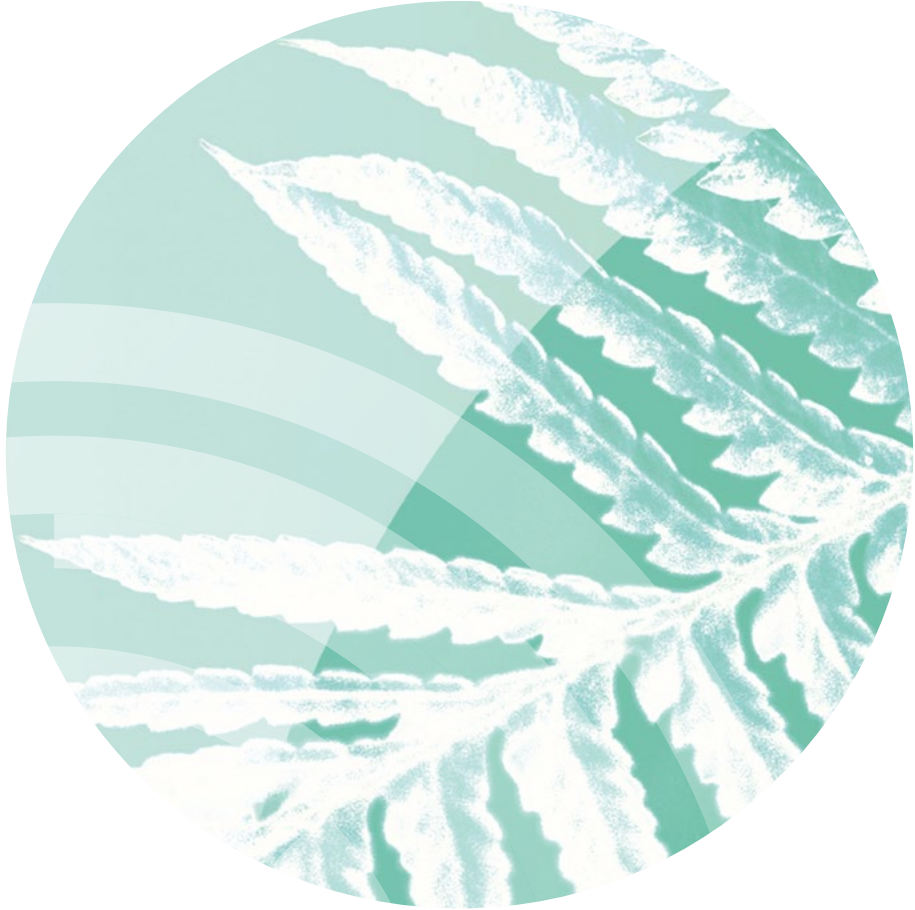


Fraunhofer Institute for Experimental
Software Engineering IESE

Annual Report 2022/2023

In focus

GREEN by IESE – Digitalization
for a sustainable future





The institute director of Fraunhofer IESE, Prof. Dr. Peter Liggesmeyer, is committed to sustainable software engineering as a means of conserving resources and protecting the environment.



Dear readers,

The past year was clearly characterized by energy shortages and the resulting high energy prices. This made it clear to us as Fraunhofer IESE that we need to focus our scientific expertise even more strongly on the topic of sustainability. After all, our mission is to use our research for the good of society and for the benefit of the German economy. We will therefore place an even greater focus on this topic and work on digital solutions for conserving resources and protecting the environment for all of us and especially for our business partners.

In addition to our research on resource-conserving production, our vision is to use digitalization to achieve the greatest possible resilience in value chains. Another focus of our work is digital agriculture, with a view to reconciling ecological and economic aspects. We will also continue to develop sustainable mobility concepts for cities and regions and implement them together with local municipalities. Read our cover story to find out how our software and systems engineering concepts and solutions provide many levers for achieving sustainability in ecological, economic, and social terms.

The topic of health is also particularly dear to us. That is why we now have a new department called "Digital Health Engineering", which has a clear focus on digital innovations

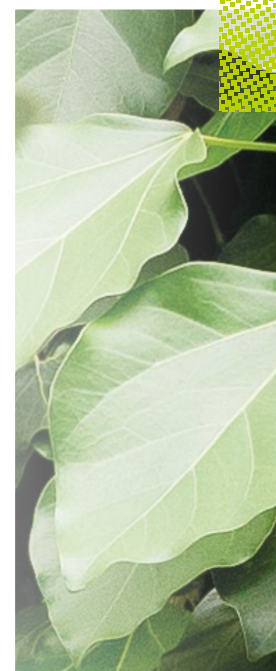
in the healthcare sector. We are researching contributions to innovative therapies for serious illnesses, such as in our project RNAuto, but we also deal with the topics of health and care in a broad sense. At the Center for Digital Diagnostics ZDD® in Potsdam, for example, innovative telemedical solutions are being developed to strengthen medical care in rural areas. You can find out more about this and other exciting trend topics in our chapter "IESE on Trend".

We cordially invite you to take some time to read this annual report and delve a little deeper into our key research areas.

Best regards



Peter Liggesmeyer



Contents

Cover Story

What exactly is sustainability?	8
Green IT: Making software engineering sustainable.....	10
Industrie 4.0 as an important building block in the fight against greenwashing..	12
Digitalization and sustainability – better together!	14
The potential of Digital Twins for sustainable Smart Cities	17
Climate-neutral urban district.....	18
DynaSoS – the future of networked systems is dynamic and sustainable	20
MobiGrid – Digital Twins in power supply	21
Ecological features of the institute building	22
Fraunhofer Alliance for sustainable energy supply	23
More than just sandstone: Fraunhofer Summer Camp 2022	24

IESE on Trend

Digital diagnostics to strengthen rural areas	28
IESE strengthens activities in the area of “Digital Healthcare”	31
Industry 4.0 optimizes pharma production	32
AI as a beacon of hope	34
The digital economy is booming	36
Smart start for Betzdorf-Gebhardshain.....	38
X-KIT – Exploiting the potential of digitalization for food and agriculture	40
Project of the future: “Digital Ecosystem”	41
Digital Ecosystem exemplified by INTERSPORT.....	42

For more security..... 44

This is what business is saying! 46

On the trail of understanding risk 48

“Enabler” Industry 4.0 50

Highlights

Hannover Messe 2023: BaSyx as a basis for sustainable production 54

Smart Country Convention: Smart City yes – but safe and secure! 55

Various events and trade fairs..... 56

MORGEN DENKER Summit..... 59

Projects 60

IESE at a Glance

About the Fraunhofer Institute for Experimental Software Engineering IESE 67

Fraunhofer IESE makes companies fit for the digital future! 68

Budget, cost development & human resources 70

Women for science 72

Research as the root of success! 74

Alliances & networks 75

Institute management and organizational chart 76

Advisory Board..... 78

Project grant numbers & locations 79

The Fraunhofer-Gesellschaft..... 80

Editorial Notes..... 81

GREEN BY IESE

What exactly is sustainability?

According to the German Federal Ministry of Economic Cooperation and Development (BMZ), sustainability or sustainable development means satisfying the needs of the present in such a way as not to restrict the opportunities of future generations. In this regard, it is important to consider the three dimensions of sustainability – economically efficient, socially just, ecologically viable – on equal terms.

We at Fraunhofer IESE also attach great importance to taking these three dimensions of sustainability into account in our research and in our applications. For us, sustainable development means considering environmental aspects on the same level as social and economic aspects, because it should be the goal of society as a whole to deal with global resources in an environmentally friendly and responsible manner. The "Council for Sustainable Development" sums this up aptly: "We must leave our children and grandchildren an intact ecological, social, and economic fabric."

Green IT: Making software engineering sustainable

Conserving resources with sustainable software and systems engineering

In the interview: Prof. Dr. Peter Liggesmeyer, Institute Director of Fraunhofer IESE

Green Computing is a collective term for all efforts to use information and communication technology (ICT) for the purpose of conserving resources in society or in the economy (Green by IT) or to operate ICT itself in a sustainable and resource-conserving manner (Green IT). According to this definition, sustainable software and systems engineering also falls within the scope of Green IT. We discussed this in more detail with Prof. Peter Liggesmeyer.

What role does sustainability play in software engineering?

For sustainability as a term, the same applies as for Green IT. The terms describe a very multifaceted topic. At its core, it is always about resource conservation, but it is clear to everyone that resource conservation can be achieved in different ways: for example, by constructing systems in such a way that they consume fewer resources, or by using them for a particularly long time so that resources do not have to be used again to manufacture them. Or by keeping resources in a cycle – i.e., reusing things.

What factors characterize sustainable software?

Over the decades, there have actually been different priorities in software engineering. At the very beginning, there was a desire to make software fast because computers were slow. Another aspect that was very important many years ago was memory consumption because memory was very expensive at that time. Now the overriding goal is the efficiency of

algorithms in order to save energy. Because if you generate a result faster, the computer does not need to compute for as long and will therefore also consume less power. In other words, the aim is to build systems – and software is a very crucial part of this – in such a way that fewer resources are consumed, which essentially means less energy.

But what happens to the energy that is still required?

Unfortunately, it is not possible to get by without any energy at all. However, using constructive measures, the energy used can be converted into something useful. For example, the waste heat from data centers should not be allowed to go to waste, but should be used to heat buildings.

How exactly is sustainable software engineering implemented?

There are certain design goals when building systems and therefore naturally also when developing software. Currently, sustainability is an important topic that ultimately affects many things in software engineering: for example, the architectures, i.e., the way in which software is structured. However, it is also reflected in the system software – in other words, in the operating systems, which must have certain capabilities on which to build. And the focus on sustainability does, of course, also have an influence on the development methodology itself – that is, on processes that allow the right decisions to be made early on and to ensure that these decisions have the effect desired by the engineer.

Prof. Peter Liggesmeyer



Algorithm efficiency was important when computers were still slow. Today, efficiency helps to save energy and conserve resources.«

And how is this realized at Fraunhofer IESE?

At IESE, we are conducting research on all these things and ensure that software engineers have the right tools at their disposal to take these different aspects into account. It is by no means the case that there is a global optimum of the desired software properties in every case. There are properties that tend to have a negative correlation with each other. As an example, I can mention "safety" and "availability". In a dangerous situation, the system can decide in favor of safety, but at the same time against availability, because it is no longer usable. You could also simply let the system continue to run, in which case it would be available, but no longer safe.

How can this idea be applied to sustainability?

We also have to make such compromises in terms of sustainability. There are properties that have to be taken into account together, and this complex optimization must ultimately be carried out by the software engineer during development. And to do this, the developer needs relevant methods, which we are researching at IESE.

Why is sustainable software and systems engineering important for industry?

Sustainable systems are important for the industrial producers of these systems because their buyers are increasingly demanding sustainability. There is a need – and I understand this need very well – not to use resources unnecessarily for one's own purposes. And so the ability of companies to develop sustainable systems is something that is necessary to satisfy market needs and sell products successfully. It makes a product more valuable in the perception of many people if it has a good sustainability attribute. However, sustainability is of no use if it does not also take economic feasibility aspects into account at the same time. Companies may be forced to find suitable compromises between resource conservation and cost aspects.

How will the topic of sustainability evolve in the future?

I would like us to be able to define sustainability more precisely in the future, in other words, to be able to distinguish greenwashing from genuinely sustainable systems. The moment a certain characteristic such as sustainability becomes important, there is naturally also a certain motivation to paint things green. Greenwashing is the fake news in the field of sustainability, so to speak. If we manage to record sustainability better – for example, by being able to pass on information on sustainability along supply chains in a tamper-proof way – then at the end of the day we can not only talk about sustainability, but actually prove it. And that is, in fact, the point that we need to reach.



Listen to the detailed interview (in German) here!

MORGEN DENKER
Podcast

Industry 4.0 as an important building block in the fight against greenwashing

Using the Asset Administration Shell to strip products of their alleged green credentials

How can often watered-down ESG (Environmental Social Governance) reports become a thing of the past? While a lot is already happening at a political level in terms of sustainable business practices, the technological side, in particular, can also make an important contribution to more transparent production methods. However, this first requires the basic idea of Industry 4.0 to manifest itself more strongly in companies.

Just as sustainable business practices have arrived on the political stage, one report about another greenwashing scandal follows the next. But why is it that greenwashing dilutes countless ESG reports to such an extent? There are many reasons for this, but what is fundamentally striking is the difficulty many companies have in correctly reporting the greenhouse gas emissions they and their suppliers generate. The majority of companies base this information on the Greenhouse Gas Protocol (GHG Protocol for short). This divides greenhouse gas emissions into three different categories, known as scopes: number 1 for direct emissions from sources owned by a company itself; number 2 for emissions from plants generating electricity used by the company; and number 3 for emissions from upstream and downstream activities within the supply chain.

While many companies still find it relatively easy to report Scope-1 emissions, they often have considerable problems with numbers 2 and 3. The reason: they simply lack the basis to adequately estimate the emissions produced over the entire product lifecycle. As a result, companies sometimes provide completely unrealistic data. So the question is: How can companies succeed in creating appropriate and fact-based ESG reporting so as not to go down the path of greenwashing in the first place? This is precisely where Industry 4.0 can make a crucial contribution to more sustainable and more transparent production.

Measuring the carbon footprint with BaSyx

The Industry 4.0 middleware Eclipse BaSyx has been developed over the past few years by Fraunhofer IESE together with many other partners. It is available to interested parties as open source and is designed as a kind of toolkit from which companies can obtain precisely those components for specific use cases that they need at the time. This also includes the principle of Asset Administration Shells, for example.

These are standardized Digital Twins with a uniform structure. Each Asset Administration Shell contains sub-models that map the status of a real asset and also provide live data as required. In short, the Asset

Administration Shell contains all the data about the properties of a product and its manufacturing history and can process this data using algorithms.

And now back to the issue of greenwashing: The principle of Asset Administration Shells also provides for the so-called CO₂ sub-model. This documents the carbon footprint of a manufacturer's own production steps across manufacturers as well as that of the production steps of all suppliers, and thus enables documentation along the entire supply chain of a product. This makes it possible to clearly trace how much CO₂ was generated during the manufacture of a product. Rough estimation errors, which are currently still very common in many ESG reports, can thus be eliminated.

Regional value chains create sustainability

In addition, a networked manufacturing environment not only helps companies to make the documentation of their greenhouse gas production more transparent. Industry 4.0 also contributes to optimization when it comes to the generation of emissions as a result of high energy consumption – again with the help of the BaSyx middleware, for example. After all, if, with its help, a company knows exactly about the utilization and downtimes of its machines, idle times can be eliminated systematically, processes can be rescheduled, and valuable resources can thus be conserved.

The keyword “conscious use of resources” ultimately leads to what is probably the most fundamental factor in terms of how the fourth industrial revolution can enable sustainable business practices and properly done ESG reporting: the focus on regional value chains. Even in a high-wage country like Germany, service-based manufacturing would make it possible, in principle, to once again manufacture more products within the country at competitive conditions – a fact that could soon make long, often environmentally harmful transportation routes a thing of the past.



Digitalization and sustainability – better together!

Fraunhofer IESE uses digital solutions to make sustainable manufacturing “easy”

In the interview: Dr. Thomas Kuhn, Division Manager Embedded Systems at Fraunhofer IESE

In principle, consumers would be willing to dig a little deeper into their wallets for sustainable products. But how can they actually tell whether the product they have chosen was manufactured sustainably, and how do they know which aspects this involves? In this interview, our Industry 4.0 expert Dr. Thomas Kuhn explains what is important in this regard and what role digitalization plays in sustainable production.

In the context of sustainability and digitalization, we often read the term Green by IT. What does this actually mean?

Companies should, of course, produce as little waste and CO₂ as possible. Green by IT is about using IT to make processes more environmentally friendly – production is a good example of this. Here, for example, attempts are made to save energy or use resources sparingly.

What are the different aspects of sustainable production?

In sustainable production, the use of resources is very important, of course. This means that you want to use as few resources as possible for each product. Ideally, production should take place in a circular economy. That is, using resources that were previously recycled – at least to a large extent. But it is also about the amount of energy used in production. This means that there are sometimes energy-intensive production steps. These are often necessary, but sometimes simple measures can be taken to reduce the amount of energy required.

How can we imagine this?

Welding, for example, requires a very high level of energy for a short period of time. A simple measure, which is already being implemented today, is to have the welding robots weld with a time delay so that the peak power required is lower. This is



the power that the power plants have to provide. We can now take this whole thing further in the sense that certain production steps could be carried out during the day, for example when energy from photovoltaic systems – PV systems for short – is available. The third important aspect is: Do I produce what is really needed or do I basically produce for the “garbage dump”, which unfortunately still happens.

Where can digitalization come in and provide support?

In principle, in all three sub-steps. In the first sub-step, for example, the digital product passport can be used to describe not only the product itself, but also the resources used and, if necessary, also recipes to recycle them as well as possible. As for the second aspect, energy consumption – this is something we are working on ourselves. Our aim is to use state-of-the-art scheduling to link production planning with a forecast of the availability of renewable energy in order to make it possible to carry our energy-intensive production steps at a time when renewable energy is available. And here you have a double advantage because this does, of course, help the environment, but it also benefits your budget because production becomes cheaper. Regarding the third case, we are working on efficient processes for the production of small lot sizes. It is not only important to be able to produce small lot sizes efficiently, but also to produce these small lot sizes at the time they are needed. This means adjusting set-up times and automating contract negotiations. This requires an integrated operating system for production, which is something we are working on in the project BaSys4Transfer, for example.

What exactly is BaSys4Transfer about?

BaSys4Transfer aims to make the middleware Eclipse BaSyx, which to date has been used extensively to implement Asset Administration Shells, ready for a broader user base. We are developing concrete applications that can be used out of the box. But there are also other projects for implementing specific applications, such as the project “greenProd”, which was launched in May. The aim here is to implement energy-efficient scheduling that also takes into account forecasting models for renewable energy. And which can talk to the MES system to optimize production and also records the carbon footprint for each product. This allows the savings to be seen and tracked directly.

So greenProd is also about the “digital product passport”?

Yes, exactly! It is about implementing this and thus recording the life history of the product, so to speak. In other words, we want to know: Where does the product come from, where do the supplier parts come from? Under which conditions were the supplier parts produced and, of course, also how much CO₂ was generated during their production? This is particularly important because manufacturers will be legally obligated to determine their carbon footprint. However, this is only possible in a supply chain. On your own, you can only determine a fraction of a product’s carbon footprint. This means that manufacturers must receive dependable data from their suppliers. To enable this, we need digital supply chains, and the digital product passport is a key asset in this regard.

Let’s go back to the scheduling processes – how are these implemented in the project?

For us, the basis of this technology is the Digital Twin, which we implement using the Asset Administration Shell. This enables us to see how much energy is actually consumed for a step and how much energy will be required for this step at a certain point in time. So we don’t just have one type of energy. If we now consume energy from our own PV system that would otherwise perhaps not be fed into the grid and could not be used, the actual energy consumption is not the final parameter, but rather the CO₂ emissions.

In other words: CO₂ emissions of renewable energies versus fossil fuels?

Yes, you could say that, because CO₂ emissions from renewable energies are zero. If, however, the energy has to be obtained from fossil fuels, they are significantly higher. So this is also something that our system takes into account. In the project we will furthermore also take into account the energy required for the IT infrastructure, for example, in order to operate this system. Then you can see whether there is actually a profit at the end of the day or whether the infrastructure is more expensive in terms of CO₂ than the savings.





While you can achieve sustainability without digitalization, it works better with digitalization.«

Our aim here is not to work with prohibitions, but with incentives. Energy is expensive. Energy will remain expensive in the future, too. And that is why companies have their own incentive to make their production energy-efficient.

Sustainable production – can smaller and medium-sized companies also join in?

Care must indeed be taken to include small and medium-sized enterprises (SMEs) that may not have a large IT department of their own. The situation at present is this: The technology is available; it can be downloaded as open source. But at the moment, it is more the large companies that benefit from it, as they also have the necessary technical know-how. However, when we talk to smaller companies, we realize that they are also very interested in these technologies. That is why we are working on making them available to everyone.

How can we pave the way for smaller companies, too?

We are, for example, developing applications that, as I said earlier, work out of the box. This means that they no longer need to be programmed, but are easy to configure for specific use cases – usually with a text file. Text files can also be configured by smaller companies. A graphical configuration, on the other hand, takes a lot of effort to develop, but a text file is feasible even for SMEs. They are already technically adept, but do not have the time to deal with large open-source software.

Our strategy is to provide as many applications as possible – including CO₂-optimized manufacturing – as such “pre-packaged” applications.

Can companies – regardless of their size – avoid the issue of “sustainability”?

No company will be able to avoid it, simply because legislators will react. That is, CO₂ emissions will end up being subject to a price. This price will rise. More cost-effective production conditions and lower CO₂ emissions will become a competitive advantage. With the digital product passport in the EU, there would, of course, also be a mechanism for directly pricing the carbon footprint of a product.

And why is the digital product passport so important, especially in the EU?

It is so important because products are also imported from outside the EU and we naturally have to ensure fair competitive conditions. I also believe that customers are becoming more aware of the carbon footprint. For example, if you could see on the label of a sweater that sweater A costs maybe €8 and was produced with a high carbon footprint, while another sweater B costing €10 was produced with a low carbon footprint, then in the future this will be a reason for more and more customers to rather choose the environmentally friendly product.

And one final question: Can sustainability be achieved without digitalization?

In my opinion, sustainability can be achieved without digitalization, but it works better with digitalization. You have more options and can use digitalization to establish completely new business models that not only cause costs, but also generate new sources of income. In other words, sustainability should not only be seen as a cost factor, but also as an opportunity.

**MORGEN
DENKER**
Podcast

Listen to the detailed interview (in German) here!



Your contact

Dr. Thomas Kuhn
Division Manager
Embedded Systems
Phone +49 631 6800-2177
thomas.kuhn@iese.fraunhofer.de

The potential of Digital Twins for sustainable Smart Cities

Smart Cities and sustainability are inextricably linked. Smart technologies in cities can make a crucial contribution to conserving valuable resources and thus overcoming the energy crisis. The Digital Twin, in particular, is seen as having great potential in this context. In industry, the added value of Digital Twins has already been recognized; now cities are also developing digital images of the diverse processes in buildings, streets, waterways, and power grids. The IESE experts are convinced that the development of Digital Twins for smart cities and smart regions is only just beginning.

Traditionally, a Digital Twin comes with a data platform that collects all data from the city – whether sensor data, mobility data, or environmental data. Based on this, various scenarios can be simulated to help city administrations make decisions. For example, the following questions can be asked: How high is the expected energy consumption of a district or a municipality next summer, assuming that it will be another hot summer as in recent years? Will the sewage treatment plants still function if rainfall is correspondingly high or low? Flexible measures that influence the environment in terms of sustainable urban development can be optimized through constant digital monitoring in the Digital Twin.

However, the Digital Twin not only offers great potential for cities, but also for rural areas. For example, mapping decentralized energy generation could be relevant for a rural area, as

significantly more photovoltaic systems in private households generate energy here compared to large cities. In a city, on the other hand, an integrated energy concept in which e-mobility plays a key role could be mapped. This means that although the use cases are similar, they may differ in their characteristics and implementation between urban and rural areas.

Steffen Hess, Division Manager Digital Innovation & Smart City, provides further insights into sustainable urban development in the podcast “CEO₂-neutral”:





Climate-neutral urban district

Pfaff site as a lighthouse project for future-oriented living

On the site of the former Pfaff sewing machine factory, Fraunhofer IESE – together with the City of Kaiserslautern and six other project partners – is working on the development of a CO₂-neutral residential, commercial, and technology district.

Energy-efficient living and working on the former Pfaff site

On the site where the Pfaff company produced sewing machines for 150 years, healthcare and technology companies, employees, and residents are set to find an attractive and sustainable working and living environment close to the city center in the future.

The climate-neutral district development on the Pfaff site is being supported by the research project “EnStadt: Pfaff”, which has been developing future-oriented concepts for the

district since 2017. The aim of the project is to use the example of the Pfaff district in Kaiserslautern to demonstrate how a climate-neutral district can be achieved with a high level of urban development quality. One focus is on investigating holistic energy supply options in terms of electricity, heating, hot water, cooling, and electromobility, taking into account local resources.

The project is funded by the German Federal Ministry for Economic Affairs and Climate Protection (BMWK) and the German Federal Ministry of Education and Research (BMBF).

Digitalization as an “enabler” of sustainable solutions

In order to show how the energy transition can succeed in cities and municipalities, Fraunhofer IESE is contributing concepts and solutions relating to digitalization. This includes, among other things, the development of a sustainable mobility concept that shows how the Pfaff district can be developed into a smart, multimodal eco- and electromobility location with few cars. This includes charging stations for electric vehicles, e-bikes with parking spaces, 20 km/h speed zones, and reduced parking space concepts. Such modern mobility concepts are also taken up in the “MiniLatern” game, in which the district can be designed virtually in a playful way.

The linchpin is to be a Digital Ecosystem. In the project, Fraunhofer IESE is responsible for setting up this district ecosystem. As construction progress on the Pfaff site was delayed, the project team developed a “mock platform” to test the digital solutions. This development platform offers the opportunity to test new digital services and prototypes in a simplified technical environment using various simulations. Examples include a Smart Home environment, smart light poles, and flexible traffic concepts. The development environment was also used at the last PFAFF-HACKS, where further solution ideas for the Pfaff district were developed in the form of hackathons.

Thanks to “EnStadt: Pfaff”, the current industrial wasteland is becoming a nationwide lighthouse project for integrated, future-oriented planning and implementation of climate-neutral districts. And the environmentally friendly solutions from Kaiserslautern can be transferred to other cities.



Click here for the mobility game “MiniLatern”:

www.minilautern.de



Further information on digital solutions can be found on the Pfaff map:

www.pfaff-landkarte.de

Project ODH@Jülich: Energy portal for urban districts

In the project “Open District Hub at Jülich” (ODH@Jülich), Fraunhofer IESE is collaborating with other project partners until the end of 2023 to develop a Digital Ecosystem for energy supply in urban districts. The project is funded by the German Federal Ministry of Education and Research (BMBF).

The energy transition is linking the infrastructures of the electricity and heating sectors ever more closely. For this sector linking in buildings and districts to be successful, state-of-the-art tools are needed for planning and operating the corresponding technical systems. These tools are being developed in the “ODH@Jülich” project. With this, the project partners are laying the foundation for cross-sector energy supply in urban districts.

At the center of the project is the web-based application platform developed by Fraunhofer IESE, which primarily serves to provide access to a Digital Ecosystem for district energy management. This energy portal provides a quick overview of the Digital Ecosystem, the Digital Twins of the district used in it, with its buildings and facilities, and the energy measures that contribute to the climate neutrality of urban districts.

The energy portal is intended to offer solution providers a platform for the integration of their services for various end users. These include housing associations, municipalities, and municipal utility companies as well as grid operators and other district planners. With the help of apps, these platform users can access the Digital Twins of districts and communicate with other services. This allows them to benefit from existing solutions in the Digital Ecosystem.



Further information:

www.opendistricthub.de/odhjuelich/





DynaSoS – the future of networked systems is dynamic and sustainable

In the publicly funded research project “DynaSoS”, Fraunhofer IESE carried out research on new software and systems engineering approaches for dynamic systems. The aim was to do justice to the complex interactions of the digitalized world, particularly with regard to technology, people, and the environment. The project was funded by the German Federal Ministry of Education and Research (BMBF) until January 2023.

In an increasingly networked world, a lot of information has to be processed quickly in order to control the “things” in the “Internet of Things” in a situation-specific manner. Such control tasks exceed human capabilities and are a driver for the introduction of Artificial Intelligence and Autonomous Systems. Moreover, the interactions of autonomous decisions will increase: The decisions regarding the material flow of a driverless transport system, for example, are related to the decisions made in the changeable factory – and these in turn to the decisions of a partially automated supply chain management system.

Such dynamic, semi-autonomous systems-of-systems, from which the project name DynaSoS is derived, have enormous potential for solving the conflict between pressing ecological, social, and economic challenges. However, these systems-of-systems require new systems and software engineering approaches in order to guarantee dependable and safe operation despite the high system complexity. Such approaches must not only be able to deal with the complex interaction of the technical subsystems, but also with the interactions between technology, people, and the environment. For example, in a Smart City there are complex relationships between the technology and the city’s inhabitants, or in Smart Farming between the technology and the ecosystem.

Some concrete use cases illustrate the topicality of the research project for business and society:

- **Smart Mobility:**
“Smart delivery zones as a dynamic system-of-systems”
- **Smart Farming:**
“Dynamic and networked: How digital will plant protection be in the future?”
- **Smart Manufacturing:**
“Dynamically reconfigurable production using dynamic systems-of-systems”
- **Smart City & Smart Regions:**
“Sustainability in urban areas through dynamic systems-of-systems”



Further information:
www.dynasos.de/

Click here for the video



Learn more about the project DynaSoS:



Your contact

Dr. Rasmus Adler
Program Manager
Research Program
“Autonomous Systems”
Phone +49 631 6800-2172
rasmus.adler@iese.fraunhofer.de



MobiGrid – Digital Twins in power supply

To achieve the climate protection goals, the energy requirements for private and public mobility must increasingly be covered by renewable energy sources. It is therefore to be expected that the power distribution grids will experience considerable strain not only because of decentralized generation plants, but also because of the charging behavior of electric vehicles. Research into the effects of increasing electromobility on the distribution grids and how to counteract them with the help of Digital Twins is the focus of the project “MobiGrid”, in which Fraunhofer IESE is involved. It is being funded by the German Federal Ministry for Economic Affairs and Climate Protection (BMWK) until April 2024.

Electric vehicles and the increasing feed-in of electrical energy from decentralized generation plants pose new challenges for distribution grid operators: Increasing battery capacities of electric vehicles, paired with the desire for short charging times, will continue to drive up the demand load in the distribution grids even more in the future. These challenges must increasingly be met by Smart Grids, in which flexibility is one building block for ensuring system and supply security.

In MobiGrid, the project partners e-netz Südhessen AG, the Institute for Electrical Energy Systems of htw saar, and Fraunhofer IESE are investigating how decentralized flexibilities can be used in a targeted manner in the electricity grid and how they can decelerate the impending grid expansion. The basis are flexibility schedules created with the help of Digital Twins of the grid infrastructure. For this purpose, the open-source middleware Eclipse BaSyx developed by IESE for Industry 4.0 applications is transferred to the energy industry. Digital Twins not only represent physical objects such as mechanical components, but also non-physical objects such as processes and services. In the field of power grids, these are often simulation models that suitably replicate the real world in the present and in the future in the Digital Twin.

Click here for
the video



Learn more about the
project MobiGrid:



Your contact

Denis Uecker
Denis Uecker
Project Manager
Phone +49 631 6800-2170
denis.uecker@
iese.fraunhofer.de

Ecological features of the institute building

The fact that Fraunhofer IESE has been practicing sustainability and resource conservation for many years already is demonstrated by the design of the institute building into which it moved in 2005. Even back then, special attention was paid to a sustainable energy concept. Fresh air is blown into the building via underground ventilation ducts. These geothermal collectors allow the incoming air to be cooled by up to 4 K in summer; in winter, the air is heated accordingly.

The building is mainly heated by combined heat and power units (CHP), which were designed in an energy network with absorption chillers. A district heating transfer station is available to cover peak loads. During the heating period, the atriums are heated, on the one hand, by the scheduled overflow of room air from the adjacent office blocks and, on the other hand, by the waste heat generated by the data centers. At Fraunhofer IESE, more than a third of the electricity required is generated by the CHP plant. In addition, the roof areas of the institute building have photovoltaic systems and are planted extensively with greenery.

Fraunhofer Alliance for sustainable energy supply

The vision of the Fraunhofer Energy Alliance is to make Germany and Europe the innovation leader in the transition to a sustainable energy system. With their research and development work, member institutes such as Fraunhofer IESE are shaping the transformation to an economical, environmentally compatible, safe, and socially accepted energy supply for electricity, heat, and mobility.

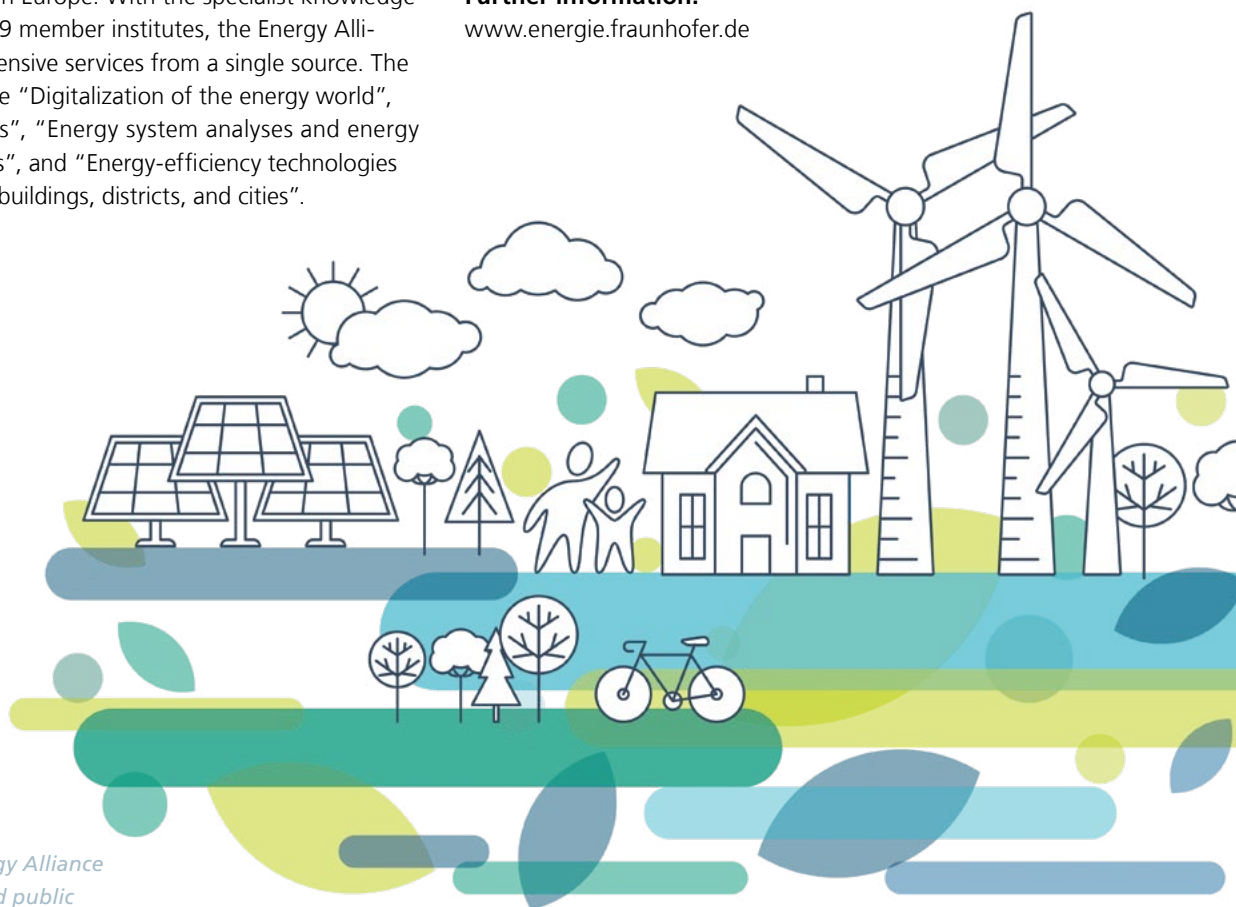
In order to be able to develop particularly investment-safe, future-oriented, and competitive products for its customers, the Fraunhofer-Gesellschaft has bundled its competencies in the field of energy technology and the energy industry. More than 2,000 employees pool their expert knowledge in the Fraunhofer Energy Alliance, one of the largest energy research institutions in Europe. With the specialist knowledge and expertise of its 19 member institutes, the Energy Alliance offers comprehensive services from a single source. The research fields include "Digitalization of the energy world", "Renewable energies", "Energy system analyses and energy storage technologies", and "Energy-efficiency technologies and components for buildings, districts, and cities".

Fraunhofer IESE has been a member of the Energy Alliance since the beginning of 2021 and is particularly involved in the research field "Digitalization of the energy world". Here, the experts contribute their competencies in software architectures, the design of Digital Ecosystems, data usage control, safety, and security.

The institutes' work covers the entire value creation process from new ideas and concepts to the development of new materials, processes, and systems, and all the way to quality assurance and support for market implementation. In this way, the Alliance supports its customers from industry as well as from public administrations in the successful transformation of the energy system.

Further information:

www.energie.fraunhofer.de



The Fraunhofer Energy Alliance supports industry and public authorities in implementing a sustainable energy supply.



More than just sandstone: Sustainable use of regional resources at the Fraunhofer Summer Camp 2022

Tradition meets high-tech at the Summer Camp 2022.

Kaiserslautern is a rather tranquil city in Rhineland-Palatinate, tucked away in the Palatine Forest. Not all of the participants of the Summer Camp were familiar with the location before they arrived. Young design students from Weimar, Berlin, Stuttgart, and many other cities embarked on a little adventure when they applied for a place at the Summer Camp. And independent of the location of the camp – which so far has always provided special and unique impressions – the Summer Camp beckons with an exciting challenge: Away from normal workplaces, students spend just under a week tinkering and working on ideas in motley teams.

With the aim of building a bridge between science, art, and design while giving young creative people an insight into how visions are brought to life at Fraunhofer, the first Summer Camp started in 2019 at Bergheider See, almost 80 km north of Dresden and its host institute, the Fraunhofer Institute for Transportation and Infrastructure Systems IVI. Fraunhofer IESE was also involved back then – our ecosystem designer Claudia Nass-Bauer supervised the winning team as a Fraunhofer researcher. After the obligatory break due to the Covid-19 pandemic, the next Summer Camp followed in 2021 on the Waischenfeld Research Campus of the Fraunhofer Institute for Integrated Circuits IIS. For 2022, the institutes IESE and ITWM from Kaiserslautern were chosen to host the third camp.

An impressive setting and exciting new mental approaches

The main venue for the creative week was the Picard natural sandstone quarry in the nearby picturesque Schweinstal valley. An impressive location, which did present its own technical challenges, but fascinated all participants and formed a great basis for the Summer Camp thanks to the successful and open cooperation with the quarry operators. Under the motto “Future Living – tradition meets high-tech”, the three teams of students and Fraunhofer researchers posed themselves the question: “How can the innovative use of regional resources provide solutions for urban transformation processes?”

This allowed them to explore both the material “sandstone” and the urban planning developments in Kaiserslautern. While two of the three teams experimented primarily with sandstone as a material and devised new sustainable uses or drew on old building techniques, the urban planners and designers of the team “LEBEN” (Living) from Fraunhofer IESE worked on innovative usage concepts for the revitalized, climate-neutral Pfaff site. With digital solutions, new community formats ensure that the residents and users of the district will experience the living and working spaces on the Pfaff site together in a sustainable way. With the “Container app”, the team “LEBEN” succeeded in creating a platform that provides a wide range of



(recreational) activities in containers for the community of the Pfaff district and thus promotes communication and exchange in small and larger groups. With their idea, the IESE crew scored second place in the competition.

The winner was the team "WERTSCHÖPFEN" (Creating Value), who studied the properties of sandstone very intensively and devised a valuable sustainable solution from the waste product of the sandstone sand using a casting process: With "MiWa", they created a minimally invasive water reservoir for urban spaces that can gradually release water in long periods of drought as if through a root system and can thus also keep deep layers of soil moist for a longer time.

Summary of an extraordinary week

From the perspective of our supervising Fraunhofer colleagues, the week was a successful excursion from the everyday working life at IESE. Yet the students were quickly able to understand that "normal" work at Fraunhofer is indeed practiced in an agile and creative way. A win-win situation for both sides. Researchers and students were able to support each other in the best possible way with their previous knowledge and personal expertise and together present convincing results in a very short time. The conclusion for everyone involved: Although it was (rock) hard work (with some very short nights), it was a lot of fun and produced remarkable results.

During this week, the host institutes were able to show how well creativity and computer science, respectively mathematics, go together – and of course, that the best ideas emerge from interdisciplinary teams.

With exciting questions about the future, the Fraunhofer Summer Camp 2022 once again attracted many innovative minds.



There was plenty of room for creative ideas in the Picard natural sandstone quarry.

Further information:



Review of Summer Camp 2022 and film impressions:

www.art-design.fraunhofer.de/de/programme/summercamp/summercamp-2022.html



More about the Fraunhofer Network Science – Art – Design:

www.art-design.fraunhofer.de/de/netzwerk.html

IESE on Trend







Digital diagnostics to strengthen rural areas

Fraunhofer Center for Digital Diagnostics ZDD® is developing telemedicine solutions

With increasing urbanization, modern and cost-efficient healthcare in rural areas requires needs-based solutions that are supported or even made possible in the first place by decentralized and digitally integrated diagnostics. This has been impressively demonstrated not least by the Covid-19 pandemic. This is where the Fraunhofer Center for Digital Diagnostics ZDD® comes in. Founded in the Potsdam Science Park in 2021, with the involvement of Fraunhofer IESE, it focuses on the targeted development of digital diagnostics solutions.

In the Brandenburg model region, new solutions and application fields for digital diagnostics are being researched and developed in order to improve patient care. A particular focus is on the development of telemedicine solutions in order to be able to ensure optimal medical-diagnostic care in the rural state of Brandenburg. Similar to the Fraunhofer IESE project "Digital Villages", which has been tested in Rhineland-Palatinate, the findings and solutions of the Fraunhofer ZDD® shall then be transferred nationwide to the other federal states and used there as well.

For the development of digital diagnostics solutions, the effective combination of competencies for technology development, digitalization, and medicine is critical to success. Accordingly, the center bundles the competencies of three core institutes: the Fraunhofer Institute for Cell Therapy and Immunology, Branch Bioanalytics and Bioprocesses IZI-BB (technology development), the Fraunhofer Institute for Cell Therapy and Immunology IZI (medical needs), and the Fraunhofer Institute for Experimental Software Engineering IESE (digitalization).

The following projects are currently being funded with Fraunhofer-internal funds for a period of three years until 2025:



"KISMADI" – intelligent, needs-oriented wound care for chronically ill patients

Nowadays, poorly healing wounds, especially the "diabetic foot", are generally treated in more or less the same way. Hardly any differentiation is made between the specific germs, and practically no attention is paid to individual metabolism-related wound-healing processes. Here, an optimized wound management approach that is decentralized and integrated into the clinics represents a major step forward in efficient and targeted treatment.

An individual, digitally available diagnosis of wounds and the resulting treatment strategy promises faster healing success

and an improvement of patient well-being. The technology and data platform KISMADI addresses these challenges and aims to offer a holistic approach to optimizing wound care both in the hospital and at home. A smart wound dressing or cuff uses integrated sensors to record the condition of the wound over the relevant treatment period. The digitally collected parameters are entered into the medical management systems automatically or via digital readout (on a smartphone) through an appropriate workflow and are then made available to medical staff immediately for diagnosis or therapy monitoring.

Project partners: Fraunhofer FIT, Fraunhofer ISC, Fraunhofer IZI-BB, Fraunhofer IZM



"Neighborhood Diagnostics" – patient-oriented diagnostics rethought for rural areas

The shortage of doctors in rural areas is a serious problem in our society. Quick and regular medical care of patients with acute or chronic illnesses is therefore often associated with great effort for those affected. In the worst case, health problems are not detected early enough or the spread of infectious diseases is not contained in time. Telemedical digital care for these patients is often hampered by the non-availability of the diagnostics required for medical decision-making.

In the project Neighborhood Diagnostics, these challenges are addressed with a Digital Ecosystem. At the core of the Digital Ecosystem is the combination of wearables, smart medical devices, and healthcare stations for recording potentially relevant health data such as heart rate, gait stability, or fall incidents. The aim is to use this data to diagnose illnesses and thus request either a doctor's appointment or laboratory diagnostics for the patients. In this way, clarity can be provided quickly and easily about clinical patterns and the progression of infectious diseases. The project is also developing a mobile, fully automated healthcare station that will enable professional medical diagnostics in sparsely populated regions in a cost-efficient manner. The healthcare station will automate the entire process of taking samples, preparing samples, and carrying out diagnostic tests on the sample material.

Triggered by medical staff – e.g., after a telephone consultation – the patient visits a healthcare station at any time. There, samples are taken automatically and analyzed for the relevant diagnostic parameters. The results are made available digitally to the patient and to medical staff so that better treatment decisions can be made.

Project partners: Fraunhofer IESE, Fraunhofer IFF, Fraunhofer IZI, Fraunhofer IZI-BB



More information
on the project:
www.zdd.fraunhofer.de



“RespiVir” – Next-generation virus tests for needs-based diagnosis and outbreak containment

The Covid-19 pandemic has made it clear that comprehensive pathogen testing in combination with infection control is an important tool for containing disease outbreaks. During the pandemic, these processes were and are still being used to regulate the restrictions for people who have tested positive (contact restrictions, quarantine, etc.). However, conventional rapid tests only detect pathogen components, but do not provide any information about the presence of infectious pathogens and thus about the actual risk of transmission.

Tests for the detection of infectious pathogens could significantly reduce the restrictions for those affected and thus also minimize the economic damage caused by outbreaks and pandemics. Current detection methods for infectious pathogens are based on complex cell cultures and are unsuitable for combating pandemics.

The aim of the project RespiVir is to develop rapid and widely applicable detection methods for infectious virus particles that can contribute to a more needs-based and economically more viable pandemic response in future pandemic situations. Connecting such methods to a digital infrastructure is also intended to facilitate the assessment of a pandemic situation and the implementation of countermeasures in real time.

Project partners: Fraunhofer IESE, Fraunhofer IZI, Fraunhofer IZI-BB



“SODIAPH” – Analysis and optimization of Digital Ecosystems in patient care

Digital fingerprints of patients along settled MD and clinical patient processes (so-called digital patient processes) are not recorded systematically and comprehensively – especially in rural areas – but are the basis of future digitalization strategies. The goal of the project SODIAPH is to identify and classify digital data discontinuities and digital data continuity in recorded patient processes. The variety of software solutions in care facilities is high and their interconnections are very complex and individual. In some cases, up to two dozen different software tools are used per patient process to document the data for admission, transfer, diagnostics, therapy, and discharge. Interfaces between the software tools are often missing. Digital communication between settled MD and clinical care structures is practically non-existent.

The findings on the digital fingerprint of patients will enable an improvement of individual medicine in the area of settled MD and clinical care structures. At the same time, the digital networking of electronic patient files, including all diagnostic findings and decision-making processes, will be enhanced, which in turn will sustainably optimize patient care, particularly in rural areas.

Project partners: Fraunhofer IESE, Fraunhofer IPA, Fraunhofer IZI

IESE strengthens activities in the area of “Digital Healthcare”

Newly founded department focuses on applications and concrete offerings

In addition to the Research Program “Digital Healthcare” headed by Rolf van Lengen, projects in the fields of “medicine”, “emergency medical services”, and “pharmacy” have been realized for six years. Since August 2022, Fraunhofer IESE has strengthened its healthcare business by adding the new department “Digital Health Engineering” (DHE). The team of the new department currently consists of six employees and is headed by Dr. rer. nat. Theresa Ahrens, who holds a doctorate in molecular medicine. The research focus of the young DHE department will be on research into Digital Patient Twins, the automation of processes in healthcare, as well as the topics of “data literacy” and “trustworthy AI” with a focus on “fairness- and transparency management”. With this, the interdisciplinary team aims to tackle the comprehensive challenges in the healthcare sector.

The Research Program and the department complement each other perfectly in their collaboration. In the Research Program, the IESE experts primarily conduct publicly funded research projects on explorative healthcare topics. This also promotes cross-departmental competence building on Digital Healthcare at Fraunhofer IESE. The DHE department, on the other hand, is developing a concrete product and service portfolio for industry on the basis of new R&D projects that contribute to IESE’s “big picture”. In this context, the experience gained from both the DHE projects and the projects in the Research Program plays a decisive role. After all, the aim of IESE is to support all players in the healthcare sector on their path to digital transformation with the help of software-based solutions – and thereby improve patient care in the long term.



Contact person

Dr. rer. nat. Theresa Ahrens
 Department Head
 Digital Health Engineering
 Phone +49 151 58 96 74 18
theresa.ahrens@iese.fraunhofer.de

Future plans developed for the healthcare sector

In order to professionally develop the future orientation of Fraunhofer IESE with regard to Digital Healthcare, a multi-stage, strategic Foresight process took place. In the process initiated by the Fraunhofer Institutes IESE and ISI, an interdisciplinary group of participants developed alternative visions of the future for key topics in healthcare and discussed possible impacts and options for action.

In March 2023, experts from various areas of the healthcare industry met with researchers from Fraunhofer IESE and Fraunhofer ISI to discuss alternative development options for key future topics in the field of Digital Healthcare.

Using a scenario approach, the participants first assessed individual topics in terms of their impact and uncertainty. For topics with high scores on both scales – including evidence-based medicine, Digital Patient Twins, and medical care in rural areas – the participants then worked in small groups to develop alternative assumptions for the future and presented these to the plenary session. In a subsequent internal workshop, the identified trends were compiled into possible future scenarios for the identification of key technological developments. The results of the workshop will be incorporated, among other things, into the institute’s strategic orientation in this important field of research.

Industry 4.0 optimizes pharma production

Fraunhofer lighthouse project “RNAuto” sets milestones on the way to automated production processes

Contact person

Rolf van Lengen
Program Manager
Research Program “Digital Healthcare”
Phone +49 631 6800-2103
rolf.van.lengen@iese.fraunhofer.de

More info on the project:

s.fhg.de/RNAuto



Innovative mRNA vaccines as well as gene and cell therapeutics are used to treat infectious diseases, hereditary diseases, and even cancer. In the future, it should be possible to make them available to an even larger number of patients – and at an affordable price at that. This is to be enabled by automated production technologies in the Fraunhofer lighthouse project RNAuto. Until the end of 2025, the consortium will be bundling interdisciplinary competencies from medicine, biology, and engineering to implement an automated production process in the style of Industry 4.0. Fraunhofer IESE is responsible for process development and digitalization. But what is the current status of this research project?

In the project RNAuto, process automation plays a key role in sustainable and economic healthcare, ensuring not only product quality, but also process scaling and product availability. A particular focus is on scalability up to industrial scale, so that both small, individual quantities and large quantities of active ingredients can be produced in an automated process.

The subproject that is being led by Fraunhofer IESE comprises the process development and digitalization of the automated production of mRNA active ingredients on a laboratory scale (up to 20 ml). In cooperation with the Fraunhofer Institutes ITEM, IMM, IPT, and IZI, an automated screening facility for encapsulating mRNA (“messenger RNA”) into nanotransporters with digital process control and data-driven quality control is being developed for this purpose. The quality control includes, for example, the parameters particle size, temperature, or flow rate of the mRNA and is based on the two aspects of product quality and process quality.

The Asset Administration Shell as a new element in the pharmaceutical industry

The screening facility has a modular design so that the various components are replaceable and can be individually combined with each other – depending on the specific requirements of the product. The development of the facility is divided into several self-contained groups of components. The advantage of this approach is that the hardware and software of each component can be developed and tested in parallel.

The project has already produced a hardware design of the screening facility with the necessary sensors. Fraunhofer IPT’s process control software COPE and Fraunhofer IESE’s Industry 4.0 middleware Eclipse BaSyx are used for the digitalization of the facility. The Asset Administration Shell of BaSyx is used as a Digital Twin to simplify a standardized industry-wide interface for communication with devices and other assets. In addition, the open-source middleware represents



Fraunhofer researchers want to make innovative mRNA vaccines for the treatment of cancer affordable.

a reference implementation of the standard of the Plattform Industrie 4.0 and offers ready-to-use software packages. The connection between the control system and the middleware allows all assets that are equipped with an Asset Administration Shell to be used for the process – without the need to create additional adapters. This combination is a completely new approach for the pharmaceutical industry.

In concrete terms, the Digital Twin in the RNAuto project can be thought of as a digital file in which all parameters relevant for quality assurance are collected. In this way, it is possible, on the one hand, to easily compile information for quality reports and, on the other hand, evaluate data in order to adapt or further optimize the manufacturing process.

What happens next in RNAuto?

As soon as the facility is operational – in terms of hardware and software –, an mRNA-based active ingredient for prophylaxis against the viral disease West Nile Fever will be produced in an automated process as part of the subsequent validation and will be tested for its effectiveness in mouse experiments by Fraunhofer IZI. The mice will receive the produced vaccine and will then be infected with the actual virus. This will allow determining whether the vaccine is effective and whether the mice are resistant to the virus. To optimize the active ingredient, the manufacturing parameters can be varied in another run and the effects on the efficacy of the sample can be checked.

AI as a beacon of hope

The project "SATURN" supports the diagnosis of rare diseases

Although we call them rare diseases, they affect about four million people in Germany alone. For patients, this means having to overcome many obstacles – even including, for example, the diagnosis of their disease. In the project SATURN (Smart Physicians' Portal for Patients with Unclear Disease), Fraunhofer IESE is investigating how Artificial Intelligence (AI) can be used to make traceable and transparent tentative diagnoses for rare diseases in light of the small amounts of data. The project is being funded by the German Federal Ministry of Health (BMG) until 2024.

Challenges in diagnostics and treatment

In Europe, rare diseases are defined as diseases with an incidence of 1:2,000 or less. Although there are so many and fundamentally different rare diseases, they still have one thing in common: They are mostly genetic diseases that are chronic and severe. On average, it takes five years until a rare disease is diagnosed correctly. This is frequently accompanied by misdiagnoses and often by inadequate medication. In addition, there is also the problem that there are still no causal therapies for many rare diseases, since both research into the diseases and the development of novel drugs in this area are difficult. However, projects such as SATURN can support the diagnosis and the appropriate further treatment by specialists. With the help of Artificial Intelligence and based on clinical case data and expert knowledge, a traceable and transparent tentative diagnosis is provided. SATURN also supports the appropriate referral to medical experts.

New opportunities thanks to AI

As a matter of principle, AI offers opportunities to reduce costs and improve the treatment of patients and the day-to-day work of medical professionals through the (partial) automation of processes that were previously labor-intensive. For example, AI is often used to analyze radiological images. In order to exploit the full potential of AI, not only large, but also high-quality data sets are required, which are unfortunately rare in clinical practice. Due to their rare occurrence, there is a lack of data on rare diseases, which is also more challenging to anonymize because it is easier to trace.

In the project SATURN, Fraunhofer IESE is therefore investigating different approaches for predicting the diagnosis of rare diseases from structured and unstructured data. The project is being realized together with the University Hospital Frankfurt, the Goethe University Frankfurt, and the Technical University of Dresden. Real and anonymized clinical case data from the university hospitals is being used, taking into account data and patient protection.

In this project, Fraunhofer IESE is working on various AI modules. The researchers are developing a rule-based system based on expert knowledge. Expert knowledge is captured in the form of diagnosis rules and extracted both manually and using AI approaches (such as Natural Language Processing) from medical guidelines for the healthcare fields of endocrinology, pulmonology, and gastroenterology as part of the project.

Podcast tip

AI – the new god in white?

More details on the project SATURN can be found in the InnoVisions podcast of the Fraunhofer ICT Group.



At the same time, the project team is working on the further development and application of interview techniques with the aim of obtaining this expert knowledge directly from medical specialists. Here, the focus is on the conceptual design and implementation of an AI module for diagnostic support using Machine Learning. The project team uses anonymized data from diagnosed disease-specific cases to train models using Machine Learning algorithms, which then serve as the basis for the AI modules.

The low availability of data for rare diseases poses a number of obstacles for the development of AI. However, state-of-the-art Machine Learning methods allow us to view the future possibilities of care optimistically.

Fraunhofer IESE is committed to contributing to faster and easier diagnosis of rare diseases, both in research and in practice. This should enable patients to receive more appropriate treatment earlier and more effectively in the future.

In the project SATURN, Fraunhofer IESE is working on supporting doctors with traceable, AI-based tentative diagnoses.

Contact person

Dr. Andreas Jedlitschka
 Department Head
 Data Science
 Phone +49 631 6800-2260
 andreas.jedlitschka@
 iese.fraunhofer.de



More info on the project:

[www.saturn-
projekt.de](http://www.saturn-projekt.de)



The digital economy is booming

Through digital transformation to digital business



In the interview: Nils Brand, Business Area Manager “Digital Innovation & Smart City” at Fraunhofer IESE

In digital business, digital business models are increasingly replacing the traditional core business. Fraunhofer IESE combines software engineering and research to support companies in this process – from consulting to technical support. We asked our Business Area Manager Nils Brand how the digital transformation to digital business can succeed.

What is digital business?

When we think of digital business, we often think of pure software companies, but this does not necessarily have to be the case. In principle, it is about generating money using digital technologies or creating value by combining hardware and software. This means that traditional companies can also combine their physical products or services with software. Any form of organization from any industry can become a digital business.

The aim is to create added value for customers – in the form of new products, process, or services.

And added value is important at this point because people are generally more willing to invest money if they receive a special customer experience in return.

How can we imagine the digital transformation using a concrete example?

Let’s take a look at the music industry: As a starting point, let’s think back to the 1950s to 1980s, when the music industry made a living from selling records. The buying process started in a physical store. There, people listened to records to see whether they liked them and then bought them. In the mid-1980s, the CD was about to be launched on the market, paving the way for “digitization”. Technology transformed media and data into digital products – from the analog record to the digital CD. This meant that although the product “music” was still tied to a physical medium, it was stored and read digitally. The buying process did not change.

At the beginning of the 2000s, the music industry underwent the next change: digitalization. This also changed the buying process. The basis for this was the MP3 format developed by Fraunhofer. Music could now be played on computers or other MP3-capable devices. At the same time, the Internet became established as well, so the buying process became purely digital. The 2010s then saw the latest digital change in the music industry to date – the digital transformation via services such as Spotify.



You can hate it or love it, but you cannot ignore digital business.«

Listen to the detailed interview (in German) here!

MORGEN DENKER
Podcast



What was so special that we are now talking of a digital transformation?

Technologies and digital business models replaced the previous buying process. From the user's perspective, this created added value that changed an entire industry, as impressively demonstrated by Spotify. For a fixed monthly fee, you buy the right to listen to fee-based music. This means that owning the music is no longer necessary. Further added value, such as the analysis of listening behavior for tailor-made music suggestions, is included. This prime example of a digital business illustrates that digital transformation can lead to the creation of a new business model.

What does digital business have to do with Digital Ecosystems?

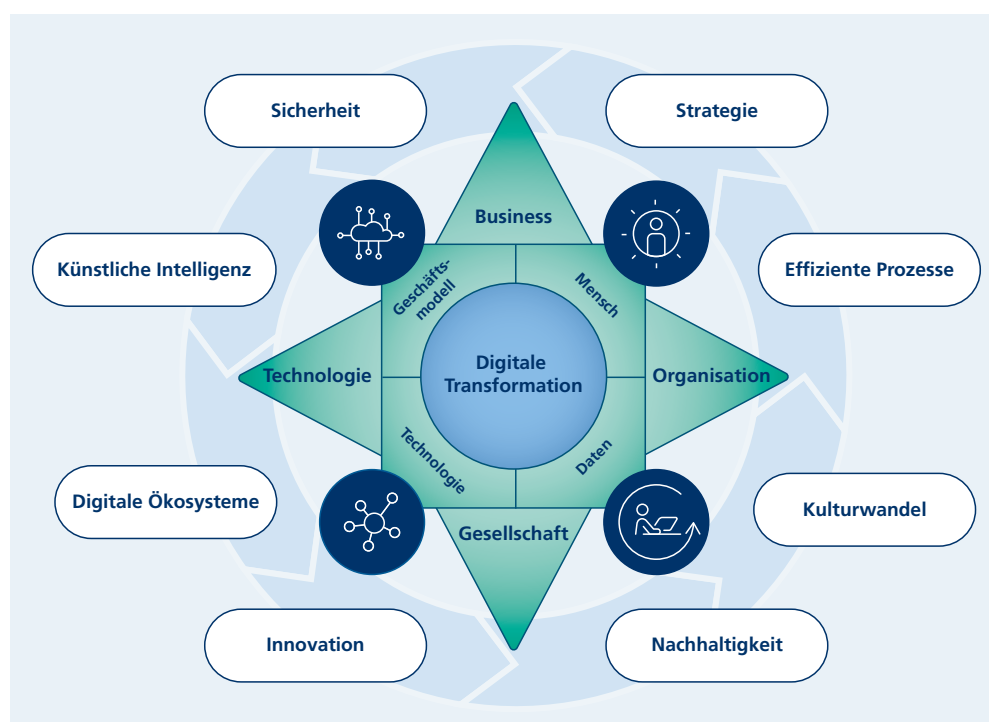
Digital Ecosystems often come into play in connection with digital business models – as in the case of Spotify. Generally speaking, a Digital Ecosystem is a socio-technical system with a digital platform at its center. Providers and consumers cooperate with each other via this platform. Although the participants are independent of each other, they expect to gain a mutual advantage from participating in this Digital Ecosystem. The interactions via the platform lead to positive networking and synergy effects.

Will only digital businesses be competitive in the future?

There is clearly an opportunity for companies to diversify their portfolio with the help of digital technologies and thereby gain a competitive edge over their competitors. Ideally, new attractions for customers will also lead to an increase in sales. And if we think a little more broadly than just within individual companies, an enormous amount of knowledge will accumulate, which will help to boost the German-European economy.

How does Fraunhofer IESE support companies on their way to a digital business?

In our initial meetings with companies, we sound out the current state of affairs: How is the business model structured and what starting points are there for digitalization projects? We offer creativity workshops to help companies come up with an idea in the first place. In other words, we provide support from the very early stages of such projects. Companies often do not know exactly where to start. We help them overcome the initial hurdles, develop a roadmap – a strategy – and support them all the way to the concrete technical implementation of their digital business.



Digital transformation – the iterative path to digital business!



Contact person

Nils Brand
Business Area Manager
Digital Innovation
& Smart City
Phone +49 631 6800-2220
nils.brand@
iese.fraunhofer.de

Smart start for Betzdorf-Gebhardshain

The project “Digital Villages” has set the right course in this association of municipalities



Sarah Brühl from Betzdorf-Gebhardshain has been involved in the project “Digital Villages” right from the start.

In the interview: Sarah Brühl from the Betzdorf-Gebhardshain association of municipalities, project coordinator of the network Digital Villages Rhineland-Palatinate

In summer 2015, Fraunhofer IESE’s flagship project “Digital Villages” (“Digitale Dörfer” in German) was launched. The aim was to examine the challenges of life in rural areas in relation to digitalization. Since that time, many concepts and digital solutions were developed in the project that bring citizens closer together and strengthen networking with the municipal administration. One of the first test municipalities was Betzdorf-Gebhardshain, an association of municipalities in northern Rhineland-Palatinate. Sarah Brühl was enthusiastically involved on behalf of the association of municipalities right from the start.

In the interview, she reports on how the project has set the course for a digital village.

How did your association of municipalities end up with Fraunhofer IESE?

At the time, Fraunhofer IESE presented the project “Digital Villages” to the state government. There were already many Smart City initiatives, but an initiative for “Smart Rural Areas” was something new. And then there was a competition in which all municipalities

in Rhineland-Palatinate could participate via the Ministry of the Interior. IESE was responsible for the coordination. Betzdorf took part and ended up among the top 3. In 2015, the first funding phase started. Even back then, there was already huge interest among our citizens.

What exactly did you implement together with IESE at the start of the project?

In the first funding phase, which was initially scheduled to last one year, the focus was on local supply in rural areas. Products of our regional retailers were offered on a marketplace. The special thing about it was that you could order these things via an app.

There was also the “LieferBar” app, which citizens could use, on the one hand, to order from local retailers and, on the other hand, find people to deliver these orders as a kind of neighborhood help. The unusual aspect was precisely this social aspect of creating a platform through which citizens could network with each other in order to support each other. And, of course, to avoid empty runs and strengthen the retail sector.

Digitalization in the retail sector took another big leap due to the Covid-19 pandemic, but back then, the retail sector barely had any online presence.

Can you say that the project “Digital Villages” set the course in your association of municipalities?

Yes, you could put it like that. The project has pushed a lot of things forward in the community, especially in terms of embracing digital tools and mutual support. This paved the way for everything that followed.

And what else exactly followed in your association of municipalities?

For example, the development of “DorfNews”, a shared platform on which news is shared both by the municipality and by citizens. This was really helpful for us back in 2017 when our municipalities merged. It gave us a digital platform that we could use to grow together and through which, for example, all associations could present themselves.

We then added “DorfFunk” on top of this so that people always know what is currently happening in the municipality. And, of course, the “LösBar”, through which we were able to bring together citizens and the municipal administration closer to each other in order to solve issues together as a team.

How long did the projects with IESE last and what happened afterwards?

Officially, our joint projects ran until 2021, but always in different funding contexts. We have, of course, continued to use the solutions. Without this project, which gave us a great jump-start, we would not be where we are today.

Is Betzdorf-Gebhardshain a real “digital village” now?

How does one define this term? I always find that very difficult. What I like is that “Digital Villages” are now a widespread brand with a very positive connotation. But there are still people who think they are coming to a digital village and then drones fly around and robots drive around emptying the garbage. For me, a region or city worth living in is a desirable goal. And I believe that digitalization has to be considered everywhere. With everything we have already established in our association of municipalities, we are already a digital village in a way, but there is certainly still a lot of room for improvement.



Listen to the detailed interview
(in German) here!

**MORGEN
DENKER**
Podcast

X-KIT

Exploiting the potential of digitalization for food and agriculture

Ensuring overarching networking and support for the AI projects funded by the German Federal Ministry of Food and Agriculture (BMEL) is a central task of the new networking and transfer project X-KIT (GAIA-X and AI Projects: Transfer & Networking). In addition, the “agriculture” domain is to be further developed in GAIA-X – a project to establish a European data infrastructure for sovereign data exchange. The overall aim of the project, which has been funded by BMEL since September 2022, is to exploit synergy effects as widely as possible and create compatible solutions.

Based on the “Artificial Intelligence” strategy adopted by the German government, the BMEL is currently funding 36 AI projects in the fields of agriculture, food chain, food, and rural areas. These AI projects are one project focus of X-KIT, of which the consortium partner Kuratorium für Technik und Bauwesen in der Landwirtschaft (KTBL) is in charge. The knowledge gained from the AI projects will be bundled in X-KIT so that techniques, recommendations for actions, and findings from the various AI projects can also be transferred to other specialist areas such as crop protection or animal husbandry. Another focus of X-KIT are the GAIA-X activities in the agricultural domain; Fraunhofer IESE is in charge of this aspect. The project is supported by an advisory council made up, among others, of representatives from the current GAIA-X agricultural projects “NaLamKI” and “AgriGaia”. The aim is to further develop the “agriculture” domain in the area of data infrastructure.

A total of seven project partners (six Fraunhofer Institutes and KTBL) are working together until January 2025 under the leadership of Fraunhofer IESE to exploit the potential of digitalization for food and agriculture as well as for rural areas in the best possible way. The German Federal Office for Agriculture and Food (BLE) is supporting the networking and transfer project X-KIT as the project management agency.

Further information:
www.iese.fraunhofer.de/x-kit



Prof. Jörg Dörr

From Lab to Field

Software is the decisive key technology in the agriculture of tomorrow. Prof. Dr. Jörg Dörr, Extended Institute Management at Fraunhofer IESE, explains in the video how the transfer of the IESE Research Program “Agriculture & Food” into agricultural practice works.



“AgriDataSpace” creates a European data space in agriculture

Launched in Paris in October 2022, the EU project AgriDataSpace is coordinating a preparatory action to pave the way to a European data space in agriculture. The project is being coordinated by Agdatahub and aims to facilitate data sharing, processing, and analysis from the domains of food and agriculture – in a secure, trusted, transparent, and responsible manner. This will create new opportunities for monitoring and optimizing the use of natural resources in order to stimulate data-driven innovations. Fraunhofer IESE has taken on the role of a technical manager for the overall project.



Project of the future: “Digital Ecosystem”

Courage and foresight lead
to new opportunities



Who is more likely to succeed in developing a Digital Ecosystem: a start-up or an established company? There is no general answer to this question, but one thing is clear: You need to have the courage to take risks if you want to establish yourself on the market with a Digital Ecosystem as a first mover.

The German industry is increasingly facing up to digital transformation. This is also the conclusion of a study conducted by the digital association Bitkom on behalf of the software company Autodesk in the fall of 2022. According to the survey, more and more companies are improving their existing products with the help of digital technologies, but only a few companies are developing truly new digital business models. And Digital Ecosystems are even used by only about a quarter of those surveyed.

Why is that? There are certainly many reasons for this, and a Digital Ecosystem can, of course, not be developed overnight. In Germany at least, many companies approach Digital Ecosystems with a certain degree of caution, as the transformation constitutes a very fundamental and long-term business decision. U.S. companies are generally more willing to take risks here.

Why a “Digital Ecosystem”?

As a first step, companies should first clarify what potential the development of or participation in a Digital Ecosystem really offers them and which opportunities need to be juxtaposed with the risks. To be more precise: You need a solid basis for making decisions. This should provide information about what individual business case can actually be derived from the transformation and why it is worth the effort to tackle this challenge.

Resourceful and established versus agile and flexible

Large companies generally have the necessary resources to implement a Digital Ecosystem. Selected employees can deal explicitly with the individual transformation steps. And even if development takes longer than expected, the financial resources are usually available to complete the project. Conversely, many companies in this category are often rather inflexible due to their size alone and find it relatively difficult to make changes.

In the vast majority of cases, the organizational structures of start-ups are much leaner and more agile, meaning that changes can be implemented more quickly. Conversely, these companies tend to have fewer financial and human resources, which is synonymous with increased risk in implementing the transformation. Spin-offs from larger companies have often emerged as the “golden mean” when it comes to Digital Ecosystems. They have the necessary resources of the parent company at their disposal and, at the same time, are agile enough due to their start-up-like structures to quickly drive the transformation forward. Ultimately, all these companies can achieve great things with courage, foresight, and a well-founded approach. One positive example is the sports retailer INTERSPORT, which actively tackled its digital transformation with the help of Fraunhofer IESE.

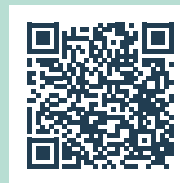
Digital Ecosystem exemplified by INTERSPORT 3 questions for...

... Marcel Müller from INTERSPORT Digital GmbH

INTERSPORT Deutschland e.G. is considered the largest medium-sized group in the global sports retail sector. INTERSPORT, too, has to compete in the online world with retailers such as Amazon or Zalando. In order to stand out from the competition and strengthen its own brand, INTERSPORT has thought beyond the classic product.

Together with Fraunhofer IESE, the company intends to build a Digital Ecosystem for Sports Experience (SPEX). The aim is to use a platform to broker sports experiences between providers and their customers. In the meantime, the project has been completed and the designed platform is being further developed by INTERSPORT.

We spoke to Marcel Müller from INTERSPORT Digital GmbH about the challenge he faced when he approached IESE and asked him how a digital platform enables sports experiences.



**MORGEN
DENKER**

Podcast

Listen to the detailed interview
(in German) here!



Not only did we have a lot of fun with the IESE team, we also optimally developed the idea for our sports experience ecosystem together. «

Marcel Müller, INTERSPORT



1

How did the idea of building a sports experience platform come about?

We are aware that we must remain active in order to continue to remain relevant as the INTERSPORT brand and also as a sports retailer – especially among the younger target group. We want to address this by offering customers added value. This gave rise to the idea of transferring the topic of “in-store advice and service” to the online world in order to enable new customer experiences in the digital environment as well. We had thought about needing new points of contact with our customers to do this. For us, it is no longer about selling a product like a running shoe; rather, we want to convey to the customer what they can experience with this running shoe. And so the idea for “SPEX”, that is, the focus on sports experiences, was born.

2

What did Fraunhofer IESE contribute to the implementation?

The concrete elaboration of the idea and the fact that we want to offer the sports experiences on a platform as a Digital Ecosystem only emerged in the collaboration with Fraunhofer IESE.

To be honest, I did not know the term “Digital Ecosystem” before the project. When you then hear examples, you quickly realize, of course, that you have often come into contact with other Digital Ecosystems in everyday life already. However, in relation to the INTERSPORT business context, the concept was still new for me. That is why it was all the more interesting to think through the various levels of sports experiences together with Fraunhofer IESE. In addition to personas of our customer groups, the information flows on the platform as well as the offerings were also discussed in the project in order to complete our customers’ consumer journey in the best possible way.

The Playmobil® diorama created in the workshops is still very important to us because it illustrates our ecosystem vision in a tangible way. We use it to guide us in the further development of the platform and can see at a glance what the next steps are that we still want to cover in this process.

3

How does a digital platform enable sports experiences?

On the SPEX platform, we offer a very wide range of indoor and outdoor sports activities, which customers can search for individually using keywords or categories. The options are very diverse – from traditional fitness studios and personal training sessions to climbing gyms, golf schools, and hiking guides. We bring together a wide range of providers on one platform. Once the right sporting activity has been found, it can be booked and paid for immediately via the platform. It is possible, for example, to directly book a suitable time slot with a personal trainer. The advantage for customers lies in the bundled view of comparable sports experiences combined with a simple search and booking function – as is the case with hotels on Booking.com, for example. It is just as easy on the SPEX platform, only with sports experiences.

The platform has recently become accessible via the website spex.intersport.de and is initially available to our core market in Baden-Württemberg. There are currently more than 150 providers on board already, but our goal is to gradually expand the offering throughout Germany and attract many more providers.

For more security

Fraunhofer IESE uses cyber security to protect systems from hacker attacks



Contact person

Dr. Christian Jung
 Department Head
 Security Engineering
 Phone +49 631 6800-2146
 christian.jung@
 iese.fraunhofer.de

The topic of “cyber security” affects small and medium-sized companies as well as large corporations. Not knowing one’s own situation, not assessing it, and not improving it continuously could therefore be described as being negligent. In addition, the professionalization of hackers is progressing steadily. Fraunhofer IESE provides companies with comprehensive support in reviewing and improving their IT security.

IT security audits

The experts at Fraunhofer IESE have been performing the IT security audits within the Fraunhofer-Gesellschaft since 2002, identifying improvement potential and providing advice on a technical and strategic level. For several years now, IESE has also been offering this service to companies from industry – always based on the ISO 27000 series and other relevant best practices.

Network-based vulnerability scans and penetration tests

In addition to IT security audits, Fraunhofer IESE also performs network-based penetration tests to ensure cyber security. A professional scanning environment was set up for this purpose, which automatically checks large amounts of assets for vulnerabilities. This measure is accompanied by manual tests using commercial and non-commercial tools. Not only are the vulnerabilities identified, but recommendations are also made on how to rectify them.

Evaluation and development of IT security concepts

An individual evaluation and development of IT security concepts comprises checking the effectiveness of implemented solutions as well as realizing prototypes for evaluation purposes.

Safety and security

The IESE experts advise and train companies in the implementation of the new standard ISO/SAE 21434 “Road vehicles – Cyber security engineering”. Moreover, integration with the ISO standard 26262 “Road vehicles – Functional safety” is part of Fraunhofer IESE’s holistic safety-security co-engineering approach, which bundles the competencies of the departments Security Engineering and Safety Engineering.



Fraunhofer IESE always takes a holistic view of its customers' IT security – from the technology to the people.

This is what business is saying!

MBCC Group: Evaluation of cyber security with IT security audits and penetration tests



DO YOU HAVE A CHALLENGE FOR US?

Talk to us!

Dr. Christian Jung
 Department Head
 Security Engineering
 Phone +49 631 6800-2146
 christian.jung@iese.fraunhofer.de



As a globally operating company with more than 7,500 employees – spread across more than 300 locations in over 60 countries – the MBCC Group from the construction chemicals industry commissioned Fraunhofer IESE to review various locations and subsidiaries with regard to their cyber security. Fraunhofer IESE performed several IT security audits and network-based penetration tests in order to use these building blocks to support the MBCC Group in implementing a holistic IT security strategy.

Neutral assessment

The IT for almost all of the MBCC Group's locations and subsidiaries is operated on a cloud basis using state-of-the-art, innovative IT security solutions. There are a few subsidiaries that have not yet been integrated into this cloud-based IT and are operated with more traditional IT infrastructures (legacy IT). Irrespective of this, the overriding premise is: Cyber security must always be preserved and continuously improved.

In addition to various websites for the many products, brands, and companies of the MBCC Group, publicly accessible systems and applications are also offered, which could be used as entry points by potential hackers. It is a challenging task to regularly check and evaluate these and to initiate suitable countermeasures in the event of vulnerabilities. When it comes to reviewing IT security, an independent and neutral assessment is of great added value. Fraunhofer IESE took on this task for the MBCC Group and examined various subsidiaries in South America and Asia.

Holistic approach

The combination of IT security audits and accompanying penetration tests offers an optimal solution for a holistic view of cyber security.

In general, the IT security audits of Fraunhofer IESE serve to determine the level of cyber security currently achieved. In addition, potential for improvement is identified and highlighted in order to further improve the level of cyber security achieved. The IESE experts generally conduct security audits in three phases – which they also did in the case of the MBCC Group:



Although we already invest and implement a great deal in the area of IT security, the collaboration with Fraunhofer IESE is proving to be a great added value. There is less a feeling of being audited and more one of exchange between colleagues.«



Dr. Manuel Rudolph, Director Global IT Security at MBCC Group

1. In the first phase, the project team contacts the site to be inspected and requests various information and documents. As soon as these are available, they are viewed and checked.
2. In the second phase, the detailed inspection of the site is carried out remotely or on site. This involves examining systems, discussing configurations in detail, taking random samples, and carrying out tests together with the IT managers at the sites. IESE documents the findings in a report and sends them to the company for further processing.
3. In the third phase, there is an optional follow-up review. Its aim is to determine the extent to which the identified issues have been eliminated satisfactorily.

Independent picture of the situation

The global network-based penetration tests show the current cyber security situation from the "outside". To this end, systems are regularly examined for vulnerabilities and potential gateways that could be exploited by external attackers (hackers). Fraunhofer IESE uses a professional scanning environment for this purpose, which was developed in-house, as well as commercial tools that make it possible to check large numbers of systems in a short period of time. The project team's approach is based on current recommendations and divides the work into the steps "Scoping", "Testing", and "Reporting":

1. During "scoping", the expectations, the attacker model, the framework conditions, such as test times or test objects, as well as the depth and aggressiveness of the test are defined.
2. During "testing", IESE performs the automated and manual tests, evaluates them, and packages the findings.

3. During "reporting", the results and recommendations are documented. In the event of critical findings, the company is notified immediately in order to prevent any delays.

At the end of the project, the summarizing reports of the IT security audits and the penetration tests were personally reviewed and discussed with the local, regional, and global IT managers of the MBCC Group. They now form the basis for the company's further planning of measures to improve its cyber security.

About the MBCC Group

MBCC GROUP

Headquarters: Mannheim
 Industry: Construction Chemicals
 Number of employees: 7.500
 Project performed: 2021–2022



On the trail of understanding risk

How Fraunhofer IESE contributes to making the risk assessment of autonomous systems better and better

In the interview: Dr. Rasmus Adler, Program Manager Research Program “Autonomous Systems” at Fraunhofer IESE

In practice, we must be able to depend on autonomous systems not taking any unacceptable risks. But what about the understanding of risk in autonomous systems? We asked our IESE expert Dr. Rasmus about this.

Why do autonomous systems need a good understanding of risk?

So that they can perform their task more efficiently and safely. In automated driving, for example, a better understanding of risk could help to avoid unnecessary slow driving or unnecessary braking.

What are the main challenges and what is Fraunhofer IESE researching?

The first major challenge is to dependably determine all relevant information about the environment. In this context, Artificial Intelligence offers many possibilities, but the output information is currently still subject to uncertainties. At IESE, we are working on approaches for dependably determining these uncertainties during operation. We are also researching safety architectures in order to take uncertainties into account in risk assessments. Methodological research for risk models is also closely linked to this.

In which projects are the approaches being researched?

We have most of our projects in the context of automated driving, if we include intralogistics and other applications. In the ongoing ICON project “LOPAAS”, which stands for “Layers of Protection Architecture for Autonomous Systems”, we

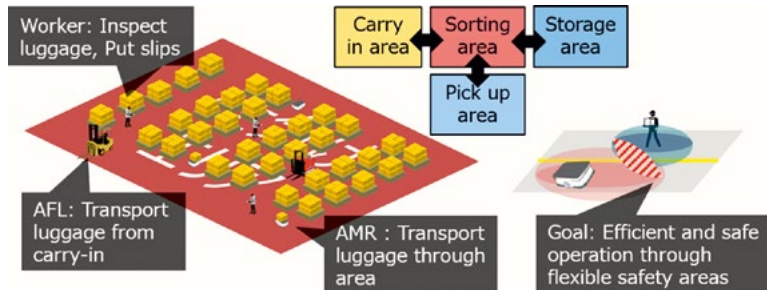
have been researching cross-application issues together with the University of York in England in the “Assuring Autonomy International Programme” and Fraunhofer IKS since 2021. In the European research project “SESAME – Secure and Safe Multi-Robot Systems”, we are also looking at autonomous drones and are researching the collective understanding of risk based on Digital Twins called “Digital Dependability Identities”. And in the BMBF-funded research project “AutoDevSafetyOps”, we are developing approaches for modeling and monitoring fleet risks of automated driving systems in the field. We apply the results in industry projects and carry them into standardization.

With which industry partners is IESE collaborating in this context?

In a project with Bosch, we used simulation tools to investigate how driving behavior can be improved in specific driving scenarios and which safety architectures are most suitable for dealing with uncertainties. Another project with Hitachi focused on the methodological development of risk models for autonomous mobile robots in order to make cooperation with human workers more efficient. We published the research results from these projects at the Safecomp 2022 conference.

What progress has been made, and what is still needed until autonomous systems with a better understanding of risk will enter the market?

The understanding of risk of autonomous systems is being continuously improved. The aim is to know which investments are necessary for which efficiency gains. Together with industry partners, we have developed reusable simulation tools to answer



From consensus in research (LOPAAS) to industrial practice

Contact person

Dr. Rasmus Adler
 Program Manager
 Research Program
 "Autonomous Systems"
 Phone +49 631 6800-2172
 rasmus.adler@
 iese.fraunhofer.de



this question as early as possible and in a use-case-specific way. Progress has also been made in the area of standardization. For example, our work in DIN SPEC 92005 "AI – Quantification of Uncertainties in Machine Learning" is contributing to a broad consensus for the definition and quantification of uncertainties. The application rule VDE-AR-E 2842-61 for the development and trustworthiness of autonomous-cognitive systems already refers to some of our approaches for implementing a good understanding of risks.

What are the benefits of such initiatives for the application of autonomous systems?

Such initiatives help to define the state of the art and transfer it more quickly into practice. I see particular potential in intralogistics, agriculture, mining, and generally wherever high levels of automation are already achieved today. Furthermore, I see the understanding of risk as the key to realizing complex urban journeys, but this requires further research and not just transfer and standardization.

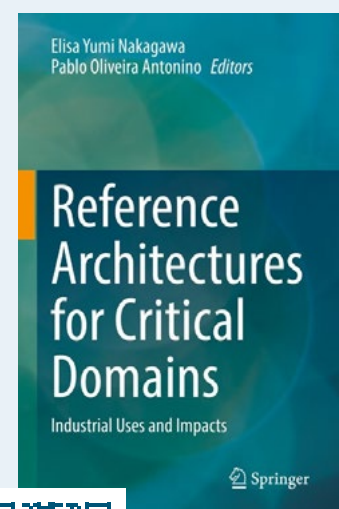
Book recommendation

Reference Architectures for Critical Domains
 – Industrial Uses and Impacts

by Prof. Dr. Elisa Yumi Nakagawa and Dr. Pablo Oliveira Antonino,
 Head of the Department "Virtual Engineering" at Fraunhofer IESE

Reference architectures are regarded as one of the most important means of reusing consolidated knowledge and experience in relation to the development, evolution, and standardization of dependable and safe software-intensive systems. Examples include the widespread use of the "Automotive Open System Architecture" (AUTOSAR) in the automotive industry, the "Reference Architecture Model Industry 4.0" (RAMI 4.0), and the "Industrial Internet Reference Architecture" (IIRA) in the manufacturing industry.

With this in mind, this book provides an overview of the field of reference architecture in its various facets, from architecture design to industry-wide deployment. This book can be considered the first to deal with reference architectures, including those related to critical domains. It offers a general introduction to reference architectures used in the following domains: Automotive, Industry 4.0, Healthcare, Aviation, and Telecommunication.



[link.springer.com/
 book/10.1007/978-3-
 031-16957-1](https://link.springer.com/book/10.1007/978-3-031-16957-1)



“Enabler” Industry 4.0

To what extent can the fourth industrial revolution solve our socio-political challenges?!?

From Lab
to Factory



Division Manager Dr. Thomas Kuhn explains in this video how Fraunhofer IESE contributes to the “Factory of the Future” with the Industry 4.0 middleware Eclipse BaSyx and how it supports companies as they enter the world of Industry 4.0.



In the interview: Prof. Dr. Peter Liggesmeyer, Institute Director of Fraunhofer IESE

It has now been more than eleven years that the term Industry 4.0 began its triumphal march around the globe. The declared aim is to be able to produce large numbers of individual, cost-effective items through flexible and self-organized manufacturing. Prof. Peter Liggesmeyer is convinced: “If we succeed in further advancing research in this area, Industry 4.0 can make a crucial contribution to overcoming the current socio-political challenges.” Our annual report editorial team wanted to know more and interviewed the software and systems engineering expert on this topic.

Many people equate the term Industry 4.0 with the digitalization of industrial production – a widespread misconception. But what does it actually mean?

Industry 4.0 is about a far-reaching transformation process that is set to fundamentally change industrial production and triggers a new level of organization and control of the entire value chain. The transformation process is by no means aimed at digitalizing industrial production. The technical “enablers” of the fourth industrial revolution are rather based on digitalization. In short: Digitalization is a means to an end, a way of enabling individual manufacturing at the cost of a mass product in the first place and addressing socio-political challenges.



With Industry 4.0, we can establish a strong economic field in the future.«

Prof. Peter Liggesmeyer,
Institute Director of Fraunhofer IESE

What are the biggest challenges that we can overcome with Industry 4.0?

A key problem that our society is facing today is the climate crisis. It makes innovations in the context of sustainability in the development of products and services as well as throughout their entire lifecycle indispensable. Resource and energy efficiency have been the focus of Industry 4.0 from the very beginning.

Resilient production has also always been an aspect of Industry 4.0, meaning that intelligently networked manufacturing is what makes it possible in the first place for a company to react flexibly to unforeseen events and prevent production downtimes. Industry 4.0 also offers the opportunity to consolidate the technological sovereignty of Germany as a business location in international competition. The development of

new, primarily data-driven and platform-based business models, in particular, could help to establish a strong future economic field for Germany in the long term.

What still needs to be done to further boost the fourth industrial revolution?

For me, the capabilities and opportunities of Industry 4.0 are on the table. Particularly from a research perspective, however, additional measures and initiatives focusing on various topics must now be initiated in order to further advance the fourth industrial revolution and implement it fully in practice. Well-founded analyses that highlight the status quo, existing deficits, and development opportunities are also needed now more than ever.

IESE Highlights







Hannover Messe 2023: BaSyx as a basis for sustainable production

The sustainable renewal of industrial production in Germany is one of the German government's absolute core political issues. Hannover Messe 2023 was also held under the motto "Industrial Transformation – Making the Difference". From 17 to 21 April 2023, Fraunhofer IESE was represented at the joint booth of the Fraunhofer-Gesellschaft (Hall 16, Booth A12) with its own demonstrator – a chocolate factory in miniature format. This showed the visitors how a fully digitalized, flexible factory can be implemented with the help of Digital Twins and Asset Administration Shells.

The Asset Administration Shell, which was realized with the open-source middleware Eclipse BaSyx, contains all data from devices, processes, and products. It describes, for example, the manufacturing history of a workpiece and can process data on its own with the help of algorithms. This ability of the Asset Administration Shell and its submodels is an important factor in making a factory not only more networked, but also more sustainable in the long term.

In addition to the possibility of calculating the carbon footprint – and the associated potential for reducing climate-damaging emissions – the use of Eclipse BaSyx offers a large number of starting points that make production more sustainable even with small measures: starting with the digital product passport and the production of small lot sizes all the way to the establishment of virtual control centers and digital type plates.

In 2024, Fraunhofer IESE will once again be present at Hannover Messe from 22 to 26 April – this time under the motto "Inspiring the World with Technology".



State Secretary Petra Dick-Walther talked to Prof. Liggemeyer to learn more about digitalization in production using the example of a chocolate factory.



Former German Federal Minister of Food and Agriculture Julia Klöckner also showed great interest in the topic of "Sustainable production".

Smart Country Convention: Smart City yes – but safe and secure!

The Smart Country Convention is Germany's leading convention for the digital transformation of the public sector. From 18 October to 20 October 2022, Fraunhofer IESE presented the specifics of a Smart City and Smart Region ecosystem at the joint booth of the Fraunhofer-Gesellschaft in Hall 27, Booth 102.

Digital Ecosystems are complex systems that function according to the principles of the platform economy. Smart City and Smart Region ecosystems face the challenge of connecting a variety of technologies and systems with each other based on suitable strategies and concepts while meeting a wide range of requirements. At the Smart Country Convention 2022, Steffen Hess, Division Manager Digital Innovation and Smart City at Fraunhofer IESE, gave a presentation on "Smart City yes – but safe and secure!" He explained to visitors how it is possible to create a safe and secure Smart City and Smart Region while at the same time using data and data platforms as drivers of innovation for urban society.

From 07 to 09 November 2023, Fraunhofer IESE will once again be represented in Berlin to present its new concepts for the smart cities and smart regions of tomorrow.



The safe and secure Smart City was the focus of the presentation by Division Manager Steffen Hess.



The topic of "Digital Ecosystems" attracted many visitors to the Fraunhofer booth.

7th International Commercial Vehicle Technology Symposium

The “Commercial Vehicle Technology” (CVT) symposium is a two-day conference that takes place every two years on the campus of the University of Kaiserslautern-Landau (RPTU) in Kaiserslautern. The conference comprises around 50 expert presentations and poster presentations focusing on international trends and technological developments in the commercial vehicle industry.

Fraunhofer IESE participated in the 7th CVT symposium held from 13 to 15 September 2022 with various presentations. The topics ranged from “Autonomous commercial vehicles” and “Safety” to “Dynamic risk management” and “Machine learning for commercial vehicle applications».

The 8th CVT symposium (12 to 14 March 2024) will again be actively co-organized by Fraunhofer IESE.



Ralf Kalmar, Head of Business Development, contributed his expertise in digital solutions for the commercial vehicle industry.

Kick-off event for the X-KIT project



The X-Kit project partners came together at the kick-off event in Kaiserslautern.

On 08 and 09 February 2023, Fraunhofer IESE hosted the kick-off event for the new project “GaiaX and AI Projects: Transfer & Networking” (X-KIT for short) with all project partners.

A total of seven project partners (Kuratorium für Technik und Bauwesen in der Landwirtschaft KTBL, Fraunhofer IAIS, Fraunhofer IGD, Fraunhofer IGP, Fraunhofer IFF, Fraunhofer IOSB, and Fraunhofer IESE) are involved in the project, which is being funded by the German Federal Ministry of Food and Agriculture until January 2025.

The aim of X-KIT is to establish an overarching network of 36 AI projects in the areas of agriculture, food chain, food, and rural areas. In the project, the IESE experts are responsible, among other things, for networking various platform projects as well as for the technical implementation and enablement of AI projects in terms of a connection to Gaia-X.



The IESE team presented its medical expertise at DMEA.

Closing event for the lighthouse project “COGNAC”

Over the past four years, eight Fraunhofer Institutes under the consortium leadership of Fraunhofer IESE jointly investigated the challenges and the state of the art in agriculture in the lighthouse project “Cognitive Agriculture” (COGNAC for short) and developed solution modules in the areas of sensor technology, robotics, automation, digital data space, and cognitive services. The research project showed how the digital transformation can succeed beyond isolated solutions – through the interaction of technological solutions with holistic concepts for the agricultural data space. At the end of September 2022, the project partners presented their results to the public at a closing event in Dresden.



The project partners of the lighthouse project “COGNAC” met at the closing event in Dresden.

DMEA 2023 – Connecting Digital Health

What drives healthcare IT today and tomorrow? Answers to this and other questions were provided at DMEA in Berlin from 25 to 27 April 2023. DMEA is one of Europe’s most important events for Digital Health. For three days, experts from the digital health industry met and exchanged ideas and experiences in more than 300 key-notes, presentations, and panel discussions.

The Fraunhofer-Gesellschaft was also present this year and presented its medicine-related competence. The Fraunhofer Center for Digital Diagnostics ZDD®, for example, showed its visitors how healthcare in rural areas can be improved through diagnostics as close to the patient as possible and through digitalization. Fraunhofer IESE is one of the three core institutes of the ZDD®.

Kick-off event for “BaSys4Transfer”

At a kick-off event in Berlin in October 2022, the project partners of the new research project “BaSys4Transfer” came together. In this research project, 13 partners from research and industry are working together to implement an Industry 4.0 toolkit into engineering solutions. The focus is on the open-source Industry 4.0 middleware Eclipse BaSyx. “BaSys4Transfer” is led by Fraunhofer IESE and builds on the results of the previous funding projects BaSys 4.0 and BaSys 4.2. In this third project, the middleware, which is currently being used successfully mainly by “early adopters”, is to be made fit for broad usage.



Prof. Liggesmeyer (2nd f.r.) receives award for software quality.

Prof. Liggesmeyer awarded the German Prize for Software Quality 2023

The Working Group for Software Quality and Training (ASQF), the Test, Analysis and Verification of Software section of the German Informatics Society (GI-TAV), and the German Testing Board (GTB) jointly awarded the German Prize for Software Quality (DPSQ23) for the third time in 2023. This year, the prize went to Prof. Dr. Peter Liggesmeyer, the institute director of Fraunhofer IESE.

Prof. Liggesmeyer has been working in the field of software quality for over 40 years. His research activities are not limited to the testing of software, but include software quality in a broader sense. Both as director of Fraunhofer IESE and as holder of the Chair for Software Engineering: Dependability at the Department of Computer Science of the University of Kaiserslautern-Landau (RPTU), he deals with the continuing development of software and systems engineering on a daily basis. The award was presented at the 48th TAV meeting in Paderborn on 15 June 2023.

E-world energy & water

E-world energy & water is the meeting place for the European energy industry. In 2023, the focus was on innovative solutions for the energy supply of the future – from generation, transportation, and storage to trading, efficiency, and green technologies. Under the motto “Smart Energy Ecosystems with Digital Twins”, Fraunhofer IESE presented an energy portal at E-World 2023 from 23 to 25 May 2023. This web-based application platform enables entry into a Digital Ecosystem for urban district energy management. On site in Essen, the IESE team provided initial insights into the app and its interactions, which were developed, among others, in the research project ODH@Jülich.

Automotive Testing Expo Europe

From 13 to 15 June 2023, the team of Fraunhofer IESE attended the Automotive Testing Expo. With over 400 exhibitors, this event is the leading international trade fair when it comes to aspects of technologies for automotive testing, development, and validation.

Fraunhofer IESE presented its simulation framework “FERAL”, which is designed to integrate a wide variety of artifacts into a simulation, as it is precisely this integration that often fails because environment simulation, functions, and stimulators come in many different formats. At the IESE booth, it was demonstrated live how it is possible to benefit from the savings potential of automated virtual testing.

Coming soon...

This is where you can meet the experts from Fraunhofer IESE in the next months:

05-10 Sep 2023
IAA MOBILITY | Munich

14 Sep 2023
MORGEN DENKER Summit | Kaiserslautern

07-09 Nov 2023
Smart Country Convention | Berlin

13-16 Nov 2023
COMPAMED | Düsseldorf

12-14 Mar 2024
CVT Symposium | Kaiserslautern

22-26 Apr 2024
Hannover Messe | Hanover

Program, speakers & more



rethink 14.09.23 your business

DIGITAL.SUSTAINABLE.AHEAD.

s.fhg.de/morgendenker-summit-23



VERBAND DER
INTERNETWIRTSCHAFT

**MORGEN
DENKER
SUMMIT**

Ein Event von Fraunhofer IESE und
eco – Verband der Internetwirtschaft

Projects from Research & Industry



Balanced Engineering

Balanced Engineering LLC provides consulting regarding architecture-centric continuous software engineering for safety-critical systems for a global agricultural equipment manufacturer, the largest recreational marine OEM worldwide, and other companies in the Americas and in Europe. Following up on previous successful collaboration projects with Fraunhofer IESE, Balanced Engineering is drawing on Fraunhofer IESE's extensive experience with this topic. The current project aims to establish and execute an evaluation roadmap strategy and to recommend

action items aimed at modernizing the software engineering culture at the companies. In these endeavors, Fraunhofer IESE supports Balanced Engineering with various software engineering competencies in analyzing development processes and ensuring alignment of safety engineering activities and software development activities. Fraunhofer IESE also provides training in topics related to functional safety and architecture-centric continuous software engineering.

BaSys4Transfer

In the project **BaSys4Transfer**, Fraunhofer IESE is conducting research on the transfer of Asset Administration Shells and Digital Twins to industry. The Asset Administration Shell was developed as a standardized digital representation of assets in digital space. It can represent different types of assets and is therefore predestined as a technological basis for Digital Twins. In the context of the project, which is funded by the German Federal Ministry of Education and Research (BMBF), the Industry 4.0 middleware Eclipse BaSyx is being further developed as a technical

infrastructure for the implementation of Asset Administration Shells and Digital Twins. Particular attention is being paid to the integration of Asset Administration Shells with existing assets so that the Digital Twin always represents the current state of its asset, and to the development of complex Digital Twins that represent a large number of assets and thereby completely virtualize a factory, for example. This enables numerous use cases such as virtual commissioning of devices or development of new business and manufacturing processes.

Bosch

Robert Bosch GmbH, the world's largest automotive supplier with the highest sales, is one of the leading companies in the area of automotive technology. In the context of a long-standing cooperation, this division of the Bosch Group has been collaborating closely with Fraunhofer IESE in order to make the best possible use of the evident advantages of virtual safety assurance of product innovations by means of simulation-based integration and evaluation of system components. For this purpose,

the simulation and module coupling tool "FERAL" of Fraunhofer IESE has become established and has been successfully integrated into the infrastructure and processes for the development of electronic control units of Robert Bosch GmbH. In order to support the upcoming technology standard CAN XL for the modernization of the on-board network communication of modern vehicle architectures, Fraunhofer IESE recently extended FERAL by a simulation model that conforms to this standard.

CRANIMAX

CRANIMAX GmbH develops software for determining configurations of cranes and attachments that are suitable for crane use. Together with Fraunhofer IESE, CRANIMAX is working on expanding its service portfolio for its customers, i.e., crane rental companies. In the future, these are to be supported in taking the availability of cranes and attachments in terms of time, their costs, and logistics into account when planning crane

operations. This is intended to enable crane operations to be carried out optimally in terms of time, financial, and ecological dimensions. In this project, CRANIMAX is making use of the support provided by experts from Fraunhofer IESE in eliciting requirements, conducting workshops with the target groups of the optimization, and designing the user experience in the jointly conducted user-centered design process.

DAITA

Systems with software components based on Artificial Intelligence (AI) enable solutions that cannot currently be realized using traditional software. However, as their learned behavior is based on data examples, this behavior must be checked using statistical methods on test data. Depending on the area of use, incorrect behavior of the AI can result in high financial costs or even put people at risk. In order to create the necessary acceptance for the use of AI, methods for safety assurance and certification are therefore required. Since the reliability of these

methods is dependent on the quality of the test data, ensuring sufficient quality of the test data is one of the crucial factors for a meaningful verification of dependability. In the Software Campus project **DAITA (Dependable AI Test dAta)**, Fraunhofer IESE identified core quality characteristics of test data and developed a framework for the qualitative evaluation and improvement of this data. The results contribute to proving the dependability of AI-based components and to possible certification.

DEMETER

The project **DEMETER** aims to make agriculture more efficient and more sustainable by helping farmers make decisions based on data collected by sensors and other technologies in agriculture. The project is being conducted by an international team of experts from different fields, including engineers, agronomists, and software developers. Another goal of the project is to foster collaboration between farmers and agribusinesses, research institutions, and companies with the aim of jointly developing and implementing new solutions. The project is carried out by a consortium of 60 partners from 18 countries (15 in Europe) and includes more than 25 demonstration sites

where the technologies and solutions are being tested. The specific use cases of DEMETER include smart irrigation systems, monitoring of livestock health and well-being, predictive maintenance of machinery and equipment, as well as improvement of energy efficiency in agriculture. In this project, Fraunhofer IESE is developing and testing which standards and methods can be applied to make it possible to evaluate data quality as uniformly, consistently, and automatically as possible. Another focus is the analysis of commercial vehicle data for the purpose of evaluating driving behavior (detection of sharp braking or acceleration, etc.).

KickStartTrustee

Data trustees play a crucial role in establishing trust in the digital space and thus promote the shared use of data. As neutral intermediaries between data providers and data users, they enable information worthy of protection and even sensitive information to be passed on to third parties in a targeted and controlled manner. But setting up and operating such offerings entails considerable organizational, legal, and technical challenges. This is where the project **KickStartTrustee** comes in. The goal is to develop a framework that supports the implementation of data trustee offerings and facilitates the setup process. At the core of this framework is a comprehensive process description for

implementing digital data trustees, with modular building blocks for each step of the process. These building blocks build on the core competencies of Fraunhofer IESE, including creativity and requirements management, positioning in the Digital Ecosystem, security, software architectures for platforms, and even user experience. KickStartTrustee is an ambitious project that covers a broad range of topics and brings together the diverse skills of Fraunhofer IESE. The framework created at the end of the project will already be ready for use in concrete projects and can also serve as a resource for the community, which can further extend it and supplement it with additional building blocks.

KTS

Since 2019, the German Federal Ministry of Housing, Urban Development and Construction (BMWSB) and the KfW (Kreditanstalt für Wiederaufbau) have been funding 73 “Smart Cities Model Projects” in three rounds. Fraunhofer IESE supervises the smart cities model projects from Rhineland-Palatinate and Saarland as part of the activities in the **Coordination and Transfer Office (KTS)**. Furthermore, it is involved in various knowledge transfer formats, especially on innovative and technically driven

topics such as urban data platforms, Digital Twins, open source, or Smart City ecosystems. In the context of the scientific support, five studies have been conducted to date with the goal of formulating innovative digitally supported concepts and thus recommendations for action. In addition, Fraunhofer IESE is advising 18 model projects on their individual needs in order to support them in strategy and project development, efficient project management, and sustainable persistence of measures.

MYDATA

The disclosure of sensitive information is a constant threat to companies and can have drastic financial consequences. Often, however, this does not happen as a result of targeted technical attacks, but rather through carelessness and/or missing information about the confidentiality level of documents. In practice, for example, it happens time and again that employees send internal documents to external recipients even though they contain confidential information. Fraunhofer

IESE’s **MYDATA Office Add-ins** have been developed to prevent such scenarios by simplifying and unifying the information classification process. This not only promotes compliance, but also helps to avoid data loss due to unintentional release of confidential documents. Support is provided for the classification of Word, Excel, and PowerPoint files, as is protection when sending documents via Microsoft Outlook, starting with Microsoft Office 2016.

Smarte.Land.Regionen

With the project **Smarte.Land.Regionen**, the German Federal Ministry of Food and Agriculture is driving forward digitalization in rural areas. The use of digital technologies is intended to significantly improve living and working conditions. Fraunhofer IESE is developing a digital platform (Digital Ecosystem) on which new solutions will be developed and existing solutions will be networked with each other. Research is being conducted, for example, on which role a rural county plays in a Digital Ecosystem and how knowledge transfer between the stakeholders can best succeed. The platform with the marketplace as its core element ensures that the digital solutions can be transferred into widespread use – beyond the model regions. The process support commissioned by Fraunhofer IESE advises the rural counties on issues such as the design of citizen participation processes, competence transfer, and strategy implementation. The results are made available in the form of a tool set.

V&V Methods

The goal of the project **V&V Methods** is to develop test procedures and provide systematic methods to engineer safety cases for automated vehicles. The VVM project is working on the use case of urban intersections and focuses on driving functions up to the complete automation of vehicles (SAE Levels 4 and 5). It builds on the results of the PEGASUS project, which dealt with the identification and description of critical scenarios and their transfer into generally applicable test cases for highly automated vehicles (Level 3) using the example of the highway pilot. V&V Methods extends the PEGASUS method to Level 4 and Level 5 driving in urban environments using the example of urban intersections. In addition, the V&V Methods project works on integrating safety case creation as an integral part of the development process.

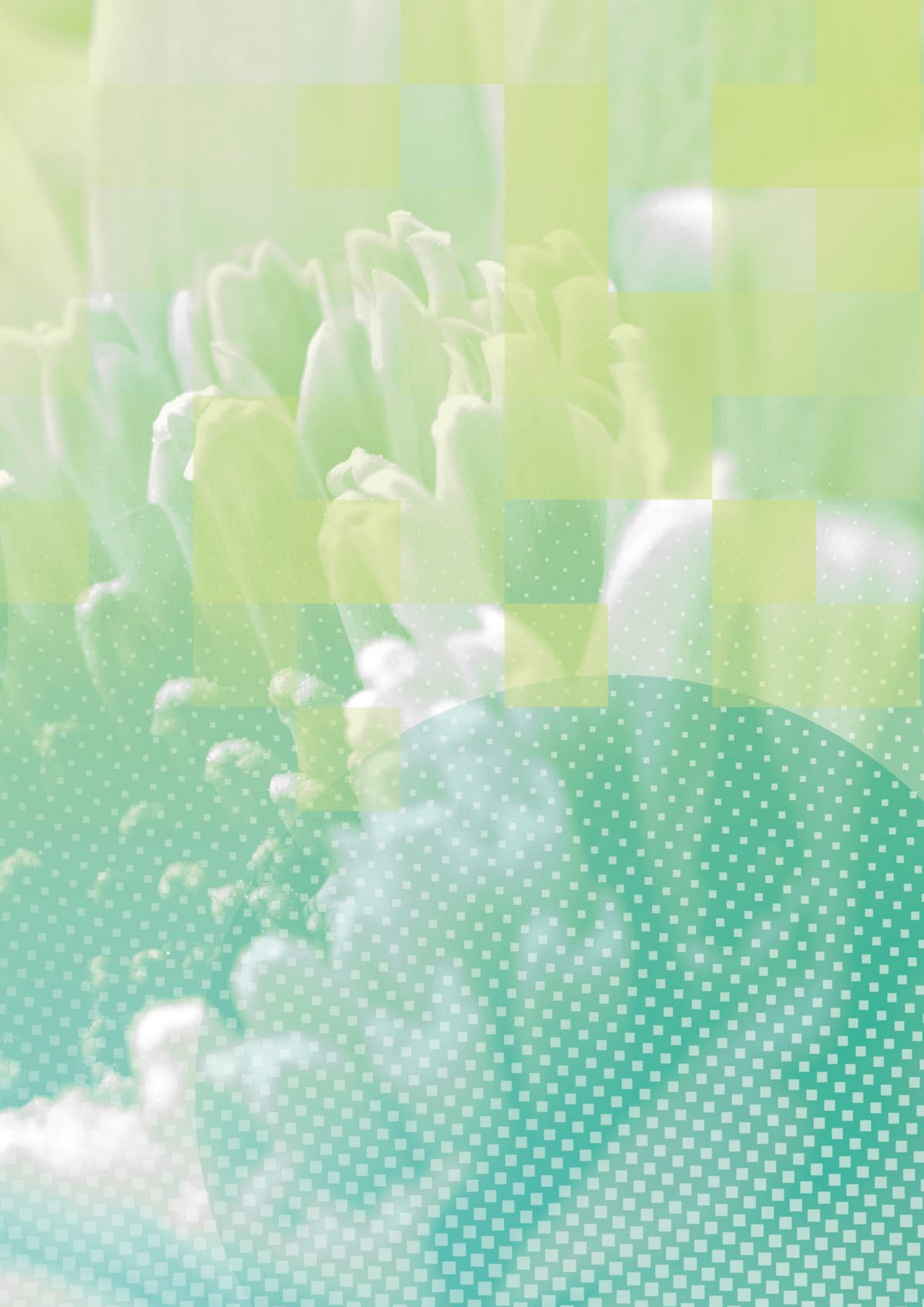
Smart Wendeler Land

Together with the county, its eight municipalities, the economic development agency Sankt Wendeler Land, the digital competence center, and the citizens, Fraunhofer IESE is developing an integrated Smart City strategy in the project **Smart Wendeler Land** that is intended to support this rural area by providing profitable digital solutions. The strategy focuses on four defined ecosystems: citizen services, public services, co-creation, and mobility. Within these ecosystems, individual measures and projects are proposed, tested, and realized. In conjunction with this strategy development, Fraunhofer IESE is realizing the conceptual design of a data platform that is to link the individual digital measures in the county in an inter-municipality manner. With the extensive support of the partner Zebralog, concepts for participation as well as communication processes are being developed. This will ensure successful development and implementation processes of the Smart City strategy in the county of St. Wendel with a focus on co-creation and citizen participation. The project partners aim to jointly develop the county in the sense of a public-welfare-oriented Smart Wendeler Land.



IESE at a Glance





Mission

Applied research on innovative solutions for the design of dependable Digital Ecosystems

Vision

A better life, sustainability, and economic success through dependable Digital Ecosystems

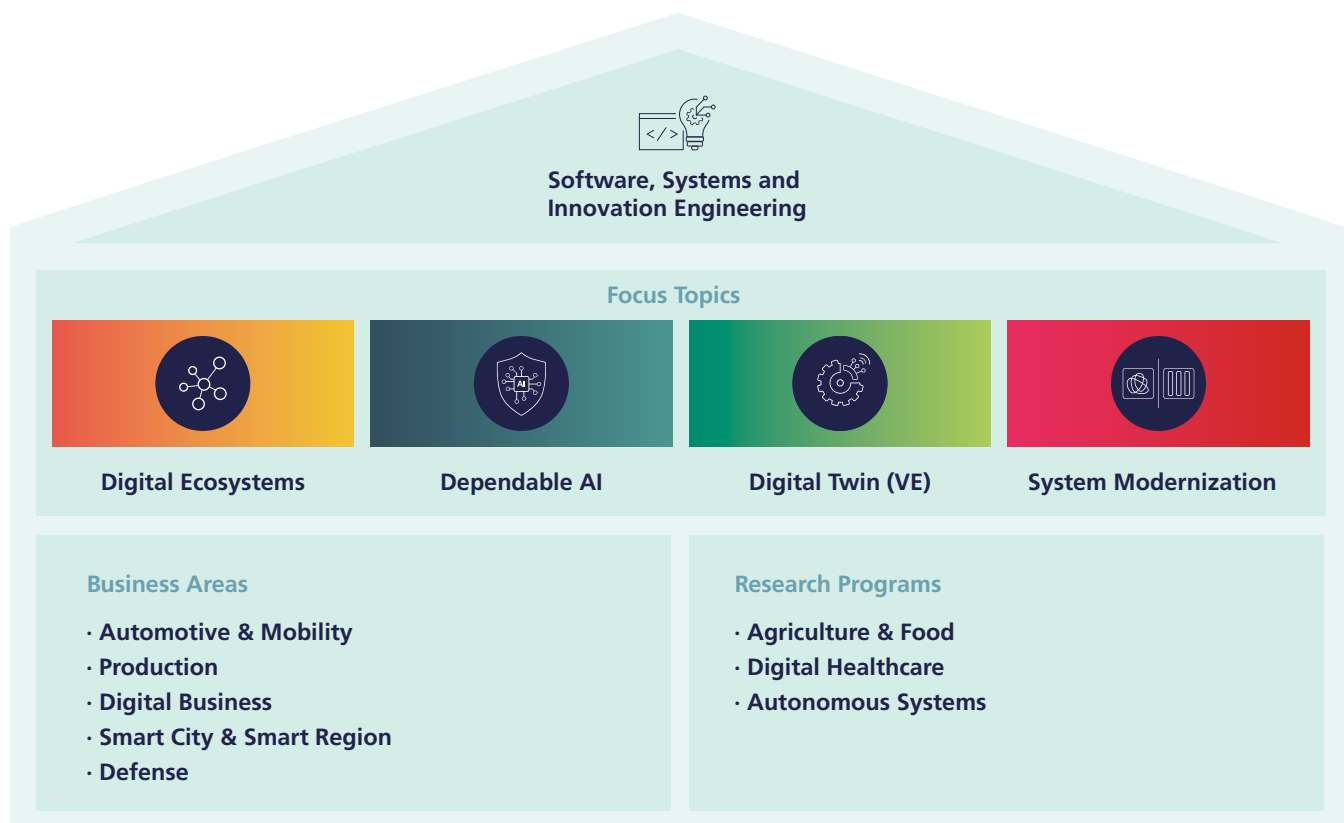
About the Fraunhofer Institute for Experimental Software Engineering IESE

The Fraunhofer Institute for Experimental Software Engineering IESE in Kaiserslautern has been one of the leading research institutes in the area of software and systems engineering as well as innovation engineering for more than 25 years. With its applied research, the institute develops innovative solutions for the design of dependable digital ecosystems, thereby accelerating the economic and social benefits for its customers.

Fraunhofer IESE provides support in mastering challenges in a wide variety of application areas, with particular expertise in the areas of "Automotive & Mobility", "Production", "Digital Business", "Smart City & Smart Region", "Defense" as well as

"Agriculture & Food" and "Digital Healthcare". In over 2,000 customer projects, the institute has transferred cutting-edge research into sustainable business practices and innovative products, with the current focus topics being "Digital Ecosystems", "Dependable AI", "Digital Twin / Virtual Engineering", and "System Modernization".

Fraunhofer IESE is one of 76 Institutes and research units of the Fraunhofer-Gesellschaft. Together they have a major impact on shaping applied research in Europe and worldwide, and contribute to Germany's competitiveness in international markets.



Everything under one roof – with software, systems and innovation engineering, IESE is driving the digital transformation in all areas of application!

Fraunhofer IESE makes companies fit for the digital future!



With its research approaches, solutions, and competencies, Fraunhofer IESE supports commercial enterprises from all industries. The IESE experts research new technologies and methods for them and together with them. After all, software is the key to innovation and business success.

For some applications, Fraunhofer IESE has special domain competencies and experience. The institute therefore bundles its offerings and research competencies into corresponding business areas and research programs.

Business Areas of Fraunhofer IESE

Automotive & Mobility

In recent years, vehicles have increasingly become “computers on wheels”, with complex software on board. Trends towards higher levels of automation and digital networking with services in the automotive industry continue to drive this development. But how do companies from this domain ensure that their software is highly dependable?

Fraunhofer IESE develops innovative software and systems engineering solutions for the automotive and commercial vehicle industry that can be depended on in every respect. Its experts support companies in the implementation of safety concepts, the development of new architectures, virtual integration and qualification, and the design of innovative products. Measurability, transparency, and quality are always at the forefront in all these endeavors.

Production

Automation in production, coupled with dependable and high-precision plants, has guaranteed the success of the German economy for many years. Digitalization in this industry (Industry 4.0) and the resulting innovation impulses are

continuing this trend. Digital Twins enable easy and flexible access to data and services and open up new possibilities for optimization and flexibilization, all the way to completely new business models.

At Fraunhofer IESE, an important building block for the future has been created with the reference implementation of the open-source middleware BaSyx, which makes it possible to support companies in an easy way to exploit the potential of digitalization and enable participation in Digital Ecosystems. Application examples include virtual commissioning, flexibilization of processes, or AI applications for process monitoring, product quality assessments, and plant optimization.

Digital Business

The key to solving many problems and optimizing existing structures lies in the cross-sectional networking of value chains in Digital Ecosystems. This is the only way to make information available in a quantity, speed, and quality that will enable not only new business models but also solutions to problems.

Digital Ecosystems and the platform economy will change every industry in many ways. Platform business differs significantly from traditional business and may require companies to completely rethink their own positioning and their own business model.

This is why Fraunhofer IESE has developed methods that provide companies with customized solutions and support them on their way from the business idea to implementation in the context of existing systems.

Smart City & Smart Region

Digitalization in rural and urban areas is important in order to benefit from the possibilities of networked data and services in these areas of life as well. Digital platforms make it possible to make services easily and quickly accessible to millions of citizens.

The “Digital Villages Platform” developed at Fraunhofer IESE is characterized by the fact that it is tailored particularly to the needs in rural areas. For communication, trade, and mobility, customized solutions exist that already have many tens of thousands of users.

In cities and municipalities, however, there are many other opportunities to offer improved infrastructures and services with IoT (Internet of Things) devices – examples are smart street lamps or parking services.

Defense

Fraunhofer IESE offers various services and solutions for the digitalization and networking of systems in the area of military technology production and defense. In addition to the introduction of Digital Twins, the Institute also implements virtual test environments for concept validation and integration tests. Other services include dynamic risk assessment of AI applications, consulting on the development of software and system architectures, and consulting on the implementation of model-based systems engineering.

Research Programs of Fraunhofer IESE

Agriculture & Food

Due to the growing demands regarding environmental protection and sustainability with limited land areas and fossil resources, agricultural technology is facing ever greater challenges, also in Germany. To master these successfully, optimized processes with high efficiency are indispensable. As in many other areas, software is a key technology in the agricultural domain as well. In modern Farm Management Information Systems (FMIS), but also in tractors and implements, software-based innovations bring crucial competitive advantages. Data and its intelligent interpretation for the purpose of automating, optimizing, and simplifying agricultural processes is an essential element of the digital transformation.

With its research program “Agriculture & Food”, Fraunhofer IESE supports companies in this process and conducts research into innovative technologies and solutions for Smart Farming.

Digital Healthcare

The healthcare sector is in a state of upheaval and is facing complex challenges. The shortage of public funds coupled with rising demand for healthcare services from a steadily aging population and the rapidly advancing digitalization in the healthcare industry are important drivers in this context.

The research program “Digital Healthcare” at Fraunhofer IESE supports all stakeholders in the healthcare sector on their way to shaping the future of healthcare through digitalization. With the help of Artificial Intelligence and digital innovations, we contribute to increasing the efficiency of the system and improving patient care, while at the same time reducing or streamlining the costs in healthcare and the healthcare industry.

Autonomous Systems

Autonomous systems offer enormous potential to solve acute ecological, social, and economic challenges. For example, field robots can reduce the use of herbicides through mechanical weed management. Cobots and autonomous mobile robots (AMRs) can be used in a variety of ways in production and healthcare to increase efficiency and counteract the shortage of skilled workers. Robotaxis and drones that fly autonomously are further examples of the potential and diversity of use cases.

With its competencies and its network, the research program “Autonomous Systems” of Fraunhofer IESE helps suppliers, manufacturers, and operators to move from prototypes and application ideas to market-ready autonomous products, dependable applications/services, and innovative business models.

Budget & Cost Development

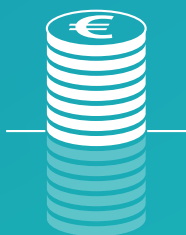
BUDGET DEVELOPMENT (IN MILLION EUROS)

- Public Projects
- Industry Projects
- Base Funding



COST DEVELOPMENT (IN MILLION EUROS)

- Investments
- Operating Costs
- Personnel Costs



Personnel (IN NUMBER OF HEADS)



201

CORE STAFF

10

**APPRENTICES &
COOPERATIVE
DEGREE STUDENTS**



61

**STUDENT RESEARCH
ASSISTANTS**

Women for Science

Fraunhofer IESE as an employer that promotes diversity and equal opportunities

It is 2023 and we are still campaigning for equal opportunities for women? And we do this at such a future-oriented and innovative employer as Fraunhofer? Of course, because there are still many adjustments to be made until we as a society have created the conditions we need to support men and women equally in their professional careers and their own life plans. Also, equal opportunity does not mean per se that women should now be favored in any way – but they should be given the same opportunities as men.

Male colleagues, too, can and should be able to apply for and take their parental leave without hesitation; part-time models for fathers are also a tried and tested means of organizing family life in parallel with professional obligations ... and perhaps we are already one step further at Fraunhofer IESE in this respect.

Flexible working as a goal – always adapted to the circumstances of one's life

In any case, we have been working on a good work-life balance in many respects for years. Women in our domain – i.e., research and science – are highly educated and usually interested in continuing their professional careers even if the circumstances of their life change when they start a family. At Fraunhofer IESE, we have a whole range of examples of women who have already been working at the Institute for several years, now have families, and have found the right balance for themselves. Others are at the beginning of their careers and should be able to work with the confidence that their career does not have to lose its momentum when the circumstances of their life change.

The Fraunhofer-Gesellschaft is attractive as an employer that not only promotes the further development of its employees, but also reacts flexibly depending on the individual's current life situation. Here, in particular, employers are called upon to make unreserved decisions when hiring and/or extending contracts and not to use gender as a factor.

The MINT challenge – still the special challenge

With its core competence, Fraunhofer IESE is a very MINT-oriented institute that recruits its researchers primarily from the fields of computer science, mechanical engineering, mathematics, and physics. And this shows that there is still a great imbalance in the choice of study subjects in Germany. Only just under 20 percent of first-year computer science students are female. And this number decreases even further during the course of studies. The reason for this may be that there is still some kind of “compartmentalized thinking” – or perhaps there is simply a lack of awareness of how varied the fields of work of computer scientists are.



Computer science is much more than just lines and codes – computer science is used by all those who solve our economic and social challenges of today and tomorrow! This is also demonstrated by the many different topics in which Fraunhofer IESE is active, on which we advise customers or work on solutions for our society in public projects. Our teams should therefore be just as colorful and diverse as the beneficiaries of our work. Different perspectives and points of view, requirements, wishes, and ways of thinking ultimately improve the results that can be achieved. The “female” component in scientific work is therefore just as important as expertise from different disciplines.

A wide range of support options

At the organizational level, too, Fraunhofer not only wants to support young researchers, but also explicitly work on making job profiles and roles more understandable to both women and men and presenting them as an option for their own professional careers. This starts at an early stage already: In addition to nationwide initiatives such as the Girls’ Day and collaborations between schools and Fraunhofer Institutes, there are also special human resources development programs for women, female mentors, and dedicated role models who

demonstrate in many different ways what they can achieve in research and at Fraunhofer.

“Talenta” is a program of the Fraunhofer-Gesellschaft that offers young female researchers at different career levels an additional development opportunity to take a close look at themselves and their own careers. “Talenta start”, “Talenta speed up”, and “Talenta excellence” are the three building blocks that pick up women at exactly the point where they currently are on their career path. This also creates a strong network within the female Fraunhofer community that offers support and help with typical career issues.

Last but not least, at all Fraunhofer Institutes our Equal Opportunities Officers are committed to ensuring that the interests of ALL employees are taken into account in the working environment and workplace culture at Fraunhofer. Together with our colleagues, we are gradually creating the conditions that are necessary for the development of an equal opportunities and diverse working environment in the near future.

Welcome @Fraunhofer IESE!

ONBOARDING is a top priority at IESE

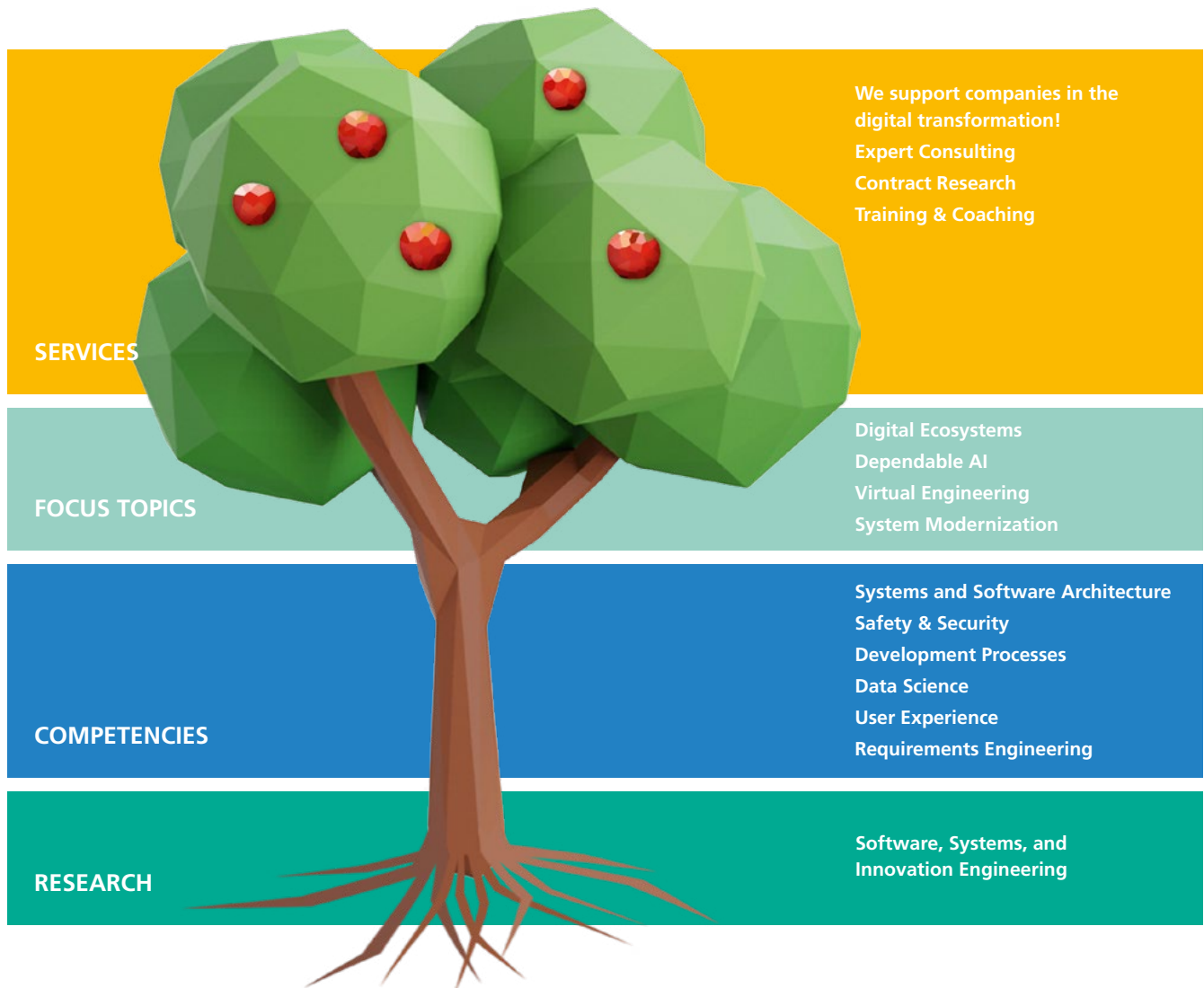
With our Newbies event as one building block in onboarding, we have created a welcoming format for new employees at IESE. At this all-day introductory event, we provide our new “MORGEN DENKER” with a lot of basic knowledge and tools relating to our Institute – combined with a lot of fun.

The aim is to make it easier for newcomers to start their job at IESE. The topics addressed range from Administrative Management and IT Services to Business Development, Corporate Communications, and Facility Management. In interactive sessions, the new employees learn all about the processes, working methods, and special features of IESE and can already establish their first contacts with their new colleagues.



Are you also thinking about TOMORROW? Then we invite you to find out about our current job vacancies and become a new MORGEN DENKER at IESE!

Research as the root of success... ...so that your projects will bear fruit!



Our research in the areas of software, systems, and innovation engineering is the root of your success, because our research results flow directly into our service offerings and customer projects – for a better life, sustainability, and economic success.

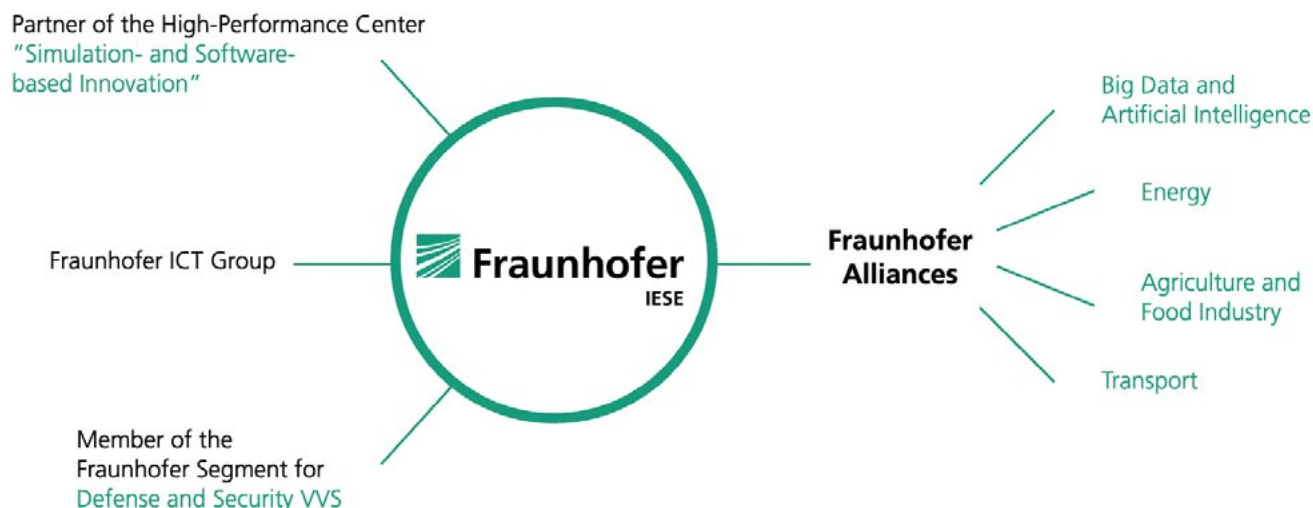
In both research and industry projects, we apply our competencies to continuously help our customers move forward. Our competencies thus form the solid trunk on which the success of Fraunhofer IESE and its customers is based. The competencies

of IESE in turn form four main branches, namely our focus topics. We have tailored these topics specifically to the requirements of our customers and are offering numerous services in this area, such as expert consulting, contract research, or training as a partner for companies.

We support you as our customer in a wide range of industries and conduct research for you on trend-setting key technologies so that your projects will continue to bear fruit in the future!

Alliances & Networks

Fraunhofer networks



Other selected networks

bitkom e.V.

Working groups: Arbeit 4.0, Projektmanagement, Qualitätsmanagement, Plattformen, Smart City/Smart Region, Digitale Landwirtschaft, Digital Design, Open Data/Open API
www.bitkom.org

Commercial Vehicle Cluster Südwest (CVC)

www.cvc-suedwest.com

Deutsches Institut für Normung e. V.

Standardization committee:
 DIN/DKE NA 043-01-42 GA "Künstliche Intelligenz"
www.din.de

DLG e.V. (Deutsche Landwirtschafts-Gesellschaft)

www.dlg.org

Gesellschaft für Systems Engineering e.V. (GfSE)

Arbeitsgruppe System Architecture Framework | www.gfse.de

GI e.V. – Gesellschaft für Informatik

Different groups, incl. Board Task Force "Data Science / Data Literacy", Fachgruppe Software-Messung und -Bewertung | www.gi.de

ISERN – International Software Engineering Research Network | isern.iese.de

Industrial Digital Twin Association e.V. (IDTA)

www.industrialdigitaltwin.org

MedTec Pharma e.V. | www.medtech-pharma.de

MiC 4.0 | www.mic40.org

Plattform Industrie 4.0 | www.plattform-i40.de

ProSTEP ivip e.V. | www.prostep.org

SIAK – Science & Innovation Alliance Kaiserslautern

www.siak-kl.com

Softwareforen Leipzig | User Group Requirements Engineering | www.softwareforen.de

VDI – Verein Deutscher Ingenieure e.V. | www.vdi.de

ZD.B (Zentrum Digitalisierung Bayern) – Plattform Digitales Landmanagement | www.zentrum-digitalisierung.bayern

Institute and Administrative Management



Prof. Dr. Peter Liggesmeyer
Director



Prof. Dr. Frank Bomarius
Deputy Director



Prof. Dr. Jörg Dörr
Extended Institute
Management



Nicole Spanier-Baro
Administrative Director

Organizational Chart

DIRECTOR Prof. Dr. Peter Liggesmeyer					
DEPUTY DIRECTOR Prof. Dr. Frank Bomarius			EXTENDED INSTITUTE MANAGEMENT Prof. Dr. Jörg Dörr		
EMBEDDED SYSTEMS Dr. Thomas Kuhn	DEPENDABLE SYSTEMS Dr. Daniel Schneider	DIGITAL INNOVATION & SMART CITY Steffen Hess	BUSINESS DEVELOPMENT Ralf Kalmar	COMMUNICATIONS & CENTRAL SERVICES Nicole Spanier-Baro	RESEARCH PROGRAMS Prof. Dr. Jörg Dörr
EMBEDDED SYSTEMS ENGINEERING (ESY) Dr. Martin Becker	DATA SCIENCE (DS) Dr. Andreas Jedlitschka	DIGITAL INNOVATION DESIGN (DID) Dr. Matthias Koch & Patrick Mennig	AUTOMOTIVE & MOBILITY Sebastian Siegmund	CORPORATE COMMUNICATIONS & TECHNOLOGY MARKETING	AGRICULTURE & FOOD Prof. Dr. Jörg Dörr
	SECURITY ENGINEERING (SE) Dr. Christian Jung	ARCHITECTURE-CENTRIC ENGINEERING (ACE) Bernd Rauch & Dr. Joachim Weber	PRODUCTION Ralf Pfreunds Schuh	ELECTRONIC LIS & MARKET RESEARCH	DIGITAL HEALTHCARE Rolf van Lengen
VIRTUAL ENGINEERING (VE) Dr. Pablo Oliveira Antonino	DIGITAL HEALTH ENGINEERING (DHE) Dr. Theresa Ahrens	SMART CITY DESIGN (SCD) Dr. Matthias Berg & Anne-Marie Kilpert	DIGITAL BUSINESS Dr. Agnieszka Krzeminska	ADMINISTRATIVE MANAGEMENT	AUTONOMOUS SYSTEMS Dr. Rasmus Adler
	SAFETY ENGINEERING (SAF) Dr. Daniel Schneider (act.)	SMART CITY ENGINEERING (SCE) Sabrina Lampe & Balthasar Weitzel	SMART CITY & SMART REGION Hannah Matheja	IT-SERVICES	BERLIN CONTACT OFFICE Gerald Swarat
				FACILITY MANAGEMENT	

As of September 2023

MORGEN DENKER



Perfect match for your career

Shaping tomorrow already today
– with Fraunhofer IESE!



s.fhg.de/iesecareer



Follow us on social media!

Advisory Board



At the last meeting, Prof. Liggesmeyer welcomed the members of the Advisory Board at a hybrid event.

Research

Prof. Dr. John A. McDermid

University of York, York, UK

Linda M. Northrop

SEI Fellow – Software Engineering Institute, Pittsburgh, USA

Prof. Dr. Arnd Poetzsch-Heffter

Technische Universität Kaiserslautern

Industry

Gerd Höfner

Siemens Healthcare Pvt. Ltd., Bangalore, India

Dr. Matthias Nachtmann

BASF SE, AP/IS, Limburgerhof

Thomas Pilz

Pilz GmbH & Co. KG, Ostfildern

Christine Regitz

SAP SE, Walldorf

Dr. Ian Thomas

OKIN Shared Services A.S., Prague, Czech Republic

Government

RDin Stefanie Nauel

Ministry of Economic Affairs, Transport, Agriculture and Viticulture of the State of Rhineland-Palatinate, Mainz

Dr. Carola Zimmermann

Ministry of Science and Health of the State of Rhineland-Palatinate, Mainz

Private Member

Renate Radon

Landau

Guest

Dr. Andreas Gerhardt

Ministry of Science and Health of the State of Rhineland-Palatinate, Mainz

Project Grant Numbers

AgriDataSpace | 101083401 (European Commission)

AutoDevSafetyOps | 01IS22087D (BMBF)

BaSys4Transfer | 01IS22089A (BMBF)

DAITA | 01IS17047 (BMBF)

DEMETER | 857202 (EU H2020-DT-IA)

Digitale Dörfer | 56:382 Digitale Dörfer
(Ministry of the Interior, for Sports and Infrastructure
of the State of Rhineland-Palatinate)

DynaSos | 01IS21104 (BMBF)

Pfaff / EnStadt: Pfaff: Pfaff-Quartier, EnergieIKT |
03SBE112D (BMWK)

greenProd | 01MN23003C (BMWK)

KickStartTrustee | 16DTM117 (BMBF)

MobiGrid | 03EI4016C (BMWK)

ODH@Jülich | 03SF0608 (BMBF)

SATURN | ZMI1-2520DAT02D (German Federal Office of
Administration)

SESAME | 101017258 (European Commission)

Smart Wendeler Land | LKWND-2021-09
(County of St. Wendel)

Smarte.Land.Regionen | 2818SL001 (BMEL)

V&V Methoden | 19A19002K (BMWK)

X-KIT | 28DK1VTA21 (BLE)

Locations



Fraunhofer Institute for Experimental
Software Engineering IESE

Fraunhofer-Platz 1
67663 Kaiserslautern, Germany
Phone +49 631 6800-0
info@iese.fraunhofer.de

www.iese.fraunhofer.de



Fraunhofer Institute for Experimental
Software Engineering IESE – Berlin Liaison Office

Anna-Louisa-Karsch-Straße 2
10178 Berlin, Germany

Your contact person: Gerald Swarat
Phone +49 171 3344883
berlin@iese.fraunhofer.de

The Fraunhofer-Gesellschaft

The Fraunhofer-Gesellschaft based in Germany is the world's leading applied research organization. Prioritizing key future-relevant technologies and commercializing its findings in business and industry, it plays a major role in the innovation process. It is a trailblazer and trendsetter in innovative developments and research excellence. The Fraunhofer-Gesellschaft supports research and industry with inspiring ideas and sustainable scientific and technological solutions and is helping shape our society and our future.

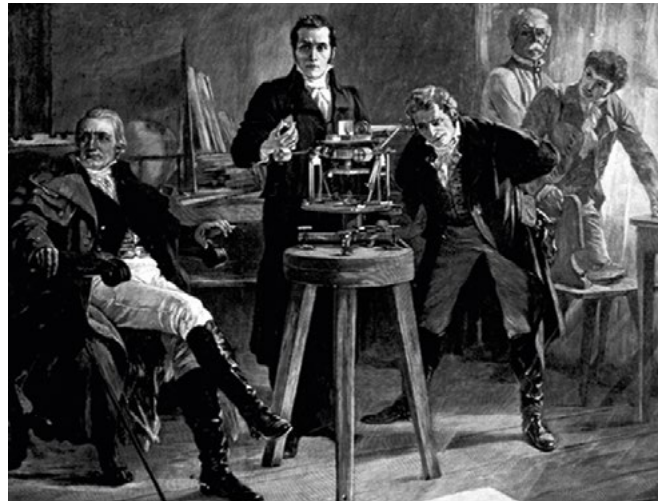
The Fraunhofer-Gesellschaft's interdisciplinary research teams turn original ideas into innovations together with contracting industry and public sector partners, coordinate and complete essential key research policy projects and strengthen the German and European economy with ethical value creation. International collaborative partnerships with outstanding research partners and businesses all over the world provide for direct dialogue with the most prominent scientific communities and most dominant economic regions.

Founded in 1949, the Fraunhofer-Gesellschaft currently operates 76 institutes and research units throughout Germany. Over 30,800 employees, predominantly scientists and engineers, work with an annual research budget of €3.0 billion. Fraunhofer generates €2.6 billion of this from contract research. Industry contracts and publicly funded research projects account for around two thirds of that. The federal and state governments contribute around another third as base funding, enabling institutes to develop solutions now to problems that will become crucial to industry and society in the near future.

The impact of applied research goes far beyond its direct benefits to clients: Fraunhofer institutes enhance businesses' performance, improve social acceptance of advanced technology and educate and train the urgently needed next generation of research scientists and engineers.

Highly motivated employees up on cutting-edge research constitute the most important success factor for us as a research organization. Fraunhofer consequently provides opportunities for independent, creative and goal-driven work and thus for professional and personal development, qualifying individuals for challenging positions at our institutes, at higher education institutions, in industry and in society. Practical training and early contacts with clients open outstanding opportunities for students to find jobs and experience growth in business and industry.

The prestigious nonprofit Fraunhofer-Gesellschaft's name-sake is Munich scholar Joseph von Fraunhofer (1787–1826). He enjoyed equal success as a researcher, inventor and entrepreneur.



The man behind the name: Joseph von Fraunhofer



Editorial Notes

Editorial Board & Interviews

Claudia Reis, Dipl.-Kauffrau (responsible)
Fabienne Bäcker, M.A.

Proofreading and Translation

Dipl.-Dolm. Sonnhild Namingha

Layout and Setting

Julia Kirch, M.A.
Bettina Wassermann, Dipl.-Industrie-
designerin (FH)

Printed by

KerkerDruck GmbH, Kaiserslautern

This annual report was produced in a climate-neutral manner. The paper used is FCS-certified and is produced 100% from recycled materials.



Your contact person for PR and marketing

Claudia Reis
Team Leader
Corporate Communications &
Technology Marketing
Phone +49 631 6800-0
presse@iese.fraunhofer.de

www.iese.fraunhofer.de

Image Credits

Fraunhofer IESE: Julia Kirch, David Kurz, Claudia Reis

Others:

Cover: [unsplash.com/Jason Leung](https://unsplash.com/Jason-Leung); Fraunhofer IESE | p. 3: unsplash.com/jason-hawke; Fraunhofer IESE | p. 10: iStock.com/In-future; [SARINYAPINNGAM](https://iStock.com/SARINYAPINNGAM); Fraunhofer IESE | p. 12: iStock.com/Tanaonte | p. 17: iStock.com/Fahroni | p. 18: [ASTOC/Mess 2018](https://iStock.com/ASTOC/Mess-2018) | p. 19: [Pfaff Landkarte](https://iStock.com/Pfaff-Landkarte) | p. 20: stock.adobe.com/arquiplay77; Fraunhofer IESE | p. 23: iStock.com/Betelgejze | pp. 24-25: Benjamin Sitzmann | pp. 26-27: unsplash.com/jason-hawke; Fraunhofer IESE | p. 28: iStock.com/Ridofranz; Fraunhofer IESE | p. 30: iStock.com/Ralwel; iStock.com/temmuzcan; iStock.com/Prostock-Studio; [iStock.com/pulfic_senior](https://iStock.com/pulfic-senior); Fraunhofer IESE | p. 32: iStock.com/luismmolina | p. 33: iStock.com/gorodenkoff; iStock.com/peterschreiber.media; iStock.com/Deagreez; iStock.com/luismmolina; Fraunhofer IESE | p. 35: iStock.com/in-future; iStock.com/ipopba | p. 38: iStock.com/RGBAlpha | p. 39: iStock.com/RGBAlpha; Fraunhofer IESE | p. 41: iStock.com/balwan; Fraunhofer IESE | p. 45: iStock.com/id-work | p. 46: iStock.com/Artis777 | p. 49: Hitachi; Springer-Verlag | p. 50: iStock.com/Annasunny; iStock.com/NataGolubnycha; Fraunhofer IESE | pp. 52-53: [unsplash.com/Getty Images](https://unsplash.com/Getty-Images) | p. 54: Markus Jürgens | p. 55: Till Budde | p. 57 bottom: Fraunhofer IVI | p. 58: Uni Paderborn | p. 60, 63: [iStock.com/Anton Vierietin](https://iStock.com/Anton-Vierietin) | pp. 64-65: unsplash.com/tim-schmidbauer; Fraunhofer IESE | p. 66: iStock.com/piranka | p. 72: iStock.com/lerbank | p. 74: iStock.com/PraewBlackWhite | p. 82: [unsplash.com/Getty Images](https://unsplash.com/Getty-Images); Fraunhofer IESE



Contact

Fraunhofer Institute for Experimental
Software Engineering IESE

Fraunhofer-Platz 1
67663 Kaiserslautern
Germany

Phone: +49 631 6800-0
info@iese.fraunhofer.de
www.iese.fraunhofer.de

#STAYCONNECTED

