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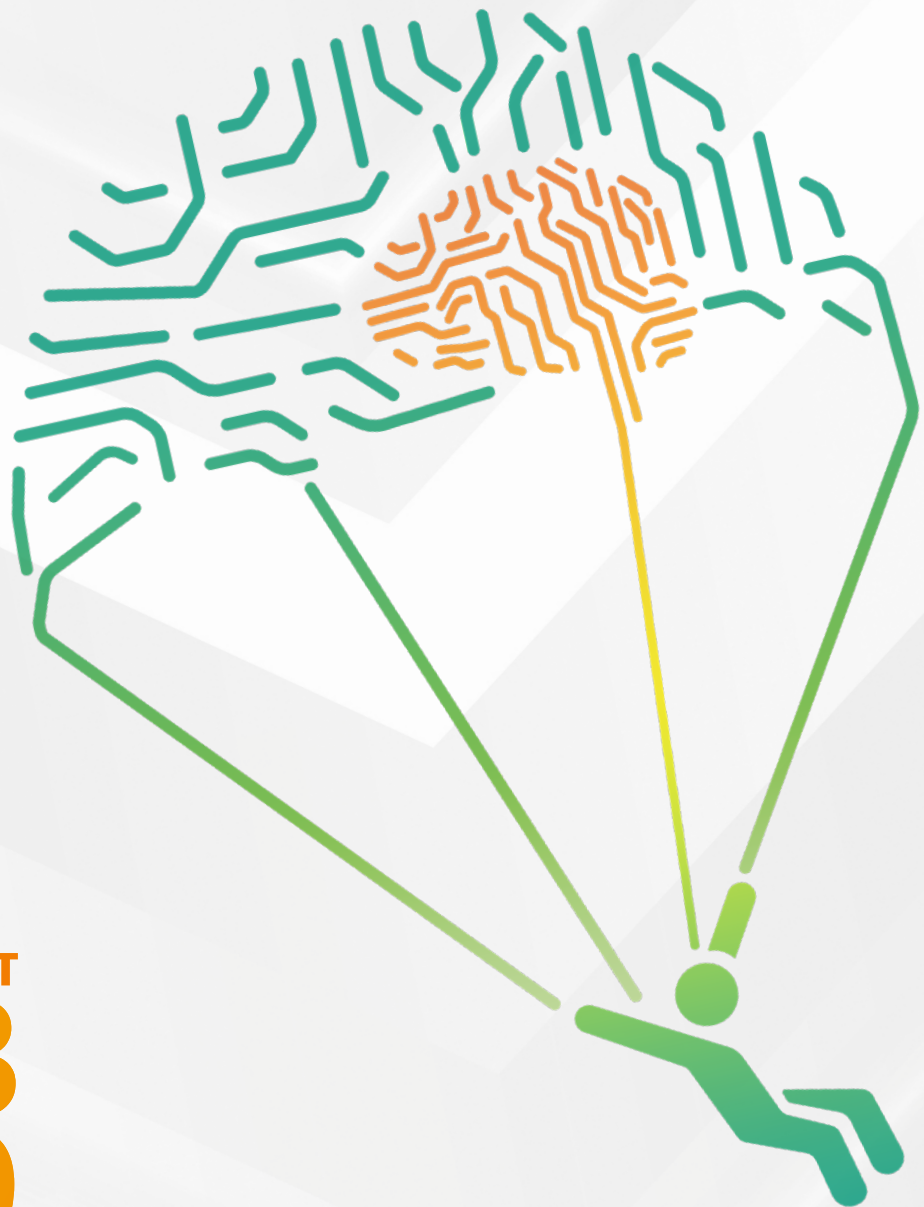
»SafeAI«
VALIDATING ARTIFICIAL INTELLIGENCE

ANNUAL REPORT
2018
2019

Dear reader,

The topic of Artificial Intelligence or AI for short is more relevant today than ever before: A Google search already delivers more than 18 million hits, and hardly a day goes by without reports about new ways of using AI. More and more domains and organizations are discovering the potential of AI for their purposes. Whether in the form of digital assistants and chatbots, cooperative robots, autonomous vehicles, or smart drones – Artificial Intelligence has left the research labs and is increasingly permeating our everyday lives.

Despite this topicality, however, the attempt to reproduce human-like intelligence is not an entirely new approach. Back in 1950 already, Alan Turing developed his well-known test aimed at finding out whether a machine can be distinguished from a human based on its responses in a "survey". Six years later, the computer scientist John McCarthy coined the term Artificial Intelligence, and the vision emerged that one day machines would be able to solve problems that only humans had been able to solve before. In part, this has already become reality, and there is a series of games and benchmarks where AI systems already do measurably better than humans. Until the 1980s, the first commercially relevant wave of AI spawned mainly expert and planning systems for narrowly defined tasks in very structured fields. Only new technologies enabled a new wave of AI in the early 2000s, which has continued since then and has already led to a multitude of new approaches and innovations.

Thanks to constantly increasing computing power, the machine learning processes of AI can learn complex associations from Big Data and use these as a basis for deriving measures and decisions for controlling devices and processes. This leads to new application areas, for instance in Industrie 4.0, in health care, or in autonomous driving. This will offer great economic potential in the future, but also requires developers to be able to use the possibilities and limitations of AI skillfully. In the future, our universities and our universities of applied sciences must ensure even more strongly that they will have the appropriate specialist knowledge.

The German economy is highly dependent on manufacturing companies – such as the automotive industry. Such companies do not sell software per se, but rather integrate software – and thus increasingly also AI components – into their products. These products are often safety-critical. If they do not work as planned, hazards occur, which in extreme cases may lead to the loss of human lives. Such systems therefore require relevant proof of their safety prior to being deployed, up to and including official certification by duly legitimated authorities. This collides with one property of current AI learning processes: The existing solutions are unsafe from the perspective of safety technology and cannot be certified in the strict sense. However, if such solutions are to be used anyway, the question arises as to how to design systems that are safe overall despite having unsafe AI components. Fraunhofer IESE is conducting very intensive research regarding this topic. This is why we have chosen "SafeAI" as the motto of this annual report. German research can make a name for itself particularly in terms of "validating AI". Results in this area are the premise for the use of AI components in a multitude of important industries, particularly in Germany.

Of course, as a software and systems engineering institute, we also work on many other important topics: We design and realize the Industrie 4.0 solution BaSys 4.0, design the digital future of rural areas, and optimize sustainability and feasibility in the agricultural sector. In addition, we work on providing digital support for the "work of the future", develop methods for eliciting requirements on complicated systems with high quality and technologies that enable the use of data and at the same time the dedicated protection of data. With this annual report, we want to invite you to delve into the exciting world of software and systems engineering.

We hope you will enjoy reading this report!

Peter Liggesmeyer

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"We enable Artificial Intelligence even in safety-critical environments."

Prof. Peter Liggesmeyer, Fraunhofer IESE

ARTIFICIAL INTELLIGENCE

AI – what is this?

Artificial Intelligence, or AI for short, has been known as a discipline of computer science since the mid-1990s already. This discipline deals with the development of systems that solve problems on their own by acting intelligently, analogously to human thought and behavior patterns. This can already be implemented to some extent, but even after decades of research, some concepts still have a rather visionary character. Increased computing power and the emergence of Big Data, in conjunction with more affordable data processing, have made it possible to significantly boost the development of AI approaches in recent years. Systems developed in the research environment of Artificial Intelligence are already shaping our everyday lives and will soon permeate ever more areas. Language assistants, for example, have already become common as helpers in cars or at home.

The greatest progress in the field of AI is currently being made in the area of Machine Learning. Machine Learning is a branch of Artificial Intelligence that deals with methods that extract knowledge from data through generalization, i.e., that learn connections contained in the data on their own. Progress in this field is the reason for the current enthusiasm for AI. Machine Learning methods make it possible to develop systems that are already better than humans in performing special tasks such as the classification of objects in arbitrary images.

The progress mentioned in this area is due to a large extent to the use of Artificial Neuronal Networks. Artificial Neural Networks are a class of models that, similar to concepts of human learning, are mainly based on strengthening, resp. weakening, the links between computational units – comparable to human neurons. These computational units are usually arranged in a series of levels. Deep Learning as a branch of Machine Learning represents a class of new methods that allows training even structurally complex Artificial Neural Networks. These networks potentially consist of very many levels, use novel computational units, and link levels into more complex structures. This enables them to process even complex input data such as images directly; in return, however, their significantly higher number of connections and computational units also means that they require significantly more data in order to reliably extract connections.

The training of an Artificial Neural Network differs fundamentally from classical software and systems engineering. Here, the focus is no longer on the development of an algorithm, but on the collection and management of huge amounts of data and the use of complex mathematical computations to train these networks. In view of these changes, Fraunhofer IESE is researching solutions for the software engineering of the future in order to be able to continue to guarantee high-quality systems.

DID YOU KNOW...
...THAT AI IS ALMOST AS OLD AS THE FRAUNHOFER-GESELLSCHAFT!

2029

According to Moore's Law, in ten years PCs will have the **computing power of the human brain**.

2018

AI can read better than humans (Stanford University Squad Test).

2016

The Deepmind software AlphaGo wins the complex Chinese board game Go.

2012

Google's autonomous car gets road approval in Nevada.

2011

Apple's language assistant Siri is launched.

2011

The computer program Watson (IBM) beats two quiz masters in the quiz show Jeopardy!.

2009

WolframAlpha is the first semantic search engine.

1997

First robot soccer world championship with 38 participants

1997

The chess computer Deep Blue wins against chess world champion Garri Kasparow.

1982

Development of the first commercially usable language recognition systems starts (Dragon Systems/NUANCE).

1979

First time that a backgammon program beats the incumbent world champion.

1971

The Stanford Cart is considered the first autonomous vehicle.

1966

The first chatbot ELIZA (Joseph Weizenbaum) pretends to be a psychotherapist.

1960

The computer Mark I learns on the basis of the trial & error principle.

1956

The computer scientist John McCarthy coins the term "Artificial Intelligence".

1951

The first neurocomputer SNARC (Stochastic Neural Analog Reinforcement Computer) built by mathematician Marvin Minsky had only 40 synapses.

1950

Test proposed by Alan Turing to compare artificial intelligence with human intelligence (Turing Test)

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Validation of AI

What if AI fails

The use of Artificial Intelligence (AI) is becoming increasingly widespread in industry, but also in our everyday lives. As long as we do not venture into safety-critical areas, the opportunities offered by AI predominate. But what about the risks, if, for example, a robot in manufacturing fails and, by making a wrong movement, jeopardizes the life of a worker standing next to it? Or if an autonomous vehicle runs a red light and thereby causes a life-threatening situation for pedestrians? Dr. Daniel Schneider, Department Head Safety Engineering, and Dr. Andreas Jedlitschka, Department Head Data Engineering, explain in this interview how Fraunhofer IESE makes AI systems safe.

What is the current state of research in the field of Artificial Intelligence?

Andreas Jedlitschka: More and more products contain components that are based on Artificial Intelligence and Machine Learning methods. The spectrum ranges from product and music recommendations on the Internet via support for radiologists in cancer diagnosis to traffic sign recognition and obstacle detection in road traffic. Other current examples include the identification of objects in images, the recognition of human speech, as well as automated text translation.

Daniel Schneider: Thanks to Artificial Intelligence, even former visions of the future, such as autonomous vehicles, are now within reach.

Nevertheless, some questions regarding AI have not been clarified conclusively yet. What are these at the moment?

Daniel Schneider: It quickly becomes clear that when the possibility of human intervention decreases, any risk of a failure, resp. any hazard to the environment caused by the system itself must be minimized. This also raises the question in which form proof of functional safety can be provided. This question arises wherever the failure of a machine-learned solution entails high risks, particularly regarding physical harm to human beings. This requires special measures to guarantee the functional safety of systems with AI components.

Andreas Jedlitschka: One of the most important factors in this regard is the quality of the data used for training the neural networks. Nonetheless, situations may always occur in open environments that were not taken into account during the development of a technical system. The ability to deal with such situations and exhibit reliable behavior even under such circumstances is called resilience. At Fraunhofer IESE, we develop technologies and methods that support engineers in the development of such dependable and often safety-critical systems.

What does safety even mean in the context of Artificial Intelligence?

Daniel Schneider: In general, safety does not mean that no damage may occur, but rather that the risk is acceptable. If, in the context of Artificial Intelligence, we stick to the

example of autonomous vehicles, the question arises as to what residual risk can be accepted and how to ensure that autonomous vehicles will cause at least significantly fewer accidents than vehicles controlled by humans. Regardless of how well autonomous driving will work in the future, the number of accidents is probably never going to drop completely to zero. Even a fast-reacting automated system needs, for example, a certain braking distance, which depends on its speed. Therefore, there will always be some residual risk that a society has to live with.

Which role can the use of Artificial Intelligence play in minimizing risks?

Daniel Schneider: Safety-relevant decisions in vehicles are increasingly made by software. It determines, for example, which of the possible reactions is most appropriate in which of the expected situations, and it is checked whether the software actually delivers the desired behavior. However, this only works as long as the situations are known in advance, so that the reactions to them can be defined in the software.

Andreas Jedlitschka: If the situations are too complicated and too numerous to define everything in advance, Artificial Intelligence methods can provide help. There are very powerful ones that often provide surprisingly good solutions. However, there is no assurance that an AI method can be depended on to always deliver good results. However, this is a requirement that will be imposed on autonomous vehicles.

How can we deal with this knowledge about residual uncertainty and what needs to be taken into account?

Andreas Jedlitschka: It is essential to eliminate identifiable sources of failure and assess the uncertainty in the provided result as dependably as possible. For example: a data-driven component for traffic sign recognition should not only provide the information that its analysis of available data indicates the presence of a right-of-way sign, but should also provide information on the degree of uncertainty in this analysis. Knowledge about poor lighting conditions or a dirty camera lens, for instance, does not provide much additional information to correctly identify a traffic sign, but it helps to assess the uncertainty in the result provided. This contributes greatly to better traceability of the decisions made by AI and the results so that these can also be questioned, if necessary. This, in turn, influences the accuracy of future decisions.

What happens if AI solutions fail?

Daniel Schneider: One strategy may be to monitor artificially intelligent systems with conventional software. It is often much easier to check whether a reaction is safe than to define the reaction itself. Applied to autonomous vehicles, this means that an AI solution with all its strengths and weaknesses could be used to deal with complicated issues. And should this AI solution fail, conventional software could prevent an unsafe situation from arising. This software would then provide a kind of safety net. As this is "normal" software, its function can be traced exactly, meaning that a failure of the AI solution would have no

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serious consequences. Artificial Intelligence can therefore make autonomous vehicles largely safe if it remains connected with classical algorithms. In this way, engineers will retain full control even in the future, not leaving it only to computers.

So can we assume that there will be greater acceptance for AI in safety-critical systems in the future?

Andreas Jedlitschka: Yes, I am convinced this will happen. In combination with new methods from the AI world, the safety net described above will help to develop and operate viable, safe systems. To achieve this, we are, for example, working on automated processes for the evaluation and assurance of data quality when learning and using AI, as well as on extending the processes to include self-assessment by the AI component regarding the uncertainty of the result. A recently performed study has shown that the development processes for the AI components have an impact on safety – thus not every AI approach is suitable to the same extent for different data qualities. In summary, I believe that a better understanding of the opportunities and risks of AI in general will lead to wider dissemination. What is important: Seizing the opportunities without ignoring the risks also applies to AI.

The interview was conducted by Claudia Reis, Press Aide, Fraunhofer IESE.

More on how Fraunhofer IESE validates AI solutions in research and industry projects can be found on the following pages...

RESEARCH PROJECT SECREDAS

IESE increases confidence in automated systems

Under the name "Product Security for Cross Domain Reliable Dependable Automated Systems", SECREDAS for short, Fraunhofer IESE is doing joint research with 68 partners from 16 European countries on a reference architecture for safe automated systems. The project, which started on 1 May 2018, is designed for a duration of three years, but the first results are to presented already at the ITS European Congress held in Helmond/Eindhoven in the Netherlands on 3-6 June 2019. In the context of the EU-funded program "ECSEL Joint Undertaking", which supports research, development, and innovation projects in the area of electronic components and systems, SECREDAS is receiving 50 million euros in funding.

The interdependence of the safety, security, and privacy of networked and automated systems is a concern for many consumers in the European Union in numerous application areas, but the current lack of confidence in the safety of these systems presents an obstacle to their further development. To solve this problem, industry and research must collaborate closely, which is the task of SECREDAS. Through this project, an important step is being taken towards the development of "confidence-building" components and systems, especially for the European transport and medical industries of tomorrow. This will contribute, for example, to making networked and automated vehicles a reality on the market, thereby ensuring that European OEMs will remain competitive.

"We are proud that we have been able to bring together the most important European stakeholders with experience in the respective application domains as well as in the area of security and privacy. This will lead to a gigantic leap forward in terms of the confidence of road users in autonomous vehicles and confidence in the health system", says Patrick Pype, project manager of SECREDAS. "The consortium expects that by 2030, one quarter of all road vehicles will be equipped with the SECREDAS technology, which corresponds to a value of 10 billion euros."

Research in the context of this project covers technologies such as radar, lidar, vehicle-to-infrastructure, and in-vehicle networks. Fraunhofer IESE is managing the tasks in the topic areas "Architecture for Mitigating Safety & Security Issues" and "Safety, Security & Privacy Analysis of Design Patterns". The planned architecture will enable assigning the most critical system requirements to a reliable channel, using the institute's expertise in safety@runtime methods. The analysis of design patterns plays a large role in this respect. To this end, different departments of Fraunhofer IESE are bundling their respective competencies in the areas of safety and security into a joint development process.

www.ecsel.eu/projects/secredas

"SafeAI"

INDUSTRY PROJECT HITACHI

Safety engineering for vehicles with higher automation levels

The challenge

Besides the technical challenges regarding the realization of vehicles of higher automation levels, there are challenges in ensuring the functional safety of such vehicles. Manufacturers of vehicles of higher automation levels can only release their products to the market if they can trust that they have been properly engineered and that their introduction will not increase the risk of accidents on the road. Ensuring the latter aspect is the genuine scope of safety engineering. Existing safety standards such as ISO 26262 are, however, not sufficient for considering the full problem scope of automated vehicles. Upcoming standards such as the Safety-Of-The-Intended-Functionality (SOTIF) ISO PAS 21448 initiative attempt to close the gap between the safety engineering currently supported by safety standards and the safety engineering needed for the release of vehicles of higher automation levels. However, it is neither guaranteed that the scope of SOTIF will be sufficient to close that gap nor does a safety engineering process currently exist that includes the necessary safety considerations for vehicles of higher automation levels.

The solution

In a joint research cooperation, researchers of Hitachi and Fraunhofer IESE have investigated the necessary scope for future safety engineering and how current safety standards and standard creation initiatives address this scope. Based on the results of this investigation, an initial process and methodology for multi-aspect safety engineering with tool support from **safeTbox**, a tool of Fraunhofer IESE, was developed. The results of this project were presented at the International Conference on Computer Safety, Reliability & Security (SafeComp) – one of the most important conferences in the safety engineering community – in Sweden in 2018. Sharing the results with the research community enabled critical reflection on them and contributed to building awareness for the full problem scope of safety engineering for vehicles of hgher automation levels.

The result

The joint research activity enables Hitachi and Fraunhofer IESE to anticipate the contents of upcoming safety standards in the field of automated vehicles and to address these contents with a tool-supported methodology.

"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
Control Platform Research Dept.
Center for Technology Innovation
– Controls Hitachi, Ltd. Research &
Development Group

RESEARCH PROJECT MInD

Enabling neural networks even in safety-critical contexts

The aim of the project "Machine Intelligence and Deep Learning" (MInD) is the identification and use of Deep Learning technologies for the socio-technical design of the digital transformation. To achieve this, the relevant important competencies and existing potentials of the research institutes DFKI, Fraunhofer IESE, and Fraunhofer ITWM, all located in Kaiserslautern, are to be bundled. Fraunhofer IESE is in charge of the activities on the topic of "Validation of Deep Learning". The project is funded by the Rhineland-Palatinate Ministry of Science, Continuing Education and Culture.

Systems with a high level of automation are often responsible for exhibiting safe behavior in arbitrarily complex situations. A mobile robot in manufacturing must not collide with the workers in its environment, and an automated vehicle must normally not cross an intersection with a red light. With higher levels of automation, no human is available anymore to monitor the situation, and the system must already demonstrate safe nominal behavior on its own. Increasingly, neural networks are used to realize such highly automated systems. The best-known example are the neural networks used for image recognition, whose results are used in behavioral planning.

The development and training of neural networks differs fundamentally from the development of classical algorithms in popular programming languages such as C or Java. Under the term Software Engineering, the systematic development of code in higher programming languages has been professionalized in recent decades by institutes such as Fraunhofer IESE and matured to such an extent that software has now become standard even as a component of safety-critical systems. For the development of neural networks, this is not the case yet. There is a study (https://ieeexplore.ieee.org/document/8416518) that shows that components developed in accordance with the Machine Learning paradigm are responsible for 64% of the failures of the vehicles being tested today on public roads in the US. This poses a serious threat to the physical safety and the lives of the people exposed to these systems.

The project MInD aims to remedy this situation. In the first project phase, approaches that can be used to improve the quality of neural networks were collected in a systematic literature review. The vision is to use these to define an engineering process in order to shift to more systematic development in the future and to enable the use of neural networks even in safety-critical contexts.

IESE IN TREND

Fraunhofer IESE –
Engineering the Digital Future!

VIRTUAL ENGINEERING

Virtual validation of safety-relevant decisions

New digital ecosystems connecting existing products and processes by means of software and data are currently emerging in all areas of life. One central challenge in this context is the integration of components and systems, which increasingly takes place dynamically and at run-time. Using the simulation framework FERAL developed by Fraunhofer IESE, complex heterogeneous scenarios can be integrated into a testing scenario and features can be tested in virtual space.

> "If a test driver were to drive 1,000 kilometers a day, more than 5,000 drivers would need to be in continuous operation 365 days a year to ensure the validation of a fully automated car."
>
> VW inside

Particularly systems that make safety-relevant decisions in an automated manner and on which, in extreme cases, human lives are dependent must be specially validated and tested. This includes, for instance, vehicle platforms that can dynamically receive and integrate driving functions. Typical questions in this regard are:

- How to remote-control safety-relevant vehicle functions with a smartphone without violating the safety properties?
- Is the new platform protected against cyber-attacks?
- Which network technology offers enough bandwidth for my vehicle platform/industrial plant?

With Industrie 4.0, industrial manufacturing is facing similar issues when it comes to dynamically integrating new devices and processes into an existing plant:

- How can my Industrie 4.0 production be planned automatically?
- What is the impact of introducing a new type of robot in my industrial plant?
- How to realize a software lockstep for controlling industrial plants?
- How to add open interfaces to an existing system and how to validate these?
- Will the new component fit into the existing infrastructure?
- Have all requirements of the system architecture been taken into account?

With the simulation platform FERAL, complex, heterogeneous scenarios can be integrated into a testing scenario in order to systematically test properties in a virtual safe space with the help of digital twins. Examples are the correct functioning of a pedestrian recognition system or the faultless interplay between two functions from different manufacturers.

The advantages of virtual engineering are diverse:

- Cost and time savings in strategic developments and changes of system concepts (control units, networks, etc.)
- Early detection of wrong developments
- Validation of decisions with measurable results
- Consideration of the requirements of the stakeholders (marketing, developers, users, project manager, etc.)
- Focus on solution concepts instead of on problems
- Testing of system concepts in the context of failures and attacks (e.g., hacker attacks)
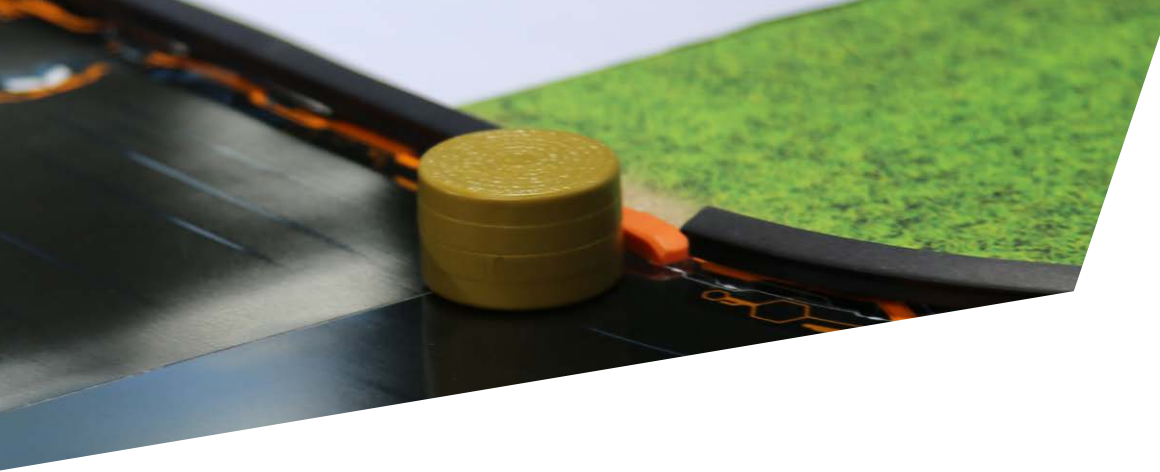
How does the underlying technology work?

The simulation framework FERAL developed by Fraunhofer IESE creates virtual prototypes by coupling simulation models and simulators, existing code, and virtual hardware platforms. This makes it possible to check the impact of decisions early on. In a very early phase of the development, the simulation can be based purely on models; this is called Model-in-the-Loop (MiL) simulation. For this purpose, FERAL uses, for example, UML state machines or activity diagrams, or coupling with Matlab Simulink. In these early phases, critical design decisions are often made, which can be validated with the help of such simulations. If initial software realizations already exist, these can be combined with the existing models in a Software-in-the-Loop (SiL) simulation. This enables more accurate predictions regarding system behavior, or allows checking compliance with previously created models in back-to-back tests.

In parallel to the design of the software, the design of the hardware is pushed in the classical V-model. FERAL supports this step by providing virtual hardware platforms, i.e., processor and network models to which the software components can be deployed in a virtual Hardware-in-the-Loop (vHil) simulation. All these simulations (MiL, SiL, and vHiL) serve to detect defects as early in development as possible, which then allows reducing the number of expensive Hardware-in-the-Loop (HiL) simulations and integration tests.

Use case "Autonomous Driving"

Autonomous driving presents great challenges for the automotive industry. These include technical challenges, such as "How does the vehicle reliably recognize pedestrians crossing the road?" or "Which decision does Artificial Intelligence have to make?". The greatest challenge relates to functional safety – it must be guaranteed that the autonomous vehicle is as safe as or safer than a vehicle with a human driver.

Due to the increased complexity of autonomous vehicles, classical validation techniques quickly reach their limits. Experts of TÜV Süd assume that 100 million critical situations must be tested in order to sufficiently test a single vehicle function. Classical field tests can never achieve the necessary coverage since a number of critical situations occurs too rarely in real driving situations. For this reason, BMW assumes that for autonomous vehicles, 95% of the tests must be done virtually by means of simulations.

The advantage: Simulations can adapt existing scenarios through variations, so that critical situations occur more frequently. As an example, let's take the testing of an intersection crossing assistant: In real driving situations, it rarely happens that two vehicles arrive at an intersection at the same time and that the assistance system must perform an emergency braking maneuver. Field tests in real driving situations would therefore require a lot of effort.

Here, simulation offers the possibility to generate virtual vehicles that cause the critical situation and thus ensure that the intersection crossing system can be validated.

However, in the virtual validation of autonomous systems,. it is not sufficient to merely look at the sensor data processing and the correctness of the Artificial Intelligence. The processors used or the capability of the network technologies deployed in the vehicles can form a bottleneck that prevents timely reaction. For this reason, an autonomous system can only be validated with a simulation that contains the entire vehicle as a digital twin, with sensors, control units, and actuators as well as the network technology connecting them. This requires the coupling of various simulation models.

CrowdRE

Dr. Marcus Trapp (left) and Eduard C. Groen from Fraunhofer IESE explain in the interview why CrowdRE is on the advance.

Using the crowd to leverage the market potential of software products

Every product has a crowd. But this refers neither to the line at the supermarket checkout nor to the crowding at a trade show booth. This crowd refers to a large number of product users who interact online, for instance via rating portals. Exploiting this enormous data potential and creating a competitive edge through skillful automated analyses is what Crowd-based Requirements Engineering is all about. More about this in this interview with Dr. Marcus Trapp, Department Head User Experience und Requirements Engineering, and Eduard C. Groen, researcher at Fraunhofer IESE.

What is a crowd? Is a critical mass needed to speak of a crowd?

Eduard C. Groen: In Crowd-based Requirements Engineering or CrowdRE for short, we define a crowd as a very large, heterogeneous, and physically distributed number of stakeholders. They are all current or potential users of a particular product, in our case a piece of software, and they exchange ideas and information with each other online. Even users of similar products of a competitor are included. The term cannot be tied to a specific number, but about 1,000 people would be the lower limit for me. However, in the case of a "private crowd", which could be the employees of one company for example, fewer people might also be enough because here, a representative sample of the crowd can be covered faster. The important thing is that the individuals in a crowd, regardless of whether it is a private or public one, actively engage with each other.

What is the goal of Crowd-based Requirements Engineering and how do I get the data?

Eduard C. Groen: CrowdRE is suited particularly for products that are already in use. By tapping the enormous potential of the crowd, you improve the product, which may include fixing bugs as well as offering new innovative functions. By using a product, the crowd gains experience with its use and reports on this via user feedback. This user feedback is often shared in review portals and via feedback channels such as social media. So these are good sources for product developers to find out what the crowd likes or maybe dislikes, or what might be missing. To do this, "text mining" techniques are mainly used. In the case of software, the product developers can also employ "usage mining" techniques to analyze how the crowd is using the product.

Can we say that automated analysis techniques are on the advance?

Dr. Marcus Trapp: Actually, "text mining" and "usage mining" have been around for some time already; first steps were already undertaken in the 1970s. Today, though, we are increasingly moving towards fully automated analysis, thanks to Machine Learning and AI technologies. Also, to analyze the feedback from a large crowd, the use of "Big Data" approaches in a way that was not available in the past is indispensable. We as Fraunhofer IESE make use of these future-oriented technologies and tools and have comprehensive expertise in classical RE methods, data analytics, creativity techniques, as well as in Machine Learning and AI – the best prerequisites for CrowdRE.

Can you explain in more detail why Big Data technologies are necessary here?

Dr. Marcus Trapp: Big Data offers real benefits for the analysis and comparison of user feedback. On the one hand, a crowd produces very diverse data. User reviews have a different structure and language than bug reports, and logfile data from apps differ from those from embedded systems. On the other hand, data must be processed fast in order to identify problems, trends, and innovations early. Big Data is thus indispensable for CrowdRE.

What is actually the difference to classical requirements engineering?

Dr. Marcus Trapp: Proven techniques used in requirements engineering are interviews, questionnaires, and workshops. However, these approaches are only suitable for a small number of stakeholders as they are too time- and cost-intensive. If you want to understand all stakeholders on every continent through a representative sample, you will quickly reach limits with traditional methods. We see CrowdRE as a complement to the proven requirements engineering techniques. Here the aim is to analyze data and feedback on products that is already available online and stems from rating sites, bug trackers, or social media for one's own purposes in an automated manner. The use of dedicated tools and techniques allows getting insights from thousands of users of a product – with minimal effort. It would be a waste not to exploit this potential.

What would be a typical application example?

Eduard C. Groen: Apps, for example, are ideal for uncovering potential for improvement through CrowdRE. The existing reports provide a huge data potential, which can be used to gain insights into bugs, complaints, feature requests, praise, as well as functional and quality requirements using automated analysis methods. In addition, "usage mining" makes it possible to find out how users use the app and which problems they might have with it. If you want to develop a completely new app, it may be worth finding out, on the basis of user reviews of competitor products, what their users are missing. And exactly this knowledge can then be used in your own product development and thus create unique selling points.

The decisive role of Fraunhofer IESE in CrowdRE

The name "Crowd-based Requirements Engineering" was introduced by Fraunhofer IESE and used for the first time in the paper "Towards Crowd-based Requirements Engineering" at REFSQ 2015. In the meantime, the term has become generally accepted and is being used by other researchers as well. In the context of the annual IEEE International Requirements Engineering Conference, Fraunhofer IESE has been co-organizer of the "International Workshop on CrowdRE" from the very beginning.

How does a CrowdRE project work?

Eduard C. Groen: What is unique in this field is the personal support and consulting that Fraunhofer IESE offers its customers. Large or small, for every project the exact implementation of CrowdRE is customized so that the issue is answered optimally by the analyses. In a workshop, we work together with the customer to elicit the needs of their company and thereby identify appropriate data sources from which our tools can automatically collect the relevant user feedback. The results of the analysis are presented as actual requirements using dashboards, automatically or semi-automatically generated reports, or even expert analyses. We as Fraunhofer IESE thus offer comprehensive expertise for custom-tailored services based on our tools!

The interview was conducted by Claudia Reis, Press Aide, Fraunhofer IESE.

AGILE TRANSITION

From the Process Engineering department of Fraunhofer IESE: Sabrina Hörner, Sven Theobald, and Anna Schmitt (from the left) advise companies on the subject of agile transition.

Let's go for holistic agility!

How agile is your company? What exactly does this mean, and what does agile mean in the context of software and systems engineering? For years, the Process Engineering department at Fraunhofer IESE has been dealing with the subject of "Agile" in software eengineering, which is now becoming a holistic topic for organizations.

When we talk about "agile", this comprises many different aspects of software engineering, which are all based on the **Agile Manifesto of Software Engineering** [1], which defines the values and principles of the "agile" approach. We advocate a stepwise transition to an agile organization: starting with a single agile team, to an agile project, via agile organizational units all the way to an agile company (see figure). This means that this transition should take place bottom-up so that the company can gently benefit from "agile".

Team level

The first steps of the transition towards an agile company start at the team level. Here, it is important to start with an AS-IS analysis of the current development process and developer team. In the context of such an AS-IS analysis, we determine, among other things,

- which methods and practices are already in use,
- in which organizational context this takes place, and
- which goals are to be pursued in the process, resp. where in the process problems and challenges exist.

Companies often ask about the agile maturity of their organization or a single project. One way to answer this question are **Agile Maturity Models (AMM)**. They make it possible to determine the maturity of a project or even of an entire organization with regard to its agility on the basis of defined criteria and steps. A comparison of existing AMMs performed by Fraunhofer IESE has revealed very different usage purposes – from benchmarking via the detection of bottlenecks to self-assessment. With this knowledge, Fraunhofer IESE supports companies in defining a maturity model that is appropriate for them – taking into consid-
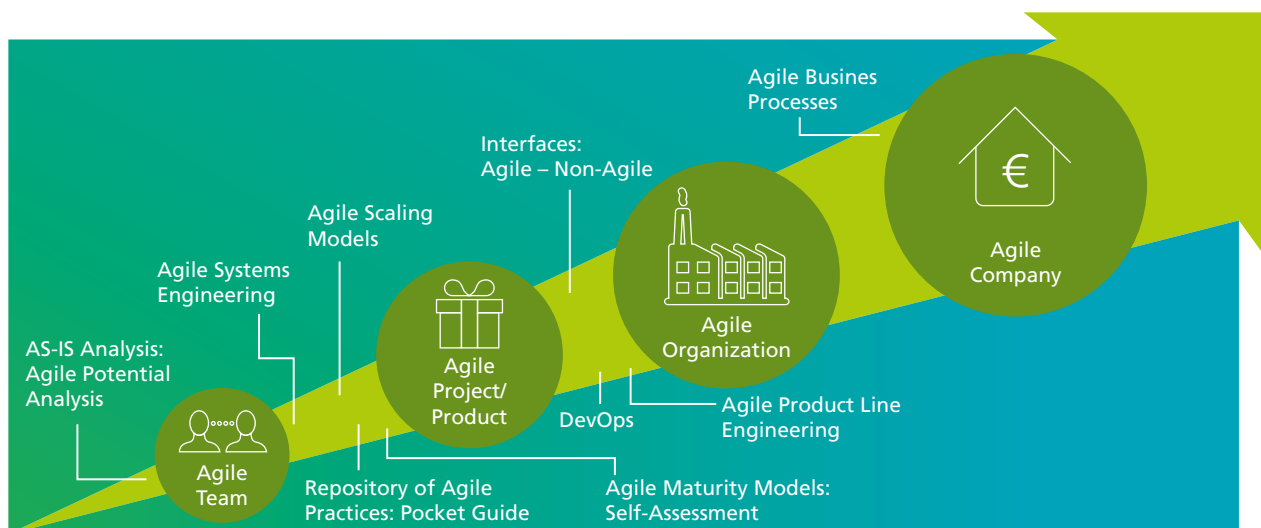
Agile transition: from agile teams to agile companies

eration both context and goals. Based on the AMMs and our practical experiences, we have development self-assessments for Scrum as well as for Culture and Mindset.

Following this analysis, we can then define how the team can evolve in terms of its processes. To do so, the **Agile Potential Analysis** created by the department is instantiated. The aim of this analysis is to define the appropriate level of agility as a series of agile practices. The established practices are selected with our objective help based on individual goals and the specific context, such as regulatory frameworks (Automotive SPICE). Fraunhofer IESE has put all of this together in a Pocket Guide.

Project level

At the interface between the transition levels "Team" and "Project", we find the issue of **"Agile Systems Engineering"**. Especially in embedded systems, synchronization between different teams is important, e.g., between hardware and software teams.

The interface between team and project is only one special case of agility in a non-agile environment. Solutions for better and more agile coordination at the interface between various business areas will play a large role in the future when it comes to making companies more agile overall. With the tighter integration of development and operations, the so-called **DevOps** (**Dev**elopment and IT **Op**eration**s**), the expansion of agility across different business areas is already being considered. In the future, other business areas such as marketing, sales, or human resources, must also be enabled to collaborate more flexibly with agile development teams.

Once a company moves past the project level in its transition, the scaling of agility comes to the fore. Scaling takes place across a project, a program, or a portfolio all the way to the entire organization. As part of an AS-IS analysis, different scaling models are compared and characterized in terms of the advantages and disadvantages of their application. Using a **tool-supported approach** developed by Fraunhofer IESE, companies can then select the most suitable individual approach for themselves.

Organizational and company level

Apart from software development processes, selected business processes can also be analyzed and improved. In this case, the focus is on the implementation of practices from agile software development in business processes from different areas of the company, e.g., daily stand-up or taskboard. First of all, suitable practices for the business process under consideration are identified and implemented [2]. Then the effects on the process are evaluated. Due to the multitude of existing business processes, this is a complex endeavor. In industry and research projects, Fraunhofer IESE investigates how agility can support companies in digitalization scenarios. This approach enables agilization of individual business areas and paves the way towards a more agile company.

Sabrina Hörner, Anna Schmitt, Sven Theobald

[1] https://agilemanifesto.org
[2] https://dl.acm.org/citation.cfm?id=2785609

FUTURE
WORLDS OF WORK

Our visions of tomorrow

Our working world is changing rapidly. In this interview, Susanne Braun, project manager "Digital Teams" at Fraunhofer IESE, explains how new concepts can help both employees and companies to benefit from the potential of "digital teams".

The project "Digital Teams":

Consortium partners: Insiders Technologies | Microsoft Deutschland | AviloX | Institute for Technology and Work; funded by the German Federal Ministry for Economic Affairs and Energy (BMWi)

Fraunhofer IESE is responsible for the functional and technical conception of the overall platform and also takes over significant parts of the actual platform development. Experts of Fraunhofer IESE from the area of Data Science provide support for the conception and development of data-driven services and features.

The buzzword "New Work" is on everyone's lips and is also an important research topic for Fraunhofer IESE. What are the researchers investigating in this context?

It is time to live and work where you want. If you ask Germans where they would choose to live if they could freely decide, then about 45% would opt for a rural community. Yet we are observing the opposite trend. There is a real run on the large cities. The negative consequences of this are well known: Exploding costs of living in the metropolitan areas, an increased number of commuters with all the negative side effects for health and environment. In addition,

we lose an infinite amount of valuable time in traffic jams or on public transport. At the same time, the rural exodus is accompanied by a downward spiral for rural areas, which thus become less attractive. Public services are also becoming less viable. In the project "Digital Teams", we want to demonstrate that new forms of work actually work in practice in such a way that employers do not experience any disadvantages as a result.

Which challenges exist? Which obstacles must be overcome?

Germany still has a very strong culture of being present at work, which conflicts with new forms of work. I have to admit that in software development projects, I also prefer having the whole team work together in the same project office. Communication channels are short and the teams are more productive. The emergence of creative ideas – and ultimately also of innovation – is encouraged by personal exchange. The issues of trust and team spirit are also important: It is much easier to develop trust when we see each other face to face. Not having direct communication anymore therefore represents an obstacle to new forms of work, but does this still have to be a problem today - in the age of digitalization - when everyone is connected to everyone else anyway, for instance via social media?

"Digital Teams" – What exactly is your research about?

Essentially, we want to start from two points: For cooperation in digital teams to work smoothly, optimized tool support is the first prerequisite. Second, it must be analyzed exactly what the success factors actually are in the area of ergonomics and social interaction. What are the optimal organizational conditions? Which company culture must

Work wherever you are: Susanne Braun from Fraunhofer IESE is advocating new work concepts.

How important is the issue of privacy in this regard?

Very important! Because work data may be very sensitive data. It is not about empowering companies or managers to exercise more control. The calculated team metrics are to be made available primarily to the team or possibly to the individual in order to provide coaching in the sense of continuous improvement and/or support them in becoming better and collaborate optimally even as a distributed team. We will also use the "MYDATA Control Technologies" developed at Fraunhofer IESE for data usage control on the platform in order to give users very fine-grained control over the sharing and use of their data. The platform is being developed entirely as open source; everyone can therefore see what is happening with the data on the platform.

More on "Digital Teams" at:
www.digitale-teams.de

exist, which mindset do the individual team members need, and how exactly do agile methods or generally more democratic forms of collaboration improve these?

What does the concrete implementation look like?

We are basically pursuing the vision of an open platform for collaboration apps around which an ecosystem of different providers can develop. Companies and teams can put together their tools and apps in the sense of a best-of-breed strategy. As our project aims especially at strengthening rural areas, we rely on offline capability for the design of the collaboration apps, so that smooth working with the tools is possible even if a good data connection is not available. Services that allow data synchronization in the background will be an integral part of our platform concept.

The decisive advantage in this project will be that data from the various applications will flow via this platform, resulting in huge potential for data analyses – keyword Big Data Analytics – and Machine Learning. With AI methods, we can learn what successful teams do right and use this as a basis to identify potential for improvement. AI can already analyze communication data (such as chat data) and determine whether there is a bottleneck in the team, i.e., a person who is behind most of the communication, which hampers the team. We could point out such issues and make them transparent. We want to use Big Data Analytics to prove empirically and as fact-based as possible that New Work concepts actually work with our tools and methods. If we can provide data-based proof that the metrics of distributed teams can be just as good as those of co-located teams, then we would provide a strong argument against the culture of being present at work and could thus make a crucial contribution to alleviating the rural exodus in Germany.

"Digital Teams succeeds in striking a balance between cities and rural areas – in this way we make a contribution so that everyone can achieve more. At Microsoft, we are already working digitally and in a distributed way. We are pleased that we can now also contribute our many years of experience in the area of productivity and collaboration to a publicly funded research project."

Thomas Treml
Technology and Strategy Consultant
Microsoft Deutschland GmbH
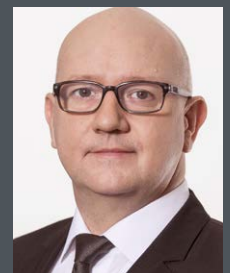
The interview was conducted by Nina Hahnel
Press Aide, Fraunhofer IESE

DATA USAGE CONTROL

MYDATA
CONTROL TECHNOLOGIES

Using data securely and flexibly

MYDATA Control Technologies (MYDATA for short) enable maintaining sovereignty over one's own data. It is based on the award-winning IND²UCE framework for data usage control developed at Fraunhofer IESE. In this interview, Christian Jung, Department Head Security Engineering, explains how data usage can be monitored and controlled with usage policies with the help of MYDATA, and how data flows are masked or filtered with MYDATA.

What is data usage control and what do I need it for?

In principle, data usage control is the logic evolution of and complement to the classical concept of access control. The aim is to be able to share data and at the same time control the usage of this data. Whether as an individual or as a company: You should be able to determine yourself how, when, and in which way your own data are used by others. The usage of your own data should be restricted, for example, by various conditions: An email address must only be used for sending invoices, but not for advertising purposes, and definitely not be passed on to third parties. We always need data usage control when we don't want to give the data processer complete freedom ito handle our data.

Why should companies use MYDATA?

MYDATA is the result of more than ten years of research and development in the area of data usage control. Our technology implements the concept of data usage control technically and enables its use in practice. We often hear that data usage can also be solved or programmed using purely access control. For some cases this may be true. With pure access control, however, you often quickly reach limits or end up in complicated situations that are difficult to control. Many requirements cannot be resolved with access control at all and demand data usage control. MYDATA offers flexible enforcement of data usage control. Policies can be adapted at runtime and the effects can be seen directly. If companies develop, i.e., program, their own solution, they often underestimate the complexity and do not design long-term solutions. Also, problems arise such as lack of uniformity in the technical implementation.
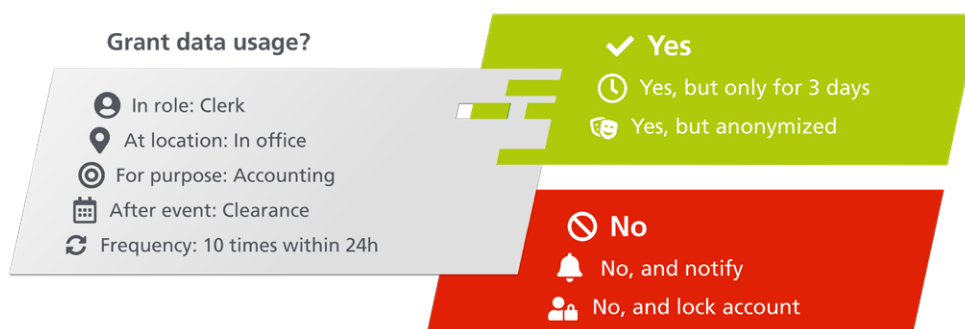
Context-based usage policies
with MYDATA

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Flexibly limiting or granting data usage by third parties with MYDATA – this is what Christian Jung, Department Head Security Engineering at Fraunhofer IESE, is working on.

What has happened with MYDATA in 2018?

I think that a major part of our activities in the last year was the introduction of the product "MYDATA Control Technologies" at ITSA. Our aim was to bring our research activities to product maturity in order to be able to use them on the market. In the context of this introduction, we completely revised our web content, our documentations, and our demo applications. In addition, our technology is available as open source and is now being offered both as a scalable Cloud solution and as a software library. This has significantly extended its usage possibilities.

What are the current research foci at IESE?

In the research area we continue to work on the development of privacy dashboards, which can be subsumed in a simplified manner in the following two questions: How do I stay in control of my data, and how can I determine myself how my data is used? The focus is on transparency and self-determination. The way things are represented often determines whether the user understands them. Then there are also some activities in the area of the language we use to implement data sovereignty. Our goal is to find a common denominator for data sovereignty requirements that can be enforced on different target systems. From my point of view, this is an essential component for a trustworthy and secure data economy.

Where can MYDATA be used?

Roughly speaking, the usage areas can be divided into three sub-areas: data exchange between two or more companies, data exchange between users and companies, and data exchange between users. On our website, we describe several use cases and offer various demo applications. One con-

crete example of the use of MYDATA is the technical implementation of our internal organizational rules for information classification at our institute. This serves to classify documents and to control their usage. For example, when attachments are mailed, MYDATA monitors that internal documents are only sent to external recipients after explicit release. Employees may only send confidential documents that are encrypted. This supports our employees in their daily work processes and prevents information from being passed on unintentionally.

The focal topic of IESE's current annual report is AI. To which extent is AI relevant for MYDATA?

At the moment, our technology does not use AI yet. However, in our research we are working on the use of cognitive methods for improving MYDATA. One promising area in this regard is the understanding of information. A user may want to know, for example, whether his or her data contains personal information. For such an automated classification of data we can use Machine Learning processes. However, if we do this, it must be ensured that the algorithm will correctly identify relevant data. The challenge thus lies in achieving a high level of accuracy so that no wrong decisions are made.

Several years of work have already been put into this research area. What do you expect in the next ten years?

One current trend is the ever greater networking among a wide variety of systems and the associated increasing exchange of information. I believe that data as an economic asset will become even much more important. Companies will need to share data in order to be able to participate successfully in this data economy. At the same time, the need for control and trust in the handling of the data will also increase. This will pose great challenges for society. We are convinced that we can solve part of these with MYDATA.

More about MYDATA at:
www.mydata-control.de

The interview was conducted by Nina Hahnel
Press Aide, Fraunhofer IESE.

INDUSTRIE 4.0

Industrie 4.0 needs a software revolution

In the automation industry, embedded systems control and automate the production processes. In the context of Industrie 4.0, the manufacturing industry is facing numerous disruptions. In order to enable also small and medium-sized enterprises to manage this revolution, the German Federal Ministry of Education and Research (BMBF) has initiated the national reference research project BaSys 4.0 under the leadership of Fraunhofer IESE.

Lot size 1 is the classical goal of Industrie 4.0. Dr. Kuhn, what other goals does this encompass in addition?

Thomas Kuhn: The term Industrie 4.0 does not represent a single concept, but rather a collection of concepts and goals. The aim is to adapt production to ever higher quality requirements, more rapidly changing markets, and a greater variety of products. Changeable production in lot size 1 is certainly one of the main goals. But Industrie 4.0 is also about open, highly networked automation systems that enable data to be accessed across several levels of the automation pyramid and even across companies. In addition, we need to integrate modern information technology concepts such as Big Data to a greater extent. There will be a change of paradigm from embedded systems to cyber-physical systems. However, the typical infrastructure found in manufacturing plants today makes it nearly impossible to achieve these goals. This is why we need new concepts for Industrie 4.0 and new architectures for production processes – in other words: a software revolution.

This sounds like a great challenge especially for SMEs. How can they, too, manage to master the software revolution with the help of BaSys 4.0?

Frank Schnicke: Our national reference research project BaSys 4.0 focuses particularly on small and medium-sized enterprises. The implementation project Eclipse BaSyx realizes an open-source reference implementation of the BaSys 4.0 middleware, which implements central Industrie 4.0 concepts and enables companies already today to develop their own solutions for Industrie 4.0. The middleware is intended to make it easy for companies to move towards Industrie 4.0 step by step, without having to invest utopian amounts of money into new manufacturing plants.

How should I imagine this? How does BaSys 4.0 work?

Thomas Kuhn: The special feature of BaSys 4.0 is the concept of service-based manufacturing, which separates the implementation of a service from the manufacturing process that calls this service. This addresses a central problem in the transition of today's manufacturing processes: Today, programmable logic controllers (PLCs) define the manufacturing process, which is distributed across implementations in numerous PLCs. A change made to a process has side effects that require adaptations in many PLCs, for example because the meaning of output terminals or bus telegrams changes. Service-based manufacturing defines interfaces for services that are called independent of a process. The manufacturing process is realized in an orchestrator that calls the services. Thus, it is possible to change the manufacturing process without changing the services and therefore without producing side effects. In all this, the asset administration shell is one of the central pillars of the Industrie 4.0 production architecture.

In the project BaSys 4.0, Dr. Thomas Kuhn and Frank Schnicke from Fraunhofer IESE make sure that individual manufacturing will not remain merely a vision for SMEs.

And what is the task of this asset administration shell within the manufacturing process?

Frank Schnicke: The asset administration shell serves as a general communication interface. The basic idea is that each asset in production, e.g., a machine, a production line, a product, or a worker, has such an asset administration shell, which contains all the information about this asset in digital form or refers to it. Among other things, it contains information about fundamental properties of the device, such as size, weight, energy consumption, as well as formulas, respectively simulation models, describing the physical process implemented by the device. The asset administration shell also serves as an abstraction layer with which access to the information about an asset is standardized. Through this standardization of the access to assets we not only increase the reusability of software, but also enhance changeability. This enables BaSys 4.0 to exchange devices with the same production capabilities for each other at will, without the need to change the application code.

The Eclipse open-source project **"Eclipse BaSyx"** realizes a reference implementation of the BaSys 4.0 middleware and makes this available free of charge. It is currently available for Java and will soon also be available in C++. It offers an implementation of asset administration shells and of the Virtual Automation Bus. In addition, various reference components are offered in order to enable quick transition to Industrie 4.0.

More about this can be found here: **https//eclipse.org/basyx**

If, as a manufacturing company, I succeed in establishing changeable production with BaSys 4.0, will this result in further advantages for me?

Thomas Kuhn: Yes, for instance with regard to the issue of "predictive maintenance". Nowadays you usually only notice that a device requires maintenance when it is broken. With the help of the BaSys 4.0 middleware, maintenance dates can be predicted. In order to prevent downtimes, the configuration of the manufacturing process can already be changed in advance. This allows companies to save enormous costs.

Frank Schnicke: In addition, it is also possible to monitor the manufacturing process from the office floor. When a new device is to be added to a manufacturing cell today, the change on the shop floor has to be propagated across several levels until it reaches the systems of the office floor. This makes the maintenance of manufacturing devices and systems very inflexible. It is currently not possible to monitor the multitude of manufacturing data being created live at runtime. With BaSys 4.0, live monitoring of the manufacturing process becomes a reality. The big advantage is that the data is available for analyses – in addition to the required device maintenance, these include, for example, analyses for optimizing the manufacturing process or for assuring product quality and reducing the number of rejects.

The interview was conducted by Claudia Reis, Press Aide, Fraunhofer IESE.

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IESE
HIGHLIGHTS

"As an innovation driver, we lead strategic initiatives to master future challenges and thus achieve technological breakthroughs."

From the Guiding Principles of the Fraunhofer-Gesellschaft

HANNOVER MESSE 2018

Fraunhofer IESE impresses with BaSys 4.0 as enabler for Industrie 4.0

In line with the motto of the joint Fraunhofer booth, "Sparking the Future", the researchers of Fraunhofer IESE presented an interactive exhibit from 23 to 27 April 2018 that showed how BaSys 4.0 works as an enabler for Industrie 4.0 and how it can revolutionize the future of manufacturing companies.

In the project BaSys 4.0, Fraunhofer IESE has realized efficiently changeable production with manufacturing services. At Hannover Messe, visitors were able to experience first-hand how the easy integration with existing automation and control systems works. They saw how production can be adapted in the plant and how individual products can be integrated into mass production, if required. In BaSys 4.0, changeability means being able to flexibly adapt a manufacturing process to unforeseen events. This is fundamentally different from existing variable manufacturing processes that are supported by existing automation technology. At the fair booth, the tool FERAL developed by Fraunhofer IESE simulated the system controls with the support of "digital twins": These virtually map the properties of the real plant and enable risk-free "what-if" analyses.

Prof. Reimund Neugebauer, President of the Fraunhofer-Gesellschaft (2nd from right), in conversation with Prof. Peter Liggesmeyer, Institute Director of Fraunhofer IESE (center), at the BaSys 4.0 demonstrator.

"SCIENCE NIGHT"

On 13 April 2018, the "Science Night" in Kaiserslautern served as a showcase for the research institutes, well-known companies, and the university, for the seventh time already. Residents of Kaiserslautern and the surrounding area were invited to inform themselves about the numerous research fields in the area. More than 500 visitors already attended the opening event, an entertaining "Science Slam", at the Fraunhofer Center. In total, Fraunhofer IESE staff could welcome more than 2,000 visitors at their place of work and offer them interesting insights into their projects in numerous demonstrations, guided tours of the buildings, and various info booths. In the lobby of the Fraunhofer Center, photographer and artist Thomas Brenner presented a staging of photo collages under the title "The Fear of Presumed Happiness".

The "Science Night" offered science and art to more than 2,000 visitors of the Fraunhofer Center in Kaiserslautern.

"LANDMARK IN THE LAND OF IDEAS"

Fraunhofer IESE is a Landmark in the Land of Ideas

"Connecting worlds – Strengthening unity" was the motto of this year's contest "Germany – Land of Ideas", where Fraunhofer IESE managed to impress the jury not once, but twice. In this competition with almost 1,500 applications, the institute was among the top 100 winners with the projects "Digital Villages" and "Designetz".

The aim of the award-winning Digital Villages Platform is to make rural areas more attractive in the future as a place to live. Whether carpooling or neighborhood delivery service – the digital services developed by the institute support the residents of a village in mastering their daily challenges and bring the quality of rural life to a new level.

As a project partner of the "Designetz" consortium, Fraunhofer IESE also received an award for its commitment in the context of the energy transition. Here, the institute contributes to the development of a smart energy system and an appropriate data protection concept. The establishment of data usage control is intended to guarantee security for all stakeholders – whether consumer or provider. Additionally, Fraunhofer IESE provides smart data analysis models for the research project, which enable making predictions about the availability of the connected wind and solar power plants as well as the energy storage systems.

CEBIT 2018

Simulation and privacy by design

At CEBIT in Hannover, which took place from 12 to 15 June 2018, Fraunhofer IESE presented its FERAL solution at the joint Fraunhofer booth in Hall 27, Booth E78. Visitors of the very last CEBIT being held were able to experience live how virtual integration and validation work with suitable models and "digital twins".

At the booth, Fraunhofer IESE used vehicle platforms as an example to demonstrate how the real and the virtual worlds can be interconnected and how the FERAL simulation framework can be used to thoroughly check individual software functions in their complex interactions. Self-driving model cars, which the visitors could follow virtually on screen, demonstrated the integration of different driving functions.

Exclusive event on Tuesday: "GDPR and Privacy by Design"

At a day exhibit at the joint Fraunhofer booth, the researchers of Fraunhofer IESE additionally dedicated themselves to the European General Data Protection Regulation (GDPR), which entered into force in May 2018. With MYDATA Control Technologies, they presented the next-generation data control technology. MYDATA enables privacy by design through simple, efficient, effective, and secure integration into existing software, systems, and digital ecosystems. The technology combines major components for the successful implementation of the GDPR: internal formalization of privacy requirements and policies, their management, as well as the technical implementation at runtime. At the Fraunhofer booth, the visitors immersed themselves into a scenario from the financial industry: As a bank customer, they could flexibly control several views of their account information for third parties using MYDATA Control technologies, without changing the underlying processing system.

Ralf Kalmar, Fraunhofer IESE (left), informs the president of the Fraunhofer-Gesellschaft, Prof. Reimund Neugebauer (right), about the simulation framework FERAL.

"PFAFF HACK"

Creative ideas at the PFAFF HACK: Even digitally, the focus is on people

From 15 to 16 June 2018, Fraunhofer IESE organized its first ever hackathon. Over the course of 24 hours, participants and researchers were invited to jointly work on developing creative ideas for the new climate-neutral Pfaff Quarter in Kaiserslautern. At the beginning of the year, Fraunhofer had launched the project EnStadt:Pfaff together with other consortium partners. Reason enough to set up an innovative workshop for all stakeholders together with the local partners. The participation of citizens in the project for the traditional Pfaff area in the heart of the city of Kaiserslautern is an important component of the lighthouse project funded by the Federal Ministry of Education and Research (BMBF) as well as by the Federal Ministry of Economic Affairs and Energy (BMWi). More than 30 participants accepted the special working conditions and got started. In small groups, they addressed various issues of the project. In addition to the mental exercise, physical activity was not neglected either: The UNISPORT team supported the event with training units and "break-time sports", while the catering provided by KLdigital took care of the culinary needs. The prototypes and visions developed by the participants provide inspiration for new ideas: The team of the EnStadt:Pfaff project is taking up many of the impulses and, following the positive outcome of this event, wants to hold another hackathon at Fraunhofer IESE in 2019.

The participants of the PFAFF HACK presenting their results in the atrium of Fraunhofer IESE.

Making Industrie 4.0 easy? At the "BaSys 4.0 Roadshow" in September 2018, small and medium-sized manufacturing companies found out how to do this. The experts from Fraunhofer IESE showed the workshop participants how to digitalize their production with the Industrie 4.0 open-source middleware BaSys 4.0 and how to realize service-based manufacturing, administrative asset shells, as well as dashboards. In addition, the companies present learned about BaSys 4.0 use cases, the BaSys 4.0 Software Development Kit (SDK), and the open-source components. Following the presentations, there was enough time for detailed project outlines for the companies and for discussions with the Fraunhofer IESE experts about the capabilities of the BaSys 4.0 SDK. In the context of the workshops in Berlin, Kaiserslautern, Mainz, and Munich, the new funding opportunities offered were also presented.

BMBF funds projects in which concrete automation problems are to be solved through the use of the BaSys 4.0 middleware. Small and medium-sized manufacturing companies are called upon to apply no later than 15 May 2019 for a satellite project for Industrie 4.0 and to benefit from the expert network of Fraunhofer IESE:

www.bmbf.de/foerderungen/bekanntmachung-1941.html

The next round of "BaSys 4.0 on Tour" will take place in 2019 with new dates in Berlin, Mainz, Munich, and at Hannover Messe.

DUTCH DELEGATION AT IESE

Exchange across national borders

On the occasion of the visit of the Dutch royal couple to Rhineland-Palatinate and the Saarland, Fraunhofer IESE presented its current research topics to two accompanying business delegations.

In October 2018, King Willem-Alexander and Queen Máxima visited Rhineland-Palatinate and the Saarland. They were accompanied by the Minister of Foreign Trade, Sigrid Kaag, who together with the Deputy Minister President and Health Minister Hugo de Jonge led a business mission to the two German states: Topic areas were digitalization (focus: safe, secure, and digital industry) as well as biosciences and health (focus: e-health and geriatric care). Both delegations also came to Fraunhofer IESE in Kaiserslautern to experience the transformation process towards the digital economy up close. On the first night of their journey, the royal couple also attended a dinner of the Dutch trade delegation in Trier, which provided an opportunity to present research done at Fraunhofer IESE and in Kaiserslautern in personal talks.

On 10 and 12 October, the two Dutch delegations with representatives from government and business arrived at Fraunhofer IESE in two buses. After being welcomed by the institute directors and by Dr. Weingarten, Department Head Innovation in the Rhineland-Palatinate Ministry of Econom-ic Affairs, Transport, Agriculture and Viniculture, the more than 60 visitors had a chance on the first day to familiarize themselves more deeply with topics relating to the digital economy. With BaSys 4.0, Fraunhofer IESE presented the middleware for changeable production. In addition, the innovative possibilities of flexible data usage control for security and privacy (MYDATA Control Technologies and the framework IND^{2}UCE) were demonstrated. Another presentation focused on the importance of Big Data Analytics in cross-manufacturer value chains, the focus of the research project PRO-OPT. This was followed by matchmaking, with an opportunity to engage in direct exchange of information with experts of Fraunhofer IESE. On the second day, another approx. 40 participants visited Fraunhofer IESE and were informed on a tour and at demonstrators about the research projects in the context of e-health. A demonstration of EPICSAVE impressively showed the benefits of training emergency medical physicians and medics using VR- and Serious Gaming approaches. With the project Susi TD, which had already been awarded the Fraunhofer Prize for Human-Centered Technology in 2017, the researchers of Fraunhofer IESE demonstrated the possibilities offered by Smart Home technologies and services for an independent life in one's own home. A lively discussion and the exchange of ideas and information in personal expert talks rounded off the program and showed all participants the potential of future collaborations across national border.

"IT Security – Made by Fraunhofer" – at Europe's leading IT security trade show in Nuremberg from 9 to 11 October 2018. With comprehensive IT security solutions such as MYDATA Control Technologies by Fraunhofer IESE, five institutes of the Fraunhofer-Gesellschaft presented themselves for the first time at a joint booth.

Cognitive Internet for Industrie 4.0? New solutions for logistics and production through Artificial Intelligence? These were the topics that experts from industry, research, and government addressed at the **Fraunhofer Cognitive Internet Day** on 22 November 2018. Fraunhofer IESE presented MYDATA Control Technologies, a technology for the implementation of data sovereignty.

The **Smart Country Convention 2018** in Berlin from 20 to 22 November 2018 was all about digital solutions for government agencies and public services. Fraunhofer IESE presented its experiences from the project "Digital Villages" and gave an outlook on the future in rural areas.

"COGNITIVE AGRICULTURE"

Designing agriculture efficiently and sustainably

On 14 November 2018, the kick-off event at the Fraunhofer-Forum in Berlin marked the official launch of the new lighthouse project "Cognitive Agriculture" (COGNAC for short) of the Fraunhofer-Gesellschaft. This lighthouse project will open up completely new perspectives for agriculture, because in the future, digital technologies are to be increasingly used in farming, which can revolutionize the sector as a whole. The aim of the project is to produce agricultural products as environmentally friendly and resource-friendly as highly efficiently. As the institute in charge of the project, Fraunhofer IESE invited experts from industry, research, and government as well as the other seven participating Fraunhofer institutes to the kick-off event in Berlin.

Heavy tractors and machinery are rolling over the fields and increasingly cause soil compaction. Other factors are intensive fertilization and excessive use of pesticides, herbicides, and fungicides, as well as genetically modified seeds. These factors cause considerable damage to the biosphere. To increase productivity, agricultural areas are subject to ever more extreme stress, with the risk that they may become unusable for farming. Organic agriculture has evolved as an alternative, which does focus on the environment, but in return deliberately accepts productivity losses. Particularly in light of the continually increasing world population, neither one of these options appears to meet the demands of our society, emphasized Prof. Peter Liggesmeyer, institute director of Fraunhofer IESE, in his opening speech in Berlin on 14 November. He continued that in the context of **COGNAC**, the Fraunhofer-Gesellschaft has therefore embarked on developing concepts for an efficient digital ecosystem that enables combining the objectives of "productivity" and "sustainability" in the agricultural sector. Prof. Reimund Neugebauer, President of the Fraunhofer-Gesellschaft, stressed that this new Fraunhofer lighthouse project is to become a milestone in the agriculture of the future.

> "Agricultural technology is a branch of industry that is not only important for our society – it is also a progressive, highly innovative industry. The use of modern information technologies offers great potential to design agricultural processes even more efficiently in the future. In our new lighthouse project, innovative automation concepts and novel sensor technology will be used to develop a data-based ecosystem that is to become a milestone in digitalized agriculture. In this way, digital technologies, new research approaches, and the problem-resolution expertise of Fraunhofer can become the enabler of a highly efficient and at the same time sustainable agriculture of the future. "
>
> Fraunhofer President Prof. Reimund Neugebauer

A forward-looking sector demands innovative technology

But what must a system look like that optimizes both the economic and the ecological aspects to the same extent? This issue was also addressed at the kick-off by representatives from research, industry, and government in their speeches. Prof. Thomas Herlitzius from TU Dresden explained that current agricul-

Prof. Reimund Neugebauer, President of the Fraunhofer-Gesellschaft (left), presents the funding approval to IESE Institute Director Prof. Peter Liggesmeyer (to his right) at the kick-off event.

tural concepts are increasingly reaching their limits, as the effort for existing agricultural technologies is increasingly economically disproportionate to their benefits. August Altherr from the John Deere European Technology Innovation Center emphasized the enormous added value that the use of digital services means for the agricultural sector. He particularly pointed out the potential of a shared Cloud to interconnect agricultural data and thus make it possible to use such data for a wide variety of purposes at any time. The Federal Ministry of Food and Agriculture (BMEL), represented by Parliamentary Under-Secretary Michael Stübgen, was also enthusiastic about the idea of advancing the digitalization of German agriculture while reconciling efficiency and sustainability.

A new ecosystem – networked via an Agricultural Data Space

Digitalization, automation, and electrification of agricultural processes offer numerous starting points for resolving the conflict between economy and ecology described above: Through optimized processes based on comprehensive data, the ecosystem developed by Fraunhofer can increase the productivity of agricultural processes, while highly automated subplot- or plant-specific field cultivation ensures sustainability thanks to the use of appropriate cultivation equipment technologies. Based on a more comprehensive understanding of the far-reaching cause-effect relationships in the biosphere, **"Cognitive Agriculture"** thus aims at processing complex data relationships and thereby support decision-making processes in the value creation network. The focus is on the following areas of innovation:

■ Open data exchange in an agriculture-specific, **digitally networked ecosystem** that enables multivalent use and linking of complex agricultural data volumes in secure data spaces;

■ Automated **interpretation and decision support** based on high-resolution measurement data from airborne or ground-based systems using multi-channel measurement information;

■ **Autonomous field robotics** for plant-specific field work as well as robot-guided sensor platforms with specific specific sensor systems.

Via a networked ecosystem of all relevant agricultural businesses, Fraunhofer wants to create broad acceptance for **"Cognitive Agriculture"**. Taking into consideration the concepts of the Industrial Data Space initiated by Fraunhofer, an Agricultural Data Space is to be designed as a platform for a digital ecosystem. This platform shall overcome the incompatibilities of existing solutions and enable cross-sector data usage by farmers, government agencies, environmental organizations, cooperatives, machine manufacturers, etc. while at the same time complying with high requirements on security and privacy.

In order to make the results applicable in practice, **real-life field trials** are to be performed to examine and analyze the highly complex interactions between biosphere and production in an ecosystem.

IESE FOUNDER RETIRES

Time to say goodbye!

Prof. Dieter Rombach, the founder of Fraunhofer IESE, retires – but his commitment to software and systems engineering continues.

In November 2018, Fraunhofer IESE bid farewell to its founder and long-time institute director Prof. Dieter Rombach at a festive retirement ceremony. The 65-year-old founded the Fraunhofer Institute in 1996, which had its origins in the Software Technologie Transfer Initiative (STTI) Kaiserslautern. Prof. Rombach was director of Fraunhofer IESE until 2014; after that, Prof. Peter Liggesmeyer took over the operative management of the institute. At the end, Prof. Rombach was Director Business Development at Fraunhofer IESE.

Prof. Dr. H. Dieter Rombach studied mathematics and computer science at the University of Karlsruhe and obtained his PhD in 1984 in Kaiserslautern – a city to which he returned after several years spent in the United States and to which he remained loyal throughout his career. Since 1994, he held the Software Engineering Chair in the Department of Computer Science at the University of Kaiserslautern and later became director of Fraunhofer IESE. "In recent years, Kaiserslautern has evolved into an important hub for software engineering. At Fraunhofer IESE and at the University of Kaiserslautern we have created the best environment for excellent applied research in this area – and I am very proud of this", said Prof. Dieter Rombach. In the course of his professional career, he published more than 250 publications, supervised approx. 500 Bachelor's and Master's theses, and guided 90 employees to their PhD. Even after retiring from Fraunhofer IESE, he will remain involved in Kaiserslautern and at Fraunhofer IESE: In October of this year, he was appointed Senior Research Professor at the Department of Computer Science of the University of Kaiserslautern, and he continues to provide advice to Fraunhofer IESE as Executive Consultant in the area of Business Development. Furthermore, he is Chairman of the Board of the Science & Innovation Alliance Kaiserslautern (SIAK) and was appointed the first Chief Digital Officer of the City of Kaiserslautern in 2018..

Prof. Alexander Kurz, member of the Executive Board of the Fraunhofer-Gesellschaft, paid tribute to the many years of service of Prof. Dieter Rombach.

Numerous awards are part of Prof. Rombach's career as a scientist: In 1990, he received the "Presidential Young Investigator Award" of the National Science Foundation (NSF) in the United States for his excellent work in the area of software engineering. In 2000, he was awarded the Service Medal of the State of Rhineland-Palatinate for his contributions to the scientific and economic development of the state. In 2009, he was awarded the Federal Cross of Merit on Ribbon of the Federal Republic of Germany, and the University of Oulu, Finland, bestowed upon him an honorary doctorate degree in recognition of his lifetime achievements as a software engineer. For his services to the Fraunhofer-Gesellschaft, he was awarded the Fraunhofer Medal in 2013. Prof. Rombach provides advisory services to a number of government bodies at the state, federal, and international level on issues concerning research as well as education and training in the area of computer science and on strategic decisions related to software.

At the farewell ceremony for Prof. Rombach, Prof. Alexander Kurz from the Executive Board of the Fraunhofer-Gesellschaft spoke alongside institute director Prof. Peter Liggesmeyer. Prof. Kurz emphasized that Prof. Rombach has turned Kaiserslautern into an excellent research hub. The Rhineland-Palatinate Minister for Science, Continuing Education and Culture, Prof. Konrad Wolf, was sure that contact would not cease and that exchange with the former head of the institute would continue even in the future. The former Minister President of Rhineland-Palatinate, Kurt Beck, the President of the University of Kaiserslautern, Prof. Helmut J. Schmidt, and the Lord Mayor of Kaiserslautern, Dr. Klaus Weichel, were also among the guests and paid tribute to the achievements of Prof. Rombach.

As a surprise, his long-term employees presented him with a doctoral hat of a special kind: With many anecdotes and stories, they acknowledged the stations in the life of Dieter Rombach tongue-in-cheek.

The IESE team thanked the founder of the institute, Prof. Dieter Rombach.

CAREER NIGHT 2018

First Career Night at the Fraunhofer Center in Kaiserslautern

At the first Fraunhofer Career Night on 12 December 2018, there were many exciting ways in which interested visitors could take a look behind the scenes of the largest organization for applied research in Europe: These included exclusive guided tours of the staff offices, the "Rapid Innovation Lab", the Living Labs of Fraunhofer IESE, insights into current projects, and an Escape Game specially developed for Fraunhofer. With over 100 participants, the number of visitors far exceeded the original expectations. The event turned out to be a complete success for the organizers.

With this joint event, the two Fraunhofer Institutes located in Kaiserslautern, IESE and ITWM, reached out to many MINT students and graduates and informed them about the numerous career and entry opportunities offered by Fraunhofer. To do so, the two research institutes invited the participants directly to the Fraunhofer Center and provided exciting insights into their work and their research activities.

Following the welcome, the participants were invited to take part in guided tours and get to know the work methods and research projects of the two Fraunhofer institutes IESE and ITWM. At Fraunhofer IESE, the projects EPICSAVE, BaSys 4.0, and Digital Villages, in particular, attracted the curiosity of the visitors. EPICSAVE showed the visitors that ICT methods have enormous importance in emergency

Teamwork and fun during the 2018
Career Night at the Fraunhofer Center

medical development: For example, EPICSAVE integrates Virtual Reality glasses and Medical Serious Games into the training of aspiring paramedics in order to enable them to prepare themselves for situations that do not typically occur in day-to-day life. In the context of the projects Digital Villages and BaSys 4.0, Fraunhofer IESE also presented forward-looking models that tackle the challenges of our society in many respects. The young guests could experience "research live" here and were directly integrated into various scenarios – controlling a drone was just one of the ways they could try something out themselves and get to know the wide range of equipment used by Fraunhofer.

Another highlight of the evening was offered by the Escape Room, which had been developed especially for Fraunhofer. Four visitor teams each had 45 minutes to solve riddles and crack codes. The use of infrared flashlights, smartphones, and even VR glasses challenged the participants to prove their "digital" skills as well as technique and creativity in order to reach their goal together. Afterwards, it was all about networking: In a relaxed atmosphere, the participants exchanged views with staff from both Fraunhofer IESE and Fraunhofer ITWM about future perspectives at the two institutes and informed themselves about current job vacancies at the Job Wall. Good talks, interesting contact, and shared team experiences made this night an exciting and insightful experience, which the Fraunhofer institutes want to repeat in the future.

PROJECTS

"We promote a well-balanced combination of excellent research and application-oriented development."

From the Guiding Principles of the Fraunhofer-Gesellschaft

PROJECTS

The central challenge of the fourth industrial revolution is the mass production of individualized products. These require efficiently changeable manufacturing processes. Changeability here refers to the ability to adapt with minimal effort to the manufacturing of workpieces that was not foreseeable when the system was planned. This ability is being realized in the context of **BaSys 4.0 (Basic System Industrie 4.0)** through the development of an open-source middleware for manufacturing systems. The central concept is the "digital twin" as a representation of all relevant components. The BMBF funds projects that aim at solving concrete automation problems through the use of the BaSys 4.0 middleware. SMEs can apply for such satellite projects for Industrie 4.0.

www.basys40.de

The aim of the project **Q-Rapids (Quality-aware rapid software development)** is to define an evidence-based, data-driven, quality-aware Rapid Software Development methodology and a Big Data platform supporting decision makers based on quality indicators and quality requirements. The incremental elicitation, refinement, and improvement of quality requirements is based on the vast amount of data generated at runtime and development time. Research at Fraunhofer IESE is about software analytics for different scenarios: quality assessment, quality requirements, prediction, and what-if analysis. In addition, evaluations of the methodology and platform are being conducted in industrial settings.

www.q-rapids.eu

In the BMBF-funded National Reference Project for IT Security in Industrie 4.0 **IUNO** (2015-18), 21 partners from industry and research, including the Fraunhofer Institutes AISEC, IESE, and SIT, developed protective concepts against future IT security threats to production and used demonstrators to test these for selected usage scenarios. The resulting solutions and tools were combined into a tool kit for secure Industrie 4.0, which helps small and medium-sized enterprises to realize secure industrial value chains. At the IUNO final event in Berlin in September 2018, the partners presented their research and development results and the tool kit to the interested public.

iuno-projekt.de

The open, cooperative nature of cyber-physical systems (CPS) creates new challenges in terms of ensuring their dependability. The project **DEIS (Dependability Engineering Innovation for CPS)** addresses these challenges with the introduction of the concept of Digital Dependability Identities (DDI). DDI are sets of models linked via an argumentation structure that provide well-founded statements about the dependability of the system. DDI are modular and allow efficient integration of systems at development time and at runtime. For integration at development time, comprehensive tool support based on various tools of the partners (in the case of Fraunhofer IESE: safeTbox – www.safetbox.de) is being developed. For integration at runtime, mechanisms are being developed that are aimed at enabling fully automatic integration by the systems themselves.

www.deis-project.eu

PROJECTS

In the BMBF-funded pioneering project **CrESt (Collaborative Embedded Systems)**, 23 partners are working on the creation of a comprehensive framework for the development of collaborating embedded systems. The goal is to address the novel challenges in the development of collaborative embedded systems in dynamic systems-of-systems with a holistic development approach and thereby give the German industry a decisive competitive edge in these future-oriented and important application areas. Fraunhofer IESE is working on the topics Context Modeling, Simulation, and Functional Safety. At the time of development, not all possible systems-of-systems and contexts can be modeled, simulated, and analyzed. This is why runtime approaches must be developed that enable dynamic situation assessment, assessment of uncertainties, and validation of systems-of-systems.

crest.in.tum.de

Germany suffers from a rural exodus. However, many people would like to live in rural areas if they only had a job there. New forms of work are therefore needed that rely on teams collaborating in virtual space. Despite digitalization, this is a challenge in practice. It must be ensured, for example, that neither the connection of the individual with the team nor the creativity and productivity in the team as a whole will suffer. The success of digital teams does not only require optimized tool support, but the mindset and the corporate culture must also change. In the project **Digital Teams**, an open ecosystem platform for collaboration apps is being developed and networking possibilities are being created. Using Smart Data Analytics and AI, improvement potentials are shown to digital teams and the long-term success factors are determined empirically and based on facts.

www.digitale-teams.de

Industrie 4.0 stakeholders consider predictive maintenance to be the key factor in optimizing the overall effectiveness of plants and creating new business opportunities. However, some constraints currently still hamper these efforts: the fragmentation of the data sets, their lack of integration, as well as low interoperability, cyber-security concerns, and limited use of state-of-the-art analysis methods. **PROPHESY (Platform for rapid deployment of self-configuring and optimized predictive maintenance services)** aims at eliminating these obstacles to the introduction of predictive maintenance and thus enable innovative business models at the same time. To support this goal, Fraunhofer IESE is detailing the reference architecture from the EU project MANTIS and is designing a technology stack for the implementation of interoperability and adaptability.

prophesy.eu

Emergency medicine is a high-risk domain in the field of medicine. Even in stressful situations, the right response and action are required immediately. Effective and efficient training is therefore of utmost importance. The aim of **EPICSAVE (Enhanced ParamedIC vocational training with Serious games And Virtual Environments)** is to complement traditional education with highly realistic, in-depth Virtual Reality scenarios in a multi-user approach. The focus of the project is on anaphylaxis, a life-threatening allergic reaction where the risk of mishandling the situation is high. The acceptance and efficiency of the novel approach is being examined with the help of apprentices from two paramedic academies.

www.epicsave.de

In the lighthouse project **EnStadt:Pfaff**, a real-life lab is being developed on the premises of the former Pfaff sewing machine factory in Kaiserslautern. Fraunhofer IESE is involved in the topics Energy and Mobility and is responsible for the development and implementation of an ICT concept. During the five-year project phase, a digital ecosystem for urban quarters will be established on the basis of the Smart Rural Areas platform and used to drive digitalization.

PROJECTS

The project **MInD (Machine Intelligence and Deep Learning)** is about the identification and use of Deep Learning technologies to enable the socio-technical design of the digital transition. To this end, the competencies and potentials of Fraunhofer IESE, Fraunhofer ITWM, and the German Research Center for Artificial Intelligence (DFKI) are bundled. The project, which is envisioned as a long-term cooperation (> 4 years), started in 2018 with a preliminary project in which Fraunhofer IESE conducted a Systematic Mapping Study to produce an overview of published methods for the use of neural networks in safety-critical applications. The results will be published in 2019 and are intended to support users of neural networks in development, particular in safety-critical areas. Based on the results, Fraunhofer IESE will develop a comprehensive methodology for the validation of Artificial Intelligence.

The project **TrUSD (Transparente und selbstbestimmte Ausgestaltung der Datennutzung im Unternehmen /** *Transparent and self-determined design of data usage in organizations***)** will give employees transparent co-determination of personal data and employers the opportunity to collect and evaluate data on various processes. In this context, novel concepts and tools for viable employment privacy will be developed. The focus is on a Privacy Dashboard, which presents all the information required to the employees in a simple and understandable way. The tasks of Fraunhofer IESE include eliciting the requirements on privacy dashboards, designing a generic privacy dashboard framework, ensuring the enforceability of the privacy requirements, as well as developing an evaluation concept and implementing it.

www.trusd-projekt.de
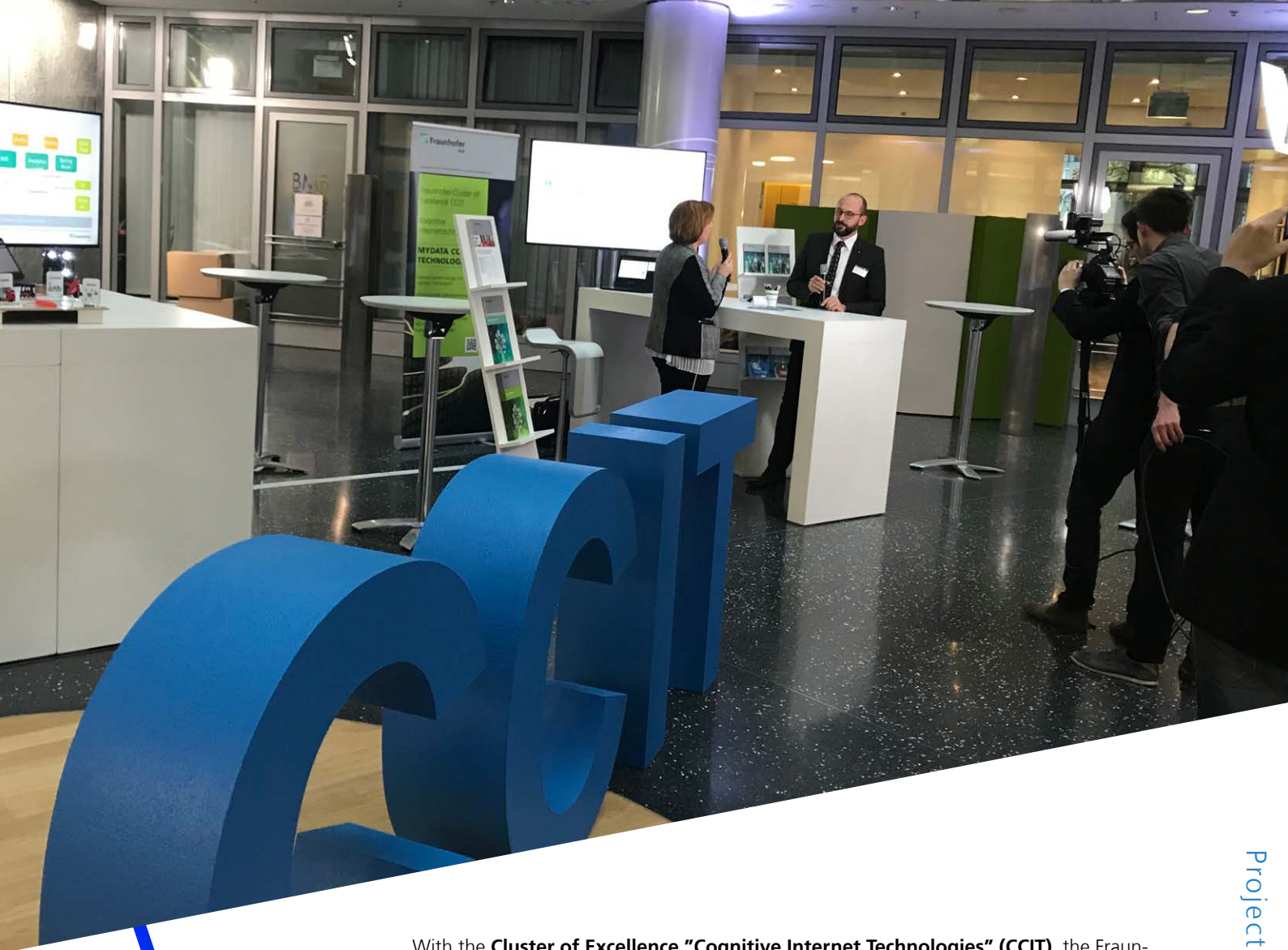
With the **Cluster of Excellence "Cognitive Internet Technologies" (CCIT)**, the Fraunhofer-Gesellschaft is working on central key technologies for the cognitive Industrial Internet with the aim of creating an infrastructure for an agile, flexible, and competitive industry. To do so, the cluster bundles the competencies of thirteen Fraunhofer Institutes from the areas of microelectronics, information and communication technologies, and production. Fraunhofer IESE contributes its expertise from more than ten years of research and development in the area of data usage control. The CCIT uses the key technology "MYDATA Control Technologies" for data usage control and thereby creates the basis for data sovereignty. This enables a decentralized and trustworthy data economy.

www.cit.fraunhofer.de

PROJECTS

The topic of e-mobility is currently very important for the automotive industry. This can be seen in the rising number of available and announced models as well as the number of new manufacturers in this area. One of these is **e.GO Mobile AG** from Aachen. Founded on the campus of RWTH Aachen, it is developing a fully electric vehicle starting from 15,900 €: the e.GO Life. A major challenge in the development of a vehicle is always the systematic assurance of functional safety. Fraunhofer IESE has been commissioned by e.GO Mobile AG to carry out the necessary engineering activities in this regard in accordance with the applicable standard ISO 26262.

www.e-go-mobile.com

More and more companies are realizing the potential of the huge amounts of data available today. This is why there is great demand for data scientists with special competencies regarding the numerous tasks in dealing with data. The Fraunhofer Big Data Alliance offers a three-level **Data Scientist Certification Program**, which teaches how business developers can tap into the potential of Big Data, how data engineers can describe and integrate data, how analysts can detect patterns and trends, and how software engineers can develop Big Data systems. Fraunhofer IESE provides training elements on the topics Data Science Business Case, Data Preparation, Data Analysis, Visualization, Architecture, and Evaluation. Furthermore, the experts of Fraunhofer IESE show the future data scientists how to assess the capabilities of their organization with regard to the implementation of a specific data science project.

s.fhg.de/data-scientist

With the support of Fraunhofer IESE, **Caruso GmbH** has developed an open neutral data and service marketplace for mobility data and services that offers all current and future actors in the automotive industry an opportunity for new business models and mobility services. Right from the start, Fraunhofer IESE has been on board as a neutral and strategic technology partner with its expertise in digital ecosystems and platforms. Currently, predevelopment is taking place on future-oriented concepts, e.g., distributed management of GDPR-compliant data processing consent in the context of a data exchange platform and development of a service execution platform with high requirements on the protection and visibility of data for the trustworthy analysis of data with several participating companies.

www.caruso-dataplace.de

Projects

Fraunhofer IESE is a key partner of **John Deere GmbH & Co. KG** supporting Automation and Autonomy efforts aiming at designing and engineering solutions to replace tasks performed by a human operator. Machine functions that will be impacted are, for example, sensing and controlling machines on a desired path, and detection and avoidance of obstacles. Fraunhofer IESE supports John Deere in this endeavor with respect to the identification and documentation of architecture-significant requirements, the design and evaluation of the architecture decisions, the safety of the intended functionality, virtual engineering, and user experience.

PROJECTS

Since 2016, Fraunhofer IESE has been collaborating with **Bosch Chassis Systems Control (CC)** on various aspects of agility, including, for example, the degree of agility used, agile scaling approaches, agile transition, and concrete project support (e.g., coaching) for these topics. In 2018, the focus was, on the one hand, on interfaces between agile units and a non-agile environment and on refinement of the comparison of agile maturity models for the development of a Bosch-specific self-assessment. On the other hand, the applicability of DevOps for Bosch and the discussion of Big Data and data mining potential as well as their interaction with DevOps were investigated.

Since 2016, Fraunhofer IESE has been supporting the **John Deere European Technology Innovation Center** in Kaiserslautern in the development of Smart Farming services based on Big Data Analytics in order to offer farmers smart decision support from the Cloud. Developing services that provide real customer benefit at a level of quality that can be accepted by farmers is a challenge. Smooth collaboration among many experts with widely varying professional backgrounds is crucial. To facilitate collaboration in the interdisciplinary teams, a Cloud app has been under joint development since 2017, which supports a systematic and collaborative approach in the development of smart services while at the same time facilitating knowledge dissemination within the team and within the organization.

In 2018, Fraunhofer IESE investigated in the project "Evaluation of the Functional Safety of Road Condition Services" on behalf of the **Bosch Connected Mobility Solutions** section of Robert Bosch GmbH how the high safety requirements can be fulfilled in the development of map-based services for highly automated driving functions, which are based, among other things, on external services. Safety analyses were employed to derive a safety concept for the system. The safety considerations focused on functional inadequacies, as addressed in the new standard ISO PAS 21448. In addition, a comprehensive analysis of standards was performed. Applicable standards were identified and the transferable normative recommendations were elaborated. There is already a follow-up project where the safety considerations are being extended to the system that provides information to the Bosch backend.

In the context of the digital transformation, being able to efficiently design and construct digital ecosystems is essential for business success. Since 2018, Fraunhofer IESE has been collaborating with **DENSO**, a major Japanese supplier of automotive components and solutions, on engineering methods for socio-technical ecosystems. One key characteristic of socio-technical ecosystems is the human in the center of the ecosystem, who interacts with technologies in multiple ways. In the context of this collaboration, methods developed by Fraunhofer IESE are used for research on designing different aspects of such ecosystems: **KREA-FUN** supports companies in defining ecosystem stakeholders and in motivating them to participate in the ecosystem. **Business Potentials Analysis** supports companies in identifying digital business models and realizing the potential of (Big) data. **Tangible Ecosystems Design** supports companies in modeling the overall ecosystem, incl. the platform, its services, and its players.
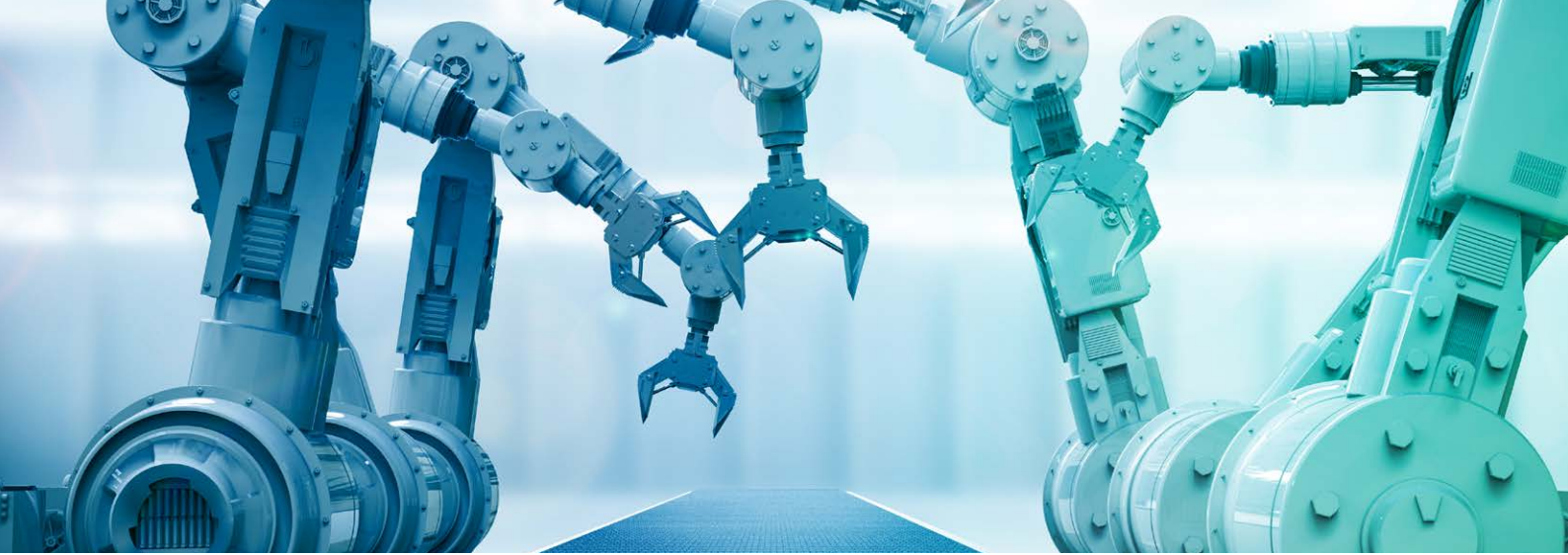
70 YEARS OF FRAUNHOFER
70 YEARS OF FUTURE
#WHATSNEXT

With our fascination for research, we are discovering the world of tomorrow. And the day after tomorrow. It is the future that drives the Fraunhofer-Gesellschaft. We ask the right questions and find new answers: Solutions that are of immediate benefit to industry and society.

How do we build intelligent machines that we all can trust? How do we manufacture drugs in a way that brings the patient relief faster and at lower cost? How do we find a responsible way to ensure that everyone feels more secure? And how do we know which answer is the right one?

As researchers, entrepreneurs, and visionaries, we see ourselves as pacemakers not just for the economy but also for society. Our success is reflected in our powers of innovation, in our partners and colleagues – and not least in our 70 years of history. As we address the issues of tomorrow, it is our history that drives our curiosity about the future. Because looking back and looking at today inspires us to never cease to ask: **What's next?**

70 years of Fraunhofer – a dynamic success story

Founded in Munich in spring of 1949, the Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. was born to help rebuild Germany's de-industrialized postwar economy. Today it is Europe's largest applied research organization.

On March 26, 1949, State Secretary Hugo Geiger invited 210 government representatives and members of the scientific and business communities to the Bavarian Ministry of Economic Affairs. He had lofty aims for this fledgling organization – it was to help revive Bavaria's economy. While children played amid the rubble, and the Wirtschaftswunder – Germany's postwar economic miracle – was yet a distant prospect, the Munich office's staff of just three people took up the challenge of advancing applied research in Germany.

The Fraunhofer-Gesellschaft elected Hermann von Siemens as its president in late 1954 and founded the first of its institutes, taking a major step toward its goal of becoming the third pillar of research in Germany alongside the Max Planck Society and the universities. By 1969, it had grown to 19 institutes and research units with 1,200 employees and 33 million D-Mark in annual revenue. Restructuring and a redoubled focus on contract research in the early 1970s set off another surge of growth. The Fraunhofer model of performance-based funding triggered the dynamic success that shows no signs of slowing. Fraunhofer had become a recognized brand by 1979. "ZEIT" editor Marion Countess Dönhoff commemorated the organization's anniversary with a high-profile editorial entitled "Die Forscher-GmbH," or the researchers' corporation. Her bottom line: "Max Planck earns the Nobel prizes, Fraunhofer the money."

Contract research accounts for more than two-thirds of the Fraunhofer-Gesellschaft's budget; base funding from federal and state governments for roughly a third. With this business model and its laser-like focus on new technologies and markets, the Fraunhofer-Gesellschaft has become the German economy's innovation engine, a synonym for German engineering, and an example for others around the world to follow. Its inventions range from airbags, mp3 technology, and white LEDs to dandelion rubber. Electromobility and the development of cognitive systems, programmable materials and quantum technology, translational medicine and public safety are but a few of the topic areas from the wide spectrum of its current research and development activities.

Today, the Fraunhofer-Gesellschaft's is headed by Prof. Dr.-Ing. Reimund Neugebauer, who has efficiently organized the work of the institutes and brought them together in excellence clusters and virtual research units. Asked to describe his vision, Neugebauer says, "It is essential to not only conduct research with excellence and efficiency, but also to identify new topics at an early stage and set things in motion for the future. This enables us to respond that much faster to market demands. Our employees are the bedrock of our success. They strike the right balance between research and entrepreneurship, take responsibility for the future, develop solutions for tomorrow's challenges, and keep asking: **What's next?**"

https://www.fraunhofer.de/en/70-years-of-fraunhofer.html

IESE AT A GLANCE

"Our success relies on the knowledge and enthusiasm of our employees for applied research."

From the Guiding Principles of the
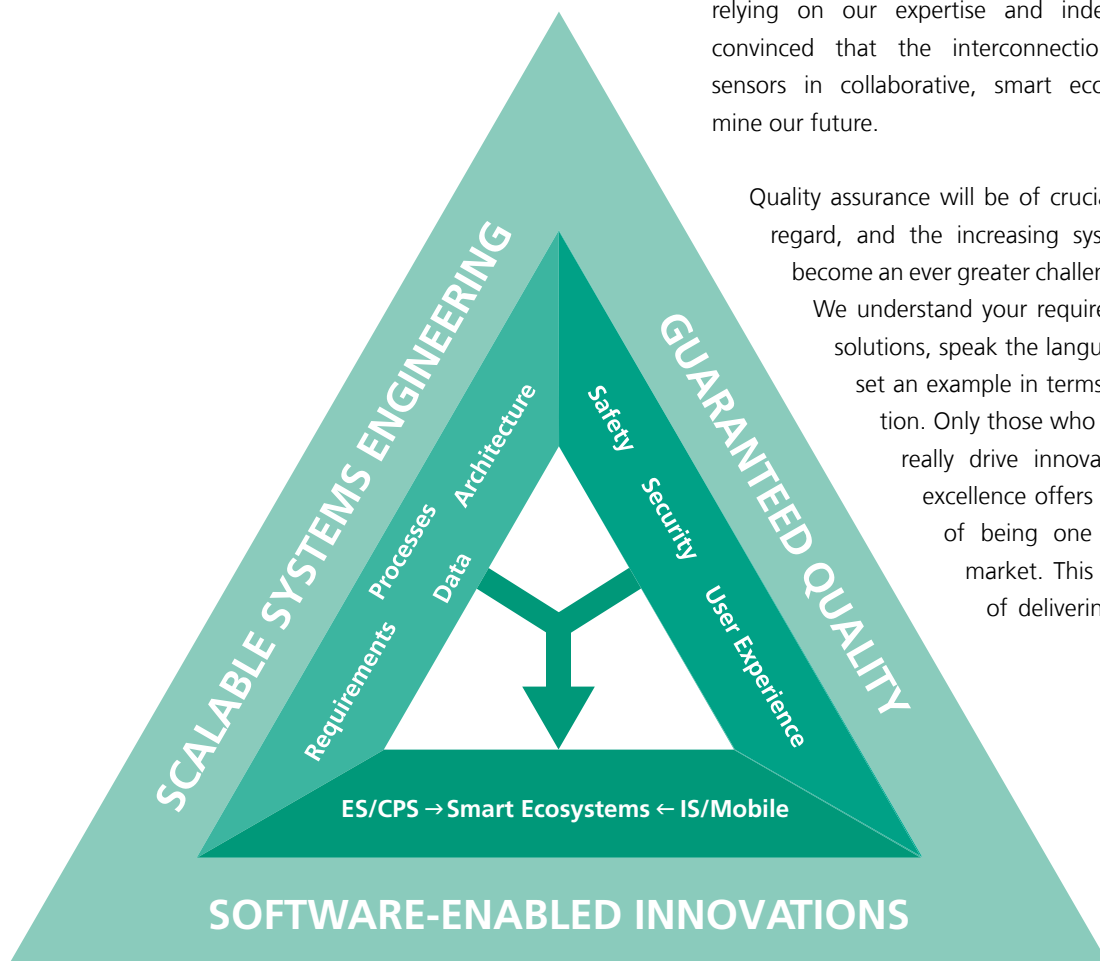Fraunhofer-Gesellschaft

OUR COMPETENCIES

FRAUNHOFER IESE

Software is at the core of innovative systems and sustainably ensures the future of our society and our economy. For 20 years we have been involved in research and collaboration with our partners to develop trendsetting key technologies for tomorrow. Leading companies as well as hidden champions – all around the world – are relying on our expertise and independence. We are convinced that the interconnection of systems and sensors in collaborative, smart ecosystems will determine our future.

Quality assurance will be of crucial importance in this regard, and the increasing system complexity will become an ever greater challenge for any company. We understand your requirements, explore new solutions, speak the language of business, and set an example in terms of practical orientation. Only those who know both sides can really drive innovations. Our scientific excellence offers you the added value of being one step ahead of the market. This is what our promise of delivering quality stands for.

SCALABLE SYSTEMS ENGINEERING

GUARANTEED QUALITY

Requirements Processes Data Architecture

Safety Security User Experience

ES/CPS → Smart Ecosystems ← IS/Mobile

SOFTWARE-ENABLED INNOVATIONS

ENGINEERING + QUALITY = INNOVATION

SCALABLE ENGINEERING

The scalability of our methods helps you to master your individual challenges in a systematic and quantifiable manner – no matter if you are an SME or a major corporation.

PROCESSES Today, agility is a key to staying competitive. But how to do this in regulatory environments, e.g., in the automotive sector? We support you in finding the right agile practices and integrating them into your systems engineering process to enable you to develop even complex systems in an agile manner.

DATA Big Data. Data Science. Machine Learning. Unsure what these buzzwords really mean? We support you in identifying data-driven solutions, in analyzing their technical feasibility and acceptance, and in controlling the quality of your software at development time and at runtime objectively on the basis of data.

ARCHITECTURE Building on a strong foundation: We already support you during the constructive phase of development, with model-based definitions, with assessments, and in optimizing your system and software architectures.

REQUIREMENTS Knowing what is important: By systematically eliciting, specifying, and evaluating your requirements, we assure the quality of your systems right from the start and help you to avoid one of the most frequent and most expensive sources of errors.

GUARANTEED QUALITY

Validated methods, quality assurance, and fact-based proofs ensure that you get the highest possible quality for your products and systems – in all phases of the development.

SAFETY Defects and failures can jeopardize human lives – functional safety is thus essential! We use innovative, model-based methods to make your products safe and to ensure efficient safety cases.

SECURITY Data and system security – particularly in distributed systems – is a must! Our usage control technologies allow you to control and protect the dissemination and usage of your data beyond the initial access.

UX User Experience refers to the total experience! With a positive UX, your products will conquer the market. The seamless integration of our innovative UX engineering methods into proven software engineering methods gives you a competitive edge.

SOFTWARE-ENABLED INNOVATIONS

INFORMATION SYSTEMS are permeating all areas of our daily lives! Modern business life has become inconceivable without secure and user-friendly systems and mobile applications. Billions of transactions are performed every single day. From ERP systems via CRM systems to online portals for various services such as online banking, social networks, eCommerce, and eGovernment – we offer you excellent know-how for your information systems.

EMBEDDED SYSTEMS must be safe and reliable! They greatly contribute to functionality, innovation, and value creation in the domains Automotive and Transportation Systems, Automation and Plant Engineering, as well as Medical Technology. During product development, our primary focus is on implementing model-based systems engineering with guaranteed qualities. We are your reliable technology partner in all phases of the development process.

SMART ECOSYSTEMS

By vertically interconnecting *Embedded Systems* and *Information Systems*, we tap new potential regarding functionality and efficiency together with our partners. The result are smart ecosystems for a wide variety of application areas. Cross-domain networking and integration of systems, services, and applications play an ever greater role for topics such as "Industrie 4.0", "Big Data", or "Smart Rural Areas". With our holistic systems engineering approach we help to develop smart systems that can be relied upon in every regard.

OUR SERVICES

STRONG PARTNERS FROM THE FIRST IDEA TO THE SUCCESSFUL PRODUCT

Successful products are based on successful partnerships. Strong organizations have strong partners. Since its foundation in 1996, Fraunhofer IESE has been a partner for many organizations, ranging from small and medium-sized enterprises to globally leading DAX companies. The experts of Fraunhofer IESE speak the language of its customers. With their many years of experience in projects with industry, they recognize challenges and find concrete solutions for practical applications, be it in the early phases of innovation and strategy development, in the evaluation and optimization of existing systems, or during development.

STRATEGIES FOR INNOVATIVE PRODUCTS

Every successful product starts with innovative ideas and an adequate implementation strategy. In the Rapid Innovation Lab, state-of-the-art rapid prototyping and simulation technologies are used in joint creativity workshops to develop innovative ideas, validate ideas early on, and answer important questions regarding technical feasibility or business models. Particularly at a time of volatile markets, one crucial factor for success is having an independent, competent partner at one's side who can bridge the gap between business ideas and technologies.

QUALITY AS AN INVESTMENT FOR SUCCESS

Increasing system complexity, continually rising customer expectations, and a volatile market landscape are only some of the aspects that pose challenges for an organization. In the 360° Diagnostics Center, the experts of IESE thoroughly analyze existing software systems. In the context of 360° analyses, Fraunhofer IESE examines both the processes and the actual products of its customers. This enables them to find problems in the architecture as well as implementation errors. If an organization asks where exactly in its software the problems are located, the 360° Diagnostics Center provides facts that substantiate its findings. Solid analysis results can support decisions about whether the renovation of a system is worth the effort, for example, or whether it would make more sense to build a new system, or can help to analyze the quality of third-party software. The institute's engineers derive improvement measures on the basis of the analysis results and of their many years of experience, and actively support their customers in optimizing their products and systems.

However, the experts of IESE do not only diagnose the quality of a system that has already been developed completely. They already predict what the expected quality of a system will be as soon as the first results are available in the development process. This makes it possible to check continually whether the development is still on the right track. Problems can be avoided before they even occur. For once a decision has been made to proceed in a new direction and to restructure a system or adapt it to a new market, more often than not this means investments worth millions. Thus it is even more important to keep an eye on the system's quality right from the start and to initiate countermeasures early on. If it looks like a system will not achieve the expected quality or will be unable to implement

the intended business models, it is still possible to take effective measures during early phases of the development. Early, independent assessment of a system's quality on the basis of reproducible facts prevents costly wrong decisions and wrong developments and thus constitutes an investment in the success of the product.

WORKING TOGETHER

Strong partners stick together until the goal has been achieved. This is why the engineers of Fraunhofer IESE will also not abandon their customers when it comes to development. Relying on innovative methods and tools, the Engineering Innovation Lab offers engineering support right from the start, but also provides help in implementing optimization recommendations, for example. From user experience designs to the validation and verification of systems: engineers from Fraunhofer IESE join forces with the experts of their customers to develop innovative products. In doing so, they rely on state-of-the-art systems and software engineering approaches, which they tailor to the needs of the customer. Upon demand, they also make the development platform including the entire tool chain available to their customers. This allows increasing innovative power as well as efficiency in the current development. And through joint work in combination with accompanying training and coaching, the know-how is transferred effectively and sustainably. Joint engineering with Fraunhofer IESE is therefore not only an investment into the quality and success of the current product or system: rather, it is a long-term investment into the success and added value of the organization.

With its more than 150 employees, Fraunhofer IESE offers companies from any domain and of any size expertise and application competence in all issues of the Digital Transformation regarding autonomous and cyber-physical systems as well as digital services.

In the last years, Fraunhofer IESE has evolved into a world-leading

competence center in software & systems engineering. This is also reflected in the participation of the institute in many publicly funded projects and industry projects in Europe and far beyond. These include, among many others:

- Fujitsu, Japan
- Hitachi, Japan
- John Deere, Germany & USA
- Toyota, Belgium
- Project CrEST, EU
- Project SECREDAS, EU
- Project EMC^2, EU
- Project MANTIS, EU
- Project Q-Rapids, EU
- Project DEIS, EU
- Project PROPHESY, EU

A special focal area of the institute's international activities are the USA. Close collaborations exist with the Fraunhofer Center for Experimental Software Engineering CESE in Riverdale, MD, USA, which is affiliated with the University of Maryland at College Park, MD (since 1998).
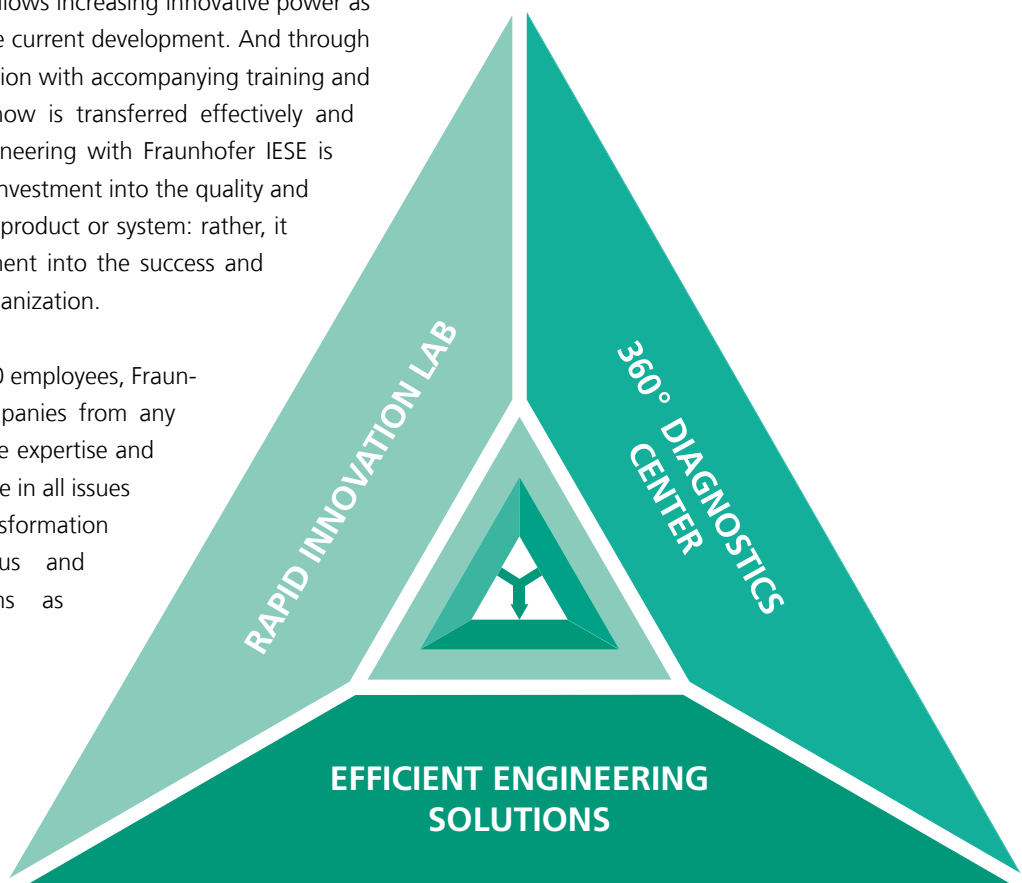
LOCALLY CONNECTED

FRAUNHOFER IESE IN KAISERSLAUTERN

Fraunhofer Institute for Experimental
Software Engineering IESE
Fraunhofer-Platz 1
67663 Kaiserslautern
Germany
Phone +49 631 6800-6000
Fax +49 631 6800-1099
www.iese.fraunhofer.de

FRAUNHOFER IESE CONTACT OFFICE IN BERLIN

Fraunhofer Institute for Experimental
Software Engineering IESE – Contact Office Berlin
Spreepalais, Anna-Louisa-Karsch-Straße 2
10178 Berlin
Germany
Your contact person: Gerald Swarat
Phone +49 171 3344883
berlin@iese.fraunhofer.de
www.iese.fraunhofer.de
http://blog.iese.fraunhofer.de

THINK LAB ENARIS® IN MUNICH

Think Lab ENARIS®
Hansastraße 32
80686 München
Germany
Your contact person: apl. Prof. Mario Trapp
Phone +49 89 547088-0
mario.trapp@esk.fraunhofer.de
www.enaris.fraunhofer.de

FRAUNHOFER CESE IN MARYLAND, USA

Fraunhofer Center for Experimental
Software Engineering CESE
5700 Rivertech Court | Suite 210
Riverdale, MD 20737
USA
Phone +1 (240) 487-2905
Fax +1 (240) 487-2960
www.cese.fraunhofer.org

The Fraunhofer Center for Experimental Software Engineering, Maryland (CESE) conducts applied research to support the software-enabled innovations created by its customers in industry, government, and academia. Fraunhofer CESE is affiliated with the University of Maryland at College Park and the Fraunhofer Institute for Experimental Software Engineering IESE in Kaiserslautern, Germany. Together with these strategic partners, it develops and uses innovative, effective, and scalable approaches to software and systems engineering, delivers powerful testing and verification strategies and tools, and uses state-of-the-art measurement and analysis methods to support its public and industrial customers in mastering their challenges.

Fraunhofer CESE works closely with customers in the aerospace and medical industries, government agencies, and research organizations. Major customers include NASA, NSF, DARPA, IARPA, and Deere and Company. For these and other customers, Fraunhofer CESE evaluates, develops, and applies state-of-the-art tools and techniques to support customer needs for advanced systems and software engineering solutions. Fraunhofer CESE provides critical skills and guidance to its customers to ensure the viability, reliability, and security of their systems and software. In addition to applied research, Fraunhofer CESE also conducts innovative basic research projects supported by NSF, DARPA, IARPA, as well as by research grants from other research institutions.

To support all of these efforts, Fraunhofer CESE relies on demonstrated competencies in the following areas:
- Model-based Development and Testing
- Safety and Security Requirements and Analysis
- Software Design and Development
- Process Analytics and Improvement
- Industrial Internet of Things (IIoT) / Industry 4.0

In addition to its project work, Fraunhofer CESE is proud of the mentoring and training of interns by its researchers. This year Fraunhofer CESE hosted 21 interns from Reykjavik University in Iceland; the University of Mannheim, Karlsruhe Institute of Technology, and the University of Kaiserslautern in Germany; and the University of Maryland in College Park, Maryland, who provided invaluable assistance in a wide variety of center projects.

Fraunhofer CESE continues to focus on strengthening its strategic partnerships with the University of Maryland, other Fraunhofer USA Centers, and Fraunhofer IESE. The resulting collaborations have positioned Fraunhofer CESE to expand its portfolio in both government and industry. Looking forward, Fraunhofer CESE will continue working hard to develop, refine, and package its own competencies and complement them with the competencies provided by its strategic partners. The goal is to be able to provide a wider array of cutting-edge services to a broader, more international customer base.

ORGANIZATIONAL CHART

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Deputy Director
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**Division
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**Division
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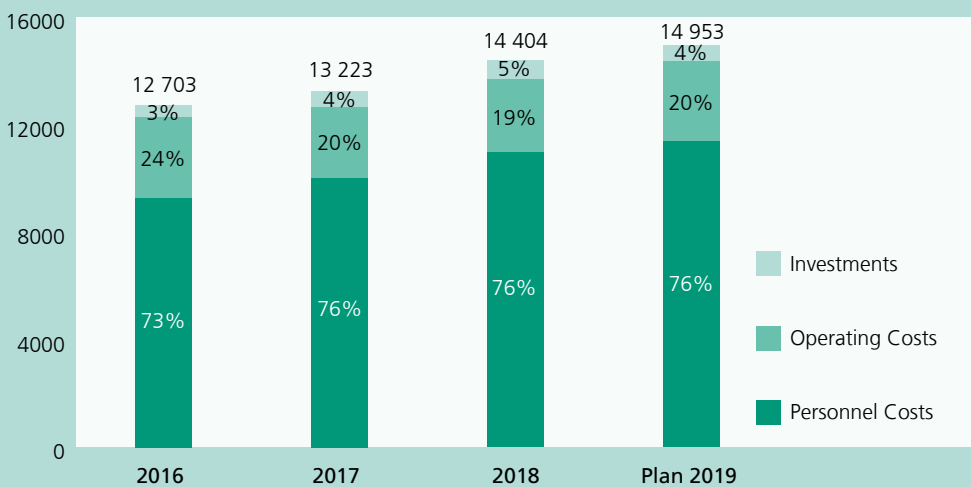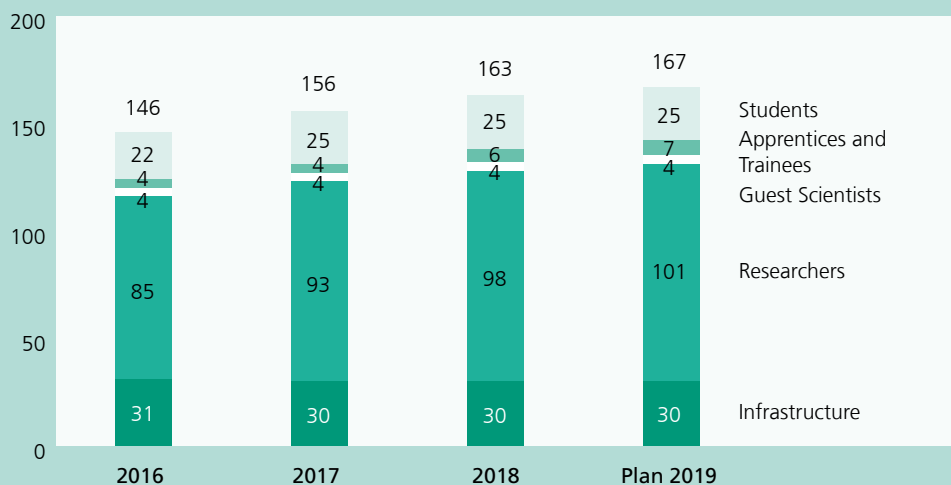
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INSTITUTE IN FIGURES

Development of Budget (in K euro)

	2016	2017	2018	Plan 2019
Total	12 703	13 223	14 404	14 953
Public Projects	52%	54%	54%	47%
Industry Projects	25%	32%	26%	29%
Base Funding	23%	14%	20%	24%

Legend:
- Public Projects
- Industry Projects
- Base Funding
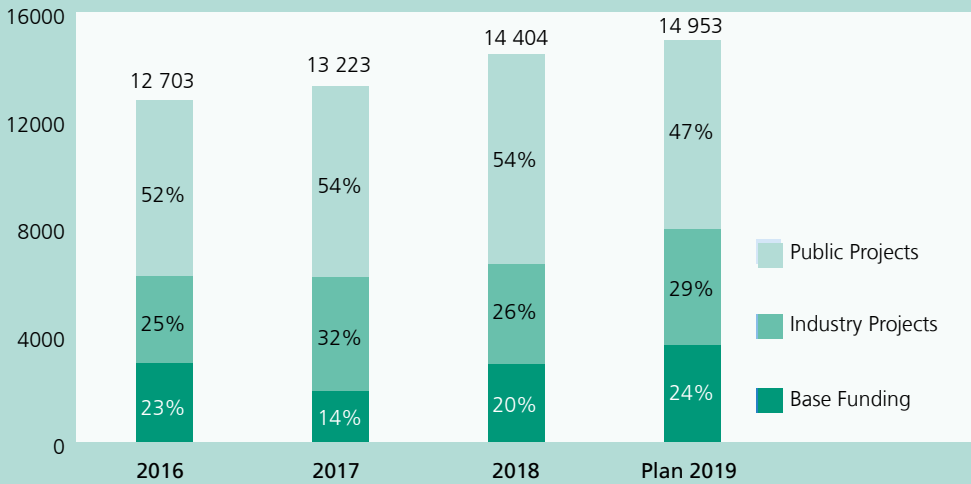
Development of Costs (in K euro)

	2016	2017	2018	Plan 2019
Total	12 703	13 223	14 404	14 953
Investments	3%	4%	5%	4%
Operating Costs	24%	20%	19%	20%
Personnel Costs	73%	76%	76%	76%

Legend:
- Investments
- Operating Costs
- Personnel Costs

Development of Personnel in # of FTE (Full-Time Equivalents)

	2016	2017	2018	Plan 2019
Total	146	156	163	167
Students Apprentices and Trainees Guest Scientists	22	25	25	25
	4	4	6	7
	4			
Researchers	85	93	98	101
Infrastructure	31	30	30	30

ADVISORY BOARD

The Advisory Board consists of representatives from research, industry, and government. The board members support the institute directors of Fraunhofer IESE with advice and counsel.
Chairman: Gerd Höfner

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University of York
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Kaiserslautern | GER

Prof. Dr. Helmut Schmidt
President
University of Kaiserslautern
Kaiserslautern | GER

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Paris | FR

Dr. Martin Verlage
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Transport, Agriculture and
Viticulture
Land Rhineland-Palatinate
Mainz | GER

Dr. Carola Zimmermann
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Education and Culture
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FUJITSU RunMyProcess
Paris | FR

THE FRAUNHOFER-GESELLSCHAFT

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

At present, the Fraunhofer-Gesellschaft maintains 72 institutes and research units. The majority of the more than 26,600 staff are qualified scientists and engineers, who work with an annual research budget of 2.6 billion euros. Of this sum, 2.2 billion euros is generated through contract research. Around 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Around 30 percent is contributed by the German federal and state governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

International collaborations with excellent research partners and innovative companies around the world ensure direct access to regions of the greatest importance to present and future scientific progress and economic development.

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies, and helping to train the urgently needed future generation of scientists and engineers.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry and in society. Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

Address
Fraunhofer-Gesellschaft e. V.
Hansastraße 27c
80686 München
info@zv.fraunhofer.de
www.fraunhofer.de
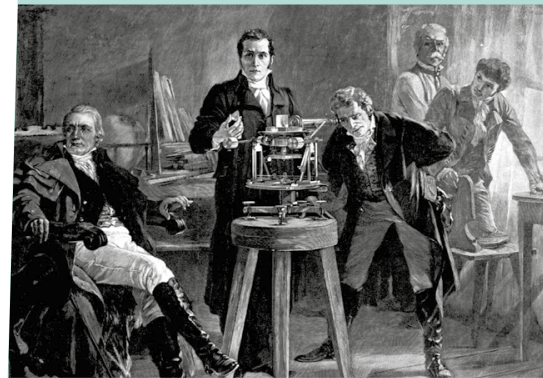
The man behind the name:

Joseph von Fraunhofer

The Fraunhofer-Gesellschaft owes its name to Joseph von Fraunhofer (1787-1826), the successful Munich researcher, inventor and entrepreneur. Born of a family of modest means, the glass-grinding apprentice Joseph von Fraunhofer joined the institute for optics headed by privy councilor Joseph von Utzschneider, who put the young researcher in charge of glass manufacturing at the early age of 22. Joseph von Fraunhofer's major developments include new methods of glass production and processing.

The optical instruments he himself developed, such as the spectrometer and the diffraction grid, enabled Fraunhofer to conduct fundamental research in the fields of light and optics. He was the first scientist to measure the spectrum of sunlight and characterize the appearance of the dark absorption strips: the "Fraunhofer lines". His work as an autodidactic researcher earned him great respect in academia and government, leading to the former apprentice becoming a full-fledged member of the Bavarian Academy of Sciences and Humanities.

IESE
WELL CONNECTED

SIAK
SCIENCE & INNOVATION
ALLIANCE KAISERSLAUTERN

Fraunhofer IESE is actively involved in the Science and Innovation Alliance Kaiserslautern e.V. (SIAK)

The Science and Innovation Alliance Kaiserslautern e.V. is the leading network for digital transformation, future innovations, and interdisciplinary cutting-edge research. Through its members from research – universities and research institutes – and industry – especially SMEs – it is deeply rooted in the region. The excellence of its members in research and practice makes Kaiserslautern and the Western Palatinate region an outstanding study, science, and technology hub for digital excellence and innovation both nationally and internationally. Fraunhofer IESE is also a member of SIAK. As an applied research institute, it uses the network as a link to business and industry as well as to the other research institutions. The megatrend "digital transformation" leaves its mark in all sectors of the economy, in society, and in private life.

Research in the Science and Innovation Alliance Kaiserslautern is characterized by broad coverage of the basic competencies in natural sciences, engineering sciences, as well as social and economic sciences that are typical of a university of technology and a technology-oriented university of applied sciences. The lighthouses of these basic competencies are the University Centers and Collaborative Research Centers.

Business and industry in the Science and Innovation Alliance Kaiserslautern is characterized by a mixture of technology-oriented large corporations (e.g., AECOM, General Dynamics, John Deere) and a multitude of SMEs – so-called Hidden Champions (e. g., Empolis Information Management, Insiders Technologies, psb intralogistics, SKS Welding Systems, TOPdesk, Wipotec).

In recent years, these companies have made a major contribution to the conversion of the city of Kaiserslautern and the region around it from a traditional manufacturing hub to a future-oriented science and technology hub. An example of this are the many high-tech companies in the PRE-Park Kaiserslautern.

Currently, the Science and Innovation Alliance Kaiserslautern is focusing on the following application areas: Industrie 4.0, Commercial Vehicles (CVA), Construction "Planning-Advising-Designing", Software, and IT. Additional application areas are under development, including Health (Smart Health) and Energy (Smart Energy).
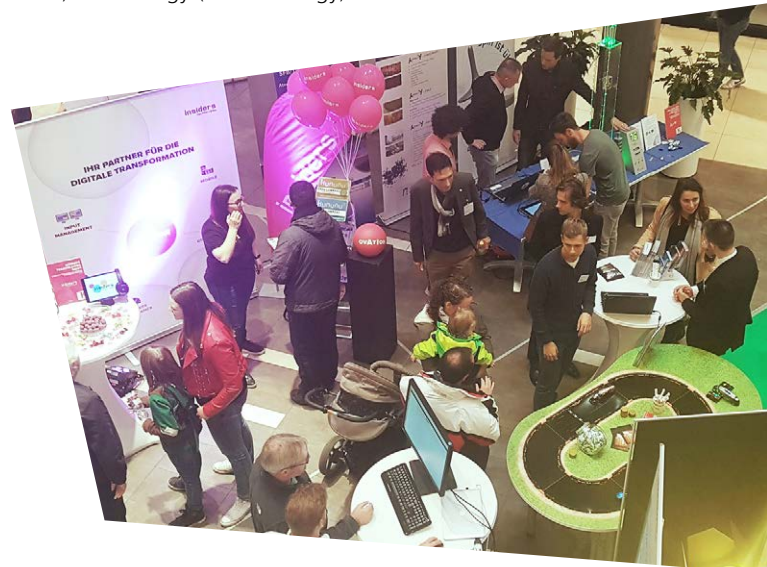

Exhibit in the mall "K in Lautern": At the Fraunhofer IESE booth, visitors could take a look at the digital future

Contact:

Science and Innovation Alliance Kaiserslautern e.V.
Dr. Melissa Ruby
info@science-alliance.de
www.science-alliance.de

REFERENCES

Project Grant Numbers

BaSys 4.0 | http://www.basys40.de
BMBF grant number 01IS16022A

CrESt | https://crest.in.tum.de
BMBF grant number 01IS16043E

DEIS | http://www.deis-project.eu
Horizon 2020 grant agreement no. 732242

Digitale Dörfer | http://www.digitale-doerfer.de
Funded by the Ministry of the Interior, for Sport
and Infrastructure of the *Land* Rhineland-Palati-
nate, 56:382 Digitale Dörfer

Digitale Teams | http://www.digitale-teams.de
BMBF grant number 01MD18007C

EPICSAVE | www.epicsave.de
BMBF grant number O1PD15004B
CCI no. of the EU's European Social Fund for
Germany 214DE05SFOP002

IUNO | http://www.iuno-projekt.de
BMBF grant number 16KIS0326

MInD
MWWK Rheinland-Pfalz 15414 – 52 207 – 2/43

PROPHESY | http://prophesy.eu
Horizon 2020 grant agreement no. 766994

Q-Rapids | http://q-rapids.eu
Horizon 2020 grant agreement no. 732253

Reallabor Pfaff
Pfaff-Quartier, EnergieIKT 03SBE112D BMWi
Pfaff-Quartier, SozioMob 03SBE112G BMBF

SECREDAS | https://www.ecsel.eu/projects/secredas
16ESE0318 (VDI), grant agreement no. 783119

TrUSD | www.trusd-projekt.de
BMBF grant number 16KIS0898

EDITORIAL NOTES

Your Contact Person at Fraunhofer IESE

Nicole Spanier-Baro
Head of Corporate Communications
and Technology Marketing
Phone +49 631 6800-6000
Fax +49 631 6800-1099
presse@iese.fraunhofer.de

www.iese.fraunhofer.de

Do you already know the Fraunhofer IESE Blog?

Take a look behind the scenes of our researchers and projects! Here our authors comment on current trends and research topics. Fraunhofer IESE is looking forward to entering into dialog with interested parties and to discussing exciting topics with them.

A look at our blog is worth your while:

http://blog.iese.fraunhofer.de