Fraunhofer Institute for Experimental
Software Engineering IESE

#ENGINEERING
THEDIGITALFUTURE
since 96

Annual Report 2020/2021
—

25 Years of Shaping the Digital Future
– with Software, Systems and
Innovation Engineering

As Institute Director of IESE,
Prof. Peter Liggesmeyer
has been driving digital
innovations since 2015.

Dear readers,

—

25 years of software-, systems, and innovation engineering – with this anniversary edition of our annual report, we cordially invite you to look back with us and review the exciting development of IESE. But above all, let es look ahead, because with our applied research, we always have the future in mind! Therefore, we would like to take you along into the digital future in our cover story or in the chapter "IESE in Trend"!

When IESE was founded in the 1990s, the focus was on software engineering, and at the institute also on the topic of software processes. After that, the requirements shifted successively, because there was a return to more technology-oriented issues. Today we primarily deal with very large, networked systems that can no longer be unambiguously assigned to one discipline. And networking is a central component of the digital transformation.

In addition, innovation engineering is taking on a whole new meaning, because our customers' requirements are also becoming increasinly complex, so we first work together with companies in creativity workshops to determine what the real issues are and which challenges exist. Always with the goal in mind of putting together an optimal service package and making the customer fit for their digital future!

Of course, this large topic complex of "systems engineering" with its nove technologies

and novel business processes – cutting across a multitude of disciplines – cannot be addressed satisfactorily by a single institute. Therefore, we have to set priorities and it makes sense to base these on existing competencies.

We have chosen the four focus topics "Digital Ecosystems", "Dependable AI", i.e., dependable Artificial Intelligence, "Virtual Engineering", i.e., virtualization in the development of systems,and "System Modernization". With these, we are addressing a relevant topic in each case, which we believe has both scientific challenges and markets that are waiting for appropriate solutions to be made available. In other words, these systems engineering topics suit us because they incorporate our expertise; but they also fit the challenges of what will happen in systems engineering in the future!

Learn more about this in our cover story or in our podcast series "MORGEN *DENKER*".

Best regards

Peter Liggesmeyer

Content

Highlights

Projects

IESE at a Glance

Editorial Notes

Cover Story

Engineering Disciplines Viewed Holistically

Software, systems and innovation engineering ensure high software quality

Innovations are increasingly based on software. Today, software controls highly complex processes and is highly networked. But if it is to be relied upon, it must meet high quality standards. However, its quality is difficult to grasp and, at the same time, software whose quality is inadequate is very problematic. The more critical the intended use, the higher the demands on quality and its verifiability. Ultimately, quality is a mix of numerous, differently weighted quality attributes and their concrete attainment.

This is why quality in software, systems and innovation engineering is a goal with many facets, which must be considered in all engineering disciplines in an engineering-style manner. Dependable quality statements require modern methods and a systematic approach.

Fraunhofer IESE supports its customers holistically. This covers the entire spectrum from strategic decisions in management to technical issues in the areas of architecture, implementation, or testing. Depending on their customers' needs and wishes, the experts of IESE accompany their customers either comprehensively from the first steps over the entire lifecycle of a project – or only for selected issues.

It's the interaction that counts!

Many problems faced by companies have to be viewed systemically and holistically. This characterizes the approach of Fraunhofer IESE: The starting point is always the respective individual situation for which effective solutions are developed together with the customer. The great advantage: as an independent institution, evaluations by Fraunhofer IESE are neutral and objective. The IESE researchers bring expertise and passion to the engineering of innovative software-based systems. They are very familiar with all necessary engineering disciplines and their interaction.

Special focus areas:

- Creativity and Requirements Engineering
- System and Software Architecture
- Data Science, Data Analytics, and Data Engineering
- Development Processes

With a focus on the following quality features:

- User Experience
- Data Security and Data Sovereignty
- Functional Safety
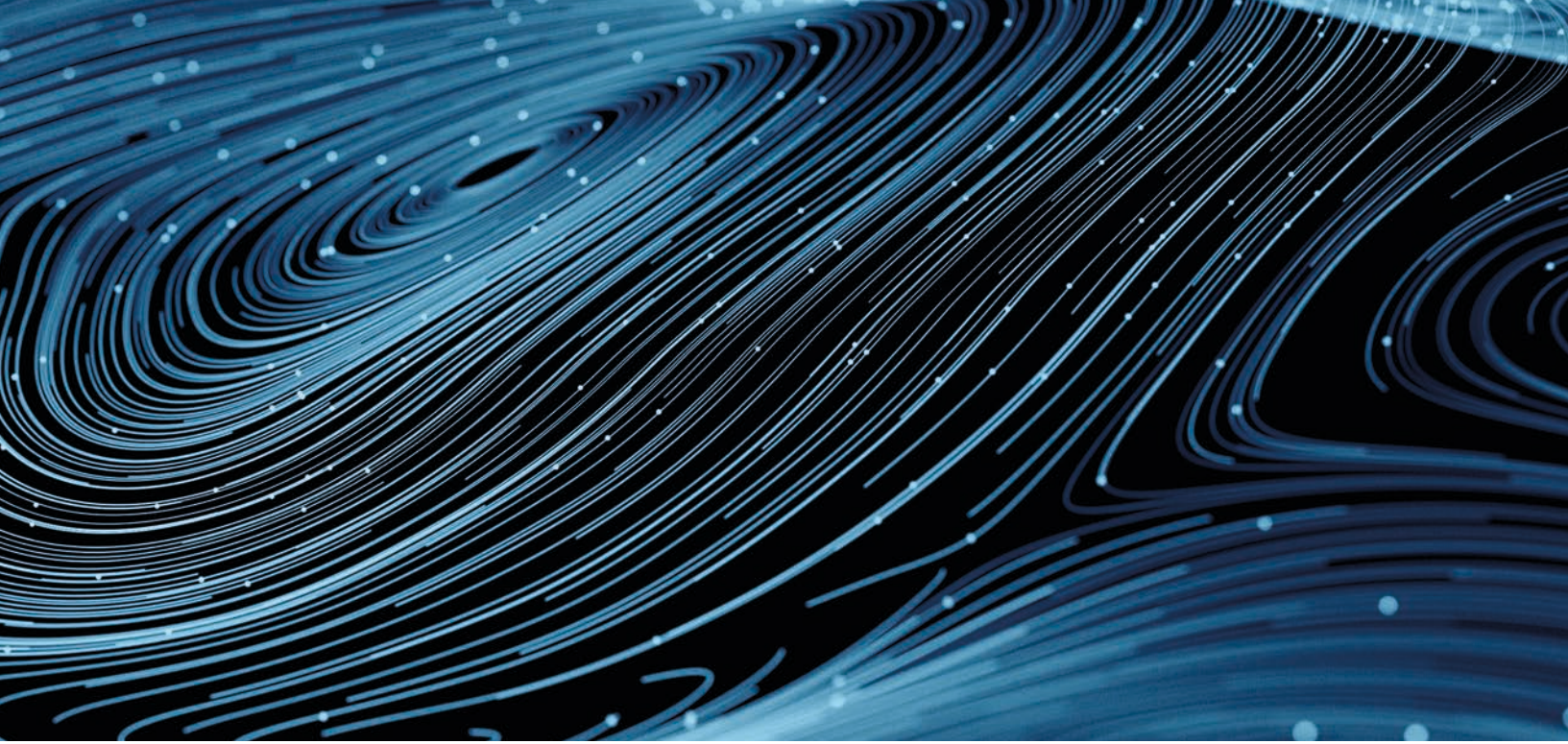
Bundling services according to requirements

Fraunhofer IESE places the focus on current, urgent, and complex challenges in the area of software and bundles its corresponding services:

Digital Ecosystems
IESE supports customers in positioning themselves with regard to Digital Ecosystems and the Platform Economy and in establishing successful Digital Ecosystems.

Dependable AI
Making it possible to use AI technologies even in critical applications – IESE works with its customers to find the right use cases and develop dependable AI systems.

Digital Twin (VE)
With Virtual Engineering (VE) and Digital Twins, IESE helps companies create virtual test environments that address the increasing complexity of systems more flexibly and cost-effectively.
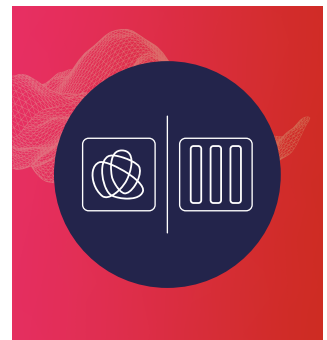
System Modernization
IESE supports companies in making their systems fit for the future: from independent analysis to the introduction of new technologies to strategic re-alignment.

Software is the innovation driver number 1!«

Dr. Marcus Trapp,
Department Head
Digital Innovation Design

Innovation Engineering

How creative ideas become innovations

Dr. Marcus Trapp, Department Head Digital Innovation Design at Fraunhofer IESE, has already gained a lot of experience in the area of innovation engineering, having completed more than 100 projects. He is also the IESE expert when it comes to conducting creativity workshops. In this interview, he provides insight into what constitutes an innovation and how the engineering process can be used to implement an idea.

What is an innovation and what types of innovations are there anyway?

First of all, it is important to clarify what "innovation" actually means. This term is often confused with the English word "invention". But a great idea for an invention is not automatically an innovation! In the case of a true innovation, a large group of people has recognized a benefit in the invention, accepts it, and uses it. Only then does the invention become an innovation.

Which types of innovations are there? On the one hand, existing products or services can be made one dimension better. On the other hand, there is "radical innovation". This includes innovations that can revolutionize an entire industry and which are often characterized by new business models. In both types of innovations, we at Fraunhofer IESE accompany businesses in turning their idea into an innovation. Of course, this is much more complex in the case of a radical innovation.

What is innovation engineering?

What is done with the help of innovation engineering is to approach the process in an engineering-style manner. Various professional principles, techniques, methods, and tools support the finding and selection of suitable ideas as well as the implementation of the innovation. The goal is to actually turn an idea into an innovation and to accelerate the process of getting there through innovation engineering.

In the digital world, the innovation cycle – that is, the speed at which new innovations are expected by society – has become much faster. As a result, companies are also under pressure to bring new products and services to market with increasing frequency.

Why is innovation engineering – together with software and systems engineering – one of the core services of IESE?

This question can be answered quite clearly, because innovation engineering plays a role in almost every one of our products, even if it is not always explicitly named as such. For more than ten years, we have already been dealing with this topic area systematically because it forms the basis for many software products. This means that innovation engineering plays just as important a role as pure software engineering.

However, there are many customers who do not associate this development of ideas with classic software and systems engineering. Since we want to make clear to these customers that we at Fraunhofer IESE can already support them in the early phase of the engineering process, we have explicitly included the term "Innovation Engineering" in our overarching service portfolio.

For which industries is innovation engineering particularly suitable?

Innovation engineering is completely independent of any industry. We have already carried out projects in many different industries, e.g., in the finance or automotive industry, but we have also worked in the areas of refrigeration technology, agriculture, aviation, chemical industry, and retail.

In these early phases of idea development, there is not only no dependence on any particular industry, but also no dependence on software. But in today's world, the likelihood that we will end up with an innovation that has at least some software content is close to 100 percent. Software is the number 1 innovation driver of all!

The "Innovation Space" at IESE is the perfect place to develop creative ideas.

What is the greatest challenge in innovation engineering?

Often, the first major hurdle for companies is to develop suitable ideas in the first place. The important thing is to create added value for their customers with the innovation. This sounds obvious, but unfortunately it is not.

If, for example, a product is manufactured at a lower price, but this price reduction is not passed on to the customer, then the benefit initially lies only with the company.

In order to become aware of what the benefit is for the customer, in innovation engineering we try to use concrete scenarios to understand how a product or service actually helps the customer, or what the risks are. We discuss such scenarios with companies in customer workshops, among other things.

Which methods are used in IESE's customer workshops?

We use a wide variety of methods and tools in our customer workshops. These workshops usually last between one and two and a half days and are individually adapted to the customers' requirements.

One concrete method is, for example, the "6-5-3 Brainwriting" method, which we have developed further in many different ways and which is used in many different variants. We also like to use scenario-based methods or "Forced Fit" approaches as well as evaluative methods such as "Buy-a-Feature". We usually base our workshop design on the work process of designers. Sometimes we also conduct specific "Design Thinking" workshops.

Are there other methods?

Of course, there are many other creativity techniques, such as the "Design Sprint" method or the "Hackathon" method, which help to develop new solutions within a short period of time. Mostly, however, our workshops are put together completely individually for our customers.

Needless to say that we also use the creativity method we developed ourselves, the "Tangible Ecosystem Design" method. This makes the design of Digital Ecosystems tangible for our customers with the help of Playmobil® figures.

Your contact

Dr. Marcus Trapp
Department Head
Digital Innovation Design
Phone +49 631 6800-2186
marcus.trapp@
iese.fraunhofer.de

What is the outcome of such work-shops and what is the next step for the companies?

The goal is to elaborate suitable solution ideas for the customer's problem in the project team. But I would also like to emphasize: Innovation engineering is about more than a pure workshop; it is more about actually accompanying the customer – from the development of an idea to the market launch of the innovation.

After the workshop, the work is not over, because now the ideas that have been worked out have to be driven forward in the company. Depending on the product in question, the innovation engineering process can take months or even years – especially if a completely new business model is being established.

But the advantage for the customers is obvious: By implementing innovative solutions, they remain competitive and fit for the future in the long term.

How does IESE get involved in the follow-up to the workshops?

The more the implementation idea has something to do with software, the more intensively we experts from Fraunhofer IESE can support the companies all the way to their final solution.

This could mean, for example, that we set up a Digital Twin or develop an AI algorithm that checks whether the designed solution actually does what the customer really wants, or whether the right data is available. But we also help companies design a user interface or build a new platform for a Digital Ecosystem. We cover the whole lifecycle in software engineering!

How to playfully design a Digital Ecosystem? With the TED method of Fraunhofer IESE!
—

Digital Ecosystems are complex constructs that are difficult to grasp for many companies. With the "Tangible Ecosystem Design" (TED) method, the design of Digital Ecosystems literally becomes tangible.

In an interactive workshop with various platform players (stakeholders), Fraunhofer IESE supports the modeling of an ecosystem with the help of Playmobil® figures – including the platform, its services, and its actors. This is a first important step in thinking holistically about new digital services.

So what does such a workshop on designing a Digital Ecosystem look like in detail?
Find out in episode 7 of our
MORGEN *DENKER* podcast!

MORGEN DENKER

Listen on
Apple Podcasts

Listen on
Spotify

Digital Ecosystems are the
passion of Dr. Matthias Naab.

Digital Ecosystems

Added value for companies through networking of organizations, people, and IT systems

Interview with Dr. Matthias Naab,
Division Manager Digital Ecosystem Engineering at Fraunhofer IESE

Digital platforms such as Netflix, Booking.com, or Amazon Marketplace have turned their respective industries upside down. Currently, however, the majority of the most successful Digital Ecosystems come from Silicon Valley and increasingly also from China. What is more, most of them are aimed directly at end customers (B2C). But there is a lot of potential for more Digital Ecosystems – especially in business-to-business (B2B). This is precisely where the strength of the German economy traditionally lies. Fraunhofer IESE provides holistic support to companies to establish themselves as players in this field in Germany as well.

What is a Digital Ecosystem and what elements does it consist of?

Digital Ecosystems are socio-technical systems. This means that a Digital Ecosystem is more than a pure IT system. It is the networking between IT systems, organizations, people, and data that is the focus and and nature of Digital Ecosystems.

The core of a Digital Ecosystem is a service that – optimally – delivers added value for many people. This ecosystem service is offered on a digital platform through which companies and people can interact. In this context, the term "platform economy" is also used often. It is important that the participants have easy access to this platform and can derive personal benefit from the Digital Ecosystem. Only then will it be successful.

What would be a concrete example of a Digital Ecosystem?

Airbnb is a good example – the platform of Airbnb acts as a kind of marketplace around which a large ecosystem of providers and consumers has formed. Airbnb brokers accommodations between private providers and travelers. This central service is provided exclusively via the digital platform.

Do Digital Ecosystems make sense in all industries?

As a matter of principle, the answer to this is: Yes! Digital Ecosystems can be initiated in any industry, and several can even coexist as competitors in one industry. As with Apple and Google, who have built two competing Digital Ecosystems with iOS and Android.

Within an industry, many different types of Digital Ecosystems can emerge. In the area of mobility, the Digital Ecosystem Uber provides a ride service, while data ecosystems – such as those of Caruso or Otonomo – are concerned with delivering telematics data to data consumers via the Digital Ecosystem.

What opportunities does this create for companies?

On the one hand, there are companies that build Digital Ecosystems and offer their services. On the other hand, there are companies that participate in a Digital Ecosystem as participants.

»

We not only give good advice – we also roll up our sleeves to help give our customers a competitive edge.**«**

Your contact

Dr. Matthias Naab
Division Manager
Digital Ecosystem Engineering
Phone +49 631 6800-2249
matthias.naab@
iese.fraunhofer.de

The first category of companies has a huge amount of creative freedom and also the opportunity to completely reposition itself with a disruptive business model. That means they can reshape entire markets. The proof is Spotify, because very few people today still buy a CD to listen to music.

The second category, i.e., companies that participate in Digital Ecosystems, benefit from very easy access to a large number of providers or consumers with whom they can do business. The digital marketplace enables so-called network effects, which makes participation increasingly attractive.

What challenges do companies face?

To be honest, it does take a lot of effort to implement a Digital Ecosystem. It is not only the IT system that has to be developed; many organizational, business, and legal aspects also have to be taken into account in order to achieve the desired network effects. After all, without participants, a Digital Ecosystem will not be successful.

Apart from that, another obstacle is that there is no predefined guidance on how to develop this innovation, only advice and methods that companies can follow.

Which support does Fraunhofer IESE provide?

Fraunhofer IESE supports companies from strategic planning to technical implementation. Over the entire lifetime of Digital Ecosystems, from initiation to the establishment of the system, we stand by the companies as a partner.

Especially the strategic positioning and the adaptation of the business model are real challenges for many companies. As experts, we have already gained experience in a wide range of different domains, which we can now put to good use for our customers. We not only give good advice, but also roll up our sleeves to give our customers a competitive edge.

More on the topic of Digital Ecosystems

Find out more on
our website!

MORGEN
DENKER

Listen on
Apple Podcasts

Listen on
Spotify

This is what industry says!

Project Caruso GmbH – Digital Ecosystem and Plat Economy in the Automotive Aftermarket

Caruso GmbH developed its open and neutral data and service marketplace for the automotive aftermarket with the support of Fraunhofer IESE.

"Thanks to its experience with the topic of Digital Ecosystems, its pragmatic approach, and especially its neutrality, Fraunhofer IESE is a very important technology partner."

Alexander Haid,
Managing Director,
Caruso GmbH (until 2020)

By the way...
___

What do Digital Ecosystems have to do with nature?

Digital Ecosystems are inspired by nature in many ways.

The term "ecosystem" comes from the field of "ecology" and refers to the interactions between organisms and their natural environment. This term was deliberately adopted for the digital world because in Digital Ecosystems, the participants interact with each other in a specific environment and engage in business relationships.

In both the natural and digital variants, an ecosystem does not consist of a single individual. An ecosystem can only exist – and remain in balance – if it has a certain mass of participants. In nature, these participants are predominantly plants and animals, while in a Digital Ecosystem, they can be, for example, people, companies, services, products, or data.

An example of a man-made, natural ecosystem compared to a Digital Ecosystem: A landscaped pond with its plants first attracts flies, then other insects join them. This creates a food base that attracts frogs. As a result, more and more animals gather and live together at the pond. In a Digital Ecosystem, the platform with an ecosystem service forms the technical basis through which users can gradually participate in the ecosystem. The larger and better known a Digital Ecosystem becomes, the more attractive it becomes and the more participants will join it. However, a Digital Ecosystem typically needs an active push: You have to take care of the first participants very explicitly, otherwise nothing will come of it.

Just as in nature, the concept of evolution is also used in computer science. Thus, an ecosystem, even a digital one, is dependent on many external influencing factors. If the balance of an ecosystem is disturbed, it can no longer exist and dies out. In a natural ecosystem, this is often related to the food supply. But in a Digital Ecosystem, too, a sufficient supply of products and services and the demand for these form a central element for the continued existence of the ecosystem. Or it can happen that an ecosystem loses its attractiveness and, as a consequence, its users will leave. Social networks that lose their followers are examples of Digital Ecosystems that are out of balance and will gradually disappear.
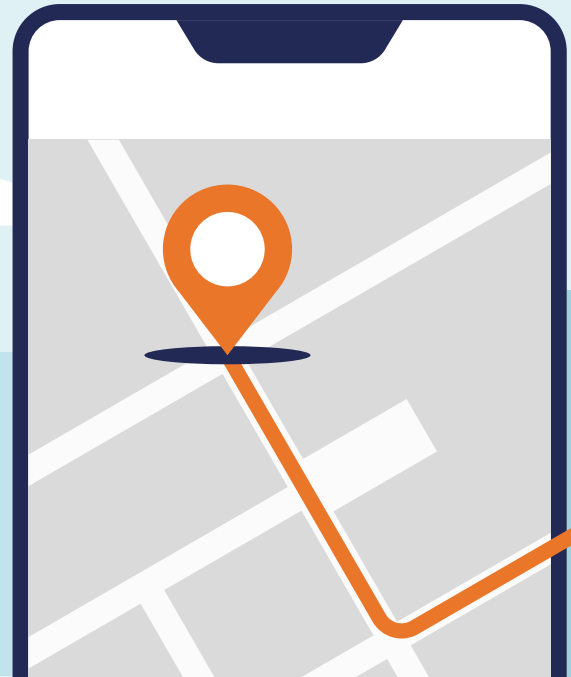
From lab to application

Smart MaaS: Digital Ecosystem as a B2B mobility service platform

Together with partners, Fraunhofer IESE developed a B2B service platform for Mobility as a Service and implemented it by way of example in the cities of Aachen and Kiel.

Smart MaaS improves collaboration in the B2B mobility sector

Already today, some major cities and regions in Germany offer their passengers the option of switching between different means of transportation via an app. In some cases, services such as carsharing, e-scooters, or rental bicycles are already networked with the respective public transport system, but the integration into a system encompassing various public transport associations is missing.

In order to bundle mobility offers in the sense of a Digital Ecosystem, Fraunhofer IESE collaborated with partners in the research project Smart MaaS (Mobility as a Service) to develop an open, modular, and service-oriented B2B platform through which mobility is offered as a smart service. This enables both established and up-and-coming companies from the mobility industry to combine their offerings. The aim is for passengers to get from door to door with the best possible and fastest connection.

In Smart MaaS, the service platform was implemented by way of an example in cities such as Aachen and Kiel for testing purposes. The project was funded by the German Federal Ministry for Economic Affairs and Energy in the technology program "Smart Service World II".

Fraunhofer IESE designed a Digital Ecosystem for Mobility as a Service

In Smart MaaS, Fraunhofer IESE contributed, in particular, its competence in the conception and design of Digital Ecosystems. For this purpose, the project team followed a comprehensive modeling methodology that, on the one hand, flexibly addresses the requirements and constraints of the mobility industry and, on the other hand, takes into account the different aspects of an ecosystem. Relevant decisions and core activities provided the framework for the design, e.g., the definition of the ecosystem actors, the business strategy, the required technical infrastructure, the openness strategy, as well as the implementation of the business strategy in services and applications.

In a business strategy, value flows, dependencies among services, contractual relationships, and money flows are taken into account, while an openness strategy determines the

Im Projekt »Smart MaaS« wurde ein Digitales Ökosystem für Mobilitätsangebote entwickelt.

exchange of information between the partners and the openness of the ecosystem for new partners.

Once the contributions of the individual ecosystem partners had been defined and aligned, Fraunhofer IESE evaluated the overall concept. In doing so, both the value of the ecosystem for all involved stakeholders and the consistency of the decisions made were examined.

New Digital Ecosystem facilitates the implementation of innovative business models

The concept of a Digital Ecosystem for MaaS on the basis of the B2B platform now enables companies from the mobility sector to build on the applications of the respective other platform participants. This allows new business models to be created on an ongoing basis. The platform allows previously largely isolated data to be securely networked and marketed as standard-compliant web services.

All important information is contained in the developed concept and can be further processed and implemented by software architects, contract departments, or product management.

With the new service platform, everyone can find a suitable mobility offer.

About Smart MaaS

Funded by:
German Federal Ministry for Economic Affairs and Energy
Budget:
approx. 3.8 million €
Duration:
04/2018 – 03/2021
Project Partners:
Fraunhofer IESE, FIWARE, Cleopa, Better Mobility, DFKI

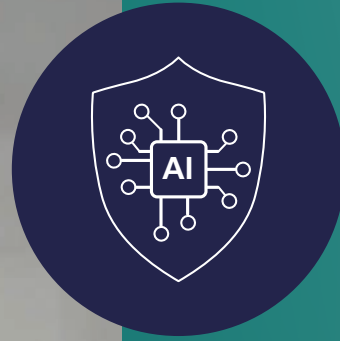**DO YOU HAVE A CHALLENGE FOR US?**

Talk to us!

Dr. Karina Barreto Villela
Project Manager
karina.villela@
iese.fraunhofer.de

For Dr. Jens Heidrich, the dependability of AI is the focus of his work.

Dependable AI

How to control the risk of unacceptable failures of AI

Interview with Dr. Jens Heidrich,
Division Manager Smart Digital Solutions at Fraunhofer IESE

Artificial Intelligence (AI) is something that we will encounter much more frequently in the future, especially in critical application areas such as autonomous systems, Industrie 4.0, or medical technology. Here, Dependable AI – that is, controlling the risk of unacceptable failures – plays an important role. Fraunhofer IESE supports companies in engineering dependable AI systems and accompanies them throughout the entire lifecycle.

What does the qualifier "Dependable" mean in relation to AI?

Dependability of an AI system describes its ability to avoid unacceptable failures. Consider, for example, an autonomous vehicle: One would, of course, want to avoid at all costs that the vehicle does not correctly recognize a child who suddenly appears in traffic, with fatal consequences. So we want a safe AI that reacts correctly in such a situation. That is, by dependability we mean all the properties related to the dependability of the AI system. Dependable AI thus refers to all AI systems that are constructed in such a way that they are actually dependable in the sense of this definition.

What is the focus of IESE in the topic area of Dependable AI?

At Fraunhofer IESE, we place a special focus on safety assurance of Artificial Intelligence, resp. functional safety, i.e., the safety of the AI system. The goal is to avoid failures that pose a danger to life and limb.

What are potential uses of dependable AI systems?

There are a great many opportunities and possibilities in this area. For example, AI is an enabler for new products that could not even be implemented without Artificial Intelligence. Without AI, there would be neither autonomous driving nor Industrie 4.0. Many AI systems are based on Machine Learning. This method offers numerous possible applications: In medicine, for example, AI can be used to analyze image data in order to carry out some preliminary diagnostics.

The possibilities of using AI systems are almost unlimited – essentially, this includes everything that is Smart X. This is what we call it at IESE; the X can be replaced in any way: Smart Mobility, Smart Health, Smart City, Smart Farming, or much more. All these systems from different domains can be equipped with a certain intelligence.

Apart from new products for smart application areas – how else can AI systems be used?

There is also AI that optimizes existing processes, as in the case of Predictive Maintenance, for example. By intelligently predicting when a machine will fail, the entire production process runs much more efficiently. This shows that dependable AI systems also provide many opportunities for industrial companies.

» Dependable AI requires multi-disciplinary expertise. And that is what we at IESE bring to the table!«

Your contact

Dr. Jens Heidrich
Division Manager
Smart Digital Solutions
Phone +49 631 6800-2193
jens.heidrich@
iese.fraunhofer.de

What exactly are the benefits for industry?

Companies will save real money. By making processes more efficient, of course. If, for example, a production machine fails, the company incurs a huge loss. However, if a defective part is replaced on time during non-load times of the machine – be it on the weekend or in the evening hours – before the failure even occurs, the company will naturally save money. In addition, AI systems offer the advantage that companies can gain a competitive edge by developing new products that would not have existed without dependable AI.

How can Fraunhofer IESE support companies in this?

First of all, we approach problems holistically. On the one hand, as an applied research institute, we are always informed about the latest developments in this topic area. On the other hand, we have implemented such AI systems in practice in numerous industry projects.

Which experts are necessary to realize a dependable AI system?

This topic is very multi-disciplinary in nature, which requires expertise in many different fields, which we can offer. On the one hand, expertise in innovation engineering is needed to clearly work out the possibilities offered by AI; for example, how a product or service can change through Artificial Intelligence. On the other hand, competencies from classic software and systems engineering are needed to really "build" the AI system. This starts with designing the system and reasoning

about what risks exist for the dependability of the system. This is followed by the architecture of such a system to ensure that the AI will work safely. And during operation, its reliability should be permanently monitored to make sure that it does not make a wrong decision. Apart from that, other experts are also very relevant: the so-called data scientists. These experts are very good at handling Big Data and developing AI models from it.

This trio is ultimately decisive in determining whether a company can implement a dependable AI system and thus gain a competitive advantage. This is exactly what we offer to companies!

More on the topic of Dependable AI

Find out more on
our website!

MORGEN DENKER

Listen on
Apple Podcasts

Listen on
Spotify

This is what industry says!

Project Hitachi Ltd. – Safety Engineering for Autonomous Driving Systems

"The cooperation with Fraunhofer IESE regarding a multi-aspect safety engineering method with safeTbox brought about substantial success for Hitachi R&D. We implemented the design method of the functional architecture for autonomous driving systems and analyzed the safety aspect simultaneously. Many thanks for the effort."

*Dr. Shiro Yamaoka,
Department Manager,
Hitachi Ltd.*

In the IAV project, IESE applied the Uncertainty Wrapper architecture to AI components.

Project IAV GmbH – AI Model with Dependable Uncertainty Estimates

In a bilateral technology transfer project with IAV GmbH, the "Uncertainty Wrapper" of Fraunhofer IESE was applied to an existing AI component to reliably estimate the situation-specific degree of uncertainty.

Dealing with unavoidable residual uncertainty in AI models

To cope more effectively with control engineering tasks, IAV product solutions from the field of automotive engineering increasingly include components based on Machine Learning methods and Artificial Intelligence (AI). Such methods are used, in particular, when interrelationships cannot be fully specified in advance, but must be learned on the basis of data. Therefore, even after intensive testing of such components, some residual uncertainty remains regarding the occurrence of faulty results in certain situations.

Use of the "Uncertainty Wrapper" of Fraunhofer IESE for dependable uncertainty estimates

The "Uncertainty Wrapper" architecture and analysis methodology developed at Fraunhofer IESE allows estimating this situation-specific degree of uncertainty reliably and und thus lays a dependable foundation for decisions made at development time as well as at runtime.

For example, certain types of situations with increased uncertainty can already be identified during development and can be mitigated by concrete design decisions. At runtime, dependable and at the same time situation-specific uncertainty information can be used, for example, as part of dynamic risk management. In this way, higher performance or availability of the normal function can be achieved, as it is not always necessary to rely on worst-case estimates to provide safety assurance for it.

Here, the "Uncertainty Wrapper" architecture addresses all three types of uncertainty sources in the corresponding shell model, i.e., uncertainty factors related to the model, the input, and the application context.

Transfer of the know-how into industrial practice

As part of a bilateral transfer project, the project team applied the IESE methodology to an existing AI component together with IAV GmbH. In a series of workshops, the corresponding know-how was successfully transferred into industrial practice based on customer-specific questions and many hands-on training opportunities for the participants.

About IAV GmbH

Headquarters: Berlin
Number of employees: approx. 8,000 (2019)
Industry: Engineering service provider of the automotive industry

DO YOU HAVE A CHALLENGE FOR US?

Talk to us!

Dr. Michael Kläs
Data Scientist
michael.klaes@ iese.fraunhofer.de

Virtual Engineering

Digital Twins optimize real systems through simulations

Interview with Dr. Thomas Kuhn,
Division Manager Embedded Systems at Fraunhofer IESE

In the world of embedded systems, which, for example, control the emergency braking function of a vehicle, the testing of new software architecture concepts plays a fundamental role. This testing would normally be done using expensive prototypes. With Virtual Engineering, these are replaced by Digital Twins – which enables companies to save real money.

What is meant by Virtual Engineering?

In Virtual Engineering, digital images of systems are created. This encompasses all devices, including the software functions, the environment, or the users. I can explain this using the example of a braking car: When you apply the brakes, many different systems interlock. One of these is the antilock braking system, which ensures that the tires do not lock up when braking. But when you hit the brakes on your car, it must be assured that the car actually brakes and does not keep going because of a software defect. All these systems and scenarios are digitally mapped with the help of Virtual Engineering.

How are such digital images created?

We use Digital Twins for this! This allows the systems to be tested virtually. Data is collected from the real world and then fed back into the virtual world. This makes it possible to examine and evaluate complex systems at an early stage.

This is particularly important for critical functions, such as highly automated or autonomous driving functions. These functions must be tested with a high number of kilometers driven – around 10 million kilometers are assumed here per software modification. Of course, this cannot be done with real vehicles. The solution are Digital Twins with simulated environments.

In which industry are Digital Twins used most widely?

At the moment, Digital Twins are very much present in the area of production. There, digital images of production processes are created in order to optimize them. For example, this makes it possible to recognize early on when maintenance is required on a system.

Digital Twins can also provide support in fulfilling documentation obligations. Errors that occur can be traced back with pinpoint accuracy if the manufacturing steps, including all devices and processes, have been recorded in a digital image. This makes it possible to ensure, for example, that a screw on the driver's seat was fastened correctly and that the seat therefore will not break loose in the event of an accident.

Apart from production – what would be other possible uses?

There are now very many possible uses, e.g., in the area of building management or infrastructure. There, Digital Twins are used to monitor the condition of bridges or buildings.

In the automotive industry, Digital Twins are used to record software statuses. This makes it possible to know exactly which configuration

With our virtual testbeds, companies save real money.«

Your contact

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

At a Glance

This is what our customers achieve with Virtual Engineering:

- Realize digital images of real systems with the help of Digital Twins
- Identify optimization potential
- Reduce downtimes of production plants
- Create virtual test environments
- Improve system quality
- Control and optimize processes
- Use virtual testing methods for new functions
- Develop suitable safety concepts
- Save time and money!

a car is running in, whether the vehicle needs a particular software update, or whether it would be vulnerable to attack.

Of course, Digital Twins are also used to develop new systems – automotive manufacturers, in particular, are leading the way here. They are already testing their new vehicles and driving functions virtually to discover potential defects.

How are Digital Twins actually implemented technically?

We have various tools at our disposal for this purpose. Among other things, we use the Industrie 4.0 middleware Eclipse BaSyx, which was largely developed by us and which implements the Industrie 4.0 asset administration shell. The asset administration shell, in turn, forms the technical basis for the very efficient creation of Digital Twins.

We have developed yet another tool: FERAL. With it, we can implement Digital Twins of complex systems, for example to build virtual testbeds.

Another tool of IESE is DRAMSys. DRAMSys is a tool that simulates accesses to DRAM memories and simultaneously allows optimizing them. This is very important because in the area of embedded systems, DRAM is not used so often yet; we can change that with our tool!

Independent of the tools – how exactly does IESE support companies?

We provide comprehensive consulting on the digitalization of systems and test environments. In production, we provide support, for example, in digitalizing a production process with the help of a Digital Twin, or we develop asset administration shells for production and products.

In the area of autonomous driving, we also realize virtual testbeds and setups so that highly automated and autonomous driving functions can be tested better.

Moreover, we support our customers in creating their own simulation solutions for company-specific challenges.

What benefits do companies gain from these solutions?

Companies can save real money with virtual testbeds. They are much less expensive than real testbeds because there is no need for expensive hardware.

In addition, virtual testbeds can also be instantiated much more easily, so they are available to developers much faster. Testing is performed earlier and time-to-market – i.e., the time until a product is ready for the market – is reduced enormously.

Production is another area where virtual commissioning can save important time. Today, the conversion of a production line to a new product is usually still tested on a real production line. This leads to downtimes and is therefore expensive. With virtual commissioning, we can shorten these times and save money as well.

More on the topic of Virtual Engineering
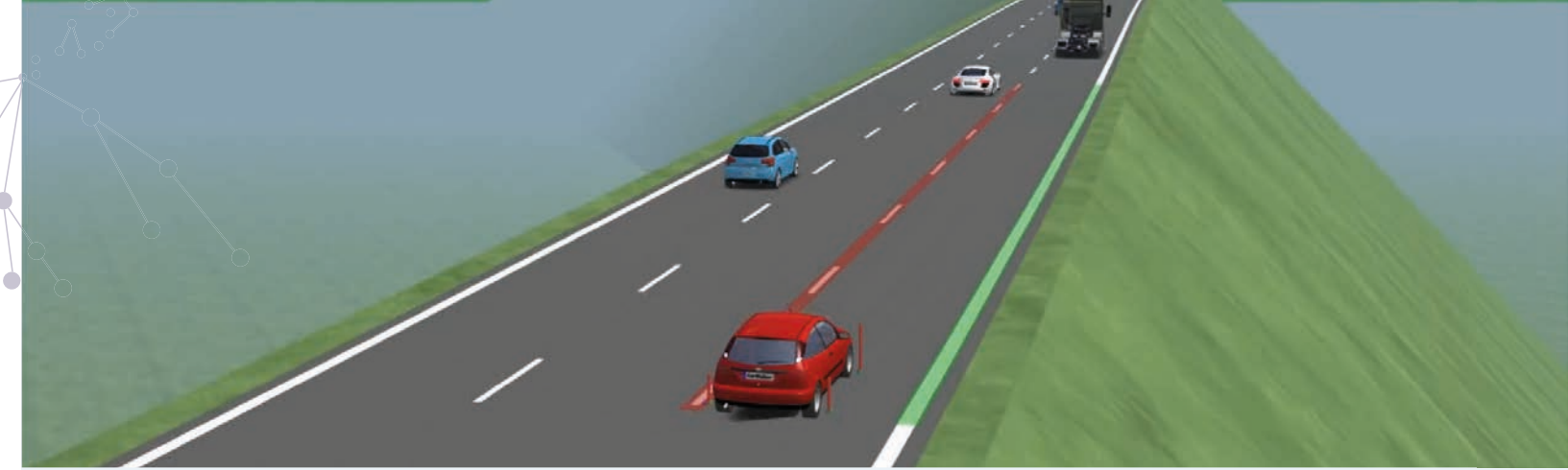
Find out more on our website!

MORGEN DENKER

Listen on Apple Podcasts

Listen on Spotify

FERAL can be used to simulate driving functions.

This is what industry says!

Project Robert Bosch GmbH: Virtual Validation of ECU Networks

Together with Robert Bosch GmbH, Fraunhofer IESE realized the virtual integration and validation of electronic control units (ECUs) using the Fraunhofer technology FERAL.

The potential of virtual validation of electronic control units

FERAL (FramEwork for Simulator Coupling on Requirements and Architecture Level) is a co-simulation platform for the virtual testing of electronic control units (ECUs). In addition to the functions of the ECU, the influences of the bus communication and the target platform can also be tested. Various buses, processors, and gateways are supported for this purpose. Robert Bosch GmbH commissioned an interface to FERAL from Fraunhofer IESE in order to use this platform in future tests during ECU development.

The challenges here mainly concerned the integration of the individual system components into a single simulation model. In addition to simulation models for vehicle dynamics and communication buses, real ECU code with an adapted AUTOSAR driver as well as mock-ups of additional ECUs were used. Together, the project team created a simulation model that can provide valuable information on quality aspects, such as vehicle bus utilization and response times.

Bosch secures electronic control units with FERAL

To integrate the system into the overall model, Bosch first equipped the virtual ECUs with an interface. For the AUTOSAR components, these were implemented in the MCAL layer, so that the application code did not have to be changed. Simulators for vehicle dynamics were loaded by means of existing Simulink and FMI interfaces. Simulation models for vehicle buses (here, CAN and Flexray were used) are already included in FERAL and could be used directly.

The resulting simulation system can be executed accordingly and is stimulated with input data from the simulation runtime environment. The integrated simulation system, in turn, realizes a co-simulation that simulates the vehicle dynamics, while the driving functions are executed in the simulated environment. Such a setup has the advantage that the system behavior can be observed at any point by means of "virtual terminals". This data can be exported and analyzed.

Due to the virtual setup, even critical system states or those that are hard to generate in the real environment can be easily recreated and evaluated. Bosch has licensed the FERAL framework in order to implement further virtual engineering tasks with it.

»

FERAL is characterized by its high flexibility. This enables us to cope with numerous tasks.«

Dr. Roland Samlaus,
Subproject Manager,
Platform Development Simulation Framework,
Robert Bosch GmbH

DO YOU HAVE A CHALLENGE FOR US?

—

Talk to us!

Dr. Thomas Kuhn
thomas.kuhn@
iese.fraunhofer.de

Bottom picture: Dr. Pablo Oliveira Antonino (left) and Dr. Dominik Rost (right) make legacy systems fit for the future.

System Modernization

Bringing software successfully into the digital future

Interview with Dr. Dominik Rost and Dr. Pablo Oliveira Antonino,
Department Head Architecture-Centric Engineering and Department Head Virtual
Engineering at Fraunhofer IESE

Successful software often lives longer than originally thought. Despite continuous maintenance, a state is often reached that practitioners refer to as "historically grown". This also manifests itself in rising maintenance costs and a lack of innovativeness. Then such systems should be modernized. But how can this be done? This is where the IESE experts support companies.

What is meant by system modernization?

Rost: System modernizations often focus on more and different aspects than just the functional further development of a system: If, for example, a technology used is no longer maintained, it has to be replaced, or if the system no longer meets expectations, it must be revised internally and externally, or you can change even fundamental paradigms. So if the user interface is redesigned, if production plants are equipped with data collection capabilities, or if even the business model is to be changed to Software as a Service, this is always system modernization. There are many different reasons for modernizing a system, but the reason is always to make the system fit for the future.

For which companies are system modernizations relevant?

Antonino: In principle, almost all companies are highly dependent on software – either they offer software-based services as their main business or they run another business, but the systems are embedded in the core of their business and they rely on software. Accordingly, all companies from any industry

have to deal with the topic of system modernization sooner or later.

What are the challenges of system modernization?

Antonino: I would first summarize it in this way: System modernization is definitely more difficult than building systems from scratch. It is often a challenge for companies to move away from things that they have become accustomed to – even if they do not work optimally. A major obstacle also lies in clearly defining a strategic goal. Does a company only want to implement some technological changes, or improve the user experience, or even optimize its business model? Companies need to think about this fundamental objective in advance.

The implementation of system modernization is often also complicated because something new has to be developed and integrated in parallel, while existing components are continued at the same time. In terms of software engineering, this is more difficult than developing software from scratch.

What are the various activities in system modernization?

Rost: After defining the modernization goal, an as-is analysis should be performed at the beginning of the modernization in order to become aware of the current state of the system and to find out where possible problems actually come from. A good way to do this are interviews with the various stakeholders. To go into even more depth, architecture reviews, quality analyses of technical artifacts (code, hardware, electronic parts), or even

» Improvement versus new development – as part of system modernization, our sound analyses help you make the right decision.«

Your contacts

Dr. Dominik Rost
Department Head
Architecture-Centric
Engineering
Phone +49 631 6800-2243
dominik.rost@
iese.fraunhofer.de

Dr. Pablo Oliveira Antonino
Department Head
Virtual Engineering
Phone +49 631 6800-2213
pablo.antonino@
iese.fraunhofer.de

3 Methods for System Modernization

1. **Refactoring:** By continuously rebuilding the code, it becomes more understandable and maintenance effort is minimized. This "small" improvement is important and useful, but not sufficient for comprehensive system modernizations.
2. **Re-architecting:** This means redesigning the basic structure of a system. This allows even risky changes or new ideas to be realized and far-reaching system modernizations to be implemented.
3. **Renewing:** In this case, the legacy system is replaced by software developed completely from scratch.

Streamlining the system can save costs in the long run. In principle, software should not serve an end in itself, but should contribute to the business objective. That is why it is very important to also rethink the business model as a whole.

Where does Fraunhofer IESE provide support?

Antonino: We can provide support in many activities because we are an institute that addresses software, systems and innovation engineering holistically. First, we analyze together with the company what the system should be able to do in the future. In this context, I would like to emphasize, in particular, that we as Fraunhofer IESE act completely neutrally and are not under any obligation to products or service providers. In the next step, we find suitable solutions for our customers' requirements – even if these are very specific. In doing so, we always keep an eye on the strategic issues in addition to the technical ones.

software analytics, i.e., data-driven code analyses, can be used.

Once a good overview of the current state has been obtained, a targeted modernization strategy should be designed. The entire range of software engineering disciplines may be relevant for this, from requirements engineering to software architecture to quality assurance.

After the strategy has been executed – i.e., once the system modernization has been implemented – a migration from the legacy system to the new system typically still has to be performed.

Is it worthwhile for companies to modernize a system instead of introducing a new one?

Rost: This is a very common question. Companies must be aware that high costs can arise. In some cases, it takes years to complete a modernization. Whether it is still worthwhile to modernize a system or whether it is better to draw a line under it is something that every company has to weigh up for itself. There is no right or wrong here. A sound analysis in advance creates an appropriate basis for making the right decision. Here, too, we at Fraunhofer IESE can provide support.

What are the main things to look out for when modernizing a system?

Rost: When it comes to system modernization, many companies initially only think about the technology, but this is a good opportunity to also look at aspects such as user experience or feature usage. What customers want and expect changes over time; not all features may be needed in a system anymore.

More on the topic of System Modernization

Listen to our podcast episode with two company examples:

Listen on Apple Podcasts

Listen on Spotify

Or take a look at our website!

This is what industry says!

Project FibuNet GmbH: System Modernization towards a Web Application with User Experience Concept, Architectur Design, and Technology Selection

FibuNet offers a very successful software for financial accounting, which has been developed successfully over many years and is used by more than 1,000 customers. While the software is characterized by high user satisfaction, its visual appearance is kept rather conventional and functional. For these reasons, FibuNet decided to modernize their software together with Fraunhofer IESE by developing a web client.

Fraunhofer IESE optimized technical and visual components of the FibuNet software

In order to create a basis for the migration to a web client, Fraunhofer IESE supported FibuNet both from a design and a technical perspective. The basis for the elaboration of corresponding concepts was a walkthrough with real users of the software. Based on this, the team of experts from Fraunhofer IESE developed a user experience (UX) concept with interaction design and visual design for the new web client.

In addition, Fraunhofer IESE prepared the migration to the web client from a technical point of view. By deriving suitable criteria, collecting background information, and prototyping and evaluating the technologies in question, Fraunhofer IESE created the basis for the dependable selection of a suitable web technology.

Furthermore, Fraunhofer IESE considered the impact of the migration on the architecture concepts of the client in order to ensure that the most important quality requirements will be met sustainably.

Safe basis created for the implementation of a web client

FibuNet completed the evaluation of the candidates for the technical framework on their own and thereby selected a technology. Based on this and on the UX concept developed, FibuNet and Fraunhofer IESE jointly started the modernization of the successful software.

About FibuNet GmbH

Headquarters: Kaltenkirchen, Germany
Number of employees: 36
Industry: Financial software

"We cannot imagine who could have supported us as well as Fraunhofer IESE did, with a comparably well-founded understanding of technology, such multi-layered application experience, and a neutral point of view all at the same time."

Ralf Graap,
Director,
FibuNet GmbH

DO YOU HAVE A CHALLENGE FOR US?

Talk to us!

Dr. Dominik Rost
dominik.rost@
iese.fraunhofer.de

IESE in Trend

BaSys überProd – from research to practice

With the Industrie 4.0 middleware, companies save real money

Establishing Industrie 4.0 applications across the board in industry – that is what 21 partners from research and industry are working on in the research project "Basic system for cross-company production support" (BaSys überProd for short). By funding BaSys überProd, the German Federal Ministry of Education and Research (BMBF) has been committed since the beginning of 2021 to creating reusable solutions for the transformation to digitalized, flexible Industrie 4.0 production.

The research project led by Fraunhofer IESE is designed to run for two years and builds on the successful results of the two previously funded projects BaSys 4.0 and BaSys 4.2 – and develops them further. By using the Industrie 4.0 middleware Eclipse BaSyx, which was developed in these projects, in concrete application areas in industry, new solutions for cross-company production are to be created and made available to all interested companies.

Industrie 4.0 users are the focus of BaSys überProd

With BaSys überProd, the project series is being continued. In order to provide as comprehensive an insight as possible into the most diverse industrial domains, the cooperating companies were specifically selected from economically relevant industries. They range from companies from the automotive industry to the pharmaceutical industry and software companies.

A customer example: How ZF saves 30 percent of time with BaSyx

ZF Friedrichshafen AG has been involved in the BaSys research projects since the very beginning. The automotive supplier is already testing the Eclipse BaSyx middleware on an industrial system prototype in their production hall at their Saarbrücken site. The technology carrier is completely modeled on a typical workstation of a pre-assembly line – meaning it is a "hard industrial use". When industrializing the next product, ZF also plans to equip a real pre-assembly line with the middleware.

In this way, ZF is providing valuable information in the project "BaSys überProd" regarding industry requirements and the practical suitability of Industrie 4.0 applications.

Gerhard Schaller, Director Digitalization Operations at the ZF Division Electrified Powertrain, describes his experiences with BaSyx as an enabler of changeable production:

What is the overriding goal in using BaSyx?

The most important thing is the changeability of production. If you are actually prepared for changeability, you will also manage the restructuring from a classic product to a new product more quickly.

The project "BaSys überProd" now enables "Plug & Produce". This means that manufacturing systems that previously had to be commissioned at great expense for the production of a new product can be converted within a very short time with the help of the asset administration shell. The asset administration shell provides all device information at the push of a button, so that the device can first be simulated in the Digital Twin and then be activated immediately afterwards.

How does this affect production in concrete terms?

The middleware enables us to digitalize the entire production – from product modification via virtual commissioning to production execution. The advantage is that this makes the commissioning of a new production line about 30 percent faster. And time is money!

An example of this time savings: Our system prototype, which is located in our Saarbrücken plant, illustrates this development. For a system like this, which we used to commission with conventional technology in the past, we normally needed 14 days because we needed PLC programmers and had to integrate the system. Recently, this took us ten minutes – and then the system was up and running. This is like switching from the classic Nokia cell phone to the iPhone.

How can BaSyx contribute to ensuring competitiveness?

Customers are also demanding new product variants ever more quickly. The cycle in which these are to be manufactured is becoming shorter and shorter. Instead of standardized production, the trend is toward customized mass production. Without changeable production and innovative technologies, it is no longer possible to survive in international competition.

Using the "Plug & Produce" process, ZF converts its production line in the demonstrator within a very short time.

37

»
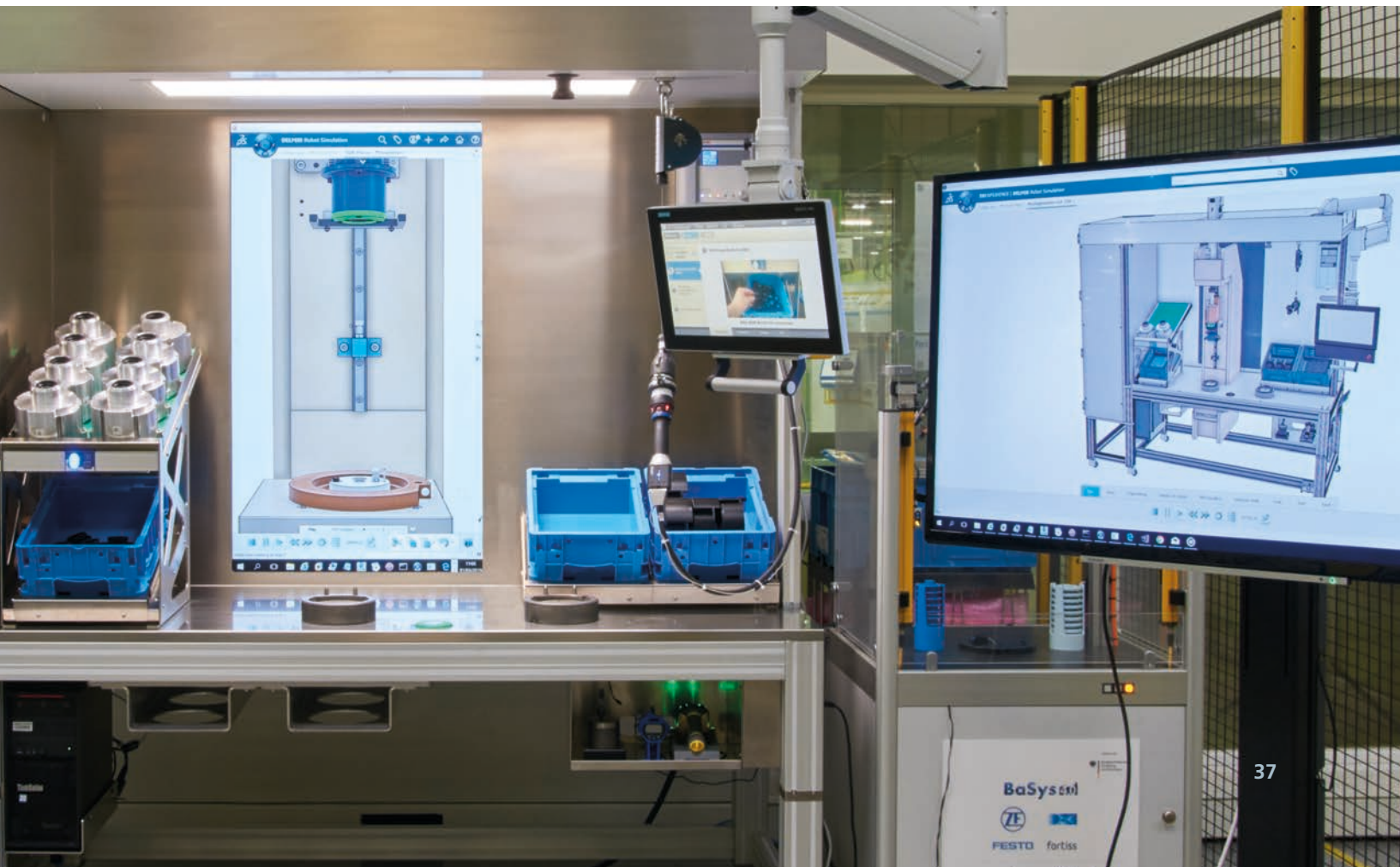
BaSyx makes the commissioning of a new production line about 30 percent faster.«

Gerhard Schaller, Director Digitalization Operations for the ZF Division Electrified Powertrain

What will be made easier or possible at all with BaSyx in the future?

Let me give you an example from transmission production: If a customer presents a modification and asks about the costs, many documents would have to be reviewed to find out whether the system can even implement the modification. Assuming that a new component is to be added that has to be tightened with a screwdriver with 40 Newton meters, the systems engineering department has to look at the specifications of the system and check where the technical limit of said screwdriver is.

But in BaSyx, the technical descriptions are stored and I can query the system at the push of a button to find out whether something is possible or not. Without looking at manuals or making many phone calls. This is new! Because there are currently no systems where you can find out from "the system's operating system" what it can do by simply pressing a button.

HOW DOES BASYX WORK?
—

Watch our explanatory film!
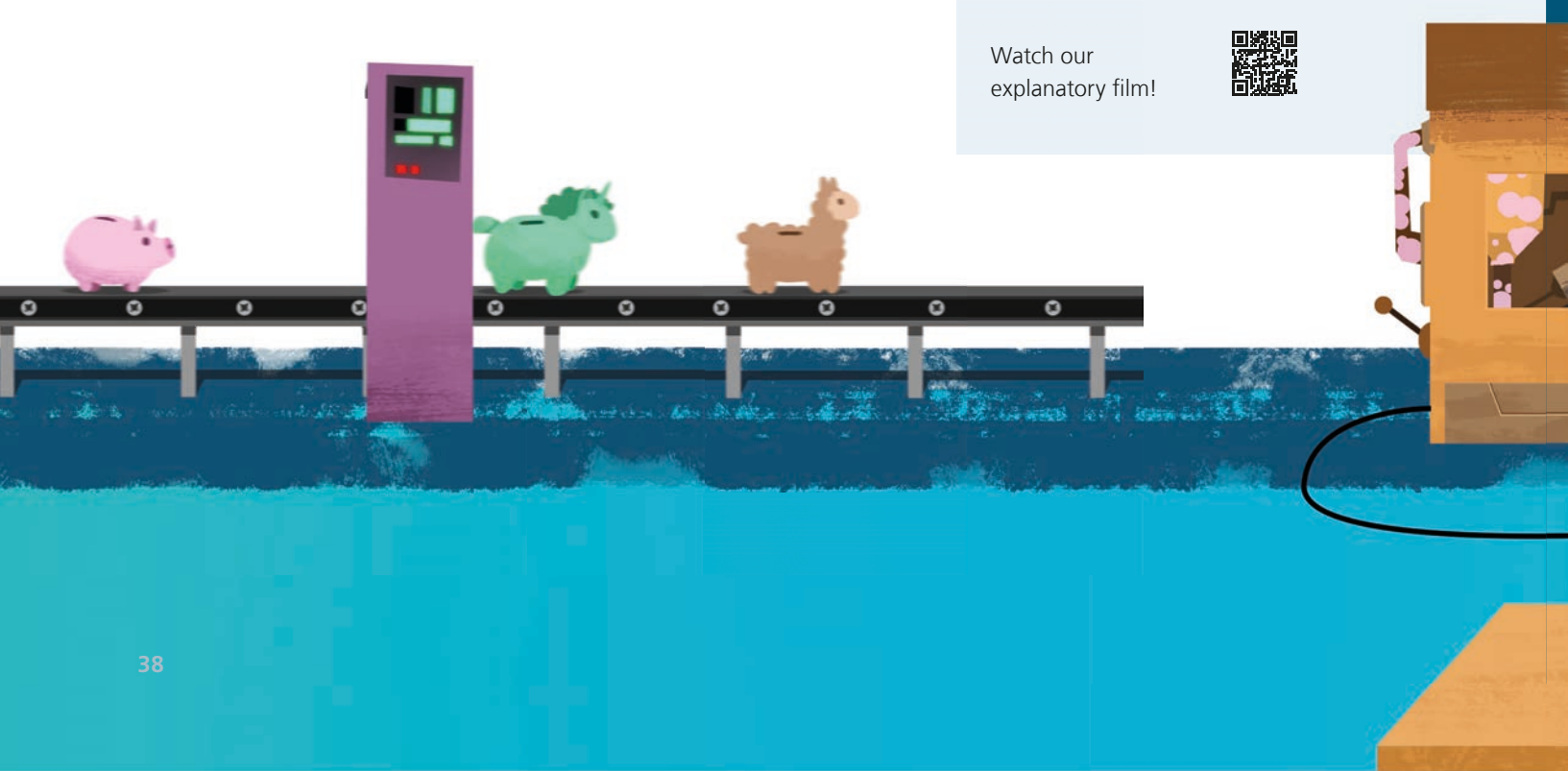
BaSys

About the background of the BaSys research series

The current BaSys überProd research project was preceded by several projects – some of which have been completed – including the core projects BaSys 4.0 and BaSys 4.2. The former started in July 2016 and was completed after three years; the latter is currently still ongoing. In addition, there were and are numerous satellite projects focusing on specific application contexts.

What the two projects are all about

While uniform standards and norms have long been part of everyday life in the world of physical machines, the digital world is still a long way from such principles. Production data is structured differently from company to company and is therefore not compatible with each other.

Fraunhofer IESE addressed this problem together with 14 other partners from industry and research and developed the open-source middleware Eclipse BaSyx as part of the BMBF-funded project BaSys 4.0. This basic technology enables companies to provide and link all services required in manufacturing with the help of the asset administration shell. In this way, production steps can be tested virtually well before they are carried out in order to eliminate possible sources of error at an early stage. In addition, production can be optimized in a targeted manner, more precise forecasts can be made, and manufacturing can be permanently monitored and controlled.

Building on this success, the German Federal Ministry of Education and Research launched the BaSys 4.2 project in summer 2019, immediately after the completion of the BaSys 4.0 project. BaSys 4.2 encompasses the overarching modeling and optimization of manufacturing – from processes to devices to products. Here, one focus is on the development of submodels that serve as digital models to define production.

TO THE BASYS WEBSITE:

Digital Ecosystem revolutionizes construction sites

Intelligent, networked, and always up to date – what has long been commonplace in areas such as Industrie 4.0 is also to become a reality in infrastructure construction projects. But how exactly to achieve this? As part of the research consortium "Infra-Bau 4.0", Fraunhofer IESE was involved in the development of a digital integration platform.

»

Our project goal was the comprehensive networking of systems and the automation of construction processes – analogous to Industrie 4.0.«

Denis Feth from Fraunhofer IESE is the technical-scientific manager of the project Infra-Bau 4.0.

Increasing the efficiency of construction projects with the help of digitalization

Short-term process changes, delayed deadlines, exploding costs: Infrastructure projects such as road and bridge construction are complex and expensive construction projects. The more complex the project, the more challenging it gets to meet the agreed deadlines, quality goals, and cost targets. It is therefore undisputed by now that digitalization is an essential factor for increasing effectiveness and efficiency in the construction industry. The aim of "Infra-Bau 4.0" was to develop a platform on which all partners involved in a construction project are digitally mapped with their resources and processes, and are networked with each other in a Digital Ecosystem. This enables effective and efficient planning as well as replanning at construction sites.

Digital Ecosystem for infrastructure construction projects

The open and intelligent integration platform developed in this research project connects all organizations, systems, and people involved in a construction project, enables end-to-end data exchange, and provides quick and well-founded decision support for problems at a construction site at any time. This improves transparency for all stakeholders involved in the construction project, the underlying processes in infrastructure construction projects are optimized, and the processes at the construction site are accelerated.

An example: If an excavator at a construction site unexpectedly delivers less output, this information can be transmitted in real time via the platform to the responsible process stakeholders. Planning changes can also be transmitted in this way without time delay and media breaks. This prevents planning backlogs and allows resources to be used sensibly throughout. To check whether the current status of a construction site corresponds to the original plan, so-called "Digital Twins" are also used. With their help, problems can be identified at an early stage and construction processes can be better replanned digitally.

As the technical-scientific project lead, Fraunhofer IESE took care of ecosystem modeling and platform design, in particular – but also of the integration of Digital Twins and end-to-end data security.

Mapping of a real-digital construction site to a central platform

Comprehensive linking of data – as well as continuous comparison of the planning with the actual situation – offers a great opportunity for infrastructure projects. In Infra-Bau 4.0, planning data was linked and supplemented by extensive construction process data reflecting the current construction situation. Thus, the platform simulates a real-digital construction site and the construction process can be recorded, analyzed, and optimized without delay.

For road builders and civil engineers, this is good news. After all, more efficient construction planning and implementation can give them more time – and thus more orders – in the long term.

Mass testing platform to improve the fight against pandemics

OPEN POCT

A testing ecosystem for the detection of the coronavirus shall be used to support the fight against the pandemic.

In the project OPEN-POCT, the Fraunhofer Institute for Microtechnology and Microsystems IMM in Mainz and the Fraunhofer Institute for Experimental Software Engineering IESE in Kaiserslautern are jointly developing an optimized test ecosystem for the detection of the coronavirus. The goal is to enable on-site testing (point-of-care, POC) at the PCR level and to make it practicable for mass application. The research project is being funded by the state of Rhineland-Palatinate within the framework of the European Regional Development Fund (EFRE REACT-EU).

Back in March of 2021, the project OPEN-POCT "Establishment of an administrative and regulatory ecosystem for a scalable, intelligent, and digitalized open-access rapid testing platform for the detection of pandemic infectious agents" was launched. Taking a long-term perspective, the focus of the work is on developing a broadly applicable, cost-effective, and sensitive testing option for everyone. In contrast to rapid antigen tests, PCR tests have a higher degree of sensitivity and

thus provide more accurate test results. Together with secure and rapid data transfer of positive test results to appropriate authorities, this new platform will offer the possibility for mass testing and will be an important step in the fight against pandemics.

The two Fraunhofer Institutes are contributing their expertise from different research areas to this project: Fraunhofer IMM focuses on aspects in the field of analytical systems and sensor technology. This includes the technical implementation of a simplified and safe sample preparation method in combination with fully automated process flows on the POC PCR test system as well as the implementation of alternative test materials such as saliva and pharyngeal rinse water. The areas of software and systems engineering methods of the project are in the hands of Fraunhofer IESE. The experts from Kaiserslautern will ensure automated and data-protection-compliant data transfer.

In the event of a disaster, the work of the control center team is characterized by complexity, which arises from confusing situations that have to be managed under time pressure in a technically demanding environment.

Artificial Intelligence for control centers and situation rooms as a new opportunity in disaster management

Research project SPELL – Managing crises with AI

―――

The aim of SPELL is to enable emergency response, emergency aid, and supply measures for the population to be initiated more quickly and in a situation-appropriate manner in crisis situations. This is to be achieved with the help of Artificial Intelligence (AI).

In June 2021, the research project "SPELL" was launched. Funded by the German Federal Ministry of Economic Affairs and Energy, it will run for three years and includes twelve partners. One of the project partners is Fraunhofer IESE from Kaiserslautern, which is responsible, among other things, for the topics "AI-supported value-added services", "Evaluation of the platform", and "Data usage control in the ecosystem".

"SPELL" stands for "Semantic platform for intelligent decision and operations support in control centers and situation centers". In crisis situations such as major incidents, pandemics, natural disasters, or widespread power outages, resources must be distributed correctly and the best decision must be made on the basis of the available information. A prerequisite for this is a data-based overview of all relevant information as an overall picture of the situation, and the networking of all those involved. This is also demonstrated by the COVID-19 pandemic currently underway. Artificial Intelligence can create this basis and significantly support decision-making and implementation in order to minimize wrong decisions.

An ecosystem for AI-supported crisis management

In the project SPELL, Fraunhofer IESE is responsible for the dependable assurance of the planned AI-supported value-added services and for the evaluation of the platform. AI-supported services process incoming sensor data to predict, for example, the spread of pollutant clouds. Due to the resulting consequences, the Machine Learning methods applied in this context must always deliver reliable results. This is where Fraunhofer IESE comes in with its methodology, providing statements with respect to the dependability of the expected results of the algorithms.

In the course of the evaluation, which is a standalone work package in the project, the requirements of the project itself as well as those for the evaluation will be elicited first, and information about the (potential) users of SPELL will be compiled. In the further course, the technical implementations will be evaluated from the perspective of the users. In addition, a didactic design will be developed to enable targeted training and instruction measures for the users.

Some of the data fed into the platform is security-relevant, valuable, relevant in terms of data protection law, and ultimately belongs to the data donor. For this reason, the "MY DATA Control Technologies" framework developed by Fraunhofer IESE will be part of the research project. The developed software will be primarily used to assess, enforce, and manage security and privacy regulations. For example, the owner of the data can specify exactly which platform service is allowed to use their data for what purpose and for how long.

Agile instead of fragile

How digital and agile are public administrations?

In view of the study results of an online survey from the research project "Smarte.Land.Regionen", Steffen Hess, Department Head Digital Society Ecosystems at Fraunhofer IESE, is convinced that agile working must be part of the working culture in German public administrations in the future. At the same time, however, he also cautions: "A county administration is no hyper-agile start-up" – in other words: Agility and digitalization only make sense up to the point where they provide a real benefit. Steffen Hess explains more about this in this interview.

Public administrations are not really known for being agile. Is that a misconception?

In any case, there is quite a bit of truth behind this image. We cannot yet speak of nation-wide agile public administration in

Germany – in fact, agility seems to be a foreign word in most public administrations. This is also confirmed by the results of our current online survey among the public administration staff of the seven model regions of the project "Smarte.Land. Regionen". 45 percent of the respondents stated that they had not heard of agile working methods at all.

At the same time, however, it must be pointed out that in discussions with public administration staff, we repeatedly discover how great their desire is for the use of new digital solutions.

… so less a question of wanting to?

Absolutely – an open attitude can definitely be seen. At the same time, however, we are facing major challenges, because strong hierarchies, explicitly predefined processes, and a high

degree of bureaucracy often still make our public administrations sluggish and inflexible. Agility, on the other hand, requires flat hierarchies, collective decision-making processes, and de-bureaucratization.

But restructuring the entire administrative apparatus takes time. To be fair, though, it must also be mentioned that quite a lot has happened over the past Corona year – at least as far as the digitalization factor is concerned. We are definitely moving in the right direction.

What do public administrations want from digital solutions?

For public administrations, the focus is always on accessibility and that such solutions are as easy to use for their staff as possible. Smart solutions that simplify, streamline, and accelerate processes are a real improvement for both citizens and public administration staff. People's concerns can be processed much faster in this way.

Where are the biggest obstacles?

The digital transformation often fails because of internal processes that require both a technical and a mental transformation. A sophisticated strategy is needed based on which everyone pulls together and welcomes the change instead of fearing it.

In addition, financial and personnel bottlenecks frequently occur. To avoid these, available and required resources must be calculated realistically. Practicable nationwide solution standards would also be of great benefit for the digitalization of public administrations.

How about a concrete example: How do mayors get their public administration to become more agile?

For example, the Agile Manifesto could be consulted as a basis for agile development. It conveys the four basic values of agility that every public administration should take to heart: Individuals and interactions come before processes and tools, working software comes before extensive documentation, collaboration with customers – or citizens

– comes before contract negotiation, and embracing change comes before following a plan.

Mayors should question the status quo in terms of the following questions: Are the four basic principles being followed? Where might there still be areas where catch-up is needed? They should provide food for thought and assistance where needed. Change is always teamwork.

And what advantages does this bring?

The advantages of an agile public administration are obvious: It is flexible and responsive, even in times of crisis. The Corona pandemic has shown us impressively that this is urgently necessary.

How was this complex situation handled? Were developments communicated transparently and in a way that was accessible to all? These are questions that can be used to determine whether the public administration has responded to the crisis in an agile and flexible mannner. Too many German public administrations are focusing on stability in their structures and are thus losing the potential to remain capable of acting in complex situations.

How does Fraunhofer IESE provide support?

With our expertise, we drive the digital transformation forwards and accompany municipalities on their way to becoming agile, digital public administrations.

» Agile public administrations can respond well even in times of crisis!«

Steffen Hess, Department Head Digital Society Ecosystems at Fraunhofer IESE

Embracing Smart Farming as an opportunity

Even smaller farms can gain benefits!

Growing demands for sustainability and environmental protection coupled with limited farmland: If the agricultural sector is to meet the increasing demands and regulations, digitalization can be an important tool. However, more applied research is needed before the full potential of "Smart Farming" can be unlocked.

"Digitalization can serve to protect crops more precisely and to improve animal welfare – based on data, facts, and research" – what German Federal Minister of Agriculture Julia Klöckner (CDU) is talking about is certainly nothing new for the vast majority of farmers. But why is it then that so many farms are still so far from fully exploiting the potential of "Smart Farming"?

We are talking, in particular, about small and medium-sized farms. Unlike large farms, they often do not have the necessary financial resources to press ahead with digitalization in all areas of operation. For example, depending on the areas they have to cultivate, the obstacles to investing in autonomous agricultural machinery are often too high for them.

In addition, a lack of user acceptance that is sometimes encountered and, on the technological side, a lack of compatibility of the applications with the individual requirements on site can be cited as reasons. Nevertheless, Smart Farming can also make a valuable contribution especially to small and medium-sized farms. After all, digitalization does not always imply high costs.

Digitalization is not an end in itself

But how can the challenges in digitalizing agriculture be mastered successfully? Before we present possible solution approaches in more detail, it is important to mention one more thing: Digitalization is never an end in itself! Only if the goal pursued with it or the solution to a problem can be described accurately will Smart Farming also provide the desired benefits in the long run.

The potential of Agriculture 4.0 is far from exhausted!

In contrast to the digital transformation of industry, the agricultural sector is characterized by enormous heterogeneity. From the resources and implements used on the farms to different soil types to weather conditions: Due to the great differences in local conditions, it is by far not enough to have only one Smart Farming solution. Rather, software solutions must be developed in such a way that they can be flexibly adapted to a wide variety of conditions – an extremely important topic in research, for example, the variation management of configurable systems.

Data interoperability is necessary

For a smooth exchange of data in the agricultural sector to become a reality, it is crucial to establish data interoperability – i.e., to agree, for example, on common technologies or a standardized language. While the steadily increasing number of digital solution providers is encouraging, the networking of the individual applications as well as their seamless use on different devices would certainly be a key to even greater acceptance.

In this context, various activities play a role, such as the research of Fraunhofer IESE with the lighthouse project Cognitive Agriculture (COGNAC) on concepts for an Agricultural Data Space as well as the GAIA-X initiative with the two large agricultural projects NaLamKI and Agri-Gaia funded by the German Federal Ministry of Economic Affairs (BMWi). Furthermore, the development of a common government-run data platform, which is currently being pursued by the German Federal Ministry of Food and Agriculture (BMEL), should be mentioned here. The latter aims to make a wide variety of public data and information available to both people and machines at a central location.

Realizing such end-to-end interoperability requires, on the one hand, uniform data management guidelines. Creating such guidelines and agreeing on them is certainly not easy. The high number of different codes for winter wheat alone makes it clear how much work goes into developing such a set of guidelines even at a very low level of interoperability. On the other hand, the introduction of standards

alone is not enough – complementary to this, machine-readable interface specifications are needed, for example, that allow making a digital service readable and understandable on different devices.

In addition to such interfaces, open-source or Farming-as-a-Service solutions also hold great potential for digitalization in agriculture. They expand the spectrum from fee-based to free offerings, especially in the technology area.

Creating acceptance, recognizing potential

And yet: regardless of how quickly the development of networked data platforms or uniform data standards will progress, it is ultimately the farmers themselves who must be open to digitalization. Without their acceptance as users, Smart Farming will otherwise remain a mere pipe dream.

Here, too, research can provide a boost to the development. With a better understanding of the requirements on Smart Farming solutions and the opinions on existing solutions, product developers in the field of Smart Farming can be given significant support. In addition, innovative crowdsourcing methods – such as evaluations of contributions and comments of farmers in social media – can be used effectively. In this way, their requirements regarding digital solutions can be elicited and new product ideas and prototypes can be evaluated at an early stage.

In addition, the development of an appropriate network of experts can contribute to answering open questions from agronomists, to understanding possible negative attitudes, and to countering these, if necessary. Digitalization should not hang over farms and businesses like the sword of Damocles; rather, it should be embraced as an opportunity.

»

The establishment of interoperability is crucial for smooth data exchange.«

Prof. Dr. Jörg Dörr, Extended Institute Management, Fraunhofer IESE

Smart Farming
3 questions for…

… August Altherr, Retired Director – John Deere European Technology Information Center

What are the greatest challenges in agriculture for you?

At the moment, several conflicting goals are hitting farms: Customers expect low-cost, high-quality food; society expects ecological, sustainable, diversified agriculture; and, of course, it must be possible to manage a farm profitably. The key to mastering these challenges lies in sensors, data, algorithms, and the segmentation of fields into the smallest possible units.

Could Agriculture 4.0 be the solution?

Similar to Industrie 4.0, agriculture will also have a Digital Twin of a field that controls the processes on the field and relating to the crops. Compared to Industrie 4.0, the challenge is that the Digital Twin of a field is subject to variables caused by natural disturbances. The biggest disruptive factor is the weather, especially precipitation during the growth period. A second challenge is the time requirement of calibration, as only one cycle can be produced per year. A third major challenge is the inhomogeneity of the field. A field must be segmented into many small plots down to individual plant plots. However, this also means that the smaller the partitioning into plots, the larger the data set of the entire field.

In your view, how can IESE contribute to solving these conflicting goals?

Not least with its "Agricultural Data Space" developed in the COGNAC project, IESE is well prepared to take on these challenges and solve the conflict of goals between economy and ecology for agriculture. With the Agricultural Data Space, a digital platform has been created in which a wide variety of data formats from agriculture, such as weather, nutrient maps, soil conditions, pest infestation, fertilizer requirements, and even nitrogen removal during harvesting, can communicate with each other. Based on this data, recommendations for actions can be derived for farmers in order to optimize the value chain ecologically and economically.

An emoji says more than a thousand words

IESE's study on understanding emojis is still ongoing. Participate at emoji-poll.de!

If you send a text message including an emoji and the recipient misinterprets it, misunderstandings are the result. Fraunhofer IESE has investigated exactly this perception of emojis in a survey. The preliminary results show: The majority of emojis are understood by the users in the same way; however, some emojis cause confusion because young people understand them differently than older people.

Simon André Scherr, Senior Digital Innovation Designer at IESE in charge of the study, summarizes the purpose of the study as follows: "Emojis are often used in the digital world to express emotions. We want to find out for which of them there is a common understanding in our society, and for which of them this consensus does not exist yet and which are therefore misleading in our communication. Here we are interested in factors such as age, demographics, or context of use, which lead to different perceptions."

Over 700 emojis were polled in the study. One emoji, in particular, was correctly understood by almost all of the approximately 6,750 participants. The emoji laughing tears of joy was perceived as positive by 98 percent of the respondents. So when it comes to humor, the generations are in agreement.

Different age, different emoji perception?!

On the other hand, emoticons, the precursors of emojis from the early days of the Internet, are misunderstood more often by younger people.

The broken heart string (</3) is mistakenly interpreted as a waffle ice by younger participants. Other misunderstandings were also revealed in the case of the mischievous emoji and the sweaty face, as well as in the case of the supervillain and the superhero.

Emojis also trigger different moods among the generations. A teddy bear clearly evokes more joy in people born in the 1960s than in those born in Generation Z (1995 to 2010). The IESE experts suspect that older people feel that this emoji reminds them of the time when they only had this one precious stuffed animal that accompanied them for many years.

Regardless of age, 95 percent of the participants rated the moods of many emojis similarly, including cat face (most common: positive), thumbs down (negative), beaming face (positive), angry face (negative), and the party hat emoji (positive).

There is, however, a clear difference between the different generations: Younger people undoubtedly use more emojis and also use them more individually than older users. On the other hand, the study found no gender-related differences in perception.

IESE Highlights
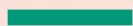
25 YEARS OF
FRAUNHOFER IESE

In 2021, Fraunhofer IESE is celebrating its 25-year anniversary! Since its foundation, the institute has been conducting research and collaborating with its partners on trendsetting key technologies – always with the goal of strengthening the economy and providing added value for society in mind.

With their research topics and solutions, the experts from Kaiserslautern not only address what is happening today, but always think about how they can shape the digital world of tomorrow. In the new podcast series **"**MORGEN *DENKER***"**, they take all fans of the digital future on an audio journey into the world of software and systems engineering!

Have you already met ISA? ISA is the anniversary ambassador of Fraunhofer IESE. ISA stands for Innovative Systems Engineering. As a virtual companion, she acts as a guide through all anniversary actions and, of course, does not pass up the opportunity to conduct the podcast interviews in this special year.

More about the anniversary on the web:

Hi, I am ISA,
the virtual anniversary
ambassador of
Fraunhofer IESE!«

Anniversary Messages

»

Whether Digital Farming, Smart Rural Areas, or Industrie 4.0: Fraunhofer IESE demonstrates scientific excellence through 25 years of cutting-edge research on dependable Digital Ecosystems. Congratulations! «

Prof. Dr.-Ing. habil.
Reimund Neugebauer
President of the
Fraunhofer-Gesellschaft

Prof. Dr.-Ing. habil. Reimund Neugebauer

President of the Fraunhofer-Gesellschaft

Dear ladies and gentlemen,

As a leading institution for applied research, Fraunhofer bears a fundamental responsibility in the worlds of research, industry, policymaking, and society. Particularly in the context of the realignment of the German economy, Fraunhofer is rising to the challenge of promoting the transformation toward sustainability demanded by society and politics, while strengthening Germany's competitiveness at the same time.

In the spirit of sustainable value creation, the Fraunhofer Institute for Experimental Software Engineering IESE in Kaiserslautern has been conducting research on dependable Digital Ecosystems as well as cross-cutting research in the areas of smart medicine, food industry, and energy for 25 years. Through its scientific excellence, Fraunhofer IESE has acquired a leading international position in the area of software and systems engineering methods and has established itself as a recognized research partner for industry as well as for the research community.

Particularly noteworthy is the cutting-edge research within the topics Smart Rural Areas, Industrie 4.0, and Digital Farming. With the project "Digital Villages", Fraunhofer IESE has shown that digitalization offers enormous potential and serves the good of all. During the Corona pandemic, for example, the Dorf-Funk app was rolled out across Germany and brought citizens of numerous communities together digitally under the motto "digital becomes social". As a notable service to society, the project received recognition from the German President, among many others.

But Fraunhofer IESE also provides innovative solutions in the context of Industrie 4.0, for example with the projects "BaSys 4.0" and "BaSys 4.2", which enable small and medium-sized enterprises to engage in digital manufacturing.

The interconnectedness and complementary strength of our Institutes is crucial for the long-term success of Fraunhofer – especially in increasingly complex times when new ways of solving central societal challenges such as climate change or the energy transition are required. Here, too, the commitment of Fraunhofer IESE is exemplary, for example in its management of the Fraunhofer lighthouse project "Cognitive Agriculture", in which eight Fraunhofer Institutes are conducting research on how to produce agricultural products in a way that is as environmentally friendly as it is resource-efficient – an important step on the way to efficient digitalized agriculture.

I would like to extend my heartfelt congratulations to the Fraunhofer Institute for Experimental Software Engineering IESE on its 25th anniversary and have high hopes for many more ideas and projects that will determine its success in the future!

Your

Prof. Reimund Neugebauer
President of the Fraunhofer-Gesellschaft

More Anniversary Messages

Some excerpts from representatives of research, industry, and government

»

Thanks to the vision and funding from the major research organizations, especially the Fraunhofer-Gesellschaft, we were able to develop an ecosystem here that could not be realized by one university alone.«

Prof. Dr. Arnd Poetzsch-Heffter, President of the Technical University of Kaiserslautern

Prof. Dieter Kempf, former president of Bitkom e.V. and BDI

»

How do you control the usage of data without immediately undoing the advantage of multiple use by different users? This is an interesting question that plays an important role especially when it comes to sharing or jointly using process data in the setting of Industrie 4.0. In this context, I became aware of IND²UCE Security from Fraunhofer IESE.«

»

A Digital Ecosystem can only work if boundaries between the respective systems and silos open up – and this is impressively demonstrated and proven by the Digital Villages approach of Fraunhofer IESE.«

Alexander Rabe, Managing Director eco – Verband der Internetwirtschaft e.V.

Malu Dreyer, Minister President of the state of Rhineland-Palatinate

»

We are glad to have Fraunhofer IESE at our side as a competent and dependable partner to shape the digitalization of our state in such a way that technical innovation becomes social and societal progress.«

*Julia Klöckner, German Federal Minister of Food and Agriculture*

»

Digital instruments must be conceived from a practical perspective, from that of the needs of the people, the municipalities, the local stakeholders.
With our model project "Smarte.Land.Regionen", we are researching what this can look like in concrete terms. With Fraunhofer IESE, we have the ideal partner for this.«

»

Fraunhofer IESE has become a top address when it comes to cyber-physical systems, Digital Twins, software verification, and software tests, as well as the BaSys system for Industrie 4.0.«
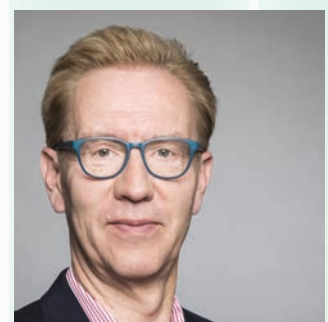
Prof. Dr. Wolf-Dieter Lukas, State Secretary at the German Federal Ministry of Education and Research

All detailed anniversary messages can be found in our virtual guestbook.

Our Journey into the Digital Future!

Software and Systems Engineering

2015

Transfer of institute management from Prof. Rombach to Prof. Liggesmeyer

Mobile Systems

Siegelbach

1996

Foundation of Fraunhofer IESE

Embedded Systems

Software Engineering

Information Systems

2005

Move to new institute building

our PORT

COGNAC

BaSyϵ
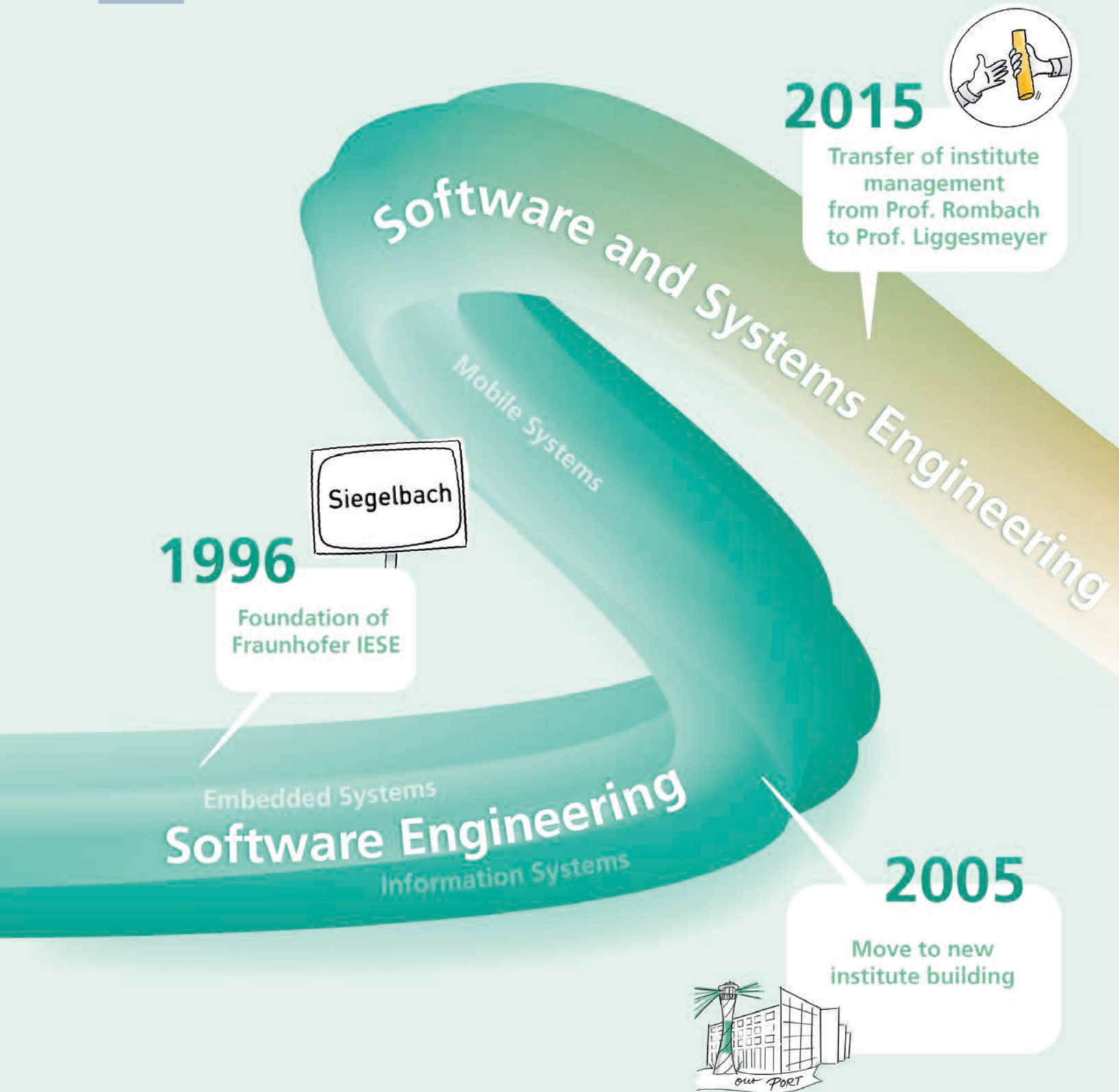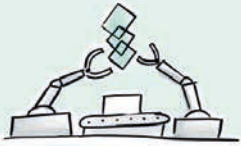
Digitale
Dörfer

Digital Ecosystems

Software, Systems and Innovation Engineering

2021

New Work –
new work models
at IESE

FRAUNHOFER
IESE

Dependable AI

Digital Healthcare

Autonomous Systems

Smart Region   Smart City   Smart Energy

Smart Farming   Digital Twin

Industrie 4.0

Promotion

Dr. Jörg Dörr receives professorship for "Digital Farming"

Prof. Jörg Dörr

Dr. Jörg Dörr was appointed to the post of Chair of Digital Farming at the Technical University of Kaiserslautern (TUK) at the beginning of April. Among other things, Dörr will focus on the digital transformation in agriculture, research new technologies, and develop these in an application-oriented manner. The main objective will be to build digital agricultural ecosystems, with a focus on software and systems engineering: managing and administering data and supporting agricultural processes with automation technologies. In addition to holding the new Chair, which is part of the Department of Computer Science, Professor Dörr's responsibilities as a member of the extended institute management of Fraunhofer IESE include the research program Smart Farming. The association Friends of Digital Farming made it possible to establish this Chair at TUK, which will be supported in the long term by the Fraunhofer-Gesellschaft and the state of Rhineland-Palatinate.

Selection

Prof. Liggesmeyer is new scientific spokesperson of the Research Council of the Plattform Industrie 4.0

On 12 March 2021, the members of the Research Council elected Prof. Peter Liggesmeyer as scientific spokesperson and Gisela Lanza as his deputy. The Research Council of the Platt-form Industrie 4.0, which is coordinated by acatech, is a strategic and independent body that advises the Plattform Industrie 4.0,

Prof. Peter Liggesmeyer

its working groups, and the federal ministries involved, in particular BMBF. With its currently 32 representatives from research and industry, it is committed to the successful further development and pre-competitive implementation planning of Industrie 4.0 in the German economy. Prof. Liggesmeyer has been a member of the Research Council of the Plattform Industrie 4.0 for more than seven years.

Award

Prof. Dieter Rombach receives prestigious international lifetime achievement award

In 2021, the Computer Society of the international engineering association IEEE (Institute for Electrical and Electronics Engineers) awarded one of the highest honors for professional lifetime achievement – the Harlan D. Mills Award 2021 – to Prof. Dr. Dr. h.c. Dieter Rombach, in recognition of his many years of sustained and impactful contributions and leadership in research, teaching, and technology transfer in the field of empirical software engineering. Prof. Rombach has been a Fellow of the IEEE Computer Society since 2003. The award has been given since 1999 and is one of the most prestigious awards in the field of computer science and information technology. As founder of Fraunhofer IESE, Prof. Rombach was Executive Director of the Institute until 2014, when Prof. Liggesmeyer took over the operational management of the Institute. Until 2018, he was part of the institute management as Director Business Development. And even after his retirement, he will remain closely associated with IESE in an advisory capacity.

Prof. Dieter Rombach

Demonstration

With BaSys 4 at Hannover Messe DIGITAL 2021

Under the umbrella of the German Federal Ministry of Education and Research, IESE demonstrated at the Hannover Messe DIGITAL 2021 from 12 to 16 April 2021 how the project BaSys 4 contributes to the changeable production of the future.

In a live stream followed by an exchange among experts as well as at the virtual booth, visitors from all over the world received information about the service portfolio of Fraunhofer IESE. The focus was on the many challenges in production, for example on how to counteract the high costs associated with changes in the manufacturing process. The experts of Fraunhofer IESE demonstrated how to identify optimization potential with the help of BaSys 4 and thus react quickly to changing demand situations. "Accepting challenges and bringing about positive changes" – true to this year's motto of IESE for the trade show, BaSys 4 enables even smaller and medium-sized enterprises to take a step towards Industrie 4.0!

Exchange

European Conference for AI made in Rhineland-Palatinate

On 26 November 2020, the Fraunhofer Center in Kaiserslautern streamed the European digital conference "TRUSTinAI. Responsible AI for Science and Society" as a virtual event. With this event, the state of Rhineland-Palatinate, together with universities and research institutions in the state, made a contribution to the German Presidency of the Council of the European Union. Minister President Malu Dreyer served as the patron of the conference. The organizers and contributors included the two Fraunhofer Institutes IESE and ITWM, DFKI, as well as the Rhineland-Palatinate Initiative for the Future (ZIRP).

With numerous players from Rhineland-Palatinate, the conference demonstrated that the state is an important
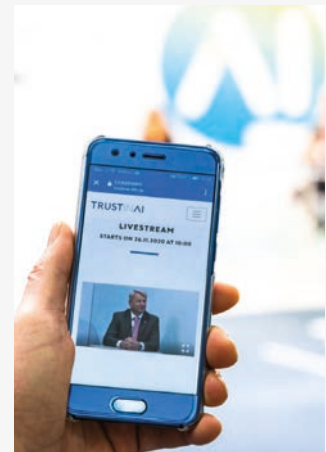
Hybrid conference TRUSTinAI

AI nucleus for Germany and Europe. The focus of the conference was on the ethical development and use of AI. The target group comprised the European scientific community, representatives of government and society, as well as users from companies and public administration.

Exhibit

Fraunhofer Solution Days 2020/2021

The Fraunhofer Solution Days took place in October 2020, for the first time in a new digital format. In addition to virtual exhibition halls with innovative projects presented by the Fraunhofer experts, there were exciting presentations on current technology highlights and significant solutions. Fraunhofer IESE also took part in the event: For the theme day "Plant and Mechanical Engineering", the Institute presented talks and virtual exhibits on "BaSys 4,

the enabler for flexible production in Industrie 4.0" – such as the explanatory film "Industrie 4.0 – making it easy with the BaSyx middleware".

In summer 2021, the success story of the Solution Days entered its second round. At the theme day "Quantum & Trusted Computing", IESE presented "Challenges and solutions for engineering dependable AI systems – Dependable AI!". In presentations and

seminars, IESE experts showed examples of how they can advise companies on the engineering of dependable AI systems and support them across the whole lifecycle: from AI strategy via AI development to the assurance of AI incl. AI validation/auditing and compliance with legal and normative requirements.

Stopover

Minister Schmitt informs herself at IESE about projects in rural areas

Daniela Schmitt, the Minister of Economic Affairs of the state of Rhineland-Palatinate, visited Fraunhofer IESE in Kaiserslautern in mid-July 2021 to learn about research projects on the topic of "Economy and work in rural areas". Institute director Prof. Peter Liggesmeyer and Steffen Hess, Department Head Digital Society Ecosystems, presented the projects "Digital Villages" and "Smarte.Land.Regionen" to her. The aim of both projects is to advance digitalization in rural areas.

Minister Schmitt emphasized the opportunities for the business location that are created by these research projects: "With its applied research, Fraunhofer IESE makes it possible to realize mobile and digital work concepts in rural areas. These modern worlds of work create a variety of new opportunities for companies and employees. This is an important building block for further strengthening the future viability and competitiveness of Kaiserslautern as a business location."

Prof. Peter Liggesmeyer in conversation with Minister of Economic Affairs Daniela Schmitt.

Communiqué

Top-level dialog of the Research Council publishes communiqué with 12 impulses for the future of Industrie 4.0

The consequences of the Corona pandemic and the global competition among systems are presenting new challenges for industry. For this reason, leading industry representatives met on 16 June 2021 to exchange views at a top-level dialog on the future of Industrie 4.0. The invitation came from the Research Council of the Plattform Industrie 4.0, which advocates that Industrie 4.0 should continue to be supported by policymakers in order to unleash its full potential regarding digital sovereignty and a sustainable economy. The two spokespersons of the Research Council, Prof. Peter Liggesmeyer, Institute Director of Fraunhofer IESE, and Harald Schöning, Vice President of Software AG, opened the panel discussion.

The Research Council summarized the results of the top-level dialog in twelve points in the form of a written communiqué.
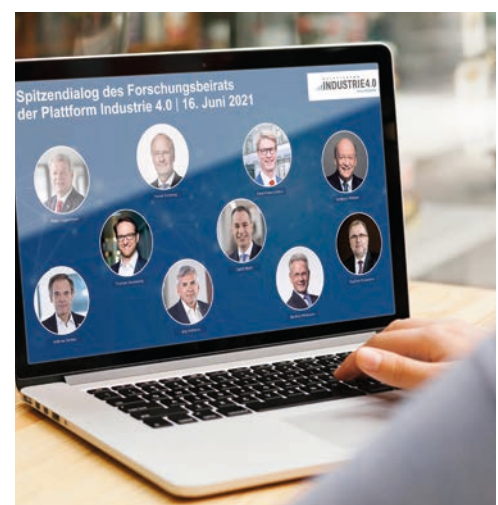
Representatives from research and industry state their position on the topic of Industrie 4.0.

Foundation

—

New Fraunhofer Center for Digital Diagnostics develops telemedicine solutions to strengthen rural care

The three Institute directors Prof. Ulrike Köhl (IZI), Prof. Peter Liggesmeyer (IESE), and Dr. Eva Ehrentreich-Förster (IZI-BB) (from the left) welcome constituency candidate Annalena Baerbock. Also pictured: Agnes von Matuschka, Managing Director of the Standortmanagement Golm GmbH at the Potsdam Science Park (2nd from right).

The newly founded Fraunhofer Center for Digital Diagnostics at the Potsdam Science Park focuses on the targeted development of digital diagnostic solutions. In the Potsdam model region, new solutions and application areas for digital diagnostics are being researched and developed in order to effectively support patient care and realize value-adding potential in the region.

One special focus in this endeavor will the development of telemedicine solutions in order to be able to ensure optimal medical-diagnostic care in rural Brandenburg. Analogous to the Fraunhofer IESE project "Digital Villages", which has been tested in Rhineland-Palatinate, the findings and solutions of the new Center for Digital Diagnostics will subsequently be transferred extensively to the other federal states and will be used there as well.

For the development of digital diagnostic solutions, the effective linking of competencies for diagnostic instrumentation, data sciences, and medicine is crucial for success. Accordingly,

the center initially bundles the competencies of three core institutes in terms of institutions: those of the Fraunhofer Institute for Cell Therapy and Immunology, Division Bioanalytics and Bioprocesses IZI-BB (instrumentation), the Fraunhofer Institute for Cell Therapy and Immunology IZI (medical needs), and the Fraunhofer Institute for Experimental Software Engineering IESE (digitalization).

Other Fraunhofer Institutes from the Groups Health, ICT Technologies, Microelectronics, and Materials will be integrated as project-specific partner institutes in order to make the best possible use of the strong interdisciplinary competencies within the Fraunhofer-Gesellschaft.

The Center for Digital Diagnostics, which has been funded since 1 July 2021, will thus create an institutional crystallization core for the fusion of interdisciplinary expertise in order to systematically bundle the synergies of all players in a sustainable regional network.
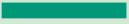
Projects

Projects from Research and Industry

BaSys 4.2

BaSys 4.2 continues to develop the open-source Industrie 4.0 middleware Eclipse BaSyx, which was developed with significant contributions from Fraunhofer IESE. The focus is on process models and submodels that enable complete digitalization of the manufacturing process. Together with IESE's partners, work is therefore being done on submodels that describe essential components of manufacturing processes and make these available with a uniform interface. Together with open-source applications, software containers that are aligned with each other are being developed to enable even small companies to implement Industrie 4.0 applications. Tutorials describing the application of the middleware are being created for this purpose.

These are made available on the wiki page of Eclipse BaSyx. A joint, cross-project demonstrator ensures that the contributions of all partners are continuously integrated with each other.

CRANIMAX GmbH

CRANIMAX GmbH from Zweibrücken offers its customers highly specialized software solutions for professional use. The software is appreciated by its users for its precise and detailed calculation results and is currently available as a pure desktop application. The further development of the software is to be simplified in order to strengthen the orientation towards the needs and tasks of the users. CRANIMAX and Fraunhofer IESE are working together on the migration of the existing software to a cloud-based SaaS solution. From requirements elicitation via design to implementation, the two partners are working hand in hand. With the system modernization, new opportunities arise to meet the needs of the users even better.

ExamAI
(AI Testing & Auditing)

The increasing use of systems that use Artificial Intelligence (AI systems) entails far-reaching changes for the world of work, particularly regarding the use of systems in the areas of human-machine cooperation in industrial production and in human resource management. What can procedures look like that ensure safe, traceable, controllable, and non-discriminatory use of AI? How can these be implemented, and what institutional requirements must be observed in this regard? For this purpose, the interdisciplinary team in the project ExamAI is deriving recommendations for action – from a legal and technical perspective for the use and further development of standards and guidelines as well as testing, control, and certification practices for AI systems.

Fraunhofer IESE is responsible for the area of human-machine cooperation in industrial production.

Fujitsu Labs

In the future, we will encounter AI systems much more frequently, especially in critical application areas such as autonomous driving, production automation/Industrie 4.0, or medical technology. The construction and operation of reliable AI systems poses a challenge in practice because many classic quality assurance procedures cannot be applied to AI components or can only be applied to a limited extent: In Machine Learning (ML), for example, functionality is created by applying algorithms to data and is not programmed in the classic way; the resulting model is hard to understand for humans.

Fujitsu Laboratories Limited is one of the leading companies when it comes to research for explainable AI, so that the reasons for decisions are easy for people to understand. In a project, Fraunhofer IESE and Fujitsu Laboratories Limited jointly developed a quality model for ML-based components in a software system. We identified critical quality requirements from different phases in a Data Science lifecycle and defined relevant quality properties of different entities in an ML-based system (such as the robustness of the trained model, the balancedness of the used data, or the suitability of the infrastructure). We also proposed example measures for quantifying critical properties and proposed a process for systematically evaluating measurement data. Such a quality model helps in objectively evaluating adherence to quality requirements. Furthermore, the process we developed for constructing and tailoring a quality model can be used in different application scenarios.

ATMP Reallabor

The production sector is experiencing significant changes today, which are driven by extensive digitalization, networking, and further advances in automation. One area that can benefit greatly from these trends is the production of so-called Advanced Therapy Medicinal Products (ATMPs). ATMPs show promising results in the treatment of serious diseases, but are currently very expensive to produce. ATMPs are individually tailored therapeutics whose production and quality assurance are largely manual today. A total of eight Fraunhofer Institutes are working across alliances in the research project ATMP Reallabor to make ATMP production more efficient by transferring concepts and solutions from Industrie 4.0 to the pharmaceutical sector. In parallel, the consortium is addressing the automation of the manual quality assurance process. In this context, Fraunhofer IESE is developing a framework for the automation (of parts) of the quality assurance of ATMPs using two basic concepts: (a) Digital Shadows or Digital Twins based on the BaSyx middleware of Fraunhofer IESE and (b) assurance cases for quality proof. The suitability of the approach has been demonstrated by means of a prototypical application as part of a case study on CAR T-cell products for the treatment of certain types of cancer.

Smarte.Land.Regionen

The aim of the model project "Smarte.Land.Regionen", in which Fraunhofer IESE plays a central role, is the digitalization of basic services (services of general interest) in rural areas. With the model project "Smarte.Land.Regionen", the German Federal Ministry of Food and Agriculture is promoting digitalization in rural areas. The use of digital technologies is intended to improve the living and working conditions for the population significantly. The use of new technical possibilities is crucial for keeping the living and working environment attractive, particularly in rural areas. For this purpose, Fraunhofer IESE is establishing a digital platform ("Digital Ecosystem") on which new prototype services will be developed and existing services will be networked. In this context, research will be conducted, for example, on the role that a county can play in a Digital Ecosystem and on how the transfer of knowledge between the stakeholders can succeed best. The platform in its central function as an open-source Digital Ecosystem will ensure the future transferability of digital services into broad use – beyond the use in the model regions.

In order to be able to actively involve the population and other stakeholders in the developments in the model regions, the counties are also given opportunities for participation via a participation platform. Process support commissioned by Fraunhofer IESE serves as a link between the counties and the research project. Among other things, the counties are being advised on the implementation of their digital solutions as well as on the design of processes for citizen participation, competence transfer, and strategy implementation.

V&V Methods

The goal of the project V&V Methods (Verification & Validation 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 project PEGASUS, 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. The V&V Methods project 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 the development of safety cases as an integral part of the development process.

Japan Manned Space Systems Corporation (JAMSS)

The Japanese company JAMSS has gained experience in manned space flights as a leading company in the operation of the Japanese module "Kibo" on the International Space Station. Their technologies and experience in regulated systems development are also used in other domains such as Automotive. JAMSS has recognized the trend of agile development approaches and wondered if and how agile approaches can be relevant or helpful in safety engineering as well as in quality assurance. In a three-day seminar, Fraunhofer IESE conveyed the basics of agile work and provided insights into scaled agility and the application of agile approaches in regulated domains. In particular, the challenges were discussed in each case, the advantages and disadvantages were presented, and solution approaches were shown. As a focus topic, the combination of safety engineering or independent verification and validation with agile approaches was addressed. Following the seminar, Fraunhofer IESE provided support to JAMMS in setting up a roadmap and planning a case study in which incremental agile work can be tested in the context of independent verification and validation as well as safety engineering.

Gebr. Pfeiffer

Gebr. Pfeiffer supplies innovative plant solutions for cement, coal, lime, gypsum, and ceramics. Due to the harsh environment and the different areas of deployment, situational maintenance is indispensable. The idea was therefore to offer a new cloud-based service to plant operators to identify the need for maintenance/repair at an early stage. In the realization of this goal, Fraunhofer IESE supported the company by developing, prototyping, and evaluating corresponding algorithms. Within the scope of the collaboration, various methods for analyzing time series data were realized for different types of mills. For the detection of error patterns, AI-based algorithms that enable the detection of anomalies were considered in addition to expert-based algorithms. The results of the collaboration were incorporated into the modular GPpro Service, under which Gebr. Pfeiffer provides the operators of its plants with innovative functions in the areas of preventive maintenance, mill protection, and operational optimization.

Mercedes-Benz AG

The amount of data that needs to be processed in real time in modern vehicles is constantly increasing. At the same time, there are requirements for low power consumption as well as great cost pressure, which leads to the increased use of components originally developed for the consumer market. The result are heterogeneous computing platforms consisting of GPUs, dedicated accelerators, CPUs, as well as DRAM memories, in particular. In a collaboration between Mercedes-Benz AG, TU Kaiserslautern, and Fraunhofer IESE, the selection of concrete memory modules for a future generation of vehicles of the Stuttgart-based company was supported with concrete measurement data: Using its own highly specialized measurement platform DRAM-Measure, the project team measured the performance parameters of different possible target architectures in order to lay the foundation for future optimizations.

City of Ulm

ulm.macht.zukunft. With numerous projects and activities, Ulm has embarked on the path to becoming a "Smart City". In the project "Ulm4CleverCity", the city of Ulm with its "Digital Agenda" office is taking on the challenge of how to shape a growing and changing city in such a way that sustainability and the quality of life of the people of Ulm take center stage. The project is funded by the German Federal Ministry of the Interior, Building and Community (BMI) and by KfW as part of the program "Smart Cities made in Germany" and aims at shaping the digital future together with the citizens of Ulm. Fraunhofer IESE is playing an active role in this endeavor. In the project "Ulm4CleverCity", Fraunhofer IESE is providing scientific support, comprising, among other things, a research status analysis and the development of visions and implementation concepts. As part of the funding project "Digitale Zukunftskommune@bw" (Digital Community of the Future@bw; where bw stands for the state of Baden-Württemberg), the focus of the collaboration is on the introduction of a data platform to enable easy exchange of data between providers and consumers of data and to create a first urban IoT data basis. In this way, data can be used better and new services can be developed. Fraunhofer IESE supports the city of Ulm in the implementation of the "Data Hub" as a technical contact in defining requirements, designing functional and technical concepts, and performing quality tests and acceptance tests. By working together, the city of Ulm and Fraunhofer IESE are creating the basis for the development of innovative solutions for a digital, smart, and, above all, livable city for all citizens.

IESE at a Glance
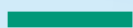
Mission

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 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 & Public Sector", as well as "Smart Farming" 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 "Dependable AI", "Digital Ecosystems", "Digital Twin / Virtual Engineering", and "System Modernization".

Fraunhofer IESE is one of 75 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.

Software, Systems and Innovation Engineering

Focus Topics

| Digital Ecosystems | Dependable AI | Digital Twin (VE) | System Modernization |

Business Areas
- Automotive & Mobility
- Production
- Digital Business
- Smart City & Public Sector

Research Programs
- Smart Farming
- Digital Healthcare
- Autonomous Systems
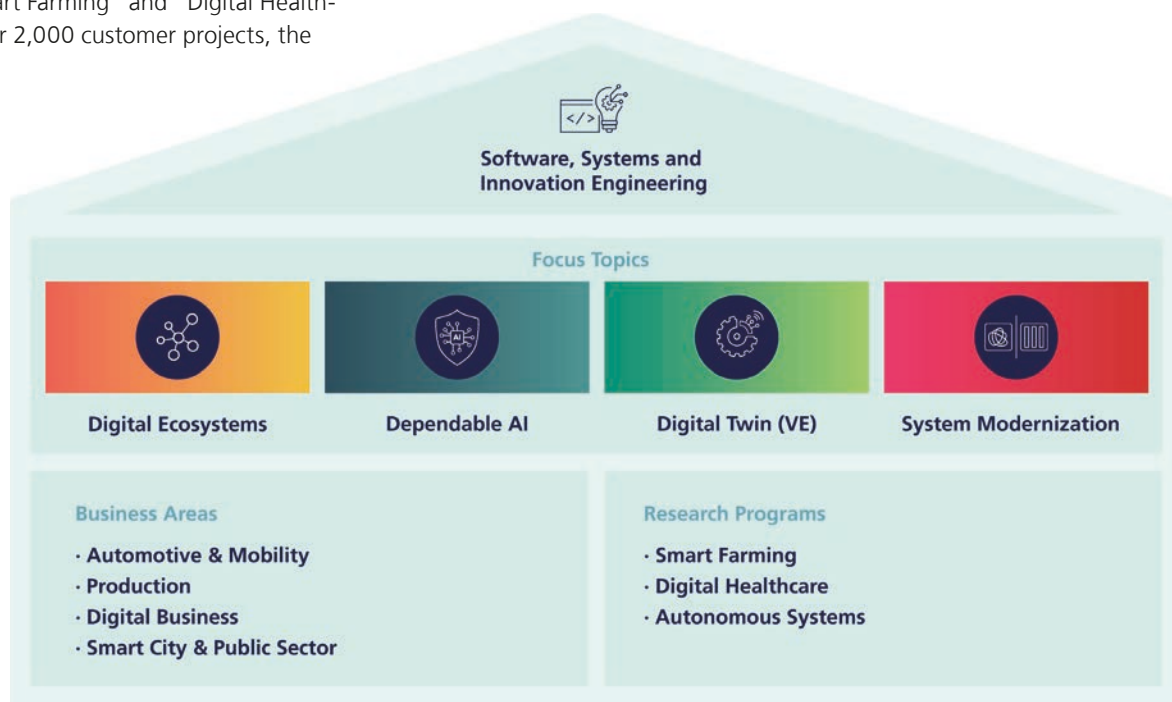
Everything under one roof – with software, systems and innovation engineering, IESE is driving the digital transformation in all areas of application!

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 (Industrie 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 & Public Sector

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.

Research Programs of Fraunhofer IESE

Smart Farming

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 "Smart Farming", 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. Robotaxies and drones that fly autonomously are further examples of the potential and diversity of use cases.
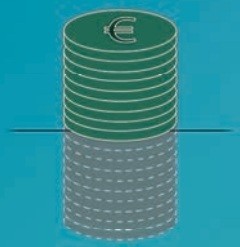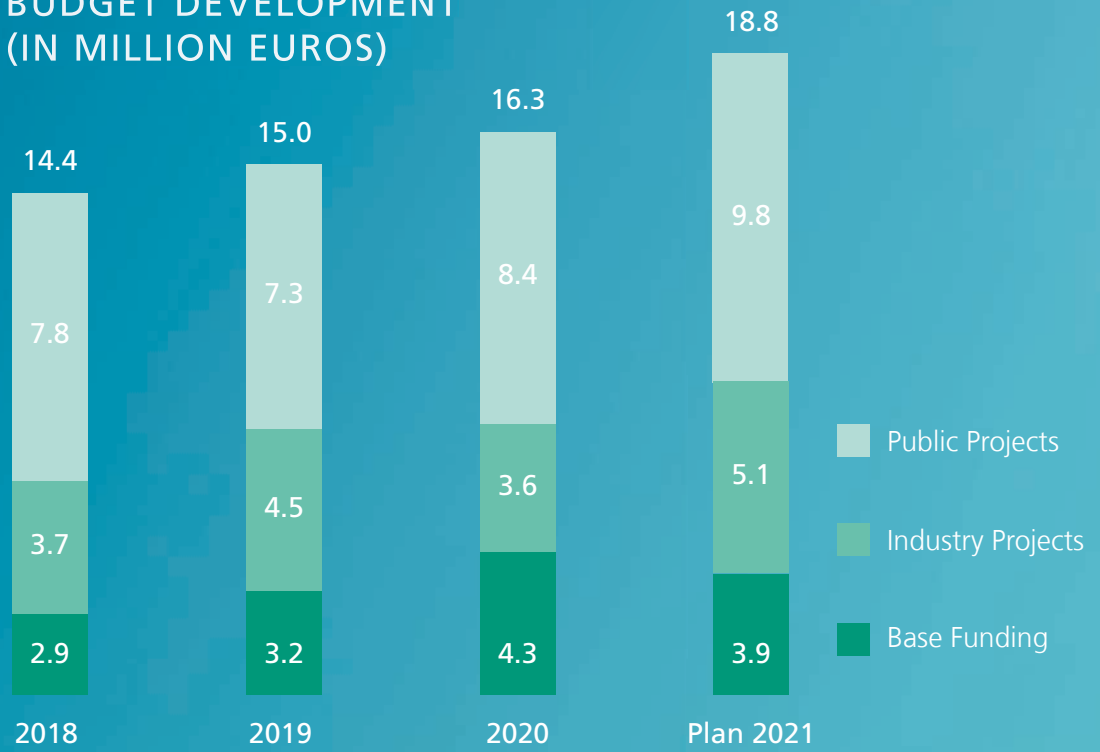
With its competencies and its network, the research program "Autonomous Systems" of Fraunhofer IESE helps suppliers, manufacturers, and operators to move from prototypes and application ideas to market-ready autonomous products, dependable applications/services, and innovative business models.
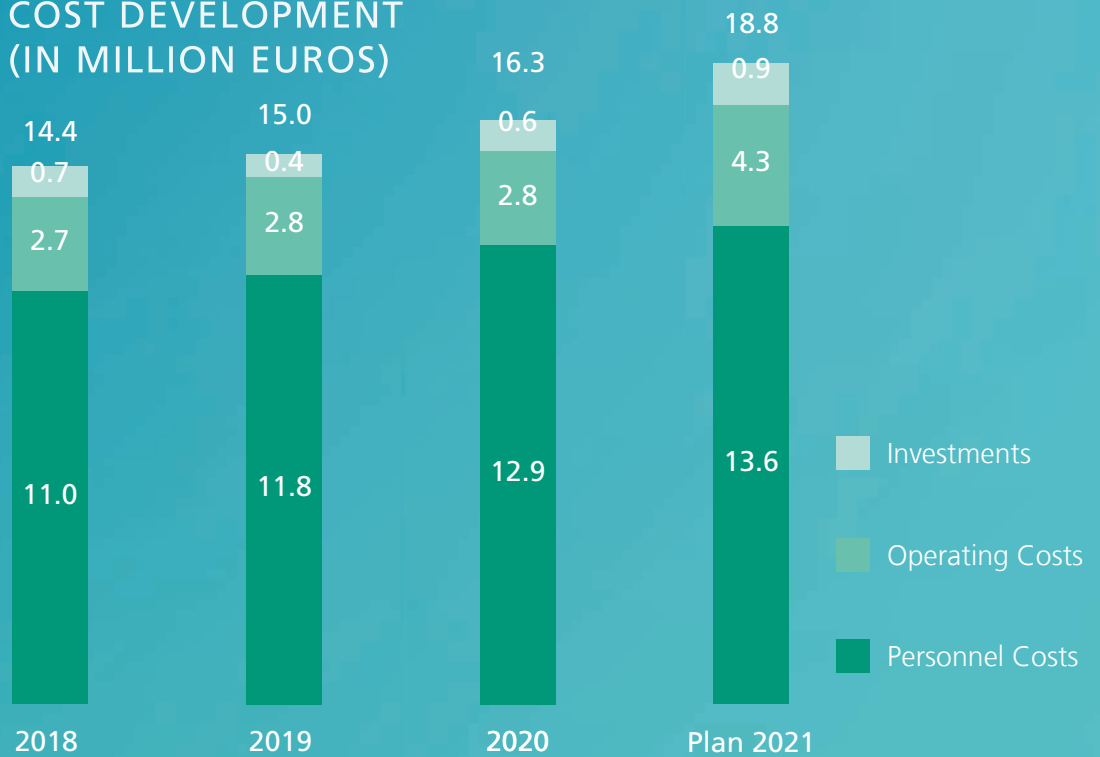
Budget & Cost Development

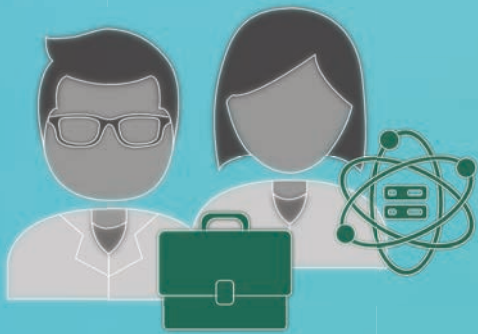## BUDGET DEVELOPMENT (IN MILLION EUROS)

2018	2019	2020	Plan 2021
14.4	15.0	16.3	18.8
7.8	7.3	8.4	9.8
3.7	4.5	3.6	5.1
2.9	3.2	4.3	3.9

Public Projects

Industry Projects

Base Funding

COST DEVELOPMENT (IN MILLION EUROS)

2018	2019	2020	Plan 2021
14.4	15.0	16.3	18.8
0.7	0.4	0.6	0.9
2.7	2.8	2.8	4.3
11.0	11.8	12.9	13.6

Investments

Operating Costs

Personnel Costs

Personnel

—

PERSONNEL IN NUMBER OF HEADS

178
CORE STAFF

10
APPRENTICES & COOPERATIVE DEGREE STUDENTS
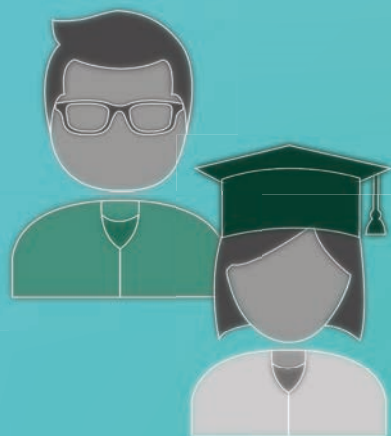
62
STUDENT RESEARCH ASSISTANTS

We approach New Work holistically

In order to remain viable as a research institute and as an employer in the long term, a new mindset regarding the factors work/life balance, flexible work arrangements, employee responsibility, and creative cooperation play an increasingly important role.

This is also the case at Fraunhofer IESE! For this reason, we pursue a holistic approach, because for us, New Work is more than just working remotely. For our joint success, we focus above all on people and on mutual trust. It is important to us that our employees can freely develop and evolve both personally and professionally thanks to modern forms of work. Digital tools and agile methods enable more efficient collaboration within teams as well as with customers and partners. This is precisely what constitutes the fertile breeding ground for successful innovation.

We see New Work as an opportunity to bring the personal goals of our employees even more in line with the goals of our Institute.
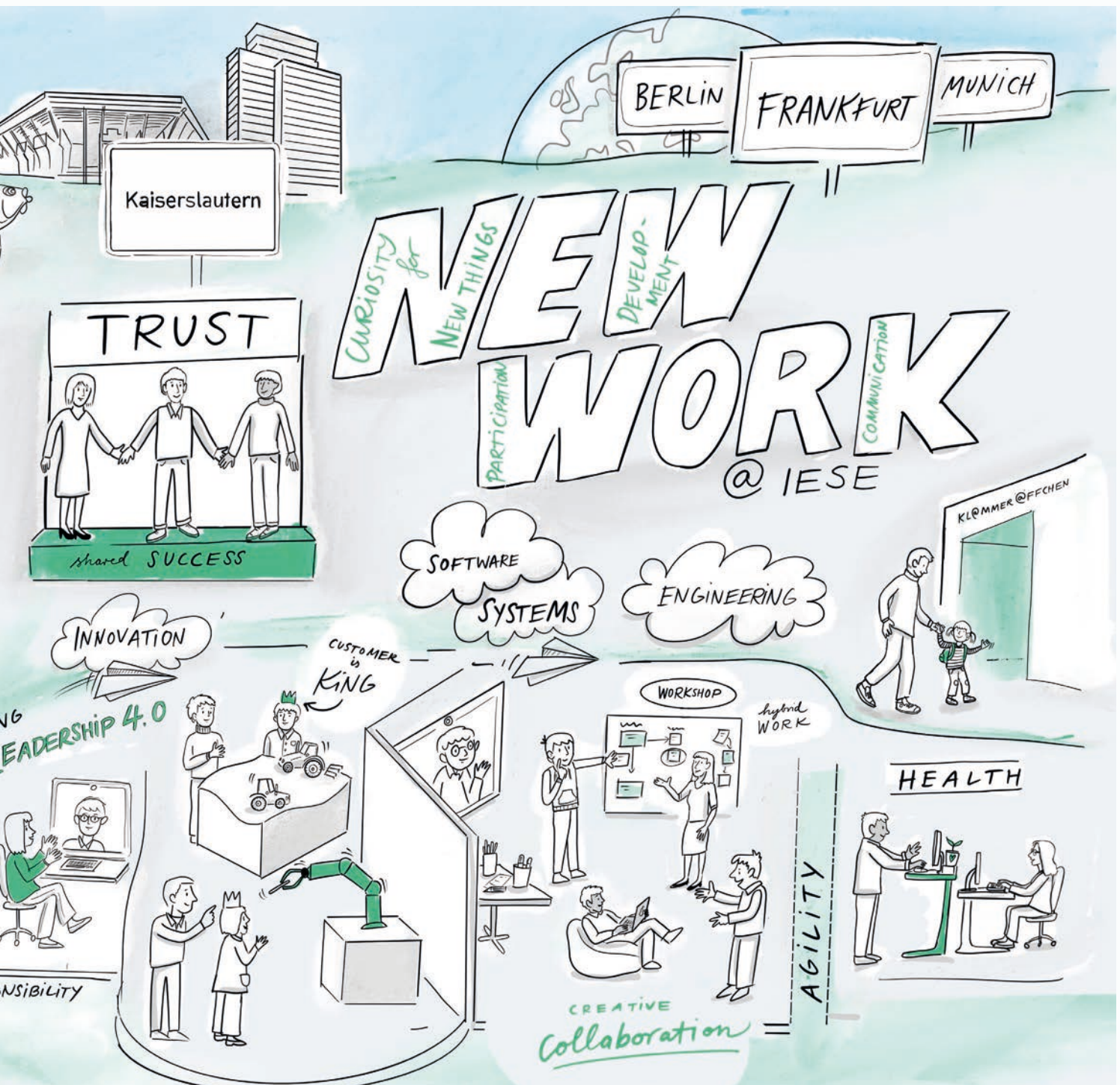
Institute Management

Prof. Dr.-Ing. Peter Liggesmeyer
Director

Prof. Dr. Frank Bomarius
Deputy Director

Prof. Dr.-Ing. Jörg Dörr
Extended Institute Management

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**	SMART DIGITAL SOLUTIONS **Dr. Jens Heidrich**	DIGITAL ECOSYSTEM ENGINEERING **Dr. Matthias Naab**	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. Marcus Trapp**	AUTOMOTIVE & MOBILITY	CORPORATE COMMUNICATIONS & TECHNOLOGY MARKETING	SMART FARMING **Prof. Dr. Jörg Dörr**
				ELECTRONIC LIS & MARKET RESEARCH	DIGITAL HEALTHCARE **Rolf van Lengen**
			PRODUCTION		
VIRTUAL ENGINEERING (VE) **Dr. Pablo Oliveira Antonino**	DIGITAL SOCIETY ECOSYSTEMS (DSE) **Steffen Hess**	ARCHITECTURE-CENTRIC ENGINEERING (ACE) **Dr. Dominik Rost**		ADMINISTRATIVE SERVICES	AUTONOMOUS SYSTEMS **Dr. Rasmus Adler**
			DIGITAL BUSINESS	HR & ORGANIZATION	BERLIN OFFICE **Gerald Swarat**
SAFETY ENGINEERING (SAF) **Dr. Daniel Schneider**		SECURITY ENGINEERING (SE) **Dr. Christian Jung**		IT-SERVICES	FOUNDING DIRECTOR & EXECUTIVE CONSULTANT **Prof. Dr. Dieter Rombach**
			SMART CITY & PUBLIC SECTOR	FACILITY MANAGEMENT	

As of October 2021

Bundling Fraunhofer Power

Since the beginning of 2021, Fraunhofer IESE has been a member of the Fraunhofer Alliances Traffic and Transportation, Food Chain Management, and Energy.

The mission of the **Traffic and Transportation Alliance** is to develop suitable technical and conceptual solutions for public and industry customers by conducting research relevant to traffic and transportation and to transfer them into application. Fraunhofer IESE is involved in the area of Automotive & Mobility through the main topics "Autonomous Systems", "Dependable AI", and "Virtual Development". In addition, it contributes mobility solutions for rural areas.

www.verkehr.fraunhofer.de

Likewise, Fraunhofer IESE is a member of the **Food Chain Management (FCM) Alliance**. The goal of the Fraunhofer FCM is to work together to develop and transfer novel approaches in food safety, microelectronics, and logistics that can be easily integrated into the entire food chain and ensure the highest possible value creation at low cost. In the topic area of Food Chain Management, the focus is on supporting companies and businesses in the digitalization of the entire chain of food production, food technology, logistics, processing, and trade. Here, Fraunhofer IESE contributes its competencies in the fields of "Smart Farming", "Digital Ecosystems", "Industrie 4.0", and "Dependable AI".

www.fcm.fraunhofer.de

The vision of the **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, the member institutes are shaping the transformation to an economical, environmentally compatible, secure, and socially accepted energy supply for electricity, heat, and mobility. Here, Fraunhofer IESE is particularly involved in the research area "Digitalization of the Energy World" and contributes its competencies in the areas of software architectures, design of Digital Ecosystems, data usage control, safety, and security to the alliance.

www.energie.fraunhofer.de

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

DLG e.V. (Deutsche Landwirtschafts-Gesellschaft)
www.dlg.org

Fraunhofer Big Data and Artificial Intelligence Alliance
www.bigdata.fraunhofer.de

Fraunhofer ICT Group
www.iuk.fraunhofer.de

Fraunhofer Segment for Defense and Security VVS |
www.vvs.fraunhofer.de

Gesellschaft für Systems Engineering e.V. (GfSE)
Working group 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

Plattform Industrie 4.0 | www.plattform-i40.de

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

SIAK – Science & Innovation Alliance Kaiserslautern
www.science-alliance.de

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

Advisory Board

Research

Prof. Dr. John A. McDermid | University of York, York, UK

Linda M. Northrop | Carnegie Mellon University, 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

Dr. Ian Thomas |OKIN Shared Services A.S., Prague, Czech Republic

Government

RDin Stefanie Nauel | Ministry of Economic Affairs, Transport, Agriculture and Viticulture
Land Rhineland-Palatinate, Mainz

Dr. Carola Zimmermann | Ministry of Science and Health
Land Rhineland-Palatinate, Mainz

Private Member

Renate Radon | Landau

Guest

Christine Regitz | SAP SE, Walldorf

At the last meeting, Prof. Liggesmeyer welcomed the members of the Advisory Board via video conference.

Project Grant Numbers

BaSys 4.2 | basys40.de
Grant number 01IS19022A (BMBF)

BaSys überProd
Grant number 01IS20094A (BMBF)

Digitale Dörfer | digitale-doerfer.de
Grant number 56:382 Digitale Dörfer
(Ministry of the Interior, for Sport and Infrastructure
of the *Land* Rhineland-Palatinate)

Digitale Zukunftskommune@bw
Order/Grant number LZBW-2018-0006

ExamAi | testing-ai.gi.de
Grant number DKI00.0002_5.20 (BMAS)

Infra-Bau 4.0 | www.infra-bau.com
Grant number DG 25 - 836.7/12 (BMVI)

OPEN-POCT | sofort-open-poct.de
Preliminary notice of measure, grant number 84009429
(Ministry of Science, Continuing Education and Culture of the
Land Rhineland-Palatinate)

Smarte.Land.Regionen
Grant number 2818SL001 (BMEL)

Smart MaaS | smart-maas.eu
Grant number 01MD18014B (BMWi)

SPELL
Grant number 01MK21005B (BMWi)

V&V Methoden | vvm-projekt.de
Grant number 19A19002K (BMWI)

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 is the world's leading applied research organization. With its focus on developing key technologies that are vital for the future and enabling the commercial exploitation of this work by business and industry, Fraunhofer plays a central role in the innovation process. Based in Germany, Fraunhofer is an innovator and catalyst for groundbreaking developments and a model of scientific excellence. By generating inspirational ideas and spearheading sustainable scientific and technological solutions, Fraunhofer provides science and industry with a vital base and helps shape society now and in the future.

At the Fraunhofer-Gesellschaft, interdisciplinary research teams work together with partners from industry and government in order to transform novel ideas into innovative technologies, to coordinate and realize key research projects with a systematic relevance, and to strengthen the German and the European economy with a commitment to creating value that is based on human values. International collaboration with outstanding research partners and companies from around the world brings Fraunhofer into direct contact with the key regions that drive scientific progress and economic development.

Founded in 1949, the Fraunhofer-Gesellschaft currently operates 75 institutes and research institutions. The majority of our 29,000 staff are qualified scientists and engineers who work with an annual research budget of 2.8 billion euros. Of this sum, 2.4 billion euros are generated through contract research. Around two thirds of Fraunhofer's contract research revenue is derived from contracts with industry and publicly funded research projects. The remaining third comes from the German federal and state governments in the form of base funding. This enables the institutes to work on solutions to problems that are likely to become crucial for industry and society within the not-too-distant future.

Applied research also has a knock-on effect that is felt way beyond the direct benefits experienced by the customer: Our institutes boost industry's performance and efficiency, promote the acceptance of new technologies within society and help train the future generation of scientists and engineers that the economy so urgently requires.

Our highly motivated staff, working at the cutting edge of research, are the key factor in our success as a scientific organization. Fraunhofer offers researchers the opportunity for independent, creative and, at the same time, targeted work. We therefore provide our employees with the chance to develop the professional and personal skills that will enable them to take up positions of responsibility at Fraunhofer, at universities, in industry and within society. Students who work on projects at Fraunhofer Institutes have excellent career prospects in industry by virtue of the practical training they enjoy and the early experience they acquire of dealing with contract partners.

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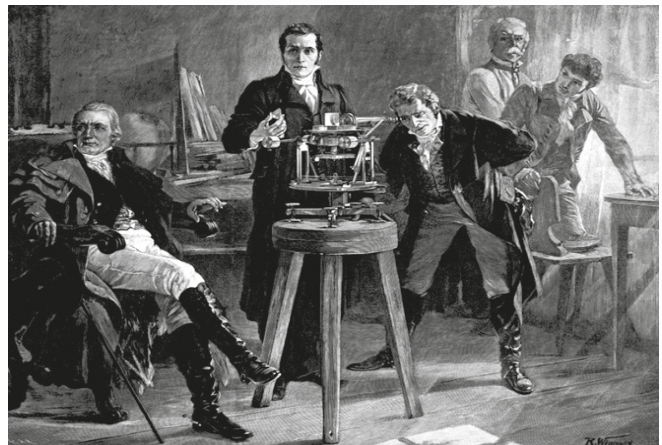
The man behind the name: Joseph von Fraunhofer

Editorial Notes

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

#ENGINEERING THEDIGITALFUTURE

since 96

#STAYCONNECTED