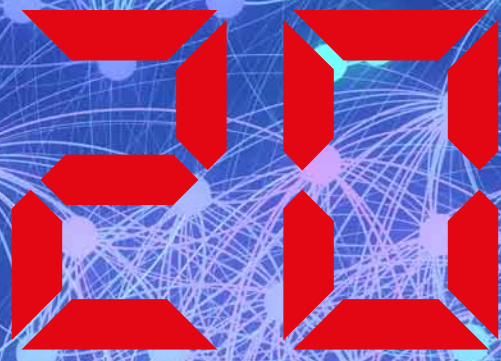




**Fraunhofer**

**IESE**

FRAUNHOFER INSTITUTE FOR EXPERIMENTAL SOFTWARE ENGINEERING IESE



**ANNUAL REPORT  
2015/2016**

# EDITORIAL



Dear readers,

Germany has a "Digital Agenda" and an "IT Summit" on the one hand. Important current topics based on computer science were conceived in Germany – e.g., Industry 4.0. The federal ministry that used to be in charge of "traditional" traffic is now also responsible for the infrastructure for the "digital" traffic. On the other hand, there are various wiretapping scandals, which are little by little becoming ever more dramatic. Many people therefore worry about where their data are used for which purpose, and whether this may result in personal detriment.

From the perspective of a research institute involved in software and systems engineering, it is a positive development that the importance and visibility of these topics are increasing rapidly. But there still remain many issues for which satisfactory answers do not (yet) exist. This is an incentive for us at Fraunhofer IESE to develop solutions for unresolved challenges using sound applied research.

## **DATA ARE THE RAW MATERIALS OF THE DIGITAL SOCIETY.**

"Big Data Analytics" does not work without data. We are convinced that most people are willing to make data available for a specific purpose. Unfortunately, it is currently almost impossible to formulate a specific purpose, to check compliance with this and possibly even enforce it. Nowadays, data are either locked away as securely as possible – which makes data-based services impossible – or are made available virtually without any restrictions – which results in complete loss of data control. We are sure that traditional data access protection must be supplemented by data usage control. Fraunhofer IESE has developed a technical solution for this problem: the IND<sup>2</sup>UCE framework, for which we have won the EARTO PRIZE.

There is much debate these days about broadband expansion – particularly in rural areas. This does make sense, considering the fact that about 70% of the German population is living in rural areas and a majority of our economy can also be found there, but the actual digital solutions for rural areas are often neglected in the debate. With our research on "Smart Rural Areas" we are addressing serious challenges in rural areas, such as insufficient medical care due to the closing down of medical practices, the loss of shopping facilities, or mobility issues as a result of unprofitable public transportation. In 2015, we drove

the research on digital support for rural areas very successfully. Furthermore, we have launched a project – funded by the state of Rhineland-Palatinate – where two test regions will be turned into "Digital Villages". The aim of this project is to test digital solutions in the areas of "Shopping/Logistics" under real-life conditions in a practical environment.

In 1996, Fraunhofer IESE was founded as the first Fraunhofer institution in Rhineland-Palatinate. For 20 years, it has been enjoying an excellent reputation worldwide in the area of software and systems engineering. This was reflected in 2015 when the institute received the "IEEE Software Engineering Distinguished Synergy Award". Fraunhofer IESE is highly regarded by companies from many different industries, research institutions all over the world, and the public sector as a competent and reliable partner. We would like to take this opportunity to thank our long-standing partners, who often collaborate with Fraunhofer IESE on innovative topics over a period of many years.

To stay ahead of the competition, you need the proper know-how. With our interdisciplinary and cross-domain expertise, we support companies in identifying new innovation ideas and corresponding roadmaps. We offer dependable methods and tools for the development of technical systems, information systems, and interconnected systems all the way to entire smart ecosystems, as well as process know-how for the successful adaptation and roll-out of such methods and tools in practice.

You, too, can become a partner of Fraunhofer IESE! Enjoy the benefits of our competence and our international network. We will support you on your path towards becoming more innovative and competitive!

We hope you find this report both informative and inspiring –

*Peter Liggesmeyer*

Peter Liggesmeyer



*Dieter Rombach*

Dieter Rombach



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# 20 YEARS OF IESE

20 YEARS OF RESEARCH  
WITH HEART AND MIND.





# 20 YEARS OF IESE

14 Feb. 1996:  
Opening of the Fraunhofer  
Institute for Experimental  
Software Engineering in Kaisers-  
lautern/Siegelbach: Prof. Dr. Dieter  
Rombach takes the lead and  
starts with a core team of 14  
employees.



Prof. Dr. Dieter  
Rombach is General  
Chair of the International  
Conference on Software  
Engineering® ICSE 1996  
in Berlin.

Expansion  
into a national  
software engineer-  
ing competence  
center



Industry partners from  
the automotive, space, and  
information technology domains as  
well as commerce, insurance compa-  
nies, and banks are using methods and  
services of Fraunhofer IESE to improve their  
software development processes and  
products. A selection: ABB, Daimler-  
Benz AG, Deutsche Bank, DLR, Er-  
icsson, Motorola, Siemens,  
Tecmath.

The first  
research depart-  
ments: "Quality and  
Process Engineering" and  
"Innovative Software  
Engineering"

Collaboration  
agreement with the  
University of Kaiserslau-  
tern – right from the start,  
IESE considers itself as a link  
between basic academic  
research and industrial  
application.

Founding of the  
Software Technologie  
Initiative Kaiserslautern e.V.  
(STI) to provide special  
support for small and  
medium-sized enter-  
prises

1996

1997



# A CHRONICLE IN IMAGES & WORDS

Internationalization of research and practice



Continual improvement and the establishment of learning organizations become central issues in joint projects, e.g., with Allianz, DaimlerChrysler, Bosch Telecom, maxess, Deutsche Telekom.

Fraunhofer IESE becomes a strategic collaboration partner for industry.



25 Feb. 1998:  
Opening of a sister institute in the USA: The Fraunhofer Center for Experimental Software Engineering in College Park, Maryland, USA, begins its work under the leadership of Prof. Dr. Victor Basili.

2 years after its foundation, IESE already has 65 employees.



First attendance at CeBIT



First permanent Fraunhofer institute in Rhineland-Palatinate: Following a successful audit, the Senate of the Fraunhofer-Gesellschaft votes to make the Fraunhofer Institute for Experimental Software Engineering (IESE) a permanent institute of the Fraunhofer-Gesellschaft.

1998

1999

The first 4 IESE staff members get their PhD degrees for the PhD theses they did at IESE. Many more will follow.

Prof. Dr. Dieter Rombach is awarded the Medal of Merit of the State of Rhineland-Palatinate.

Opening of the Virtual Software Engineering Competence Center ViSEK. Under the leadership of IESE, 7 research institutes are offering methodological software engineering knowledge – bundled, evaluated, and centrally available.



In its role as a German software engineering competence center, IESE and two partners are commissioned by the federal government to conduct the study "Analysis and Evaluation of Software Development in Germany".

Re-organization of IESE: the line structure is complemented by a dynamic matrix structure of business areas and competence areas.



Dr. Frank Bomarius becomes Deputy Director of IESE

Equal opportunities: A 27% proportion of women at IESE means rank 3 in the Fraunhofer-Gesellschaft overall and rank 1 among the IT institutes.



IESE celebrates its 5-year anniversary with a large gala event at the Fruchthalle in Kaiserslautern.

2000

2001

# 20 YEARS OF IESE

Strategic re-orientation of IESE along application areas and industries as well as focus on business areas. New types of strategic collaboration with industry customers emerge.

Prof. Dr. Dieter Rombach is elected Fellow of the IEEE Computer Society.

In the competence center "Virtual Office of the Future" (VOF), requirements on a new type of office are being explored by IESE together with the German Research Center for Artificial Intelligence (DFKI) and Ricoh Co. Ltd. (Japan).

A Fraunhofer Center with interdisciplinary high-tech character is to be created in close proximity to the University of Kaiserslautern, consisting of Fraunhofer IESE and Fraunhofer ITWM (Institute of Industrial Mathematics).



New research topics at IESE: "Ambient Applications", "Value-based (Dependable) Software Engineering", "IT Security", "E-Government"



IESE is in 6th place in the worldwide ranking of the Journal of Systems and Software regarding publications in international software engineering journals (only German and best European institute among the Top 15)

2002

2003



30 Apr. 2004:  
Foundation stone laid for the new institute center on Trippstadter Strasse in the vicinity of the University of Kaiserslautern.

New research topic "Ambient Intelligence"

Re-orientation of the business areas at IESE: "Automotive and Transportation Systems"; "Telecommunication, Telematics & Service Providers"; "Medical Systems"; "Information Systems & Public Sector"

Collaborations with companies, organizations, and universities in Hungary, India, and Japan

IESE reaches 4th place in the worldwide ranking of the Journal of Systems and Software regarding publications in international software engineering journals.



Prof. Dr.-Ing. Peter Liggesmeyer joins IESE as second institute director.

Collaboration agreement with the Kaiserslautern University of Applied Sciences

1 Aug. 2005: IESE moves into its new building at Fraunhofer-Platz 1. In an amazing logistical feat, the entire institute moves within one week. The new building is equipped with sophisticated high-tech features.

With Prof. Dr.-Ing. Peter Liggesmeyer, the topic of "Embedded Systems" is given greater weight at IESE.

2004

2005

# 20 YEARS OF IESE

IESE celebrates its 10-year anniversary with a large ceremony.



7 Nov. 2007: German President Horst Köhler visits IESE and is impressed by the AAL Lab.



Opening of the "Ambient Assisted Living (AAL) Laboratory" at IESE as an application focus of the international project BelAml. In a regular home environment, numerous sensors are installed that allow simulating and evaluating concrete scenarios in a realistic environment.

Soccer World Championship 2006 in Kaiserslautern: In cooperation with Ricoh Co. Ltd., Fraunhofer IESE provides journalists from all over the world with a "Virtual Printer".

Opening of the Fraunhofer Innovation Cluster "Digital Commercial Vehicle Technology"

"E-Government" becomes a business area of its own.



Prof. Dr. Dieter Rombach becomes spokesman of the Fraunhofer Information and Communication Technology Group.



The business area "Medical Systems" is extended into "Health Care and Medical Systems".

2006

2007

22 Oct. 2008:  
1st Annual Conference "Digital Commercial Vehicle Technology" at the Fraunhofer Center



March 2009: Software engineering conference "SE 2009" at IESE under the motto "Guaranteed Quality – A Requirement of Industrial Software Development" with 200 participants from business, research, and government



Prof. Dr. Dieter Rombach receives the Federal Cross of Merit on Ribbon of the Federal Republic of Germany.

New research topic "Smart Energy Management": IESE produces its own solar energy.



17 Jun. 2009:  
The "German Center for Emergency Medicine and Information Technology DENIT" is launched. Its numerous research and development activities make an important contribution to the improvement of medical and social care structures.

Contest "Germany – Land of Ideas": IESE becomes "Selected Landmark 2008" with its research focus "Ambient Assisted Living".



Another award (for the Fraunhofer Center) as "Selected Landmark 2009" for the conference "Digital Commercial Vehicle Technology"

Prof. Dr. Dieter Rombach receives an honorary doctorate from the University of Oulu, Finland.

2008 2009

# 20 YEARS OF IESE



January 2010:  
Foundation of the  
"Kaiserslautern Innovation  
Center Applied System Modeling  
for Computational Engineering",  
a collaboration between the local  
Fraunhofer institutes and several  
departments of the Univer-  
sity of Kaiserslautern



Establishment of  
the Fraunhofer Project  
Center for Software and  
Systems Engineering  
in Salvador, Bahia,  
Brazil

New business  
area "Automa-  
tion and Plant  
Engineering"



15 years of  
application-oriented  
research: IESE has great  
ambitions for the future. At the  
anniversary ceremony, representatives  
from government, research, and  
industry emphasize the enormous  
importance of the institute for  
the development of the city  
and the region.

Europe's largest software  
cluster "Emergent Software for  
the Digital Enterprise" is created. As the  
only pure IT cluster selected in the "Leading  
Edge Cluster" competition of the BMBF, it is  
considered Europe's "Silicon Valley" and extends  
over the cities of Karlsruhe, Darmstadt, Kai-  
serslautern, Saarbrücken, and Walldorf. IESE  
participates in several large projects as a  
cluster partner. Prof. Dr. Dieter Rombach  
becomes the spokesman for  
Kaiserslautern.

Prof. Dr.  
Dieter Rombach  
is elected Fellow  
of the ACM.



18 Jun. 2010:  
Opening of the  
European Innovation and  
Technology Center (ETIC) of the  
international agricultural machinery  
manufacturer John Deere in Kaiser-  
slautern. The collaboration with  
IESE was a major factor for  
the choice of location.

The topic  
"Cyber-Physical  
Systems" arrives  
at IESE.

18 Oct. 2010:  
Foundation of the  
"Fraunhofer Embedded Sys-  
tems Alliance". Prof. Dr.-Ing.  
Peter Liggesmeyer, Scientific  
Director of Fraunhofer IESE,  
becomes spokesman of  
the alliance.

2010

2011



Award "Selected Landmark 2012" for the project ZLB of DENIT at IESE: The central state-wide treatment capacity indicator ZLB makes the search for treatment capacities at hospitals easier and faster, especially beyond the immediate region.

On the occasion of his 60th birthday, Prof. Dr. Dieter Rombach is awarded the Fraunhofer Medal for his achievements.



In 2013, IESE is strongly engaged in youth development: It participates in the organization of the "German National Computer Science Competition" and stages the student competition "IT'sAPP2you", where students from grades 9 to 13 developed ideas for their own apps together with IT professionals.

IESE recognizes the signs of the times and increasingly focuses not only on Software Engineering, but also on Systems Engineering.



The topic "Smart Ecosystems" becomes a new strategic research focus.

IESE and Insiders Technologies found a Joint Research & Development Lab in order to jointly develop innovative products in the future using innovative development methods.



Prof. Dr.-Ing. Peter Liggesmeyer is elected president of the Gesellschaft für Informatik e.V. (German Informatics Society, GI), the largest professional association for computer science in the German-speaking world, with about 20,000 members.

2012

2013



# 20 YEARS OF IESE



IESE sharpens its profile: focus on 6 core competencies.

20 Jan. 2015:  
After many years as Executive Director of IESE, Prof. Dr. Dieter Rombach passes the torch to Prof. Dr.-Ing. Peter Liggesmeyer. Prof. Rombach remains at IESE as Director Business Development.



50th PhD completed at IESE



15 Oct. 2014:  
IESE researchers are awarded the renowned Innovation Prize of the European Association of Research and Technology Organisations EARTO for the IND<sup>2</sup>UCE framework for data usage control.



Prof. Dr. Dieter Rombach is elected Chairman of the Science Alliance Kaiserslautern.

May 2015:  
IESE receives the renowned international award "2015 IEEE Software Engineering Distinguished Synergy Award" of the largest professional association worldwide of engineers in recognition of its achievements as an innovation driver for industry.



With the initiative "Smart Rural Areas – Intelligent Technologies for the Land of Tomorrow", Fraunhofer IESE is one of 100 Selected Landmarks in the Land of Ideas 2014 in the category "Science". SRA as an application scenario for Smart Ecosystems becomes a strategic research topic at the institute.

July 2015:  
Launch of the project "Digital Villages". In two test regions, IESE will test smart technologies for future-proof infrastructures in rural areas over the course of three years.

Spin-off OSSENO Software GmbH founded



2014


2015

# WHERE WE STAND TODAY ...





**QUALITY**



Together with two test regions in Rhineland-Palatinate – the municipality of Betzdorf in Altenkirchen County as well as the municipalities of Eisenberg and Göllheim in Donnersberg County – Fraunhofer IESE will perform research in the next two years and work on solutions for combining the potential that exists primarily in the areas of mobility and logistics with smart technology in a way that is profitable for all stakeholders.

To realize these goals, existing systems must interact and be aligned with each other:

- When regional retail businesses get together and, with the help of mobile citizens, are able to deliver food and goods on the day of the order,
- when elderly people and disabled people receive support from their fellow citizens to go shopping, visit the doctor, or do their daily tasks,
- when commuters can take along and deliver packages without noticeable extra effort on their daily routes to work or on the way home,

it becomes clear that a small miracle is happening unseen: Software helps to create a network among mobility and logistics systems; services from different areas are combined and add great value for everyone involved. The complex aggregation and integration of a wide variety of systems is the subject of research at Fraunhofer IESE, under the term "Smart Ecosystems". The test regions now provide the real basis for evaluating and testing visions and ideas.

Duration: 2015 - 2017

Funded by: Ministry of the Interior, for Sport and Infrastructure of the State of Rhineland-Palatinate

Partners: Municipality of Betzdorf, Municipalities of Eisenberg and Göllheim, Rhineland-Palatinate Development Agency

Further information: [www.digitale-doerfer.de](http://www.digitale-doerfer.de)

# SMART RURAL AREAS – DIGITAL VILLAGES

During the course of last year, the spotlight has moved a little more from the **cities of the future** to our rural areas. In some sense, this trend does not come as much of a surprise. Whereas Smart Cities are usually associated with the images of metropolises with millions of inhabitants, two thirds of all Germans live in rather manageable towns and municipalities with fewer than seventy thousand inhabitants. Accordingly, it is important to think about digital transformation in rural areas as well and to prepare not only the cities for the future.

In the context of its research program “Smart Rural Areas”, Fraunhofer IESE has therefore teamed up with the Ministry of the Interior, for Sport and Infrastructure of the State of Rhineland-Palatinate and the Rhineland-Palatinate Development Agency to launch the project “Digital Villages”. In close collaboration with citizens and companies, ideas are being studied and actual solutions are being implemented in two test regions. The (software-)technical implementation is done by Fraunhofer IESE in the context of so-called “Smart Ecosystems”. This means that the next generation of software systems is already coming to rural regions today to make them fit for the future.

## JOINING FORCES

In comparison to cities, large areas must be covered in rural regions to supply services to a comparatively small number of people. This can be seen in all areas of life: in medical care, in mobility, in logistics, or in local supply. The approaches proposed for Smart Cities can therefore not simply be used as is. This is where digitalization comes into play: It is expected to create cost-efficient, individual, and very flexible alternatives to the mass supply found in the cities.

In Rhineland-Palatinate, 50% of the population live in communities with fewer than 7000 inhabitants

Let's take local public transportation: In rural areas, acceptable services can only be maintained with great effort. The situation is similar in logistics, where package delivery to rural areas leads to very high costs per package, which in reality are unfeasible. In the long term, it will no longer be possible to fund all these individual silos by themselves. The answer lies in intersectoral services offering cross-domain solutions.



I have a doctor's appointment and need a ride.

Is anyone going to the fruit farm and can bring me 3 kg of apples?

I will be at the strawberry farm today and can bring orders to Göllheim.

I need help installing an anti-virus program on my PC.

I offer delivery of fresh rolls on Sunday to the street "Am Kreuzhof".

I'm offering a ride to go shopping at the supermarket.

Can someone take my package along to the post office?

**"And if the benefit is only this big, we will take part!"**

Adolf Kauth,  
Mayor of Eisenberg



## IT'S THE NUMBERS THAT COUNT

From journey planners to the reservation of means of transport, software interfaces and Cloud-based services continue to build ever more bridges between a great variety of domains. This makes it possible, for instance, to adapt package deliveries to the timetables and routes of local public transportation systems. And new ecosystems and business models emerge that work across company or industry boundaries. Companies that still hesitate today to join this digital transformation increasingly run the risk of being left behind economically when the markets change ever more strongly in the future.

However, interfaces alone are not enough – existing systems that have sometimes evolved over the course of decades do not lose their inflexibility so easily and have a hard time competing with much more flexible solutions. This is where innovation is needed: Carpool services and citizen logistics services are already showing today how existing services can be re-thought. In the context of the project “Digital Villages”, for example, new systems are being developed that will offer people and packages shared rides on individual routes instead of having large, almost empty buses circle on fixed routes and sending delivery vehicles including drivers to small villages to drop off merely a handful of packages. This granularity enables flexible adaptation to customer needs in real time. This is a crucial cost advantage and makes such solutions feasible in rural areas despite the low population density.

## THE POWER OF SMALL THINGS

Composing complex tasks flexibly from many small parts instead of developing large and inflexible monolithic systems is one of the great opportunities. However, this is not only restricted to the people in the crowd. Under the keyword “Internet of Things”, even the tiniest devices, sensors, and everyday objects are given more and more intelligence and become part of a network. One example of this in the context of the project “Digital Villages” is the development of a “Smart Bag”. A simple bag gets its own software intelligence and is connected with other things and the Internet. This allows the bag to do such things as automatically detecting packages that are placed into it and informing its owner via smartphone about all the necessary information, such as recipient and deliv-



### Logistics

Packages are no longer transported only via parcel delivery services, but are given a ride – even in private vehicles.

### Mobility

Software creates a network between mobility and logistics systems. This leads to services from a variety of areas and adds great value for everyone.



Stationary local retailers benefit from joint logistics solutions and can offer a comfortable shopping experience to their customers, who like to buy regional products.

ery times. The bag thus provides a small service in a complex logistics chain. On the other hand, its owner can also simply place items into her bag when she is shopping at the supermarket. The bag will recognize the items and add them to the shopping cart on her smartphone. At the same time, the retailer can save spending money on an expensive checkout system because the customer's smartphone can completely process the checkout of the goods via the payment service of his online shop. A simple thing like a bag is thus seamlessly integrated into a variety of business processes by flexibly offering a simple service. This intense networking on all levels – from simple things to the Cloud – makes it possible to cost-efficiently offer services that, as in this case, could otherwise only be delivered by expensive delivery vehicles of large logistics companies or effort-intensive purchasing systems of large retail chains.

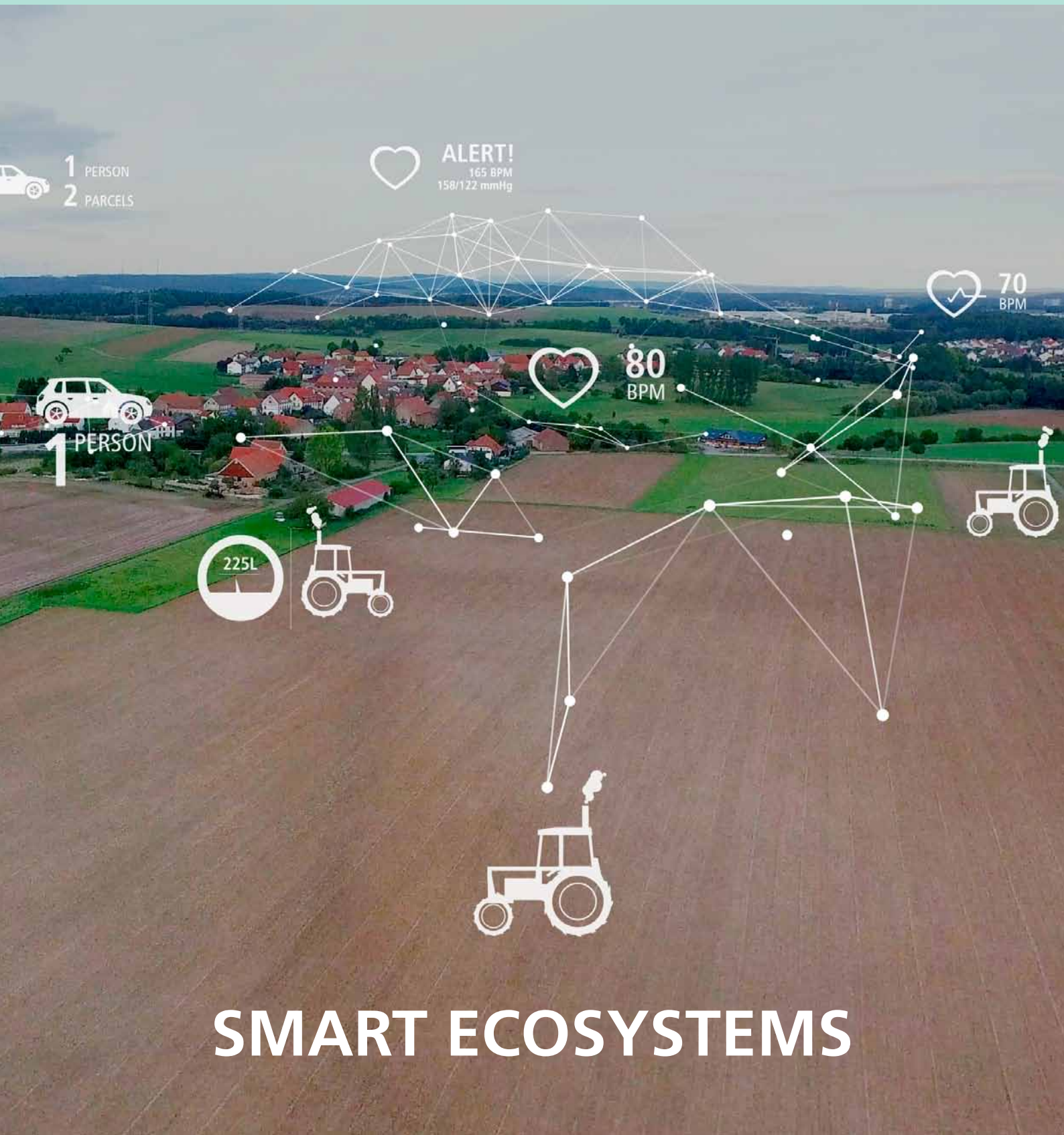
## SMART ECOSYSTEMS – MORE THAN THE SUM OF THE PARTS

This trend towards seamless integration can be found in all domains – from Industry 4.0 to Smart Farming. Networks are created that encompass more and more people and things and form a self-organizing system, which in its combination can offer a seemingly endless range of services. When such a web of things, systems, and services replaces simple interfaces, “Smart Ecosystems” are born. And the heavyweight special systems developed top-down are replaced by a flexible network of many different elements that can dynamically adapt to the requirements of the customers and of the market.

For a long time, such a web of things and services appeared to be too complex to master it with guaranteeable qualities. Smart Ecosystems now provide the necessary technology for resolving the conflict between high flexibility and guaranteeable quality. Simulation processes that are unique worldwide allow efficient development of even the most complex ecosystems. Modern architectures allow flexible networking among devices, things, people, and services across company and industry boundaries. Award-winning data usage control processes allow data to be used intensively without the need to jeopardize privacy. And a unique “system police” continuously monitors the ecosystem in order to be able to ensure its safety and reliability at all times. With these and many other unrivaled innovations of Fraunhofer IESE, the land of the future is being created in the “Digital Villages”. “Smart Ecosystems” are the basis of the new generation of systems that will lead our society to a form of digitalization that we can rely on. Safely and securely.

■ Mario Trapp





1 PERSON  
2 PARCELS

ALERT!  
165 BPM  
158/122 mmHg

70  
BPM

80  
BPM

1 PERSON

225L

# SMART ECOSYSTEMS



In digitalization, the system architecture is crucial for performance and overall success – just as in a great building.

# INNOVATION LABS FOR INDUSTRY 4.0

The digitalization of enterprises offers the greatest **opportunities for growth** and competitiveness in the next few years. However, particularly small and medium-sized enterprises and companies that have not developed many of their innovations through software to date have many unanswered questions regarding the actual implementation as well as possible risks.

The key to digitalization are digitally captured data and the networking among such data from different process and production areas. The information available in one place often allows resolving tasks and issues in another place faster, easier, and better. Organizations that recognize and use these opportunities can create a clear competitive edge for themselves by improving internal efficiency or offering better customer benefits. However, if we take a closer look, it quickly becomes clear that a systematic procedure is necessary to restrict the scope of opportunities to use cases that make sense and promise to be successful. This is why collaborations of Fraunhofer IESE frequently start with a corresponding potential analysis or with creativity workshops aimed at combining services, products, and data in a useful manner.

The addition of data-based products and services to its portfolio often represents a turning point in a company's history, which is why the term "Fourth Industrial Revolution" (Industry 4.0) was coined in Germany. Naturally, orientation towards a new project business has implications regarding processes and products, as well as the tasks and qualification of the employees. Fraunhofer IESE supports companies in this transition as well as in piloting. An offer that is particularly attractive for smaller enterprises in this regard is the possibility to develop new solutions in a joint "Innovation Lab".

In digitalization, the system architecture is crucial for performance and overall success – just as in a great building. In synergy with the technologies being used, the architecture determines aspects such as flexibility, modifiability, performance, or safety to a major degree. The state of the practice in software and systems engineering already offers a broad range of mature possibilities for planning, construction, and quality assurance. In numerous bilateral projects, Fraunhofer IESE supports companies in developing appropriate system architectures.

In addition to the transfer of new technologies into practice, Fraunhofer IESE collaborates with companies in research projects to develop new solutions aimed at minimizing risks and addressing practical challenges. In the context of digitalization and Industry 4.0, Fraunhofer IESE started three large projects in 2015, which will provide new solution components for industry during the next few years: **IUNO**, **MANTIS**, and **PRO-OPT**.





“IUNO” is the National Reference Project for IT Security in Industry 4.0. In a consortium of leading partners from industry and research, practice-oriented concepts and solutions for IT security in Industry 4.0 are being developed in this project. This is a major contribution to a new security culture for Industry 4.0 aimed at realizing its value-adding potential for Germany. What is so special about it: IUNO combines a multitude of scenarios along different, but always complete value chains – from the furniture industry, the automotive industry, tool machine manufacturers – and brings the lessons learned during this process together in a tool kit that can also be used for other areas of application and by other companies. A large variety of measures ensure transfer of the results to small and medium-sized enterprises.

Duration: 2015 - 2018

Funded by: German Federal Ministry of Education and Research (BMBF)

Partners: Accessec GmbH, Bosch Rexroth AG, Bosch Software Innovations GmbH, DFKI GmbH, Duravit AG, Escrypt GmbH, Fraunhofer AISEC, Fraunhofer IESE, Fraunhofer SIT, HOMAG Holzbearbeitungssysteme GmbH, Infineon AG, Nobilia Werke, Phoenix Contact GmbH, Robert Bosch GmbH, Siemens AG, Trumpf GmbH, TU Darmstadt, TU München, Universität Kassel, Volkswagen AG, WIBU-SYSTEMS AG. The coordinator is HOMAG GmbH.

Further information : [www.iuno-projekt.de](http://www.iuno-projekt.de)

### SECURITY IS NO OBSTACLE

Digital networking among processes and products takes place over corresponding interfaces, which – depending on how they are set up – may also represent potential points of attack for data theft and data manipulation and can thus cause damage. In information technology, there are tried and proven mechanisms for securing data traffic and protecting systems. It is thus important first of all to know the attack potential and take appropriate protective measures.

In addition, challenges also exist in the context of digitalization or the creation of a uniform digital market with regard to the costs as well as to the consistency and flexibility of the available solutions. There is also the risk of causing physical damage via control facilities;

damage that may affect products or the plant itself, for example – in chemical plants, power plants, or production plants. No good solution exists yet to date to support planners and security experts in their work.

These are the reasons why Fraunhofer IESE is collaborating with 20 partners in the national Industry 4.0 reference project **IUNO** to develop demonstrators for typical problems with solutions that are intended to support German companies in implementing their Industry 4.0 projects with regard to cyber-security. The experts of Fraunhofer IESE are involved especially in the integration of security aspects for the protection of data into the planning of the overall system and their modeling in systems engineering.

### FLEXIBILITY IS KEY

A major feature of the age of the Internet is the speed with which new offers and solutions emerge. Even if software-based services can be developed and provided within a short time, they still require a solid basis and underlying concepts, for example to enable customer-specific offers and new data linkages.

ing the data from a large number of machines, the manufacturer can use “Big Data” analyses to make predictions about the likelihood of failures, which can be used for maintenance planning. However, standards and structures for an integrated, comprehensive solution are still missing to date. Each manufacturer does their own thing, and many individual solutions are expensive and inflexible when used together.

This is where the European project **MANTIS** comes into play, which started in 2015: Across several areas of application, a tool kit for predictive maintenance shall be developed that can be configured flexibly for a wide variety of application purposes via a uniform reference architecture. Support will be provided for both stationary facilities, such as wind power plants, and mobile machinery, which may also have to operate for some

**Predictive maintenance** of plants and machinery with the help of data represents a use case that has great potential for cost savings and has already been used for several years for individual capital goods.

The procedure is usually quite similar: Sensor data about the status of a machine are correlated with the usage profile and the application context. By evaluat-



## RESEARCH INNOVATION

In the project “MANTIS”, research is being performed to develop a service platform architecture for the proactive maintenance of complex systems. With its help, future performance can be estimated, failures can be predicted and prevented early on, and proactive maintenance schedules can be created. Maintenance thus becomes an important function and a competitive advantage. It adds value to the business process and also enables new business models with stronger service orientation. In addition, data and services from MANTIS can be used in other systems to offer solutions that build upon these, such as logistics platforms, energy management systems, or production plant control systems.

Duration: 2015 - 2018

Funded by: European Union, German Federal Ministry of Education and Research (BMBF)

Partners: STILL GmbH, Liebherr EMTEC, Robert Bosch GmbH, M2Expert GmbH, Fraunhofer IESE (in Germany), as well as 35 additional EU partners

Further information: [www.mantis-project.eu](http://www.mantis-project.eu)

time without any data connection. Fraunhofer IESE is contributing its competencies in systems engineering to the project and is in charge of the work on the design

of the reference platform, which aims to deliver one platform for different application purposes.

## TRUST-BASED COOPERATION

In addition to the vertical digital integration from the business process level down to individual plant components and sensors in a factory, horizontal integration into a smart ecosystem via value chains enables some completely new business models. However, collaboration among companies and (automated) data exchange on a large scale call for trust-based cooperation in terms of data protection, data quality, and data security.

For this purpose, the concept of data usage control has been implemented at Fraunhofer IESE in various technical solutions. It combines data protection and data security with a flexible and easy-to-understand definition of who is allowed to use which data how, when, and where. In the context of the project **PRO-OPT**, different partners have been studying and evaluating digital cooperation models since the beginning of 2015. The

usage context in this project is the automobile: In car repair shops, data and features of millions of vehicles are being captured in a distributed manner at various times and in numerous different locations. This is valuable information that could be used by manufacturers and suppliers to detect defects early on and to optimize the development of future systems. But under which circumstances and with which billing modalities are data being exchanged here? Is it possible to set up a needs-oriented flexible service? How to ensure data protection and data security? How to prevent misuse and manipulation? These and other issues are being investigated in PRO-OPT and are being illustrated with the help of demonstrators and examples. The contribution of Fraunhofer IESE is its IND<sup>2</sup>UCE framework for flexible data usage control, which has already been applied successfully in other projects as well.

■ Ralf Kalmar

**“The data sources are distributed across different, economically independent stakeholders of the ecosystem. The generated data volumes are very large and heterogeneous and must be used in real time to control the running operations.”**

Dr. Simon Becker  
DSA Daten- und Systemtechnik GmbH  
(Project Manager of PRO-OPT)

The project **“PRO-OPT”** stands for Big Data Production Optimization and is aimed at developing Big Data solutions for companies and thus at mining the existing wealth of data. PRO-OPT pursues an integrative approach that takes into account local data sovereignty by modeling information together with its usage constraints and its quality. In a second step, these data under usage control can then be analyzed by the involved companies in a targeted manner and can be integrated into their own processes. In addition to packaging the data, PRO-OPT also provides the platform for decentralized data analysis and its visualization, as well as for the secure exchange of internal and external data in compliance with usage policies.

Duration: 2015 - 2017

Funded by: German Federal Ministry of Economic Affairs and Energy (BMWi)

Partners: DSA Daten- und Systemtechnik GmbH (consortium leader), AUDI AG, camLine GmbH, German Research Center for Artificial Intelligence (DFKI), Fraunhofer Institute for Experimental Software Engineering IESE

Further information: [www.pro-opt.org](http://www.pro-opt.org)



The “digital transformation” has picked up a lot of speed particularly in agriculture.



# DIGITAL TRANSFORMATION IN AGRICULTURAL TECHNOLOGY

The question of how to design **product innovations** has become a hot topic in all domains today. Particularly the ever increasing networking, collaboration, and merging among different branches of industry has led to the need to question one's own product portfolio in order to remain competitive. "Digital Transformation" is the keyword under which Fraunhofer IESE is collaborating with its customers to help them improve their competitiveness by means of software-based product innovations.

How product innovations can be designed together with Fraunhofer IESE will be illustrated in the following using the example of the agricultural industry – an industry in which the focus has not been on software to date. Historically, the agricultural industry has been a domain very strongly influenced by mechanical engineering; in recent years, however, the focus has increasingly been on product innovations through and with software as well.

Contrary to popular belief, the agricultural industry domain is a highly innovative domain, which strongly benefits from technical support. The fact that the industry is currently undergoing changes leads to major challenges. On the one hand, there are the experienced farmers, who have great domain knowledge and are capable of coordinating the farm through high cognitive load. On the other hand, there is the generation of young farmers with university degrees, who have learned to run a farm like a business and to modernize it with the help of technical support. The diversity of the users can also be seen in many other areas: The number of fields, for instance, that are cultivated by an agricultural business ranges from about 40 to several hundreds. Classical crop farmers also face different challenges than farms that raise livestock, for example. In addition, there is great regional diversity. Even within Germany, there are widely different conditions and requirements depending on the state. In North America, we find mostly very large agricultural businesses, which primarily grow corn and soybeans. Furthermore, the users in this industry are characterized by a very high degree of individuality. Every user believes that he has found the optimal combination for running his farm effectively and efficiently, considering his unique

situation and his combination of soils, cultivation areas, employees, years of experience, etc. From an objective point of view, this is often not the case and makes it harder to provide software support. In this context, Fraunhofer IESE is primarily involved in the establishment of an ecosystem consisting of different mobile apps – a so-called Mobile Ecosystem.

A strongly user-centered process that is continually updated and aligned with organizational strategy aspects such as business models has proven to be extremely successful in this regard.

However, it is not easy to design product innovations in the area of apps. The high expectations of the users and the short-lived market contribute to the fact that here it is necessary to respond to the market within the shortest possible amount of time. Mobile Software Engineering offers the chance to act as an innovation driver since the changing requirements create an inherent need for change. However, this is a longer process, which often demands re-thinking within the organization. Design Thinking methods are frequently mentioned in this regard when it comes to being a pioneer.



At Fraunhofer IESE, we have developed our own format for the early phases of innovation generation, the “Product Innovation Workshop”, which is used to generate and refine innovation ideas. It is based on software engineering methods from the areas of Requirements Engineering and User Experience. These particular aspects, which are needed for product innovations, are applied in the form of a methodological process. In every app development, the following steps are therefore performed: The strategy phase deals with the general Mobile strategy, which should always be followed by a context analysis where the innovation idea is extended with ideas from possible future users. This is followed by a phase for sharpening the innovation idea, whose purpose is primarily to make the existing idea more concrete in terms of a wide variety of aspects. Central in this regard are the Product Innovation Workshops, but also input from a technical perspective and explicit consideration of the potential of mobile devices. When things actually take shape, there is no way to avoid classical implementation before the first iterations or prototypes can be tested by end users.

For the development of a Mobile Ecosystem in the agricultural context, the currently used software solutions and the resulting requirements on the software

architecture are also of special interest. It can be observed, for instance, that individual solutions such as customized Excel sheets are used very frequently. Farm management systems are currently being used more in terms of invoicing and documentation, but their use for the actual planning and execution of the daily work is rather rare. Mobile solutions can basically be found everywhere where the structure of the staff allows their use. Chat solutions are often used for communication, but tablets permanently mounted in the driver’s cabin are also widely used. These are typically used for navigation or for coordination purposes in fleets. Even second and third displays are often installed in addition to the main display, the actual human-machine interface.

The facts that almost every employee has a mobile device and that the entire daily workflow is completely mobile demonstrate the great potential of an ecosystem for mobile apps. The main problem of the target group in terms of software is the lack of an integrated solution, which would be necessary particularly in Europe, where mixed fleets are common. A mixed fleet is a pool of machinery in which machines from different manufacturers are used. Here, Mobile Software Engineering also offers a chance to develop an integrated solution.



## “Product Innovation Workshop”

The Product Innovation Workshop is a central element in designing product innovations. Here, innovative ideas are generated in a structured manner; depending on the objectives, they may also be put into initial concrete terms already. It may be called the think tank of product innovation. The participants frequently come from different sections of a company and work on the evolution of the company and the associated products in a highly focused manner.

PRODUCT INNOVATION



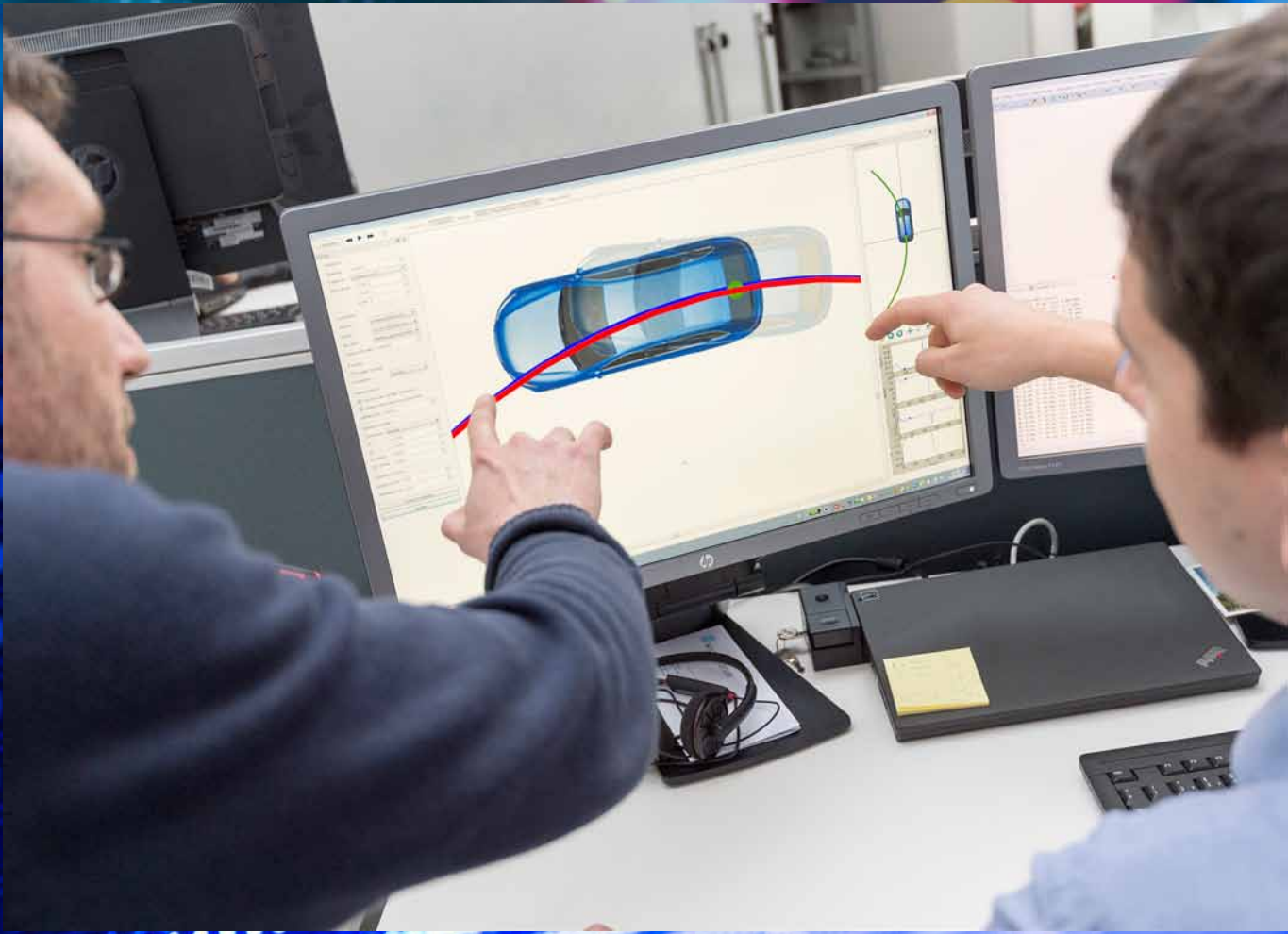


All these aspects show that in this context, we quickly stop talking about individual apps and rather talk about highly complex, integrative overall systems in which Mobile Software Engineering and the resulting “professional apps” only represent one access channel for information processing among many. Building up product innovations systematically and incrementally requires an excellent combination of domain knowledge and software engineering. One key advantage is therefore the mixture of experts from a wide variety of different software engineering areas that Fraunhofer IESE can offer: their expertise covers areas such as software architectures, Big Data, information systems, and embedded systems. For innovation is frequently the result of combining already existing technologies and ideas in new application areas.

Fraunhofer IESE can provide support for the entire cycle from idea generation to the development of high-quality (mobile) clients, backends, as well as Cloud solutions. At the same time, it can optimize qualities such as User Experience, Safety, and Security. Particular value is added by the fact that the researchers of Fraunhofer IESE work in a very large number of domains and are thus able to recognize opportunities for innovation that others who know only one domain often fail to see.

■ Steffen Hess





Jointly developing revolutionary concepts

# JOINT TEAMING RESEARCH

As one of the **leading suppliers** of automotive systems, Robert Bosch GmbH is continually developing new control units, which fulfill numerous safety-critical tasks. Already today, the software in an automobile is the main driver for innovations. Nowadays, more than 90% of all innovations are being realized in software, and more than 30% of value is added by means of software. In the future, the vehicles on our roads will be interconnected and automated; the importance of safe software will then increase even more as a result.

As a non-physical product, safe software must be primarily safe in functional terms. Functional safety is the term used for that part of a safety concept that ensures that a system functions correctly. In the case of a vehicle this means that no assistance system must bring the vehicle into a state in which it can no longer be controlled by the driver, neither as a result of a malfunction nor through an unintentional operating error. It must be assured, for instance, that a vehicle will brake when the driver operates the brake. If the cruise control is not working correctly and wants to continue to maintain the speed, it must be possible to overrule it. Among other things, this is the task of functional safety concepts.

## IS SAFETY A MATTER OF COURSE?

Safe operation is assumed as a matter of course by the users when it comes to vehicles. But it is not easy at all to develop software that always works safely and is free of faults. Failure conditions and possible operator errors must be detected and dealt with in such a way that risks for people, the environment, and property are minimized. The effort for the correct validation of a system can easily surpass the effort for the construction of the actual functionality itself. An example of this are steer-by-wire functions, where the driver's directional change intentions are no longer transmitted to the wheels hydraulically, but rather electrically. In principle, this function can be implemented using currently available technologies, but the validation of such a system is very effort-intensive and expensive. This is why it is not being used yet in the automotive domain. In the avionics industry, on the other hand, fly-by-wire systems have become indispensable as their failure probability is significantly lower than that of hydraulic systems.

The functional safety required for such systems is achieved by means of various measures that influence the software and system architecture of a system. These include, for example, fall-back levels, monitoring mechanisms, and defect correction mechanisms. Safety concepts and architectures must be well aligned in order to prevent the extensibility, portability, or adaptability of a system from being affected. Due to the increased complexity of modern systems, interdisciplinary collaboration is required between researchers and developers contributing different competencies to a project. In addition to domain experts who know the application domain and its regulations very well, these frequently include software and system architects as well as experts on functional safety and on all other relevant aspects of the system.





Using specialized competencies regardless of location with the help of "Joint Teaming".



### WHAT TO DO IF ESTABLISHED SAFETY CONCEPTS ARE NOT ENOUGH?

The safety concepts being used today are based on hazard and risk analyses that identify the impact of defects on systems in a defined environment. In addition to operator errors, these defects also include possible defects in the software or faults in the hardware of a system. Safety concepts define countermeasures for such defects that limit their impact. For future systems, however, classical safety concepts will no longer be sufficient. Open systems, autonomous vehicles, and changing hardware platforms require safety concepts that can validate even future systems safely and dependably. In this context, researchers of Fraunhofer IESE are collaborating with specialists and developers of Robert Bosch GmbH in a joint team to

develop revolutionary safety concepts for areas where existing concepts can no longer be used.

In such endeavors, early testing of the concepts is crucial. The jointly developed concepts are therefore implemented as prototypes, for example, and tested in order to ensure that they will fulfill all requirements of future systems and that they can be integrated with the planned system architectures. This allows making decisions in a traceable way and based on facts, which significantly reduces the risk of expensive wrong decisions and makes development projects plannable.

“Let’s just quickly implement this in software.”

The development of software does not require any factories or machinery. Software does not need to be manufactured, but can simply be deployed to the hardware when it is finished. This often leads to the erroneous belief that changes can be made to a piece of critical software until the very last minute, and that new functions can be integrated into software systems without any problem at all.

Modern software is very complex. Like the development of mechanical parts, its development must be carefully planned and realized. Only then is it possible to complete high-quality software on time and avoid project delays.

### ADVANTAGES / BENEFITS OF JOINT TEAMING

Work on revolutionary safety concepts demands numerous competencies, which are not always available locally. In such a situation, Joint Teaming is an option to increase local competencies. In Joint Teaming, staff from different organizations are organized in a joint team, which jointly works on one problem. These Joint Teams have numerous advantages: Specialized competencies that cannot be made available quickly in one location can still be integrated into development teams in a timely manner. The resulting joint teams can tackle problems holistically and contribute their different perspectives on the underlying problem.

In addition to domain experts, the Joint Team with Robert Bosch GmbH also comprises application experts and platform experts from Robert Bosch GmbH, as well as safety experts, architecture experts, and prototyping experts of Fraunhofer IESE. Regular workshops and teleconferences allow close synchronization among the involved members of staff and rapid clarification of arising issues.

■ Thomas Kuhn

# WHERE WE ARE HEADED ...



## A LOOK AT THE FUTURE



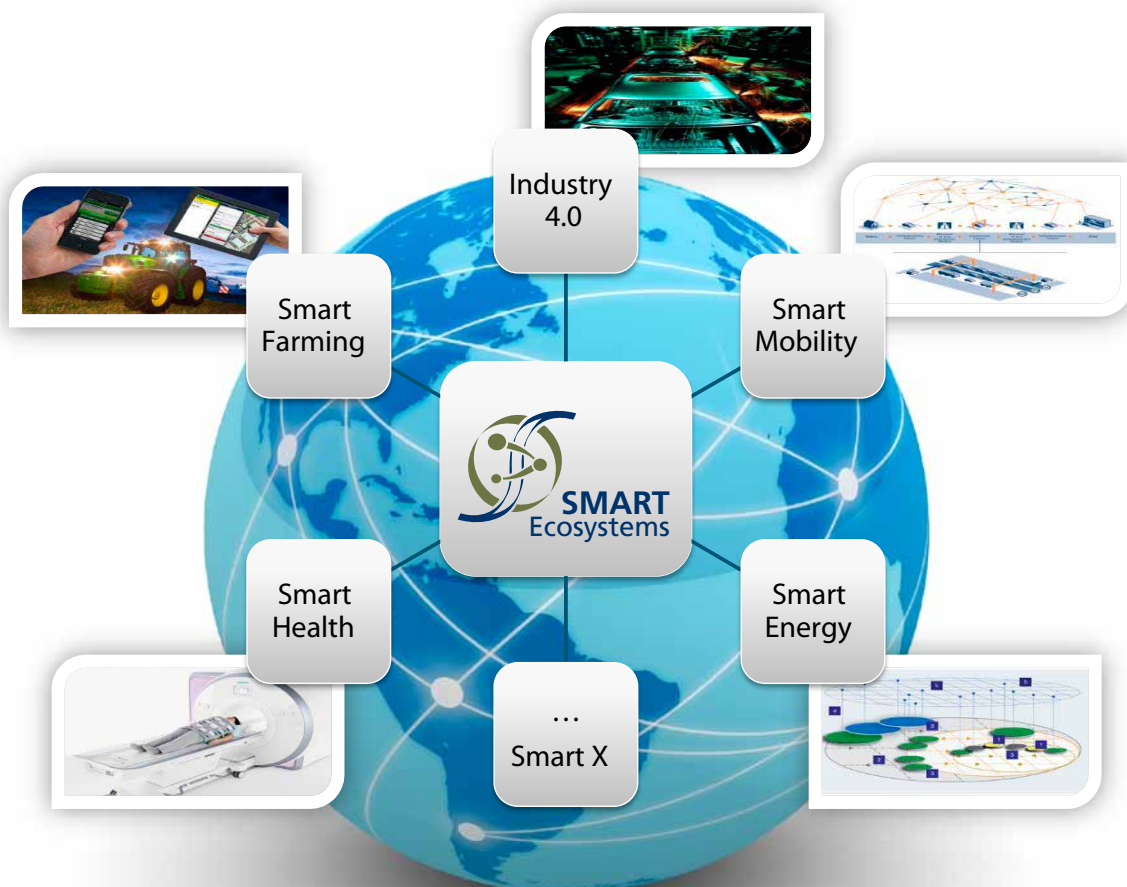


# SMART ECOSYSTEMS & THE DIGITAL SOCIETY 2.0

The vision of the future we call “Digital Society 2.0” is based upon the assumption that in the future, all business, private, and social activities and services will be supported throughout and without any breaks in media by software-based systems, and that additional, completely new synergies can be created by integrating a broad range of different applications. The trend we are observing across almost all domains points in the direction of complete integration of all systems into smart ecosystems which, driven by a common goal, offer customer-specific solutions across companies. These “Smart Ecosystems” are breaking down former insular solutions for the control of business processes

and technical processes and make them converge in an integrated overall solution. Good examples of this trend can be found everywhere, regardless of whether they are called Smart Energy, Smart Health, Smart Mobility, Smart Farming, or Smart Production – also known under the keyword Industry 4.0.

One concrete application area for Smart Ecosystems at Fraunhofer IESE is the project “Digital Villages”, which was already mentioned above and where system solutions for the creation of such ecosystems are being evaluated using rural areas as an example.



## WHICH BENEFITS DO ORGANIZATIONS GET FROM SMART ECOSYSTEMS?

If organizations are well positioned to address the challenges of Smart Ecosystems, they will also be able to reap various benefits on the market. With new products and business models, they will conquer new markets and will be perceived as innovative organizations. They will secure their share of existing markets and will be able to face new competitors on existing markets, who might come from other industries to invade their own target market, in a suitable manner. The prerequisite for this is that such organizations adapt their existing products as well as their development methods to the realities of Smart Ecosystems.

## HOW DO I POSITION MYSELF FOR THIS IN THE BEST POSSIBLE WAY?

How must organizations position themselves in the future in order to exploit this trend and be able to act successfully on the market? In order to position themselves in the best possible way to address these challenges, they must strengthen various areas:

### **“Need for Partnering”**

One core element of a successful strategy is to start thinking beyond the boundaries of one’s own organization, to establish business models that span different organizations, and to make use of synergies. The fitness check offered by Fraunhofer IESE, the Fraunhofer Ecosystem Assessment (see description on page 47), supports organizations in checking their capabilities with regard to Smart Ecosystems and helps them to entrench corresponding areas of excellence sustainably in the organization.

### **“Need for Creativity & Speed”**

Another core element of a successful strategy, however, is the ability to continually generate new ideas and innovations that transcend company boundaries, to quickly check their feasibility, and to bring them to market as fast as possible. Regarding the use of creativity techniques, it can often be observed that many organizations do not have the courage to use these systematically. The creative potential of their staff is thus not exploited sufficiently. Crowdsourcing offers another opportunity to unlock the wealth of ideas that current and future end users have. Creativity is not a coincidence and can be directed in a purposeful and efficient manner if systematic methods are used.



## THE FRAUNHOFER ECOSYSTEM ASSESSMENT (FEA)

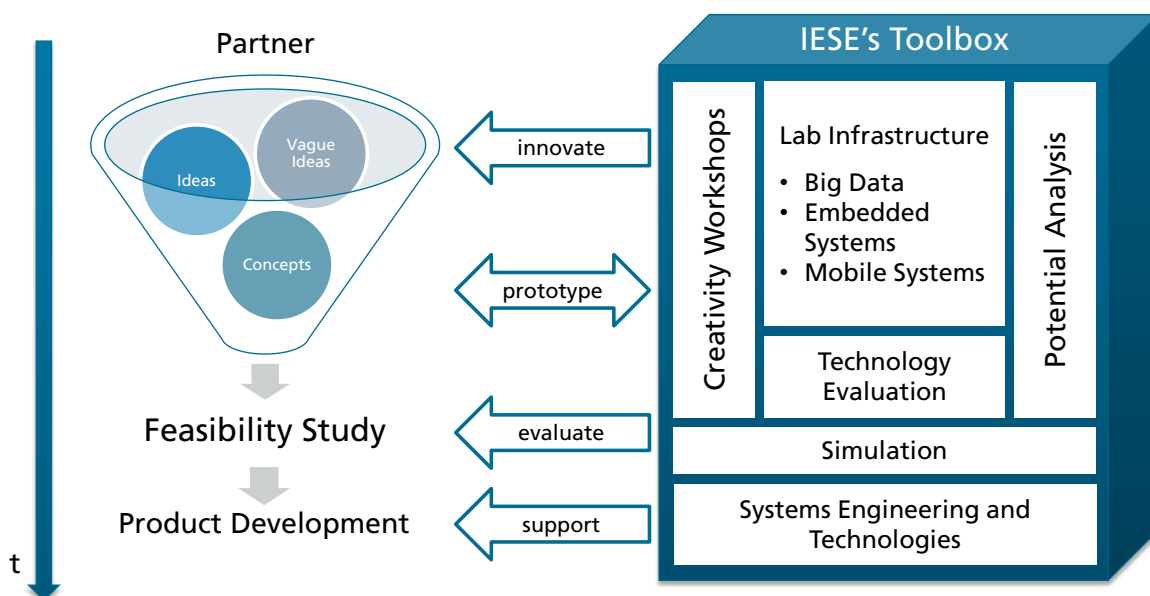
What does maturity of development processes mean in the context of Smart Ecosystems? Is this classical CMMI or is there more to it? According to Fraunhofer IESE, organizations must position themselves in a fundamentally different way and must prove excellence in areas that are usually disregarded by established maturity models. When is an organization mature enough for a Smart Ecosystem? Does the organization want to drive an ecosystem or take part in it? This essentially starts with a feasible business model and a solid technical basis with regard to the platform used and the infrastructure (technical linchpin). The organization must be capable of establishing a vision and a strategy that are feasible for their business model, but which are also technical at the same time, and to roll these out from engineering via operation to governance. One central element is partnering with other organizations, since most of the value will be added by transcending organizational boundaries. This raises issues such as which players to consider as partners, how to set oneself up as a consortium with regard to collaboration and development, and how to learn efficiently from the collaboration. Another area includes the Community and the users of the offered products or services: how to create a Community, how to expand and maintain it over time? In this area, the classical Internet companies such as Google, Amazon, or Facebook appear to be well ahead. And finally it is also about keeping an eye on one's competitors, watching their actions, and being able to react appropriately.



But when is there potential in an idea? Using targeted potential analyses such as the mobility potential analysis, the Big Data potential analysis, or the SES potential analysis, Fraunhofer IESE assesses which potential for innovative models can be unlocked in an organization.

As for the issue of speed, it can often be observed that many organizations are capable of producing high-quality products, but lack the skills to quickly implement, resp. evaluate, ideas. In addition, great reluctance can be seen when it comes to implementing new concepts such as Cloud and DevOps, which would enable rapid development. Successful organizations have the ability to do development at revolutionary speeds, while their long-term development cycles are stable and mature.

For the evaluation and implementation of new product ideas, the “Rapid Innovation Labs” of Fraunhofer IESE offer an ideal environment. They provide a comprehensive toolbox to support companies from the generation of ideas by means of creativity workshops via implementation through prototypes all the way to the assessment of customer acceptance and technical feasibility. In addition, the systems engineering methods and technologies of Fraunhofer IESE can support successful product development.



Prototyping of ideas in the Rapid Innovation Labs of Fraunhofer IESE



## FRAUNHOFER IESE AS AN IDEAL PARTNER

The development of Smart Ecosystems requires a combination of a wide range of competencies, from software engineering for information systems via systems and software engineering for embedded systems to process engineering, including important organizational aspects. As one of only a handful of research institutes, Fraunhofer IESE and its staff are among the leading experts worldwide in all of these areas. This is also true, in particular, for engineering processes that make it possible to guarantee important quality properties. For more than a decade, the researchers of Fraunhofer IESE have been leading the way in the areas of Safety, Security, and User Experience, which are exactly the properties that will determine the acceptance of Smart Ecosystems on the market.

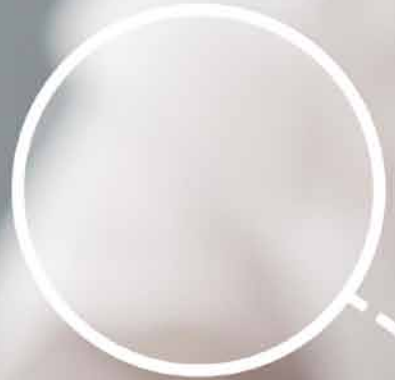
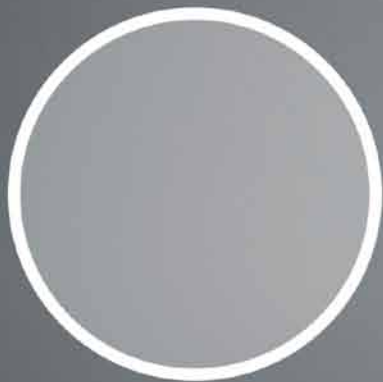
For Smart Ecosystems, the central factor for success will also continue to be the existence of a suitable architecture to allow mastering the resulting complexity and guaranteeing the quality of the system. The many years of experience of Fraunhofer IESE regarding the evaluation and interpretation of architectures is reflected not least in the largest number of publications worldwide in the area of architecture evaluations for embedded systems and information systems. This has enabled the experts of Fraunhofer IESE to make their institute the first to develop a cross-domain reference model for Smart Ecosystems, which does not only allow illustrating partial models such as the Industrial Internet or the Internet of Things, but also permits a holistic view across abstraction levels, views, and industries.

On the basis of this broad and long-time experience, Fraunhofer IESE supports its customers as a competent partner on the path of digital transformation.

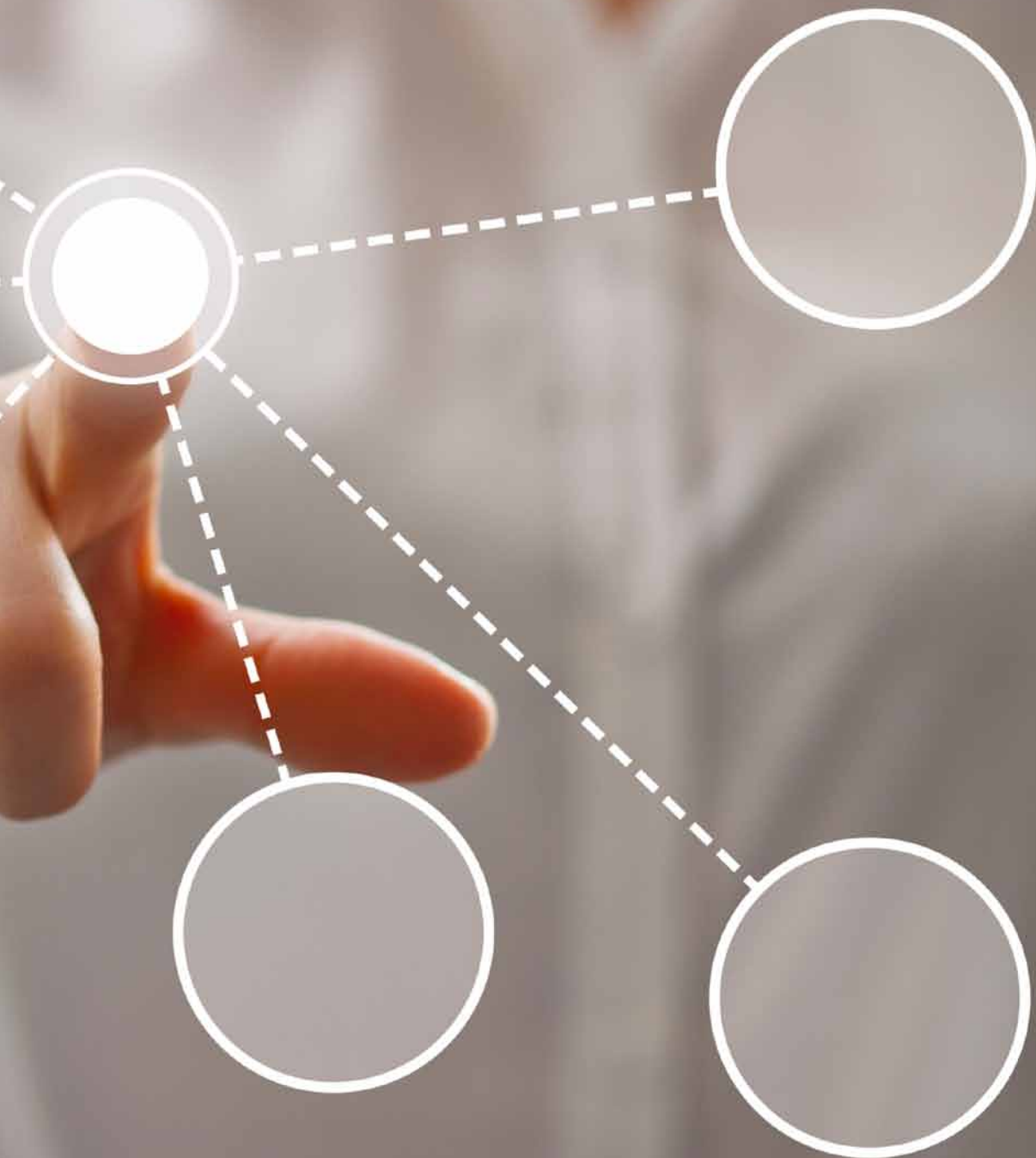
■ Jörg Dörr, Jens Heidrich, Mario Trapp



# PROJECTS, EVENTS & AWARDS



## HIGHLIGHTS



## IEEE SOFTWARE ENGINEERING DISTINGUISHED SYNERGY AWARD

With the “2015 IEEE Software Engineering Distinguished Synergy Award”, Prof. Dieter Rombach accepted an international award for Fraunhofer IESE from the largest professional engineering association worldwide. The award honors the institute’s long-time contributions as an innovation driver for the economy. The award is presented annually by the Technical Council on Software Engineering of the IEEE to an institution that serves as a model of the intensive partnership between industry and research. Due to the increasing importance of software as an enabler of nearly all innovations, Fraunhofer IESE is an important collaboration partner of leading large companies as well as small and medium-sized enterprises from all domains. In the tradition of the Fraunhofer philosophy, the institute acts as a go-between between research and practice to enable businesses to gain customized access to applied research results.



## JOHN DEERE HARVESTING GOLD AND SILVER



At the Agritechnica 2015 trade fair, three gold medals and ten silver medals were awarded by the German Agricultural Society (Deutsche Landwirtschaftsgesellschaft (DLG)) to John Deere and its partners for their joint development work. Overall, companies had submitted more than 311 innovation registrations to the largest trade fair for agricultural machinery worldwide. The European Technology and Innovation Center Kaiserslautern (ETIC) of John Deere exploited the full potential of its global research alliances, but also benefited from its close ties with institutes and universities in the region, including its long-time collaboration with Fraunhofer IESE. The awards for John Deere are related both to hardware solutions for machines and components and to software solutions for precision agriculture to optimize machine performance, logistics, and decision support.

# PROJECTS, EVENTS & AWARDS



Malu Dreyer, Minister President of Rhineland-Palatinate, and Heike Raab, State Secretary, with institute director Prof. Dr.-Ing. Peter Liggesmeyer

## SMART RURAL AREAS – RESEARCH HIGHLIGHT AT CEBIT

At the joint booth of the Fraunhofer-Gesellschaft, the main research topic of Fraunhofer IESE, “Smart Rural Areas – Zukunft Land”, was met with great interest by politicians and business representatives. The aim of the institute is to optimize quality of life outside Smart Cities in rural areas as well by offering smart digital solutions: How can life in rural areas be made more attractive in the future with the help of information technology? Which new possibilities and business models are created through smart networking of systems? In concrete scenarios shown on a demonstrator, the guests – which also included Malu Dreyer, Minister President of Rhineland-Palatinate – learned how digitalization can reshape rural areas in the future. In addition, the visitors were shown how potential risks, e.g. with regard to the security, dependability, or usability of such systems, can be avoided right from the start with the help of technologies developed at Fraunhofer IESE.

In a “Letter of Intent”, Fraunhofer IESE and the state of Rhineland-Palatinate agreed on intensive collaboration in this

area. Only a few months later, the Minister President came to Kaiserslautern to launch the project “Digital Villages”: Using the municipalities of Betzdorf and Eisenberg/Göllheim as examples, concrete testing will take place in this project to find out how the digitalization of villages can contribute to making these areas an attractive living choice for both younger and older people.

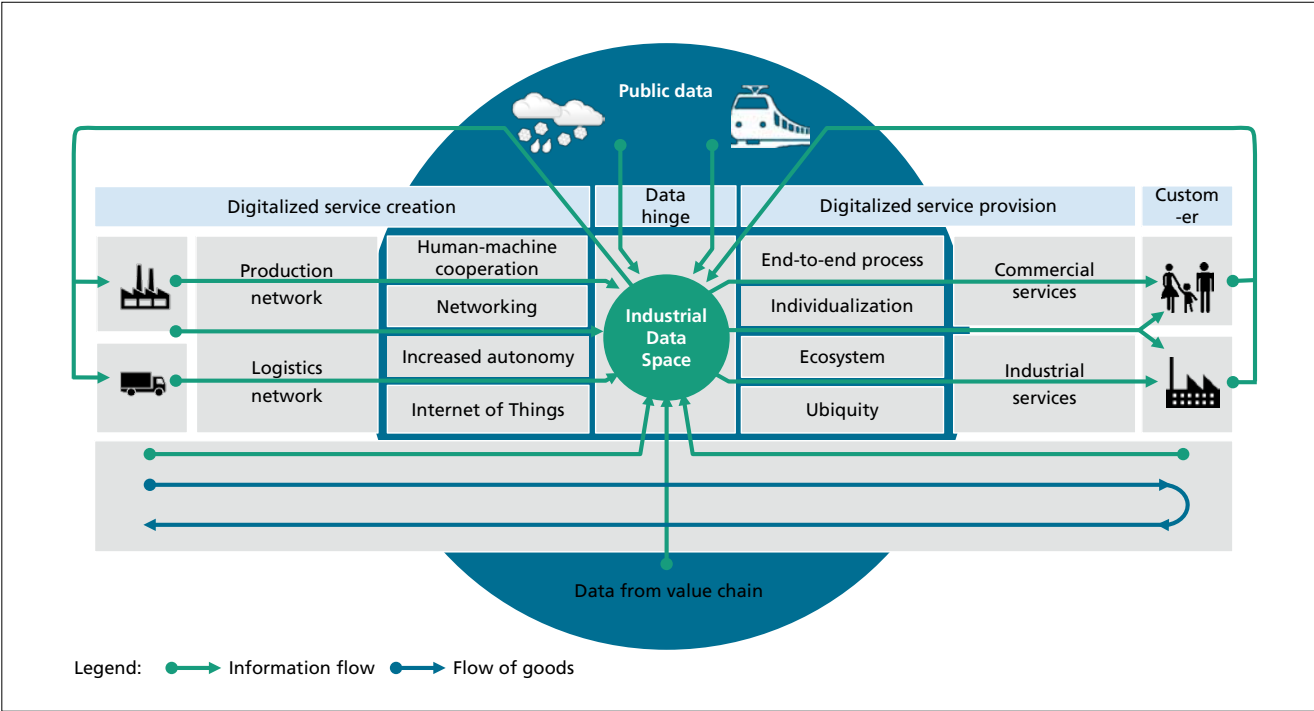
At CeBIT, Prof. Dieter Rombach presented Sabine Bätzing-Lichtenthäler, the Rhineland-Palatinate Minister for Social Affairs, Work, Health and Demography, with the final report on the pilot study of “SUSI TD”, a highly developed assistance system for senior citizens, which defined clear objectives for sustainable improvement of the quality of life for elderly people. Leading a self-determined life in their familiar environment is not a matter of course for many senior citizens. Limited mobility, fears, and not feeling safe all influence the decision to leave this environment. In 2016, the topic of assistance systems for senior citizens continues with the project “STuDI” (s. page 60).

# INDUSTRIAL DATA SPACE – SECURE DATA SPACE FOR THE DIGITALIZATION OF GERMANY

The digitalization of companies and their business processes represents a central component of Industry 4.0. The digital mapping of processes, goods, and resources, as well as cross-company networking lead to product, service, process, and organizational innovations in a multitude of application areas.

The basic prerequisites for these innovations are the secure exchange and easy combination of data in value networks. This is where the Industrial Data Space (IDS) comes into play, which is characterized by comprehensive, cross-industry networking in an open data space. This data space makes it easier for companies to exploit the potential of digitalization for their business models without relinquishing control over their data.

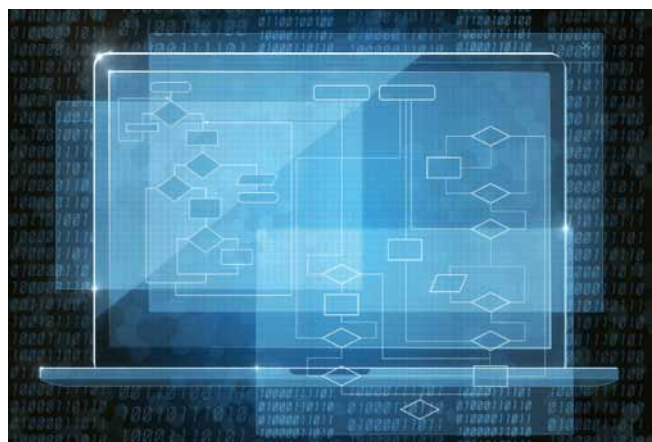
The basis of the Industrial Data Space is a reference architecture model that is being developed by twelve Fraunhofer institutes in the context of a research project with the same name, which is funded by the German Federal Ministry of Education and Research (BMBF). The research project started on 1 October 2015 and has a duration of three years. Important contributions by Fraunhofer IESE include data usage and access control as well as measurement and evaluation of the data quality of data and information made available in the IDS.



# PROJECTS, EVENTS & AWARDS

## FROM BIG DATA TO SMART DATA

The exploitation and processing of mass data creates ever more challenges for us in both private and professional contexts, but also offers huge opportunities. One of the challenges consists of identifying the necessary and important data (Smart Data) out of the mass of data (Big Data) and to interconnect them. The aim is, among other things, to optimize decision-making processes and business workflows. An important prerequisite for this is our data usage control approach – one of the core research topics at Fraunhofer IESE, which allows customers to maintain control over their data. Smart Data thus promotes the creation of trust between provider and user.



In the context of the technology program “Smart Data – Innovations from Data”, the German Federal Ministry of Economic Affairs and Energy (BMWi) is funding a total of 13 beacon projects with about 30 million euros from 2014 to 2018. These projects are aimed at opening up the future market of Smart Data technology for the German economy. The participating

companies and organizations are contributing an additional 25 million euros, increasing the total volume available to the program to about 55 million euros. The core topics industry, mobility, energy, and health represent the focal areas of this technology program.

## MBAT – EXCELLENCE IN ANALYSIS AND TESTING

In March 2015, the project MBAT received the ARTEMIS “Recognition Award”. MBAT is about the integration of various analysis and testing activities in the quality assurance process, since defects in highly complex software systems such as in the automotive industry or in avionics can have serious consequences, from high financial losses to risk to human lives. Researchers from nine countries worked on this multi-year project, performing 15 industrial case studies. In addition to innovative model and tool development, Fraunhofer IESE also evaluated the studies. This led to the derivation of recommendations for a wide variety of combinations of analyses and tests, which offer added value for the development and quality assurance of software in other contexts as well.





## EMC<sup>2</sup> – SAFE TEAM WORK IN OPEN SYSTEMS

Thanks to multi-core CPUs, the newest generations of embedded systems are able to manage highly complex tasks at comparatively low costs. Self-contained systems are turning into open systems – so-called “Smart Ecosystems” –, which have to act dependably in every situation. This is why researchers in a major European project are now making sure that safety is not forgotten: Almost 100 partner institutions, a volume of almost 100 million euros, and about 800 person-years of planned effort – these are the key figures of the European project EMC<sup>2</sup>, the largest of its kind to date. Research and industry want to jointly create the prerequisites that will enable tomorrow’s control units to master diverse and changing tasks safely. Many of these control tasks are “safety-critical” in nature, meaning that the brake assistant or the lane-keeping assistant in a vehicle, the throttle control in an airplane, or the motion control of an industrial robot on the assembly line must simply be 100%

dependable; otherwise, human lives might be jeopardized in the event of an emergency.

In the EMC<sup>2</sup> work package “System Qualification and Certification”, researchers are developing basics and solutions under the leadership of Fraunhofer IESE. One crucial aspect in this regard is that the multitude of systems involved and the expansion of the communication distances offer hackers many opportunities for attacks. With the help of safety & security co-engineering, the challenges on functional safety are being addressed together with the issue of vulnerability. Furthermore, due to the openness and adaptability of these systems, certification with established approaches is not easily possible. Processes are therefore being developed to automate part of the certification activities and shift them into runtime.



# PROJECTS, EVENTS & AWARDS

## ENERGIZE!

The energy transition is coming, and digitalization is paving the way for it! The role of IT is no longer an issue of debate in the context of the energy transition – but the “How” still remains an open question. Whatever the networked energy system of the future will look like: it must be trustworthy and fully accepted by all stakeholders in society, government, and industry.

Fraunhofer IESE is taking part in several large projects in this context: In the **“Cross-Energy Management (CEM) Demonstrator”**, which is funded by the Rhineland-Palatinate Ministry of Economic Affairs, Climate Protection, Energy and Regional Planning MWKEL, a demonstrator for the “Internet of Energy” illustrates what a networked, cellular-hierarchical design of IT for a resilient energy system of the future could look like. Control over software quality is essential for making systems fit for the Internet of Energy. Safety & security, privacy & trust, resilience (dependability, availability, robustness), and acceptance (User Experience, performance, efficiency) are necessary prerequisites for the digitalized and trustworthy energy system of the future.

Together with members of StoREgio Energiespeichersysteme e.V. and other partners, Fraunhofer IESE is developing a trading platform for flexibility potentials on the level of the distribution grid in the project **“Flex4Energy”**. The German Federal Ministry of Economic Affairs and Energy (BMWi) is funding the project with approx. 3 million euros.



Fraunhofer IESE is also involved in two major projects of the BMWi program **SINTEG (Schaufenster intelligente Energie, Smart Energy Showroom)**. The showroom projects are intended to illustrate how the energy transition can be implemented in terms of major technology and major areas. A total of up to 230 million euros of funding has been made available by BMWi for this purpose. In the project **“Designnetz: Baukasten Energiewende – Von Einzellösungen zum effizienten System der Zukunft”** (*Design Network - From Insular Solutions to the Efficient System of the Future*), energy from solar plants and wind power is used to supply urban and industrial consumers in Northrhine-Westfalia, Rhineland-Palatinate, and in the Saarland. The role of Fraunhofer IESE in this project is, on the one hand, to establish usage control for data in order to ensure privacy and preserve business confidentiality. With this, Fraunhofer IESE is making an important contribution to increasing acceptance for the energy transition by making software systems trustworthy. On the other hand, Fraunhofer IESE is pushing the use of Smart Data approaches for flexibility management in rural areas.

In the project **“enera: Der nächste große Schritt der Energiewende”** (*enera: The next large step in the energy transition*), regional system services are being tested in Lower Saxony that stabilize the grid locally and further increase the reliability of the electricity supply on the basis of renewable energies. Here, Fraunhofer IESE is tasked with performing a safety and security audit of the resulting software systems.

By participating in these projects, Fraunhofer IESE is actively contributing to designing trustworthy software systems and provides innovative solutions to the central IT challenges – trustworthiness, data security, and dependability – of the energy transition. On the basis of its CEM demonstrator and its experiences from research projects, Fraunhofer IESE is now able to intensively test energy-related IT systems and to offer its customers important support regarding the design and operation of such systems.



## RESCUER – EMERGENCY MANAGEMENT THROUGH MOBILE CROWDSOURCING

Be it a major sports event, a music festival, or a church convention – at such events, up to hundreds of thousands of people can congregate in a relatively small space. In order to assure that major events can run their course without incident, it is important to have suitable measures in place to prevent mass panic. Furthermore, in the event of an emergency, it is crucial to inform rescue and emergency staff as quickly as possible and to keep them up to date. The situation is similar in the event of emergencies occurring at industrial plants.

Two major events in Brazil, the soccer world championship in 2014 and the Olympic Summer Games in 2016, were the reason for the Brazilian government and the EU to collaborate in a joint project to develop a smart and interoperable computer-based solution to support emergency and crisis management on the basis of mobile crowdsourcing information. In the project RESCUER (“Reliable and smart crowdsourcing solution for emer-

gency and crisis management”), smart information technology shall be used to develop a more effective and efficient emergency and crisis management system. The consortium comprises nine project partners in Europe and in Brazil, with Fraunhofer IESE being the coordinator of the European consortium. RESCUER will be based on mobile technologies, which almost everyone carries around in the form of a smartphone or tablet these days. This is how the project participants in RESCUER want to support a “mobile crowdsourcing solution” with first responders and eyewitnesses at the place of an incident: People shall voluntarily transmit important information; communication and coordination between the people involved on site and the emergency center shall take place via smartphone. Information will be transmitted via an easy-to-use app that is optimally adapted to the exceptional circumstances in which the user finds himself or herself at the time.

# PROJECTS, EVENTS & AWARDS

## CUMULATIVE FRAUNHOFER COMPETENCE FOR AUDI

For years, AUDI AG has been one of the most successful manufacturers of premium automobiles. In order to maintain and expand their high standards, the company is continually investing into the improvement of their products, processes, and infrastructure. Exchange and cooperation with research partners ensure that new technological possibilities and processes can be identified and implemented promptly.

In the context of a concept study guided by Fraunhofer IESE, new ideas and solution suggestions for testing systems in production were developed in this regard. In collaboration with a total of seven Fraunhofer institutes, the interdisciplinary project team developed suggestions for new concepts that take up current trends and anticipate examples from other industries. The basis for this were two creativity workshops, which are always

used by Fraunhofer IESE when the application potential of new software-based technologies or market trends is supposed to be presented to customers. The creativity workshops rely on widely accepted methods, such as Flip-Flop, Brainwriting, Lotus Blossom, KREA-FUN, Product Boxing, or Force Fit, and are fun to boot. The creativity techniques were selected and adapted specifically for the task definition at hand. In this case, the creative Fraunhofer team consisting of institutes from the areas of production technology, testing technology, mechanical engineering, and software engineering set the bar high. "This much efficiency and productivity has hardly ever been achieved in any of our other workshops," said project manager Marcus Trapp about the result. Bertram Münch, Manager Testing Systems at AUDI AG, confirmed this: "The proposals offer interesting and valuable impulses for our future orientation."



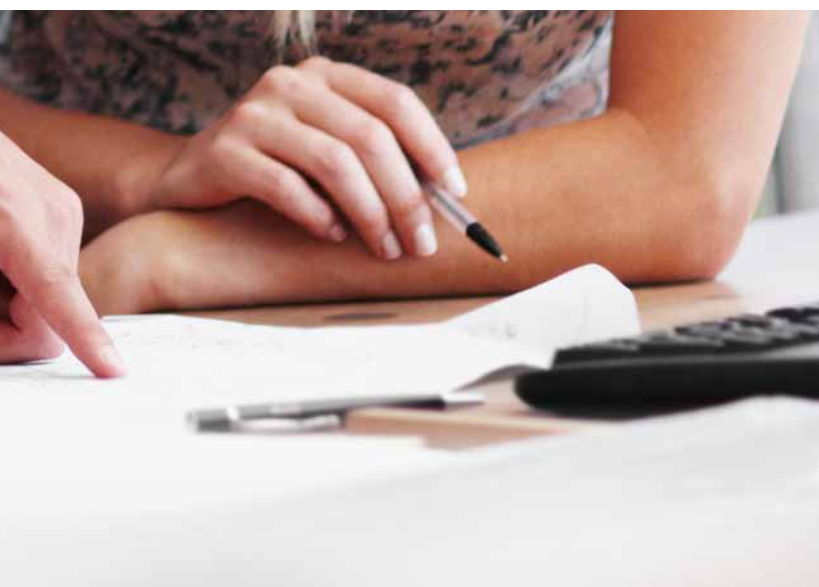
## STuDi – SAFE LIVING FOR SENIOR CITIZENS

“STuDi – Smart Home Technology and Services for Independent Living at Home” is a telematics project in collaboration with the German Institute for Applied Care Research in support of autonomous life for elderly people. With the help of modern sensor and communication technology in the home, deviations from the usual activities of daily life or situations of helplessness can be detected rapidly and support can be provided fast. Particularly for medical and nursing care it is important to realize that increasing digitalization and social interaction can support each other and do not contradict each other: In a predecessor project, “Ambient Assisted Living” technologies were installed in 24 senior citizen households in the areas of Trier and Trier-Saarburg in 2012 already. The technology was complemented by preventive counseling and home visits by staff from nursing care centers and was assessed very positively by the test persons. “STuDi” shall now help to create the conditions for large-scale implementation in a professional, age-appropriate

assistance system for permanent usage. Additional regions in Rhineland-Palatinate are to be included and technical improvements as well as nursing care and health care related counseling concepts shall be integrated.



## RANKED TOP IN PUBLISHING



Within the Fraunhofer Embedded Systems Alliance, Fraunhofer IESE stands out when it comes to publications on the topic of Embedded Systems, as evidenced by an independent literature analysis. During the investigated period between 2004 and 2014, there were a total of 155 publications by the 12 partner institutes of the Fraunhofer-Gesellschaft that form the Fraunhofer Alliance, with one third of these being authored by researchers from Fraunhofer IESE. Overall, Fraunhofer was ranked fifth worldwide and number one in Germany and Europe with a total of 331 publications on this topic. With 53 publications, Fraunhofer IESE clearly demonstrates its research competence in the area of Embedded Systems. Additionally, it has a distinction in this research area in terms of above-average networking with collaboration partners both within the scientific community and with business and industry, nationally as well as internationally.

# PROJECTS, EVENTS & AWARDS

## ECONOMICS MINISTER GABRIEL AT IESE

On 22 October 2015, Sigmar Gabriel, German Minister of Economic Affairs and Energy, visited Fraunhofer IESE to learn about its work. Prof. Peter Liggesmeyer explained the potential that digitalization and automation can unleash in the economy. Fraunhofer IESE used various projects to demonstrate its expertise in systems engineering. The presentation of the “Rapid Innovation Labs” showed the Minister of Economic Affairs how Fraunhofer IESE provides practical support to SMEs when it comes to developing and testing new business models in the digital economy and how it supports them on this path with guaranteeable assurances.



## TRANSATLANTIC COLLABORATION ON INDUSTRY 4.0



In January 2016, representatives from science and business in Germany and the USA met at a workshop in Washington, D.C., and agreed on goals for collaboration on Industry 4.0. In the future, there is to be joint work on the modeling of dependable systems and infrastructures and research shall be performed on interdisciplinary topics concerning the Internet of Things. The focus will be particularly on the standardization, certification, and evolution of self-learning and adaptive autonomous systems. Case studies are planned to investigate topics such as production, health, mobility, or the City of the Future. The two-day workshop under the leadership of Prof. Peter Liggesmeyer from Fraunhofer IESE and Prof. Manfred Broy from TU München was organized by the German Federal Ministry of Education and Research (BMBF), the German Embassy in Washington, D.C., and the National Science Foundation (NSF). It was attended by 50 high-calibre experts from Germany and the U.S. In addition to numerous universities and research institutions, the participants also included representatives from companies such as SAP, Bosch, Infineon, Cisco, General Electric, and General Motors.

# ABOUT US



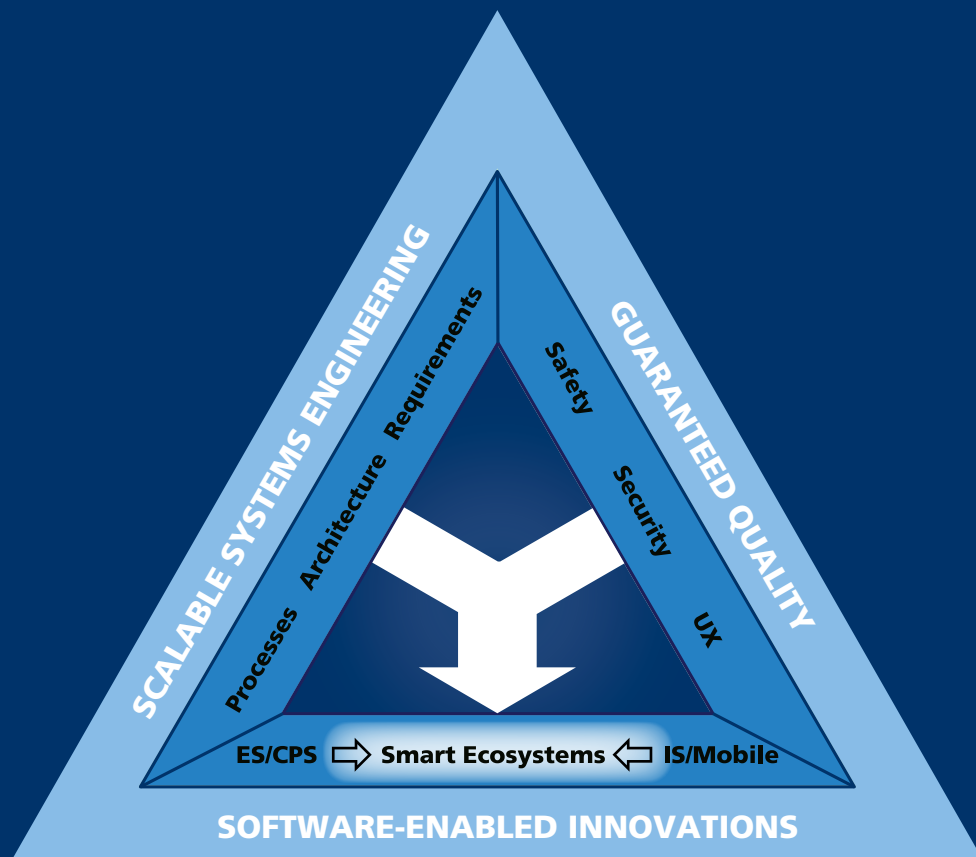


# OUR COMPETENCIES

## FRAUNHOFER IESE

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

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



ENGINEERING + QUALITY ⇒ INNOVATION



## SCALABLE ENGINEERING

The scalability of our methods helps you to master your individual challenges in a systematic and quantifiable manner – 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

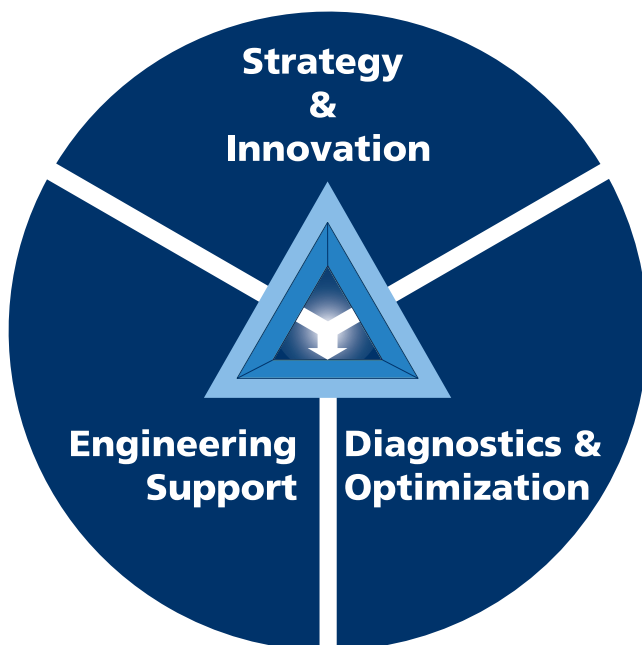
By vertically interconnecting *Embedded Systems* and *Information Systems*, we tap new potential regarding functionality and efficiency together with our partners. The result are intelligent ecosystems for a wide variety of application areas. Cross-domain interconnection and integration of systems, services, 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 application.

Fraunhofer IESE supports its partners in the following types of services: in the early phases of innovation and strategy identification, in the evaluation and optimization of existing systems, and during development.



## STRATEGIES FOR INNOVATIVE PRODUCTS

Every successful product starts with innovative ideas and an adequate implementation strategy. Innovative ideas can be developed in joint creativity workshops. With the help of state-of-the-art rapid-prototyping and simulation technologies, ideas are validated early on and important questions regarding technical feasibility or business models are answered. Particularly in an era of quickly changing markets, one factor that is crucial for success is to have 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 changing market landscape are only some of the aspects that pose challenges for an organization. In the context of 360° analyses, Fraunhofer IESE examines both the processes and the actual products of its customers. In the Prognostics Center, the experts of IESE thoroughly analyze existing software systems. 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 Prognostics Center provides facts that substantiate its findings. 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 can thus be supported by solid analysis results. The same applies to the quality of third-party software. The institute's engineers derive improvement measures on the basis of the analysis results and of their many years of experience, and actively support their customers in optimizing their products and systems.

However, the experts of IESE do not only diagnose the quality of a system that has already been developed completely. They already predict what the expected quality of a system will be as soon as the first results are available in the development process. This makes it possible to check continually whether the development is still on the right track. Problems can be avoided before they even occur. For once a decision has been made to proceed in a new direction and to re-structure a system or adapt it to a new market, this often means investments in the amount of 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 into the success of the product.

## WORKING TOGETHER

Strong partners stick together until the goal has been achieved. This is why the engineers of IESE will also not abandon their customers when it comes to development. They support their customers from the onset, in engineering as well as, for example, in implementing optimization recommendations. From user experience designs to the validation and verification of systems: engineers from 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 customize 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 the joint work in combina-

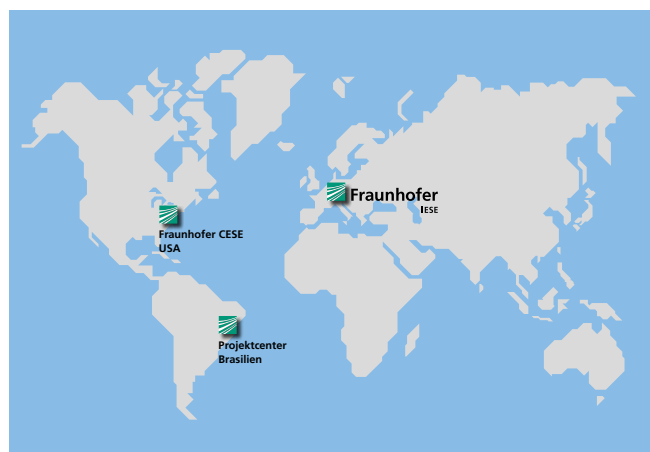
tion with accompanying training and coaching, the know-how is transferred effectively and sustainably. Joint engineering with Fraunhofer IESE is therefore not only an investment into the quality and success of the current product or system: rather, it is a long-term investment into the success and added value of the organization.

Fraunhofer IESE offers expertise and application competence specifically in the following domains:

- Automotive and Transportation Systems
- Automation and Plant Engineering
- Energy Management
- Health Care
- Information Systems (banks, insurance companies & software)
- E-Government

International branches of Fraunhofer IESE exist in the USA and in Brazil:

- Fraunhofer Center for Experimental Software Engineering CESE at the University of Maryland, College Park, MD, USA (since 1998)
- Fraunhofer Project Center for Software and Systems Engineering in Salvador, Bahia, Brazil (since 2012)



# OUR INTERNATIONAL CENTERS

Fraunhofer IESE has evolved into a worldwide leading competence center in software and systems engineering. This is also reflected in the institute's participation in many publicly funded projects and industry projects in Europe and far beyond. These projects include:

- Denso, Japan
- Fujitsu, Japan
- John Deere, Germany & USA
- Murex, France
- Tafe, India
- Wittenstein, USA
- Project EMC<sup>2</sup>, EU
- Project MANTIS, EU
- Project RESCUER, EU & Brazil

The main focal areas of Fraunhofer IESE's international activities are in the USA and in Brazil. The respective satellite organizations are the Fraunhofer Center for Experimental Software Engineering CESE, affiliated with the University of Maryland at College Park, MD, USA (since 1998), and the Fraunhofer Project Center for Software and Systems Engineering FPC, affiliated with the Federal University of Bahia UFBA in Salvador, Bahia, Brazil (since 2012).

## **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 the year 2015, 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 Ford Motor 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 Analysis
- Rapid Prototyping of Mobile and Web Applications
- Process Analytics and Improvement

In more and more public and industrial projects, it combines its competencies with complementary competencies from Fraunhofer IESE in Germany and from the University of Maryland.

In addition to its project work, Fraunhofer CESE is proud of the mentoring and training of interns by its researchers. In 2015, 17 interns from Reykjavik University in Iceland, the University of Mannheim, 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.fc-md.umd.edu](http://www.fc-md.umd.edu)



**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.

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 (see RESCUER, page 58). In 2016, new projects will start in the areas of Smart Cities and Big Data. In publicly funded projects as well as industry projects, the Center's competencies are complemented by the competencies of Fraunhofer IESE and UFBA.

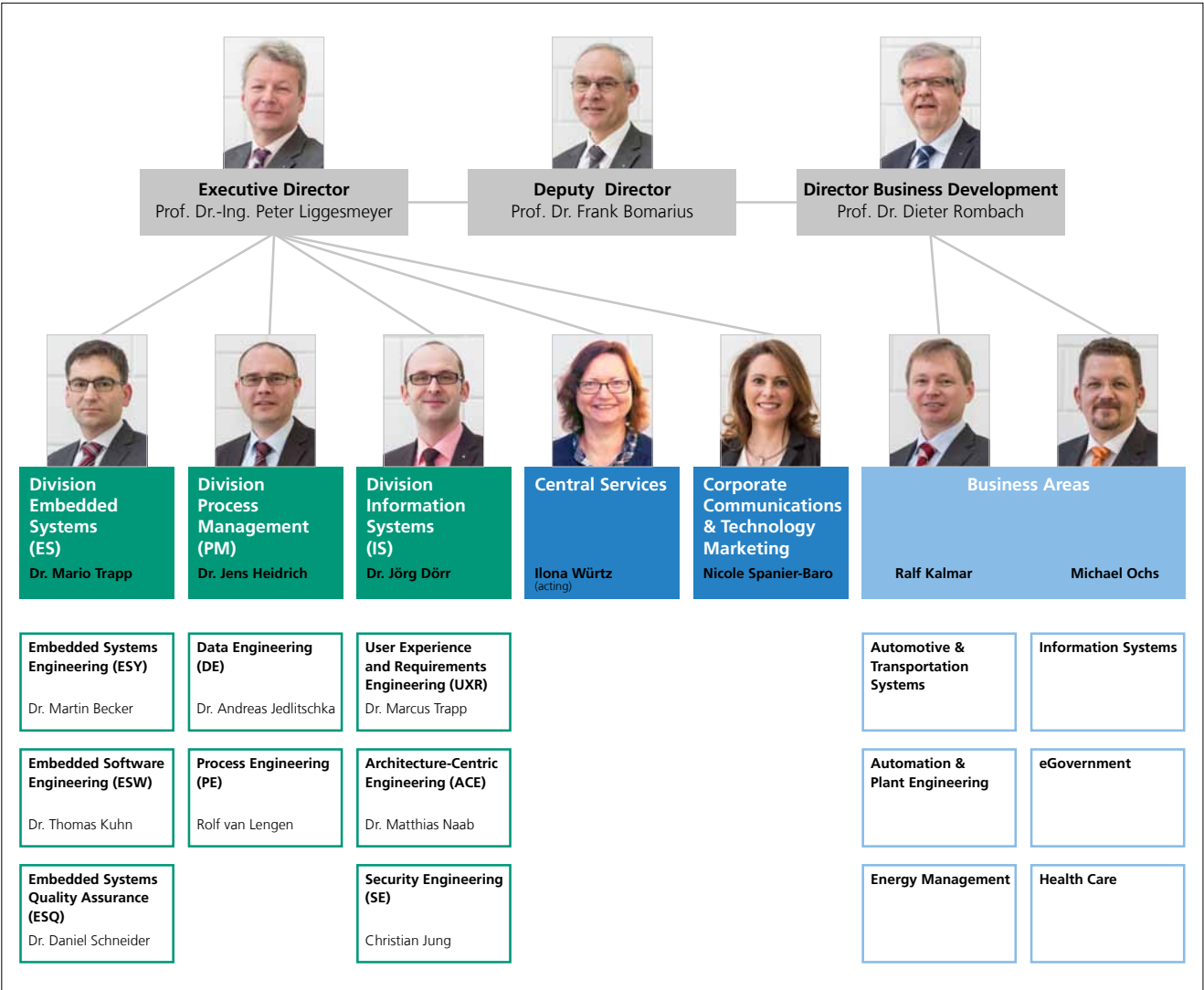
Regarding knowledge dissemination and the improvement of partnerships with local industries, FPC-UFBA designed a series of workshops in 2015, which were held in the Technology Park of Bahia and addressed issues related to requirements engineering, software processes, system architecture, and visual data analytics. In addition, a series of webinars on software product lines, software for drones, and Big Data were offered.

The plans of FPC-UFBA for 2016 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:  
[fpc.dcc.ufba.br](http://fpc.dcc.ufba.br)



# OUR ORGANIZATIONAL CHART

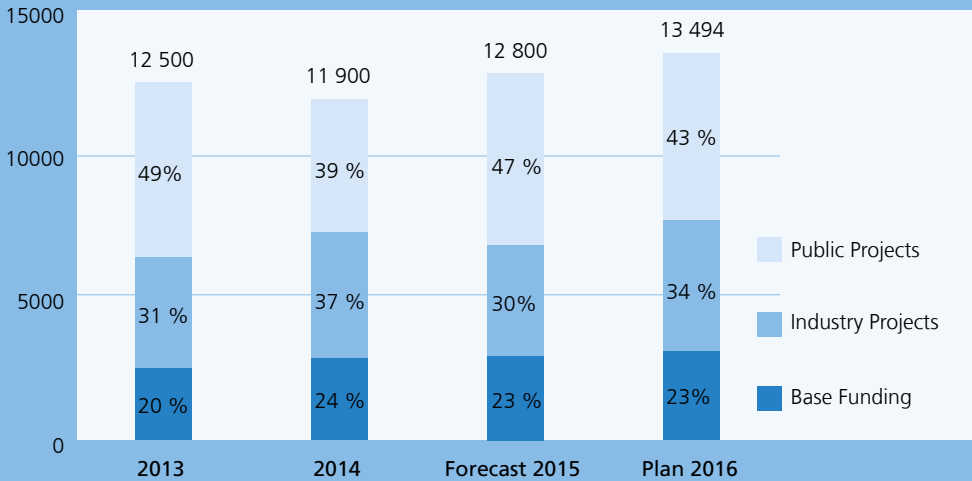


All contact information can be found at:  
[www.iese.fraunhofer.de/de/kontakt.html](http://www.iese.fraunhofer.de/de/kontakt.html)

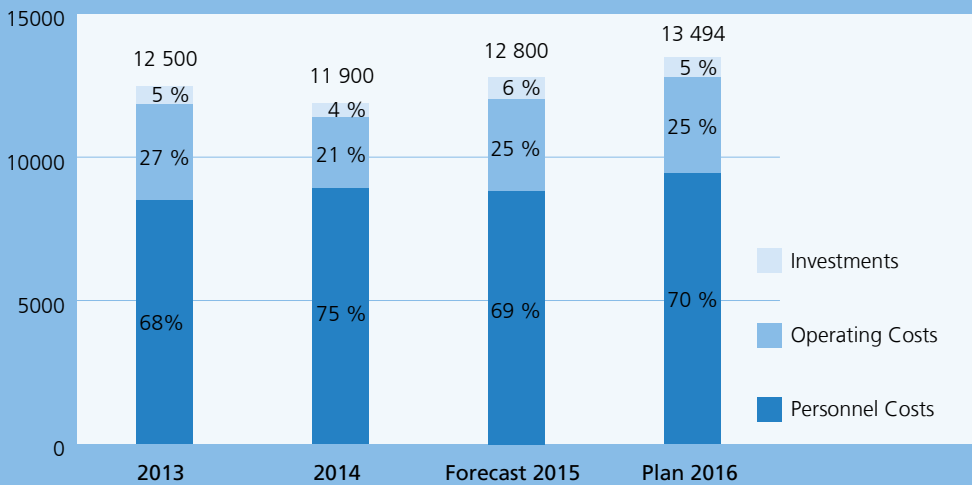


# OUR INSTITUTE IN FIGURES

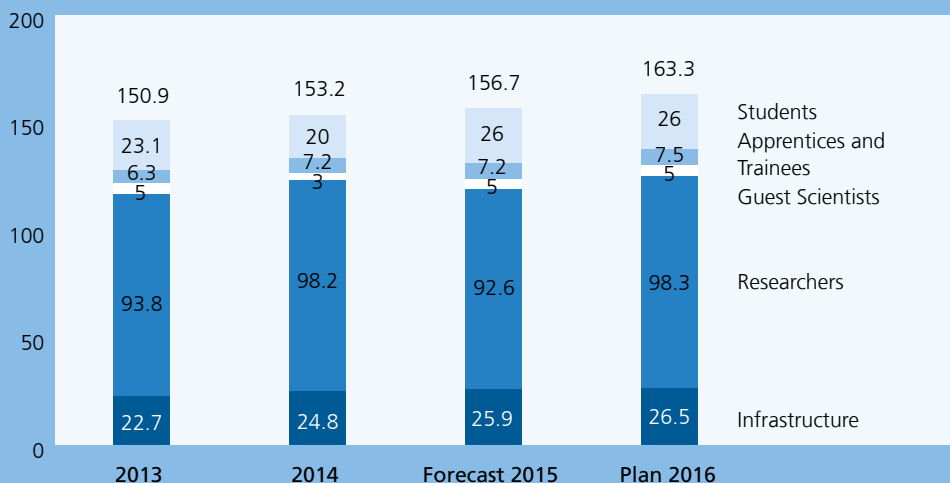
Development of Budget (in T euro)



Development of Costs (in T euro)



Development of Personnel



## Personnel and Budget Development

In 2015, investments in the amount of about 1 million euros were made into modernizing our facilities. The main focus was on the establishment of a democenter as well as on work spaces for R&D projects in cooperation with customers from industry. In addition, approx. 600,000 euros were invested into setting up laboratories for the topics Big Data and Embedded Systems.

Following the realignment of our activities in the U.S. and in Brazil, our special focus for future areas of growth in 2016 will be on content for our strategic research topic Smart Ecosystems with the application area Smart Rural Areas.

Our employees currently come from 18 different nations. The proportion of women is 31%.



# 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.

Chairman: Prof. Dr.-Ing. Heinrich Daembkes, Deputy Chairman: Prof. Dr. Jürgen Nehmer

## RESEARCH

**Prof. Dr. Victor Basili**  
Advisor

Fraunhofer Center for Experimental Software Engineering CESE  
College Park, MD | USA

**Prof. Dr. Helmut Krömer**  
Chair for Information Systems

TU München  
Munich | GER

**Prof. Dr. John A. McDermid**  
Dept. of Computer Science

University of York  
York | UK

**Prof. Dr. Jürgen Nehmer**  
Fraunhofer IESE  
Kaiserslautern | GER

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

## INDUSTRY

**Dr. Reinhold E. Achatz**  
Head of Corporate Technology,  
Innovation & Quality  
ThyssenKrupp AG  
Essen | GER

**Prof. Dr.-Ing. Heinrich Daembkes**  
Executive Advisor Engineering  
CEO  
Airbus Defence and Space GmbH  
Ulm | GER

**Gerd Höfner**  
Managing Director and Chief  
Executive Officer  
Siemens Technologies and Services  
Pvt. Ltd.  
Bangalore | IND

**Harald Hönninger**  
Vice President CR/AE2  
Robert Bosch GmbH  
Renningen | GER

**Dr. Yuji Takada**  
CEO  
Fujitsu Enabling Software  
Technology GmbH  
Munich | GER

**Dr.-Ing. Martin Verlage**  
Chief Technology Officer  
vwd Vereinigte Wirtschaftsdienste  
GmbH  
Frankfurt | GER

## GOVERNMENT

**Stefanie Nauel**  
Oberregierungsrätin  
Ministry of Economic Affairs,  
Climate Protection, Energy and  
Regional Planning, Land Rhineland-  
Palatinate  
Mainz | GER

**Dr. Carola Zimmermann**  
Head of Unit  
Ministry of Education, Science,  
Continuing Education and Culture,  
Land Rhineland-Palatinate  
Mainz | 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 67 institutes and research units. The majority of the nearly 24,000 staff are qualified scientists and engineers, who work with an annual research budget of more than 2.1 billion euros. Of this sum, more than 1.8 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 Länder 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.

# OUR SPIN-OFF "OSSENO SOFTWARE GMBH"

The importance of systematically elaborating and managing requirements and solution concepts for the success of a system development or procurement project is undisputed nowadays. Companies of various sizes and from different industries therefore increasingly invest into training, method consulting, and coaching to establish professional requirements engineering in order to optimize their requirements, tendering, and offer processes accordingly.

"The sustainability of such measures, however, is often limited", knows Dr. Sebastian Adam, who spent many years as a team leader in Requirements Engineering (RE) at Fraunhofer IESE supporting a multitude of companies in introducing requirements engineering.

In order to be able to perform good requirements engineering and ultimately add real value to one's project business as a result, it is indispensable to take a systematic approach. Requirements cannot be formulated "any which way" but need a description structure that fits the circumstances of an organization on the one hand, but also conveys the expectations of the stakeholders as completely and unambiguously as possible on the other hand. Such a systematic approach also comprises assignment of unambiguous identification numbers, combination of requirements for the purpose of traceability, determination of priorities and other attributes, creation of graphical representations to improve comprehensibility, and systematic storage and reuse of requirements to avoid double work and inconsistency.

Accordingly, despite being recognized as important, requirements engineering is often rightly perceived by many project stakeholders as challenging, complex, time-consuming, as well as error-prone, which often makes it harder for corresponding improvement projects in a company to be successful and sustainable.

Established software tools for requirements engineering, which mainly deal with managing requirements and of which



*Questions over questions – Requirements Engineering often presents challenges to project teams.*

a multitude exist on the market these days, generally do not offer adequate support for these issues and often present an additional obstacle for the stakeholders. In order to stabilize the success of requirements engineering in industry in the long term, new approaches are therefore needed that are expedient for all stakeholders in their individual organizational context and which, most importantly, can actually be applied. This is the only way to assure more efficient, simpler, and thus ultimately more successful application of requirements engineering in organizations in the long run.

OSSENO Software GmbH, a spin-off of the Fraunhofer Institute for Experimental Software Engineering IESE, has therefore set itself the goal of automating challenging tasks in requirements engineering with the help of smart software tools or at least simplifying them such that the project stakeholders can focus on the actual content of the requirements.

"It has been known for a long time that it takes several thousand hours to turn an amateur into an expert. The fact that in many companies people have to do requirements engineering in addition to their regular project work is not helpful at all in this regard", says executive manager Norman Riegel about the background of this mission.

As a remedy for this situation, the tool "ReqSuite®" was developed on the basis of many years of experience with industry projects of Fraunhofer IESE. Through automation and smart work support, ReqSuite® permits increasing both the quality and the efficiency and standardization of requirements processes, which enables not only experts but also users with less experience to create good requirements documents.

Özgür Ünal, the initiator of OSSENO Software, likes to draw a comparison with navigation systems or tax declaration programs: "You do not need to know every route, and you do not need to be a tax expert either. With the appropriate tools, you will still be guided reliably to your destination, resp. to a correct result. ReqSuite® offers such a benefit in requirements engineering."

In addition to being easy to perform and relieving project stakeholders of "formal" activities, ReqSuite® also helps to determine a reasonable procedure and elicitation sequence in the requirements process or to derive concrete process steps including corresponding work instructions. Thus, not only the



*Like a navigation system – Dependable assistance even in unknown areas*



*The Osseno team: Norman Riegel, Dr. Sebastian Adam, Özgür Ünal.*

end users benefit from this innovative software, but also those who are responsible for quality or processes and who aim to standardize their methodological processes.

One year after the company was founded, the customers of OSSENO include not only small and medium-sized enterprises, but also renowned large companies from various industries, such as insurance and automotive.

In collaboration with Fraunhofer IESE, integrated services from the areas of method transfer and tooling for requirements engineering are also being offered in addition to the tool solution itself, so that both the customers of Fraunhofer IESE and the customers of OSSENO Software can get everything "from a single source" according to their needs.

#### Contact

[www.osseno.de](http://www.osseno.de)





# 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, eleven renowned research institutes and research-oriented institutions, six 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 distinguished location in the field of research and academic studies at a regional, national, and international level.

The major topics include:

- Energy & Sustainability
- Mobility, Commercial Vehicles & Manufacturing as well as
- Health & Demographics.

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

## FULL MEMBERS



[www.science-alliance.de](http://www.science-alliance.de)



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