

# ANNUAL REPORT 2014/2015

## Zukunft Land

smart  
logistics

smart  
economy

smart  
health

smart  
trade

smart  
energy

smart  
mobility

smart  
work

smart  
farming

# EDITORIAL



Dear readers,

Software is increasingly used and perceived as an enabler for new, innovative services in all sectors of business and industry as well as in other social environments. If applied in the areas of mobility, energy supply, health care, production, or safety and security, software must comply with consistently high quality standards. This can only be guaranteed if engineering-style development approaches are used.

As a result of new technological developments in the areas of mobile communication as well as sensor technology we can observe a trend towards the integration of safety-critical systems and security-critical information systems into so-called Smart Ecosystems on the one hand, while on the other hand, a trend towards self-adaptation based on context recognition has emerged. These trends pose two fundamentally new software engineering challenges: the integration of safety and security on the one side, and the exploitation of the potential of self-adaptation even for critical systems on the other side.

**SMART ECOSYSTEMS:  
HIGHLY INTERCONNECTED SYSTEMS  
PLACE NEW DEMANDS ON SYSTEM  
DEVELOPMENT COMPETENCE**

Fraunhofer IESE is a competent and reliable partner for businesses from all sectors of industry regarding the issue of "Systems Engineering". We offer dependable methods and tools for the development of embedded systems and information systems. Another focus of IESE is on the development of 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. With our interdisciplinary and cross-domain expertise, we support companies in identifying new innovation ideas as well as corresponding roadmaps.

To stay ahead of the competition, you need innovative software and the leading expertise of your domain in terms of software engineering paired with systems engineering competence. In an era where different system classes are interconnected, the challenges are becoming even greater, and dependable software requires professional development

processes. Building on our competencies for smart ecosystems, including those for mobile devices, last year we focused on how to make more efficient use of Big Data. We are, for example, helping manufacturers of agricultural machinery such as John Deere develop and test integrated support of agricultural workflows through the use of various data sources and support them in evaluating the resulting added value.

In 2013, we drastically increased our preliminary research on the topic of "Smart Ecosystems" in the BMBF Software Cluster "Software Innovations for the Digital Enterprise". In 2014, we pushed the development of methodologies for model-based safety engineering in the BMBF project SPES\_XT as well as in the EU project CRYSTAL. In 2015, our main focus will be on the smart usage of Big Data for Smart Ecosystems in the BMWi project PRO-OPT as well as in industry projects, e.g., with John Deere. Another focal area will be our main theme for 2015, "Smart Rural Areas", the counterpart to "Smart Cities" for rural regions. We are convinced that in many areas, IT can help to find solutions that can make life in the countryside attractive (again).

Much remains to be done. The rapid technological developments continually present us with new challenges, which we address in a highly focused manner. We have many ideas for new projects with our collaboration partners and those wanting to collaborate with us in the future. Fraunhofer IESE enjoys global visibility. This is reflected in the rising number of international collaborations with partners from research and industry. 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 way towards becoming more innovative and competitive through dependable software!

We hope you find this report both informative and inspiring –

*P. Ligges*

Peter Liggesmeyer

*Dieter Rombach*

Dieter Rombach



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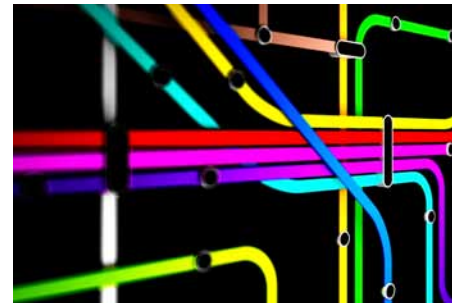
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# ZUKUNFT LAND

SMART ECOSYSTEMS

PROCESSES SAFETY  
ARCHITECTURE SECURITY  
REQUIREMENTS UX

Telemedizin

SMART TRADE

SMART HEALTH

SMART RURAL AREA

Fraunhofer IESE

Living Lab

VERNETZUNG

IM AUFTRAG DER ZUKUNFT



# WELCOME

Dear readers,

The state of Rhineland-Palatinate is located in the heart of Europe. As a state with a large area and low population density, it is characterized by decentralized structures. A large proportion of life and business takes place in rural areas. The people and the companies in Rhineland-Palatinate appreciate the diversity of the different regional areas of the economy and of life, with their variety of cultural facets. One essential criterion, however, is to ensure fair and comprehensive supply in rural areas.

The constant structural changes, the consequences of the demographic development, including demographic changes, economic adaptation as a consequence of the need for strict spending discipline in public budgets – this ultimately results in increasing difficulties to offer all government services across the entire state in the usual high quality.

The development and use of new digital media and infrastructures, however, help us to achieve an adequate balance between “living” and “working” in rural areas. Digital services and applications, in particular, could provide the right basis for allowing our state to continue to be one of the leading regions in Europe. The most important feature here is the state-wide expansion of the broadband infrastructure. According to evaluations done by TÜV Rheinland, basic access (2 Mbit/s) rose from about 91 percent of all households in the year 2010 to currently 98.6 percent. For high-speed bandwidths of 50 Mbit/s, there has been an increase from almost seven percent in the year 2010 to 58.3 percent of the households now.

The strategy of **“Smart Rural Areas”** is used, on the one hand, to analyze the major areas of activity and, on the other hand, to interconnect these via functional interfaces. Due to this network between services and economic activities on one side and public services on the other side, the people in Rhineland-Palatinate are enjoying modern and satisfying living

and working conditions.

The state government has initiated this connectivity through the expansion of the broadband network. This is one side of the coin. The other side is the realization, respectively the need to appropriately engage with this digital dimension of living and working. Both in the business world and in private households, digital offers must be discussed more frequently and thoroughly. In the private sector, surveys about the regular usage of the Internet have already revealed high acceptance of digital networks and offers. According to an analysis by Eurostat, in 2013, about 76 percent of the population of Rhineland-Palatinate made online purchases. This puts our state in first place, even AHEAD of the other non-city states, and shows that we have an open mind regarding the offers of the trendsetting digital industries.

With the research results and strategies not least of IESE, we can contribute to the sustainable and smart usage of already existing networks in the areas of infrastructures, traffic and energy grids, as well as digital networks. Mobile applications do not only serve to offer universal accessibility, but the scope of their usage possibilities can also contribute to higher quality of life for people. The work done by IESE is an elementary contribution in this regard. IESE is one of the flagships of research in Rhineland-Palatinate, which the state government supports very gratefully and appreciatively. In the same way, my thanks go to all of its highly committed employees.

The quality and the value of the work done by IESE are documented very vividly in this report. May it get the wide dissemination it deserves.



Minister President of the State of Rhineland-Palatinate







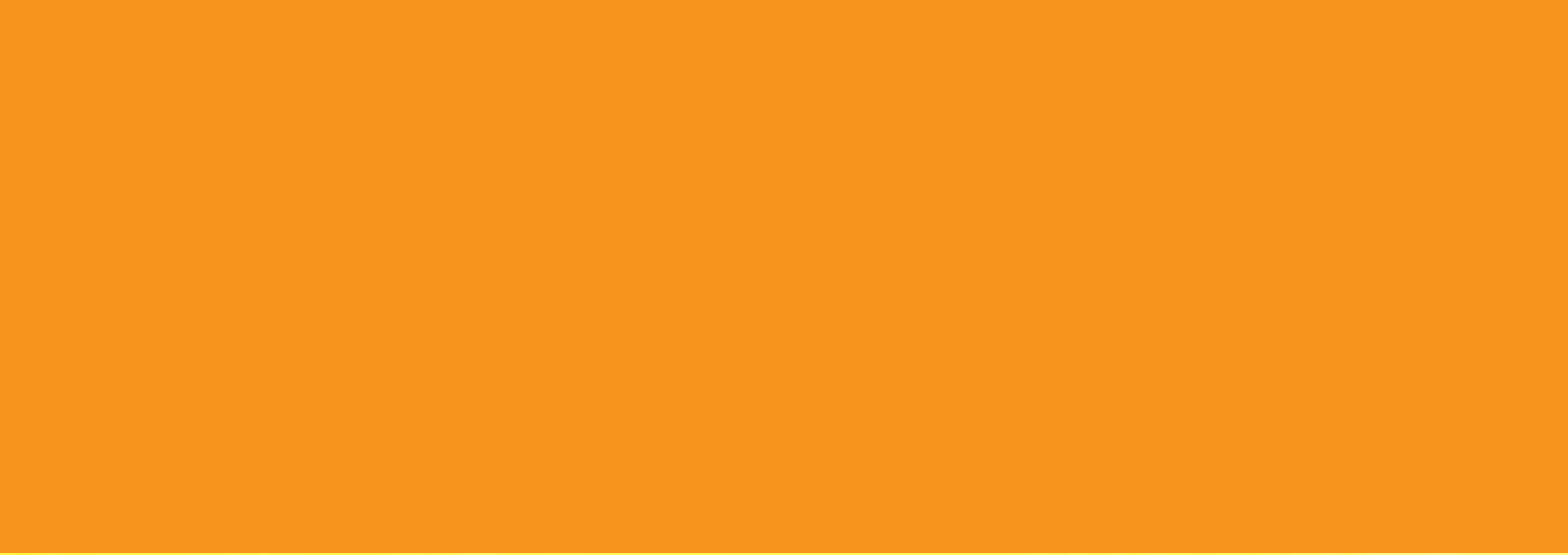
# SMART CITIES – SMART VILLAGES

“Zukunft Land” is the motto of the research initiative Smart Rural Areas. “Zukunft Land” translates as both “country of the future” and “future of the country”. With this initiative, Fraunhofer IESE is an international pioneer when it comes to preparing rural areas for the future. A prize winner in the contest “Landmarks in the Land of Ideas”, the institute shows how intelligently interconnected information and communication technology enables future solutions for mobility, new shopping experiences, sustainable medical care, or new forms of work and education. With the support of the state government, a globally unique model region is being created for this purpose in Rhineland-Palatinate, which will serve as an innovation platform for research and industry to lead the state into the future with information and communication technology.

## ZUKUNFT LAND

We invent the future. The mandate of every Fraunhofer institute summarized in four words. We perform research aimed at leading our economy and our society into the future. So what could be more fitting than to think about how we will be living in the future. The demographic changes, the transformation towards a digital society, and many other aspects show us that we must adapt. Often, the answer to many of these questions is simply “Smart City”. People are moving to the cities. The cities must get ready to support even more people living in the tightest of space. Our perspective for the future takes shape in expressive images of mega-cities. Comfortable life in the city – enabled through information and communications technology. For it is the use of IT that is intended to make the cities smart, enabling them to use their resources more efficiently.

If we look at Germany, however, we do not find any of these colorfully illustrated mega-cities. With a population of just over three million, even Berlin is rather modest compared to the metropolises in other parts of the world. Hamburg, Munich, and Cologne at least break the one-million barrier. Ultimately, then, Germany is a rather rural country. Just half of all Germans are living in towns and cities with more than twenty thousand inhabitants. In states with large areas and low population density such as Rhineland-Palatinate, half of the population is even living in towns and villages with fewer than seven thousand inhabitants. The real mega-cities are very far away. So what would Germany be without its rural areas? And how can we design a future for Germany if the focus is placed solely and exclusively on the cities? In addition to asking how Smart Cities will shape our future, we should therefore quickly ask another question, which is actually more relevant: what about the future of rural areas? Rather than being on Smart Cities, the focus should shift to Smart Rural Areas if we want to shape the future in Germany. ►►



**OPEN SPACES INSTEAD  
OF OVERCROWDING**



**COUNTRY LIFE AS A PERSPECTIVE**

However, we must not overlook the fact that many people are drawn to the cities. They do not see any perspective for living in the countryside. But many of them would have liked to stay. The countryside offers open space instead of overcrowding, single-family homes instead of apartments, tranquillity instead of city noise, meadows and forests instead of concrete landscapes, a life for children where they are still allowed to grow up as children. Getting the cities ready for tomorrow is an important contribution of the Fraunhofer-Gesellschaft for Germany and for Europe. For the citizens and for the economy. But rural areas are also part of Germany. As a place to live, as a market, and as a business location. Already today, 60% of all companies are located in Germany's rural areas, including many small and medium-sized enterprises. We as the Fraunhofer-Gesellschaft therefore do not only invent the cities of tomorrow, but also the country of tomorrow. We invent the future. For all of Germany. For Europe.

The great challenge faced by rural regions lies in their sparse population. Compared to cities, very large areas must be sup-

plied in order to reach comparatively few citizens. This affects many areas, from mobility to medical care. In light of the demographic changes, this challenge becomes even greater.

In order to be able to ensure affordable and yet comfortable supply in the future as well, resources must be used efficiently. Here, information technology will play a key role in various fields. On the one hand, IT enables us to avoid having to overcome distances physically, since home office jobs, new educational concepts, and innovative shopping experiences will allow us to forego many time-consuming trips. If we have to travel, software also forms the basis of future technologies such as autonomous driving, which will not only make traveling more comfortable, but will also allow sick and elderly citizens to remain mobile. The greatest challenge, however, will arise when systems have to collaborate across traditional industry barriers. When, for example, packages are no longer transported only via package delivery services, but are taken along in public transport vehicles and even in private vehicles – similar to the way that digital car-sharing services have brought hitchhiking to the future as a safe and comfortable transport option. To make this a reality, a wide variety of systems must collaborate, from smart address labels and reading devices in the car via smartphone apps to overarching coordination and optimization in the interaction between logistics systems and passenger transport systems offered by many different providers.

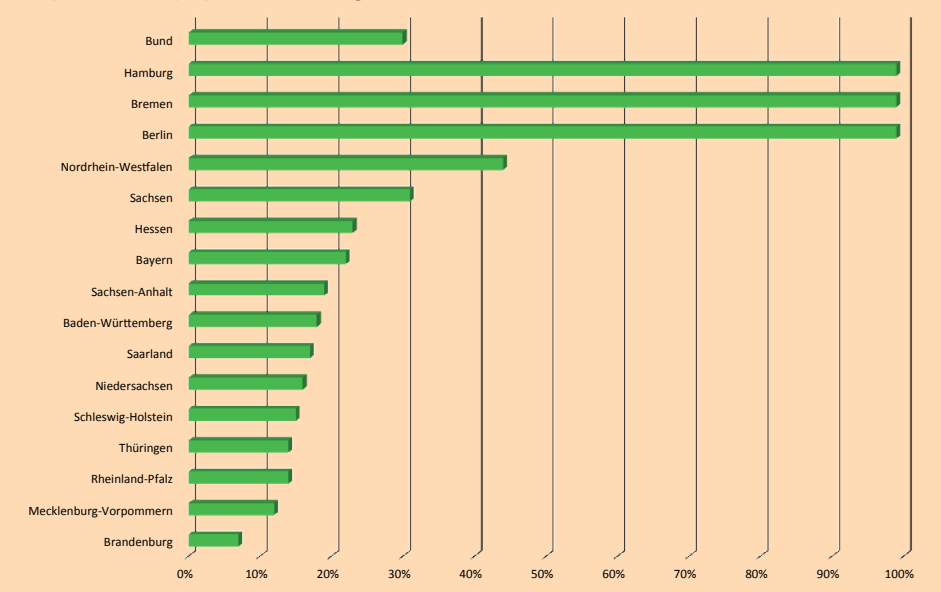
To accomplish all this, it is no longer sufficient to look at individual systems in isolation; rather, smart ecosystems are created, consisting of a wide variety of systems from different

**Classification of municipalities in Germany according to the German Federal Statistics Office**

<b>Urban Area</b>	Population density of more than 500 people/km <sup>2</sup> and at least 50,000 residents
<b>Semi-Urban Area</b>	Population density of 100 to 500 people/km <sup>2</sup> and at least 50,000 residents
<b>Rural Area</b>	Population density below 100 people/km <sup>2</sup>



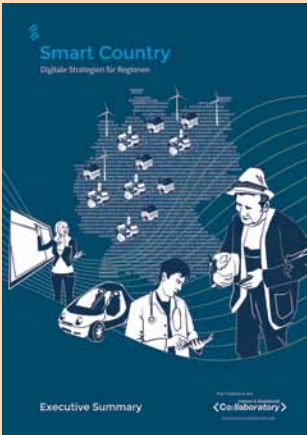
Proportion of population living in cities with more than 100,000 residents



manufacturers and resulting in integrated interplay encompassing everything from sensors to Cloud services. Such "Smart Ecosystems" form the technological basis for making the reality of a Smart Rural Area come alive. The ability to master the complexity of such smart ecosystems in order to ensure their quality across system and manufacturer boundaries is one of the greatest challenges on the path towards this future vision. Only if the security and safety of such systems are ensured to the same extent as intuitive user experience will they be accepted by the market.

With its internationally renowned expertise in the areas of both information systems and embedded systems, Fraunhofer IESE is the ideal partner for developing smart ecosystems with guaranteed quality features. For leading rural regions into the future as Smart Rural Areas. And for the many other applications in which smart ecosystems will open up completely new opportunities.

More about this topic



Background Report (in German)  
**"Smart Country – Digitale Strategien für Regionen"**  
<https://smartcountry.collaboratory.de>

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**"Smart Rural Areas – Intelligent Technologies for the Land of Tomorrow"**  
 is a "Landmark in the Land of Ideas".

Deutschland  
 Land der Ideen  

 Ausgewählter Ort 2014/15

# WHAT WOULD GERMANY BE WITHOUT ITS RURAL AREAS?

## Guest Comment

Franz-Reinhard Habel, spokesman of the German Association of Towns and Municipalities, about the opportunities digitalization offers for rural areas



Germany's regions are competent. They don't need to hide. More than half of the people are living in the regions. Almost 60 percent of the 3.5 million companies in Germany are located in rural areas. They contribute to growth and to jobs. The number of hidden champions, particularly among small and medium-sized enterprises,

makes Germany an attractive business location. So is everything fine? No! The demographic development as well as digitalization will change our country in the long term. How we live, work, educate ourselves, and spend our spare time is increasingly determined by the Internet. The new wave of the Internet – also called Industry 4.0 – is changing production and companies along with it. Tools are interconnected with each other, global value chains emerge. Social networks connect people with people even more intensely. We must adapt to these changes.

In all important policy areas such as mobility, energy, education, health care, nursing care, safety and security, information technology will play a vital role. Holistic urban development is called for. Municipalities, businesses, and civil society are collaborating more intensively. The city is a network with many stakeholders. What does all of this mean for the regions? What will the map of the future look like in the small towns or in the villages in our country? Will rural areas become the refuge of retirees? Will rural regions become the place where everything stands still? Will there be a "total rural exodus"? Or will there be structural changes in the regions as well, changes that will

bring growth and wealth? In a remarkable project that took place last year, 40 mostly young people came together in the Berlin CoLab. With the support of the German Association of Towns and Municipalities and others, they developed a guideline for strengthening rural areas, under the motto "Smart Country – the Future of the Digital Region". The subject was, among other things, to place new technological possibilities and innovative administrative concepts that build upon these into a strategic context with structural challenges faced by the regions. "Smart Country is cool" – so cool that requests for information are becoming ever more frequent, from German mayors to Chinese conference organizations.

Germany's regions do have a future. The aim is, in particular, to bring together creative and innovative people there and to establish a new relationship between humans and the environment. Communication is the key word in this context. Global villages are emerging, combining global knowledge with local and regional knowledge. Places of learning that citizens map and collect themselves are an important part of educational landscapes; virtual universities can also establish themselves in villages. Interconnected health care centers in rural areas do not only improve medical care on site, but can also serve as recreation centers for people from the big cities. The city needs the country and the country needs the city. Both will benefit from interconnection. The prerequisite is an intensive and broad dialog with the citizenship.

Villages that want to get ready for the future must embark on new paths, must try out a lot of new things. The challenges are often much greater than in urban areas. To master them, the



willingness of the villagers to accept changes must be activated and supported. Young people must be given the chance early on to participate in designing their region. Start-ups can also exist in the regions. ONE infrastructure, however, is indispensable – broadband access. It will not only be the lifeline in the world of tomorrow, but is already the lifeline in the world of today.

The project **“Smart Rural Areas – Intelligent Technologies for the Land of Tomorrow”** in Rhineland-Palatinate demonstrates that people are on a good path, that they are taking the future into their own hands, but also that they are getting support from government, public administration, business and industry.

It is up to us to exploit the opportunities offered by digitalization to revitalize the regions in Germany. Without its rural areas, Germany would surely be a poor country.



# WHAT DOES AN ECOSYSTEM HAVE TO DO WITH SOFTWARE?

Institute director Prof. Dr.-Ing. Peter Liggesmeyer about the interplay between digital systems and technologies of the future

## **Smart Ecosystems are a central element of the strategy of Fraunhofer IESE. What exactly are these, and what does software have to do with an ecosystem?**

The term ecosystem is known from biology and is used there to describe a system resulting from interacting organisms and their environment. All the organisms of an ecosystem try to accomplish certain goals, taking into account their environment. A smart ecosystem consists of different systems interacting with each other like biological organisms in order to achieve certain goals, while having to take into account environmental influences. Smart ecosystems in the technical sense typically comprise both information systems and technical systems, which are interconnected with their environment in numerous ways, for example via sensors and actuators. A typical example of a smart ecosystem are modern integrated mobility solutions that are able to jointly use different means of transportation smartly in order to solve a given transportation problem.

## **Is this then simply another word for cyber-physical systems, Industry 4.0, or the Internet of Things?**

Cyber-physical systems are typically a component of smart ecosystems. Cyber-physical system is the term used very often for software-intensive technical systems that interact with their environment. Industry 4.0 is the name given to the 4<sup>th</sup> Industrial Revolution. Its characteristic feature is the replacement of mass products by mass-customized products. This calls for flexible autonomous re-planning of production at runtime on the basis of data. Industry 4.0 is therefore an area in which cyber-physical systems will play an important role, and Industry 4.0 production plants can, of course, form a smart ecosystem. The Internet of Things can form the technical backbone for many smart

ecosystems, as its central idea is to make things addressable and thus enable them to communicate with other partners in the sense of a smart ecosystem.

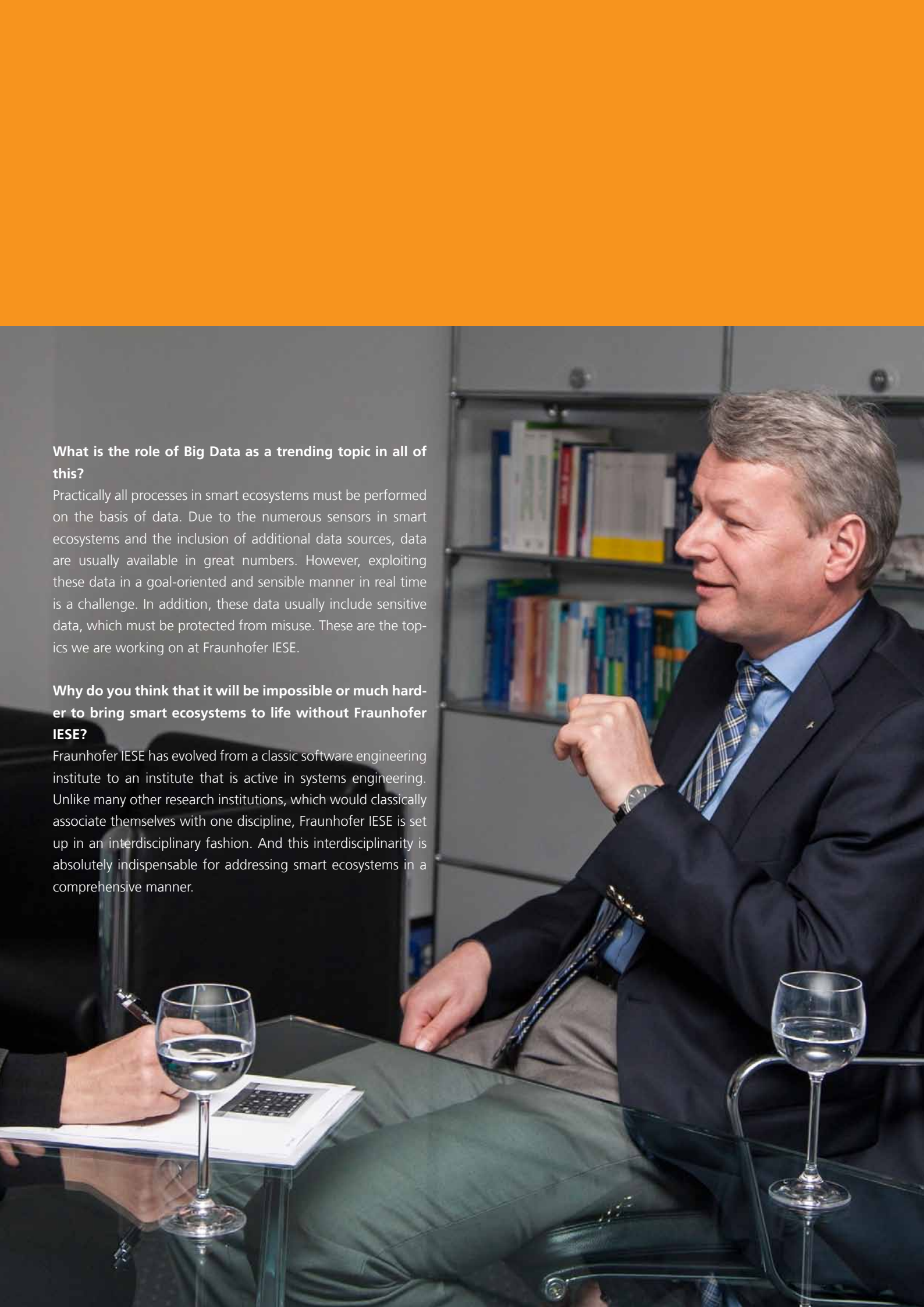
## **This appears to be a vast subject area – what is the focus of Fraunhofer IESE?**

Many research issues have already been answered sufficiently for information systems on the one hand and for embedded technical systems on the other hand. In smart ecosystems, however, information systems and technical systems are interconnected intensively, which means that issues must be resolved in a way that spans the entire smart ecosystem. The solutions available today are often unable to do this. A typical example are the reciprocal effects between security and safety. IESE very much focuses on solving such overarching issues.

## **What exactly is Fraunhofer IESE doing in the area of safety and security?**

In the area of safety, the central challenges are the modularization of safety cases and the shift from safety cases produced by humans at development time to autonomous safety cases produced by systems at runtime.

In the area of security, it is quite obvious that data access protection, which is still common today, must be replaced by much more specific data usage control. To meet these challenges, we have developed processes for both safety and security at Fraunhofer IESE. The next step will consist of integrating these solutions in order to be able to guarantee comprehensive safety and security for smart ecosystems.

A man with grey hair, wearing a dark suit, light blue shirt, and patterned tie, is seated at a glass table. He is looking towards the left, engaged in conversation. On the table in front of him is a wine glass filled with white wine. To his left, another person's hand is visible, holding a pen and writing on a notepad. The background shows a bookshelf with various books. The top of the image has a solid orange gradient.

**What is the role of Big Data as a trending topic in all of this?**

Practically all processes in smart ecosystems must be performed on the basis of data. Due to the numerous sensors in smart ecosystems and the inclusion of additional data sources, data are usually available in great numbers. However, exploiting these data in a goal-oriented and sensible manner in real time is a challenge. In addition, these data usually include sensitive data, which must be protected from misuse. These are the topics we are working on at Fraunhofer IESE.

**Why do you think that it will be impossible or much harder to bring smart ecosystems to life without Fraunhofer IESE?**

Fraunhofer IESE has evolved from a classic software engineering institute to an institute that is active in systems engineering. Unlike many other research institutions, which would classically associate themselves with one discipline, Fraunhofer IESE is set up in an interdisciplinary fashion. And this interdisciplinarity is absolutely indispensable for addressing smart ecosystems in a comprehensive manner.

# RESEARCH PROJECTS AND SUCCESS STORIES

STAGE SET FOR OUR  
HIGHLIGHTS





The IND<sup>2</sup>UCE researcher team: Denis Feth, Dr. Yehia Elrakaiby, Michael Eisenbarth, Dr. Jörg Dörr, Christian Jung, Andreas Eitel, Manuel Rudolph, and Cornelius Moucha (from left to right) at the EARTO Prize award ceremony in Brussels.

## IND<sup>2</sup>UCE WINS EARTO PRIZE

Researchers of Fraunhofer IESE have won the renowned Innovation Prize of the European Association of Research and Technology Organisations EARTO for the IND<sup>2</sup>UCE framework. With the help of the IND<sup>2</sup>UCE framework, sensitive information is protected from future misuse and new business models are made possible. For this purpose, all data are equipped with small information packages containing information about what is permitted and what is not. The data owner can use these to precisely define, e.g., which data may be read, copied, or forwarded how often, whether they may be read on smartphones

and if so, whether this shall only be possible on the company premises or in public areas as well.

Every year, the EARTO Innovation Prize is awarded to innovations that have a major social and/or economic impact. An independent, high-profile jury assesses the submissions and selects the winners at an award ceremony held in Brussels, Belgium, in the presence of numerous politicians and industry representatives.



# PROJECTS

## LANDMARK IN THE LAND OF IDEAS

With “Smart Rural Areas – Intelligent Technologies for the Land of Tomorrow”, Fraunhofer IESE is one of the winners in the Germany-wide competition “Landmarks in the Land of Ideas” 2014/15. About 1,000 research institutions, companies, and associations from all across Germany submitted ideas for this year’s competition topic “Innovative Country – Rethinking Rural Spaces”. Information technology is the decisive factor when it comes to giving life in the countryside a perspective for the future. The interconnection between smart software and systems in all areas of our daily lives offers a potential that has not been exploited to date: the potential of leading rural regions from the sidelines to the fast track towards the future as so-called “Smart Rural Areas”.



Juliane von Throta (Initiative “Germany – Land of Ideas”), Prof. Peter Liggesmeyer, Prof. Dieter Rombach and Uwe Schmidt (Deutsche Bank) (left to right) at the award ceremony.

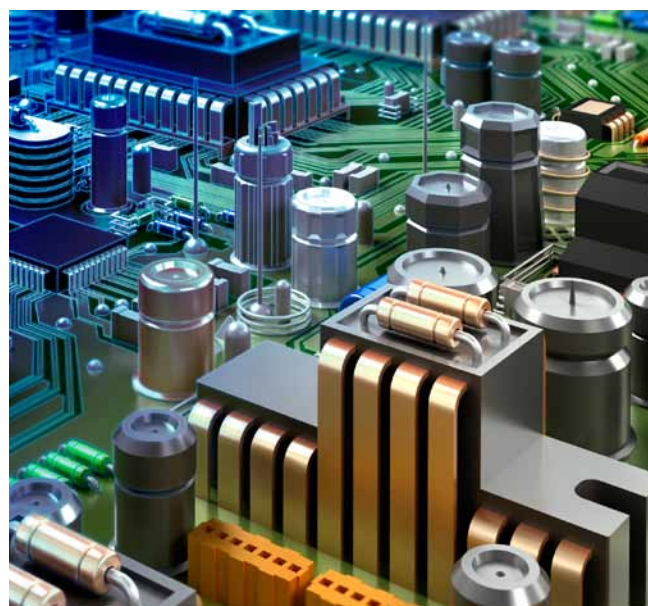
## BMBF PROJECTS OF THE MONTH

Collaboration with small and medium-sized enterprises (SMEs; KMU in German) plays a central role for Fraunhofer IESE in the development of innovations that are suitable in practice. At the KMU-innovativ: IKT 2014 symposium, the projects “PQ4Agile” and “SmartOffer” were selected from among more than 100 projects as “BMBF Projects of the Month”. In PQ4Agile, Fraunhofer IESE is developing software engineering best practices, i.e., clearly designed method components that enable integrated quality evaluation and predictably high product quality for companies using agile development processes such as Scrum or Kanban. In SmartOffer, the aim is to optimize the pre-project phase of software projects to allow SMEs to spend less effort on making their customers offers that are as accurate and as convincing as possible.

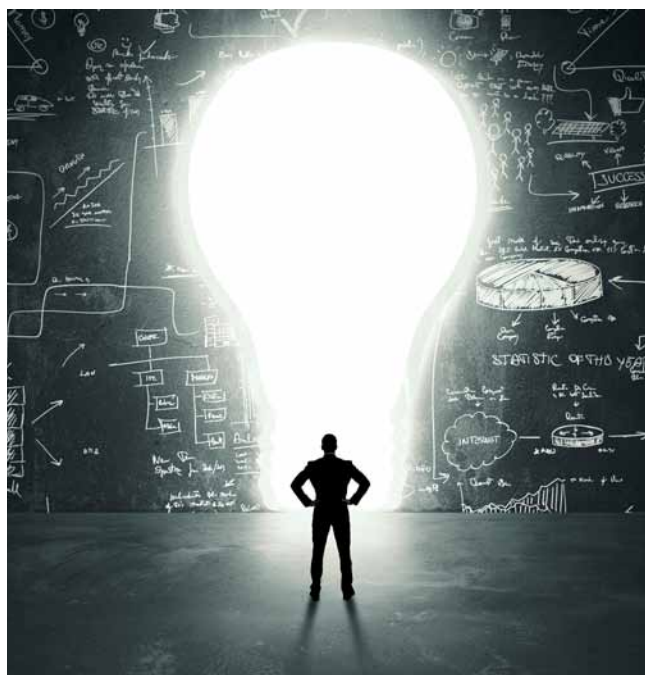


## EMC<sup>2</sup> – THE GIANT IN THE AREA OF CYBER-PHYSICAL SYSTEMS

Almost 100 partner institutions, a budget volume of close to 100 million euros, and about 800 person-years of planned work effort. These are the figures of the European project EMC<sup>2</sup>, the largest of its kind to date. Regarding its subject, EMC<sup>2</sup> is positioned at the transition point from closed embedded systems or systems of systems to open and adaptive embedded multicore systems in the sense of the paradigm of cyber-physical systems. Within EMC<sup>2</sup>, Fraunhofer IESE is in charge of the work package on the topic of qualification and certification (of safety and security), which is one of the project's six science and technology work packages. In addition to these horizontal activities, there are six vertical activities, so-called living labs dedicated to concrete use cases from a series of different domains. The project is funded in the context of the ARTEMIS Joint Undertaking of the European Union and by the German Federal Ministry of Education and Research (BMBF).



## PRO-OPT – BIG DATA | BIG BUSINESS



Everyone is talking about Big Data. Ever greater amounts of data are a challenge that the German economy will have to address in the near future. The value of a company is increasingly hidden in its data and can only be exploited fully if these are used efficiently along the entire value chain. The project "PRO-OPT – Big Data Production Optimization in Smart Ecosystems" makes a core contribution to the technology contest "Smart Data – Innovations from Data" of the German Federal Ministry for Economic Affairs and Energy, using the automotive industry as an example. It will enable companies to perform effective and smart analyses of large amounts of data in smart ecosystems. The aim is to improve production and increase product quality. This will allow the German economy to respond to the challenges posed by digitalization and automation in manufacturing: the ever greater amounts of data originating from different, economically independent stakeholders will be packaged for efficient use taking into account access authorizations. (also see p. 47)



# PROJECTS

## DENIT – IT IN EMERGENCY MEDICINE

Even emergency services can no longer do without data and software nowadays. Since 2008, the state government of Rhineland-Palatinate and the relevant public agencies have been getting competent advice and support for the analysis and provision of data regarding emergency service issues from the German Center for Emergency Medicine and Information Technology (DENIT) located at Fraunhofer IESE. Currently, 99 acute-care hospitals and 8 emergency service centers and integrated emergency dispatch centers in Rhineland-Palatinate are relying on the award-winning (in 2012) information system eZLB, which supports dispatch centers in selecting a hospital that is both able to accept a patient and equipped to handle the respective illness or injury. The system is also suitable for other states and is to be developed further towards mass casualty care. In another DENIT project, indication areas for telemedicine applications will be identified and prioritized in 2015, true to the motto "Software can save lives". DENIT is funded by the



Ministry of Internal Affairs, Sports and Infrastructure of the state of Rhineland-Palatinate; the operative collaboration partner is the Westpfalz-Klinikum GmbH (hospital) in Kaiserslautern.

## SUSI TD – MORE QUALITY OF LIFE THANKS TO IT

The project SUSI TD – "Safety and Support for Senior Citizens through Integration of Technology and Services" – makes an important contribution to helping elderly people lead autonomous lives and enjoy quality of life: Using a new sensor and communications technology, a pilot project performed in collaboration with Fraunhofer ITWM and dip (Deutsches Institut für angewandte Pflegeforschung e.V.; German Institute of Applied Nursing Research) in 16 apartments of senior citizens in the area of Trier/Trier-Saarburg tested how residents' physical helplessness can be detected on time in the case of an emergency. The project was complemented by preventive counseling. The Ministry of Social Affairs, Labour, Health and Demography of the state of Rhineland-Palatinate funded the evaluation of the "SUSI TD" assistance program in the context of the future-oriented program "Health and Care – 2020". This allowed a final evaluation of this successful pilot project to be performed over the course of another seven months in

2014. The focus was now on issues related to the effects and to the cost effectiveness of the integration of modern ambient assisted living technologies and on the system's acceptance by its users. SUSI TD combines competencies in the areas of health technologies, care science, and socio-economics to develop a viable care concept for the future.





## SAVING LIVES WITH RESCUER

The response to emergencies occurring during major events or to serious incidents in industrial plants must be well orchestrated. The right information in the right place at the right time determines the scale that an incident will reach. This information contributes to ensuring that the command center and the operational forces can make the right decisions at the right time. Eyewitnesses, residents, and last but not least the public also want to be informed as quickly as possible about the situation and about potential risks.

The European-Brazilian partnership project RESCUER (“Reliable and smart crowdsourcing solution for emergency and crisis management”), which started in November 2013 and is being coordinated by Fraunhofer IESE, is based on the use of information provided by the crowd at the site of an incident via mobile

devices such as smartphones and tablets. The mobile crowdsourcing solution offers optimal support for control centers in terms of coordination of the various operating forces and thus enables them to quickly handle an emergency. Information is available right from the start and can be confirmed by the number of similar reports coming from the crowd. The design of the user interface and of the interaction model is particularly important for an IT-supported solution, considering that people react differently under stress and their cognitive abilities are impaired. A first version of the interoperable RESCUER platform was evaluated during the FIFA World Cup 2014. The project is funded by the European Commission and by the Brazilian Ministry of Science, Technology and Innovation and comprises a total of nine project partners from Europe and Brazil.



# PROJECTS

## THE NEXT GENERATION OF IT LEADERS

Applied research means that research must be grounded on concrete challenges encountered in practice. Teaching this philosophy is particularly important for the education of our most valuable asset – the next generation of researchers in the areas of IT and Systems Engineering. For several years now, IESE has been involved in the “Software Campus”, together with 18 well-known partners from industry and research. This development program for the next generation of leaders is funded by the German Federal Ministry of Education and Research (BMBF) and brings together young scientists and Germany’s leading companies in this area. Accepted participants from computer science or related disciplines are supported from the application process all the way to the execution of a funded project and benefit from tried and tested leadership training as well as mentoring by an experienced industry partner. In 2014, IESE supported six young scientists in this way.



## THE SOFTWARE-CLUSTER – EUROPE’S SILICON VALLEY

Fraunhofer IESE has been a part of the Software Cluster, Europe’s highest-performing network of companies and research institutions in the area of software development, ever since its inception. About 11,000 software companies are located in the region of the Software Cluster, with a joint annual turnover of 25 billion euros and more than 100,000 employees. This means that one fifth of all employees in the German software and IT service industry are working in the area of the Software Cluster. Eleven of the 25 largest software companies in Germany are collaborating with Fraunhofer IESE and other research partners in designing and developing emergent enterprise software in the areas of trade, production, services, and logistics. The next generation of enterprise software will support process chains across companies. The challenge lies in providing business

processes as required together with several partners. In order to accomplish this, it must be possible to combine different software components from different manufacturers into new business applications flexibly and at any time. The digital enterprise of the future will span several domains, which will enable various highly specialized providers of goods and services to join forces in order to fulfill individual customer wishes with custom-tailored offers.



# CHANGE IN LEADERSHIP

Prof. Dieter Rombach hands over leadership of Fraunhofer IESE after many years spent as its executive director: On 20 January 2015, numerous guests from the worlds of politics and business attended the ceremonious passing of the torch to Prof. Peter Liggesmeyer.

Close to twenty years ago, it was Dieter Rombach, then (as now) professor of computer science at the University of Kaiserslautern, who founded the first Fraunhofer institute in Rhineland-Palatinate in Kaiserslautern. From the start, the Institute for Experimental Software Engineering offered its partners from business and industry applied research with practical relevance. Together, tangible innovations were realized using future-oriented software engineering methods. This turned out to be very successful: The institute quickly grew into an ever larger, throbbing organism with currently over 200 employees. In 2005, the institute's move from Siegelbach to a new building in Trippstadter Strasse and thus to the immediate vicinity of the University of Kaiserslautern offered a chance for even tighter integration. During the course of the years, other renowned research institutes such as the Max Planck Institute and DFKI settled along the axis University – Fraunhofer Center. With the foundation of the Science Alliance – the partnership among research institutes and other partners in Kaiserslautern – in the year 2007, Kaiserslautern had definitively arrived in the major league of German science hubs.

“We owe all of this largely to Professor Rombach, who never grew tired of standing up to support science in Kaiserslautern in general and IT in particular when dealing with representatives of the city, the state, the federal government, as well as business and industry.” With these words, Minister President Malu Dreyer honored Rombach's achievements and his commitment at the handover ceremony. “For me, Professor Rombach is the very embodiment of a productive scientist and at the same time that of a busy networker – in other words, a researcher personality who puts himself at the service of both science and business.” Professor Rombach and Fraunhofer IESE are a suc-

cess story, she continued. “The splendid development of IESE is due to the commitment of its employees, but primarily to the dynamic personality of Professor Rombach”, concluded the Minister President.

August Altherr, Director of the John Deere European Technology Innovation Center, emphasized: “Without IESE and Dieter Rombach, John Deere would certainly not have come to Kaiserslautern”.

Back in 2004 already, Prof. Dr.-Ing. Peter Liggesmeyer, then professor of software technology and quality management at the University of Potsdam and previously working, among other places, in research and development at Siemens AG, joined Fraunhofer IESE. The resulting dual leadership consisting of an executive director and a scientific director brought cumulative strength and new perspectives to the institute in the past decade.

“This will neither be a farewell for me nor a completely new beginning for Peter Liggesmeyer – after ten years, we are merely transferring the job of executive leadership. Together we will continue to keep Fraunhofer IESE on course in the future, with great commitment and loyalty. For me as the founder of this research institution, IESE is like a child: I want to see it grow and flourish. And here we are on a good course as well. After twenty years as executive director, however, I am now looking forward to new strategic tasks as Director Business Development of Fraunhofer IESE and as Deputy Chairman of the Board of the Science Alliance Kaiserslautern”, summarized Dieter Rombach.

Peter Liggesmeyer thanked his predecessor for his great commitment. “Dieter Rombach has accomplished an enormous feat in transforming Fraunhofer IESE from an idea into a well-established, globally visible institute. Now our joint goal must be to continually update IESE with current research topics and projects in order to position it permanently as a successful part of the international science landscape.” Liggesmeyer himself is not only the new executive director of Fraunhofer IESE, but



Prof. Dieter Rombach passes the torch to Prof. Peter Liggesmeyer

also holds the Software Dependability Chair at the Department of Computer Science of the University of Kaiserslautern and is the current President of the Gesellschaft für Informatik (G.I. e.V., German Informatics Society). With his background – academic experience on the one hand, industry experience on the other hand – Liggesmeyer personally embodies the Fraunhofer-Gesellschaft's principle of applied research and will make his own contributions to further sharpening the profile of IESE.

The IT topics that will dominate the upcoming years – including Big Data, Industry 4.0, the Cloud, Smart Ecosystems – are already the subject of research at IESE today. The issue at present is how to combine embedded systems and information systems on various levels. Information Systems have been a research focus at IESE from the very beginning of the institute, represented by Prof. Rombach. When Prof. Liggesmeyer joined the institute, he added the focus on Embedded Systems. The result of the successful combination of these two different areas are so-called Smart Ecosystems for a wide variety of application areas.

In order to be ready for the upcoming challenges, the leadership of Fraunhofer IESE recently changed the institute's strategy and gave it a new orientation. With its core competencies in software engineering and quality assurance, IESE is combining its know-how regarding current and future application areas into the success formula: Engineering + Quality = Innovation. In other words: With scalable systems engineering methods, IESE guarantees that it will provide its customers with top-quality customized solutions for all branches of industry and for companies of any size. In the future, IESE as well as its partners and customers will continue to benefit from the great commitment of the two institute directors in a new constellation, but with familiar faces.

Welcome Speakers (top to bottom):

Malu Dreyer, Minister President of the state of Rhineland-Palatinate; Prof. Dr.-Ing. Alexander Verl, Executive Board of the Fraunhofer-Gesellschaft; Panel Speakers: August Altherr, Director ETIC John Deere; moderator Nicole Spanier-Baro; Prof. Dr. Arnd Poetzsch-Heffter, Vice-President, University of Kaiserslautern; Dr. Klaus Weichel, Lord Mayor, City of Kaiserslautern.



# WE DESIGN THE FUTURE WITH THESE TOPICS







Using opportunities safely.



# THE DIFFERENCE IS TEN TO THE POWER OF MINUS NINE

**Ten to the Power of Minus Nine** – The highest quality standard for safe software expressed in a single number. One billionth, which makes the difference between an effective marketing idea and a marketable innovation. And although safety is frequently still considered a restrictive obstacle today, these ten to the power of minus nine actually incorporate one of our greatest opportunities: The competence of being capable of developing new products not only innovatively, but at the same time safely offers a competitive edge, which can be further sharpened through innovations in Safety Engineering.

We take it for granted that we can rely on cars, planes, and trains to get us safely to where we are going. While we assume and accept without questioning that in the software installed in our computers, smartphones, or tablets, some kind of defect will practically always lead to problems, we obviously have completely different expectations regarding quality in technical products such as automobiles. And this is true despite the fact that we are quite aware that even a car is nothing but a highly complex software system these days. The software embedded in technical devices and machinery inherits the quality expectation we have for the overall product. And quality issues do indeed have totally different effects. Whereas in classic software systems, the issue may be annoying delays or financial damage in the worst case, defects in embedded systems may easily lead to plane crashes or car accidents and thus to the death of people.

## WHEN SOFTWARE BECOMES VITAL

These are the reasons why software in safety-critical systems must fulfill the highest quality standards. A number that is frequently heard in this context is “ten to the power of minus nine”, which means, in very simplistic terms, that it is a thousand times more likely that you will win the jackpot at the next lottery drawing than that you will crash during your next plane trip due to a software defect. If, vice versa, an airplane were to be controlled using systems with the

It is a thousand times more likely to win the jackpot in the next lottery drawing than to crash during the next plane trip due to a software defect.

quality of those used in smartphones, the provable likelihood of survival of the passengers would probably not be much higher than during the days of the pioneers of flight, and airplanes would be useless as a means of mass transport. Yet, it is very tempting to transfer technological achievements, from the smartphone to the Cloud, to safety-critical systems. And the software giants are increasingly active in the area of technical systems, which they develop using processes and





In embedded systems, this **new hardware generation** is just now being introduced, as it is still difficult to provide safety evidences of multicore systems.

technologies that had been limited to classic software systems before. At first glance, traditional automobile and airplane manufacturers may then appear to be very backward. Whereas, for example, multicore processors in PCs and smartphones have long since been considered standard, this new hardware generation is just now being introduced into embedded systems, as it is still difficult to provide safety evidences for multicore systems. At second glance, one will therefore realize that the software giants still have to overcome the obstacle of “ten to the power of minus nine”, and since it is very hard to retroactively make a system safe that was not developed with safety in mind right from the beginning, there is still a long road ahead to proceed from these ideas, which are great for marketing purposes, to a certifiable product. And it is right here that opportunities exist for German and European companies, as the necessary competencies, processes, and technologies for developing safe products are already available.

**The head start** of the German and European industry is clear to see: It can not only develop innovations, but also prove that they are safe.

### SAFETY IN THE AGE OF SMARTPHONES & THE CLOUD

At the same time, smartphones, Cloud & Co. are inevitably changing customers' expectations. Whereas in the past, software in embedded systems had longer development and innovation cycles and the technology progressed more slowly, it will become increasingly difficult in the future to escape the development speed of IT systems. Customers increasingly expect technical systems to have the flexibility and intelligence they have come to take for granted in smartphones and Cloud applications, for example. However, it will be crucial not to engage in a catch-up race with the software giants. Rather, one should be aware of one's strengths and exploit the head start in safety engineering. Doing so, however, requires further strengthening of the safety culture in companies and looking at innovations not only within the limits of system functionality, but expanding them to include the ability to provide relevant safety cases. Safety is not an obstacle, but a chance to not only survive in international competition, but to lead the way.



## SAFE AND SUCCESSFUL WITH INNOVATIONS

In the light of ever faster system extensions and the great multitude of variants, safety cases are increasingly becoming bottlenecks, even today already. System development is continually evolving methodologically and technologically with new approaches such as model-based development. This makes it possible to develop ever more complex systems within ever shorter cycles. The safety case processes that are being used, however, have only evolved very slowly and do not scale – which is necessary, however, in order to be able to efficiently prove safety despite the rapid increase in system complexity. More investments into innovative safety processes are therefore required.

## A SAFE PERSPECTIVE

For example, processes are already available today that allow performing even the safety lifecycle in a completely model-based manner. Based upon the same concepts as model-based systems engineering, safety can be seamlessly integrated into development and into the existing tool chain – in a modular, hierarchical way that can be automated and integrated into variation management. Particularly for the frequent adaptations and the variety of modern systems, this leads to significantly more efficient safety cases. As demonstrated, for instance, in the research project SPES\_XT, which is funded by the German Ministry of Education and Research and in which research and industry are collaborating closely, the entire safety lifecycle from the first risk analysis to the final safety case can be integrated seamlessly into model-based development. That these concepts have left the realm of pure research and have come of age on their own can be seen in their increasing practical application in industry – from the automotive industry via the rail industry to the medical device industry.



Embedded systems are becoming more and more intelligent, flexible, and interconnected in fast innovation cycles. In order to ensure that safety will not become an obstacle in the future either, both the function itself and the safety mechanisms must become more intelligent and flexible. Safety models offer an ideal basis here as well, by transferring them to runtime. If systems become “aware” of their safety through these models, they can react to new situations at runtime intelligently and still safely. If, for example, a farmer connects farming equipment to a tractor from a different manufacturer and the farming equipment assumes control of the tractor in order to optimize the process, it is not possible anymore for a safety check to be performed by a specialist. Testing all possible combinations in all conceivable and inconceivable usage scenarios is impossible in practice. It is, however, possible to give the machines safety intelligence through model-based runtime certificates, enabling them to dynamically check themselves whether or under which restrictions safe cooperation is possible. Such approaches offer great potential for the future and are therefore also being continuously developed further in research projects such as the ARTEMIS project EMC<sup>2</sup>.

### MODELS FOR A SAFE FUTURE

Even if safety is still often considered an obstacle today, in international competition, this is exactly where a great opportunity exists, since it costs a lot of time and money to build up experiences, technology, and processes in order to overcome the obstacle of “ten to the power of minus nine”. This means that companies that are already developing safety-critical systems today have a big head start. They can use this head start as a competitive advantage if they continue to invest into safety engineering innovations. Particularly the use of model-based approaches offers great potential for the future. Even today, the efficiency of safety cases can already be increased. By using models at runtime, however, they will form the basis for safety cases for open, intelligent, and dynamically interconnected systems.

■ Mario Trapp



**"IND<sup>2</sup>UCE is the response to the increasing security challenges that accompany technological interconnection and dependency."**

EARTO Innovation Prize jury

# TRUST IS GOOD, CONTROL IS BETTER!

It is the very nature of humans to minimize risks.

On the other hand, it is also human nature to be lazy. Security and the need for security are therefore always a tricky issue. Take payments for example. The most secure method would be to pay the creditor directly, preferably in cash, in order to prevent accidentally entering the wrong numbers for the recipient's account. But who wants to go to the office of the utility company every month to pay for electricity, water, and gas in cash?

It is much more comfortable, of course, to entrust one's money to a bank and give all creditors a direct debit mandate. For the debtor, this makes things a whole lot easier. However, debtors must trust creditors not to abuse their mandate. It is also assumed that the banks will only grant access to a debtor's account to authorized creditors.

Between these two extremes lies the possibility of regulating the control of payment transactions, which reduces the risks for the debtor. Account owners can decide how much risk they are willing to accept in exchange for comfortable payments and how much control they want to retain for their own protection. The banks offer a variety of settings for this purpose, such as setting a limit for direct debits or a credit line, and securities, such as the right of cancellation.

## DATA PARSIMONY COMES AT A PRICE

The starting situation is similar in our dealings with data. The data owner can opt for strict secrecy, which prevents others from gaining access. In such cases, however, only the data owner can use his or her data and can get little benefit from them. If you do not give your address to anyone, you will probably never get invited to a class reunion. But if you thoughtlessly share your data with everyone, you must not be surprised to find countless advertising materials in your mailbox. Would it not be nice if data usage could be controlled based upon demand and upon the trustworthiness of the user?

**DATA USAGE CONTROL FOR THE CLOUD** – For many small and medium-sized enterprises, Cloud Computing offers an alternative to running a computing center of their own. Yet the use of external resources causes a loss of control over one's own IT applications and data. In addition, legal prerequisites must be fulfilled when processing personal data, such as data storage in the European judicial area. Data usage control offers the possibility to detect, resp. prevent, policy violations.





**“Whenever data are shared, there is always a risk of data protection breaches.”**

Christian Jung  
Fraunhofer IESE



**CONTEXT-SENSITIVE PROTECTION OF MOBILE DEVICES** – In financial services, the customers' portfolio data represent the highest asset requiring protection. When talking to their customers, investment advisors need access to these data. Increasingly, consulting will take place at the customer's site, using mobile devices. Still, the data should be protected in the best possible way. Mobile devices should therefore adapt to the respective usage situation and should restrict data access correspondingly. This also includes automatic detection of the environment as well as measures intended to determine the presence of the advisor and the customer prior to access being granted to sensitive data.

### **RICH DIVERSITY OF DATA AND PROTECTION GOALS**

Control and protection of data are much more diverse than control of payment transactions. Data can be copied and processed without major effort. This represents a problem for copyright owners and rights proprietors if their intellectual property is exploited by others without compensation.

Furthermore, there may be different protection needs. Some data must be treated with strict confidentiality. A person who is authorized to gain access cannot give data to unauthorized third parties, neither with malicious intent nor unintentionally. The revelations made by Edward Snowden or the sale of CDs containing the data of tax evaders are well-known examples from this area. Other types of data must be protected from falsification, such as online transactions or billing data.

### **DIFFERENT USAGE SCENARIOS – VARIABLE NEED FOR PROTECTION**

But protection needs may also change depending on the situation at hand. As a matter of principle, personal data such as medical reports should be protected from unauthorized access. In an emergency, however, it is more important to grant access to sensitive data in order to allow the best possible treatment.

The diversity of protection needs calls for a flexible possibility to control data usage. If needed, restrictions must dynamically adapt in order to do justice to both the user and the data owner.



## DATA USAGE CONTROL

**DATA PROTECTION IN HEALTH CARE** – In health care, there is a wide variety of sensitive patient data. In addition, there are different individuals who need access to subsets of the elicited data, but not to all the data. The treating physician must see the medical data (diagnosis), but does not need to know any billing details. Vice versa, the hospital administration only needs access to the billing information, but not to medical reports. There are also care relationships and guardianships, meaning that third parties can also obtain access to certain patient data, even though not to all of them. Classic access control reaches its limits here; usage control enables new models.

### USABILITY VERSUS SECURITY



In order to make reasonable decisions, users must be aware of their situation and must understand which security settings are available and which risks are associated with these. The security settings should offer support for the users and should not constitute an obstacle.

Even better are security settings and mechanisms that automatically adapt to a given usage scenario and relieve the user of this tedious task. It would be nice, for example, if a stolen device were to recognize the theft on its own and delete all the data stored on this device.

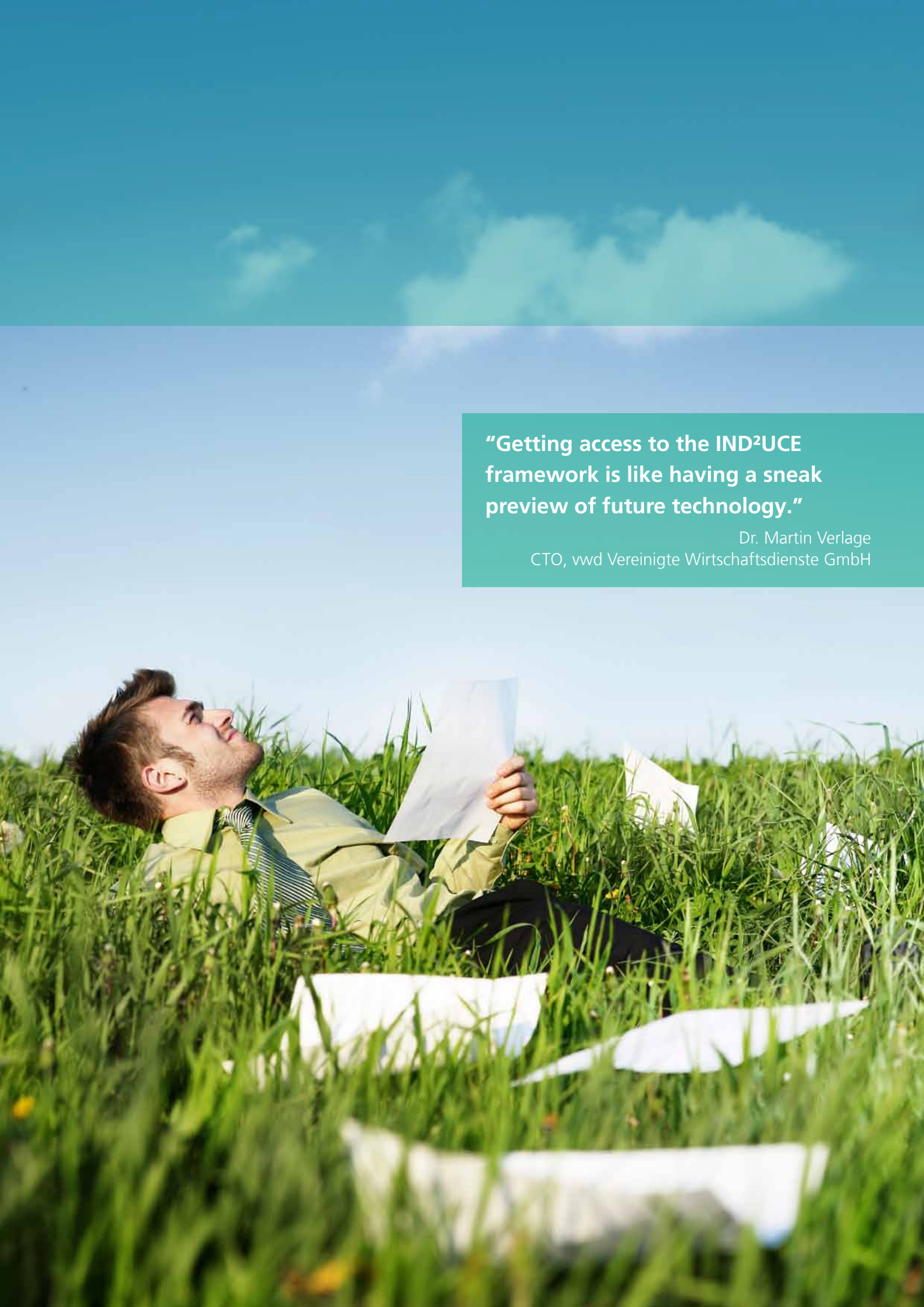
Since 2008, Fraunhofer IESE has been developing methods, models, and technologies in the area of data usage control that allow comprehensive control of the access to and the further usage of data. Use cases include, for instance, securing

cross-company big data analyses, applications in the context of mobile applications, as well as Cloud-based backend technologies in which the focus is on the protection of sensitive data.

In order to allow flexible control of data and system functions, Fraunhofer IESE developed the framework IND²UCE (Integrated Distributed Data Usage Control Enforcement) for the enforcement of data usage policies. IND²UCE allows the data owner to part with data and still maintain control over their further usage. It is easy to integrate into existing system and software landscapes. To this end, Fraunhofer IESE has a research and demonstration lab where data usage control is tested and demonstrated in various usage scenarios. In 2014, the framework IND²UCE was awarded one of the innovation prizes of the European Association of Research and Technology Organisations EARTO.

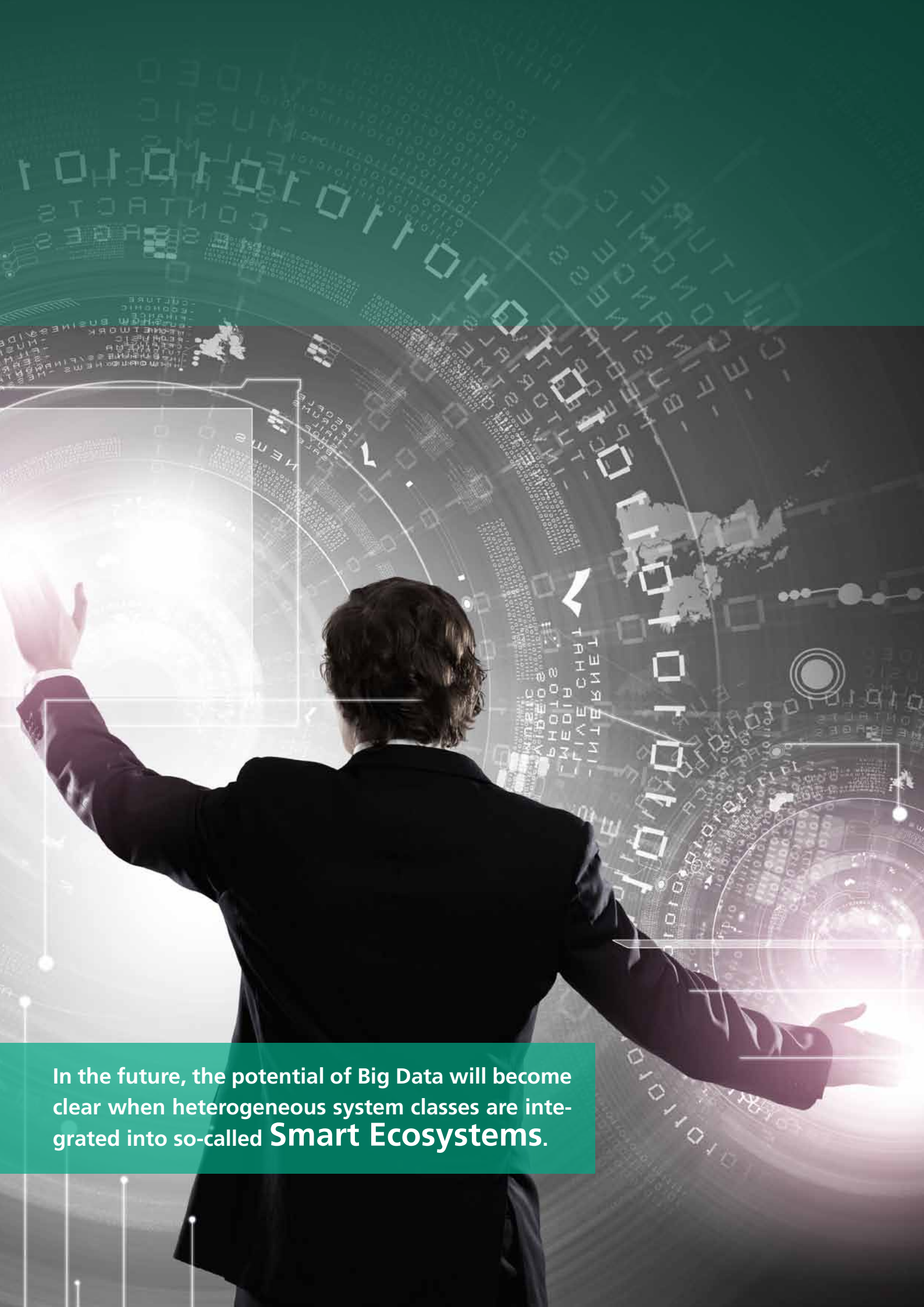
**USER-FRIENDLY SECURITY SETTINGS** – The great diversity of protection goals for data and the needs of the data owners make it harder to describe them in an understandable way. Users are often faced with the problem of how to express their protection needs and have difficulties grasping the impact of their requirements. The security settings of the Internet Explorer or the privacy settings of Facebook are not easy to figure out at first glance. Furthermore, users cannot weigh the pros and cons of convenience and security if they do not understand the consequences. Readymade security components make it easier for the users to select suitable settings and get a better understanding of their impact.

■ Christian Jung, Reinhard Schwarz

A man in a light-colored suit and striped tie is lying on his back in a field of tall green grass. He is holding a white document in his hands and looking up towards the sky. The background is a clear blue sky with a few wispy clouds. A teal gradient overlay covers the top portion of the image, containing white text.

**“Getting access to the IND<sup>2</sup>UCE framework is like having a sneak preview of future technology.”**

Dr. Martin Verlage  
CTO, vwd Vereinigte Wirtschaftsdienste GmbH



In the future, the potential of Big Data will become clear when heterogeneous system classes are integrated into so-called **Smart Ecosystems**.

# EXPLOIT DATA TREASURES – BUT DO SO SYSTEMATICALLY

To the same extent to which **digitalization** increasingly permeates all areas of our lives, more and more data are generated as well. The term “Big Data” is very popular today – but when are data actually “big”? This is not only a matter of size. The German Informatics Society (Gesellschaft für Informatik, GI) defines Big Data via three principal dimensions: Volume – Velocity – Variety. In addition to the amount of data (Volume), the speed with which they have to be processed (Velocity) as well as the heterogeneity of the data that must be considered in conjunction (Variety) play an important role. This means that even if the total amount of data to be analyzed might not be so large, a Big Data problem may still arise.

Currently the central question posed by many companies is: Do we need Big Data and does it pay off for us to invest in the relevant technology? A first indication can be obtained from thinking about how much of the company's work is data-driven, whether information from a large variety of sources must be combined and processed, and whether decisions are made with the help of business intelligence solutions. The discussion about Big Data is much more than the clever and profitable analysis of Internet data. In the age of the Fourth Industrial Revolution, the emergence of cyber-physical systems and ultimately of highly integrated smart ecosystems, the issue is all about adding actual, tangible value for companies and individuals out of the potential availability of a seemingly infinitely large treasure trove of data. However, the strategic benefits of Big Data are often accompanied by substantial costs for hardware, software, training, etc. With the help of an individual potentials analysis, every company must set up its own Big Data strategy. This is where Fraunhofer IESE supports its customers: Based upon the goals as well as on the availability and accessibility of the necessary data sources, we jointly investigate whether a Big Data strategy makes sense for the respective company and if so, which one; which technologies can be used; and which competencies are required for the exploitation of the data.

The goal is to increase the company's own efficiency and effectiveness, to master risks, and to realize new products and services. Companies can prevent bottlenecks in business and workflow processes or can integrate processes such as quality control, production as such, resource management, and customer service better and thus make them easier to plan. Critical states in the value chain, such as the failure of production machinery, can be detected early on with the help of a suitable strategy. The use of Big Data ultimately contributes to innovative products and services, since the available data and their quality can be analyzed quickly and reliably. Decision models can be constructed systematically from the business goals and data that are aggregated, resp. condensed appropriately, enable efficient decision-making. ►►

## DO BIG DATA PAY OFF?

In the future, the potential of Big Data will become visible particularly in the integration of heterogeneous system classes into so-called Smart Ecosystems: In **PRODUCTION TECHNOLOGY**, for instance, increasingly complex production facilities must interact with merchandise management systems and ERP systems in order to efficiently control and optimize value chains and production processes. The use of Big Data analyses allows global optimization across company borders on the one hand and flexible adaptation and process control all the way to custom manufacturing on the other hand. In addition, quality defects can be analyzed across the entire supply chain and can be eliminated once and for all. Intelligent commercial vehicles in the **AGRICULTURAL INDUSTRY** are equipped with correspondingly integrated devices and communicate with sensor networks and business management systems in order to capture all relevant environmental data, analyze them, and condense them into a decision proposal for the control and optimization of work processes. This does not only occur regionally for a particular agricultural business, but extends all the way to data analysis involving a number of businesses. Big Data also enables a holistic approach in **ENERGY MANAGEMENT**: From the generation of energy via storage to consumption, data from a wide variety of systems, such as traditional power plants, wind power plants, solar power plants, storage power plants, and smart meters in the commercial and residential sectors must be analyzed across companies and corporations. Big Data enables more effective and efficient balancing of the energy consumption. Humans experience benefits from Big Data first-hand in **MEDICINE AND HEALTH CARE**: Medical devices are integrated with social and social policy processes and measures to prevent diseases and risks and make medical processes more effective and efficient. In the context of age-appropriate assistance systems, for example, Big Data analyses can enable early detection of dangers and risk situations through clever

integration of existing local data with global prediction models. Another important sector is **VEHICLE TECHNOLOGY AND MOBILITY**: Vehicles are interconnected with each other and communicate with other systems within a Smart Ecosystem. In this context, Big Data analyses can globally optimize traffic flows, reduce transport times and idle times (of goods), and provide smart mobility services. With this, they contribute to minimizing fuel consumption and reducing the emissions of pollutants.

Increasingly, these application areas should not be considered separately, but should rather be seen as one section of a continually evolving holistic ecosystem.

If such systems are to become a reality, it is important to master some central aspects of Big Data in Smart Ecosystems. The challenge in practice will be to find suitable infrastructures: Small and medium-sized enterprises, in particular, will be unwilling or unable to buy dedicated infrastructure with the appropriate computing power. Here, new solution strategies must be found: The trend towards storing data in the Cloud offers first approaches for Big Data analyses; for studying sensitive data, temporary renting of infrastructure may also be a conceivable alternative. Another serious problem is the increasing establishment of different, partly incompatible technologies for Big Data analyses: For cross-company analyses, de-facto standards must be established in an ecosystem, as well as compatible interfaces between the provider systems and a suitable, high-performance intermediate data exchange layer. A stable foundation for using Big Data to add value for everyone in the future must be established together with partners from research and industry. With its scalable systems engineering methods, Fraunhofer IESE guarantees top-quality solutions for a holistic approach.

■ Jens Heidrich, Jörg Dörr, Andreas Jedlitschka, Adam Trendowicz, Nina Hahnel

## “PRO-OPT – Big Data Production Optimization in Smart Ecosystems”

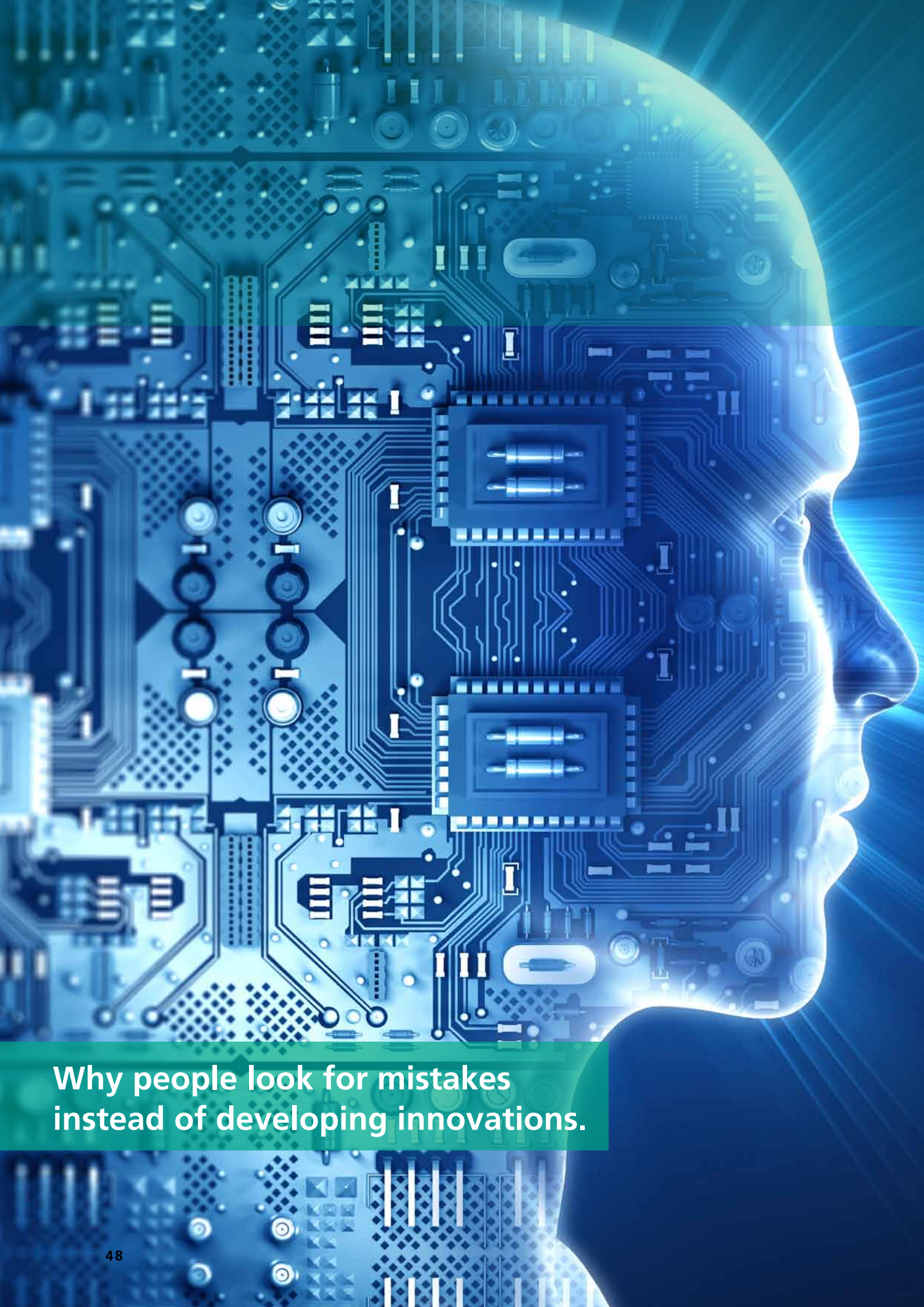
wants to enable automotive companies to analyze large amounts of data effectively and intelligently in decentralized cooperative structures. The project with renowned partners from industry and research started in 2015 with the vision of exploiting existing data in Smart Ecosystems and making them usable in practice for the involved companies. The core result will be a holistic modeling approach and associated technologies. It will then be possible to interconnect data across companies and analyze them systematically. At the same time, qualities such as data security will be guaranteed. Companies will thus be able to implement new, innovative business models and processes or optimize existing models and processes in terms of quality and efficiency. In production technology, the goal of PRO-OPT is a significant reduction in the number of defects and increased efficiency in the automotive manufacturing supplier chain.

Industry partners: DSA - Daten- und Systemtechnik GmbH, Audi AG, camLine GmbH

Research partners: Fraunhofer IESE, DFKI

Associated partners: Continental Automotive GmbH, SmartFactory KL e.V., VDMA

BMW grant number 01MD15004E



Why people look for mistakes instead of developing innovations.



# ARE WE STILL ON THE RIGHT TRACK?

Can I still accomplish **my business goals** with my software? In recent years, the complexity of software has increased continually. Software and systems architects face numerous challenges, such as porting software to multicore platforms or integrating open interfaces. Far-reaching decisions must be made early, frequently under time pressure. If, at this point, decisions are made based primarily upon one's gut feeling, the further course of the project will be jeopardized: A wrong decision will lead to huge delays and additional costs. Strategically important decisions should therefore always be substantiated with facts.

In the area of Embedded Systems, software is nowadays responsible for almost all innovations and for a large part of value creation, which is why the development of modern software systems constitutes a major challenge. Unlike electronic or mechanical components, software does not follow the laws of physics, nor is it bound by them. What appears to be a major advantage at first glance reveals the central problem upon closer investigation: Developers have a great degree of freedom when developing their software. As a result, this software often turns out to be complicated and is not transparent – particularly when it is a construct that has grown over time. Whereas mechanics can often rely on the laws of physics and thus can quickly acquire a basic understanding of an unknown system, software developers must first learn the laws of a new software system before they can understand it. The time available to do this is often very limited, but it is very important. If developers do not understand the system on which they are working, any changes they make may quickly lead to undesired side effects. These will, in turn, cause defects in other, seemingly unrelated system components. Such defects occur unexpectedly and might only occur much later. Sometimes the new product is already on the market by then. Locating and correcting these defects is then much more expensive in the end than the development time itself and more often than not results in considerable delays.

## MAKE CORRECT DECISIONS

Avoiding such defects requires the definition of unambiguous rules. These rules correspond to the physics of a software system. They define central guidelines for developers and thus restrict them, but also guide them. Only at first glance are such restrictions unwanted: upon closer inspection, clear rules help to understand a system and support maintenance and extension of the system. Software developers can rely on these rules – just like mechanics can, and must be able to, always rely on the laws of physics. ►►

The ability to define one's own physics offers great opportunities. Central concepts define whether a piece of software can grow, whether it supports product variants, and whether it is always safe, secure, and dependable, or whether developers spend a large amount of their time eliminating defects that occur due to undesired side effects resulting from basically simple changes. This is as though a car were only able to drive sideways after the tires were changed – who would want to look for this defect?

In order to support the maintenance and evolution of a piece of software, however, the concepts must fit the software. Here we

can already see a crucial problem: The laws of physics must be known to the mechanics before they can install the first parts. In the same way, the central concepts of a software system must be established before the developers can start programming. This is true for the development of new systems as well as when making revolutionary changes in existing systems. These central decisions must therefore be made early and often under time pressure. This must happen so early that the effects of these decisions cannot be tested easily. They are therefore made on the basis of experiences, opinions, and often one's gut feeling. Frequently this is done knowing that they will be very hard to revise later on.

## VALIDATE CRITICAL DECISIONS

Critical decisions must therefore be validated early with facts. In the meanwhile, there are various approaches for generating these facts. Software and system models as well as virtual prototypes allow early evaluation of concepts and provide quantifiable results. These represent a sound and meaningful basis for making decisions. They ensure that even difficult decisions are made objectively and transparently. The models that are required for this purpose can nowadays be generated with relatively little effort thanks to specialized tools and modeling languages, and their benefit for architects and developers is even greater because of that.

One important aspect is the definition of goals. Goals determine which aspects are important for a software system – and what the physics of the software system shall look like. Goal definition often raises the first problems: Such goals are frequently not known to everyone, are defined only implicitly, or are perceived in different ways. A system's extensibility in terms of specific features is an example of such a goal. If this is not

taken into account during the design, central concepts of the software system will not fit the product. This is as though one were to attempt realizing something in contradiction to the laws of physics – numerous problems would occur, the implementation would be very expensive and entail many problems. If the design of the software fits, then the variability design, the safety and security concepts, and the software architecture will support the extension of the software.

Decisions determine how to realize these designs. Models allow simulating and analyzing central aspects early on and thus provide early evidence regarding whether a certain decision is beneficial for achieving all goals or not. This makes it possible to validate decisions at an early point in time – using models that provide a prognosis of decisions and that allow measuring a system's current status on the basis of facts. And which check throughout the lifecycle whether models and code continue to match, so that the software can be maintained and extended in the future as well. This is what we call Prognostics.

■ Thomas Kuhn



What if you could predict the future of your IT system?



Does this remind you of your IT system?

# “HISTORICALLY GROWN ...”

**Successful software** often has a longer lifespan than originally anticipated. Continuous extensions lead to a state that practitioners like to call “historically grown”. This state is characterized by inconsistent user experience, quality that suffers, rising maintenance costs, and a lack of innovative ability. Hence, sooner or later every software company has to ask itself how to successfully renovate its own software and how profound this intervention must or may be in order to continue achieving the business goals in the future. In order to set the right course for renovation, the actual condition of the software must be analyzed thoroughly, particularly because experience has shown that this condition deviates significantly from previous plans and documents. Renovating a software system successfully requires taking an integrated look at the target state and at the migration path, careful familiarization of developers and users with new concepts, and continual management of risks and goals. Software renovation thus concerns all those who want to set standards with their software in the future as well as in the present.

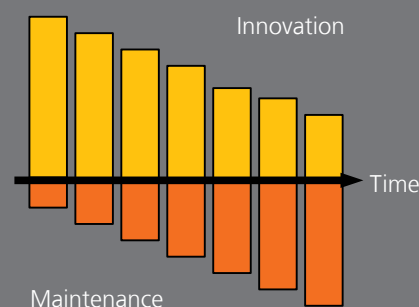
## INNOVATION INSTEAD OF MAINTENANCE

Software is THE means by which innovation is created today. Unfortunately, during the lifecycle of a software system it becomes increasingly difficult to remain innovative and to respond to new requirements and conditions. Software evolves continually and new features are added, even if they do not fit into the original design. So software ages noticeably and entails numerous problems. For the users, the user experience is no longer uniform on the one hand and no longer up to date on the other hand. For the developers, the software becomes ever harder to understand and changes become more error-prone, resulting in more and more time having to be spent on maintenance activities. Consequently, less and less time is available for the development of innovative features, and cutting-edge innovation, in particular, becomes almost impossible.

Business software often lasts for several decades. The evolution of technologies and the increasing permeation of our professional and private lives by IT are enormous during this time. Even today, a very large number of applications in companies are still running on mainframes and causing huge maintenance and operation costs. Not surprisingly, there is a clear tendency to port software to more cost-efficient and up-to-date standard hardware, especially since the number of developers for old technologies keeps decreasing. Sooner or later, all software companies are faced with the issue of having to renovate “historically grown” software. The challenges then range from unsuitable architecture and code quality via outdated and extinct technologies to requirements that are impossible to realize. The goal is always to remain innovative and competitive.

### “SOFTWARE DOES AGE!”

There is a rumor that doggedly persists: that software cannot age. This may be true at the most for the code as such. As soon as technologies evolve and expectations rise in the environment of a software system, it feels as though software is indeed aging. It is mainly continuous evolution with many compromises that mostly leads to a situation at some point in the software lifecycle where more and more effort must be spent on maintenance than on innovation.





**Renovation is always  
full of surprises.**

**“Successful software products become drivers of the ›digital transformation‹ of companies. But they will only remain successful if they allow continuous innovation.”**

Werner Weiss  
CEO, Insiders Technologies

**“Software renovation is like renovating a building that continues to be used, where the residents must not be affected.”**

Timo Rihtnieni  
Manager Product Architecture  
Tekla

### BUILD, RENOVATE, OR JUST RE-PAINT?

The renovation of a software system can be done very differently depending on the initial condition and the objectives. Many companies first consider doing refactoring, which is relatively cost-efficient and can be done locally. Unfortunately, however, the improvement effects are rather limited because global challenges cannot be solved in this way. Therefore, the question often arises whether a system should be renovated, including a re-alignment of its architecture, or whether it even makes sense to develop a completely new system. In practice, a complete new development is often not an option either,

however, since the development team cannot maintain the old system and develop a new system all at the same time.

Software renovation is often unavoidable and does entail risks. Many decisions must be made about the future product and the development path to be taken. These decisions range from features and the interaction design via the future architecture to the type of quality assurance. A comprehensive analysis of the history and good planning of the renovation are therefore indispensable prerequisites.

### “SOFTWARE IS NOT SOFT!”

One of the greatest accomplishments of software is that it can be changed without the need for physical changes. This has led to the situation where all aspects in which changes must be made to a system are nowadays implemented as much as possible via software. This is true for software in companies as well as for software in automobiles.

Although software can basically be changed easily and in nearly every direction, in practice this is usually not possible. Many changes extend across vast areas of the system, have large and unexpected side effects, and make it very hard to get back to a state of high quality.


### NO RENOVATION WITHOUT ANALYZING THE HISTORY

“After the renovation, our software must be able to do at least the same things it is doing now!” is a sentence frequently heard at the start of a renovation project. The reason for this is, on the one hand, that this requirement is very easy to formulate and that nobody can say exactly what the software really does. On the other hand, many companies find it very easy to add new features, but very hard to give up existing features. Experience has shown, however, that any renovation should always be accompanied by a consolidation of features, too.

A renovation project can almost never be built upon consistent documentation of the software. In other words, an analysis must not only investigate the current state of the software, but usually it must first reconstruct it. In this endeavor, the source code is often the only reliable truth and source. The reconstruction

of implemented requirements and interaction designs is time-consuming manual work, which requires an understanding of the domain. The existing code basis is often large and hard to comprehend. With the help of reverse engineering tools, the code can be examined semi-automatically. Only by recording the identified information in a re-documented architecture can a level of abstraction be created on which the complexity of the system to be renovated can be mastered.

It is important to realize that the analysis of the existing system is an investment that is needed for the renovation to be successful. This analysis must be comprehensive in nature and needs to cover all aspects regarding usage, operation, and development of the system in a methodological manner. ►►



# Complex renovations require engineering tools.

**"A well-conceived architecture that is implemented as strictly as possible means that expenses for costly repairs can be saved. The unavoidable, natural degeneration is then tackled in the context of value-adding renovation measures."**

Dr. Dirk Muthig  
Head of Product and Systems Design  
Lufthansa Systems



### ANYONE CAN BUILD, BUT IT TAKES SPECIALISTS TO RENOVATE.

Many renovations of software systems fail although they would be necessary. Whereas new developments are often quickly excluded as an option for numerous reasons, renovation appears to be a feasible and controllable way to get a software system back on the right track. But the result is often that the priority given to such a project is too low, or that it is performed half-heartedly. Then even the analysis sometimes appears to be too great an obstacle.

Software renovation must be addressed as a strategic task and requires the use of technical and methodological specialists. Building on an analysis of the history of the software system, the new target state is constructed. While new construction can work with significantly fewer restrictions, renovation must always take the existing software system into consideration. This means constant trade-offs between the renovation costs and the new benefit being created, which are hard to quantify.

From a holistic point of view, features and quality requirements must be taken into account from the perspectives of usage, operation, and development. Renovation must regard the external design of a software system in the sense of interaction design and visual design as closely linked with the internal design in the sense of the software architecture. The decisions about future features, interfaces, and interactions affect many stakeholder groups and should not be made unilaterally (e.g., only by Sales). In particular, they should be underpinned by facts, e.g. by measuring the actual usage.

The challenge lies not only in designing a target state for the software system, but also in the matching design of a migration path. Renovation almost always takes place concurrently to the evolution of the system, and these two activities must therefore be coordinated in order to enable incremental renovation. Renovation also includes a lot of change management. There are not only changes to the software, but also impacts on the users, the developers, the operators, and the sales department. Changes are often perceived as negative, even if they constitute improvements. These stakeholder groups must therefore be involved early on and, depending on the software changes, also need to get new qualifications or at least training. Constant and goal-oriented migration is very demanding for quality assurance and especially requires automated tests for checking the impact of changes.

The renovation of a software system is always a complex and individual task, and there is no silver-bullet solution for it. This is why Fraunhofer IESE relies on experience gained from more than 100 renovation projects and provides a well-filled tool box of methods and tools.





Fraunhofer IESE has already supported many software companies in the renovation of their software systems and is continuing its research into further improving methods and tools for software renovation.

■ Marcus Trapp, Matthias Naab

### “AFTER THE RENOVATION IS BEFORE THE RENOVATION!”

Even after the successful renovation of a software system, the world continues to revolve, new requirements appear, and new technologies become available. Renovation should therefore not be seen as a one-off, but rather as a continuous activity that can be designed according to the required level. However, the option of completely new development should not always be excluded categorically either, since a renovation should remain a renovation, and its objective should not be to remodel an existing system into a completely different one.



	2000	2014
Renewable Energies		+ 114 TWh
Export Surplus		+ 34 TWh
CO <sub>2</sub> Emissions		± 0
Nuclear Energy		- 72 TWh

# IT FOR THE ENERGY TRANSITION

Energy is the indispensable basis for the functioning of our economy. Despite all efforts to increase efficiency, we still consume ever more fossil energy and are dependent on suppliers. Our locally available renewable energies offer independence, security of supply, and affordability in the long term.

In the project **“CEM-CROSS-ENERGY MANAGEMENT”**, we are building the IT architecture for a safe energy supply in the future. Smart coordination between the various sources of energy (such as electrical power, heating/cooling, gases, energy-intensive semi-finished products) does not only lead to optimization of system efficiency, but also helps to compensate for the fluctuation in the energy provided by sun and wind. The necessary prerequisite is an interconnected, resilient IT that flexibly integrates all stakeholders from the energy supply chains. We provide answers to questions regarding the system architecture, system security, data security, as well as openness and interoperability.

**WHERE DO WE STAND TODAY?** The changes in the energy industry in Germany in the past 15 years are remarkable, considering the increase in the proportion of renewable energies. However, this success is put into perspective if one takes into account that an import/export balance that was still balanced in the year 2000 today shows a strong export surplus fed from cheap fossil power plant outputs. The desired reduction of CO<sub>2</sub> emissions in power generation failed to materialize because, due to the no longer functioning trade with CO<sub>2</sub> certificates and low fuel prices, the coal-fired power plants, which are particularly harmful to the environment, are able to produce power at competitive rates, whereas modern gas-fired power plants are unable to compete.

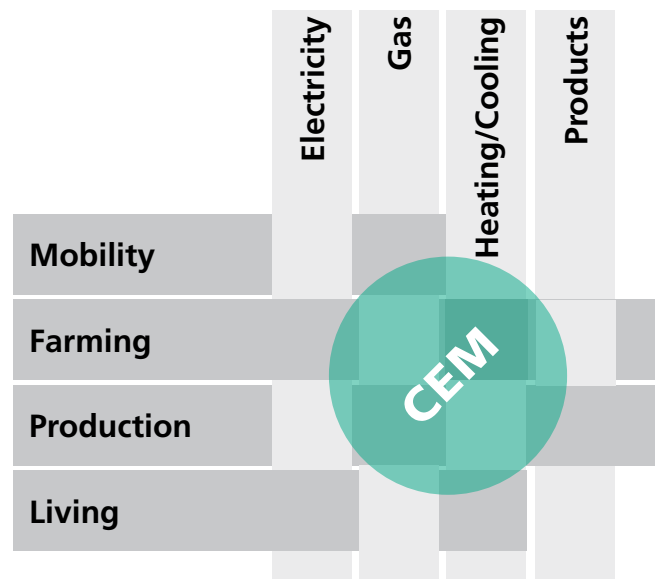
**HOW WILL IT GO ON?** The energy system is becoming the more decentralized the more electricity is generated from photovoltaics and wind, but also from CHP and biogas plants. Already today, several millions of volatile plants are connected to a (by historical design) centrally controlled power grid in Germany, whereas prior to the turnaround in energy policy, there were only a few thousand plants with stable generation. Are these plants interconnected via ICT? No, they are not!

**WHAT DOES THIS MEAN?** It is common knowledge that electric power from renewable energies is volatile depending on the time of day and the weather and that it can fluctuate very strongly in extremely short intervals (minutes). At least this can be predicted with a fair degree of accuracy. Since, however, an intentional increase in power generation is not possible, other energy sources (gas-fired power plants, hydroelectric power plants, batteries) must fill the gap, or consumption must be adjusted to the available power. According to the current state of the practice, the only feasible way to jointly reach climate and efficiency goals and achieve independence from international fuel markets appears to be the coordinated combination of the available flexibility potential of generators, storage facilities, and consumers. This requires both a suitable design of the market, which in the future must honor these flexibilities as well as the achievement of climate goals, and technical controls that are adequate for this task. ▶▶

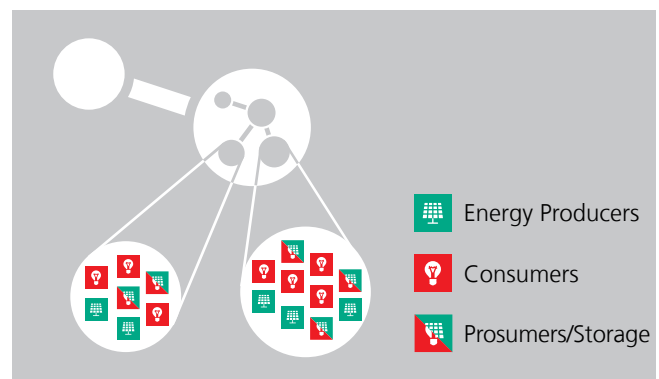
## ENERGY SYSTEMS OF THE FUTURE

The systemic view of the different energy businesses in one technical system consisting of generators, storage facilities, and consumers is known under the term Cross-Energy Management (CEM). CEM means that in addition to electrical power, gas, heating, and cooling, (energy-intensive) products are also viewed in an integrated manner in terms of control technology, which allows the resulting system to respond flexibly to fluctuating energy supplies (according to availability and price) instead of assuming (as is the case now) that energy is available at a stable price all the time. How CEM systems are actually designed depends on the application area and can differ widely in terms of the technologies used: In residential areas, for example, electric heating systems (such as heating pumps) might provide flexibility; batteries of (hybrid) electric vehicles might open up new options in manufacturing plants and in farming, or district heat could be generated electrically as an alternative in the case of a surplus supply of electric power.

On the level of control technology, individual CEM systems would have to be combined into regional clusters that are integrated with the distribution grids (electricity, gas, heat) in terms of control technology. In this way, the existing distribution grids would be complemented by an additional all-inclusive, but open and extensible cellular-hierarchical ICT structure. This is still a vision!



Systemic view of the different energy businesses



The cluster structure of CEM systems

If we look at the installed ICT infrastructure of the energy industry, we must come to the sobering conclusion that to date, there is no "architecture" that could map an energy system based on renewable energies. The task of coordinating many millions of plants in a strongly decentralized, but transnational grid means that a completely new ICT network must be set up, comparable in complexity to the Internet.

### THE NEW ERA IN ENERGY – A CHALLENGE FOR ICT!

The Internet was and is successful because it has some simple and robust architectural features and comes with basic standardization aimed at interoperability; however, as it is open, it does not pre-determine possible applications. In particular, the topology of the infrastructure does not determine the logical topology on the application level.

For an “Internet of Energy”, these features must be transferred. And even more is necessary: The highest degree of reliability and safety, data security and data usage control, openness for all types of plants, and flexibility for mapping business processes that have not been defined yet are all essential design objectives.

In order to achieve these goals, system architects are needed who are independent of self-serving interests and who can swiftly design such an architecture, develop a prototype, and then subject it to an international standardization process. In its entirety, this is a range of tasks for a whole series of institutes of the Fraunhofer-Gesellschaft. Regarding the software system architecture and the required specific software qualities, IESE, in particular, has already demonstrated numerous times in other application areas how to successfully implement these goals in dependable systems.

### THE CONTRIBUTION OF FRAUNHOFER IESE

IESE makes very specific contributions to realizing the vision of the energy system of the future. It focuses mainly on a safe and reliable ICT system architecture (by design), on integrated, transparent data usage control, on standardization, and on openness. In various projects, the above-mentioned cellular-hierarchical system is being implemented prototypically and is the subject of ongoing research; concepts for integrated data usage control (from collection to final use) of data are being tested; and safety and security features are being defined, tested, and demonstrated.

■ Frank Bomarius, Jens Knodel



# IN DIALOG



WITH YOU  
AND FOR YOU



## CEBIT – D!CONOMY & DATABILITY FOR SMART RURAL AREAS

Soon after the 1<sup>st</sup> Industrial Revolution had triggered the transition from an agrarian society to an industrial society, the 2<sup>nd</sup> Industrial Revolution followed, with conveyor belts and electric energy enabling mass production. Next came the 3<sup>rd</sup>, the Digital Revolution, where the use of electronics and IT led to further automation of manufacturing processes. Today we are experiencing the 4<sup>th</sup> Industrial Revolution, where ubiquitous technologization – D!conomy – and IT are becoming major drivers for innovation. What the resulting opportunities are for rural regions, how economic power can be brought to rural areas, and how technology can make life in the countryside attractive for residents of all ages are topics demonstrated by Fraunhofer IESE at this year's CeBIT. The all-encompassing networks are spawning new business models – for global players as well as for small and medium-sized enterprises – and affect manufacturing processes such as mass customization of products. With the increasing complexity of systems, competencies such as safety, security, and user experience are becoming ever more crucial. How important the issue of data is in this context was shown



Prof. Peter Liggesmeyer in conversation with Thomas de Maizière, Federal Minister of the Interior

at CeBIT 2014. Last year's main topic, which will continue to keep us busy in the next few years as well, was Datability – “the ability to use large amounts of data rapidly in a responsible and sustainable manner.”

## UX-DAY – USER EXPERIENCE WITH A CAPITAL UX



“Innovation of software and digital products is no longer characterized solely by new technologies. Today the winners are those who revolutionize the user experience. This aspect offers great opportunities, also for small and medium-sized enterprises”. This is what it says on the event website of the UX Days. Those who have been there are full of enthusiasm for the creativity and inspirational power of the presentations and the presenters. Ever since 2009 already, Fraunhofer IESE has attended the UX Day (resp. the World Usability Day) to present methods and ideas that allow users to gain intuitive access to new technologies. In 2014, valuable impulses were given on the topic “How important and correct is consistent interaction design?”



# IN DIALOG

## EMBEDDED WORLD – IT'S A SMARTER WORLD

Hidden in transportation systems, medical devices, household appliances, and almost all other technical products, embedded systems are performing essential tasks that make our daily lives safer and more comfortable. The requirements on the dependability and functional safety of these systems are correspondingly high. Failures can rarely be tolerated – particularly if they would jeopardize human lives or harm the environment. At the same time, the systems are quickly becoming more complex, are strongly interconnected, are being developed in a distributed manner, and must fulfill numerous, partly contradictory, functional and non-functional requirements in addition. At the Embedded World exhibition and conference, Fraunhofer IESE provides insights into its unique Prognostics Center, where virtual prototypes can safely support decision-making in systems engineering – particularly in early phases. Safety concepts can already be validated reliably before the implementation of the system starts. Wrong decisions are detected early on or can even be prevented. Depending on the organization and on the



system, this may result in several hundred thousand euros worth of savings. Visitors of this year's Embedded World can find out how to support parallelization of existing code on multi-core platforms and how to port systems to multi-core processors.

## CVT SYMPOSIUM – FOCUS ON COMMERCIAL VEHICLES



At the 3<sup>rd</sup> International Commercial Vehicle Technology Symposium Kaiserslautern, about 300 experts attended more than 50 presentations on state-of-the-art research results, innovative processes and products for trucks, buses, as well as agricultural and construction machinery over the course of two days. The organizer was the Commercial Vehicle Alliance Kaiserslautern, in which Fraunhofer IESE is active as well. Modern commercial vehicles are rolling high-tech investment goods with lots of software on board. In the past decade, Kaiserslautern has evolved into a competence center for commercial vehicles: The University of Kaiserslautern, for example, offers a dedicated study program "Commercial Vehicle Technology". The industry also plays an important role for the region: One fourth of all commercial vehicles produced in Germany are built in Rhineland-Palatinate.



## SAFETY & SECURITY – WE DO BOTH!

The future is open and interconnected. All kinds of different systems, from the tiniest microcontroller in a household appliance to high-computing Cloud services, are coming together, are communicating and cooperating to optimally support humans in their everyday lives. This is already an all-encompassing trend today that transcends individual domains. And everyone knows that this is just the beginning and that in a few years' time, we will see smart ecosystems in whose context applications will be possible that we can barely imagine today. The potential is downright gigantic.

On the other hand, as of today, several serious challenges still remain to be mastered. One particularly critical challenge is how to ensure safety and security, without which the market roll-out of innovative applications based on the idea of smart ecosystems may be delayed or may even be prevented completely. Both safety and security are important in this regard. On the one hand, there is (functional) safety, which ensures that under no circumstances shall humans be exposed to physical danger.

On the other hand, there is security, which is about protecting systems and their data from attackers. Both aspects are of fundamental importance for smart ecosystems, but the state of the practice does not offer any approaches for adequately addressing the existing challenges.

In September, IESE invited about 60 experts working on different topics and in different domains to attend a workshop in Kaiserslautern to discuss challenges in the areas of safety and security. The first day focused on the interplay between safety and security in smart ecosystems. On the second day, the focus was on safety certification and safety qualification. Keynote presentations by leading experts led to an interactive part of the workshop. The participants arrived at the conclusion that the topic is so important that a cross-domain group of experts should be established to further drive the issue of safety certification and to allow facing the interdisciplinary challenges in a consistent manner.

# IN DIALOG

## REQUIREMENTS ENGINEERING – BRIDGING GAPS

**“Bridging Gaps – Connecting People”** – this was the motto of REConf® 2014: Requirements engineering is the bridge that must always be crossed in software development if there is to even be a chance of ultimately being able to deliver the product that the customer really wants to have. How important this topic is for practice as well as for science is demonstrated very clearly at REConf®. In 2014, Fraunhofer IESE once again attended THE German conference on requirements engineering (RE) with presentations and an exhibit. The booth of Fraunhofer IESE offered the ideal platform for discussing current and innovative issues regarding requirements engineering, the results of the RE-Kompass, as well as possibilities of collaboration.

**RE-Kompass navigates:** The highlight of the conference with more than 400 participants was the joint presentation by HOOD GmbH and Fraunhofer IESE of the results of the current RE-Kompass – a study on the current state of requirements engineering in practice and on the needs and challenges as well as the visions for the future of requirements engineering. Fraunhofer IESE is continuing to push the topic of RE in 2015 as well and is a reliable partner when the issue is really successful RE. For one thing is clear: RE is anything but trivial. Even if requirements are elicited systematically and comprehensively at the start of the development process, this is not a guarantee that you will end up with what you wanted.

**Qualified for the future:** The aim of the International Requirements Engineering Board (IREB) e.V. is to provide a certification model with curricula and examinations and thus promote the standardization of education and continuing education in the area of RE. Fraunhofer IESE offers not only best practices and customized qualification measures, but also training for the IREB Foundation Level (FL).



**Spin-off OSSENO:** “Particularly when solid methodological skills in the area of software or systems engineering methods are missing, people are often reluctant to use structured processes”, says the leader of the eleven-member RE team at Fraunhofer IESE and Executive Director of OSSENO Software GmbH, Dr. Sebastian Adam. This observation spurred Adam and two of his colleagues to develop a novel tool and to found a spin-off company in the area of requirements engineering. The young company is supported by the program “FFE – Fraunhofer fördert Existenzgründung (Fraunhofer supports startups)”. The young spin-off will present itself to the general public for the first time at REConf® 2015.



The team of OSSENO: Norman Riegel, Dr. Sebastian Adam, Özgür Ünalın.

# SMART ECOSYSTEMS WILL REVOLUTIONIZE OUR BUSINESS MODELS!

Dr. John F. Reid, Director of Product Technology and Innovation at John Deere about the importance of Smart Ecosystems for his company and for business in general



**Many people consider Smart Ecosystems to be a new generation of software systems which have the potential to create entirely new business models. How much actual potential do you see in Smart Ecosystems?**

I believe that there is significant potential in Smart Ecosystems to create new business models and that they will impact my area of business in at least two distinct ways.

First, there is how Smart Ecosystems impact our current customer base. Technology convergence has connected a growing number of agricultural production systems globally into increasingly integrated solutions linking equipment on the farm site and linking the farm site into production systems and socio-economic systems. The value chains connecting producers and consumers are increasingly linked.

Similarly, Smart Ecosystems are impacting our manufacturing solutions and providing new opportunities in how factories and supply chains are managed and linked.

**Which business models will prevail in your opinion, and will these have an impact on the strategy of companies that had not focused on software systems before?**

It is really difficult for me to see the limit to business model innovations that will occur going forward. I believe that we must

keep our “eyes on the horizon” for significant change driven by opportunities to increase productivity and convenience. And we need to be open to experimentation and willing to embrace new business model opportunities. Companies not willing to understand how this impacts their specific business run the risk of being displaced by the opportunities Smart Ecosystems provide for newcomers to compete and challenge incumbent business models.

**From your point of view: Which prerequisites have to be fulfilled and which challenges remain to be mastered to make these visions a reality?**

It is my perspective that the architectures that will drive Smart Ecosystems are coming into place and even exist in many application domains. Companies will increasingly provide products and services that leverage these architectures to provide customer value in new ways, including new business models. There are challenges in terms of the global pace of change towards Smart Ecosystems, but I feel there are equally compelling opportunities for Smart Ecosystems to allow “leap” solutions to occur in some markets. An easily recognized example would be non-linear technology adoption in emerging markets.

In general, the increased connectivity required to achieve Smart Ecosystems creates challenges in safety and security of systems and solutions that need to be properly designed, managed, and protected in use. Failure to develop the capabilities and strategies to do this will lead to some critical failures that will tarnish the positive opportunities Smart Ecosystems will enable society to achieve.

**How has Fraunhofer IESE been able to support you so far on your way towards achieving this vision?**

Fraunhofer IESE has been core to our understanding the critical technology capabilities we need to grow to enable our company to transform our products, services, and business to be prepared to participate in a world of Smart Ecosystems. Their deep technical expertise and focus on experimental software engineering and the principles of the Fraunhofer mission enable our company to focus on the key issues we must address and mature in order to ensure our ability to participate in this space. We significantly benefit from the learnings they accumulate from working across other industry domains that are experiencing similar changes.

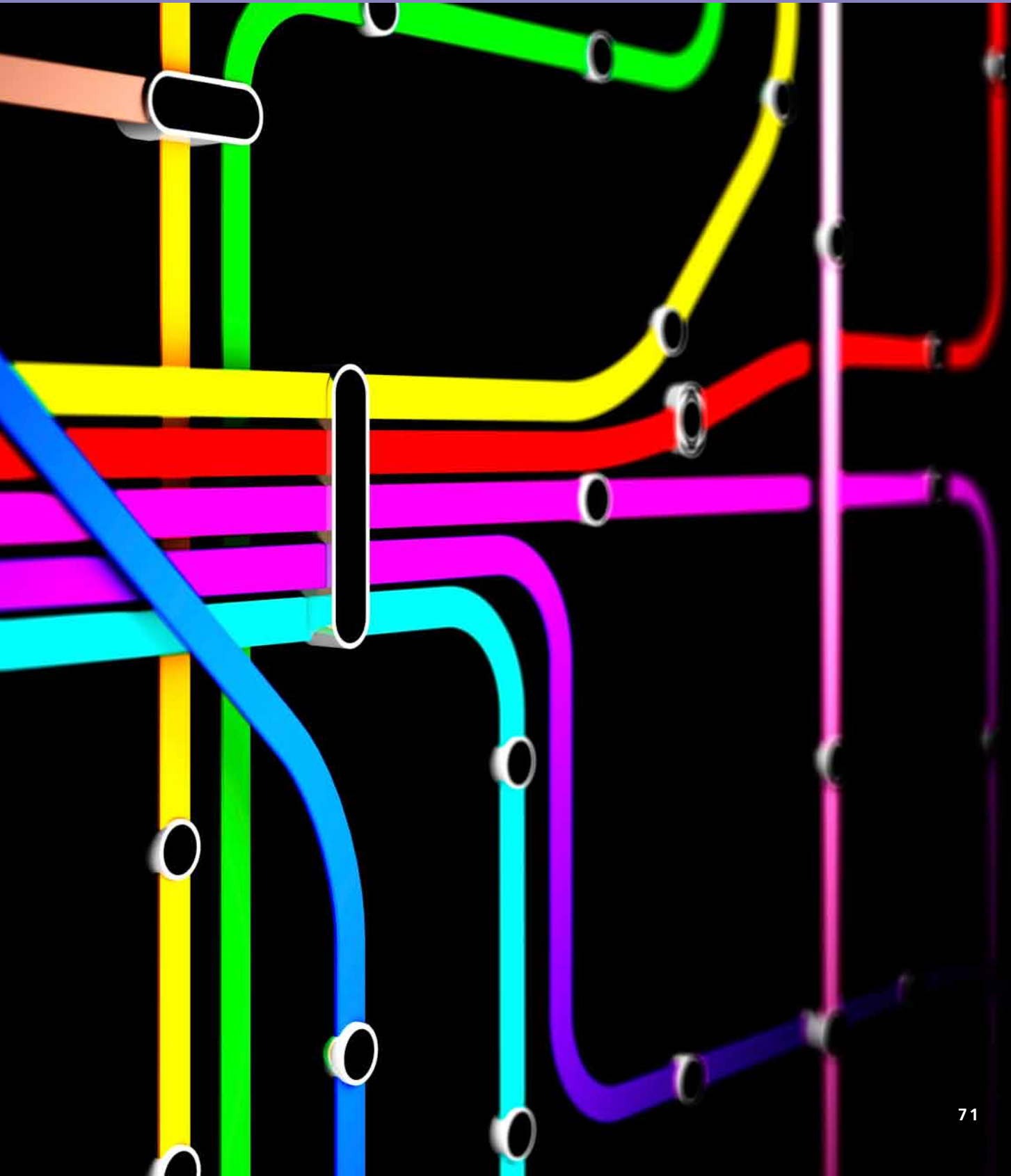
In summary, Fraunhofer IESE has been an essential guide for our technology strategy and our plans with respect to how our products and services will participate in Smart Ecosystems. The result is that we have confidence that we have an objective and realistic perspective of what we need to do to build our capabilities to move our business forward.



# WE SET TRENDS



ROADMAPS AND  
STUDIES



## COMMERCIAL VEHICLE ROADMAP

The use of software and information technology in commercial vehicles, i.e., trucks, buses, construction and agricultural machinery, and special-purpose vehicles, and their interconnection with the IT infrastructure has great potential. Specific trends and opportunities can now be found in a document published by the Commercial Vehicle Cluster Südwest GmbH. Under the leadership of Fraunhofer IESE, usage scenarios, technical solution approaches, and challenges were collected, structured, and documented in a report published at the IAA 2014 trade fair in Hanover. The document serves as orientation for organizations as well as for the preparation and development of viable solutions for the future. To this end, research and industry are collaborating in the Commercial Vehicle Alliance Kaiserslautern. The application focus on commercial vehicle industry has already existed in Rhineland-Palatinate since 2007; there is also a Fraunhofer Innovation Cluster in this context.



Dr. Barbara Jörg, Manager of the Commercial Vehicle Cluster (l.) and Prof. Peter Liggesmeyer (r.) present the Commercial Vehicle Roadmap 2030 to Minister for Economic Affairs Eveline Lemke and State Secretary Uwe Hüser.

## POSITION PAPER ON CYBER-SECURITY



Federal Minister of the Interior Dr. Thomas de Maizière, Federal Minister of Education and Research Prof. Dr. Johanna Wanka, and the President of the Fraunhofer-Gesellschaft, Prof. Dr. Reimund Neugebauer (left to right) at the presentation of the Cyber-Security position paper at CeBIT 2014.

Everyone is talking about data security – awareness of the relevance of this issue is great and the associated expectations are high. On 10 March 2014, the Fraunhofer-Gesellschaft presented the position paper “Cyber-Security” to the Federal Minister of the Interior, Dr. Thomas de Maizière, and to the Federal Minister of Education and Research, Prof. Dr. Johanna Wanka. In this paper, experts from Fraunhofer summarized their recommendations regarding security research for Germany as a strong IT nation. In its core, the position paper provides recommendations in the areas of security by design, privacy by design, as well as relevance of interdisciplinarity, flexibility, user acceptance, and social aspects in security research. Fraunhofer IESE as one of the authors contributing to this position paper emphasized, among other things, the relevance of the issue of data usage control as well as the reciprocal effects between security and safety, which are gaining particular relevance for the newly emerging system class of Smart Ecosystems.



# TRENDS

## NEW MARKET ANALYSIS FOR BPM SUITES



The development of Business Process Management (BPM) is making rapid progress. Particularly in light of process automation, more and more companies are using corresponding tools – the BPM Suites. In order to provide decision support to users regarding the selection of a suitable program, Fraunhofer IESE performed a market analysis in 2014 – the second one already – in which almost 20 BPM products were studied and evaluated in terms of practical aspects such as ease of use, modifiability, integratability, and usability in daily contexts. Although making a general recommendation for or against a particular BPM Suite makes no sense and is not possible objectively, a coarse selection recommendation can still be given. To this end, the report presents, among other things, a decision tree, which proposes BPM Suites that can serve as candidates for selection considering the individual importance of single categories.

## QUALITY MADE TRANSPARENT – CAST SOFTWARE AIP CHECKED

Systematic analyses of the source code of a piece of software are an important part of efficient quality assurance, aimed at minimizing, at an early stage of the development cycle already, quality risks and costs that may arise later on. The technical term used to describe this is “Technical Debt”, which is incurred when quality aspects are neglected during development. Its result is that increasingly high costs must be expected when new functionality is to be integrated. Since not all development projects are the same, IESE supports organizations in creating customized quality models for evaluating software quality and helps them to implement these in corresponding tools. In collaboration with CAST, the company’s globally utilized Application Intelligence Platform (AIP) was studied and evaluated in 2014 in comparison to the current state of the practice. The complete report can be accessed via the website of IESE.





## STRATEGIC COOPERATION WITH FKA

Current trends in the automotive industry, such as electrification and autonomous driving, present new challenges with regard to functional safety. In order to be able to provide the automotive industry with a one-stop solution for all services needed for the development and validation of innovative driving functions, the fka Forschungsgesellschaft Kraftfahrwesen mbH and Fraunhofer IESE entered into a strategic partnership in June 2014. "The computer science competence of Fraunhofer IESE and our automotive technology competence ideally complement each other and allow us to validate complex mechatronic systems and innovative functions regarding functional safety efficiently and

competently – including evaluation of the controllability of system defects and system boundaries", states Professor Lutz Eckstein, Chairman of the Advisory Board of fka. For the automotive industry, this means more efficient processes in product innovations as well as time and costs saved in pre-development. The collaboration is a result of successful cooperation in the BMBF-funded project eperformance, in which the project partners spent three years working on the idea of developing a completely novel system concept for a high-performance electric vehicle.



# TRENDS

## VDMA GUIDE FOR APP DEVELOPMENT

In 2016, the number of employees working mostly with mobile communication devices will already be in excess of 40%. "Industry 4.0" therefore also means that these devices must be integrated into production and business processes in a feasible way.

This year, the VDMA Working Group Smart Devices published the first version of the guide »App Development for Industry«. The guide is aimed at decision makers, product managers, software and hardware developers who deal with the issues of "Smart Devices" and "Apps" in their companies, or who want to develop an appropriate strategy for these. The guide is therefore a perfect basis for decision-making and can be used independent of the application domain.

However, business apps are not only a small piece of software. Their integration into the existing IT infrastructure requires major effort and must be planned well.

As a member of the Working Group, Fraunhofer IESE is mostly driving the research area "Mobile Software Engineering" and contributes its experiences from the area of software engineering to the guide, with a focus on the quality aspects User Experience and Security as well as on issues regarding the topics "Requirements Analysis" and "Useful Usage Scenarios".



# PROFILE OF FRAUNHOFER IESE



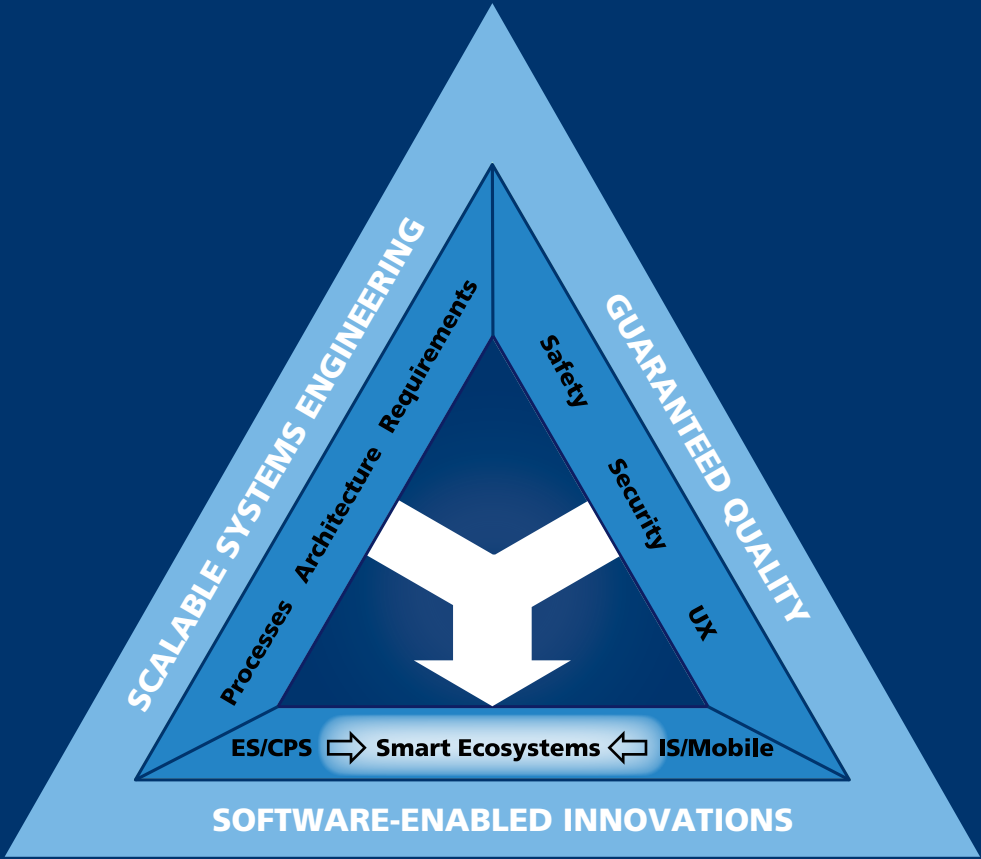


# OUR COMPETENCIES

## FRAUNHOFER IESE

Software is at the core of innovative systems and sustainably ensures the future of our society and our economy. For almost 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

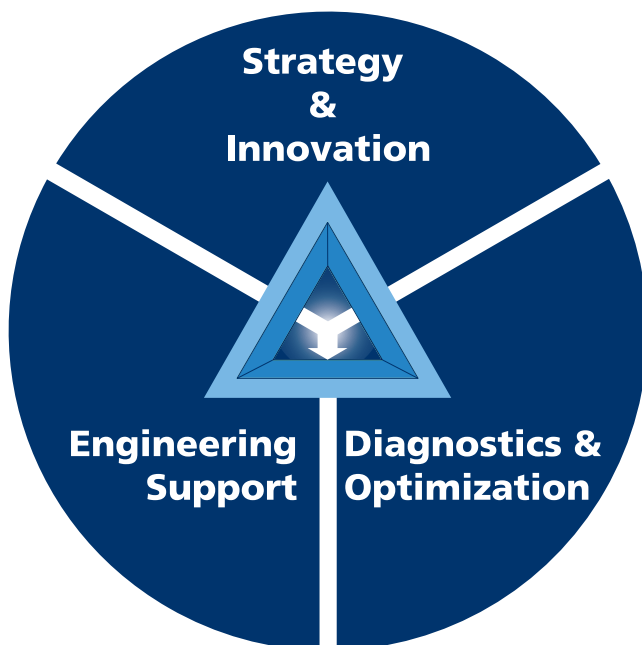
By vertically interconnecting *Embedded Systems* and *Information Systems*, we tap new potential regarding functionality and efficiency together with our partners. The result are intelligent ecosystems for a wide variety of application areas. Cross-domain interconnection and integration of systems, services,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

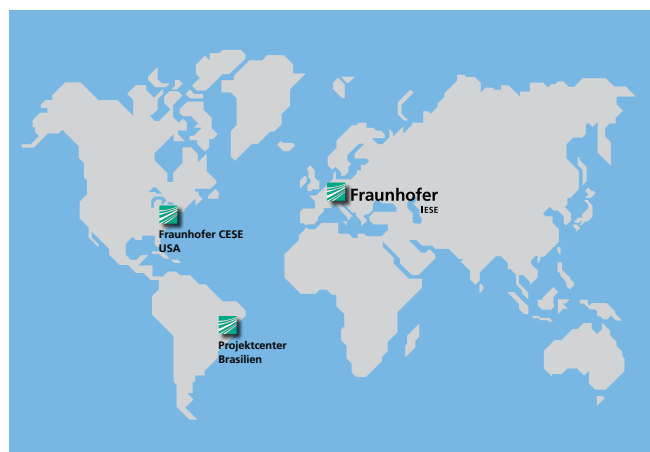
tion with accompanying training and coaching, the know-how is transferred effectively and sustainably. Joint engineering with Fraunhofer IESE is therefore not only an investment into the quality and success of the current product or system: rather, it is a long-term investment into the success and added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

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

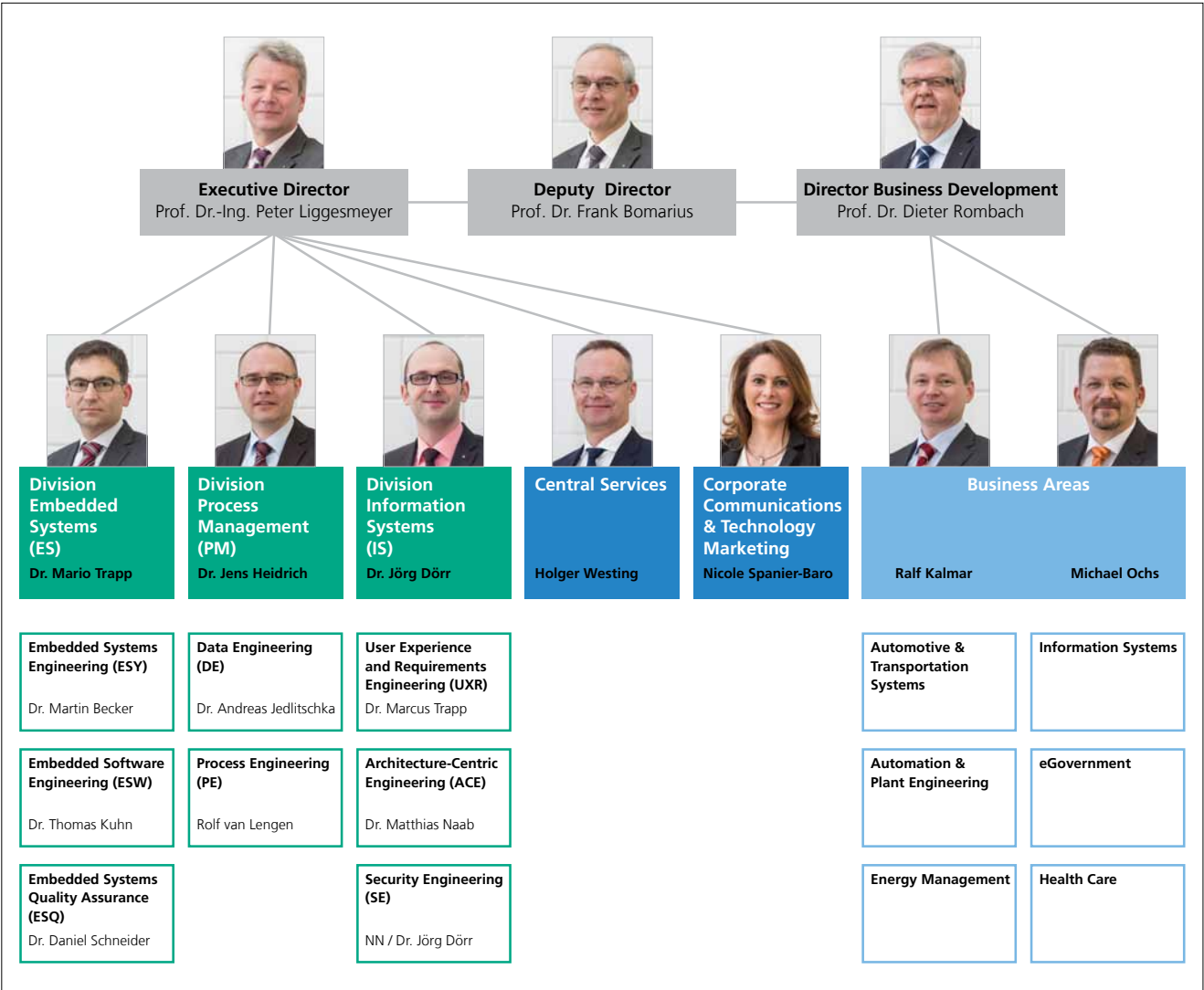
- Automotive and Transportation Systems
- Automation and Plant Engineering
- Energy Management
- Health Care
- Information Systems (banks, insurance companies & software)
- E-Government

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)



# ORGANIZATIONAL CHART

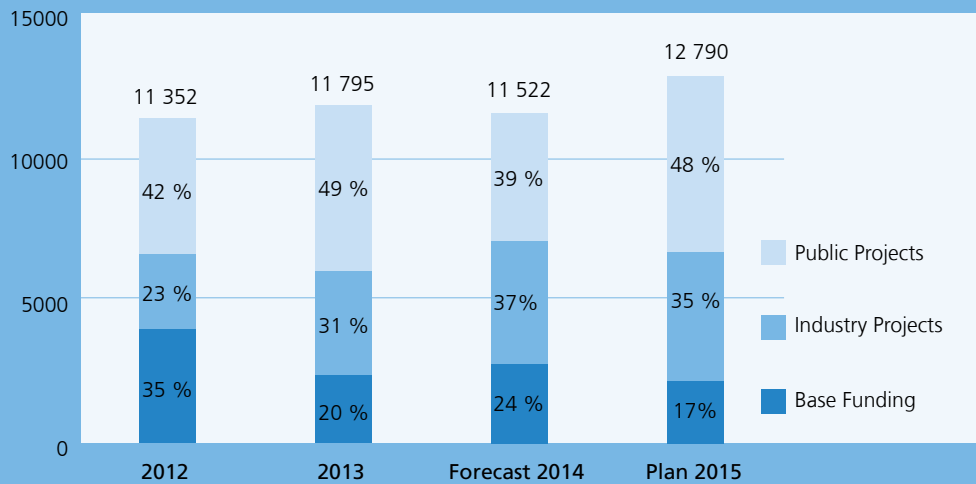


All contact information can be found at:  
[www.iese.fraunhofer.de/de/kontakt.html](http://www.iese.fraunhofer.de/de/kontakt.html)



# THE INSTITUTE IN FIGURES

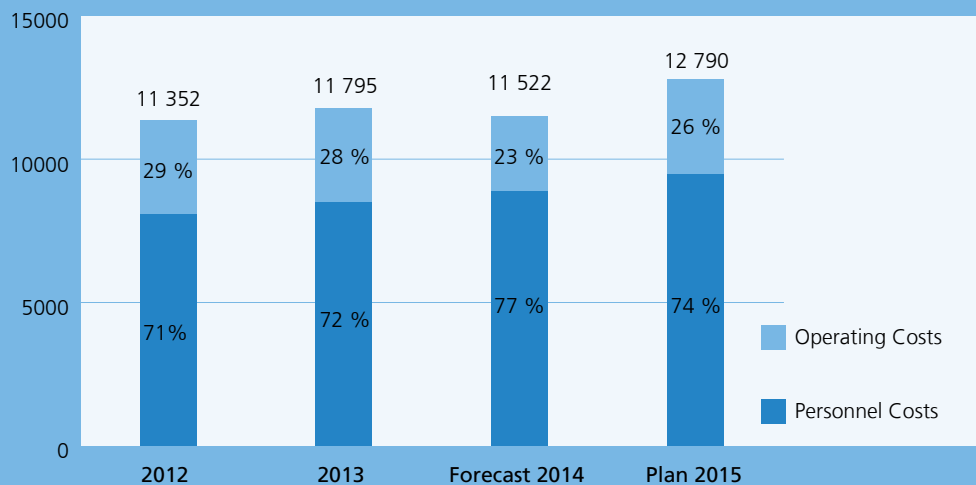
Development of Budget (in T euro)



## Personnel and Budget Development

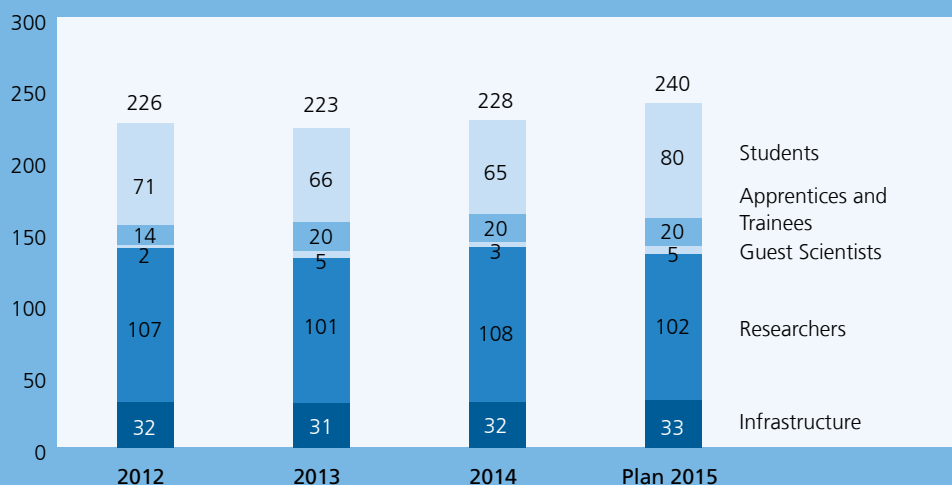
In 2014, we continued to focus on the strategic competencies of the institute. The associated re-organization and closer ties with strategic partners were also accompanied by adjustments in the personnel structure.

Development of Costs (in T euro)



In 2015, we will make large investments into modern work environments and into our building technology. Special attention will be given to our international activities in the USA and in Brazil. Investments into personnel development will accompany this path. Particular consideration will be given to expanding and stabilizing the high proportion (30%) of female employees. Employees from 18 different nations are currently working at IESE.

Development of Personnel





# THE ADVISORY BOARD

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

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 Deputy Chairman: Prof. Dr. Jürgen Nehmer

# 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 66 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 billion euros. Of this sum, around 1.7 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.

# EDITORIAL NOTES

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This Annual Report is also available in German.

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EMC<sup>2</sup>  
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