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FRAUNHOFER INSTITUTE FOR EXPERIMENTAL SOFTWARE ENGINEERING IESE

"PLATFORM ECONOMY"

ANNUAL REPORT
2017
2018

Dear readers,

The English Oxford Living Dictionary defines the term "platform" as a "raised level surface on which people or things can stand", alternatively also as the "declared policy of a political party or group", and finally as a "shoe with very thick soles". We can obviously ignore the latter definition for our intents and purposes. The former two definitions, however, do indeed make sense if we transfer them to our intended use case. And our platforms also imply various meanings of this term. For example, there is the "Platform Industrie 4.0" as an association of industry, research, government, and federations. The members of this platform share the interest of wanting to drive the topic of "Industrie 4.0". We could also say: Within this platform, there is a stated position on this topic. On the other hand, however, this term is also used to describe the technical basis for a specific area. One example of this is building automation on the basis of the EIB/KNX standard, which makes it possible to use random devices of various manufacturers together, provided these devices are compliant with the platform standard. Here we might say: The devices are located on the EIB/KNX platform – the platform forms the basis.

But what, then, is "Platform Economy"? One of the explanations given by the English dictionary mentioned above for the term "economy" is that it refers to the "state of a country or region in terms of the production and consumption of goods and services and the supply of money". The term "economy" explicitly includes business models. It is about making an offer and earning money with it.

"Platform Economy" thus obviously means that there is a business model for a platform that finances its operation. The form of this financing is not fixed; it only matters that it exists. Whether this is done via membership fees, usage fess, royalties, or advertising revenues does not matter initially. Platforms can be open to anyone willing to stick to the rules – e.g., EIB/KNX – or can be operated by a single company – e.g., music streaming providers. What is always crucial is the existence of a large enough group of interested stakeholders that supports the financing model. In addition to the platform itself, a successful "Platform Economy" requires a business model and users.

Fraunhofer IESE does research on the topics of "Platforms" and "Platform Economy". The actual platforms are generally very complicated, heterogeneous, open systems that can be changed during operation, are sometimes even autonomous systems, and must fulfill a multitude of criteria. Ensuring this requires powerful "Systems Engineering" technologies, which are part of our work. In addition, the business model and the markets also need to be considered. Many organizations wonder what their business model should look like in the age of digitalization. Excellent technology alone does not guarantee success. Fraunhofer IESE also provides support for this aspect. It is always essential to look at the whole picture.

In this annual report, you will find descriptions of selected work done by Fraunhofer IESE on the topic of "Platform Economy". This includes, for example, platforms for dealing with data in the automotive industry, the area of "Industrie 4.0", solutions for data protection using data usage control, and open platforms providing digital support for real life in rural areas.

We hope you will enjoy reading this report!

Peter Liggesmeyer

Dieter Rombach

CONTENTS

CONTENTS

PLATFORM ECONOMY

“Together with our partners we are working on the great challenges of the platform economy.”

Prof. Peter Liggesmeyer, Fraunhofer IESE

PLATFORM ECONOMY
Exploiting Digital Business Models

The establishment of platforms is becoming an ever more important element for the implementation of digital business models. According to a study by Accenture from the year 2016 [1], 81 % of the managers surveyed stated that platform-based business models would form the core of their growth strategy within three years. But what does the term platform economy actually mean, and does it really constitute such a boost for our economy?

The "Big 4" Google, Apple, Facebook, and Amazon – often also called GAFA – are showing us how it is done. The successful platform forms the technical basis for the digital business model and is therefore an essential part of the digital transformation. The latter often happens in three characteristic steps: The digitalization of products is followed by the digitalization of processes, which transitions into the digitalization of business models.

Platform strategy – more than the sum of all parts

The difference between a platform strategy and a product strategy is that an external ecosystem is required for the generation of comprehensive product or service innovations and synergies between such offers and the platform that enables them. The result may be a larger innovation and growth potential than what a single organization could achieve using only a product-oriented strategy.

Value is added by digital partners and communities of users that use the platform and make contributions to it. The platform concept itself is not new. It has existed in various forms since the 1960s already. But nowadays it enjoys particular attention due to the success of companies such as Facebook and LinkedIn in the area of social networking, Amazon and eBay in retail, or Uber in the area of transport, to name but a few examples.

Turning platforms into Smart Ecosystems

For some time now, the term "disruption" has been popular – particularly in the context of digitalization – , often with the intent to specially emphasize the fundamental character of an innovation. Some innovations really cause a significant change of the rules, but often this is not the case and if so, not for all.

This can be explained very well using the changes in the music industry as an example. The introduction of the CD was the digitalization of a product. The analog product of the vinyl record was replaced, to a large extent, by the digital product. Initially this entailed little change in terms of the processes and business models. It was not disruptive for the payment of the artists, the work of record companies and factories, or for the sales model of record stores. The transition to music being downloaded as files was the subsequent digitalization step of the process. For record factories and record stores, this was disruptive because they are not needed in the digitalized processes. The third step – the digitalization of the business models – was performed by the streaming services, which now no longer sell sound storage mediums or pieces of music, but rather permit practically unlimited access to music for a fixed fee. This is made possible by appropriate platforms, which provide the service itself on the one hand, but also enable additional

functions on the other hand and ultimately tie the customer to the company. The platform becomes its own ecosystem, intended to satisfy the needs of the users with regard to a particular topic in the best possible way. This typically requires the integration of a variety of issues in way that is comfortable and pleasant for the user, and may affect a variety of components, from payment services via rights management and privacy issues to data analyses.

Platforms are therefore usually very heterogeneous. They are open and can be adapted to various needs, or they may even adapt themselves autonomously. And what might be the most important aspect: They must create trust. In other words: Platforms are a core component of many Smart Ecosystems.

There is no such thing as the "one" successful platform strategy!

Fraunhofer IESE has been involved in research on Smart Ecosystems for quite some time. Answers need to be found to many questions, such as: "How to develop heterogeneous, dynamically changeable systems with guaranteed quality? Which architecture concepts are promising? How to design the interaction in order to get the best possible acceptance? How to evaluate data and protect it against misuse at the same time?"

These questions also need to be answered with regard to platforms. However, platform concepts also require the creation of the ecosystem used by the platform. It is remarkable how differently successful platforms can be designed and which criteria determine their success or failure. "Smart Home", for instance, is already an old hat for automation experts. In the area of building automation, the standards EIB/KNX, in which practically all large manufacturers are involved, has existed for about 20 years. On the one hand, this is an open standard. There are components for every purpose. Basically, it can be used to address every "Smart Home" issue. On the other hand, setting up an EIB/KNX solution requires extensive professional expertise and a rather large amount of effort and planning. In other words: This is a platform concept for experts, and its entrance barriers are rather high. Yet it is extremely successful. Its market share is reported to be about 75 %. The ecosystem addresses manufacturers, experts, and professional applications. It is not primarily geared towards private customers, which, however, has not prevented it from being successful. Many of the systems currently being discussed under the term "Smart Home" advertise that they are easy to realize and intuitive to operate. This may also be a promising path to success. This example illustrates that there are not always specific criteria that determine a successful platform strategy; rather, very diverse factors may be relevant.

Fraunhofer IESE is currently working on a variety of platform concepts related to application areas such as Industrie 4.0 or digital support for rural areas, as well as cross-sectional topics such as data usage control. More information about this and about how we guide our partners towards a successful platform economy with the help of our three service packages can be found on the next pages.

Prof. Peter Liggesmeyer
Director, Fraunhofer IESE

PLATFORM ECONOMY
Systems Engineering for Smart Ecosystems

Fraunhofer IESE: neutral partner for platform economy and digital ecosystems

It has been our experience that our partners and customers are primarily interested in two types of platforms: Innovation and development platforms enable platform providers to attract external innovators and give developers the possibility to offer their products and services. Examples of such platforms are iOS by Apple Inc. and Android by Google in the area of mobile applications. Transaction platforms help the partners in an ecosystem to find each other, facilitate data sharing, and enable interactions. Examples of transaction platforms in retail are Amazon and eBay.

The topic of platform economy fits very well to Fraunhofer IESE's mission of being the preferred partner in systems engineering for smart ecosystems. In many ecosystems, platform providers are enablers for the digital ecosystems to start, evolve, and grow. Our partners therefore work with us on key challenges for platform providers and platform consumers.

Some years ago, Fraunhofer IESE decided to tackle these challenges as part of its applied research in the area of Smart Ecosystems. The results get incorporated into its three service packages, which are described in greater detail on the following pages:

Rapid Innovation Lab

Efficient Engineering Solutions

360° Diagnostics Center

Dr. Jörg Dörr, Dr. Jens Heidrich, Dr. Thomas Kuhn
Division Heads at Fraunhofer IESE

SUCCESS STORY

Digital Ecosystem for Data and Services in the Automotive Aftermarket

With the support of Fraunhofer IESE, Caruso GmbH has developed its open and neutral data and service marketplace for the automotive aftermarket. With its expertise in digital ecosystems and platforms, Fraunhofer IESE has been on board right from the start as a neutral and strategic technology consultant. On 16 November 2017, the Caruso GmbH presented the Caruso Platform during an exclusive event at Fraunhofer IESE in Kaiserslautern. The institute will continue to support the company in its future growth.

Which benefit does the automotive aftermarket get from the platform?

Caruso is an open and neutral data marketplace. It enables new business models and mobility services for all current and future actors in the automotive aftermarket. It creates all the prerequisites for making relevant automotive data accessible to the digital, networked world. The digital transformation of the automotive aftermarket is gaining ground and offers real opportunities for all those who want to be part of this market now and in the future. In the modern, digital world, the traditional value chain is turning into a value network, and as a platform Caruso offers the possibility to establish an ecosystem. This is why Caruso does not only have an eye on the parts industry, but also on complementary segments such as trade, insurance companies, and fleet and leasing companies.

Fraunhofer IESE has supported Caruso in the following areas:

- Working out the ecosystem- and platform idea
- Selection of basic technologies and decision support
- Design of fundamental concepts for the platform and the marketplace
- Design of the User Experience and the user interface of the marketplace
- Elicitation and structuring of the Caruso data catalog, also as a study with companies from the automotive aftermarket
- Design of the architecture and development of the first version of the platform, and onboarding of the partners
- Fundamental reasoning on the business model of Caruso
- Marketing and communication
- Design of the security concept

The study is available at:

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

Alexander Haid, Managing Director Caruso

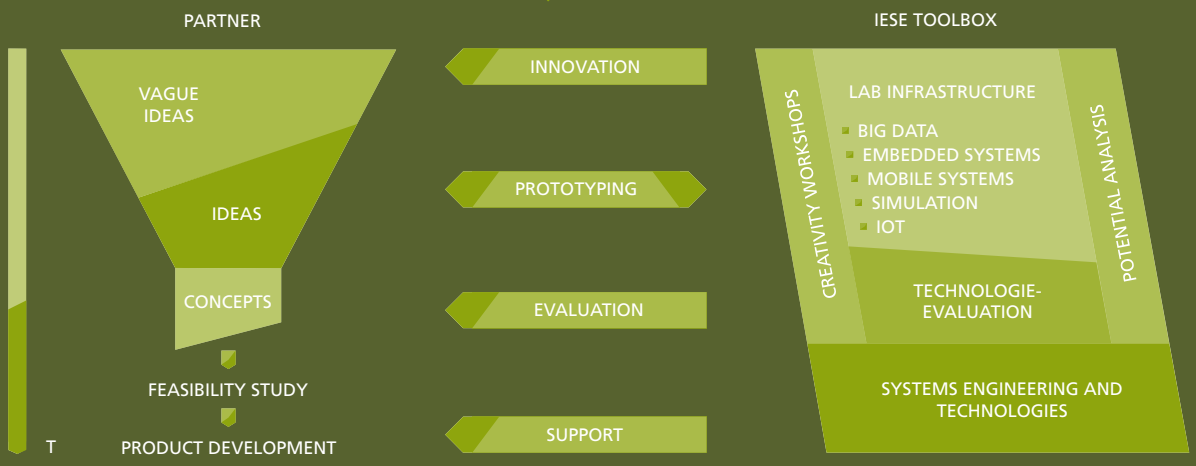
Product Innovation: What is my role in the ecosystem and how to get it started?

- How to determine whether to start my own platform or join an existing initiative?
- What does my business model look like?
- How to get the platform economy off to a quick start and at the same time engineer the ecosystem systematically?
- Which infrastructure needs to be implemented in the platform? Which technologies to use for the platform?
- Which data and services will be handled by the platform? How to integrate existing systems and services?

In our Rapid Innovation Lab, we support platform providers in getting their ecosystem started. We perform dedicated Ecosystem Innovation Workshops, where we bring together various stakeholders in the ecosystem on neutral ground to define the future roadmap for the evolution of the platform. Once the vision of the platform ecosystem is ready, we support them in the rapid prototyping of the platform and the ecosystem, the onboarding of partners with their systems into the ecosystem, and the successful launch of the platform.

RAPID INNOVATION LAB

Companies nowadays face a lot of (technological) trends, such as digitalization, IoT, Big Data, Industrie 4.0, Cloud, etc. Often it is not really clear what such a trend means for a company (e.g., in terms of new products or business models). We provide our customers with a comprehensive toolbox that helps them find new ideas and develop prototypes for the rapid evaluation of potentials, and which supports integration into products.



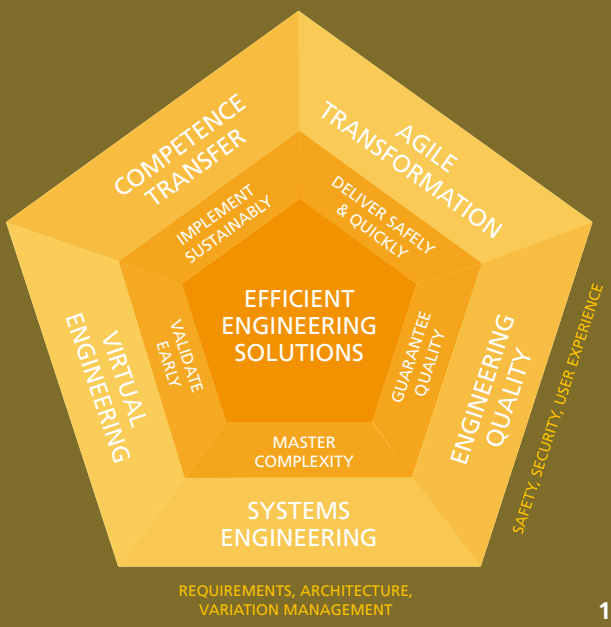
Systems Engineering Innovation: How to properly engineer systems and platforms?

- Which architecture is appropriate for handling future requirements in terms of scalability, reliability, interoperability, privacy, and security?
- How to achieve a high level of User Experience and attract partners so that the platform ecosystem can grow?
- How to deal with the increasing complexity and heterogeneity of systems of systems?
- How to integrate intelligence and autonomy safely and securely?

The architecture is at the center of our Efficient Engineering Solutions: We support platform providers with our ACES approach in defining a robust, interoperable, yet pragmatic and simple architecture. With our simulation framework FERAL, we evaluate architecture alternatives that are fit for future demands.

EFFICIENT ENGINEERING SOLUTIONS

Software is increasingly becoming an enabler for innovative systems of the future (such as Industrie 4.0 or autonomous systems). However, various challenges exist regarding the engineering of these systems, such as dealing with increased complexity, shorter innovation cycles, or guaranteeing dedicated qualities (such as safety and security) at runtime. We provide our customers with efficient and innovative engineering methods and tools to enable them to develop the systems of the future.



MANTIS – Ecosystems for Collaborative Maintenance

The almost complete penetration of all technical areas with algorithms and Cloud Computing can also be used profitably in industrial systems maintenance. In this way, maintenance does not need to be an expensive evil, but can become a process that can be tied seamlessly into the business processes. In the EU project MANTIS, Fraunhofer IESE is working on collaborative maintenance ecosystems.

Unlocking new market potentials through Predictive Maintenance

If the maintenance needs of systems and their components can be predicted early on the basis of machine and usage data, then maintenance work becomes easier to plan and can be performed as needed. This makes it possible to avoid longer periods of machine standstill, increase the availability of the systems, and save resources overall. With proactive and predictive maintenance (PM) for OEMs, suppliers, and service providers, new market potentials can be unlocked. This is why in recent years, a rapidly rising interest in PM can be observed. Even though promising approaches and technologies already exist, a closer look reveals that the potential can only be used in part by many industrial enterprises. This is where MANTIS comes into play. In addition to typical Big Data analyses, a reference architecture for PM is being developed in this project – consisting of distributed process chains that transform raw data efficiently and systematically into knowledge, with minimal bandwidth requirements. One core challenge is how to bring together various sources of information. Furthermore, economic models are being developed that take into account the new collaboration possibilities. Through the collaboration of 47 European partners in eleven use cases, the results of MANTIS cover industry domains such as production, energy, commercial vehicles, and health care, with the German part of the consortium focusing on the commercial vehicle industry.

Toolkit for Predictive Maintenance paves the way towards a PM ecosystem

With the MANTIS project, Fraunhofer IESE is pushing forward its competence development in the context of platform economy and is working on a PM toolkit that systematically brings together drivers, business models, solution approaches, and technology components and makes them usable. The experiences from the eleven use cases show that a systematic approach is absolutely essential for the development and use of coherent PM solutions and that the availability of data is only a small step towards achieving the goal. For most of the partners in MANTIS, a cross-company PM ecosystem in which information from various companies is used collaboratively was a step that was still to big for them to take at this time. They took an intermediate step onto a company-internal PM platform, to which they add external data and analysis competencies as needed.

The PM toolkit developed in the project helps our customers to address the challenges of modern maintenance strategies faster and more efficiently, and to integrate them systematically into their corporate structures. With the EU project PROPHESY, Fraunhofer IESE is now focusing on the evolution of a PM technology platform in the area of industrial automation.

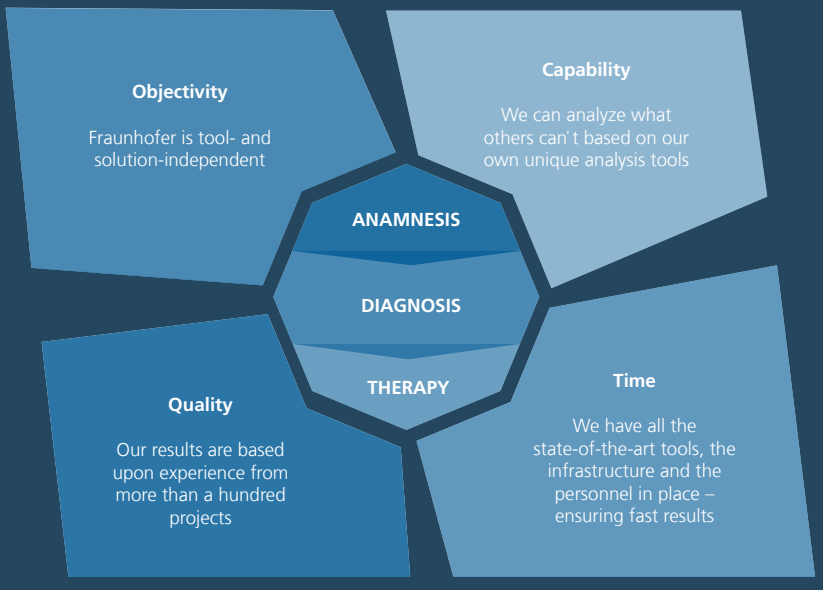
Independent Diagnostics: Where am I and what needs to be improved?

- How mature is my organization with regard to setting up a platform or participating in an existing platform?
- How well are my systems and products suited for onboarding to a platform?

In our 360° Diagnostics Center activities, we assess our customers' existing solutions and highlight areas of improvement. We identify business models that must be supported by systems, evaluate different facets of systems with respect to these goals, and develop holistic improvement strategies that will gradually and systematically improve the suitability of the evaluated systems for a platform ecosystem.

360° DIAGNOSTICS CENTER

The quality of systems and their engineering processes is essential for companies to stay competitive and deliver product features meeting certain quality criteria on time and within budget. Companies therefore need a benchmark for their product and process quality and for what actions to take in order to cope with future challenges. In our 360° Diagnostics Center, we provide independent, objective, and comprehensive assessments of products and processes.



Bitkom promotes exchange on the topic of platform economy

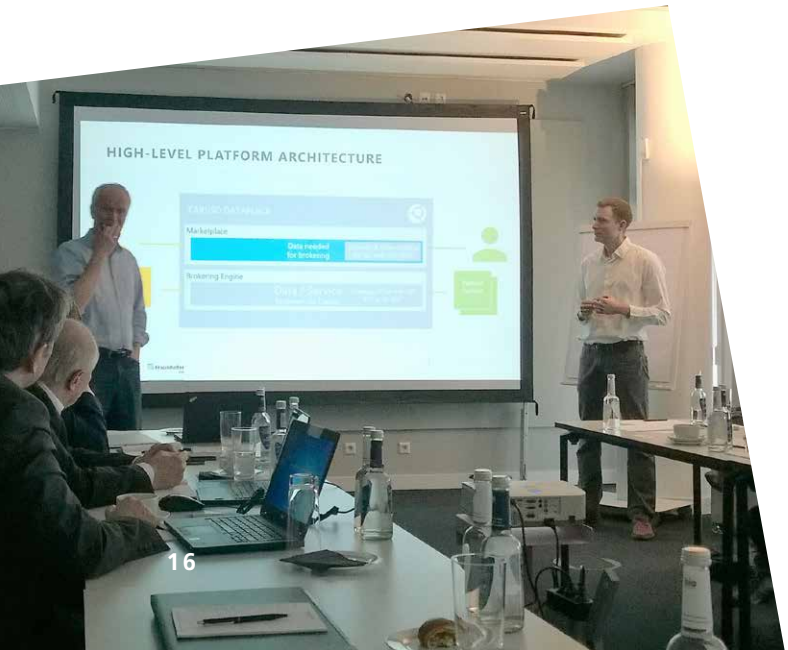
Digital platforms will change the markets. They drive innovations and new business models and have the potential to transform conventional markets. However, they may also be disruptive for conventional products and markets. The well-known quote "Platforms beat products every time" by Marshall van Alstyne (MIT Initiative on the Digital Economy) [2] clearly shows one thing: It is essential to master the Digital Transformation at all levels – from digital business models to the technical implementation – in order to keep up with the competition or stay ahead of it. The large German industry associations have recognized the importance of this issue for Germany, Europe, and the whole world. One of them is Bitkom, the German Association for Information Technology, Telecommunications and New Media, which initiated the Platforms Working Group in March 2018. In order to make the adaptation process successful, the association wants to promote exchange between traditional and new players in the economy on the one hand and exchange between business and government on the other hand.

Topics of the Bitkom Platforms Working Group:

- B2B and B2C aspects of the platform economy
- Types and characteristics of platforms
- New platform actors on classical markets
- Disruption or transformation?
- IoT platforms
- Platform economy and Industrie 4.0
- Impact of the platform economy on the economy and on society

Fraunhofer IESE is also actively involved in this working group and is contributing its expertise from numerous projects with a focus on platform economy and software platforms. About 30 participants attended the first meeting on 13 March 2018. The program consisted of three presentations on platform economy from very diverse areas, which provided lots of material for exciting and stimulating discussions. Dr. Matthias Naab from Fraunhofer IESE and Ulrich Keil, CTO at Caruso GmbH, jointly presented the B2B service and data platform Caruso Dataplace. The institute is supporting its customer Caruso in establishing this market platform and an ecosystem for data and services in the automotive aftermarket.

Further information and registration for the Bitkom Platforms Working Group:



Dr. Matthias Naab (right), Department Head Architecture-Centric Engineering at Fraunhofer IESE, explains how the topic Platform Economy is implemented for the automotive aftermarket in the project with Caruso.

Digitale® Dörfer

SUCCESS STORY

Digital Ecosystem for Smart Rural Areas

Smart digital services can make life easier in rural areas and increase the attractiveness of municipalities in these regions. In the research program "Smart Rural Areas", Fraunhofer IESE is developing a digital ecosystem for rural areas that supports municipalities in embarking on this path.

Being "smart" in rural areas with the Digital Villages Platform

Digitalization is changing the lives of people in rural areas with far-reaching effects. It is leading to the emergence of new potential and new challenges for municipalities in rural areas. With our "Digital Villages Platform", municipalities in Germany have a tool at their disposition since the beginning of this year that they can use to exploit this potential and address the challenges in the areas of local supply and communication. The platform provides a good basis, and the first services developed by Fraunhofer IESE can be used directly as well. In addition, the complete ecosystem does not only support networking among rural areas, but also networking with potential additional partners, who can offer their services via the platform. The continuous evolution, the scalable software architecture, and the networking in the ecosystem allow ensuring the future viability of a region with regard to digital services.

A uniform platform with flexible services

The flexible use of the available services enables individual development of a rural area on the basis of the existing situation, allowing every region to take into account its own "DNA" when designing their digital services. Currently we are focusing on the areas of Communication and Local Supply as central components of the platform.

In particular the communication among the citizens, but also between citizens and the municipal administration, can be realized in an innovative manner with the help of DorfNews and DorfFunk. This does not only mean that one can get information about regional happenings and events easily and quickly, but also allows citizens to actively take part in designing the future in rural areas.

Sustainably designing local supply is possible with the help of the BestellBar. This flexibly configurable online marketplace can be used in whichever way makes sense for the region. Particularly the combination with the LieferBar, a flexible delivery service, offers innovative added value and the chance to achieve more in the community.

During the further evolution of the platform, additional components will be added in the areas of mobility in rural areas, digitally supported work, medicine, and nursing care.

IESE IN TREND

Fraunhofer IESE – Engineering the Digital Future!

AUTONOMOUS DRIVING
Artifical Intelligence and Safety

The future belongs to self-driving cars, that much seems clear. But how to prevent accidents? When does a risk become acceptable, and how to create safety if AI solutions were to fail?

Generally, safety does not mean that no damage may occur, but rather that the risk is acceptable. In the case of self-driving cars, the question thus arises which residual risk can be accepted and how to assure that they will cause at least significantly fewer accidents than vehicles driven by humans. There will be no one hundred percent protection against accidents here either. Which role can Artificial Intelligence play in this context?

Safety-relevant decisions in automobiles are increasingly made by software: This can be programmed in the classical manner. It is determined in the program which of the possible reactions is suited best in which of the situations to be expected, and it is checked whether the software actually behaves as desired. The drawback of this procedure is obvious: It only works well if situations are known in advance, so that the reactions to them can be defined in the software in advance. What to do, however, if the situations are too complicated and too numerous to define everything in advance, such as is to be expected in real road traffic?

When you evaluate the pictures of a camera in a vehicle, it is of course not possible to check every possible pixel combination and determine whether the picture shows a particular object or not. This is also true for all kinds of driving situations and the decisions on how to steer and accelerate. For such cases, Artificial Intelligence (AI) processes could be a suitable instrument. In this area, there are methods with very high levels of performance that often deliver astonishingly good results. However, there is no guarantee that an AI method will always dependably provide good results. But this is a requirement that will be raised regarding autonomous vehicles. If you do not know exactly how the software will behave, then how can you demonstrably achieve safety?

This is indeed still a topic of current research. But it is quite interesting to compare the performance of current solutions for autonomous driving, the "official" requirements, and the actual performance of human drivers.

When does the risk become acceptable?

Various principles exist for determining the risk acceptance threshold. Safety standards such as ISO 26262 for (non-automated) road vehicles contain high requirements on safety: According to these regulations, one would drive an average of 5 billion kilometers at an average speed of 50 km/h before the first fatal accident would happen. All the Tesla vehicles together, however, had only driven a total of 210 million kilometers in automated mode [3] before the first fatal accident happened, and not 5 billion. If these 210 million kilometers were the general average as well – which, statistically speaking, is not really tenable – and if the Tesla vehicles would drive 50 km/h on average or faster, then Tesla would have missed the risk acceptance threshold by a magnitude of more than 20.

According to the U.S. Department of Transportation, however, in 2015, the kilometer average for a fatal accident in manual driving in the USA was 140 million kilometers [4] and in Germany 219 million kilometers, according to ADAC [5]. The question thus arises whether automated systems must really achieve the extreme value or whether they might not simply need to "only" be better than the best human or significantly better than the average human. For automated driving, this would mean that the goal is not only to a reach a specific accident rate and then stop as soon as that is reached, but rather to try and minimize the accident rate to the extent to which this makes sense and is practically feasible.

If AI solutions ever fail

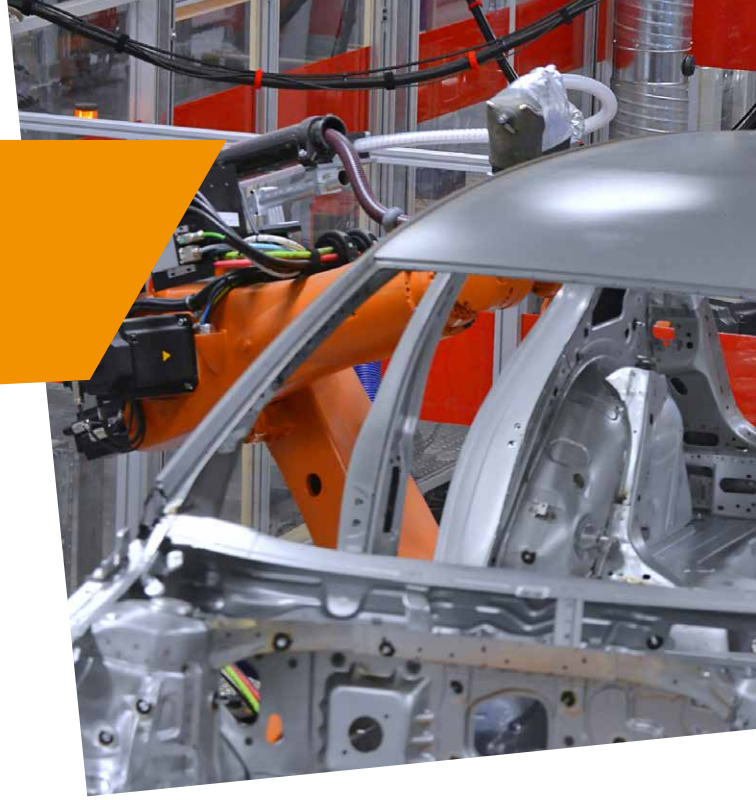
One strategy may be to monitor the Artificial Intelligence systems with conventional software. This may appear strange at first glance, but makes sense when one takes a closer look. Often, it is much easier to check whether a reaction is safe than to determine the reaction itself. This is a little like with high-wire acrobats and their safety net. The acrobats can repeat very complex processes very precisely. Should they fail once, this unsafe situation – the fall – is gently slowed down by the safety net. Preventing the fall through the net is a much simpler function than executing a precise double somersault. One might say: The acrobats take care of the function – good acrobatics. The net guarantees safety in the case of emergency.

Transferred to self-driving 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 ever fail, conventional software could prevent this from turning into an unsafe situation. This software would form a sort of safety net. As this is "regular" software, its function could be traced exactly, so a failure of the AI solution would not have any serious consequences.

So Artificial Intelligence can make self-driving cars safe to a large extent if it remains connected with classical algorithms. In this way, the engineer will retain control in the future as well, not just the computer.

Prof. Peter Liggesmeyer
Director, Fraunhofer IESE

AUTONOMOUS SYSTEMS
Efficient and safe



The discussion about autonomous driving is currently being conducted on a broad public level. Similar to the Digital Transformation, the topic of "Autonomous Systems" is permeating almost all branches of industry because such systems are increasingly being deployed in numerous areas to increase productivity.

In technical systems, autonomous or self-sufficient systems that do not require any human monitoring or control lead to higher efficiency and increased performance. This is why this step in automation is being discussed for use in manufacturing plants, in medical technology (e.g., in patient monitoring), or in transportation systems such as rail, mobile work machinery, avionics, or shipping.

The complex processes of such systems are controlled via software. In it, we characterize the difficulty of developing such a system via its degree of independence as well as via the complexity of the tasks and the environment. It quickly becomes clear that if there are fewer human controls, the risk of a failure, resp. any risk to the environment must be minimized by the system itself. This means great responsibility for the respective companies and their employees, and many challenges arise in the implementation. When engineers have to develop such dependable and often safety-critical systems with the required level of care and quality, they are supported by appropriate technologies and methods, many of which are also being developed to a significant extent at Fraunhofer IESE.

Addressing complexity

Already at the beginning of such development, the question of system specification arises, which must take into account not only purely functional aspects, but also numerous non-functional properties. These range from data quality, security, and privacy via performance and data throughput to effects in the physical world such as electromagnetic compatibility and functional safety. In these so-called cyber-physical systems, interdisciplinary interaction is also important. At Fraunhofer IESE, we are further evolving corresponding systems engineering notations and processes, paying particular attention to the interaction between different quality aspects of a system architecture. One major aspect of autonomous systems is the elicitation and assessment of the context. In our Data Engineering department, we design analyses for this purpose and define suitable structures in coordination with system architects. In the case of complex situations and a lot of training data, machine learning methods are also used often in this context.

Agile methods are gaining ground

The requirements for the development teams increasingly include the demand for flexible and quick reaction to changes. To this end, our staff evaluates together with or-

ganizations how agile methods can be used reasonably in such development processes. The development of systems that are embedded in digital ecosystems never really stops. In line with continuous engineering particularly for autonomous systems, current data is used to continually evolve the systems. If this evolution takes place automatically, we also call such systems self-learning systems.

Finally, the development processes themselves are also getting increasingly automated. Doing so requires adapting the mostly "human-based" development process, e.g., to allow automated testing of quality aspects. Without such virtual validation it will not work – these highly automated and autonomous systems are simply too large and too complex. With the simulation framework FERAL, Fraunhofer IESE has developed a tool in the past few years that can already be used for validating many design decisions and which makes a significant contribution to saving time and costs.

Ralf Kalmar
Business Area Manager, Fraunhofer IESE

More about the simulation tool FERAL:

DIGITAL TWIN
The technology trend for Industrie 4.0

In 2017, Gartner [6] considered the concept of the digital twin one of the 10 most important strategic technology trends. What exactly it means and which crucial role it can play in the business network of the future is explained by Dr. Thomas Kuhn, Head of the Embedded Systems Division at Fraunhofer IESE.

What is the definition of a digital twin? How did this idea even come about?

A digital twin is the digital image of things from the real world. It describes both physical objects and non-physical things, e.g., services. In principle, the digital twin is a software unit that behaves exactly like the real system – all relevant properties of the real system are present. The term first appeared at NASA. Back in 2012 already, its scientists proposed the digital twin as a solution for reducing the escalating costs for certification and tests. Since tests with airplanes and rockets are very expensive, the idea emerged to do these with the help of digital twins.

How good a digital twin is depends on how good its simulation model is, i.e., how many properties of the real system it can reflect with which degree of accuracy.

The digital twin is mostly found in the context of Industrie 4.0. How can this idea be transferred to the manufacturing industry?

The manufacturing industry is the most prominent application domain. Here, digital twins are a tool for enabling flexible production for Industrie 4.0. The digital twins are a virtual image of a real machine or plant. In other words, they form a bridge between the real and the digital world and have all the functions and services that their real models can provide and execute. In addition, the respective virtual representations continually collect data about the current state of the plant components. If all the digital twins are combined, they become a comprehensive image of the production environment, resp. the plant.

Which benefit can an organization gain from the use of digital twins? Do you have any examples?

One advantage is that "What-if" analyses can be performed, meaning specific alternatives can be tested, e.g., in production planning, without having to shut down the existing plant. Another benefit is virtual integration or commissioning: With the digital twin it can be determined whether a new part of the plant is compatible with an existing part. Most of the time, certain adaptations will be necessary, of course. Whether a machine with these adaptations will be compatible with the existing machine can then be tested virtually. Of course, this also applies to the replacement, addition, or removal of components. The great advantage

Dr. Thomas Kuhn, Head of the Embedded Systems Division at Fraunhofer IESE, is convinced of the idea of the "digital twin".

More on the trend topic Digital Twin:

is that virtual testing allows a huge reduction of standstill times, meaning the plant can run productively much faster. Modifications in production are thus becoming much more flexible. And this is where the circle closes again to Industrie 4.0.

In your Industrie 4.0 project BaSys 4.0, digital twins also play a central role. What are their tasks here?

In our research project BaSys 4.0, which is funded by the German Federal Ministry of Education and Research (BMBF), we and 14 other partners from the area of production technology are jointly developing concepts and solutions for the realization of digital twins as digital representations for production. Our focus is on the implementation of a cross-site and cross-network, safe, and self-organizing communication interface that manages self-describing data objects. In our project, we equate the terms digital twins and administrative asset shell. For as soon as the administrative asset shell has a unit that can simulate a device, we can call it a digital twin. The administrative asset shell contains the data structure encompassing everything that is important for the device, such as data sheet, operating instructions, or real-time data such as device condition, services, etc. In BaSys 4.0, the administrative asset shell takes over the job of general communication interface. It tells me which service I have to call to move a conveyor belt forward or backward, for example. However, BaSys services can also be used without a simulation model.

In April, the Hannover Messe trade fair is coming up for you. Which demonstrator will you use there to show the use of digital twins?

We will go to the trade fair with a demonstrator of our research project BaSys 4.0, which combines the virtual world with the real world. With the help of an interactive table and the model of a production line, we will simulate an Industrie 4.0 production plant into which we have integrated BaSys 4.0 as the middleware. We will allow our visitors to experience changeable production by letting them play different roles. Depending on whether they will act as a production worker, a production manager, or a plant operator, they will be able to execute different scenarios live, such as integrating new machines. In their active roles, the visitors will learn about the abstract concepts of administrative asset shells, resp. digital twins, service-based production, and middleware – right in the middle of Industrie 4.0. A visit will definitely be worth it.

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

GDPR
New responsibility – new opportunities

The new General Data Protection Regulation presents a great challenge for organizations. The GDPR will enter into full force on 25 May 2018 and will offer consumers better data protection. Customers will benefit from the long overdue updating of the regulation – for companies, this will mean greater responsibility in dealing with their customers' personal data; otherwise seriously high penalties loom. Companies will now be obligated to document transparently and without gaps how they handle their customers' data. So does this only mean more obligations and more effort for organizations? Our expert Michael Ochs says no: This also has great innovation potential!

Where will we as consumers feel the benefits of the GDPR in the future?

Consumers will get higher transparency, e.g., through the right of access (to data) by the consumer. At the same time, there are also clear and unambiguous information obligations for organizations that process data. The consumers get more data sovereignty, which will ultimately also mean that service providers will have to continually improve their services in the distribution battle for customer data. Furthermore, the principle of "Privacy by Design" is new and very important. It ranges from the handling of data in business processes via such things as physical and digital access and protection mechanisms to the enforcement of the protection of privacy when corporate processes are automated, i.e., into the software itself. For instance, an architecture layer for privacy can be integrated into the software that records the usage of data regarding customer contracts and consents in Privacy Cockpits and enforces it end-to-end in processing within the system. Our IND²UCE technology is such an architecture layer for privacy; it can be integrated very easily and efficiently into one's own systems and requires almost no maintenance.

Conversely, for organizations this means very time-consuming maintenance of their customers' data, right?

The answer is a clear "Yes and No". Initially, there is greater effort for organizations to become GDPR-compliant. Once they have accomplished this, however, they will be in a very advantageous position with regard to security and privacy. The risk of data leaks decreases and thus also the risk of suffering from major damage to one's image – let alone possible recourse claims of the persons concerned or rising fines.

Your opinion: Are German organizations sufficiently prepared for the requirements of the GDPR?

Here I would like to draw a mixed picture, with a positive tendency. In conversations with data protection officers, I have sometimes even heard the sentence "Everything will remain the same anyway". I believe that such an attitude is risky. Particularly now, shortly before the end of the transition period, there are offers by legal consulting companies

Michael Ochs, Business Area Manager Digital Services at Fraunhofer IESE, knows the new requirements of the GDPR.

Series of articles on GDPR on the Fraunhofer IESE blog: http://blog.iese.fraunhofer.de

advertising "GDPR parachute packages", which demonstrate that there still exists the need for support regarding the implementation of the GDPR. At the same time, very many companies are also close to the successful completion of their GDPR implementation projects and will thus be in a solid position on the date it becomes effective.

You speak about innovation potential for organizations – where do you see that?

One of the greatest areas of potential for business model innovations in the Digital Transformation is the right to data portability. I like to affectionately call the corresponding Article 20 of the GDPR the "Ecosystem Article". It grants me as a consumer the right to transmit my personal data from one service provider to another when I have made a contract or given my respective consent. This enables the sharing of data while preserving the consumer's data sovereignty and the frequently encountered data lock-in gets undone. Transmission can take place via export and import, but also directly between service providers via a digital interface. This is exactly what we need for the digital economy – in digital ecosystems and in the platform economy: the ability to use personal data across companies in networked services. Switching from one provider to a competitor and taking along the relevant data thus also becomes as simple as can be.

If organizations do not only want to fulfill the requirements of the GDPR, but are additionally thinking about new business models – how can this happen? Where can Fraunhofer IESE offer support for such organizations?

For digital cross-company and cross-domain business models, the right to data portability mentioned above is the greatest innovation driver in the GDPR, in my opinion. New data-based business models become much easier to implement, as customers can use their personal data with several services. These are even obligated to release such data if so desired by the customer, and make them available to other providers. Fraunhofer IESE can support companies in the development and implementation of digital and disruptive business models on all levels – from the idea, born from Design Thinking approaches, to the technical implementation and ultimately the go-live of a digital ecosystem or a platform. We have already gained a lot of experience in projects, e.g., with Caruso, with John Deere, or with the Digital Villages Platform. Furthermore, with its IND²UCE technology, Fraunhofer IESE can make a major contribution to assuring that data in ecosystems and platforms – even when shared across company boundaries – are processed and used securely and in compliance with consents or contracts. This makes it easier for organizations to ensure data protection on the software level and significantly reduces the risk of reportable data protection incidents.

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

DATA SCIENTISTS
In hot demand thanks to Big Data!

Data Scientist is one of the sexiest jobs of the 21st century. This impression is confirmed when you take a look at relevant online job portals. According to a study by the McKinsey Global Institute [7], in the USA demand exceeds supply by far – and this does not appear to be any different in Germany. But what is it that makes this job so attractive in the first place? Someone who knows this is Dr. Andreas Jedlitschka, Head of the Data Engineering Department at Fraunhofer IESE and a member of the Expert Committee on Data Science of the Personal Certification Body at the Fraunhofer Institute FIT, Sankt Augustin.

Why do companies have such an enormous need for data specialists?

With the increasing networking among all areas all the way to digital ecosystems, the deluge of data in companies and organizations also increases exponentially. At the same time, the growing data availability and the success stories published in the press also lead to an increasing desire to use data systematically, i.e., to perform data analyses, and thus the need arises for experts who can perform these. These "data specialists" are frequently combined under the term Data Scientists.

What makes a Data Scientist in the first place?

First of all, I would like to define the term "Data Science": Data Science is about extracting knowledge from data and doing so ideally for the benefit of the company. To do so, methods and techniques from computer science, mathematics, and statistics are used. The job profile is varied and ranges from Big Data analytics and visual analytics via Big Data architecture to integration. In addition, business models must be taken into account, resp. developed, and thus must also be understood. Furthermore, you need to talk to the customer, i.e., the user of the information as the addressee, and with the domain expert.

What are the tasks that Data Scientists do, and which skills do they need?

Data Scientists must be experts in several disciplines at the same time: They do not only assess data, but must also understand the business contexts in companies and organizations. They must identify suitable data sources, determine and improve data quality, put together data, prepare and perform analyses, and then assess the results in terms of given criteria. If you work as a Data Scientist, you often bear great responsibility since far-reaching strategic decisons or even human lives may depend on the results of the data analyses – just think of systems used for diagnosis support in the medical domain or learning processes used in various areas in autonomous vehicles. This is why the underlying data and the analysis results must be continually checked in terms of plausibility, completeness, correctness, and relevance, in cooperation with domain experts. The requirements profile of a Data Scientist grows according to how

their work is embedded in the company and includes not only technical skills, but also a number of soft skills such as ability to work in a team, strong communication skills, and creativity.

How to become a Data Scientist? What are the prerequisites, resp. what previous knowledge is required?

At Fraunhofer, we are offering a certified course in the context of the Big Data Alliance, where we make the participants fit for Big Data projects. The participants are often decision makers, but mainly business developers, analysts, data managers, and software developers. The prerequisite is basic knowledge of computer science and mathematics. In the beginner courses, the participants learn about the important fundamentals, processes, and best practices for dealing with large amounts of data and for the development of smart solutions with high standards on privacy and security. In the advanced courses, individual processes are studied in detail; then the focus is on being able to apply what was learned. In these courses, we teach state-of-the art knowledge in a manufacturer-neutral, practically relevant, and at the same time theoretically sound manner.

Dr. Andreas Jedlitschka, Fraunhofer IESE, explains in the interview why Data Scientists are in such demand today.

More about the continuing education program "Data Scientist"

You also send your own employees to this certification course. Why are you also offering them the chance to become qualified Data Scientists?

Our researchers mostly come straight from university. They have excellent subject knowledge, especially from their study program, such as computer science or mathematics. What the young colleagues are often lacking, however, is a broad overview and the practical experience required to collaborate in Big Data projects. And this is exactly what they learn in our Data Scientist course. The training is designed for a wide range of applications. They learn how business developers unlock the potential of Big Data in their company, how data engineers describe and integrate data, how analysts use machine learning processes to detect patterns and trends, and how software engineers use modern databases and distributed calculation methods to develop robust and scalable Big Data systems. All this while taking into account privacy and security. The aim is to get basic knowledge in all relevant areas. Those who want can then go on to become certified Data Scientists. In order for us to be able to use our expertise to provide competent support to our customers on their way to Big Data, we do, of course, also use such qualification measures for our own scientists.

Numerous industry customers have already completed training at Fraunhofer. If the Data Scientist training is in such demand, doesn't the number of people interested exceed the number of places in the courses?

Yes, this is really the case. Last year we had to place almost 80 interested people on the waiting list. The fact that the course at Fraunhofer is worthwhile for the participants is reflected in the enormous number of applicants, which also speaks for the quality of our program. So if you are interested, you should register early.

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

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

ENARIS®
The Resilient Intelligence Think Lab

Since the end of 2017, Fraunhofer ESK in Munich and Fraunhofer IESE in Kaiserslautern have been collaborating in the context of the Think Lab ENARIS® (**EN**gineering and **A**rchitectures for **R**esilient **I**ntelligence in **S**mart Embedded Systems). Under the leadership of Prof. Dr. Peter Liggesmeyer and Dr. Mario Trapp, solutions are being sought that enable Resilient Intelligence. We asked both of them in our interview how the collaboration came about, what Resilient Intelligence actually means, and which added value the competencies of the two institutes offer for companies.

Prof. Liggesmeyer, how did the idea of collaboration between Fraunhofer ESK and Fraunhofer IESE originate?

Prof. Liggesmeyer: We had the idea for collaboration due to the new challenges arising from the trend towards autonomous systems. If these are to be accepted in daily life, the focus must not only be on Artificial Intelligence, such as machine learning. Rather, the challenge is to develop smart systems that are highly dependable and safe at the same time. The key lies in system architectures that assure system reliability and safety even when errors occur in the Artificial Intelligence or in the event that AI behaves in a completely unexpected manner. We call this vision of the future Smart Embedded Systems.

In which way do the two institutes complement each other?

Prof. Liggesmeyer: Fraunhofer IESE has a long history in the area of safety engineering and in the validation of innovative approaches such as Artificial Intelligence or intensive networking of systems. The expertise of Fraunhofer ESK is in concrete system architectures, which, e.g., extend established platforms such as AUTOSAR and increase system reliability through Graceful Degradation approaches. Thanks to our cooperation, ENARIS® therefore enables us to offer comprehensive solutions for the development of safe and reliable autonomous, highly networked systems.

Which added value do companies get from this collaboration?

Prof. Liggesmeyer: The exciting thing is that the two institutes address the topics in different ways, even though there are overlaps in some areas. IESE focuses on the engineering of safety-relevant and highly dependable embedded systems, with a special focus on safety engineering and virtual engineering. The focus of ESK is on the development of concrete components that expand system- and communication architectures with innovative mechanisms for increasing the safety and reliability of a system. Depending on what is required, we can thus use our knowledge and our project expertise to develop solutions for devices and technologies considered unsafe in the past and realize them with existing components. At the same time we are working on joint solutions for our customers.

Dr. Trapp, are there already first results from this project?

Dr. Trapp: In the fall of 2018, we will present the Virtual Engineering Space – ENARIS B. Based on a new generation of model-based development, with B-Space a concept is born that extends the basic idea of the digital twin with far-reaching possibilities. ENARIS B will make it easier for companies to make ideas such as the Internet of Things, cyber-physical systems, or smart ecosystems a reality. For in ENARIS B, companies will be able to jointly develop new solutions in a virtual development environment and test and validate them in a simulated Internet of Things and Services. Even safety cases can be created in the virtual engineering space. This will save development time and costs and thus enable new applications to enter the market faster.

Those interested can already admire the core of ENARIS B at HMI in Hannover in April.

The directors of the Think Lab ENARIS®: Prof. Peter Liggesmeyer and Dr. Mario Trapp

The superordinate aim of the Think Labs is to enable Resilient Intelligence. This sounds really good, but what does this mean, and what does this kind of intelligence allow me to do?

Dr. Trapp: As Prof. Liggesmeyer already mentioned, research is currently going on at breakneck speed in the area of autonomous systems. Too often, research only revolves around questions of Artificial Intelligence (AI). The development of autonomous systems is, however, a systemic challenge. In many situations, AI quickly behaves in an unpredictable manner. It would be much too dangerous, for example, to simply use it in vehicles, which is why current safety standards explicitly prohibit the use of AI in safety-critical applications. It is therefore important to rely on architectures that guarantee safety on the system level. In addition, autonomous systems will need to have intelligence on a wide variety of different levels. They will encounter numerous unexpected environmental situations. They will be seamlessly networked and will cooperate with systems that are not even known yet at development time. Autonomous systems require high-performance hardware, which does not fulfill current safety requirements, and must therefore be developed to be tolerant towards hardware defects. And they must continually evolve. Despite all these almost unpredictable changes in a smart system and its environment, its safety and reliability must always continue to be guaranteed. This balance between intelligence, safety, and reliability is what we call "Resilient Intelligence". With our research on Resilient Intelligence, we are developing both methods and concrete software components in the Think Lab ENARIS®, which enable our customers to efficiently develop smart systems with guaranteed safety and reliability while taking into account typical cost constraints.

The interview was conducted by Nadine Stumpf
Technology Manager Marketing
Fraunhofer ESK

You want to know more about ENARIS®?
www.enaris.fraunhofer.de

CONTACT OFFICE BERLIN

Right in the center of Berlin: Fraunhofer IESE opens its contact office at Spreepalais

On 1 March 2018, the Contact Office of Fraunhofer IESE was opened officially right on the banks of the Spree River in the Fraunhofer-Forum. With this office, the institute offers its partners, interested parties, and the media a point of contact for its expertise regarding digitalization.

Prof. Peter Liggesmeyer opened the evening together with Gerald Swarat, who will act as the research institute's contact person in Berlin in the future. Prof. Liggesmeyer emphasized the importance of collaboration between research and industry for keeping Germany competitive in international comparison. Berlin is therefore the right place to make contacts and show the many different ways in which Fraunhofer IESE can contribute to innovations in the area of digitalization for partners from companies of many different sizes. At the opening event, Fraunhofer IESE presented itself with some of its research topics – Smart Rural Areas, Industrie 4.0, and Data Sovereignty. Following the presentations, the guests had the opportunity to deepen various aspects in personal conversations with the researchers. In the context of the panel discussion with representatives from industry, research, and government, issues regarding Germany's digital future were debated. In an entertaining exchange of views, the panel discussed where Germany currently stands, where the journey is headed, and where the greatest technological challenges are awaiting us. As conclusion of the evening, many of the more than 100 guests took with them: With the applied research that the Fraunhofer institutes are doing Germany-wide and in various research fields and application areas, they offer companies independent consulting regarding numerous strategic issues – and in the case of Fraunhofer IESE primarily about the forthcoming path towards digitalization.

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PRIZE-WORTHY!

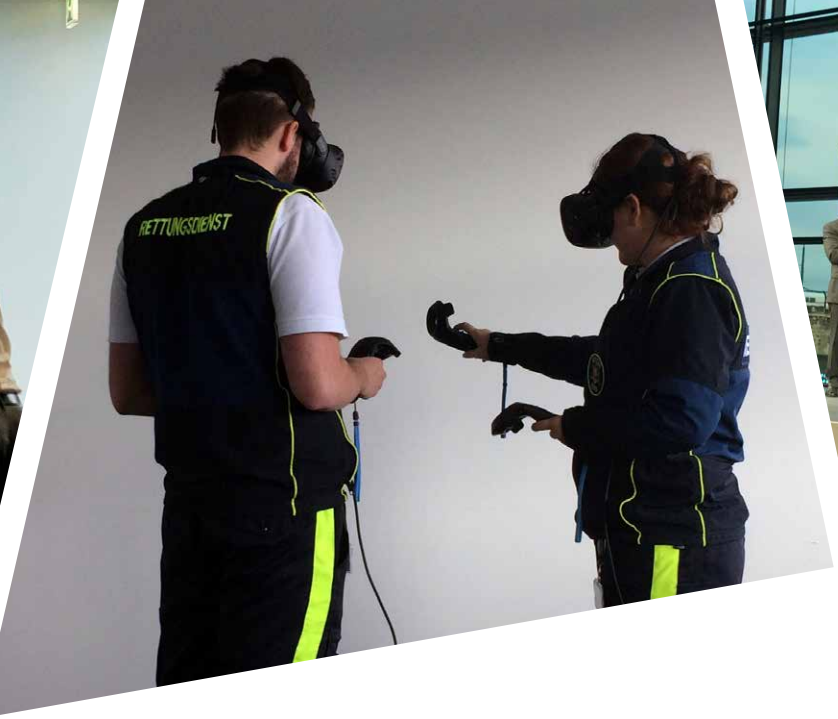
Last year, not one, but two projects of Fraunhofer IESE from the area of Health earned awards for the institute. EPICSAVE, which received an award in the innovation contest "Land of Ideas", shows the future of education and training in the medical field thanks to Serious Gaming and the use of virtual data glasses. The project SUSI TD uses AAL (Ambient Assisted Living) technology to enable senior citizens to live independently in their own homes for a longer period of time.

Ready for emergencies – medical staff do virtual training

A rare critical emergency – this might be an allergic shock suffered by a child. This situation is quite unlikely to occur during the course of the 3-year training undergone by paramedics, meaning that fully responsible paramedics might only be faced with such a critical incident in their professional work at a later time. This is why the interdisciplinary project team of EPICSAVE is developing suitable training methods in virtual emergency scenarios. EPICSAVE integrates didactics, medicine, virtual reality, and gaming into a novel training medium that can improve paramedic education in the long term and in a team-oriented manner. The virtual reality environment used in the project allows the aspiring paramedics to experience risk-free learning and to reflect on situations to which they are exposed only rarely in everyday life and which could not be represented realistically enough with previous training methods. The project exploits the potential of openness and curiosity for new things by enabling learning in critical situations based on reflection about virtual experiences without any risk. It masters future challenges by strengthening the competence of paramedics to act in rare critical emergencies. It is innovative because didactics is combined with virtual-reality and gaming methods into novel training media. It is a model because different disciplines work together to improve medical education and training in a sustainable and team-oriented manner.

At the "Land of Ideas" award ceremony (from left to right): Marcel Brünnen (Deutsche Bank); Dieter Lerner and Dr. Thomas Luiz (Fraunhofer IESE); Ina Scharrenbach (Minister for Homeland, Municipal Affairs, Housing and Equal Opportunities of the state of North Rhine-Westphalia); Prof. Dr. Jonas Schild (Bonn-Rhein-Sieg University of Applied Sciences); Ute E. Weiland (Land of Ideas).

The EPICSAVE consortium: Bonn-Rhein-Sieg University of Applied Sciences | Institut e of Visual Computing IVC, St. Augustin (coordinator) | Fraunhofer IESE, Kaiserslautern | Malteser Hilfsdienst GmbH | Training Center of the Hesse/Rhineland-Palatinate/Saarland (HRS) Region, Wetzlar | Falck Rettungsdienst and G.A.R.D. gGmbH, Hamburg | Academy for Emergency Medicine, Hansestadt Hamburg | TriCAT GmbH, Ulm | Hannover University of Applied Sciences



Living safely in old age – in one's own home

Many elderly people want to feel safe without having to give up their own home. A new technology concept designed by Fraunhofer IESE makes this possible now – while also preserving privacy. A communication tool integrates nursing care agencies and ensures social integration.

An interdisciplinary team from the Fraunhofer Institute for Experimental Software Engineering IESE, the German Institute for Applied Care Research, and CIBEK GmbH has been awarded the Joseph-von-Fraunhofer Prize for Human-Centered Technology. With SUSI TD (Safety and Support for Senior Citizens through the Integration of Technology and Services), a system was developed that enables elderly people to live longer independent lives in their own homes. In this context, a process was developed that detects activities of daily life (ADL) and situations of helplessness. But no cameras or other such devices can be found in the homes equipped with the system: The system is based on non-invasive sensors, especially on motion sensors such as those used in lamps or alarm systems, as well as on touch sensors located on frequently used drawers or on the refrigerator. Without the need for complicated configuration, the normal behavior of the person is captured by the sensors and is then modeled. Based on the sensor data, the system learns to identify recurring actions and to recognize when help is needed. This process is an integral component of the SUSI TD platform, which combines assistance systems based on AAL technologies with preventive home visit approaches in conjunction with the existing social space. The senior citizens use a video communication tool that can be used in various ways: Via touchscreen, they can talk directly with the advisors of the nursing care centers, whose care support is then no longer restricted to occasional home visits. Maintaining social contacts is also made easier. People can meet virtually with friends and family members, play games together, or share photos.

At the ceremony for the award of the Joseph-von-Fraunhofer Prize for Human-Centered Technology (from left to right): Prof. Heinz Gerhäuser, former director of Fraunhofer IIS; Anne Gebert from the German Institute for Applied Care Research; Bernd Klein from CIBEK technology + trading GmbH; Prof. Dr. Reimund Neugebauer, President of the Fraunhofer-Gesellschaft; Cornelius Moucha, Mario Schmitt, and Rolf van Lengen from Fraunhofer IESE.

PRO-OPT Successfully completed!

Big Data applications in smart ecosystems and Best Practices

On 15 November 2017, the PRO-OPT consortium presented its final results in the context of the Big Data and Data Analytics Working Group in Frankfurt. The speakers demonstrated what a collaborative data analysis in complex ecosystems can look like. Of particular interest for the audience were the action recommendations derived by the partners from their Big Data projects. PRO-OPT is a research and development project in the context of the technology program "Smart Data – Innovations from Data" of the Federal Ministry of Economic Affairs and Energy.

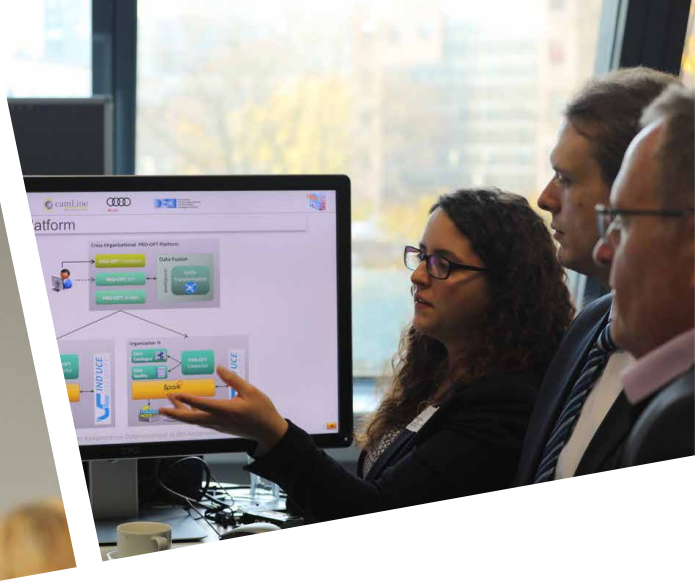
Project leader Dr. Liliana Guzmán Rehbein, project manager Dr. Henning Barthel, and division head Dr. Jens Heidrich from Fraunhofer IESE explained the PRO-OPT platform, demonstrated how the response times of traceability analyses could be accelerated enormously, and at the end revealed proven Best Practices for the successful implementation of cross-site and cross-organizational Big Data application scenarios.

Everyone agreed that technology alone is not enough in Big Data projects – experts must also be taken aboard. Two of these experts were Dr. Roland Stoffel, data scientist at DSA Daten- und Systemtechnik GmbH, and Oliver Lepp, project manager at Audi AG. They stressed that it is absolutely essential to proceed methodologically in such projects and to place the business use case in the center right from the start.

PRO-OPT is a project funded by the Federal Ministry of Economic Affairs and Energy (BMWi). Volker Genetzky from the department "Development of Convergent ICT" praised the outstanding commitment of the PRO-OPT consortium, in particular its international networking, which even included participation in the Asia Roadshow in May 2017. According to him, this is not a given for such projects.

The PRO-OPT platform: collaborative data analysis in smart ecosystems

In complex ecosystems such as in the automotive industry, huge amounts of data are generated. Up to 100 control units are already installed in one vehicle; added to this is a multi-stage supply chain that lies ahead of the vehicle manufacturer itself. After delivery, the remaining lifecycle starts, in the form of visits to the repair shop or as Connected-Car solutions. In the project PRO-OPT, which is funded by BMWi, the consortium decided to focus on collaborative data analysis in the automotive industry particularly because of the complexity of the overall system, said Dr. Simon Becker from DSA Daten- und Systemtechnik GmbH and Dr. Liliana Guzmán Rehbein from Fraunhofer IESE. "The supply chain always gets exciting when systematic defects occur, since the evaluation often ends at the company boundary", stated Becker. He emphasized the great potential inherent in the optimization of complex products and production processes offered by collaborative data analysis. "With the PRO-OPT platform, the consortium has created the basis for distributed analyses while at the same time considering the need to control the use of the data. Throughout this process, the raw data never leaves the company boundaries; instead, only the aggregated results of the local analyses



are shared." Guzmán Rehbein underlined the importance of data sovereignty as an enabler for overarching data exchange: "By using the security framework IND²UCE, the parties involved in an ecosystem retain their data sovereignty and can control what happens with their data when and for how long. In the concrete use case of the automotive industry, the supplier can define, e.g., that specific local analysis results are only released if there is a warranty case and after they have been pseudonymized. With PRO-OPT, we have created the technical basis for performing collaborative data analyses in an ecosystem – while safeguarding the commercial interests of the respective companies."

Successful implementation of Big Data in organizations

Big Data projects in smart ecosystems frequently fail because they are neither aimed at the fulfillment of strategic organizational goals nor realizable in the context of the business and operative constraints. In their presentations, Oliver Lepp from Audi AG, Dr. Ansgar Bernardi from DFKI, and Dr. Jens Heidrich from Fraunhofer IESE explained their experiences as well as proven Best Practices for the successful implementation of cross-site and cross-organizational Big Data application scenarios. The partners especially stressed the following aspects:

1. Business Alignment: Success depends on concrete use cases: Goal-oriented analyses of the Big Data business potential should be performed first and then these should be complemented by data-driven strategies.
2. Technology alone is not enough: Technology is only an enabler. It is no guarantee for sustainable Big Data projects. Rather, close collaboration between domain experts and data scientists is needed.
3. Data Catalog: The integration of data sources often requires (more) effort: Since (automated) analyses presume (formalized) knowledge about data elements and internal contexts, data sources should be modeled semantically.
4. Features and Analysis Method: Data analyses of actual data often do not reveal much, as possible findings in raw data may be hidden in things such as "noise", for example. Appropriate (in terms of content) summaries, groupings, etc. enable statistically significant findings.
5. Data Sovereignty: This acts as an enabler for the overarching exchange of data. Know-how and IP can be protected through data usage control with IND²UCE.

The Best Practices obtained from the PRO-OPT project shall subsequently be exploited in smart ecosystems through joint consulting. For, as Volker Genetzky from the federal ministry stressed, the results should lead to economic application in the medium to long term.

More information at: www.pro-opt.org

WELL CONNECTED!

Interior Minister Lewentz visits Fraunhofer IESE in Kaiserslautern

On 8 June 2017, the Rhineland-Palatinate Interior Minister Roger Lewentz met with Prof. Peter Liggesmeyer, director of Fraunhofer IESE. At the institute in Kaiserslautern, the Interior Minister got informed, among other things, about the second phase of the project "Digital Villages 2.0". The project demonstrates how innovative solutions can be used sensibly to exploit the opportunities offered by digitalization in rural areas as well. Interior Minister Lewentz sees great potential, for example, in the topic of mobility in rural areas. In addition to the Digital Villages, the issue of data privacy was also on the agenda. Prof. Liggesmeyer explained how the institute's solution IND²UCE, a security framework for data usage control, can help to fulfill the requirements of the European General Data Protection Regulation, which will become effective in 2018. Prof. Liggesmeyer: "With IND²UCE we are offering a solution that enables citizens and organizations to keep control over their data at all times. Data usage control makes it possible to exploit the huge potential of data, use the opportunities it offers, and take into account data protection at the same time. In the Digital Villages, a lot of sensitive data are also generated during the networking among citizens, organizations, and municipal administration, which is why we also want to integrate IND²UCE into the 'Digital Villages Platform'."

Roger Lewentz, Minister of Interior Affairs of the state of Rhineland-Palatinate (left), in conversation with Prof. Peter Liggesmeyer, Executive Director of Fraunhofer IESE.

Prof. Rombach is new spokesman of the Software-Cluster

Prof. Dieter Rombach, Director Business Development at Fraunhofer IESE and holder of the Software Engineering Chair at the University of Kaiserslautern, took over the role of spokesman of the Software-Cluster in August 2017. Already today, the Software-Cluster is the largest software cluster in Europe. Its focus is mainly on digitalization in the German industry. The Cluster is composed of various research institutions and companies in Saarbrücken, Darmstadt, Karlsruhe, and Kaiserslautern. In addition to universities and universities of applied sciences, these also include renowned research institutes such as several Fraunhofer institutes, the German Research Center for Artificial Intelligence (DFKI), the Max Planck Institute for Informatics, and the Helmholtz Center for IT Security. These are joined by companies such as the Scheer Group, the Software AG, and Insiders Technologies. Overall, approx. 100,000 employees are working in more than 11,000 IT and software companies in the region. With its increasing internationalization, the Software-Cluster mainly aims at expanding and ensuring new jobs. All these goals are coordinated by a Strategy Board led by representatives of important IT institutions from business and research, which was also responsible for the election of Prof. Rombach as the new spokesman, replacing his predecessor Dr. Harald Schöning from Software AG.

More about the work of the Software-Cluster: www.software-cluster.com

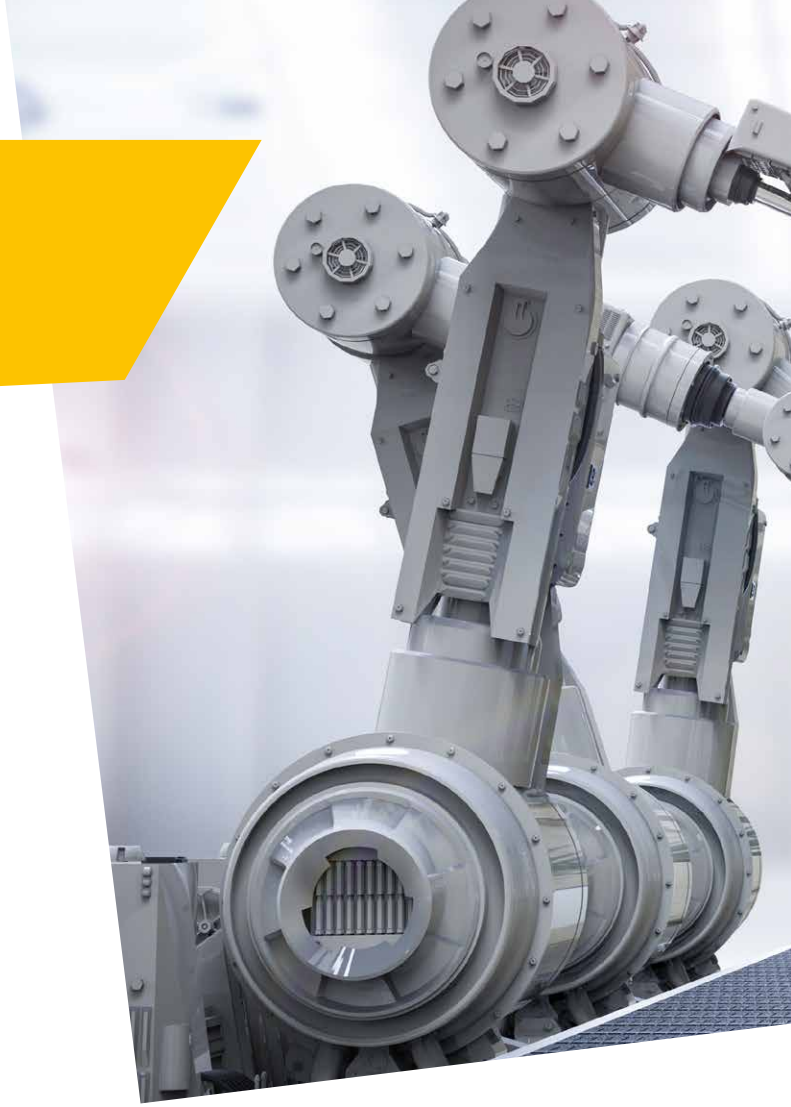
Prof. Dieter Rombach, Director Business Development at Fraunhofer IESE, has been elected new spokesman of the Software-Cluster.

PROJECTS

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

From the Guiding Principles of the Fraunhofer-Gesellschaft

BASYS 4.0
The platform for Industrie 4.0



In the project BaSys 4.0, an open-source middleware is being developed for Industrie 4.0 that enables the rapid realization of Industrie 4.0 control systems. It addresses the changeability of production processes as a major challenge of Industrie 4.0.

Changeability denotes the ability to change a production process with respect to unforeseen changes. This is significantly different from already existing variable production processes, which are supported by existing automation technology. Variable production processes support built-in variance of products – changes beyond this predefined level of variance become very expensive without changeability.

Existing automation solutions are commonly based on PLC (Programmable Logic Controller) systems. While PLC systems are perfectly suited for real-time tasks and provide quick results for engineers, they lack the ability to express complex production tasks. As a result, complex automation solutions consist of a tremendous number of interconnected tasks that are hard to maintain and to change. BaSys 4.0 replaces this approach with a service-based production paradigm. PLC controllers are used for the implementation of real-time tasks of manageable size. Supervising control layers, such as group and line controllers, are implemented with the help of service-oriented paradigms that have proven their value for the development of manageable and changeable complex software systems and that support changeable production.

BaSys enables the use of heterogeneous systems for Industrie 4.0

The technical foundation of BaSys 4.0 is a technology-independent end-to-end communication layer that enables direct and secure communication between devices, even if these devices are not connected to the same network and even if they communicate via different protocols or are connected to different middleware platforms. This is necessary since not only numerous Industrie 4.0 communication protocols are used in different parts of the world (OPC-UA, OneM2M, REST Web Services), but also because many IoT platforms employ proprietary communication protocols. The path to end-to-end communication is therefore not yet another communication protocol, but rather the ability to integrate existing technologies. The BaSys middleware therefore defines a small number of logical communication primitives that enable end-to-end communication be-

tween devices and that can be mapped to major Industrie 4.0 communication approaches. This mapping is open and allows third parties to integrate additional protocols and mappings.

Administrative asset shells as central communication interface

BaSys 4.0 provides an abstract and self-describing representation of production line properties and services. Administrative asset shells are reflective data structures that digitally represent all relevant aspects of a plant. Sub-models provide detailed and focused information about specific aspects of an asset. BaSys 4.0 provides defined meta-models for common types of sub-models: These include available services, operational status of a service or a device, topology of the plant, history of the production steps applied to an asset, as well as the steps required to produce a product. Additional plant-specific models can be created on top of the generic BaSys meta-model.

BaSys 4.0 is an open toolkit that enables the rapid development of Industrie 4.0 solutions. Its focus is not only on providing the software, but also on building a living community. Example applications such as dashboards, the virtualization of production processes, and general optimization approaches will therefore be publicly available by the end of the project. Additionally, simulated Industrie 4.0 deployments will be ready for download in order to support even smaller companies in adapting to Industrie 4.0.

More about the project:
www.basys40.de

PROJECTS

In the context of **IUNO**, the National Reference Project for IT Security in Industrie 4.0, 21 partners from industry and research are developing practice-oriented concepts and solutions for a new security culture for Industrie 4.0 in order to realize the value creation potential for Germany as a business location. IUNO combines scenarios along different value chains and aggregates the results in a toolkit that can also be used for other areas of use and by other organizations. Transfer measures ensure that the results are disseminated into small and medium-sized enterprises.

IUNO

Nationales Referenzprojekt
IT-Sicherheit in Industrie 4.0

prodebt

In the project **ProDebt**, an innovative, tool-supported method for the strategic planning and control of technical debt in agile software projects was developed and validated empirically. When software is evolved or adapted, budget and time constraints often lead to software quality being neglected – intentionally or unintentionally. With every new version, costs (technical debt) are incurred. The interest is reduced development speed and increased maintenance effort, or even standstill.

The aim of the **Q-Rapids** project is a methodology for evidence-based, data-driven, quality-aware rapid software development (Rapid Software Development, RSD). The incremental elicitation, refinement, and improvement of quality requirements is based on data elicited at development time, resp. at runtime. Research at Fraunhofer IESE is about their identification, elicitation, and integration, as well as about analysis approaches relevant to quality requirements; in addition, evaluations are planned in labs and industrial settings.

Q-Rapids

In 2016-2017, the consortium of the research project **Abakus** investigated how to improve effort and cost estimation for software development projects. The project partners developed a new estimation method and a tool for the calculation of software projects and evaluated them in a study. Fraunhofer IESE was the research partner responsible for the development of the estimation methodology and the visualization concept as well as for the planning of the evaluation. The project's target group were especially small and medium-sized enterprises from the IT industry.

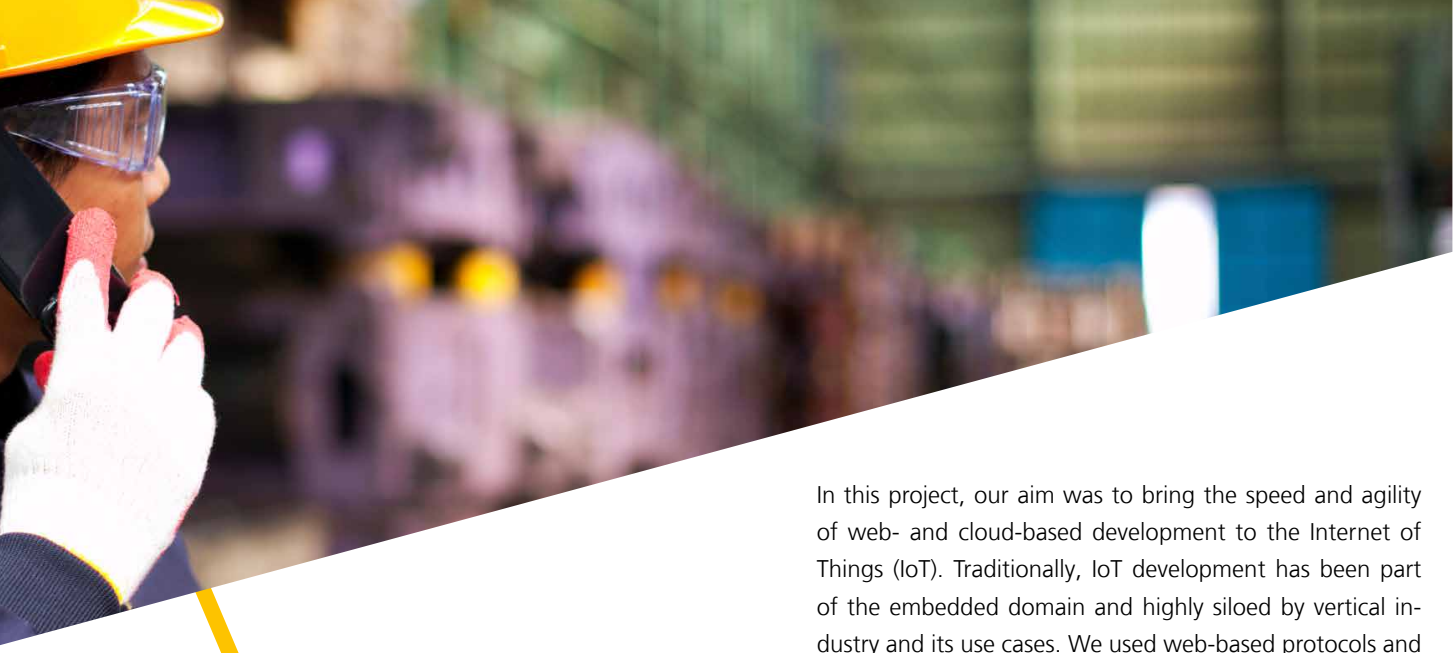
The project **ProKob** aims at an evolutionary transition towards more agility in software development in order to address the challenges, resp. the improvement goals, in SMEs. As SMEs are often unable to afford launching extensive process improvements, such a transition will prevent disruptive process changes from one day to the next. For this purpose, Fraunhofer IESE as the leader of the consortium is collaborating with its project partners in the development of a systematic catalog of process components that describe concrete software engineering Best Practices.

The open, collaborative nature of cyber-physical systems (CPS) poses new challenges in assuring dependability. The project **DEIS – Dependability Engineering Innovation for CPS** – addresses these by introducing the concept of Digital Dependability Identities (DDI) for (a) efficient synthesis of information about the dependability of components and system across the supply chain, and (b) effective evaluation of this information in the field to assure safe composition of CPS configurations.

PROJECTS

In the area of highly automated and autonomous driving, the enormous increase in the complexity and resource needs of the systems employed poses great challenges for the providers of automotive solutions, among them **Robert Bosch GmbH**. Together with Fraunhofer IESE and additional project partners, a flexible software safety architecture was developed that enables the use of non-validated hardware for safety-relevant applications, which allows reducing the use of extensive special-purpose hardware to a significant degree.

In order to orient their strategy towards the future even better than before, **LOTTO Hessen GmbH**, one of the most innovative lottery companies in the German Federation of State Lottery Operators, commissioned Fraunhofer IESE with the moderation of their strategy process. Detailed analyses of the market environment, the sales channels, the company's strengths and weaknesses, as well as the associated risks and opportunities were followed by a strategy workshop, which resulted in a Strategy Plan 2022 complete with strategic guidelines, topic areas, and concrete measures.



In this project, our aim was to bring the speed and agility of web- and cloud-based development to the Internet of Things (IoT). Traditionally, IoT development has been part of the embedded domain and highly siloed by vertical industry and its use cases. We used web-based protocols and technologies together with cloud-based development and deployment to break down silos and accelerate the delivery of end-to-end digital systems that span a variety of environments, industries, and domains. Together with **Fujitsu Labs** (Japan), **RunMyProcess** (France), and **INRIA**, we developed the first solution that enables (a) unified modeling for cloud, mobile, and IoT device behavior in the cloud; (b) generation of directly executable code for cloud and IoT nodes; (c) direct deployment of the executable code on low-power IoT nodes (e.g., small, inexpensive ATMEL boards).

Together with **John Deere**, Fraunhofer IESE is working on the long-term realization of the **iFarm 5.0** vision. The iFarm predicts and monitors a farm's success through the combination and evaluation of agronomic, economic, and historical data from different sources and offers decision support. In addition to making contributions to the project's vision and the long-term project roadmap, Fraunhofer IESE is mapping Big Data data sources, provides supports in ecosystem partnering, develops software architecture and data science concepts, implements demonstrators, and supports product development.

The topic of e-mobility is currently very important in the automotive industry. This is reflected in the increasing number of new automotive manufacturers in this field. One of these is **e.GO Mobile AG**. Founded as a spin-off of RWTH Aachen University, it is planning to sell a fully electric vehicle starting from 15,900€: the **e.GO Life**. As a safety-critical system, every vehicle must fulfill standards in order to get certified for road use. Fraunhofer IESE supports e.GO Mobile AG in taking the first steps in the safety engineering process for the series production of the e.GO Life.

PROJECTS

In the **Digital Villages** project, Fraunhofer IESE is demonstrating that digitalization is definitely not only an option in urban areas, but also in and for rural areas. Attractive new work models, good mobility concepts, and an appropriate communication structure can set the course here. Together with the Rhineland-Palatinate municipalities Betzdorf-Gebhardshain and Eisenberg / Göllheim, Fraunhofer IESE is testing smartly networked digital solutions for life in rural areas 2.0 with the help of a joint platform, which means that new, innovative business models can pay off for a smaller group of users as well.

Digitale® Dörfer

In the lighthouse project **EnStadt:Pfaff**, a Living Lab is being developed on the grounds of the former Pfaff sewing machine factory in Kaiserslautern, which will be a climate-neutral residential, commercial, and technology district. Fraunhofer IESE is developing energy, mobility, and ICT concepts for this context. During the five years of the project, a digital ecosystem for urban districts based on the Smart Rural Areas platform will be set up and used to promote digitalization.

The energy system of the future will be strongly decentralized. In a three-year research project funded by the Federal Ministry of Economic Affairs and Energy (BMWi), the consortium of **Flex4Energy** has been the first to develop a regional marketplace with suitable trading mechanisms that brings together grid operators and operators of flexible plants. Grid operators can acquire "flexibility" from the plant operators exactly in those places and at those times where, resp. when, it is really needed.

FLEX ENERGY

The digitalization of companies and their business processes is a central component of Industrie 4.0. Innovations in this area require the secure exchange and easy combination of data in value networks. This is where the **Industrial Data Space (IDS)** comes in, which ensures comprehensive, cross-industry networking in an open data space. The basis is a reference architecture model that is being developed by twelve Fraunhofer institutes. In this context, Fraunhofer IESE makes important contributions on data usage and access control as well as on the measurement and assessment of the data quality of the data and information provided in the IDS.

INDUSTRIAL DATA SPACE

IESE ON TOUR

“International networks are the key to outstanding research results.”

Prof. Dieter Rombach, Fraunhofer IESE

IESE ON TOUR

CEBIT
20-24 MAR 2017

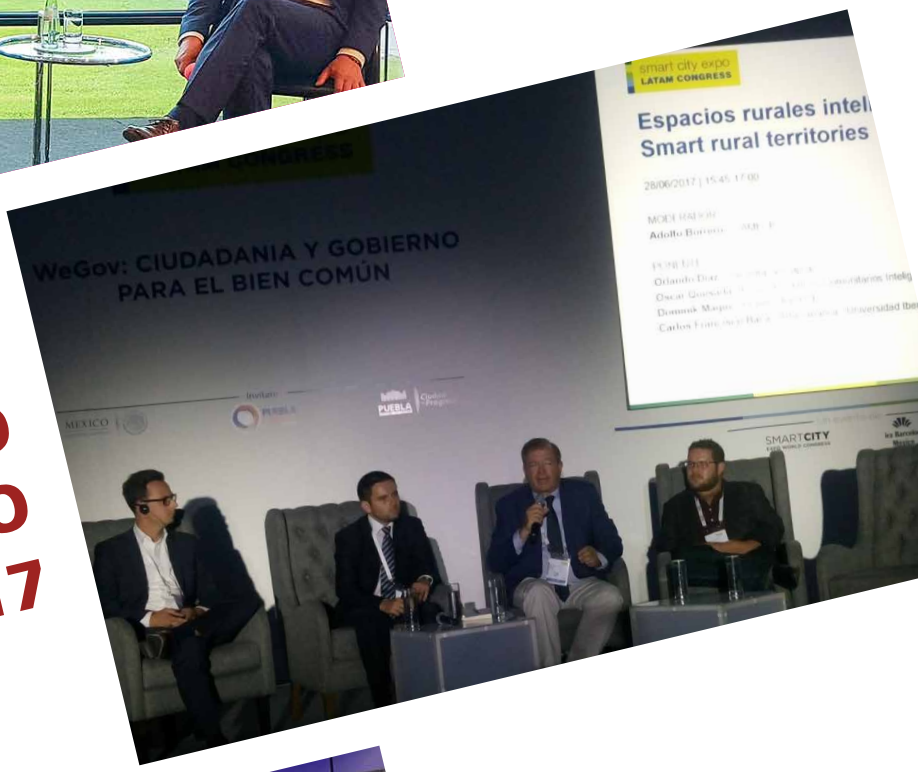
IESE ON TOUR

HANNOVER MESSE 24-28 APR 2017

ANNUAL FHG CONFERENCE 31 MAY 2017

IESE ON TOUR

DIGITAL BREAKFAST BERLIN 09 JUN 2017



SMART CITY EXPO PUEBLA, MEXICO 21 JUN 2017

VBW ZUKUNFTS-KONGRESS MUNICH 21 JUN 2017

DAY OF GERMAN UNITY MAINZ 03 OCT 2017

EUROPE ELIV BONN 18-19 OCT 2017

HUB BERLIN 28 NOV 2017

IESE ON TOUR

FRAUNHOFER ICT GROUP NEW YEAR'S RECEPTION BERLIN 29 JAN 2018

CVT SYMPOSIUM, TUK KAISERSLAUTERN 14-16 MAR 2018

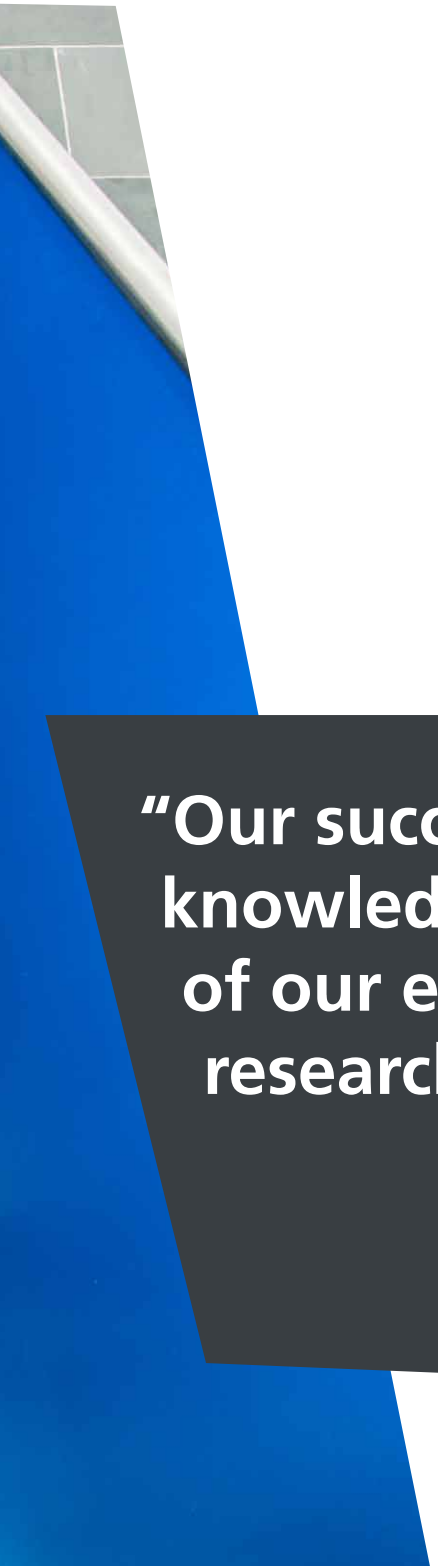
COMING SOON

HANNOVER MESSE 2018
23-27 APR 2018

CEBIT 2018
11-15 JUN 2018

MORE UPCOMING EVENTS:

IESE AT A GLANCE



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

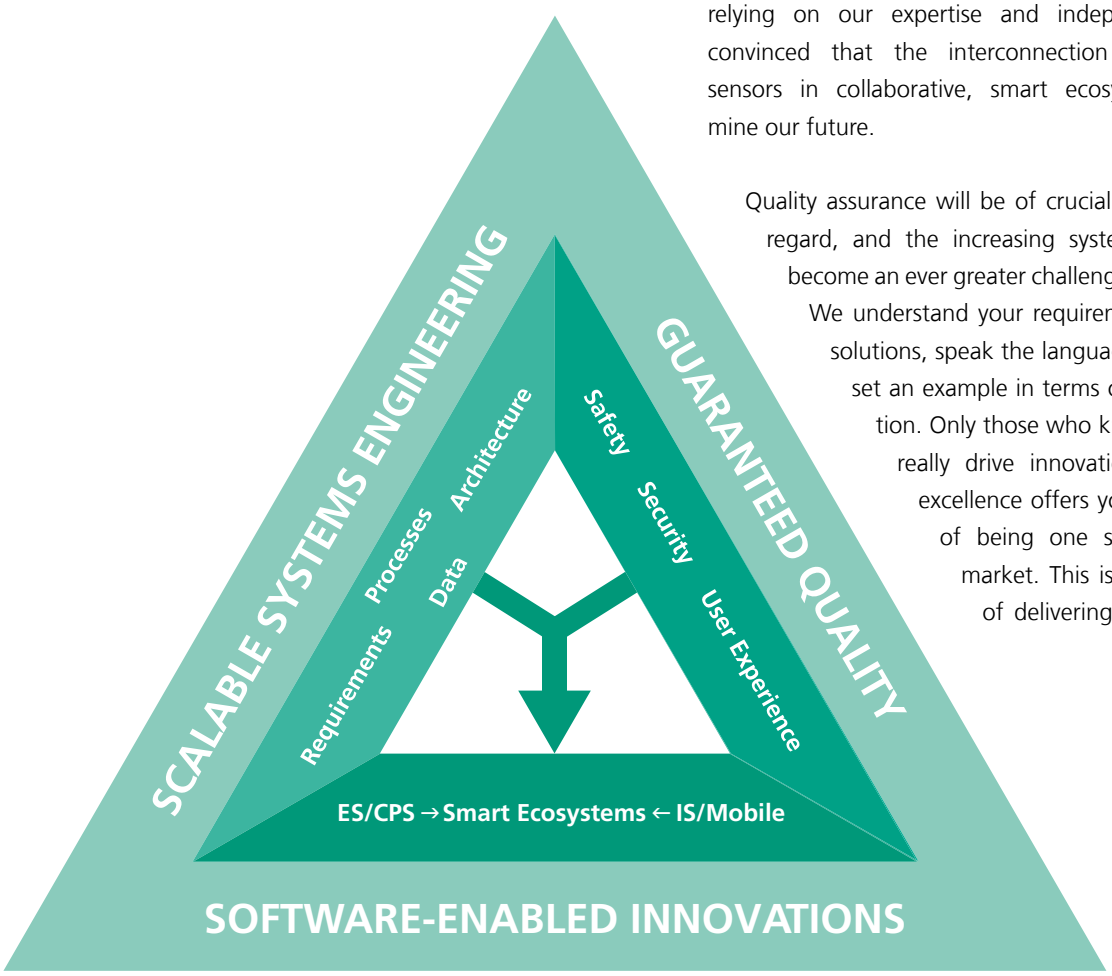
From the Guiding Principles of the Fraunhofer-Gesellschaft

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.



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

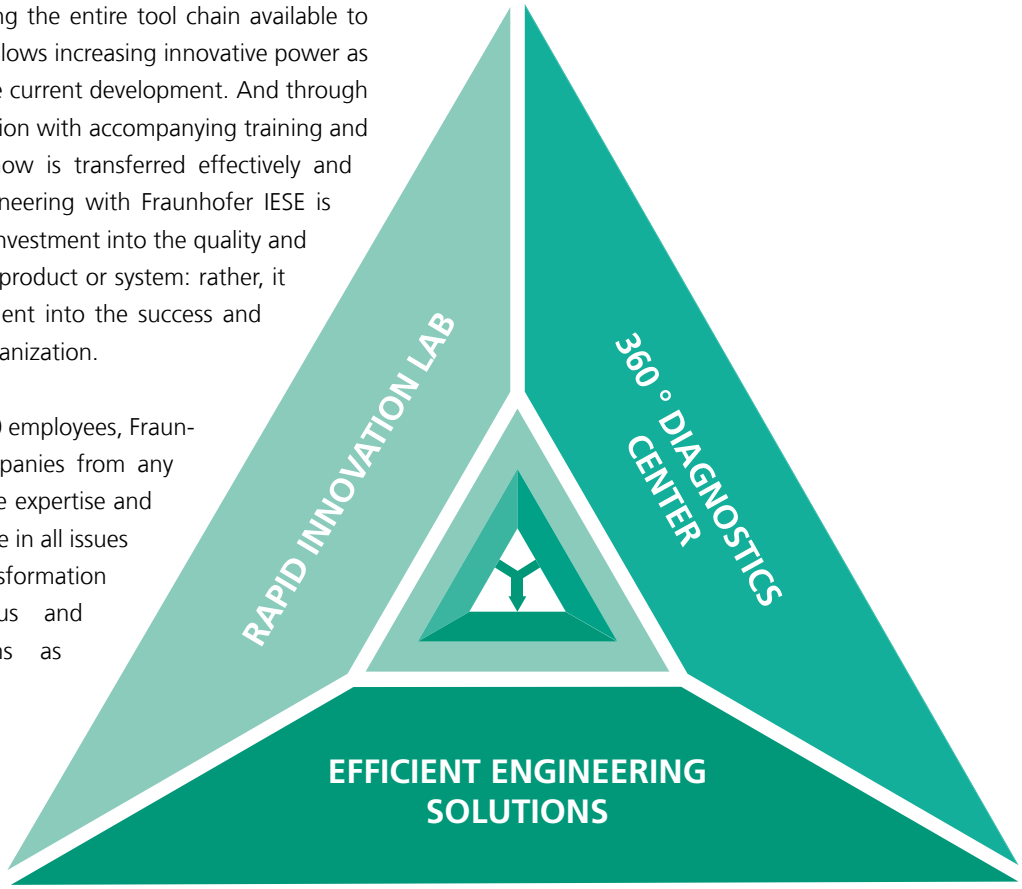
Strong partners stick together until the goal has been achieved. This is why the engineers of Fraunhofer IESE will also not abandon their customers when it comes to development. Relying on innovative methods and tools, the Engineering Innovation Lab offers engineering support right from the start, but 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:

- Denso, Japan
- Fujitsu, Japan
- IPA/SEC, Japan
- John Deere, Germany & USA
- Toyota, Belgium
- ABB, Switzerland
- Trimble, Finland
- 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 College Park, MD, USA, which is affiliated with the University of Maryland at College Park, MD (since 1998).



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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, IARPA, and Deere and Company. For these and other customers, Fraunhofer CESE evaluated, developed, and applied state-of-the-art tools and techniques to support customer needs in systems, software, and acquisition areas. Fraunhofer CESE provided critical skills and guidance its customers needed to ensure the viability, reliability and security of their systems and software. In addition to this applied research, Fraunhofer CESE also conducted 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

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 23 interns from Reykjavik University in Iceland, the University of Mannheim and the University of Kaiserslautern, Germany, and the University of 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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Prof. Dr.-Ing. Peter Liggesmeyer

DIRECTOR BUSINESS DEVELOPMENT
Prof. Dr. Dr. h. c. Dieter Rombach

DEPUTY DIRECTOR
Prof. Dr. Frank Bomarius

DIRECTOR THINK LAB ENARIS®
PD Dr. habil. Mario Trapp

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AUTONOMOUS & CYBER-PHYSICAL SYSTEMS
Ralf Kalmar

DIGITAL SERVICES
Michael Ochs

RESEARCH PROGRAM

SMART RURAL AREAS
Steffen Hess

BERLIN OFFICE
Gerald Swarat

DIVISION EMBEDDED SYSTEMS
Dr. Thomas Kuhn (act.)

EMBEDDED SYSTEMS ENGINEERING (ESY)
Dr. Martin Becker

EMBEDDED SOFTWARE ENGINEERING (ESW)
Dr. Pablo Oliveira Antonino de Assis (act.)

EMBEDDED SYSTEMS QUALITY ASSURANCE (ESQ)
Dr. Daniel Schneider

DIVISION PROCESS MANAGEMENT
Dr. Jens Heidrich

DATA ENGINEERING (DE)
Dr. Andreas Jedlitschka

PROCESS ENGINEERING (PE)
Rolf van Lengen

DIVISION INFORMATION SYSTEMS
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Dr. Matthias Naab

SECURITY ENGINEERING (SE)
Christian Jung

COMMUNICATIONS & CENTRAL SERVICES
Nicole Spanier-Baro

CORPORATE COMMUNICATIONS & TECHNOLOGY MARKETING (UKTM)

HR & ORGANIZATION (HRO)

ADMINISTRATIVE SERVICES (AS)

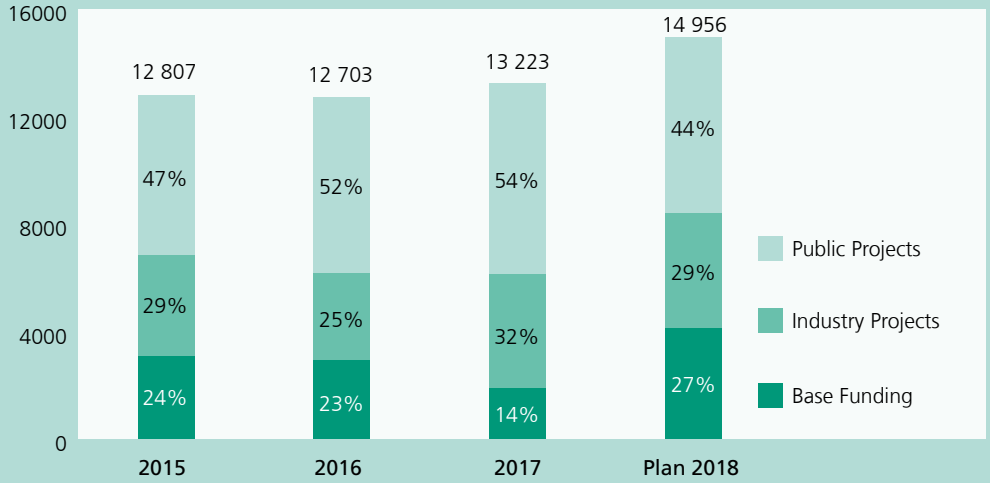
ELECTRONIC LIS & MARKET RESEARCH (ELIS)

IT SERVICES (ITS)

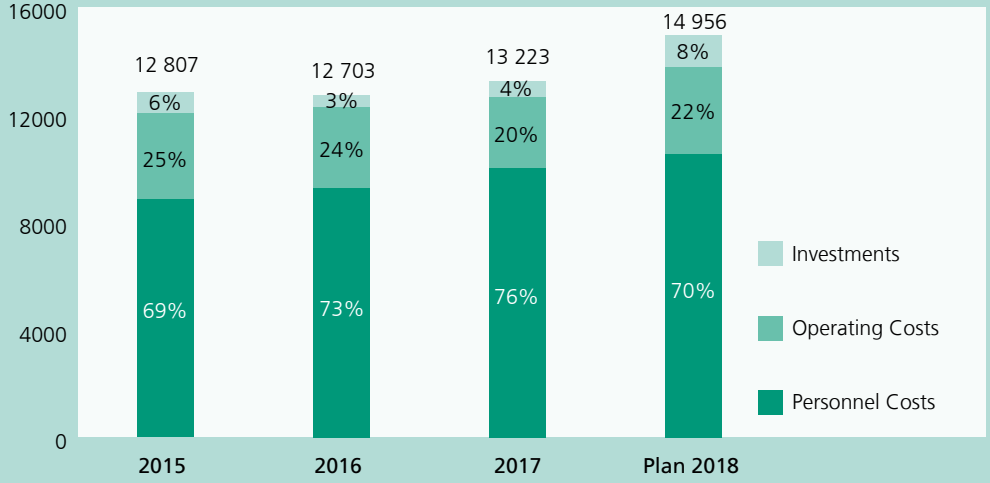
FACILITY MANAGEMENT (FM)

INSTITUTE IN FIGURES

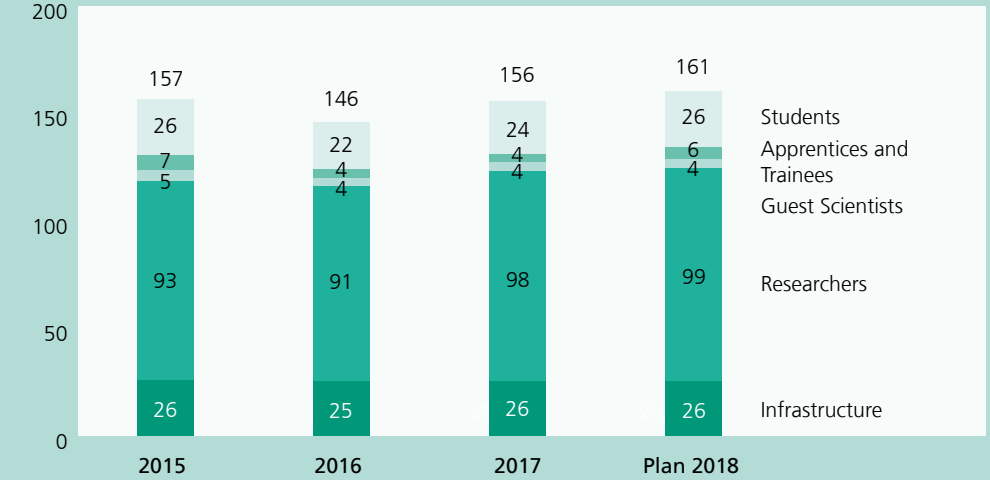
Development of Budget (in T euro)



Development of Costs (in T euro)



Development of Personnel in FTE (Full-Time Equivalents)



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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 25 000 staff are qualified scientists and engineers, who work with an annual research budget of 2.3 billion euros. Of this sum, almost 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.

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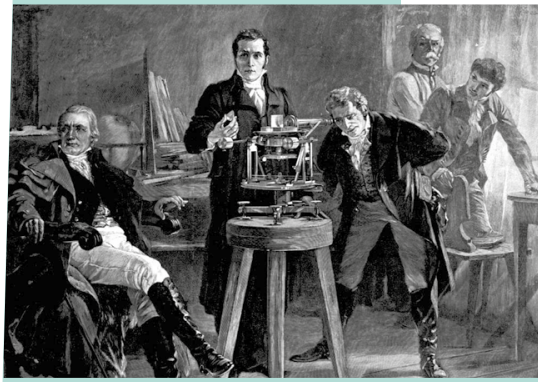

The man behind the name:

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 councillor 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.

SIAK

SCIENCE & INNOVATION ALLIANCE KAISERSLAUTERN

Research & Innovation

Network

Finding solutions to the complex scientific and technological issues we face today often calls for an interdisciplinary approach. The University of Kaiserslautern, ten renowned research institutes and research-oriented institutions, ten companies as well as numerous supporting members have joined forces to form the Science and Innovation Alliance Kaiserslautern e.V. Together they aim at boosting the city's reputation as distinguished location in the field of research and academic studies at a regional, national, and international level.

Major topics:

- Industry 4.0
- Commercial Vehicles
- Construction
- Energy
- Health

As competent partners and with a special focus on the area of digital transformation, the members of the Science and Innovation Alliance explore these topics in order to address the challenging economic and social issues of our time.

Full Members

Science and Innovation Alliance Kaiserslautern e.V.

www.science-alliance.de

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ibwf Institut für Biotechnologie und Wirkstoff-Forschung

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ifos Institut für Oberflächen- und Schichtanalytik GmbH

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psb Creating your intralogistics

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Automated welding solutions.

TOPdesk Your guides to service excellence

International software company for service management with over 500 employees at 12 locations around the globe.

WIPOTEC Innovation. Passion. First.

Global market leader in industrial weighing technology and production inspection solutions.

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BMBF grant number 01IS15050

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

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 State of Rhineland-Palatinate, 56:382 Digitale Dörfer

Flex4Energy | http://www.flex4energy.de
BMWi grant number 0325780B

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

MANTIS | http://www.mantis-project.eu
ECSEL grant agreement no. 662189
BMBF grant number 01IS15017C

ProDebt | http://www.prodebt.de
BMBF grant number: 01IS15008A

ProKoB | http://www.prokob.info
BMBF grant number 01IS15038

PRO-OPT | http://www.pro-opt.org
BMWi grant number 01MD15004E

PROPHESY | http://prophesy.eu
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