-place for digital content producers, customers and partners interested in using and optimizing the technologies developed by Fraunhofer FOKUS.

Smart Cities and Communities Lab

Fraunhofer FOKUS has many years of experience in modeling and implementing public ICT and open-access platforms – including urban data spaces. The Lab works with partners from business and government (both local and national) to design public ICT infrastructure to be secure, interoperable, user-friendly and trustworthy. When networking a municipality's digitalized infrastructure systems, the interoperability and scalability of these solutions must be modeled and trialed, as must the approach to software/ hardware, data security and data protection. To do so, methods, architectures and tools are developed and optimized in agile processes together with local government stakeholders.

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