Fraunhofer

IESE

ANNUAL REPORT
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Digital Transformation in Balance

EDITORIAL

Dear readers,

The focus of this annual report is on digital ecosystems. Now we could simply leave it at that, trusting that our readers will intuitively know what this means, of course. We could, however, also make an attempt to define this term in greater detail and elaborate its relevance in economic terms as well as its topicality in scientific terms. This is what we want to try to do in this editorial before leaving you to peruse the interesting contents of our annual report.

To find a suitable definition, it makes sense to take a look at "natural ecosystems" and find out what their characteristics are. The relevant definitions all agree that an ecosystem always comprises a symbiosis of organisms from various species and their inanimate environment, that it is heterogeneous, and that interactions among its components are important. All the while there exist constraints that can only be influenced by the members of such a system within limits. An ecosystem in a swamp will remain moist, and a desert ecosystem will always be dry. If seeds of a plant that thrives in dry conditions are blown into a swampy area, it will find that the conditions for growth are unsuitable for it there. This is an unfortunate, but unalterable constraint.

DIGITAL ECOSYSTEMS ...

... are heterogeneous systems consisting of interacting actors and their environment. The actors may be IT systems, technical systems, or even humans. Just like the individual members of a natural ecosystem, they try to achieve certain goals and depend on interaction with other actors of the digital ecosystem to do so. At the same time, they must consider given, barely influencable constraints. The so-called "Smart Grid" – that is, the system for the generation and distribution of electrical energy – is a good example of a digital ecosystem. Households can feed surplus energy into the grid or need energy from the grid. They want to sell energy for the highest possible price and use it at the lowest possible price. The energy balance in the grid must be right. But if there is no wind, the wind generators will not supply any energy. To a certain extent, controlled intervention is possible via the price structure. However, any measure is subject to certain constraints. A high-energy power line, for example, can only transmit a defined maximum amount of energy. Any excess transmission would have immediate safety-critical consequences.

The analogies between natural and digital ecosystems are clearly visible. The economic relevance of digital ecosystems is high because the increasing networking between traditionally separate systems leads to the creation of digital ecosystems in many application areas, for instance in production (Industrie 4.0), in medicine, in transportation, and in many other areas. Mastering the challenges arising in the context of digital ecosystems is therefore of crosscutting importance for many areas of business and life. The scientific topicality of digital ecosystems lies particularly in mastering their interdisciplinarity. For example, we need development methods for systems of systems. Classical software engineering methods or construction processes from mechanical engineering alone no longer suffice. The issues to be resolved are much more comprehensive as well. In digital ecosystems, the interdependencies among safety, security, and privacy must be taken into account when performing safety assessments. And, finally, the answers to many questions need to be shifted from development time to runtime, e.g., because the systems change autonomously and configurations are therefore not known in their entirety at development time.

Digital ecosystems raise many issues that are difficult to answer, but it is worth investigating these because the results can be used in many different ways. In this annual report you will find contributions about selected activities regarding the topics described above. This includes information about research projects – for instance on Industrie 4.0; technologies – e.g. data usage control; or dedicated research programs – e.g. our work on the topic of "Smart Rural Areas" –, to name but a few.

With our work on digital ecosystems we help to actively design our joint future. We invite you to take part in this endeavor as a partner of Fraunhofer IESE. But first – following this short excursion into digital ecosystems – we hope you will enjoy reading our annual report.

Peter Liggesmeyer

Dieter Rombach

CONTENT

"Through our research we contribute to the sustainable development of an ecologically sound environment, and an economically successful and socially balanced world. We are strongly committed to this responsibility."

From the Guiding Principles of the Fraunhofer-Gesellschaft

SERVICE PORTFOLIO

DIGITAL TRANSFORMATION IN BALANCE

By offering well-balanced interaction between Digital Services and Autonomous & Cyber-Physical Systems, Fraunhofer IESE is laying down the right tracks in digital ecosystems.

According to a current survey by the market research company Gartner, integration into digital ecosystems is at the very top of the agenda of the 2,600 Chief Information Officers surveyed. They see great opportunities for their companies to move in a fast, multidimensional network. Differentiation from one's competitors, better market access, faster innovation, and higher productivity are the arguments presented. However, there are also completely new challenges that these companies must address, which result from the open networking among a wide variety of different systems.

We are already in the middle of topics such as Industrie 4.0, Internet of Things, and Digital Transformation. The future belongs to dynamic and digital ecosystems with extremely high demands on the quality of the system architecture and implementation. In such ecosystems, embedded systems (Autonomous & Cyber-Physical Systems) and information systems (Digital Services) no longer present separate insular solutions – their boundaries are becoming increasingly blurred. The challenges faced by each individual discipline remain, however. At the same time, this ever increasing interconnection will leave us no choice but to develop strategies for dealing with issues such as Big Data, Cyber-Security, and Smart Data, as the huge amount of data not only increases the need for data security, but also allows companies to develop completely new business models through "smart" usage of data.

In all these situations companies need to make the right decisions and seize the emerging opportunities without disregarding the risks. Fraunhofer IESE offers one-stop expertise for the digital transformation.

Digital Services + Autonomous & Cyber-Physical Systems = Digital Ecosystem.

DIGITAL SERVICES

The world is becoming digital – are you in the game?

In recent years, digital services have become ever more popular and are being used increasingly by companies as well as by consumers. This trend is supported by new technologies: Mobile devices, mobile Internet, and ultimately apps with customized functionality permit practically any kind of infomation and services to be accessed comfortably nearly anywhere by anyone. But this is just the beginning: This trend will continue and even accelerate. New technologies in combination with innovative or disruptive business ideas have already led to significant upheavals in several domains. These and other aspects – such as direct access to customers, simple and expedient app functionality, the potential to implement disruptive business models quickly and over a large area, as well as linking existing services, processes, and systems even across company boundaries and making them available comprehensively, directly, and beneficially – all this is rapidly propelling the digital transformation forward. It also creates pressure for companies to act, to keep up with the digital transformation, to optimize internal workflows, and to ensure their own survival.

ON THE ROAD TO THE DIGITAL FUTURE

On the road to the digital future, processes get digitized, automated, and interconnected. Information systems and software on mobile deveices control these processes and workflows, and allow them to be experienced directly by anyone. At the same time, the age of digitization also means that a variety of new and partly disruptive business models are being created that allow customers to experince new services and create new markets – and which may even force conservative business models and services out of the market: Digitization will change our daily lives at the social, political, and economic level. Digital Services are in the focus of all this. In all branches of industry and all service sectors, IT systems are starting to get interconnnected in order to make more comprehensive and optimized services available. In doing so, companies strive to realize two major aspects:

- Optimizing their internal workflows to make processes more efficient and smarter and thus save costs and increase the quality of the results

- Extending their offers and improving the quality of services provided to customers as well as developing new business models

Networked IT systems and mobile applications already permeate our lives in many areas. In the future, company-internal systems such as ERP, CRM, ICIS, accounting and invoicing systems will not only support and automate business processes and the daily processing of millions of transactions, but will also share networks with other system classes and interact with them, such as social media, eCommerce, FinTech, systems in other companies – even from other industries – in vehicles, in the Internet of Things (IoT). This is how better, more available, data-based, and more personalized services are created: digital ecosystems. With the increasing networking among and the integration of existing and new systems, processes, and services, the amount of data that is available and can be exploited for services and their optimization (Big Data) also grows rapidly.

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But how do organizations proceed on the road to the digital future in such a way that they will get the greatest benefit and ensure that the company and its business model will continue to exist?

CHALLENGES OF DIGITIZATION – THERE IS MUCH TO DO

Service and Process Integration. Internally, companies must digitize their processes. By integrating digitized processes further, workflows can be optimized and (semi-)automated on the basis of data. This saves costs and significantly increases quality and efficiency.

Big Data, Privacy, and Security. Digitization and increased netweorking lead to more and more data that are available and can be analyzed – data about services and their usage, about people's personal preferences and characteristics, or about the know-how and Intellectual Property of companies. In part, such data are highly sensitive. These data need to be protected without blocking their actual value. The right degree of privacy is an important aspect in the area of Digital Services and Big Data. Privacy must also be digitized and automated, for example to allow safe prevention of misuse of data and information even during regular access. Secure exchange of large amounts of data is another challenge.

Flexibilization of Systems. Many services are still being operated on the basis of backends developed and maintained over decades. These systems are often static and cannot be adapted quickly and easily to new market requirements. Such systems must be renovated and redesigned efficiently to allow their structure to support the new speed with which services and products must change in the digital age. Aspects such as

variation management and microservices are becoming important here.

Individualization and Customer Journey for Customer Retention and Customer Acquisition. Customized offers and "anticipating" the customers 'interests and actions (Next Best Offer and Next Best Action) help to increase the conversion rate. This ultimately means higher revenues. Individualization is important and interesting for almost all domains and all types of services and products, e.g. banks, insurance companies, eCommerce, automotive, energy, or healthcare. Artificial intelligence methods help to improve accuracy, and traceable bundling and usage of all channels to the customer (Omni Channel) enables even better business success.

Shortening of Development Cycles. In addition to more flexible systems to support faster and shorter development cycles, fast and agile development processes are also needed to satisfy the rapidly changing market demands and product requirements. Agile transformation of the development promises to speed up the relevant processes for the benefit of an organization. But what is the right introduction and transition strategy, and which aspects of agile development processes are the right ones for which organization? How can agile processes be used beneficially in regulated environments without violating security and safety guidelines or requirements on availability or performance?

Time to Market. Flexible systems and shortened development cycles are only two components of accelerated product lifecycles. The entire cycle from the creation of a service or product idea to its rollout on the market is subject to new laws regarding speed. Important complements on the road towards more

flexible systems and agile development processes are Design Thinking for the systematic generation of ideas, and Rapid Prototyping, which can help to quickly assess an idea in operative terms and test it on the market.

Regulation. Digitization and the proliferation of digital services mean that new regulations come into play. One general guideline is the new EU-wide General Data Protection Regulation (GDPR), which regulates informational self-determination in a new and more concrete manner than has been the case to date. Furthermore, it applies to all branches of industry and all services in exactly those cases where no specific regulation exists. This is the case in many domains. However, specific regulations, such as the upcoming new Payment Services Directive (PSD2) in the financial industry, must also be implemented quickly in a purposeful manner. On the other hand, however, new regulations always also offer room for innovation, which needs to be exploited optimally.

HOW WE HELP YOU

Recognize Problems. Solve Problems. With our services in the area of independent diagnostics (s. 360° Diagnostics Center, p. 29ff.), we assist you in explicitly and transparently identifiying the capabilities of your development and IT processes, the flexibility and future readiness of the software architecture of your systems, or the readiness of your system and process landscape for digital services and digital ecosystems – backend as well as frontends – with optimal User Experience. Based on these strengths and weaknesses, we determine the improvement potentials. Together with you

we then derive concrete and detailed improvements in alignment with your business goals. We make your processes, systems, and products fit – so that you can confidently face the digital future, too.

In addition, with our services in the area of systems engineering innovation (s. Efficient Engineering Solutions, p. 23ff.) we offer systematic support for building up your capabilities for the development of complex systems and for assuring quality right from the start of development, and we support you in agile transformation. To round off our portfolio, we also offer cost-saving and highly efficient virtual engineering methods, which can be used to test services and products already prior to development, based on front-loading and simulation in actual use – even in complex interconnected digital ecosystems. Here, the use of suitable competence transfer approaches turns our know-how into your know-how.

Create Innovations. Design the Future. We are your incubator and your workshop: With our services in the area of product innovation (s. Rapid Innovation Lab, p. 17ff.), we support your digitization projects from idea generation to rapid prototyping with guaranteed qualities such as security, privacy, and user experience in our Rapid Innovation Labs. We also help you to modernize your systems and get them ready for the digital future. And we create the bigger picture in the digital world for you: For you and with you, we design your digital ecosystem in order to ensure your long-term business success with new or disruptive business models, and provide support in implementing these.

■ Michael Ochs

AUTONOMOUS & CYBER-PHYSICAL SYSTEMS

The next step in the evolution across different application domains lies in the automation of entire systems or systems of systems, such as trucks driving autonomously on the motorway or automatic adaptation of production systems to the current availability of energy. As manual controls are no longer necessary, the response times to changes in the environment are shorter in such systems. This allows saving costs and fulfilling goals in a more optimal way. However, it is also necessary to precisely analyze and validate the risks, for instance with regard to possible dangers for people and the environment, or the failure safety of critical systems. There are also many challenges in terms of mastering the complexity and variability of these systems in their different application-specific manifestations. For several years, Fraunhofer IESE has been researching and developing solution components for these aspects. Now these different offers have been bundled into one business area.

Process automation has been a basic pillar of productivity improvements in business and industry for over 100 years. Most of the time, this refers to well-described processes with fixed system boundaries, such as a production line in the steel industry, or the control of heat output. **Autonomy** constitutes the next step in automation and thus in efficiency. We speak of autonomy when systems can change their behavior on their own as a reaction to previously unplanned events (originating, e.g., from the system's environment). Different degrees of autonomy can be distinguished. A well-known example are the automation levels in automobiles: In the case of conditional automation, the vehicle takes over steering control and the human only acts as a fall-back for intervention at short notice. The next level of high automation can autonomously bring the vehicle into a safe state (e.g., stopping at the side of the road) and only has to rely on humans in very few cases (e.g., off-road driving). In the case of complete automation or in an autonomous vehicle, finally, we can do completely without a driver. The first manufacturers are planning to bring such systems, e.g. robot taxis, to the market in five years already; development is currently running at full speed.

The term **cyber-physical systems** characterizes interconnected software-based systems that control physical processes in the real world in an automated manner, such as turning on pumps, opening weirs, or deactivating wind power plants. The opportunities and benefits from automating these interconnected systems lie in the fact that they enable a higher degree of efficiency and reliability. However, these examples also reveal that safety risks may potentially arise here and that particular attention must be paid to the reliability of such systems. Especially the complexity of cyber-physical systems, which can easily encompass several hundred individual components, presents a great challenge in this regard. Finally – despite all their autonomoy – it must still be possible for such systems to be operated and controlled by humans.

Combined in networks with digital services, entire digital ecosystems are created in this way. These will map a multitude of business and work processes and will shape how we will live and work in the 21st century. This is why Fraunhofer IESE is bundling a series of solutions in its new business area **Autonomous & Cyber-Physical Systems**. ▶▶

CHALLENGES

The development and operation of such systems presents many different challenges for manufacturers and operators in various domains. One major impact factor regarding development effort and error proneness is obviously the **complexity** of the systems, which is characterized, for instance, by their total size as well as by the number and scope of their interfaces. In addition, there is the complexity of the usage environment (e.g., navigation of an autonomous vehicle in city traffic) and the complexity of the task (e.g., coordination of delivery drones). One key to mastering this complexity lies in the possibility of automation – during implementation through code generation from representations on a higher level of abstraction, but also in quality assurance and validation. These higher levels of abstraction are usually called model-based development, i.e., the formal description of structure and behavior with the help of more complex components, such as a "control unit".

Especially for embedded systems, Fraunhofer IESE has a modeling method that was developed in the context of several national research methods and with the collaoration of leading businesses (SPES XT Modeling Framework). Different levels of abstraction and views of the system facilitate its application. Hardware aspects – which are important for embedded systems – are dealt with in a special view. The approach is based on the industry standards UML and SysML.

Another great challenge is related to the requirements on **adaptivity**: Systems must adapt to changes – ideally autonomously. But the usage environment is often so complex that it is not completely known at development time. Hence, dealing with a certain degree of uncertainty in this regard is necessary, which leads to conflicts regarding safety and dependability. Approaches for solving this situation work with adapted system architectures and system concepts, such as the validation of core components (e.g., a power generator), which are extended and opened incrementally (to a power plant that can be controlled remotely) and which can also handle new technologies, such as machine learning.

The basis for this is the ability to evaluate and master non-functional, **cross-cutting quality aspects** (such as functional safety, cyber-security, or usability). The corresponding departments of Fraunhofer IESE are staffed with competent experts who know the state of the practice and are driving it in application-oriented research projects. In our solutions for future cyber-physical systems, dependencies among quality aspects are made explicit so that possible influences and quality deficits can be discovered early on.

WHAT WE OFFER

The methodological and technical core competencies of Fraunhofer IESE regarding software engineering systems, paired with the application competence of our customers, enable us to create innovative solutions in the form of future autonomous cyber-physical systems. Even if the remit is complex, we can make valuable contributions with the help of our partner network with more than 20,000 employees worldwide.

Our employees support companies in a variety of situations: in designing product innovations (s. Rapid Innovation Lab, p. 17ff.), in elaborating adequate engineering processes (s. Efficient Engineering Solutions, p. 23ff.), or in diagnosing and assessing existing systems and system designs (s. 360° Diagnostics Center, p. 29ff.). Talk to us! We are looking forward to addressing your challenges.

■ Ralf Kalmar

"Thanks to the solution realized together with Fraunhofer IESE to safely detect sporadic defects, we can now make do without expensive special hardware and still achieve safety.
We are so much convinced by the results of our collaboration with Fraunhofer IESE that we will transfer them into series production."

Markus Schweizer, Project Manager, Central Research, Robert Bosch GmbH

PRODUCT INNOVATIONS FOR OUR CUSTOMERS
RAPID INNOVATION LAB

Continuous generation of new innovations is a core element of a successful strategy. It should, however, be complemented by the ability to quickly assess the feasibility of such an innovation and bring it to market. This is exactly what is being implemented in Fraunhofer IESE's Rapid Innovation Lab – for all companies, irrespective of size. Organizations nowadays face a multitude of challenges in software and systems engineering: increasing complexity of the systems, high demands on quality, short product innovation cycles, and disruptive technologies that need to be evaluated. Business success increasingly depends on an organization's ability to generate new and innovative ideas, to implement these ideas in prototypes, and to evaluate them quickly in a suitable environment. In recent years, many customers of Fraunhofer IESE have used the institute's capabilities in these strategically important areas. Now Fraunhofer IESE has bundled them along with the corresponding technical and methodological equipment in one central service – the Rapid Innovation Lab, or RIL for short.

"**Creativity techniques**? In our company? We don't have time for such gimmicks!" Many companies are unfamiliar with the use of effective creativity techniques for generating innovative product ideas. We often find brainstorming being used, which is one of the most ineffective techniques. We, on the other hand, draw on a repertoire of more than 200 techniques – meaning we can find the right creativity technique for any situation. Some orgnaizations simply do not have the courage to systematically use creativity techniques, so unfortunately they do not exploit their staff's creative potential to the full extent. Creativity is no coincidence – it can be guided deliberately and efficiently through the use of systematic methods. This ensures that viable product innovations are not created randomly, but in a purposeful manner. But do such ideas have **potential**, too? With the help of goal-oriented potential analyses such as mobility potential analysis or Big Data potential analysis, we assess the potential that new technologies offer for an organization.

Implementation speed is another important factor. We observe that many companies know how to develop high-quality products, but often lack the ability to quickly implement or evaluate ideas. In addition, we see great reluctance in implementing new concepts and technologies such as Cloud and DevOps, which would enable fast development. Successful companies have the ability to develop at revolutionary speed, but they also manage to run long-term development cycles in a stable and mature manner.

For the generation, evaluation, and implementation of new product ideas, our "Rapid Innovation Labs" (RIL) present an ideal environment. We support companies from the generation of ideas via creativity workshops and implementation through prototypes all the way to the assessment of customer acceptance and the evaluation of technical feasibility with a comprehensive toolbox. And last but not least, our systems engineering methods and technologies can also help to support successful product development.

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As illustrated in the figure on the opposite page, our Rapid Innovation Lab is divided into four phases: Innovate, Prototype, Evaluate, and Support. Whereas the first three phases serve to find and evaluate ideas, the Support phase is aimed at the subsequent implementation of the idea in a concrete product. Each of the four phases is supported by a toolbox of tried and tested methods, tools, and competencies. These are divided into five clusters:

CREATIVITY WORKSHOPS

A systematic procedure and creative ideas are no contradiction! Quite the opposite is true: in the RIL, a wide variety of different techniques are combined effectively. Creativity techniques are used not only at the beginning of the product lifecycle to find product ideas. Later as well, when it comes to elaborating detailed product features or dealing with matters of design, our techniques are used with great effect.

POTENTIAL ANALYSES

Which technologies offer the greatest added value for my new products? Will Big Data really help me? Where can I use mobile technologies to the greatest advantage? And shouldn't I start getting into the emergent world of software ecosystems in order to maintain my position on the market, to strengthen it, or to completely realign it? Answers to these and similar questions are offered by the methods in the RIL cluster "Potential Analysis" – be it the use of the Fraunhofer Big Data Potential Analysis, the mPotential method, or the Fraunhofer FEA (Fraunhofer Ecosystem Assessment) method.

LAB INFRASTRUCTURE

In order to evaluate product ideas quickly, an adequate lab infrastructure is needed. Fraunhofer IESE offers a variety of development lab environments for Rapid Prototyping, e.g., for embedded systems, Big Data analysis, and mobile applications. This lab infrastructure combines technological equipment with domain- and system-specific expertise. Common state-of-the-art technologies and tools, development and integration environments are integrated there, as are Fraunhofer IESE's own developments. Examples of these are the simulation framework FERAL, which allows executing existing or prototype behavior components in a simulated environment, for instance to check properties of a planned software architecture, and the IND^{2}UCE framework for the integration of data usage control into distributed systems.

TECHNOLOGY EVALUATION

Before such speedily developed prototypes are introduced to the market, they should, of course, have adequate quality. To assure this, methods and tools are used in the RIL cluster "Technology Evaluation" that examine a wide range of product-related aspects: How well is the product accepted on the market and by the customers? Which user experience does it offer? What are the architecture-related challenges that I will have to address now, but also in the future? How about the important qualities security and safety? Not only a company's own product gets evaluated in this way, but also intended partner products.

SYSTEMS ENGINEERING AND TECHNOLOGIES

The transition from prototpye to product is often fluid. The last RIL cluster, "Systems Engineering and Technologies", therefore complements the RIL portfolio with all competencies and services of Fraunhofer IESE in the area of software and systems engineering (www.iese.fraunhofer.de/en/competencies.html).

We combine the tools and technologies from the RIL Toolbox to adequately address the great variety of requirements that our customers have. This means that we encounter very diverse scenarios in our customer projects. In the following, we will describe the most typical customer scenarios and issues that we address with the RIL:

INNOVATIVE PRODUCTS:
How can my organization benefit from topics such as 'Big Data' or 'Internet of Things'?

On the one hand, the focus of these projects is on finding concrete product ideas to extend a company''s own product portfolio. On the other hand, this includes projects where we evaluate new technologies for our customers by means of potential analyses and thus demonstrate short- and long-range potentials for their own product portfolio. When it comes to finding new product ideas, concrete future-oriented topics and innovative technologies such as Big Data, Internet of Things, or cyber-physical systems are frequently discussed. In such cases, product ideas are to be found systematically in these areas. But many projects happen even without these technology-oriented ways of thinking: then the focus is on the company's own market and its own product portfolio.
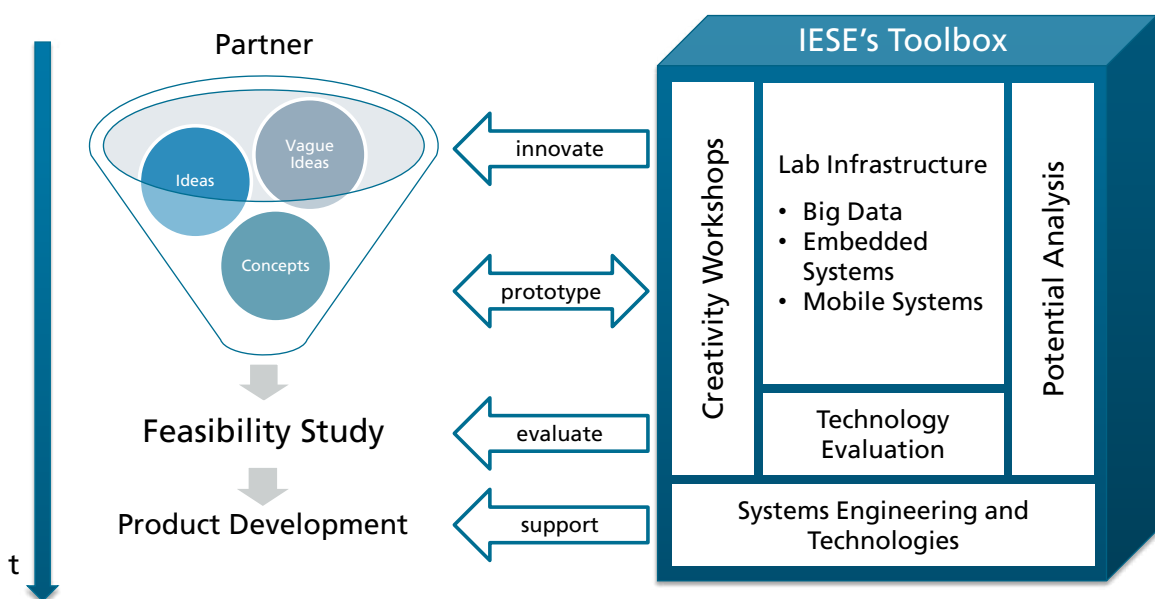
Prototyping of ideas in the Rapid Innovation Labs of Fraunhofer IESE

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PROTOTYPING OF PRODUCTS:
New concepts and technologies in practice

The aim of these projects is to create prototypes, resp. MVPs (minimum viable products) together with the customers. The prototypes serve to either implement previously developed innovative concepts or to test innovative technologies. The concepts are often from the areas of user experience or security, but also include innovative architecture and safety concepts. They are developed in collaboration with the companies and are then integrated into the prototypes. In addition, we find projects that integrate innovative technologies into existing products, for example regarding the testing of systems with the data usage control technology IND^{2}UCE.

CONSTRUCTION OF ECOSYSTEMS

In almost all branches of industry, the future lies in participative ecosystems. High-quality services are increasingly made possible by new networks created among companies and their systems. In the projects in this area, our customers ask questions such as: Is it worthwhile designing an ecosystem on a major scale? Which ecosystem is the right one for me? Who are the right partners with whom can I start the ecosystem? How will my business benefit from the ecosystem? In these projects, Fraunhofer IESE often acts as an incubator for a new ecosystem. As a neutral authority we bring interested parties together and explore new ecosystem ideas in creativity workshops. Business models and software development are thought of as being in balance and are no longer considered solely from the perspective of one's own company. Classical, long-established boundaries of thinking in systems are regarded in a new light. Are further competent partners and technologies needed for the ecosystem? Fraunhofer IESE as a neutral partner evaluates them with the help of its RIL methods from the cluster "Technology Evaluation". And once the ecosystem is ready for implementation, the lab infrastructure quickly allows getting a feeling for the ideas implemented in the ecosystem.

SYSTEM MODERNIZATION

Many systems have grown historically. But if dealing with their maintenance or user interface reaches a dimension that is no longer feasible, the question arises inevitably how to protect the old investments. Regardless of whether legacy systems are to be migrated to new technologies or whether existing systems or system landscapes are to be simplified: with the help of the RIL components from the clusters "Potential Analysis" and "Technology Evaluation" as well as with the lab infrastructure for the rapid development of prototypes, system modernization will be a success, without any unwelcome surprises.

■ Jörg Dörr
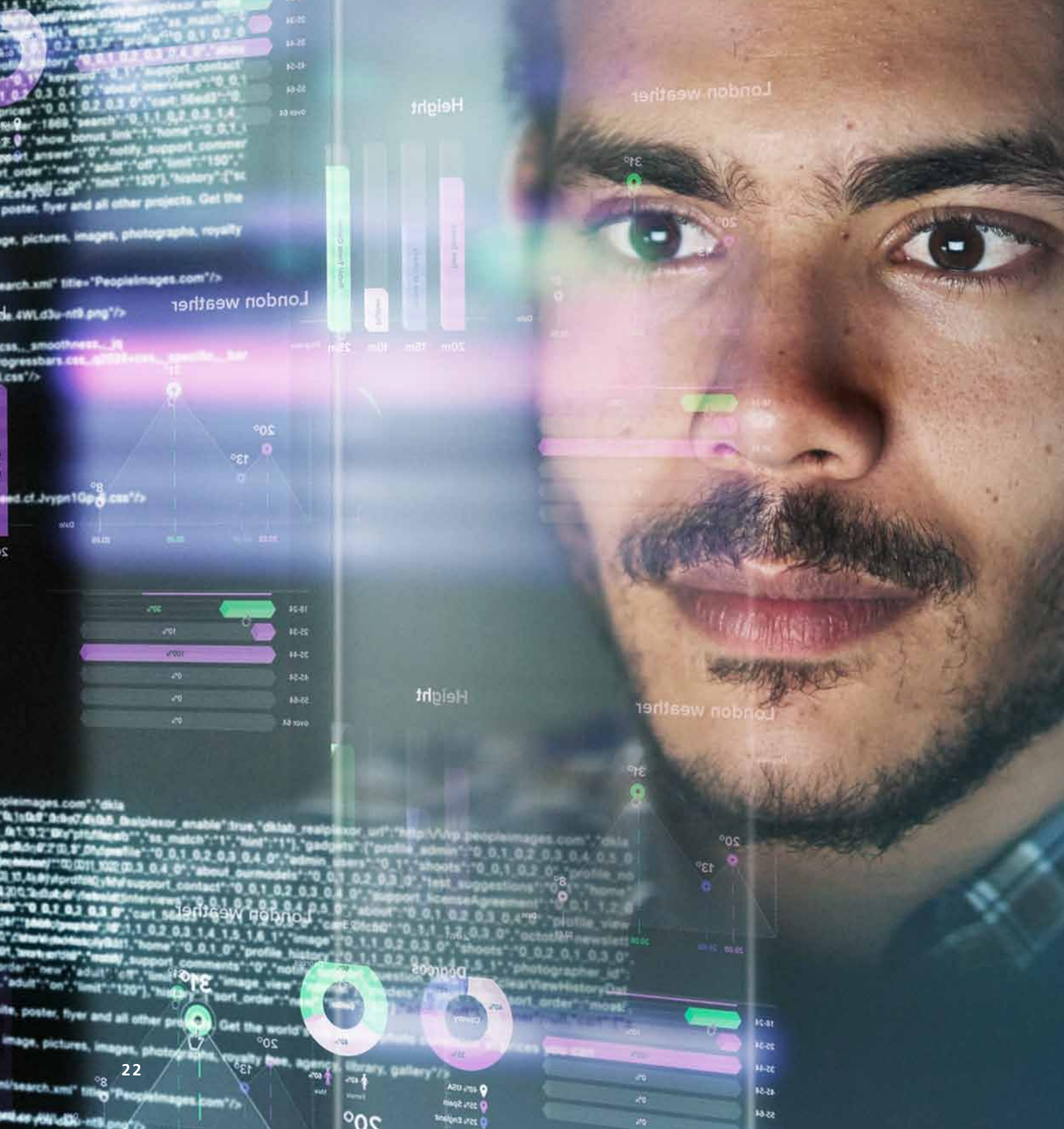
EFFICIENT ENGINEERING SOLUTIONS

Systems Engineering Innovation – Software-based systems are becoming ever more important both in our professional lives and in our private lives. Autonomous driving, Industrie 4.0, Internet of Things, or Big Data represent innovations that are only made possible by software. However, this trend also leads to various challenges that must be mastered with regard to the efficient engineering of software-based systems. In the context of our service "Efficient Engineering Solutions", we are offering you a portfolio of innovative and well-proven processes, methods, and tools aimed at dealing with typical challenges encountered in the the development of modern systems. We customize these systems engineering methods to your organization and support you in successfully applying them in projects.

The engineering of modern software-based systems increasingly poses challenges for companies. These are the result of particular characteristics of these systems, such as those described below:

Complexity: More and more system functionalities are mapped in software. The functional as well as the non-functional requirements are becoming ever more complex. In order to deal with this challenge efficiently, model-based approaches to systems engineering – from the requirements via the architecture to quality assurance – are necessary.

Variety: When we talk about modern systems, it is more correct to rather speak of systems of systems, since they integrate a multitude of different systems and also because it must be possible to extend them in a flexible manner – partly even at runtime. This requires placing a particular focus on the interoperability of architectures and the management of system variants in order to allow systems to integrate with each other easily and to be able to give quality guarantees.

Uncertainty: Modern systems must be able to react to their environment in an increasingly flexible and smart manner, and must be able to adapt to it as easily as possible. This calls for a paradigm shift: Instead of giving quality guarantees at development time, it must also be possible to give a wide variety of them at runtime, for example with regard to system performance, functional safety, or data protection and data sovereignty.

Safety/Security: In highly integrated systems, requirements on data access (Security) and on functional safety (Safety) come together. Unauthorized access to a safety-critical system can lead to a hazard to life and limb. This implies that an overall concept must exist in order to be able to assure both system qualities during operation.

Usability: Despite the increasing complexity of its functionality, the integrated system must still remain usable. The focus is on the human as the user. This makes it necessary to pay attention to a positive user experience across all involved systems already at desgin time.

Intelligence and Autonomy: Autonomous or semi-autonomous systems are playing an ever greater role today. Particularly significant in this regard is the smart usage of data (Smart and Big Data). This requires the identification and collection of appropriate data, model development on the basis of large historical data sets, as well as the smart application and evolution of such models (e.g., as self-learning systems).

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In addition to the systems themselves, the way systems are constructed is also changing:

Innovation Cycles: New products must be brought to the market ever more quickly, all the way to concepts such as DevOps, where development and operation are fused into one. This calls for development processes and innovative methods that allow responding flexibly to customer requirements and trends, and which will quickly deliver results.

Collaborative Development: Today the task is often the integration of very diverse systems, which do not necessarily come from a single source. This calls for clear interfaces between all partners involved in the development and for tools to be available that enable efficient collaboration.

In order to develop an innovative product efficiently, innovations are need in the area of systems engineering that offer support for mastering these characteristics.

AGILE TRANSFORMATION

The ability to quickly bring innovations to the customer is an important factor when it comes to survival in a highly competitive market. In this context, agile development paradigms and DevOps approaches, in particular, have gained great popularity. They are aimed at rolling out new features as fast as possible while ensuring that they are suitable for the customer requirements. However, applying these methods and mastering the practices underlying them requires various adjustments, particularly in domains with extensive regulatory requirements (e.g., functional safety or laws on medical devices).

Fraunhofer IESE supports companies in using the potential of agile processes and DevOps and in transforming existing processes incrementally. Factors that play a large role in this regard include scalability and firmly entrenching the process in the organization, as well as collaboration with classical processes and with external development partners.

In the context of the Software Campus projects, we are, for instance, collaborating with the industry partner Robert Bosch GmbH on investigating the impact of agile practices when used in regulatory domains and on establishing an experience database with agile practices. At Fujitsu EST, we provided conceptual support for the introduction of DevOps.

As our partner, you will benefit from our comprehensive knowledge of agile methods and practices and how they work and can be used in systems engineering projects.

ENGINEERING QUALITY

The more complex and heterogeneous systems become, the more important it gets to take required system qualities into account already during engineering and to assure them at runtime. To do so, we offer you a rich portfolio of methods:

Safety: Systems are increasingly interconnected, open, and adaptive. Established safety engineering methods are therefore only usable to a certain extent. Our ConSerts approach offers safety-related guarantees that are dependent on the respective requirements on the environment. Properties are checked at runtime. In a project with John Deere in the area of agricultural

technology, for instance, we used modular safety certificates to validate combinations between tractors and connected equipment.

Security: IT and data security is an important requirement for any organization. In security engineering, Fraunhofer IESE supports you in the verification and validation of the system design and in balancing security needs with other system qualities that are just as important. In the national reference project IUNO, we are working on practice-oriented concepts and solutions for IT security in Industrie 4.0. Our IND²UCE

framework, which was awarded the EARTO Prize, supports companies in integrating data security flexibly and efficiently into different technologies.

UX: Functionality and good usability of a software system alone are no longer sufficient for a company to be successful with its users. Fraunhofer IESE supports innovative companies in designing their systems in such a way that users are not only supported effectively and efficiently, but also have a positive user experience (UX). In the project automotiveHMI, we are working on a human-centered, optimized user interface. At

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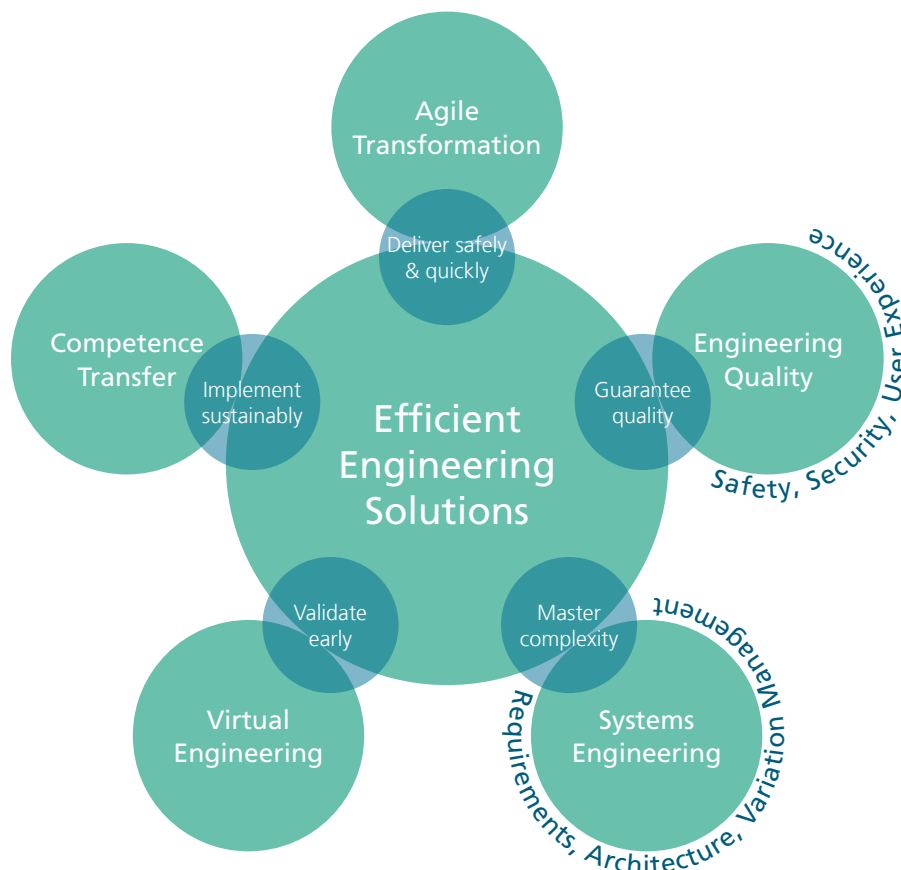
Our application areas for Efficient Engineering Solutions – your benefits

FinanzInformatik GmbH & Co. KG, for example, we have identified important improvement potentials with the help of usability tests.

As our partner you will benefit from scalable, innovative approaches for validating quality properties by construction, which cannot be validated if classical approaches are used, or which can only be validated very inefficiently.

SYSTEMS ENGINEERING

According to INCOSE, Systems Engineering is the name of an interdicsiplinary approach that combines the business needs and technical needs of all customers with the aim of creating a quality product that satisfies the users' needs. Fraunhofer IESE supports companies in the efficient construction of complex systems across all task areas.

Requirements: Only if you know what the actual needs and wishes of your stakeholders (customers, users, etc.) are can you develop products that will be successful on the market. Fraunhofer IESE supports you with offers ranging from creativity techniques for requirements elicitation to the systematic management of complex requirements in all areas of Requirements Engineering. In the project MKS180, for instance, Fraunhofer IESE supported the German Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support (BAAINBw) in the specifikation, modeling, and analysis of requirements as well as in system modeling. Since 2006, Fraunhofer IESE has been collaborating with Fujitsu Labs in the areas of requirements specification, non-functional requirements, requirements reviews, and traceability of requirements. As a member of the Fraunhofer Big Data Alliance we determine the potential

of Big Data together with you and derive requirements on the data to be elicited and the necessary algorithms.

Architecture: The architecture is the key for developing innovative and high-value software systems with predictable and adequate quality within time and budget constraints. Our ACES method supports you in defining and documenting your architecture. With the help of scalable models, even large and complex systems can be mastered. In order to validate the design early on, we integrate simulations, if necessary, or rely on prototypes for testing a concept. For embedded systems, we use the SPES-XT meta-model, which was elaborated in collaboration with renowned partners in national reference projects. John Deere ISG (Intelligent Solutions Group), for example, was supported by Fraunhofer IESE in its transition to agile development methods: We used architecture-related principles to improve communication across the different sites. In the context of the PRO-OPT project, we are examining suitable Big Data architectures in order to be able to analyze data across company boundaries and uncover hidden data treasures for Industrie 4.0.

Variation Management: The development of comprehensive software systems is nowadays strongly driven by individual customer requirements. Providing and maintaining customer-specific solutions results in increasingly complex products and a rapidly growing number of variants and versions. Our variation management approach, which we have been using successfully for many years, supports you in mastering this complexity and ensures that long-term evolution and adaptation of existing systems is possible. The company Knorr-Bremse, for example, has developed a reuse approach in the area of rail and commercial vehicles based on UML/SysML together with Fraunhofer IESE.

As our partner, we support you in the efficient development of complex systems across all task areas so that development cycles are shortened through the use of our innovative technologies, methods, and tools; that aberrations can be avoided; and that required quality properties can be achieved.

VIRTUAL ENGINEERING

Open interfaces, the consolidation of functions on just a few high-performance control units, as well as multicore processors are leading to numerous challenges in embedded systems. Functions can no longer be regarded in isolation during development; they interact in numerous different ways with other functions and devices of the system. Our virtual engineering approach provides tools that allow early evaluation of functions in a realistic system context. Our FERAL framework makes it possible to execute existing or protoype behavior components in a simulated environment that reflects the relevant properties of the planned software architecture. In the context of the national reference project BaSys 4.0, we are collaborating with renowned industry partners on developing a basic platform for Industrie 4.0, which will massively use virtual engineering techniques. In the context of the project "Digital Villages" we are simulating a smart ecosystem in order to study digitization concepts in rural areas.

As our partner you will benefit from the fact that the impact of design and deployment decisions can be predicted at an early point in time and can be corrected, if necessary. This allows you to already validate your system virtually in advance and thus increases your development efficiency.

COMPETENCE TRANSFER

In order to sustainably roll out and establish innovative engineering approaches in an organization, one of the issues is dealing with how to get competencies into one's own organization. Together with you we will develop a concept that is tailored to your needs. In the context of joint R&D Labs, such as the one with Insiders Technologies GmbH, our experts will work with your staff in a joint development lab equipped with state-of-the-art technology, methods, and tools to transfer innovative approaches.

In addition to all this, Fraunhofer IESE offers a very diverse program of seminars on a variety of engineering topics. We will also be happy to put together an individual inhouse seminar for your needs. Furthermore, we are collaborating with the University of Kaiserslau-tern in offering a career-compatible Master study program "Software Engineering for Embedded Systems" as well as courses in the context of the EIT Digital Professional School.

■ Jens Heidrich

QUALITY THROUGH INDEPENDENT DIAGNOSIS
360° DIAGNOSTICS CENTER

Software is the **central driver for innovation**. And its quality is the central factor that ultimately determines the success or failure of a product and a company, because quality is reflected in many facets. In addition to failures in the behavior of the software that the user can experience, quality defects are also reflected in excessive development costs and times – even for small changes or extensions. A lack of quality is also visible in wrong technologies and architectures that no longer allow urgently needed features to be realized. If user experience is missing, market acceptance and thus success will not be achieved even if the best functionality is offered. And if the safety and security of a system cannot be proven at the end of the development, the best innovation is destined to fail. In markets that move ever faster, such defects become a crucial competitive factor that determines success or failure. Thus, it is even more important now to be able to rely on an objective, well-renowned partner who considers quality to be more than the correctness of a function and who thus contributes right from the start to the success of your innovations: Fraunhofer IESE with its 360° Diagnostics Center.

Andreas Huber is working at a well-known automotive supplier as a developer in charge of a driver assistance system. His customer would like to order an extension of the system. However, he has clear expectations regarding the price. Andreas Huber finds himself in a dilemma: The driver assistance system has steadily evolved over the course of the years. The focus was on new features, paid for by the customer. In the meantime, every small change to the system means enormous effort. In addition, there are more and more quality problems. Now the point has been reached where the effort for system adaptations and extensions would be much too high and the customers of Mr. Huber would no longer be willing to pay the price. His employer thus has no choice but to initiate refactoring of the driver assistance system. But how? In parallel to their daily business? And how is Mr. Huber as the person in charge of development going to get an honest assessment from his team members about the state of the system? How can he ensure that the new system will actually be fit for the future and will not degenerate again? This is a case where external support by an independent expert is called for.

Kerstin Neu is also in a difficult situation. As the person in charge of components at a large automotive company, she is the customer of Mr. Huber and thus finds herself on the other side. Her problem: In recent times, more and more defects have crept into the delivered software and performance problems have jeopardized her schedules. At the same time, her automotive supplier is having a hard time interconnecting their system safely with her Cloud and implementing new concepts such as over-the-air updates or on-demand functions. Since the supplier denies full access to their architecture specification, the source code, and other development artifacts, she can often not assess the quality and future viability of the delivered software properly. She is asking herself how high her own project risk might be. As her employer has the delivered software integrated into the control unit of another supplier, all stakeholders blame each other. Ms. Neu as the person in charge of components will have to find a solution to get a better assessment of the supplier software. But who could perform an objective, professional analysis whose results she herself could trust and which the supplier would also permit? And how can she continuously keep track of the quality of the software?

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Regardless of whether you have doubts about the actual quality of third-party software or even your own software, whether you are urgently looking for solutions to problems that have already occurred, or whether you want to ensure right from the start that your investment into a development will have the desired success: The issue of objective assessment of the software and the corresponding development processes is an indispensable component for the success of a product. Software defects, insufficient performance, and especially excessive development costs and times for extensions and adaptations are things that a company cannot afford in today's ever faster and more fiercely fought competition. This is true for the fast-paced business of digital transformation as well as for embedded systems.

INDEPENDENT AND COMPETENT

If a company invests into the new development or adaptation of a system, a lack of quality therefore represents a substantial business risk. Checking the software provided by a supplier is mostly only possible to the full extent if an independent third party does it. But even for one's own software it is important to get an independent opinion.

Performing a robust analysis requires a great deal of experience and competence in quality evaluation. The main reason for this is that the really expensive defects are often not functional defects, which can be identified in the context of tests and reviews, but are often already present in the requirements and particularly in the system architecture. Especially defects in the architecture remain undetected for a long time, until the first symptoms are revealed, such as performance problems, quickly rising costs for extensions and ad-

aptations, and ultimately more and more frequently occurring software defects. When the first symptoms emerge, the damage is already so great that repairing the software causes enourmous effort and thus costs. Therefore, it is important to identify problems in the requirements and in the architecture already in early phases. This does, on the one hand, require special tools that many companies are not using and whose procurement in combination with the necessary user training would cause unrealistically high costs. On the other hand, their application requires a great deal of experience, and even though tools can complement manual analysis, they cannot completely replace manual checks performed by experienced experts. And for the evaluation of the results, reference values from comparable products in comparable applications are needed in order to be able to evaluate the obtained values as good or bad.

THE GERMAN SOFTWARE TESTING CENTER

For more than 20 years, Fraunhofer IESE has been a trusted partner for companies from a wide variety of domains. We perform independent, high-quality quality analyses according to the state of the art and the state of the practice. In doing so, we analyze both the products and processes of our customers and, as an independent third party, the quality of the products and processes of suppliers.

The experience we have gained from hundreds of analyses, the availability of state-of-the-art tools, and a portfolio consisting of unique analysis tools developed by us form the basis for the German software testing center – the 360° Diagnostics Center at Fraunhofer IESE.

360° – EVERYTHING IN VIEW

The 360° Diagnostics Center is much more than a test center. It examines the quality of systems, processes, and organizations from all relevant perspectives, and does so for embedded systems, for information systems, and for their seamless interaction in smart ecosystems.

It is not unusual, for example, for the experts of Fraunhofer IESE to be asked by a company to find and fix problems in their quality assurance. Most of the time, however, the problems are not in testing, but rather in the architecture of the system. In many cases, the problems reappear after some time because the causes in the development processes or in the orgnaization continue to exist. The diagnostics center therefore supports companies in having sustainable success by examining the real causes with a 360° analysis; checking the interaction between the organization, its development processes, and the product itself; and eliminating the identified weaknesses together with the customer. This is how our customers resolve not only their current problems, but sustainably improve the quality of their development and thus their success.

INNOVATIVE TESTING PROCEDURES FOR INNOVATIVE PRODUCTS

In addition to the comprehensive analysis of a system, it is also important to be able to test individual aspects of the system in detail. Due to the great innovative power of our customers, every test is as individual as the products to be tested. Depending on the system and the issue, an individual test plan is worked out. Many years of experience in testing methodologies enable us to efficiently implement individual testing concepts.

One of the central tasks of analysis is, for example, the evaluation of the architecture. Usually, the architecture of a system degenerates unnoticed for a long time. Insufficient performance and exponentially rising costs for extensions and adaptations together with malfunctions are the symptoms that occur when it is almost too late to intervene. In the context of our ACES methodology for pragmatic architecture evaluation, which has matured over the course of many years, our architects detect problems in the architecture already very early. A central element in this regard are the business goals and the derived architecture goals that the software must fulfill in order to enable the success of the product. Starting from these, scenario-based analyses are used to test not only the structure of the system, but also, for instance, the platform and development technologies used in terms of their suitability. In addition, special tools are employed to analyze and evaluate the current architecture on the basis of the existing source code. As an architecture generally does not only serve a single system, but rather an entire product family, commercial tools can also be complemented with special tools developed at Fraunhofer IESE, such as those from the PuLSE™ framework, to evaluate the suitability of the architecture and the variation management from the perspective of the current and the future product family. ▶▶

FORESIGHT LEADS TO SUCCCESS

However, if you want to have a clear competitive edge as a result of speed, quality, and lower costs, it makes sense not to wait until the first problems appear, but rather keep an eye on your system right from the start with the help of continuous evaluations. In cases such as the introduction of multicore processors or new communication technologies such as TTEthernet in the area of embedded systems, it is important to be able to decide very early whether the system can be ported, which technology should be used, and which hardware platforms and operating systems should be considered. At the same time, new issues emerge, such as over-the-air updates or downloadable apps for safety-critical automotive functions.

In addition to manual evaluation, the FERAL tool uses co-simulation of function, software, hardware, and communication systems to support us in testing initial system concepts and offering decision support based on facts already in early phases, where one had to depend on the developers' "gut feeling" before. In addition to the systematic selection of technologies and the evaluation of the architecture aimed at achieving the desired business goals, this also allows performing simulation-based validation of the necessary safety concepts. This, in turn, makes it possible to avoid making expensive wrong decisions right from the beginning.

SUCCESS THROUGH QUALITY

The boundaries between embedded systems and information systems are becoming more and more blurred, not only in terms of technology, but also in terms of innovation culture and speed. Never before has software changed the value chains so radically and created completely new business models. The landscape of opportunities is changing at breakneck speed. This development offers many chances and risks at the same time. If you want to handle problems quickly in this fast-paced competition, or if you do not even want to let such problems emerge at all by making the right decisions from the start, you can count on the support provided by Fraunhofer IESE with its 360° Diagnostics Center and many other testing procedures available to its partners. Because we believe that your success is based on the quality of your decisons, your processes, and your products.

■ Mario Trapp
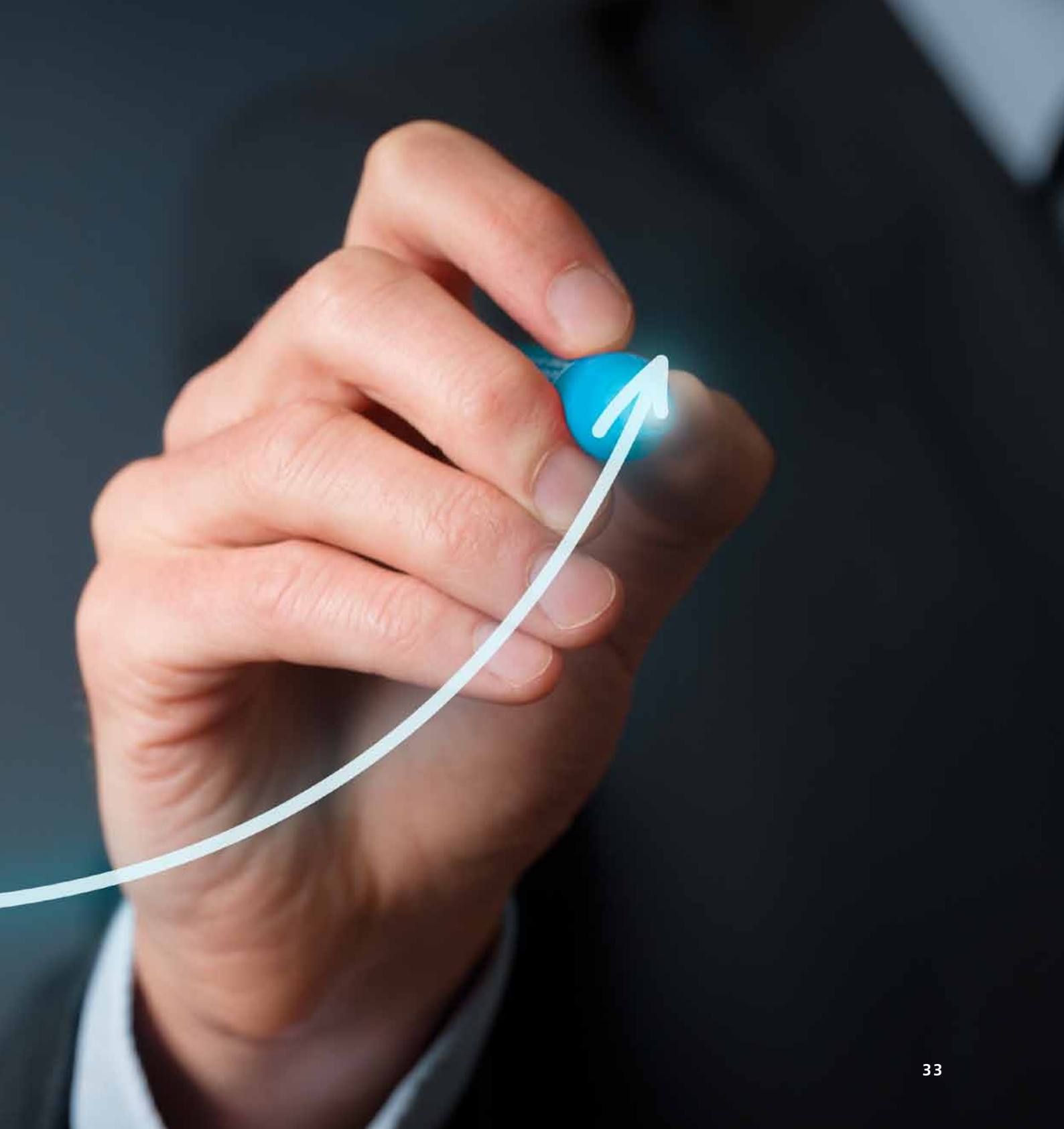
SEMINARS FOR EXPERTS

SEMINARS AT FRAUNHOFER IESE – ALWAYS A STEP AHEAD

Fraunhofer IESE offers a broad range of scientific continuing education programs to interested individuals from industry as well as from research and academia. Seminars on software architecture and requirements engineering, and a large selection of seminars from the competence areas Processes form the core of the continuing education offers by Fraunhofer IESE. In addition, we are collaborating with the University of Kaiserslautern in offering the career-compatible Master degree program "Software Engineering for Embedded Systems". Current dates and offers can be found on our website:

www.iese.fraunhofer.de/en/seminare_training.html

20th seminar on software architecture – using software architectures pragmatically

In 2016, the 20th seminar on software architecture was held. The planning for the next seminars is running at full speed. The software architecture seminar is one of the most sought-after continuing education and training programs of Fraunhofer IESE. Software architectures contribute significantly to success in the development and evolution of software systems. Construction plans for properties, behavior, and structures of software are defined by software architectures. In the seminar, the participants learn how to use software architectures in their company. After the seminar, the graduates know how to define, use, and

evaluate software architectures on their own. The seminar is offered by the Fraunhofer Academy and Fraunhofer IESE both in Kaiserslautern and as in-house training. The next dates can be found on our website:

www.iese.fraunhofer.de/en/seminare_training/softwarearchitecture.html

Certificate program Data Scientist – packaging and analyzing huge data sets

Since 2016, the Fraunhofer Big Data Alliance has been offering a three-step certificate program "Data Scientist". Data scientists have a partiuclar mix of competencies from the areas of computer science, statistics, and mathematics. More and more companies are recognizing that they need experts who can master the potential of the available data sets. In the first step of this new continuing education program, the basic certificate "Data Scientist Basic Level", the participants are taught a broad range of knowledge to help them work efficiently in data science teams. Taking into account data protection and security, the participants learn how data engineers describe and integrate data, or how software engineers use databases and distributed calculation methods to develop stable and scalable Big Data systems. In this context, Fraunhofer IESE is in charge of teaching the topic area "Potential Analysis for Big Data". The training concludes with an examination to obtain the certificate "Data Scientist – Basic Level". To register, learn about further constraints, and take a look at the curriculum, go to:

www.bigdata.fraunhofer.de/de/datascientist/seminare/zertifizierung.html

WE SET TRENDS

"We understand our clients and know their challenges of tomorrow. Together we develop integrated solutions for their long-term success."

From the Guiding Principles of the Fraunhofer-Gesellschaft

SYSTEMS ENGINEERING

FROM SOFTWARE ENGINEERING TO SYSTEMS ENGINEERING

The general trend towards digitization leads to various challenges that must be mastered with regard to system development. Autonomous driving, Industrie 4.0, Internet of Things, or Big Data stand for innovations for which software is the enabler. Understanding hardware and software development processes as a single entity is the basic prerequisite for efficient systems engineering. This trend from software engineering to systems engineering is reinforced by the fact that systems are being integrated beyond the boundaries of their traditional domains.

From June to August 2015, Fraunhofer IESE performed a series of interviews at 18 important companies from various domains in order to find out which challenges they see in the area of systems engineering and what their best practices are in terms of the technologies, methods, and tools they use to address these challenges.

The complete report is available via our website. The main results include, among others:

- Trends in product development: Companies are mainly driven by the increasing complexity of system requirements (aspect mentioned by 60%) as well as by the ever increasing number of product variations requested by their customers (mentioned by half of the companies).
- Importance of systems engineering: On a scale from 1 (not important) to 10 (essential for survival), the average importance of systems engineering is 7.6 and will rise within the next five years to 8.5.
- Challenges for systems engineering: 80% reported that change management within the company is the no. 1 challenge, followed by management of complex requirements and interfaces.
- Systems engineering process: The larger companies cover practically every process area of ISO/IEC 15288 and 12207, whereas the SMEs clearly focus on technical processes and implementation processes.

- Systems engineering practices: Regarding already established practices, the companies mainly (close to 50% or more) selected methods, technologies, and approaches dealing with model-based development, requirements engineering, test-driven development, as well as verification and validation.
- Specification languages and tools: More than 80% of the participants named UML as the most important relevant specification language. Large companies tend to use SysML as a more concrete language for system modeling. More than 50% of the systems engineering tools mentioned are related to the modeling of various aspects of the overall system or of the software as part of the system.
- Improvement potential: The greatest improvement potential for systems engineering lies in more virtual engineering and better integration of the tool chains used; 50% of those surveyed mentioned these two areas.
- Systems engineering capabilities: The majority of the companies/business units rely on internal and external training programs to improve their systems engineering capabilities. In addition, participation in systems engineering conferences was also mentioned.

Based on these main results of the study, several recommendations and action areas can be derived for companies planning to do systems engineering:

- Organizational development: Companies should establish the right change management strategy for the introduction of systems engineering practices and build up suitable competencies in systems engineering in general and in software engineering in particular. Especially larger companies should think about how to manage their portfolio of different systems engineering projects.
- Technical development: Companies should develop and integrate a systems engineering approach that includes all stakeholders and that establishes practices in the areas

of system requirements development, model-driven system development, as well as system verification and validation. More mature companies should prepare themselves for the establishment of practices in the areas of virtual systems engineering and integrated systems engineering tool chains.

■ Jens Heidrich
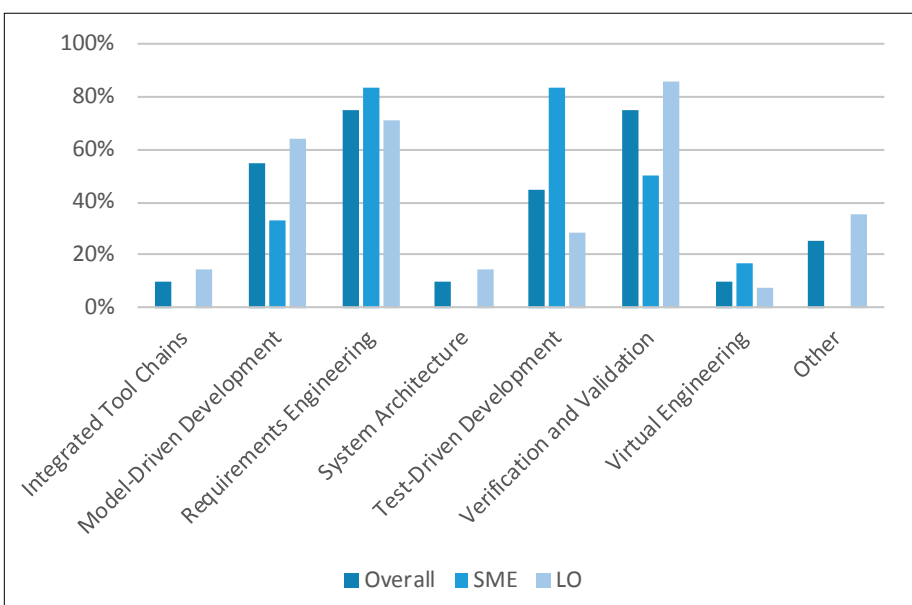
The most important established systems engineering practices

INDUSTRIE 4.0

INDUSTRIE 4.0 IS GAINING GROUND

The economy is on the cusp of the fourth industrial revolution. Manufacturing companies must adjust to ever greater volatility of the markets, new global competition, increasing numbers of variants, and increasingly customized products all the way to lot sizes of 1. Production lines that can realize very small lot sizes efficiently and cost-efffectively require a significantly higher degree of flexibility. Change effort and cost must be reduced significantly in order to achieve the required degree of flexibility. This calls for new, decentralized system architectures that focus on the flexibility of the production. Suitable production means must be found, assessed, selected, combined, and configured rapidly. To do so, a degree of networking and consistency unknown to date is necessary, which is not achieved in today's plants.

The core aspect of Industrie 4.0 consists of making use of the advances in information and communication technologies (ICT) in order to deal with the new challenges. ICT thus increasingly permeates production and its machinery and plants and is thus becoming a key technoloy for the smart and networked factory of the future.

Management shells are the central concept that enables efficient communication in Industrie 4.0 plants. They are digital representations that exist for all physical and non-physical entities. They provide uniform interfaces that make the current status of an entity available at any time and allow accessing the services of this entity. These interfaces are independent of whether the represented entity is a machine, a human, or an order. Real and simulated entities are both represented by management shells with the same interfaces. This makes it possible to virtualize individual entities or complete production lines – even mixed operation using real and virtual entities is possible.

In the context of the flagship project BaSys 4.0 of the German Federal Ministry of Education and Research (BMBF), which is being coordinated by Fraunhofer IESE, an international consortium consisting of 15 leading companies, universities, and research institutions is developing a middleware as a reference implementation for Industrie 4.0, which implements, among other things, the concept of management shells as "digital twins". Digital twins enable secure, overarching communication between all units involved in production. Uniform interfaces ensure that this communication takes place independent of the manufacturer and the technology.

The middleware resulting from the project BaSys 4.0 is being realized as an open standard. All interfaces as well as the reference implementation are made openly available. The Eclipse Foundation, which is involved in the project as a partner, ensures the availability of the implementation. From summer 2017, a first prototype will be made available under an open-source license.

Interdisciplinarity is the key factor driving the resolution of upcoming challenges in new technology R&D. The fourth industrial revolution will only be successful if partners from various domains – computer science, electrical engineering, information technology, and mechanical engineering – develop joint solutions. In order to strengthen this interdisciplinary procedure in the long term independent of individual projects, the High-Performance Center "Simulation- and Software-based Innovation" was founded in Kaiserslautern. This Fraunhofer High-Performance Center bundles the competencies on site and offers a framework for communication between disciplines and for working jointly on new topics.

■ Thomas Kuhn
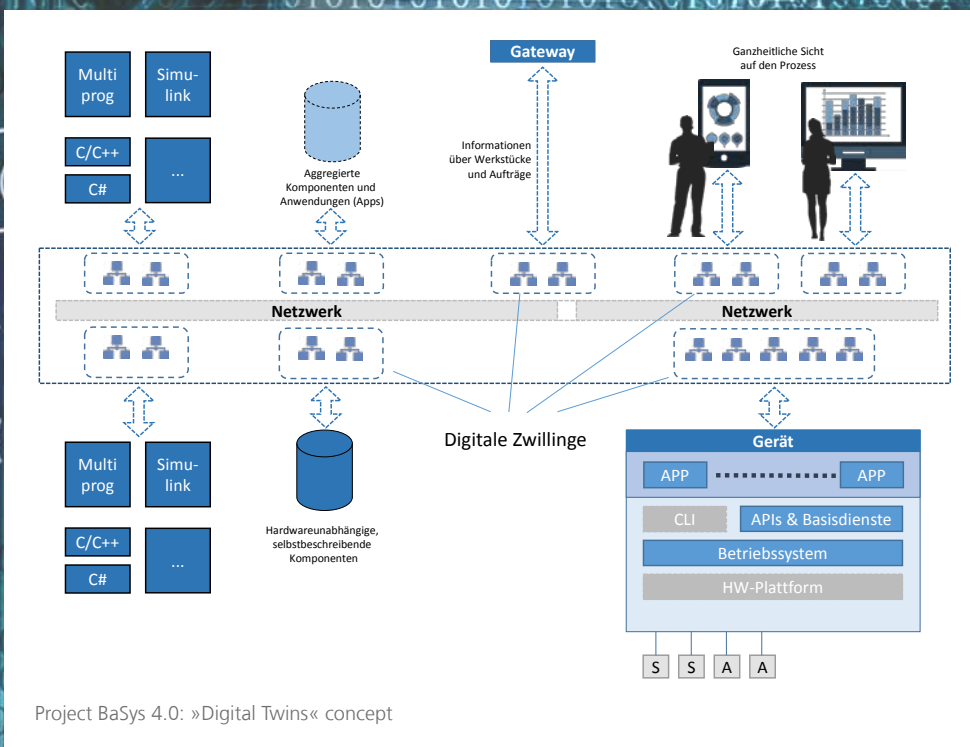
Project BaSys 4.0: »Digital Twins« concept

CYBER-SECURITY

CYBER-SECURITY IS BECOMING AN URGENT TOPIC

We are living in an ever more closely interconnected world. Today, we all own numerous devices that can connect with the Cloud or with each other. Some of these devices even need to interconnect in order to exploit their full functionality. Mobile devices such as smartphones, smartwatches, or fitness trackers only represent the start of ever tighter networking among devices and services. For example: My car connects with my smartphone, reads incoming messages to me, shows me information about the weather, or suggests possible service dates at the repair shop. To do so, the vehicle communicates with various Internet services, with the manufacturer, and potentially also with other road users. My TV automatically updates itself via the Internet. In my smart home, my refrigerator informs me about my supply of milk; the heating system tells me on my smartwatch what the current room temperature is, and I can comfortably adjust my preferred temperature for my personal well-being remotely. These and many other possibilities are the result of comprehensive interconnection and networking among services and devices. This is the so-called Internet of Things: Everything is smart and interconnected.

This networking is also becoming common in the area of industry, of course. Production machines are interconnected among each other and with the manufacturer. Machine manufacturers can be informed about problems early on and can prevent failures through smart maintenance, or can at least reduce them to a minimum. Logistics and production sites can be coordinated with each other so that runtimes and storage areas can be optimized, for example. Such possibilities and others are core elements of the so-called Industrie 4.0.

The possibilities sketched above only represent a fraction of the actual potential of comprehensive networking. All of this requires extensive sharing of data among the different services. There is a reason why data are also called the new oil, or the 4th production factor. You may or may not agree with these statements, but one thing is certainly true: Data are valuable!

Unfortunately, this brave new world also has its downsides. Valuable data arouse the interest of criminals. The value of data may be their business value, but privacy is just as valuable. Cyber-crimes nowadays cause significant economic damage in Germany. According to Bitkom, the losses for the German industry amount to more than 22 billion euros, and in the meantime every second company (51%) has fallen victim to cyber-crimes. Thus it comes as no surprise that many companies are rather hesitant when it comes to data sharing. Data are often not made available – but this excludes the company from new, innovative business models.

This does not need to be the case, however. The research area of data usage control offers suitable concepts for allowing data sharing without losing data sovereignty. Ultimately, what is of interest is not mere access, but rather the intended usage purpose. For instance, data access can be restricted to specific usage purposes or limit access frequency. The component-based IND²UCE framework provides the technical implementation of the theroetical concepts of data usage control. Its benefits have already been demonstrrated successfully in different application areas (incl. mobile systems, enterprise software, Industrie 4.0, Cloud).

Currently, the benefits of data usage control are being tested in diffferent research projects (incl. Industrial Data Space, IUNO). Together with industry, the product maturity of the IND²UCE technology is being pursued vigourously.

■ Christian Jung

Flexible data control in the digital world

DATA USAGE CONTROL

IND²UCE enables companies to exploit the potential of data-centered business models and at the same time avoid data misuse!

Find out more: **www.ind2uce.de**

IND²UCE
SECURITY

LET'S TALK ABOUT... THE TREND TOPIC CYBER-SECURITY AND DATA USAGE CONTROL WITH IND²UCE

The Fraunhofer-Gesellschaft has identified the topic of cyber-security as one of its strategic topics. Increasing interconnection and huge amounts of data lead to an extreme increase in the need for data protection solutions. Division Head Dr. Jörg Dörr explains how companies can exploit data potentials securely by using the IND²UCE technology of Fraunhofer IESE, and which role this solution plays in the Industrial Data Space of the Fraunhofer-Gesellschaft.

In 2016, the first ever Cyber-Security Day was organized in Berlin. Which security issues were the biggest problems for the participants?

The range of challenges is really wide. There are classical issues such as the need for innovative processes in the area of encryption or innovative authentication possibilities. And then there are the new challenges in the area of data sharing, for instance in the context of Industrie 4.0. This automatically leads to the topic of privacy. Sometimes from the developer perspetive, sometimes from the perspective of the company that does not want to release its data so easily, considering them a sensitive item. Here, in particular, our IND²UCE solution comes into play as a strong solution in the area of distributed data usage control.

Which domains are affected particularly strongly by the issue of security in data sharing and are increasingly looking for solutions?

The classical domains in the area of digital services have long needed to deal with the challenges posed by data sharing. But as a result of the strong networks and the ubiquity of topics such as Big Data and Industrie 4.0, we now observe more discussions in practically all domains about the fundamental question: Do I lock up my data? Then they will be secure, but then I will not be able to benefit from them to the same extent as if I combine them with partner data and analyze them. This

leads to thinking in terms of black and white, which often impedes innovative business models.

What is the approach taken by the IND²UCE solution?

IND²UCE is a product-mature technology developed at Fraunhofer IESE that companies can use to implement data usage control in their products. Interestingly, this concept is known to very few companies only and is often confused with access control. However, data usage control extends classical access control mechanisms and develops solutions for the comprehensive control of data usage. The underlying idea is to create comprehensive control possibilities that users can employ to control the usage of their data in a fine-granular way. And to allow them to do so even after they have granted access to their data to others. This makes it possible to overcome the above-mentioned thinking in black and white terms and to use data for innovative business models. At the same time, whoever decides what may be done with the data continues to keep control over the data. He or she can, at any time, update the guidelines and thus restrict or expand the usage purposes of the data.

Can you explain with some concrete application cases how IND²UCE works?

We have tested IND²UCE in a large number of concrete application cases: in the Cloud area, where the issue is to detect

migration of data out of the country; in the area of health care, where the issue is to allow sensitive end-user data to be used or not depending on the context; or in the financial industry, where we can, for instance, detect and prevent mass access to data.

Which organizations can use IND²UCE and how does the integration of the security framework into the organizational infrastructure work?

IND²UCE is a technology from which all organizations, no matter whether large or small, from the finance industry or the automotive industry, will be able to benefit. It can be used as a Cloud service or can be embedded specifically into the customer's existing system landscape. Typically we employ a lightweight, standardized potential analysis to determine the added value of the use of IND²UCE for our customers. Prior to integration into the productive envrionment, a proof of concept is performed.

IND²UCE received the EARTO Prize in 2014. How has the solution evolved since then?

Quite a lot has happened since then. Back then we used demonstrators to show the social and economic benefits for organizations. Today we have a mature technology, which has already been used in initial customer projects.

How can IND²UCE be delineated from the Industrial Data Space of the Fraunhofer-Gesellschaft? Where are the differences?

We are frequently asked about the delineation between the two technologies. Mathematically, it is best to use a Venn diagram for comparison: There is a cut set between the Industrial Data Space (IDS) and IND²UCE. And this is intentional. It is not without a reason that Fraunhofer IESE contributes its IND²UCE technology to the IDS to realize data usage control in the IDS. But this is just one of many topics in the IDS. On the other hand, the use of IND²UCE is not limited to applications in industry, and some features of IND²UCE, which are not needed in the IDS, can unfold in other areas.

PERSONAL DETAILS

Dr. Jörg Dörr has been Head of the "Information Systems" Division at Fraunhofer IESE in Kaiserslautern since 2010. Before that, he spent five years as Head of the "Requirements and Usability Engineering" department. His work in research and transfer projects centers on requirements engineering with a focus on non-functional aspects, which was also the topic of his PhD, which he completed in 2010. He studied computer science at the University of Kaiserslautern, Germany, with a minor in electrical engineering. Since 2002, he has been working at the Fraunhofer Institute for Experimental Software Engineering IESE. Jörg Dörr has comprehensive knowledge in the area of requirements engineering for software and systems engineering. He manages various training, technology transfer, and research projects in industry, and is the author of more than 70 academic and industry-related publications. Since 2006, he has been working as a university lecturer on the topic of Requirements Engineering. Jörg Dörr is actively involved in the GI (Gesellschaft für Informatik e.V.; German Informatics Society), was the spokesperson of the special interest group Requirements Engineering for several years, and is a founding member of the GI Regional Group Kaiserslautern. He is also the technical lead of the User Group Requirements Engineering of the Softwareforen and active in various national and international program committees.

LET'S TALK ABOUT... THE TREND TOPIC SMART RURAL AREAS

As an innovation driver, Fraunhofer IESE is in charge of strategic initiatives aimed at solving future challenges. One of these topics is Smart Rural Areas. Division Head Dr. Mario Trapp tells us in this interview how digitization can empower communities in rural areas and presents his vision for life in rural areas in the future.

SRA stands for Smart Rural Areas. But what exactly do you mean by that?

SRA is a research program aimed at solving the challenges in rural areas with digital solutions. The idea arose from discussions about Smart Cities. In the end, it turned out that the actual problems in the areas of mobility, medical care, or public services are found in rural areas and not in the cities. In SRA research we are studying how this deficit in rural areas can be offset by interconnecting a wide variety of different systems and companies across domain boundaries in order to automate workflows and increase efficiency. And this is also exactly the idea of Smart Ecosystems, which is the central research topic at Fraunhofer IESE. Our idea is to use our competencies from there to develop digital solutions for rural areas.

So this project perfectly matches one of your guiding principles, namely, to contribute to a socially balanced world with research. How can you help to get society closer to this goal with SRA?

Two thirds of the German population are living in rural areas. Also, almost two thirds of German companies are located in the countryside. Rural areas thus have great societal relevance. At the same time, cities appear to have greater economic attractiveness for many companies, as the purchasing power is concentrated in a smaller area and is thus easier to reach. This

creates the risk that a large part of the country will increasingly drift out of focus. To date, all digitization measures have aimed at making cities smarter. But due to different challenges, these solutions cannot be transferred to rural areas as-is. Being a part of Fraunhofer, we consider it our task to also focus our research on rural areas and to contribute to the realization of equal living conditions in the city and in the country. In the end, people should be able to decide freely where they want to live, and not be forced to move to large cities because the living conditions in rural areas are worse.

In the meantime, you occupy a pioneer position both nationally and internationally with your research topic SRA and your Living Lab "Digital Villages". Which role do you as Fraunhofer IESE want to play in the future when it comes to the topic of SRA?

In 2015, we started with the project "Digital Villages" in Rhineland-Palatinate, and since 2016 we have been active in Bavaria with the project "eVillage". We no longer receive inquiries only from other German states – other countries have also become aware of us. Nationally and internationally, rural areas have to deal with similar challenges, and many are hoping for support on the basis of our solution. This shows us that we have struck a chord with our idea. Now the next step will be to raise the topic of SRA from individual projects to the next level, with the

aim of developing a platform "Digital Rural Areas", as a central lynchpin in a state-wide or national infrastructure. We want to build a joint digital ecosystem in which all municipalities in the country can participate. This shall help to create a platform that can fulfill the quality demands of users today and which, as an ecosystem, will give municipalities sufficient freedom at the same time to adapt it to their own requirements. In addition, municipalities, companies, and start-ups will get the chance to contribute their own solutions and concepts. In order to be able to achieve this, we must build up a partner network and make use of the broad competence of the Fraunhofer-Gesellschaft. Only then can we cover all facets of rural life. We see ouselves in the central role of building the digital ecosystem, but also consider ourselves a part of a partner network within the Fraunhofer-Gesellschaft and with competent partners from government, business, and various associations.

How can we envision Society 2.0 in rural areas in the near future in the overall context of Smart Ecosystems?

Digitization alone cannot be the solution for rural areas, but it can help to empower communities by making it possible to reach a larger group faster and easier. It interconnects people, things, and services. If I look at current carpooling platforms, I can directly reach hundreds of people in my region who can give me a ride – and I don't even need to make a single phone call. The coordination – from the times via the route to the compensation for expenses – is performed by the digital system, meaning that many things can be done easier, faster, and in a less complicated manner. Digitization also helps in automation. It relieves us of work, as I can, for example, loan my car to someone, and everything, from the payment to the insurance cover, is taken care of by the software. One major aspect is that digital innovations such as autonomous driving will bring us completely new concepts of mobility. The case is similar for medical care. Telemedicine systems will allow closer and faster medical care than what is possible today. The complex billing mechanisms and the coordination among different doctors and

nursing stations will be handled invisibly in the background by digital systems so that we will have less work to do and thus will have more time to spend on the more important and nicer things in life.

PERSONAL DETAILS

Dr. habil. Mario Trapp is Head of the "Embedded Systems" division at the Fraunhofer Institute for Experimental Software Engineering IESE. Following his PhD in 2005, he moved to Fraunhofer IESE, where he was initially responsible for the topic area Safety-Critical Software as a department head before becoming Division Head in 2009. For more than ten years, he has provided advice to internationally leading corporations as well as to small and medium-sized enterprises in almost all branches of industry regarding the development of innovative embedded systems. The focus is on innovative software and systems engineering methods that make it possible to efficiently develop new software-based innovations and at the same time guarantee the reliability and safety of the systems. Mario Trapp is also the author of more than forty international scientific publications and teaches as a lecturer at the Department of Computer Science of the University of Kaiserslautern.

PROJECTS –
HIGHLIGHTS 2016/2017

"We promote a well-balanced com-
bination of excellent research and
application-oriented development.
This unique characteristic motivates
us and achieves added value for our
partners."

From the Guiding Principles of the Fraunhofer-Gesellschaft

IUNO – IT SECURITY FOR INDUSTRIE 4.0

The term Industrie 4.0 stands for the tight interconnection between industrial production and modern information and communikation technology, which enables networked, highly flexible, and highly efficient production and logistics beyond company boundaries. For Germany as a globally leading industrialized nation, Industrie 4.0 represents an important key technology. However, the increasing digitization of production, "smart" components, and networking across sites and applications also lead to higher vulnerability, which could open the door to industrial espionage, manipulation, or sabotage. At the same time, the established security concepts for information systems cannot be transferred as-is to production plants: In contrast to office IT, production plants cannot simply be turned off or restarted to defend themselves against attempted attacks, and production systems often only have few IT resources that can be used for IT protection mechanisms.

In the research project IUNO, the national reference project on IT security in Industrie 4.0, threats and risks for networked production are being identified, and protective measures are being developed, implemented, and tested in four application cases. The aim is to develop solutions for IT security challenges in industrial application environments that can be used as generally as possible. The IT security solutions developed in IUNO can be used as a template for secure Industrie 4.0. This will be beneficial particularly for small and medium-sized enterprises that have so far decided against digitization of their production due to incalculable economic risks.

In the context of IUNO, 14 German industrial companies and seven universities and research institutions – including the Fraunhofer institutes AISEC, SIT, and IESE – are studying security concepts for smart production. The project is being funded in the context of the German federal government's research framework program on IT security, "Self-Determination and Security in the Digital World 2015-2020".

IUNO
50
Nationales Referenzprojekt
IT-Sicherheit in Industrie 4.0

PRO-OPT – PRODUCTION OPTIMIZATION IN SMART ECOSYSTEMS

Everyone is talking about Big Data. Ever greater amounts of data are becoming a challenge that the German economy will have to address in the near future. The value of a company is increasingly found in its data and can only be fully exploited if these data are used efficiently throughout the entire value chain. In the context of the technology program "Smart Data – Innovations from Data" of the German Federal Ministry of Economic Affairs and Energy, the project "PRO-OPT – Big Data Production Optimization in Smart Ecosystems" makes a key contribution using the example of the automotive industry. It will enable companies to analyze large data sets in smart ecosystems across sites and across companies, to visualize them, and to securely share internal and external data while complying with usage restrictions. The goal is to improve production and to increase product quality. This will allow the German economy to respond to the challenges posed by the digitization and automation of

production: taking into consideration access authorizations, the ever larger data sets from different, economically independent participants will be made usable efficiently.

Opti4Apps – IMPROVED QUALITY MANAGEMENT THROUGH AUTOMATED COLLECTION OF USER FEEDBACK

In order to present an innovative digital idea on the market as quickly as possible and to achieve early return on investment, providers consciously accept releasing a product with limited quality and functionality. This is frequently the case for mobile applications. The challenge for the provider lies in quickly optimizing the mobile application following its release by applying a suitable quality assurance approach, as it will otherwise not be accepted by the market and economic losses may result. In order to increase and expand the potential of this minimalistic development approach, the partners in the BMBF-funded joint project Opti4Apps are developing and testing a quality assurance method that takes user feedback into account early and quickly and also focuses on typical flaws in mobile service applications. Such feedback comprises information about the

actual use of the applications as well as explicit statements by the users. The resulting more agile response of the provider to usage behavior and derived requirements will increase the product acceptance of mobile applications.

FUJITSU EST – FASTER RELEASES WITH DEVOPS

Nowadays, short development cycles and high software quality are two essential components of a company's success. For Fujitsu EST, the next step in further implementing these goals was to move in the direction of DevOps. Together with Fraunhofer IESE, it was first clarified what DevOps even means in this context and what exactly is to be achieved with DevOps. Selected DevOps practices were implemented incrementally and their success was measured. One major success of the joint project was the introduction of an almost completely automated deployment pipeline in a project, which allows making releases available significantly faster with improved quality. In addition, one of the crucial goals of DevOps was achieved, namely the closer intertwining of development and operation, and communication was improved as well. Another result of this success is that in the future, Fujitsu EST will share their experiences with DevOps both with their parent company and across the boundaries of their own organization in order to also provide support for others regarding the introduction of DevOps.

STuDi – SMART HOME TECHNOLOGY FOR AN INDEPENDENT LIFE AT HOME

In the context of the future program "Health and Care – 2020" and the "Initiative Healthcare Industry", an approach that was tested and proven in the predecessor project SUSI TD will be implemented sustainably in a model region in the project STuDi, and the prerequisites for transferring it into standard care, resp. into a feasible business model, will be identified. Widespread rollout will be further developed and tested in the context of smart home technologies. The technical platform, security aspects, as well as the possibilities for the user to participate will be optimized in order to improve their autonomy, independence, and quality of life. The financial burden on the senior citizens using STuDi is to be kept as low as possible. 100 households are to be equipped with a STuDi Smart Home System, which comprises, among other things, a target-group-oriented frontend incl. a service portal, as well as passive detection of helplessness. Particular attention will be paid to ensuring privacy.

DIGITAL VILLAGES – NETWORKS FOR RURAL AREAS WITH SMART CONCEPTS

Smart Cities – everyone is talking about networked cities. But how to use the benefits of digital technology in rural areas as well is the topic of investigation for researchers from Fraunhofer IESE in the project "Digital Villages", which is being conducted in collaboration with the state of Rhineland-Palatinate, the Rhineland-Palatinate Development Ageny, as well as the two Rhineland-Palatinate test municipalities Betzdorf and Eisenberg/Göllheim. The digital villages are all about evaluating concepts for creating networks among citizens using digital technology, in the sense of modern neighborhood support.

On the Digital Villages platform of Fraunhofer IESE, offers are available online that cover all needs of the rural population, from shopping and mobility to medical care. The system does, for instance, allow rural retailers to become online traders thanks to volunteers who deliver packages. Citizen volunteers pick up the ordered packages from the retailer and deliver them to the person who ordered the merchandise, or to a package station. The digital solution developed for this purpose is always running in the background.

The two model regions are pioneers both in Rhineland-Palatinate and for all of Germany in terms of digitization. The project "Digital Villages" demonstrates how smart life in rural areas can be in the future, because with creative digital solutions, life in the country can become easier in many areas.

PROJECT CARUSO – A SMART ECOSYSTEM FROM THE AUTOMOTIVE AFTERMARKET FOR THE AUTOMOTIVE AFTERMARKET

CARUSO is developing a neutral data and service marketplace for everything related to telematics sercvices for drivers, vehicles, and vehicle fleets. CARUSO helps its partners – outfitters, repair shops, suppliers, logisticians, insurance companies, parts dealers, and service providers – realize their business cases on the CARUSO platform. To this end, CARUSO offers supporting functionalities for networked services and data management.

This is a highly challenging mission, which CARUSO as a start-up in foundation (currently still under the roof of the TecAlliance GmbH as of January 2017) is leading as a joint initiative of many companies in the automotive aftermarket. This means that the chances of succcess are very promising, also because CARUSO can rely on the comprehensive expertise and the many years of experience of Fraunhofer IESE when it comes to designing and realizing the platform. Fraunhofer IESE supports this start-up in the design of the smart ecosystem, in the conception of a future-oriented and scalable architecture, in the generation and visualization of possible use cases and customer journeys via storyboards, as well as in the making of make-or-buy decisions, in the evaluation of different candidates for the basic platform, and in scouting for partners and technologies.

THE ENERGY TRANSITION: ALSO A JOB FOR IT!

Software systems are the pioneers for the implementation of the energy transition. Networking, decentralization, and digitization are central building blocks for the success of the energy transition. Only if the digital IT platforms for energy supply and management are trustworthy, safe, secure, and reliable will they achieve broad acceptance on the part of all stakeholders. The crucial thing is to achieve the quality of these software systems right from the start – in other words, by design.

This is exactly the goal to which Fraunhofer IESE is dedicated in various projects. Together with members of the asssociation StoREgio Energiespeichersysteme e.V. and other partners, Fraunhofer IESE is, for example, involved in the project **"Flex-4Energy"**, where a safety concept is being developed for a trading platform for flexibility potentials on the level of distribution grids (this project is funded by the German Federal Ministry of Economic Affairs and Energy BMWi). Furthermore, Fraunhofer IESE is also taking part in two major projects of the BMWi program **SINTEG (Schaufenster intelligente Energie)**. In the project **"Designetz: Baukasten Energiewende – Von Einzellösungen zum effizienten System der Zukunft"**, demonstrators for a successful energy transition are being im-plemented in Northrhine-Westphalia, in Rhineland-Palatinate, and in the Saarland. In this context, Fraunhofer IESE is setting up data usage control for protecting privacy and for preserving business secrets, and is developing smart data approaches for flexibility management in rural areas. In the SINTEG project **"enera: Der nächste große Schritt der Energiewende"**, regional system services are being tested in Lower Saxony that will stabilize the grid locally and further increase the reliability of the energy supply on the basis of renewable energy. Here, Fraunhofer IESE is in charge of performing a safety and security audit of the resulting software systems.

Fraunhofer IESE actively contributes to the topic of trustworthy software systems and provides innovative solutions for the central IT challenges posed by the energy transition – trustworthiness, functional safety, data security, data protection, and reliability. The results and experiences gained from its research projects make Fraunhofer IESE a competent source and partner when decisions have to be made about the development and operation of IT systems related to the topic of energy. In addition, Fraunhofer IESE provides important help and support to its partners already during the design of such systems.

ETAS GMBH OPTS FOR THE 360° METHOD

ETAS provides innovative solutions for the development of embedded systems for the automotive industry and other embedded industry fields. With its INCA software products, ETAS offers flexible tools for the application, diagnosis, and validation of electronic systems in vehicles. The tools are being used in development and series projects worldwide in more than 35,000 installations. In parallel to product maintenance of the version currently on the market, a new development is currently being implemented (INCA NextGen). Its development takes place at different sites.

Due to the high expectations of the customers regarding thiis product and the significant use of resources, the risks are to be assessed neutrally and objectively by an external team of experts (Fraunhofer IESE). The aim is to identify potential project risks and their causes and demonstrate possibilities for preventing them, respectively for early taking early countermeasures. To do so, Fraunhofer IESE employs the 360° Method, where – starting from the goals – the organization, the product, and the process are assessed (also see page 29).

ProKoB – FRAGMENTED APPLICATION OF SCRUM & CO.

The project ProKoB aims to enable an evolutionary transition to more agility in software development in order to address the challenges, resp, the improvement goals of SMEs. As SMEs can often not afford to launch extensive process improvements, such a transition helps to avoid changing the process disruptively from one day to the next. This is ensured by the establishment of a systematic catalog pf process components that describe concrete software engineering best practices. Depending on the improvement goal, the project context, and the company context, SMEs can identify suitable components via mutual dependencies among the process components and combine these with each other. Based on the selected process components, an individual, specific transition path is then suggested to the company. In addition, the components as well as an upload, search, and evaluation function will be made available to all German companies via a web platform. ProKoB is being funded by BMBF and DLR; Fraunhofer IESE is the consortium leader.

NEWS FROM THE CENTRAL STATE-WIDE TREATMENT CAPACITY INDICATOR (ZLB)

The selection of suitable hospitals that are ready to accept a patient and the registration of patients with illnesses or injuries where timely treatment is critical is frequently still a time-consuming and error-prone task for emergency medical services in Germany. With the ZLB, Fraunhofer IESE has created a state-wide, uniform information platform for emergency medical services and emergency dispatch centers in Rhineland-Palatinate that is suitable for modern emergency medical treatment concepts. Based on information about the place of the emergency, the diagnosis, the patient's age, as well as treatment sources expected to be required, the inquiring emergency medical vehicle receives, within the shortest possible time, information about the closest suitable hospitals that are actually able to accept the patient. In addition, the new DIVONO module (Digital Pre-Annoouncement of Emergency Patients) can now already digitally provide medically relevant information to the accepting hospital prior to the patient's arrival. To this end, a minimum data set about the announced emergency patient that is accepted by hospitals, dispatch centers, and emergency medical staff is transmitted electonically by the dispatch center and is displayed on a dashboard or PC monitor in the hospital.

IN DIALOG

"We cooperate with the world's best in science and business. This strengthens our own innovative capacity and that of the German and European economy."

From the Guiding Principles of the Fraunhofer-Gesellschaft

Dr. Mario Trapp and Prof. Peter Liggesmeyer in conversation with Johanna Wanka, Federal Minister for Education and Research, and Prof. Reimund Neugebauer, President of the Fraunhofer-Gesellschaft e.V.

RURAL AREAS ATTRACT PEOPLE – CEBIT ATTRACTS VISITORS

How to make life in rural areas more attractive with creative solutions was demonstrated by the Fraunhofer Institute for Experimental Software Engineering IESE at CeBIT 2016. With its research, the institute addresses the challenges posed by smart networking among systems and services in a wide range of areas and performs future-oriented research on so-called "Smart Ecosystems". In its research program "Smart Rural Areas", the focus is not on Smart Cities, but – and this is a first – on rural areas.

At the booth of the Fraunhofer-Gesellschaft, the Internet of Things came to life. At the demonstrator of Fraunhofer IESE, the audience was able to take on the role of the different stake-

holders and discover what the future in rural areas might look like with the help of "Smart Services".

In addition, the visitors had a chance to talk to the researchers of Fraunhofer IESE about the project "Digital Villages", which was initiated in the context of this topic. This project is about evaluating concepts for creating networks among citizens with the help of digital technology in the sense of modern neighborhood support. The first test phase in Betzdorf ended just in time for CeBIT. The results were already presented in Hanover. Two more test phases performed in May and October 2016 demonstrated in the two test municipalities Betzdorf and Eisenberg/ Göllheim which mobile solutions actually work.

HANNOVER MESSE 2016 – WITH TRANSATLANTIC COMPETENCE ON THE PATH TOWARDS INDUSTRIE 4.0

At the Hannover Messe, the largest industrial trade fair world-wide, US President Barack Obama presented the United States as the partner country and as an important provider of Industrie 4.0 technologies. In line with this, a genuine transatlantic part-nership was the focus at Fraunhofer IESE: The German institute demonstrated its international collaboration with its American sister institute, the Fraunhofer Center für Experimental Software Engineering CESE in College Park, Maryland, USA. A team of experts from two continents presented innovative systems and software engineering in the context of Industrie 4.0.

Exemplified by the research platform Concept Car, the visitors saw how the institutes are addressing the challenges faced in the development of future, strongly networked and highly automated vehicles with new processes for development and testing. In the context of Industrie 4.0, the Concept Car also supports new business models such as aftermarket purchasing of vehicle functions over the Internet.

NEW HIGH-PERFORMANCE CENTER BUNDLES COMPETENCIES

Since January 2016, the intensive sharing of knowledge among the three Fraunhofer institutes IESE, ITWM, IPM in Kaiserslautern and the two local universities, and the good cooperation with business have been institutionalized in a High-Performance Center. Its name, "Simulation- and Software-based Innovation", documents scientific strenghts that have evolved in Kaiserslautern in the past two decades. The participating industry partners include BASF SE, Daimler AG, John Deere GmbH & Co. KG, Liebherr, Procter & Gamble, Robert Bosch GmbH, Schmitz Cargobull AG, and Volvo Construction Equipment Germany GmbH. The Rhineland-Palatinate Minister President Malu Dreyer commented: "In Kaiserslautern, universities, non-university research institutions, and companies are working as one to develop innovative solutions for the great technological challenges of this day and age."

The three application foci of the High-Performance Center have emerged from existing strong local activities: Digital Commercial Vehicle Technology, based on the Fraunhofer Innovation Cluster DNT and the Commercial Vehicle Alliance; MSO-based

(from left to right) Dr. Mattias Schmidt, Procter & Gamble, Dr. Christoph Großmann, BASF, Prof. Dr. Dieter Prätzel-Wolters, ITWM, Prof. Dr. Arnd Poetzsch-Heffter, TU Kaiserslautern, Prof. Dr. Peter Liggesmeyer, IESE, Prof. Reimund Neugebauer, President of the Fraunhofer-Gesellschaft e.V.

Process Engineering, with strong partners such as BASF and Procter & Gamble; as well as Smart Ecosystems in cooperation with Bosch, John Deere, and the StoREgio Network.

FRAUNHOFER IESE STARTS BLOGGING

Since September 2016, there has been a Fraunhofer IESE Blog. It offers readers a chance to take a look behind the scenes of the researchers' work and the projects they are working on; furthermore, our authors provide statements on current trends and research topics. Fraunhofer IESE is looking forward to entering into a dialog with interested readers and hopes to discuss exciting topics with you. A look at the blog is definitely worthwhile: http://blog.iese.fraunhofer.de.

CVT SYMPOSIUM – FOCUS ON COMMERCIAL VEHICLES

At the international Commercial Vehicle Technology (CVT) Symposium 2016 at the University of Kaiserslautern, the focus was on international trends and technological developments specifically in the commercial vehicle industry. In the context of the symposium, Fraunhofer IESE organized a workshop on Big Data applications for commercial vehicles.

All roadmaps and future scenarios clearly show one thing: Between the product "commercial vehicle" and the customer, a service layer will get established that is aimed more strongly at the customer's business processes and which creates value – for manufacturers, service providers, and customers – particularly by linking systems and data. In this context, everyone is talking about "Big Data". But is it even worth investing into Big Data? What will future applications look like, how to make money with which data? How to significantly improve the energy and resource efficiency of trucks, buses, agricultural and construc-

tion machinery, or special-purpose vehicles using the right data support at the right time? The workshop provided answers to these questions.

FRAUNHOFER CYBER-SECURITY DAY

On 20 October 2016, the first ever Fraunhofer Cyber-Security Day took place at the Spreepalais in Berlin. The approx. 150 visitors enjoyed a varied program with interesting workshops and high-level talks. Among others, Wolf-Dieter Lukas from the German Federal Ministry of Education and Research (BMBF) talked about "Cyber-Security Research – a question of national sovereignty" and State Secretary Matthias Machnig from the Federal Ministry of Economic Affairs and Energy (BMWi) presented "Cyber-Security – the foundation of the digital economy in Germany". Following the conference, four industry workshops were offered for Automotive, Energy, Industrie 4.0, and Digital Services. Fraunhofer IESE organized the industry workshop Digital Services and presented its technical solution IND²UCE for data usage control and data protection.

UX-DAY – THE "HOW" IS WHAT IS IMPORTANT

"Today, the competition is won by whoever revolution-izes the user experience", say the organizers of the UX-Day, a conference on User Experience in e-commerce, marketing, and industry. Innovation is often no longer created through new technologies alone – intuitive access can be crucial for success. Good communication skills are an important prereq-uisite for nearly every role in user experience engineering. At UX-Day 2016, Fraunhofer IESE presented tips and tricks used by reporters, policemen, and lawyers for better UX stakeholder interviews under the title "We must talk!" The personal inter-view is still one of the most important instruments for eliciting and validating UX requirements. There are many techniques, methods, and tools that support us in planning the interviews and identifying the right stakeholders for these interviews. But no matter how well prepared and organized an interview is, the success ultimately depends to a major extent on the personal communication skills of the UX expert – and thus on the "HOW". Many tips and tricks from the above-mentioned

domains and disciplines can also be used in UX stakeholder interviews. This is not only true for the various phases of the actual interview, but also for the preparation of the interview as well as for the follow-up activities.

INTERNATIONAL COLLABORATION WITH TNO-ESI (THE NETHERLANDS)

For 20 years, Fraunhofer IESE has been collaborating with research instituitons and companies around the globe. In April 2016, another collaboration was added: On the fringes of the TNO-ESI Symposium, the annual scientific conference for embedded systems held in Eindhoven, The Netherlands, Fraunhofer IESE and the Dutch research organization TNO-ESI (Embedded Systems Innovation by TNO) signed a letter of intent regarding future research collaborations. The Organisa-tion for Applied Natural Science Research TNO is the largest research organization in the Netherlands. Just like the German Fraunhofer-Gesellschaft, TNO also focuses on applied research. The research group TNO-ESI is part of TNO and performs re-search in the context of embedded systems. In the future, lively exchange is to take place in this area on the scientific level. Plans include collaboration in areas such as research projects,

continuing education, development of research tools, exchange of scientific staff, as well as jointly offered services and projects.

RESULT PRESENTATION "DIGITAL VILLAGES" – THINGS ARE MOVING ALONG!

On 24 November 2016, Fraunhofer IESE presented the results of the citizen science project "Digital Villages" in Kaiserslautern. In the context of this project, Fraunhofer IESE had spent the last two years evaluating concepts for networking among citizens in the sense of modern neighborhood support through the use of digital technology in the "Digital Villages", the two test regions in Rhineland-Palatinate, Betzdorf and Eisenberg/Göllheim. One of the goals of the event was to give other municipalities a chance to take part in the results and to demonstrate to them the opportunities offered by digitization. In the context of the result presentation at Fraunhofer IESE, the guests were able to give the platform that had been tested in the Digital Villages and the associated apps a try and to talk with the researchers as well as with the mayors and community representatives from Betzdorf and Eisenberg/Göllheim.

Among the invited guests was State Secretary Randolf Stich as the representative of the State of Rhineland-Palatinate, who already indicated in November that the project was likely to continue. State Secretary Randolf Stich: "In the future, too, we must not only focus on urban areas. With the project "Digital Villages" we have embarked on the right path to make life in rural areas more attractive with the help of digital solutions. We do research with and for the people and see digitization as a motor for our rural areas. Therefore I am convinced that the project will continue."

The test phases have shown that the willingness to create networks via digital solutions and to volunteer in the community is immense. The project "Digital Villages" has proven: Digitization makes a difference in rural areas – today and in the future.

Randolf Stich, State Secretary at the Rhineland-Palatinate Interior Ministry, during the presentation of the results of the project "Digital Villages"

OUTSTANDING!

AWARDS, TITLES, APPOINTMENTS

"Our success relies on the knowledge and enthusiasm of our employees for applied research. Fraunhofer offers its staff excellent work conditions paired with a high degree of autonomy."
From the Guiding Principles of the Fraunhofer-Gesellschaft

PROF. DR. ATIF MEMON RECEIVES FRAUNHOFER BESSEL RESEARCH AWARD

In 2016, the Humboldt Foundation and the Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. presented the Fraunhofer Bessel Research Award to Prof. Dr. Atif Memon. In addition to his professorship at the University of Maryland (USA) in the area of computer science, the renowned researcher also works as a consultant for the Fraunhofer Center for Experimental Software Engineering CESE in Maryland (USA). CESE is the sister institute of Fraunhofer IESE in Kaiserslautern.

Prof. Memon received the awared, which is endowed with 45,000 euros, for his successful work in applied research to date. He is considered an internationally renowned, outstanding scientist. The focus of his research contributions is on model-based testing of interactive software systems with a special focus on graphical user interfaces (GUIs).

For the Fraunhofer Bessel Research Award, researchers from all countries outside Europe can be nominated whose success to date has already led to their recognition as internationally outstanding scientists. It is expected that they will have a sustainable impact on their area of specialization in the future through further top scientific performance, even beyond their immediate area of work.

SUCCESS AND HONOR FOR DR. MARIO TRAPP

With a habilitation thesis on the topic of "Safety Assurance in Open Systems of Systems (Safety in the Internet of Things and Cyber-Physical Systems)", Dr.-Ing. Mario Trapp, Head of the Embedded Systems Division at Fraunhofer IESE, successfuly completed his habiliation at the University of Kaiserslautern in February 2016. Shortly thereafter, success was followed by honor, as in June 2016 he was accepted by the Fraunhofer-Gesellschaft into the so-called "Vintage Class" – as one of only 20 members from more than 24,000 employees of the Fraunhofer-Gesellschaft.

The Vintage Class is an "Executive Management Development Program" of the Fraunhofer-Gesellschaft for scientific leadership staff with the potential to occupy leading positions in a Fraunhofer Institute. In the context of the program, the participants receive individual coaching via qualification components in the areas of strategic management, leadership, and self-competence. There is also support for networking within the scientific community, within Fraunhofer and outside, in science, business, and government. Coaching, mentoring, build-up of individual experience, as well as annual meetings are further parts of the program.

OUTSTANDING!

FRAUNHOFER SPIN-OFF OSSENO WINS START-UP AWARD 2016

OSSENO Software GmbH from Kaiserslautern, a spin-off of the Fraunhofer Institute for Experimental Software Engineering IESE founded at the beginning of 2015, has won the Start-up Award 2016. The award, which is worth several thousand euros, was presented in Pirmasens on 29 November 2016. The Science Alliance Kaiserslautern e.V. along with the Kaiserslautern Start-up Office presents this award to young companies that impress not only with an innovative product, but also with a solid business model.

Both the ReqSuite solution, a tool that supports requirements engineering, and the perfectly complementary founders' team consisting of Dr. Norman Riegel, Dr. Sebastian Adam, and Özgür Ünalan were the decisive reasons for the award. Unlike other requirements engineering tools, ReqSuite also allows smaller companies or those with limited expertise in requirements engineering to master such tasks in their development processes more successfully. In the future, it is planned to offer the product as a Cloud solution, resp. as Software as a Service, and to pursue internationalization.

Prof. Dr. Matthias Baum from the Chair for Entrepreneurship at the University of Kaiserslautern presenting the Start-up Award to Dr. Norman Riegel, Dr. Sebastian Adam, and Özgür Ünalan.

DIVISION HEAD DR. JÖRG DÖRR WINS BEST LECTURE

In October 2016, Dr. Jörg Dörr, Head of the Information Systems Division at Fraunhofer IESE, received the Instructor Award for his lecture "Requirements Engineering" at the University of Kaiserslautern. With this award, the student body of the Department of Computer Science of the University of Kaiserslautern recognizes particularly popular lecturers. The award is based on a survey among the students who attended the lecture of Dr. Dörr in the winter semester 2015/16.

PROKOB WINS BEST PAPER AWARD AT PVM

Every year, national experts meet at the PVM Conference of the Gesellschaft für Informatik e.V. (German Informatics Society, GI) for discussions on "Project Management and Process Models". Only ten papers were accepted in October of this year, including one about the research project ProKoB, where Fraunhofer IESE is the consortium leader (also see page 57).

Philipp Diebold, Anna Schmitt, Thomas Zehler (all from Fraunhofer IESE), Birger Kruse and Frank Simon (both from Bluecarat) presented the idea of ProKob as well as the first results obtained to the PVM conference audience. For their paper "Project Management Process Models 2016", the authors received the Best Paper Award 2016 of the PVM Conference.

Prof. Dr. Oliver Linssen, spokesperson of the IT Project Management Group of GPM/GI, presents the award to Philipp Diebold, Fraunhofer IESE

PROF. LIGGESMEYER APPOINTED TO THE STATE COUNCIL ON DIGITAL DEVELOPMENT AND CULTURE

On 4 October 2016, Minister President Malu Dreyer presented a dialog paper entitled "Digital Rhineland-Palatinate. We create networks for people in rural areas" and started a broad process in this context. Among other things, she presented the new State Council for Digital Development and Culture.

One of its members is Dr. Peter Liggesmeyer, professor of computer science at the University of Kaiserslautern, President of the German Informatics Society (GI e.V.), and institute director of the Fraunhofer Institute for Experimental Software Engineering IESE in Kaiserslautern. With the digital dialog, the state government intends to further develop digitization in Rhineland-Palatinate together with citizens and experts. Specific questions include, for example: How can rural areas remain attractive with the help of digitization? Which new forms of work will evolve, and what are our wishes regarding work in the future?

IESE institute director Liggesmeyer will advise the state government as a member of the State Council for Digital Development and Culture and contribute his expertise in the area of digitization in rural areas. This expertise is based, among other things, on the fact that Fraunhofer IESE has initiated the first real lab worldwide for digitization in rural areas in the context of its research initiative "Smart Rural Areas".

ABOUT US

"We emphasize the great variety and interdisciplinary cooperation of our institutes. Faithful collaboration and team work promote synergies and enhance our performance."

From the Guiding Principles of the Fraunhofer-Gesellschaft

OUR COMPETENCIES

FRAUNHOFER IESE

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

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

SCALABLE SYSTEMS ENGINEERING

Processes
Architecture
Data
Requirements

Safety
Security
User Experience

GUARANTEED QUALITY

ES/CPS ⇒ Smart Ecosystems ⇐ IS/Mobile

SOFTWARE-ENABLED INNOVATIONS
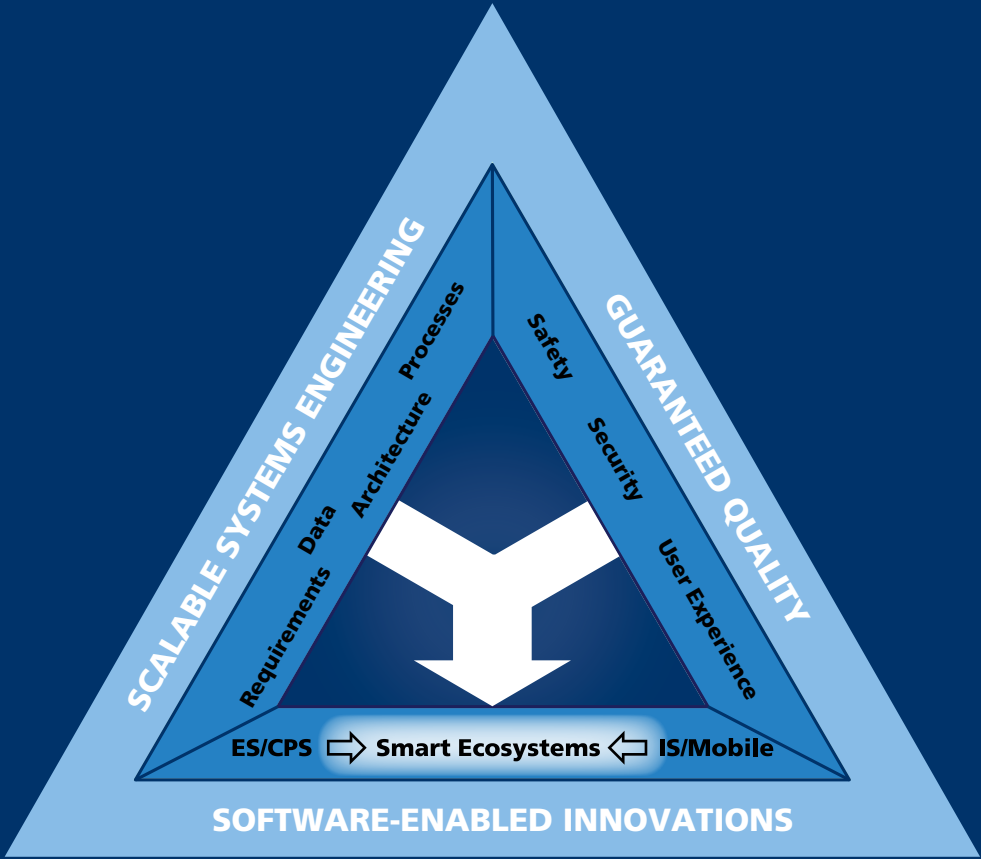
ENGINEERING + QUALITY ⇒ INNOVATION

SCALABLE ENGINEERING

The scalability of our methods helps you to master your individual challenges in a systematic and quantifiable manner – regardless of whether you are an SME or a major corporation.

PROCESSES Optimizing through transparency: Develop complex systems with the highest quality with our help, based on the definition, measurement, and optimization of software and systems engineering processes.

ARCHITECTURE Building upon 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 contribute to a great extent 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 intelligent ecosystems for a wide variety of application areas. Cross-domain interconnection and integration of systems, services, and applications play an ever greater role for topics such as "Industry 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

Rapid Innovation Lab

Efficient Engineering Solutions

360° Diagnostics Center
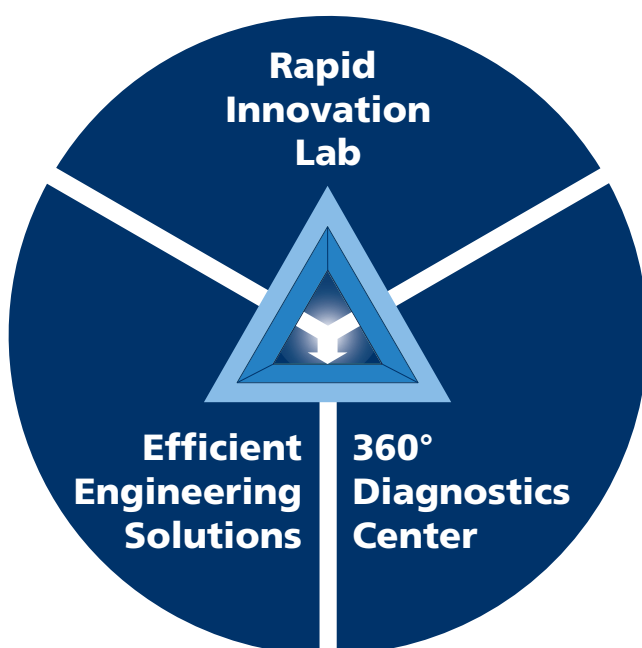
already predict what the expected quality of a system will be as soon as the first results are available in the development process. This makes it possible to check continually whether the development is still on the right track. Problems can be avoided before they even occur. For once a decision has 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 coach-

ing, 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
- Wittenstein, USA
- ABB, Sweden
- Project EMC², EU
- Project MANTIS, EU
- Project Q-Rapids, EU
- Project DEIS, EU

Special focal areas of the institute's international activities are the USA and Brazil. 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) and with the Fraunhofer Project Center for Software and Systems Engineering FPC in Salvador, Bahia, Brazil, which is affiliated with the Federal University of Bahia UFBA (since 2012).

INTERNATIONAL CENTERS

FRAUNHOFER CENTER FOR EXPERIMENTAL SOFTWARE ENGINEERING CESE IN COLLEGE PARK, MD, USA (AFFILIATED WITH THE UNIVERSITY OF MARYLAND)

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..

Throughout 2016, Fraunhofer CESE worked closely with customers in the aerospace and medical industries, government agencies, and research organizations. For instance, major customers included organizations such as NASA, the National Science Foundation (NSF), and Deere and Company. For these and other customers, Fraunhofer CESE evaluated, developed, and utilized state-of-the-art tools and techniques to support customer decision-making and implementation in systems, software, and acquisition areas. Fraunhofer CESE provided the critical skills and guidance that allowed its customers to ensure the viability and reliability of their systems and software and enabled them to identify and prevent security-related vulnerabilities. In addition to this applied research, Fraunhofer CESE also conducted innovative basic research projects supported by the NSF, 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 Analyses
- Software Design and Development
- Process Analyses and Improvement

In addition to its project work, Fraunhofer CESE is proud of the mentoring and training of interns by its researchers. In 2016, 16 interns from Reykjavik University in Iceland, the University of Mannheim and the University of Kaiserslautern, Germany, and the University of Maryland provided invaluable assistance in a wide variety of center projects.

Fraunhofer CESE will continue 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.

Further information:
www.cese.fraunhofer.org

FRAUNHOFER PROJECT CENTER FOR SOFTWARE AND SYSTEMS ENGINEERING IN SALVADOR, BAHIA, BRAZIL (AFFILIATED WITH THE FEDERAL UNIVERSITY OF BAHIA – UFBA)

The Fraunhofer Project Center for Software and Systems Engineering at UFBA (FPC-UFBA) is located in the Technology Park of the state of Bahia in Salvador. It brings together the research competence and industrial practice of Fraunhofer IESE and of the Software Engineering Laboratory of the Federal University of Bahia (LES-UFBA) to boost the development of innovative software solutions for the Brazilian industry.

Its team is composed of 30 scientists – including software engineers with industry experience, system analysts, and IT experts in the areas of emergency and energy management as well as Smart Cities. In publicly funded projects as well as industry projects, the Center's competencies are complemented by the competencies of Fraunhofer IESE and UFBA.

Since its foundation in 2012, FPC-UFBA has conducted projects for the Brazilian Ministry of Health, with oil and gas companies, as well as with automotive and manufacturing companies. Furthermore, it is active in the area of emergency management via a consortium sponsored by the EU and Brazil (RESCUER project). In 2016, the Secretary of Science and Technology of the State of Bahia commissioned FPC-UFBA to establish a Smart City Living Lab within the Technology Park, where interested partners will have the opportunity to quickly prototype, evaluate, and/ or demonstrate their innovative business ideas or outstanding

software engineering competencies. The year 2016 was also the energy management year at FPC-UFBA. Together with STI e.V. (Software Technology Initiative) and Fraunhofer IESE, the team coordinated several activities aimed at establishing an energy management network between German and Brazilian organizations. In the first concrete project (called SCIKE), German companies will collaboratively develop an energy data platform to support Brazilian business cases, including smart public illumination and management of production and/or consumption of energy.

In 2016, FPC-UFBA was audited by the International Development section of the Fraunhofer-Gesellschaft; the quality of its project results and professionals ensured its further joint operation. The plans of FPC-UFBA for 2017 are to continue to develop projects and solutions for the Brazilian industry and to disseminate innovative technologies in order to promote the development of the local industry and economic growth through software engineering innovations.

Further information:
www.fpc.ufba.br

OUR ORGANIZATIONAL CHART

Executive Director
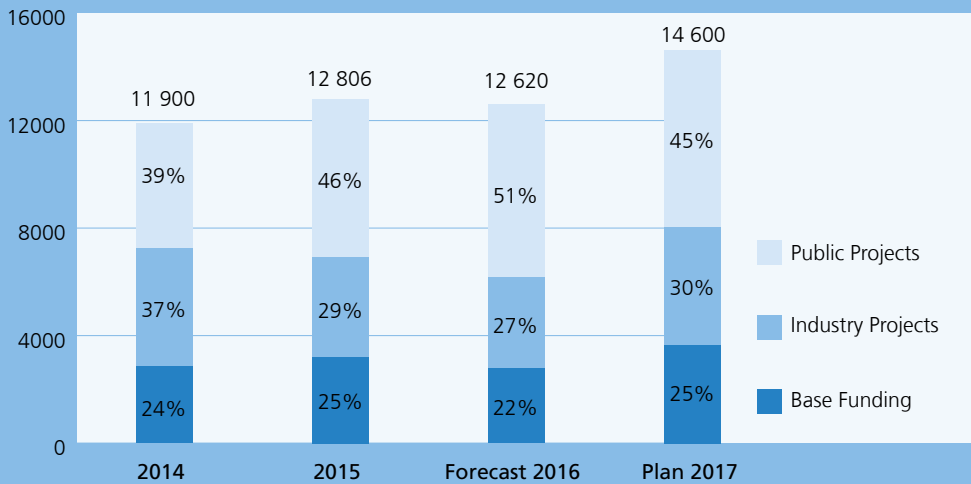Prof. Dr.-Ing. Peter Liggesmeyer

Deputy Director
Prof. Dr. Frank Bomarius

Director Business Development
Prof. Dr. Dieter Rombach

Division Embedded Systems	Division Process Management	Division Information Systems	Communication & Central Services	Business Areas	
				Autonomous & Cyber-Physical Systems	Digital Services
Dr. Mario Trapp	Dr. Jens Heidrich	Dr. Jörg Dörr	Nicole Spanier-Baro	Ralf Kalmar	Michael Ochs

Embedded Systems Engineering (ESY)	Data Engineering (DE)	User Experience and Requirements Engineering (UXR)	Corporate Communication & Technology Marketing	Automotive	Software Industry
Dr. Martin Becker	Dr. Andreas Jedlitschka	Dr. Marcus Trapp			
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			HR & Organization	Automation	Cross Industries
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			IT Services	Avionics	Healthcare
Dr. Daniel Schneider		Christian Jung			
			Facility Management	Energy Management	eGovernment

All contact information can be found at:
www.iese.fraunhofer.de/en/contact.html.

OUR INSTITUTE IN FIGURES

Development of Budget (in T euro)

	2014	2015	Forecast 2016	Plan 2017
Total	11 900	12 806	12 620	14 600
Public Projects	39%	46%	51%	45%
Industry Projects	37%	29%	27%	30%
Base Funding	24%	25%	22%	25%

Development of Costs (in T euro)

	2014	2015	Forecast 2016	Plan 2017
Total	11 900	12 806	12 620	14 600
Investments	4%	6%	3%	6%
Operating Costs	21%	25%	24%	22%
Personnel Costs	75%	69%	73%	72%

Development of Personnel in FTE (Full-Time Equivalents)

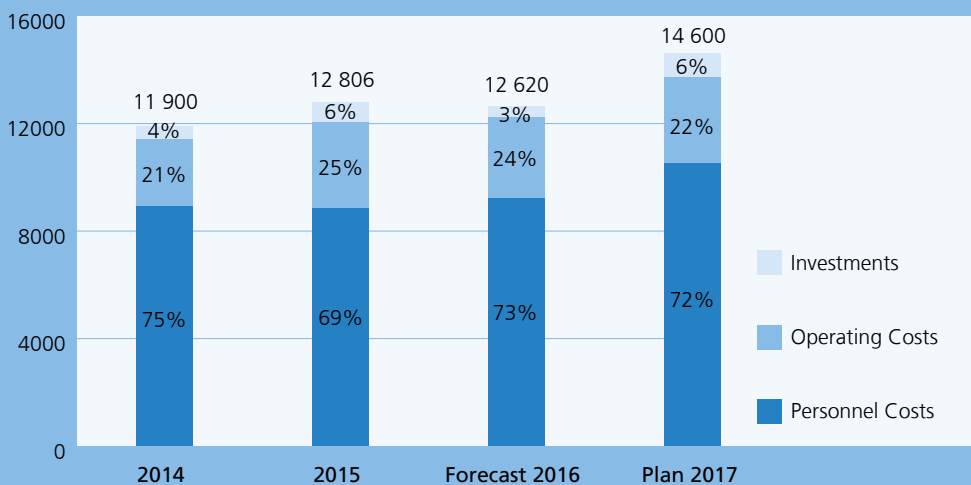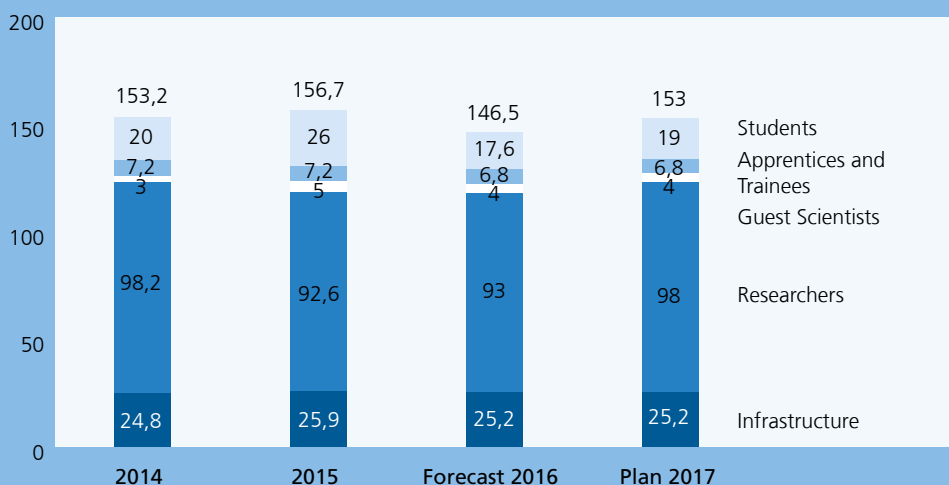|	2014	2015	Forecast 2016	Plan 2017
Total	153,2	156,7	146,5	153
Students	20	26	17,6	19
Apprentices and Trainees	7,2	7,2	6,8	6,8
Guest Scientists	3	5	4	4
Researchers	98,2	92,6	93	98
Infrastructure	24,8	25,9	25,2	25,2

Personnel and Budget Development

Over the last three years, the institute's budget has developed in a stable manner. In 2016, the focus was on further developing the research work on Smart Ecosystems in strategically relevant application areas such as Industrie 4.0 and Smart Rural Areas. For these, large strategic research projects could be acquired, which resulted in a funding focus on public revenues.

To complement the high amount of public revenues, growth in terms of staff and an increase in industrial revenues are planned for 2017.

OUR ADVISORY BOARD

The Advisory Board consists of representatives from research, industry, and government. The board members support the institute directors of Fraunhofer IESE with advice and counsel.
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Chair for Information Systems
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Prof. Dr. Helmut Schmidt
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University of Kaiserslautern
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Prof. Dr. Heinrich Daembkes
Elchingen | GER

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 69 institutes and research units. The majority of the 24,500 staff are qualified scientists and engineers, who work with an annual research budget of 2.1 billion euros. Of this sum, 1.9 billion euros is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 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.

THE SCIENCE ALLIANCE KAISERSLAUTERN E.V.

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, the University of Applied Sciences Kaiserslautern, ten renowned research institutes and research-oriented institutions, ten companies as well as numerous supporting members have joined forces to form the Science Alliance Kaiserslautern e.V.. Together they aim at boosting the city's reputation as a distinguished location in the field of research and academic studies at the regional, national, and international level.

The major topics include:

- Industrie 4.0 & Commercial Vehicles
- Health
- Energy

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

www.science-alliance.de

FULL MEMBERS

Hochschule Kaiserslautern University of Applied Sciences

TECHNISCHE UNIVERSITÄT KAISERSLAUTERN

DFKI — Deutsches Forschungszentrum für Künstliche Intelligenz GmbH

Fraunhofer IESE

Fraunhofer ITWM

ibwf — INSTITUT FÜR BIOTECHNOLOGIE UND WIRKSTOFF-FORSCHUNG

ifos — Institut für Oberflächen- und Schichtanalytik GmbH

iTA — INSTITUT FÜR TECHNOLOGIE UND ARBEIT

Institut für Verbundwerkstoffe

Max Planck Institute for Software Systems

Photonik-Zentrum Kaiserslautern e.V.

Westpfalz-Klinikum GmbH

AECOM

EMPOLIS INFORMATION MANAGEMENT

GENERAL DYNAMICS European Land Systems

insiders technologies

JOHN DEERE

MaTelSo Marketing . Telecom . Solutions

psb CREATING YOUR INTRALOGISTICS

SKS WELDING SYSTEMS

UPLINK IT

WIPOTEC

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