Fraunhofer
IESE

FRAUNHOFER INSTITUTE FOR EXPERIMENTAL SOFTWARE ENGINEERING IESE

Why the future needs digitalization

AUTONOMOUS SYSTEMS
"Challenge: Dependability"

DIGITAL ECOSYSTEMS
"Digitalization of Business Models"

SMART FARMING
"High-Tech Data Platform for Agriculture"

INDUSTRIE 4.0
"Flexibilization in Manufacturing"

ANNUAL REPORT 2019 / 2020


Engineering the
Digital Future

Dear readers,

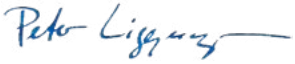
I am convinced that we will increasingly encounter autonomous systems in many areas. There are good reasons for this assessment: The merging – the networking – of previously separate systems leads to such large, open, heterogeneous "systems of systems" that humans will often be overwhelmed with their manual control. They will also lack an overview or the ability to react quickly enough. Moreover, autonomous behavior is also necessary to realize certain projects economically. For example, the basic idea of Industrie 4.0, i.e., the manufacturing of mass-individualized products, requires a flexible production environment that must autonomously adapt to changes in requirements. Manual conversion by humans would most likely make mass-individualized production economically unattractive in the majority of cases. And finally there is the motivation of increased comfort: We do not need autonomous driving because people are incapable of driving, but rather because it would be quite pleasant to use driving time for more meaningful activities instead of concentrating exclusively on road traffic.

On the one hand, the expected benefits of autonomous systems are often very large; on the other hand, by no means have all the questions related to autonomous systems been answered already. There are unresolved technical challenges, such as those concerning the aspect of comprehensive safety and security – that is, especially the interaction between data security and functional safety. For the joint analysis of these features, there are hardly any accepted methods and especially no standards. According to current standards, the use of components employing Artificial Intelligence is not recommended either in safety-critical application areas, but "Machine Learning" techniques, for example, will of course play an essential role, meaning that methods must be found to enable using such techniques even in critical applications. And this is exactly where we come in with our research in the area of Safety Engineering: With our dynamic risk management approaches, we are capable of identifying and controlling the risk at runtime. This makes it possible to avoid hazardous situations or manage them in a controlled manner.

Overall, all the steps in the development of autonomous systems must be re-assessed and put to the test again in light of the special requirements. We therefore need systems engineering that is adapted appropriately. That is why, as a software- and systems engineering institute, we have dedicated the cover story of this annual report to autonomous systems. Find out about the opportunities and risks these systems entail, and discover with concrete practical examples how we support our customers on their way towards an autonomous system.

Further focal points of this annual report are the digitalization of business models in the context of Digital Ecosystems, Industrie 4.0 with our research project BaSys 4.2, and the topic of Smart Farming with the Fraunhofer lighthouse project COGNAC.

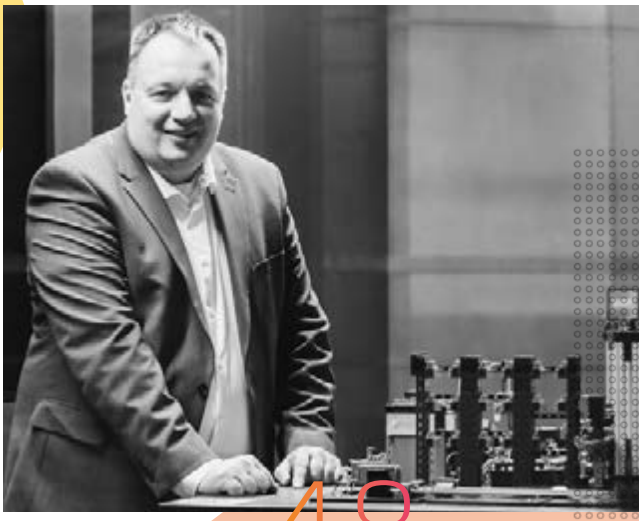
We wish you an informative read!

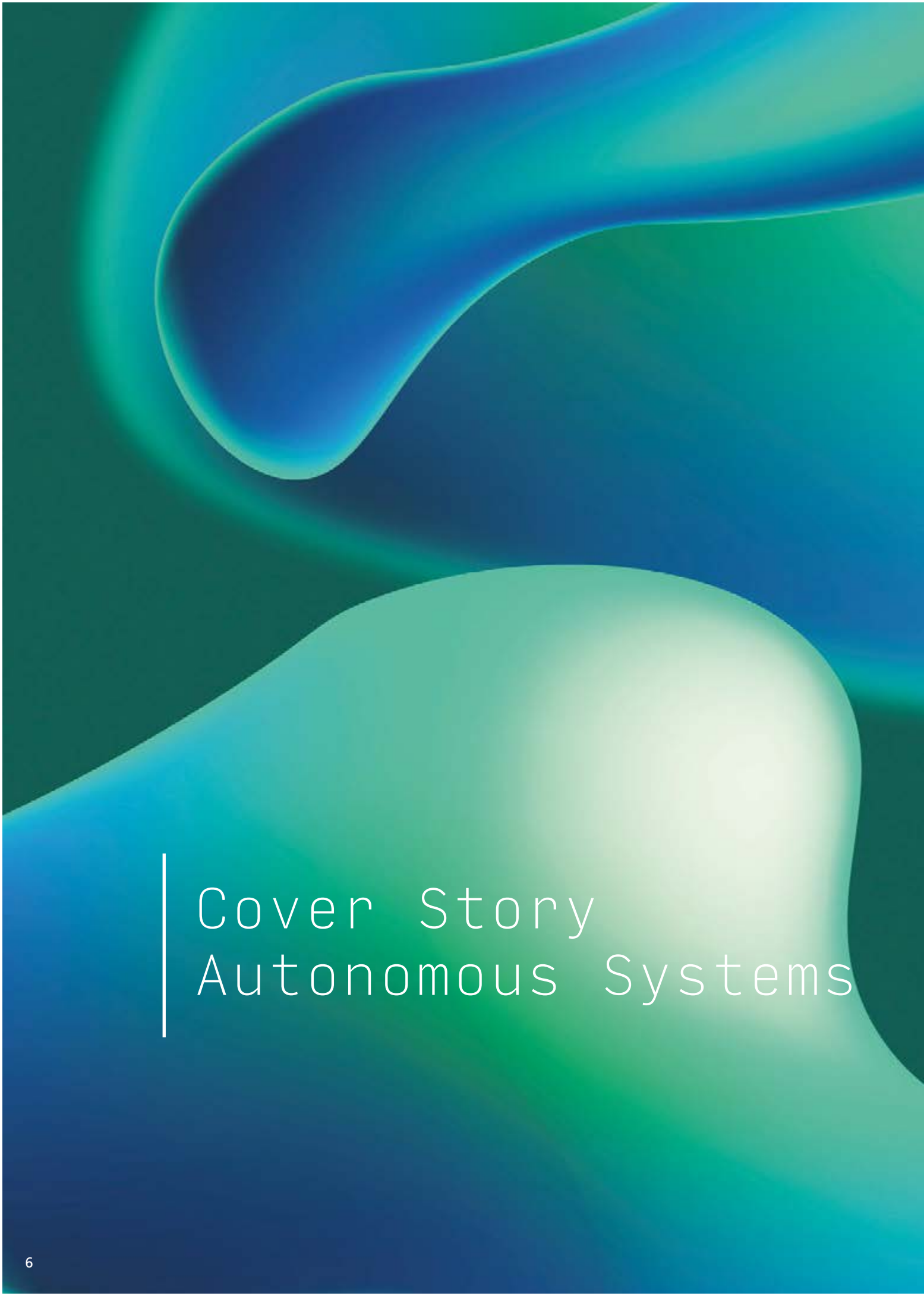


Peter Liggesmeyer

10

Interview
"AUTONOMOUS SYSTEMS"





Cover Story
Autonomous Systems

Autonomous = Everything out of Control?

How can autonomous systems still be dependable?

Autonomy, automation, AI… many terms are circulating in the context of "autonomous systems". For example, some already speak of autonomous driving if the vehicle takes over certain driving tasks on its own and without human intervention. But what is actually hidden behind these terms? What is important in engineering such systems, and why does everything always end with the question of how to make autonomous systems dependable?

For the development of a system from remote control to complete autonomy, models of different levels can be found in the literature: The SAE (Society of Automotive Engineers), for example, divides automated driving into six levels (see illustrations). Some experts differentiate between "digital assistance systems", "automated systems", and "autonomous systems", according to which a system would only be called autonomous if it is able to achieve a given goal independently and adapted to the situation, without human control or detailed programming. But autonomous also means taking responsibility for one's own actions. In other words, the aim is not for the system to do something without direct or indirect directives from humans, but rather that humans are not responsible for the system's decisions and therefore do not need to monitor them.

Networking supports autonomy

Good decision-making usually requires timely and sufficiently detailed perception of the current situation and prediction and assessment of possible future scenarios. In this respect, networking plays a crucial role: In order to perceive the current situation, it makes sense to use the sensor systems and the "knowledge" of other systems. In order to consider the development of a situation already in advance, the future actions of other systems must often also be taken into account. One example of such cooperation is truck platooning, which would be inconceivable without networking. For in truck platooning, the individual trucks drive so closely behind each other as though they were connected by an invisible drawbar. Technical control systems ensure that road safety is not impaired. This is

These illustrations visualize the 6-level model of the SAE (Society of Automotive Engineers).

Level 0 | **No Automation**
The driver drives on their own, even though supporting systems (e.g., ABS or ESP) are available.

Level 1 | **Driver Assistance**
Driver assistance systems provide assistance with **either** longitudinal **or** lateral vehicle motion control during the operation of a vehicle; e.g., ACC (Adaptive Cruise Control).

why we at Fraunhofer IESE see networking as a necessary "enabler" for autonomy and speak of a closed or an open autonomous system to clearly indicate whether it is networked or not.

Challenge: Dependability

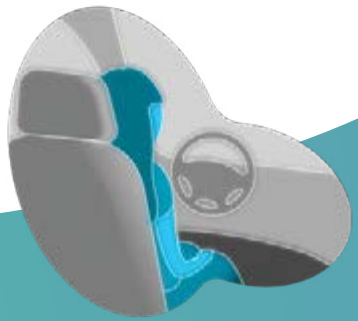
In many use cases, the decisions of open autonomous systems are critical, as wrong decisions may lead to financial losses or even personal injury. This entails special challenges for safety technology, as this "openness" and this "intelligence" are in contradiction to traditional methods and fundamental assumptions such as "setting the limits of the machine" and "predictability" of the system behavior.

This is exactly where we as Fraunhofer IESE come into the picture: We offer innovative solutions for validating dynamic systems of systems and Artificial Intelligence. In this context, runtime certification via ConSerts, virtual certification with FERAL, and dynamic risk management are crucial, but by no means the only core components with which we enable critical autonomous systems to enter the market.

Level 5 | **Full Automation**
Fully automated driving, where the dynamic driving task is performed under any road and environmental condition that a human driver would also master.

Level 4 | **High Automation**
Automated operation of the vehicle without the expectation that the driver will respond when prompted to intervene. Without human reaction, the vehicle will continue automated operation.

Level 3 | **Conditional Automation**
Automated driving with the expectation that the driver must react when prompted to intervene.



Level 2 | **Partial Automation**
One or more driver assistance systems help to operate the vehicle with longitudinal **and** simultaneous lateral vehicle motion control.

SUCCESS FACTOR SYSTEMS ENGINEERING

What really matters in the development of autonomous systems

Interview with Institute Director Prof. Dr.-Ing. Peter Liggesmeyer and Dr.-Ing. Rasmus Adler, Program Manager "Autonomous Systems"

Autonomous systems have an enormous potential to make a key contribution to the solution of current ecological, societal, and economic challenges. In the future, they will play an important role not only in the area of mobility, but also in industrial production and in agriculture. With its "Autonomous Systems" program, Fraunhofer IESE intends to play a major role in the design and validation of such systems.

Prof. Liggesmeyer, what level of autonomy have market-ready products reached?

Liggesmeyer: When we look at safety-critical applications – such as the evaluation of data in medicine – then the final verification of the results is done by humans, who ultimately take responsibility. In the narrow sense, these are not autonomous systems. Of course there are safety-critical applications that run on their own without human intervention, e.g., production lines control or operational management systems in rail technology. But in these cases we only speak of automated systems. These systems have a firmly established behavior; all reaction possibilities are predefined and could, in principle, be checked at any time. However, such systems are rather inflexible. They do not learn new things and are unable to adapt their behavior to changed conditions on their own. Outside the safety-critical area, we are already moving more towards autonomy. But these are comfort functions where occasional failures can be tolerated, e.g., voice control in a vehicle.

For which sectors and branches of industry are autonomous systems particularly interesting?

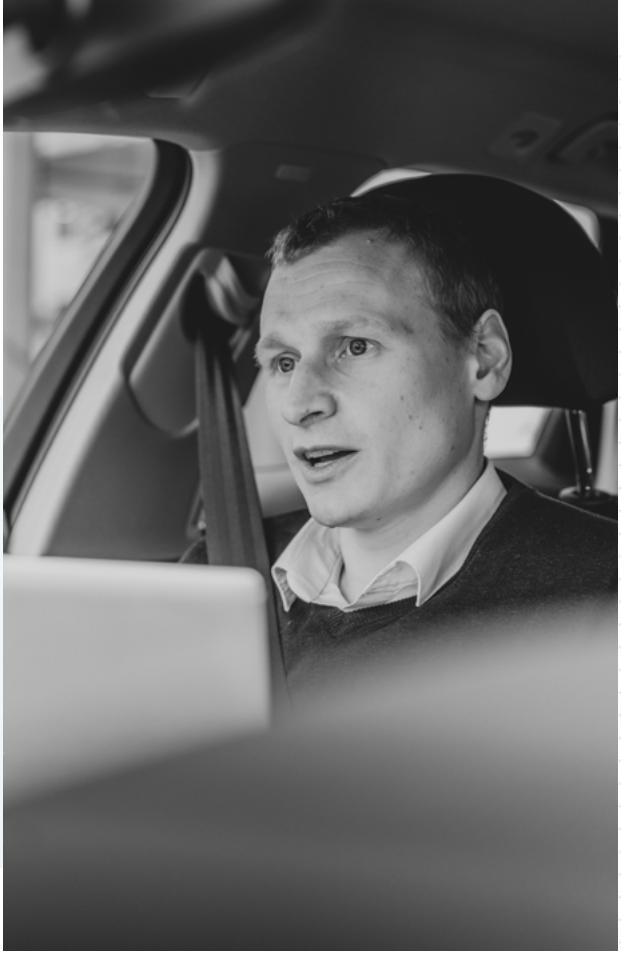
Liggesmeyer: I can hardly think of any area where the use of autonomous systems would be unattractive from the outset. Yet there are, of course, many situations where autonomous systems are unnecessary. If the situations arising during the operation of a system are known in advance, then autonomous capabilities are obviously not needed. The disadvantages of autonomous systems are then not offset by their advantages – in this situation, conventional automation technology is fully sufficient. It can be assumed, however, that this will be the case less and less often, because some systems or their tasks will keep changing continuously.

What would be a typical example of a system that changes continuously?

Liggesmeyer: A good example of this is the system for supplying electrical energy – the energy distribution grid. New system components are added as a result of the introduction of photovoltaics. However, whether this supplies energy depends on the factor sunlight, which cannot be influenced. Still, the energy balance must be right. This system is too complex to be controlled manually by humans, and it changes its structure too often to be operated using conventional automation technology. Only a suitable self-learning, autonomous system can be of help here. Humans would be overwhelmed with this task.

Keyword mobility – in general, we are not overwhelmed with driving a car. So why the trend towards automation?

Liggesmeyer: Because in some cases, the desire for autonomous systems is justified differently. Everyone knows that humans can drive a car; however, autonomous driving would be more comfortable. In agriculture, for example, workers are not available in sufficient numbers. Here, autonomous systems provide the opportunity to work with a similar degree of flexibility that normally only humans can provide. An autonomous field robot can distinguish weeds from corn plants. The former are removed mechanically, ▶



> "Good systems engineering is a key success factor for the development of autonomous systems."
>
> Dr.-Ing. Rasmus Adler

while the latter are fertilized precisely. This reduces the use of herbicides and prevents over-fertilization. Humans could do this as well, but they are often not available. We investigate such scenarios in the Fraunhofer lighthouse project COGNAC, which is coordinated by IESE.

What is the situation in the Industrie 4.0 sector in particular? Do real autonomous systems already exist in manufacturing?

Liggesmeyer: What we can currently see in production are primarily fully automated systems. However, it is also obvious that Industrie 4.0 cannot be realized without autonomous systems. The production of individualized products makes it impossible to plan every conceivable product in advance, meaning that the production technology must also be able to adapt to products that were not planned in advance. This is only possible autonomously. We are currently establishing the foundation for this with our Industrie 4.0 middleware BaSyx.

Dr. Adler, which factors play a special role in the development of autonomous systems?

Adler: The topic of "Systems Engineering" plays a very central role in this context, but we need to look at it on different levels. On the one hand, we are dealing with a single system, such as a vehicle, and the aspect of how to integrate software or hardware. In the case of autonomous systems, however, the environment is of crucial relevance, as the complexity of the environment will be reflected in the complexity of the system. You can try to make the environment so simple that you can prescribe for every situation exactly what the system must do. Then you head towards automation instead of autonomy. Or you decide that it is too expensive to control the complete environment and you use AI methods, which allow you to react confidently even in situations that have not been considered explicitly. Another important point is that autonomous systems must be able to perceive their environment. The perception of a single system, however, is limited to

its own sensor system, respectively to what its algorithms can derive from that. This limited perception can increase enormously when physical systems are networked and share their knowledge about the environment. In any case, good systems engineering is a key success factor for the development of autonomous systems.

Will autonomous systems ever be so safe that we can depend on them?

Adler: This depends on many factors, not all of which are of a technical nature. Generally, one does not want to have human lives depend on whether an autonomous system "happens" to behave safely in a certain situation. One will always attempt to explicitly check all critical situations, but to do so, all critical situations must first be known. If you think of driving a car, for example, this is unfortunately not the case. Nevertheless, there is much that can be done to minimize the risk of autonomous wrong decisions and to assess it as accurately as possible. Research in this area is already very advanced, yet is far from being complete. It is hard to estimate how far we will get, but a residual risk will always remain. So the non-technical question arises as to what residual risk can be accepted. In the case of autonomous driving, the expectation is, of course, that it has to be safer than manual driving. Currently emerging standards such as the "UL 4600" or the cross-industry whitepaper "Safety First for Automated Driving" do not make any concrete statements on this.

And how can one make autonomous systems at least safer?

Adler: A typical strategy is to separate safety-critical aspects from non-safety-critical aspects. We cannot completely specify the "good", the intended behavior of an autonomous system, but often we can still describe the safety-critical behavior well through safety functions. The trend is now to move away from established, rather simple safety functions, as these only perform a worst-case analysis during the development of a system. Normally, however, not all worst-case scenarios occur together in a situation. In truck platooning, for example, a lot of potential would be wasted in this way, as the vehicles would have to keep far too great a distance from each other. This is where dynamic risk management comes into play: Risks are recorded at runtime and controlled optimally. Often it is sufficient to slow down slightly instead of shutting down the entire system. In other words, the system is enabled to become "aware" of the current risk and to respond by adapting correspondingly.

"Industrie 4.0 cannot be realized without autonomous systems."

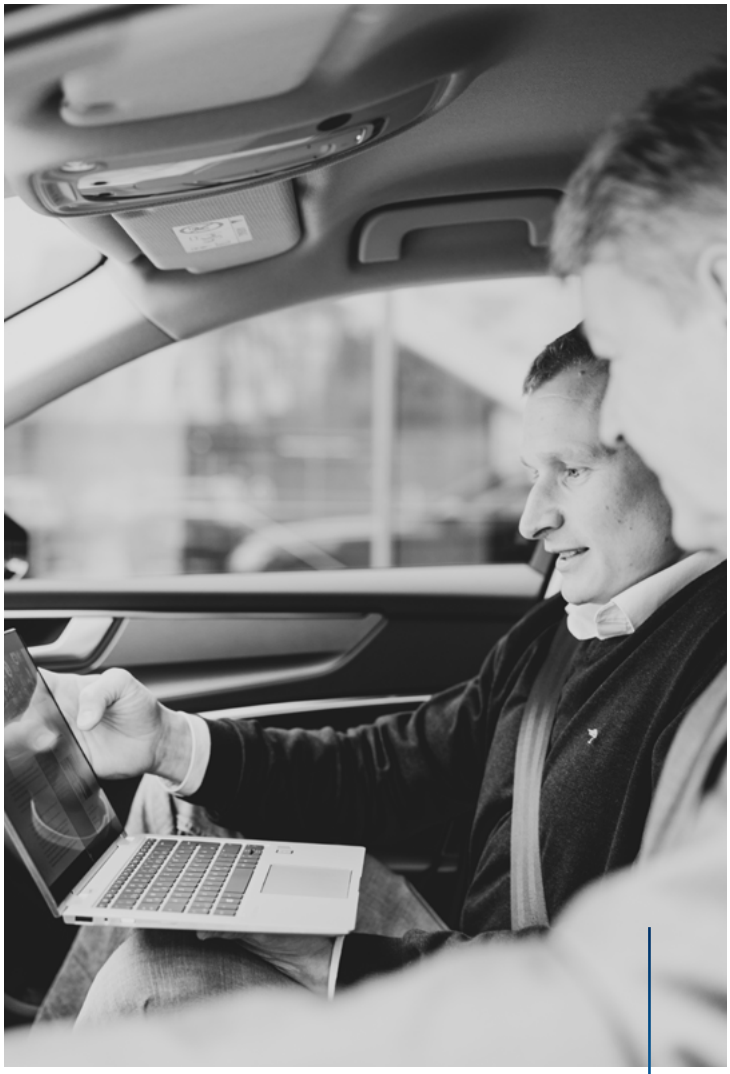
Prof. Dr.-Ing. Peter Liggesmeyer

Does this dynamic risk management also work without complete networking of the systems?

Adler: In principle, yes. Without networking, the system merely has less information at its disposal to correctly assess the current risk. Furthermore, it cannot influence the behavior of other systems to control the risk. In the context of warning systems and simple assistance systems, standardized metrics already exist today, such as "Time-to-Collision" for measuring the risk of a rear-end collision. But for highly automated driving, this is not sufficient, let alone for autonomous driving. In this context, we are pursuing a multi-layered approach where the risk regarding different time horizons is measured and controlled. This makes it possible not only to manage dangerous situations, but also to constructively avoid them.

And how do you as Fraunhofer IESE provide support on the way to an autonomous system?

Liggesmeyer: First of all, we offer our customers creativity workshops in order to examine all aspects of the situation together with them: What is the benefit of the autonomous solution? What do the corresponding business models look like, and what does the path from the current system to the envisioned solution look like? Mainly, however, we help our customers engineer autonomous systems. We offer very powerful methods for the modeling and simulation of such systems and their environment. However, we are also prepared to carry out the modeling and the analyses that build on them for our customers. This applies in particular to safety and security engineering. In addition to modeling and analysis tools, we also supply very concrete technical solutions, e.g., MYDATA Control Technologies for data usage control or BaSyx as a solution for Industrie 4.0. ■



In autonomous vehicles, mobile work becomes a reality.

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

V&V Methods

Project for the verification and validation of autonomous systems

Highly automated driving poses new challenges for developers and requires new methods for safety cases. The goal of the flagship project "V&V Methods" for the verification and validation of autonomous systems, which is funded by the German Ministry for Economic Affairs (BMWi), is to develop a methodological approach for safety cases for highly automated and autonomous vehicles (SAE Level 4/5) for approval in urban environments.

Safety for highly automated driving functions

"V&V Methods" is a project of the VDA's lead initiative "Autonomous and Interconnected Driving". It builds on the results of the project PEGASUS, which examined the validation of Level-3 driving functions in the operating area "German Autobahn". It can therefore be described as its successor. In addition to the OEM-/Tier1-wide definition of the state of the art for the validation of highly automated driving functions, a comprehensive basis for the discussion of legislation and standardization is to be created.

The urban intersection as a key location

The project considers urban intersections in all the facets relevant for the systematic conduct of a safety case as the overarching use case. The reason for this is that the main challenges of highly automated driving converge at urban intersections. The complexity of crossing and turning traffic, the effect of light signal systems, as well as the consideration of pedestrians can underlie essential aspects of a methodological approach.

Role of Fraunhofer IESE in two subprojects

Fraunhofer IESE contributes its expertise to "V&V Methods" in the two subprojects TP3 "Safety Analysis and Functional Architecture" and TP4 "System and Test Requirements Framework". In TP3, the work consists of determining how to systematically generate an end-to-end safety case on the basis of models of the autonomous system and its environment. In this regard, the functional specification of a safe target behavior and the argumentation for the complete coverage and analysis of the safety-critical situations play an important role. Fraunhofer IESE will here build on its research work on the topics of "Digital Dependability Identities" (H2020 project DEIS) and "Dynamic Risk Management" (DRM).

Design of validation test cases in the second subproject

TP4, which builds on the results of TP3, aims to derive a complete set of validation test cases that can be applied to concrete system components such as sensors, controllers, and ECUs. Decision criteria will also be developed to determine whether and which of these tests must be performed in simulation, on the test track, or in real traffic. Ultimately, all the methodological components developed in "V&V Methods" with the participation of Fraunhofer IESE are aimed at introducing highly automated driving functions safely into traffic in the future.

Research Project SECREDAS

More security in autonomous driving

Letting cars drive autonomously? Allowing the sensors installed in the car to collect data about the driver's current health status? Most people are very reluctant in this regard. In the SECREDAS project, a consortium of researchers including the Fraunhofer Institute for Experimental Software Engineering IESE is increasing the security of such systems – in an attempt to boost general trust in the technology.

When it comes to the acceptance of new technologies such as self-driving cars, there is still much convincing to be done: Human drivers are usually trusted to make better decisions in road traffic than any software. Boosting trust in such networked automated systems in mobility and medicine – in terms of both security and privacy – and keeping European OEMs competitive is the aim of the consortium of the project "Product security for cross domain reliable dependable automated systems SECREDAS". A total of 69 partners from 16 European countries are participating in the project, including Fraunhofer IESE. The EU is funding the project with around 15 million euros; the total volume of the project is 51.6 million euros.

Increasing safety and security in self-driving cars

In autonomously driving vehicles, neural networks play an ever greater role in control and situation recognition: Is the traffic light red? Is another vehicle crossing the intended route? The difficulty is that how exactly neural networks make their decisions cannot be traced in detail. "We are therefore developing a Safety Supervisor that monitors the decisions of the neural network live, so that, if necessary, corrective action can be taken on the basis of these assessments", says Mohammed Naveed Akram, researcher at Fraunhofer IESE. "This supervisor is based on algorithms that make use of traditional approaches. These are not used to capture the overall situation like neural networks do, but rather critical key points. In the context of the SECREDAS project, we mainly address the question of suitable metrics; the initiation of appropriate countermeasures to control the risk will be the subject of future work."

How this works exactly can best be illustrated with an example, for instance at an intersection. The neural network is designed to capture the overall situation: Which right-of-way rules apply, is the traffic light red or green, are pedestrians in the danger zone, do other vehicles cross the projected future route? The algorithms of the Safety Supervisor are unable to do this; instead, they rely on specific metrics. These include, for instance, "General-Time-To-Collision (GTTC)", that is, the time until a collision occurs, considering the expected trajectory, or the "Worst Case Impact Speed" metric to assess the severity of the damage based on the expected collision speed. If the car is now heading towards another road user that the neural network might have missed, the algorithms of the Safety Supervisor will detect that the distance to the other traffic participants is shrinking to a dangerous degree. They can take over command of the vehicle and decelerate the car if the automatic control fails. "We have examined various metrics: How well can we use them to assess the current hazardous situation?" says Akram. In a simulation, the researchers evaluated the suitability of these metrics for various hazardous situations. The result is impressive. "The approach of monitoring the neural networks at any time and live using traditional approaches can, along with dynamic risk management, significantly increase safety", summarizes Akram.

More data privacy or more service?

If another driver has used your car, this often means readjusting the seat and the mirrors, selecting your own favorite music, entering your own favorite locations into the navigation system, etc. – only then can you set off. It is true that it is possible to save this information so that all settings fit automatically. But while some people like to use this feature, others are reluctant to do so due to privacy issues. Things become even more delicate if the vehicle also collects medical data, such as blood sugar levels or heart rate – in order to issue an appropriate warning to the driver or call for help, if necessary. After all, users currently find it hard to tell whether the data remains in the vehicle or is processed in a cloud. "A one-fits-all solution is therefore hardly a solution here", says Arghavan Hosseinzadeh da Silva, software developer at Fraunhofer IESE. "In general, the more data you share, the more service you get. How much data you want to share in which case, however, differs greatly from person to person."

Under the name "IND²UCE" (product name: MYDATA Control Technologies), the researchers are therefore developing a framework that enables restricting the use of all personal settings depending on the situation and personal preferences. You want to have your WhatsApp messages shown on the vehicle's display – unless you are not alone in the car? Should the same contacts and playlists be shown in a rental car that are shown in your own vehicle, and should the seat, the steering wheel, and the mirrors be adjusted properly right away? Should the health data, such as measurements of the heart rate, stay in the car and not be sent to a cloud – unless urgent help is necessary, which then should be called automatically, for instance after an accident? In the future, users should be able to set such things themselves via an app, and these privacy specification will then be transferred via smartphone to every vehicle currently used by the user, whether it is a business car, a rental car, or a private vehicle.

The framework components necessary for this are integrated into the vehicle. A query – for example, whether the data about the user's heart rate may be sent to the cloud – is first run through the "Policy Decision Point PDP". It checks whether it is permissible. If it is, the PDP sends a release to the "Enforcement" or gives it the information which data is to be deleted or anonymized prior to being sent. Within the context of SECREDAS, the Fraunhofer IESE researchers want to develop a prototype for the framework that is to be ready by the end of 2020. In the long term, the SECREDAS consortium wants to establish a standard for data usage control in vehicles that should be adopted by all car manufacturers, if possible, in order to enable informational self-determination of the vehicle users.

Further information about the project: www.secredas.eu

Safety Supervisor

The Safety Supervisor is a software component that is executed in parallel to the actual function itself and which monitors the decisions made by the latter in terms of safety. The basic idea of the Safety Supervisor is dynamic risk management (DRM), which gives systems the ability to assess and manage their risk at runtime on their own. This allows dealing with uncertainties caused by the great complexity of the systems and of their context. Without adequate runtime approaches, this would either lead to unsafe systems or to worst-case assessments, which would significantly limit performance or even make certain applications impossible. In recent years, such sub-concepts of the approach have been successfully implemented in numerous bilateral projects with industry partners for concrete applications in the domains Automotive as well as Agricultural and Industrial Automation.

Memory Bottleneck in Autonomous Driving

Research project wants to close research gap

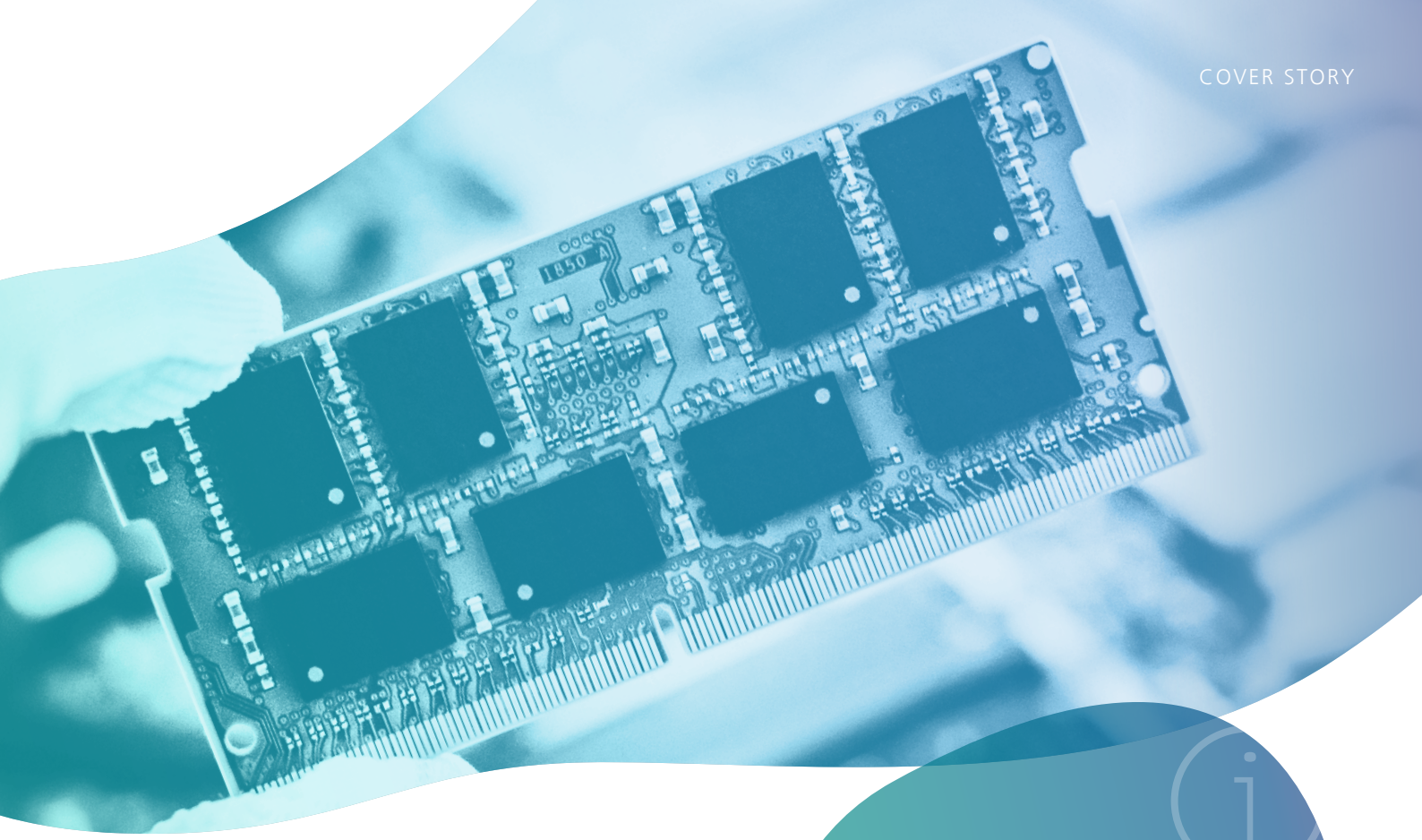
Assistance systems, domain controllers, highly automated driving functions, neural networks, and cloud-based services – all these new applications present great challenges for the automotive industry. The need for communication increases as do the requirements on computing power, memory latency, and memory bandwidth. The latter is often neglected. The issue of "memory" is considered easy to solve in autonomous driving, but it is not!

One would think that similar to the way computing power draws on classical IT, memory should be able to do the same thing. Far from it! The requirements for processing sensor data from many channels are very high, not only in terms of volume, but also in terms of guaranteed latency and bandwidth. What many do not know: Even if memory devices such as DRAMs (Dynamic Random Access Memories) have a specified maximal bandwidth, in practice this is often far lower owing to the complex protocol. In addition, the storage cells, which are very temperature-sensitive, must be refreshed regularly. Considering the high temperatures in the automotive sector, this leads to an additional drop in bandwidth and an increase in latency. These features make it very difficult to use DRAMs in safety-critical applications. Memory manufacturers like Micron estimate the demand for memory bandwidth for autonomy levels 4-5 at 400-1024 GB per second. On top of this, there are the growing demands on memory size, with Daimler predicting more than 50 GB DRAM for premium vehicles in 2025.

Approaches to solving the memory problem in autonomous driving

For several years, Fraunhofer IESE and its partners at the Technical University of Kaiserslautern (TU Kaiserslautern) have been conducting research in the High-Performance Center "Simulation- and Software-based Innovation" to develop solutions for optimized memory systems and memory controllers that are optimally adapted to special requirements – a scenario that can be mapped very well to high-performance sensor data analysis and Machine Learning applications, e.g., the interference of neural networks.

In recent years, many new DRAMs have been presented (e.g., DDR4, LPDDR4, GDDR6, Wide I/O, HMB2). It is not yet clear, however, how to use these memory modules in the automotive context with respect to bandwidth, latency, power, temperature, reliability, safety, and security. To date, scientific DRAM research has mainly focused on mobile devices and data centers.



These applications have totally different profiles than safety-critical applications in the automotive domain. With the trilateral research project "Memtonomy" (Optimizing Memory for Advanced Driver Assistance Systems and Autonomous Driving) of the DFG (Deutsche Forschungsgemeinschaft / *German Research Foundation*) and the Fraunhofer-Gesellschaft, Fraunhofer IESE, TU Kaiserslautern, and Robert Bosch GmbH are attempting to close this research gap.

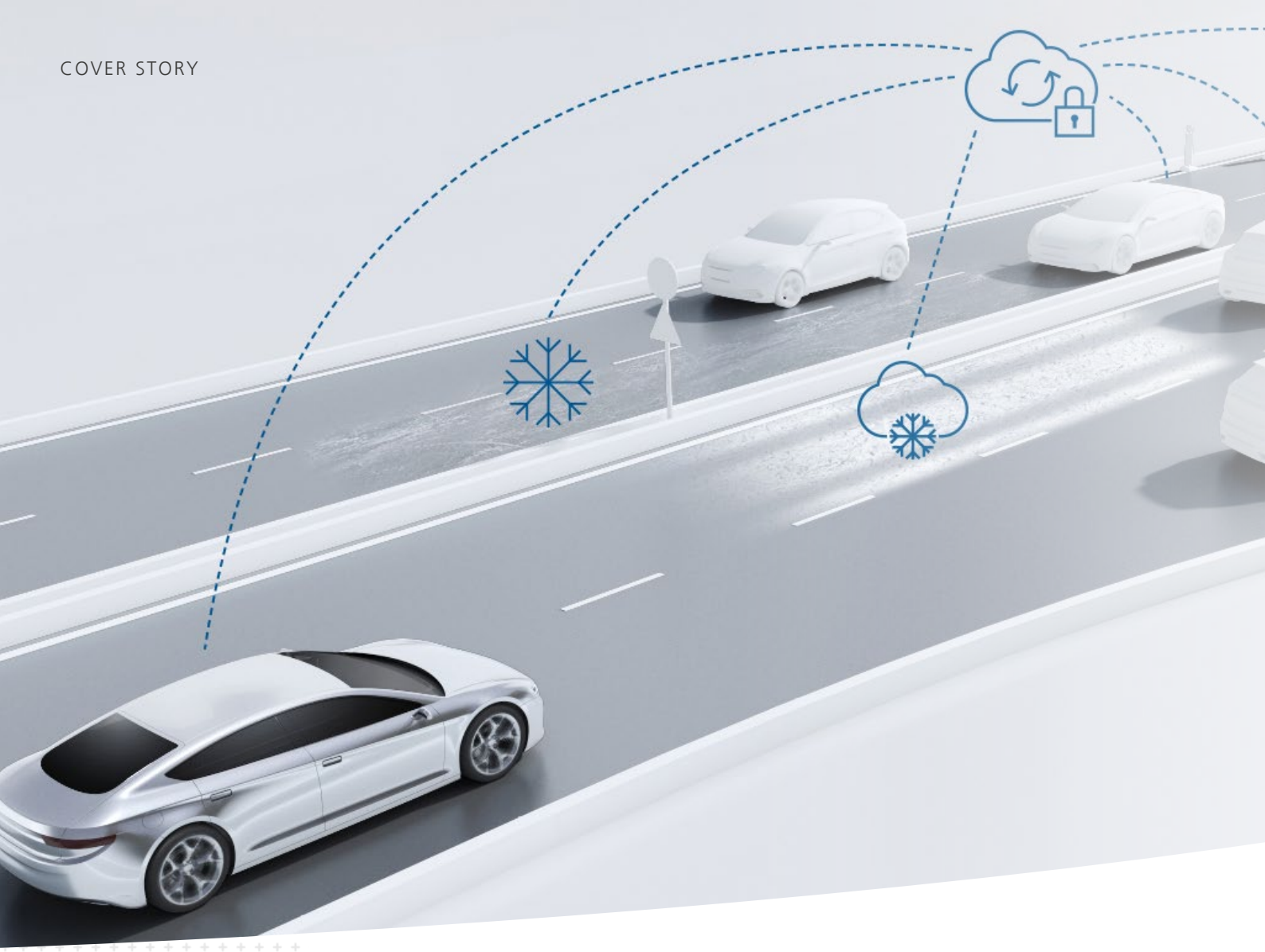
Further information about the project: http://s.fhg.de/memo

FRAUNHOFER IESE: EXPERT ON MEMORY AND AUTONOMOUS DRIVING

The services that Fraunhofer IESE already offers automotive manufacturers and suppliers today include measurement and selection of suitable memory technologies, development of highly optimized, application-specific memory controllers, and hardware-based simulation of performance parameters with the tools DRAMSys and DRAMMeasure as well as the institute's own simulation framework FERAL.

FERAL simulates and tests critical situations of autonomous systems

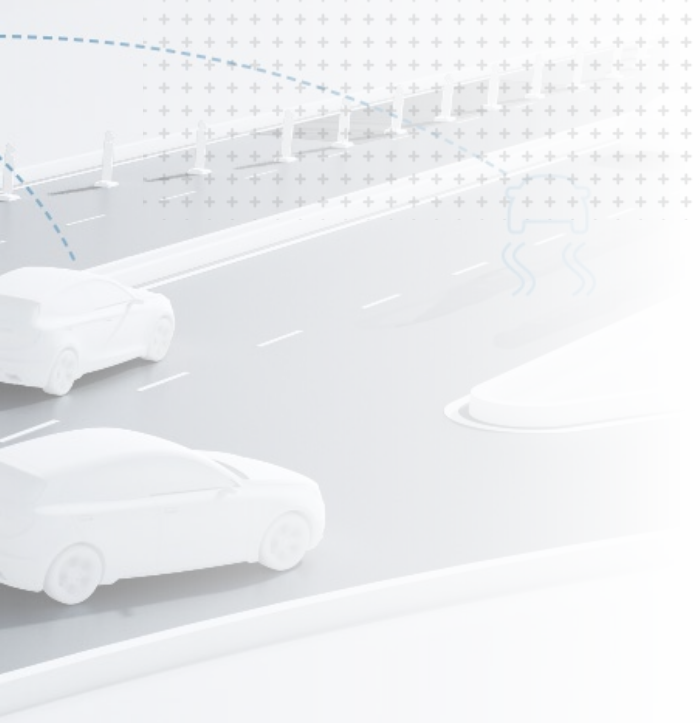
Special validation and testing is required for systems that make safety-critical decisions – and may do so in an automated manner – and on which, in extreme cases, human lives depend. FERAL from Fraunhofer IESE is a simulation platform with different components, which make it possible to integrate even complex, heterogeneous scenarios into a testing scenario and to systematically test properties in a protected virtual environment with the help of Digital Twins. One relevant application example is autonomous driving: Due to the increased complexity of autonomous vehicles, conventional validation techniques quickly reach their limits in this regard, so innovative simulations are needed that, unlike field tests, can enable more frequent critical situations.



Industry Project Bosch

Safety considerations for a cloud service for automated driving

In the future, automated driving will be increasingly supported by cloud services: A vehicle's sensor system only has limited range and is expensive, which is why in the future, vehicles will be supplied with information via the cloud. This information may originate from other vehicles, but also from other sources such as online weather services. For example, a cloud service informs a highway pilot about the weather conditions on the road and the road's static friction coefficient. Highway pilots are reliant on this information since their area of application and their driving behavior depend on the level of friction. Developing a safety concept for this cloud service – despite the lack of standards for safety issues in the automotive sector – was the challenge facing the experts of Fraunhofer IESE.



Lack of safety standards hampers development

There is as yet no standard explaining how to develop cloud services for highway pilots. The safety standard ISO 26262 and the Safety-Of-The-Intended-Functionality (SOTIF) standard ISO PAS 21448 do refer to vehicles, but their application cannot be transferred easily to cloud services. IT security standards also address cloud services, but not the safety issues from the automotive sector. However, just because there is no standard does not mean that such services can be developed any which way. One should still keep to the state of the art.

Researchers of Fraunhofer IESE accept the challenge

The researchers at Fraunhofer IESE are familiar with the state of the art as well as with current developments in the area of safety and autonomous driving. Based on this background knowledge, they compiled relevant requirements from standards in this project with Bosch and demonstrated how to implement these methodologically. Furthermore, Fraunhofer IESE supported Bosch in the methodological implementation. In cooperation with the domain experts from Bosch, they developed a functional architecture that represents the entire information processing. Subsequently, the team analyzed the individual processing steps using component fault trees. They also conducted a safety analysis regarding the cloud platform on which the software developed by Bosch runs. Based on the analysis results, the Fraunhofer experts derived a safety concept and developed a safety argumentation using the Goal Structuring Notation (GSN). They modeled all artifacts with safeTbox, the tool framework developed by Fraunhofer IESE to support the development and certification phases of safety-critical systems. Due to their modular character, the modeled artifacts can be easily tailored to different customer requirements.

Customized concept for Bosch

As the result of the project, Bosch received a comprehensive safety concept for its special cloud service. However, the approach and the methods and tools employed can be easily transferred to other cloud services. Thus, the project also provides a model-based safety engineering approach for cloud services and lays the foundation for a hitherto missing standard.

> "For us, the cooperation with Fraunhofer IESE was groundbreaking for the safety engineering of our cloud services. The model-based analysis techniques enabled us to systematically examine the entire chain of effects, from sensors via different cloud services all the way into the vehicles, and to derive a comprehensive safety concept from this."

Erik Lesser, Chief Product Owner, Robert Bosch GmbH

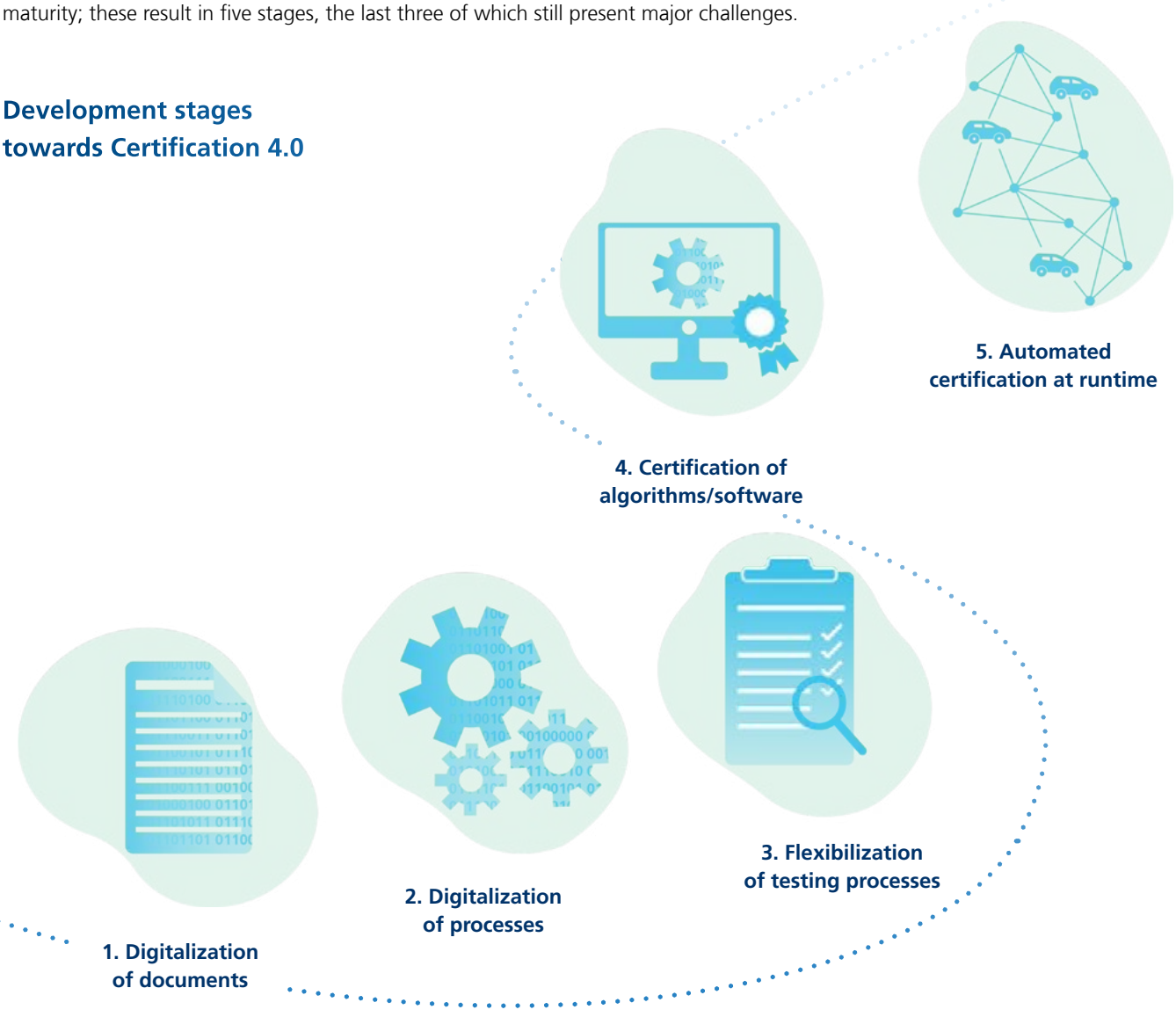
Certification 4.0

The digital transformation of certification is still in its infancy

Almost all areas of technology are currently being raised to the level “4.0” – but for the topic of certification, this does not seem to be apply yet. And this despite the fact that for many products, this important aspect is a prerequisite for their release onto the market. The topic therefore equally concerns product suppliers, the TIC (Testing, Inspection, Certification) industry, and the customers, respectively users.

The digital transformation of certification can be divided into several evolutionary steps or levels of maturity; these result in five stages, the last three of which still present major challenges.

Development stages towards Certification 4.0



Challenges caused by digitalization

The first two stages already represent great effort for many companies: Interfaces to digitalized documents must be created and processes must be recorded and formalized. The required technologies, however, are well known and proven. We still speak of "Certification 3.0" here.

In order to render test processes more flexible, existing organizations must be changed. In some cases, the regulatory and legal prerequisites must also still be created, which is much more difficult. This is where "Certification 4.0" begins: The flexibilization and customer-specific adaptation enabled by the digitalization of processes and products also benefits the TIC industry, the suppliers, and the customers. Completely new business models are thereby made possible.

Certification of algorithms

For the certification of algorithms, such as decision support systems, or the continuous assessment of safety, the appropriate technologies are still lacking in many cases – not to mention standards. If AI-based algorithms are to take over human decisions or support them, many unanswered questions arise regarding transparency, traceability, fairness, equal treatment, liability, reliability, and data privacy. The answer to these questions is strongly dependent on the application context, as it ultimately specifies what is hidden behind these properties in a concrete case and what is acceptable in this particular case.

Dynamic certification at runtime

Finally, automated certification, possibly even during operation, is a running research topic. In the recently concluded EU research project DEIS, Fraunhofer IESE researched further solutions in this area (www.deis-project.eu). Despite its relevance, the topic has been rather neglected so far, especially considering the scenarios "Highly Automated Driving" and "Collaborative Autonomous Systems" envisaged for the next years. It is precisely here that the lack of legal and regulatory constraints inhibits the digital transformation and can quickly become a disadvantage in global competition. When it comes to certification, not only the TIC industry, but also legislators and standardization committees are called upon to act.

Which laws, standards, and research initiatives exist to make "Artificial Intelligence" and "Autonomous Systems" safe? And which other ones should there be in addition? These are issues that Dr.-Ing. Rasmus Adler deals with as Program Manager for "Autonomous Systems" at Fraunhofer IESE. He actively contributes his expertise in various standardization committees.

Further information on the IESE Blog: http://s.fhg.de/norm

Industry Project SICK

Reuse of modular function blocks in safety-critical contexts

Industrie 4.0 opens up a new era of industrial automation. Whereas large-scale mass production was the driving force in the past, new technological possibilities nowadays ensure flexible and adaptive manufacturing plants, right down to small lot sizes or customized products. As innovation leader at the forefront of the development of state-of-the-art sensor technology, SICK AG offers solutions that are ready to take up these challenges.

Validation of safety-critical systems as a challenge

Flexibility and adaptability always increase complexity. This is especially true for sensors: Information for monitoring and controlling the quality, efficiency, and safety of production processes must be provided with a very high degree of reliability. The validation of safety-relevant data is a particular challenge. The aim of the project with Fraunhofer IESE was to create and establish a methodology that enables the development of modular, flexible, and yet "safe" function blocks. This allows safety-relevant functionalities to be composed of numerous independent function blocks, to be executed on various platforms, and to be reused in different applications. SICK therefore approached Fraunhofer IESE, as the latter has comprehensive expertise in the area of safety engineering and model-based approaches. The combination of the knowledge of Fraunhofer IESE in this area with the experience of SICK in the area of sensor technology enabled a custom-tailored solution for the problem.

> "The model-based approach proposed by Fraunhofer IESE provided the ideal basis for our project: All interfaces are well described, both in terms of the services rendered and required and regarding the safety-relevant features. This allows the function block to be executed on different platforms and to be reused in different sensor systems. Our colleagues from Fraunhofer IESE did excellent work and successfully adapted their approach to our requirements."
>
> Dr. Magnus Albert, Expert Safety Methods Corporate, Unit Functional Safety, SICK AG

Fraunhofer IESE contributes expertise in the area of Safety

The cooperation in the project focused on the development of a specific function block for collaborative applications in which humans and machines share the same workspace. With the help of a service-oriented approach, a block model of the overall architecture of the application was created in the first step of the model-based development approach. Based on this service architecture, the horizontal interfaces to other services and the vertical interfaces to the platform services were identified. Using comprehensive and service-specific keyword lists, every single interface was analyzed and all relevant failure modes were identified. The corresponding failure logics were then created with the help of component fault trees. In the third and final step, a safety case was developed on the basis of the analysis, which provides a comprehensive and indispensable argumentation for the overall safety. The model-based approach ensures that all modules can be reused in other projects, together with the corresponding function block.

safeTbox combines the results in a toolbox

The model-based development approach proposed by Fraunhofer IESE could be integrated optimally into the development project at SICK and has already been transferred successfully to other development projects. The safeTbox tool developed by Fraunhofer IESE combines all necessary model-based techniques in one toolbox and facilitates the use of the methodology.

Integrated Safety Engineering with safeTbox

safeTbox by Fraunhofer IESE is a modeling and analysis tool for the efficient creation and reuse of safety artifacts such as hazard and risk analysis, fault tree analysis, or safety concept. It extends traditional modeling tools such as Enterprise Architect and integrates the modeling of safety issues into systems engineering models. This avoids inconsistencies between models and enables many automated tests, such as completeness tests or impact analyses in the case of changes. It also facilitates maintainability and reusability as well as the relationships between suppliers and OEM and the integration of third-party components.
safeTbox also supports the modeling of ConSerts and thereby dynamic runtime validation of networked autonomous systems.

Further information about safeTbox: https://s.fhg.de/RbC

IESE in Trend

Autonomous Agriculture in the Year 2045?

Fraunhofer IESE publishes new study on autonomous agricultural machinery

The development and introduction of agricultural machinery at levels ranging from highly automated to driverless will have a strong impact on the future form of global agriculture. This inevitably raises the question of how fast and when the new technologies will conquer and dominate the market – something that was also discussed frequently at Agritechnica 2019. The overall conclusion of this trade fair was that visitors were mostly interested in autonomous solutions for tomorrow's agriculture. This is precisely the context in which the new study of Fraunhofer IESE was conducted.

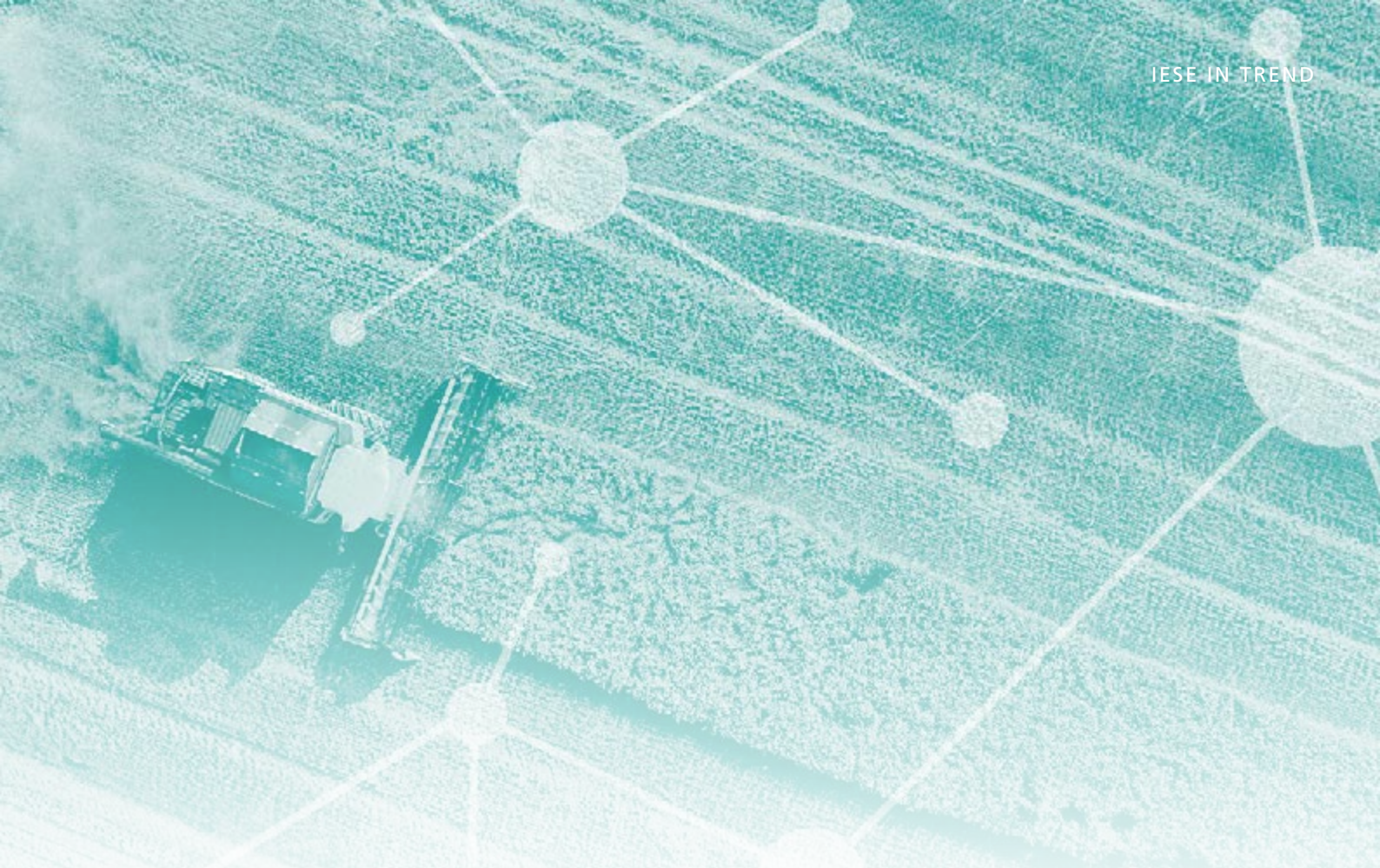
Work processes will change

In cooperation with the Kleffmann Group (KG), Fraunhofer IESE carried out a study on the state of the art as well as the future development of the autonomous agricultural machinery market. Several paths were taken in the study: The first step was the identification and classification of market-related impact factors. This was linked to the identification of changes in agricultural work processes in the context of the development of autonomous agricultural machinery. These impact factors were then used together with corresponding expert assessments as well as market data on tractor sales figures as part of an empirical modeling approach to develop possible future scenarios up to the year 2045.

Not all autonomy is the same

The study outlines the possible development of the following four types of autonomy levels for the years 2025, 2035, and 2045:

- **entirely human-driven machines** (i.e., with no or low technological assistance)
- **assisted human-driven machines (**i.e., with technological assistance, e.g., GPS-assisted driving)
- **supervised autonomous machines** (i.e., with autonomous functions that are directly supervised by a human being)
- **fully autonomous machines (**i.e., without human supervision)



What does the future development of agricultural machinery look like?

In summary, it can be seen that the increasing automation in agriculture will lead to an even stronger focus on the individual plant and to increasing automation of the work steps around the plant due to the potential increase in efficiency achieved through reduced use of resources.

However, it can be observed that this shift towards autonomous agricultural systems follows a rather slow, but continuous process. The speed at which farmers will adopt autonomous systems will also differ substantially between different regions/markets. This is, of course, also a consequence of the different farm and production sizes and structures.

You can read the entire study here:
https://s.fhg.de/hw6

Prof. Liggesmeyer is the scientific spokesperson at the Center for Digitalization Bavaria

The young thematic platform Digital Land Management at the **Zentrum Digitalisierung.Bayern** (ZD.B, *Center for Digitalization Bavaria*) is to provide impulses and support, and act as the driving force for digital land management in Bavaria. For the position of scientific spokesperson, the thematic platform was able to enlist the services of Prof. Dr.-Ing. Peter Liggesmeyer, Director of Fraunhofer IESE in Kaiserslautern. Prof. Liggesmeyer has been working on digitalization in agriculture for many years and can contribute his competencies in the area of digital agriculture. Among other things, the Fraunhofer-Gesellschaft's current lighthouse project "Cognitive Agriculture" (COGNAC) is about the design and realization of an integrated platform for information-based (cognitive) agriculture.

3 Questions for...

Dr. Matthias Nachtmann, Digital Farming expert at BASF SE and chairman of the association Friends of Digital Farming e.V.

Autonomously driving tractors, drones for monitoring crops, or data-supported use of crop inputs – these examples show that agriculture is undergoing a digital transformation. In our lighthouse project COGNAC, which has been running since 2018, we focus on digital transformation in agriculture and the development of a vibrant Digital Ecosystem for the agriculture of the future. The high importance of this topic is also demonstrated by the fact that companies such as BASF SE, John Deere GmbH & Co. KG, ALDI Süd Gruppe, and many others have founded the association Friends of Digital Farming e.V. Its aim is to optimize yields and food quality while preserving all natural resources.

Dr. Matthias Nachtmann, BASF SE

The promotion of young talents, the research and development of new technologies, as well as the testing of new business models play a decisive role in this regard. Together with Fraunhofer IESE and the Technical University of Kaiserslautern (TUK), the association will therefore establish a professorship for digital farming in the course of the year. The aim of this professorship is to research new technologies and develop them in an application-oriented manner. In addition to holding the professorship in the Department of Computer Science at TUK, the position includes a leading function at Fraunhofer IESE.

Chairman of the association is Dr. Matthias Nachtmann, Director Digital Farming Data Business Development at BASF SE and since 2019 also a member of the Advisory Board of Fraunhofer IESE. In this interview with us he talks about his motivation for getting involved in the topic of Smart Farming in order to shape the use of resources in agriculture in a sustainable way.

1 Balancing sustainability and efficiency in agriculture – why do you think this is a big issue?

Natural resources such as arable land are limited, while the world population and its demand for food are constantly growing. This means that farmers all over the world face the challenge of how to increase their crop yields with limited resources. This race between technologies for better yields and a growing population is also described very well in the book "Unser tägliches Brot gib uns heute – was der Mensch alles erfinden musste, um satt zu werden" (*"Give us today our daily bread - what mankind had to invent to get full"*) by the food technologist and specialist author Prof. Jochen Hamatschek from Landau. In this book, Prof. Hamatschek not only delves into the history of our diet, but above all takes a look at the future and at the new challenges brought on by the climate change and rising population figures.

2 Why is it also so important for BASF to cooperate with other players from industry and research to develop and establish digital solutions for agriculture?

A farmer has to answer 48 questions per field during the course of a season. These range from the question of which crop to grow to harvesting and selling. No supplier exists today who can answer all these questions, and therefore we as an industry must work in partnership with experts. With existing partners we have found that outside our strategic projects we face similar challenges when it comes to access to young talents and the testing of new technologies and business models. This was the trigger for the idea of Friends of Digital Farming e.V.

3 What is the first big task of Friends of Digital Farming e.V.?

Together with Fraunhofer IESE, the association Friends of Digital Farming e.V. supports TUK in setting up the chair "Digital Farming" – the appointment procedure is currently underway. In addition, the association is involved in the promotion of projects.

Agricultural Data Space

The High-tech Data Platform for Agriculture

At the technical level, the digital transformation in agriculture requires digitally available data from agricultural products, the environment, farms, machines, and processes, so that software-supported agricultural processes can be supported in a targeted manner. In the Fraunhofer lighthouse project COGNAC, eight Fraunhofer institutes are researching and developing innovations for the digital transformation in agriculture.

Our vision is to create a living Digital Ecosystem for the agriculture of the future, the **Agricultural Data Space** (ADS). A cross-system and networking agricultural data space offers direct added values for farmers, who are supported in making farm-related decisions on the basis of high-resolution measurement data from airborne or ground-based systems and the refinement of this data by means of cognitive services.

High-tech data processing through the ADS

As the amount of data collected by modern sensor technology in agriculture is growing rapidly, aggregating and refining this data makes it possible to provide information with ever higher quality as well as more precise recommendations to farmers and other agricultural stakeholders. This creation of value by turning data into decision recommendations can be achieved especially if cognitive services with Machine Learning methods and appropriate decision models are available. This requires the collection of a large amount of data and the provision of corresponding cognitive services in an ADS, which can be offered via appropriate marketplaces for data and services.

Farmers actively participate in the project

In order to obtain valid requirements for an Agricultural Data Space, our researchers conducted numerous interviews with farmers, manufacturers of agricultural products and machinery, as well as service providers in the agricultural sector in 2019. From these we were able to derive the cornerstones of a digital agricultural ecosystem. The ADS must enable easy access to data and services by being interoperable with sensor systems and agricultural machinery on the one hand and by communicating with existing agricultural platforms and systems on the other hand. Moreover, correct decisions depend on the availability of high-quality data.

Gaining added value and retaining data sovereignty

The basic willingness to make data available for services exists among farmers and other stakeholders in the agricultural sector. It is, however, linked to two conditions: First, a clear added value is desired in return for the release of data, which can be achieved, for instance, through precise decision support or privileged access to cognitive services. Second, the actors do not wish to lose data sovereignty over their data. They want to decide who is to use which data for which purposes. Based on these and other requirements, in 2020 we will start on the detailed design and development of a reference ADS.

More information about our work to date can be found in our whitepaper "AGRICULTURAL DATA SPACE (ADS)" and at www.cognitive-agriculture.de.

Agriculture of the future in Acatech HORIZONTE

Sustainability is an important aspect in the digitalization of agriculture. This is also known to the publishers of the trade journal acatech HORIZONTE. The current issue addresses the three dimensions of sustainable agriculture: ecological balance, economic viability, and social acceptance and compatibility. With this, the publication wants to stimulate a fact-based and solution-oriented discourse between all stakeholders in agriculture and society. Fraunhofer IESE is also involved in this issue: Institute Director Prof. Peter Liggesmeyer and Ralf Kalmar, Business Area Manager, contributed to the success of the publication with their expert knowledge. Prof. Liggesmeyer is also a member of the acatech HORIZONTE project group.

Digital Villages and Smart Rural Regions

Making Germany future-proof

The research program Smart Rural Areas is establishing itself – municipalities across Germany are participating in the successful concept of the Digital Villages. Now a new research department "Digital Society Ecosystems" has been created at Fraunhofer IESE. Following the success of the Digital Villages, a new research program of the German Federal Ministry of Food and Agriculture (BMEL) – "Smarte LandRegionen" (*Smart Rural Regions*) – has started.

Germany is a country of rural areas

How can digitalization benefit people even outside of big cities? This was the central question that researchers of Fraunhofer IESE in Kaiserslautern asked themselves five years ago. While the potentials of Smart Cities were being discussed in many places, the IESE researchers felt that it would make more sense to look at the typical situation in Germany and find solutions for everyday problems – especially those of the rural population. Germany is a country of rural areas, meaning that more than 70% of the population does not live in large cities, but rather in rural areas. This presents completely different requirements and challenges regarding digitalization than those considered by concepts for metropolitan areas. Fraunhofer IESE, together with the Rhineland-Palatinate Ministry of Interior Affairs and for Sport and the Rhineland-Palatinate Development Agency, initiated a competition on "Digital Villages" because the participation of all stakeholders was and is crucial for the success of their idea. Motivated municipalities in Rhineland-Palatinate were called upon to outline their visions and ideas as future-oriented communities. Ultimately, the municipalities of Eisenberg, Göllheim, and Betzdorf-Gebhardshain were selected from the numerous submissions and designated as model regions of this research project.

The "Digital Villages" establish Neighborhood Help 2.0

In many workshops, both the municipal administrations and the citizens worked out together with Fraunhofer IESE and the Development Agency with which digital services municipalities could work in the future. Where can technology support us? How does an app have to work in order to be used by as many of our fellow citizens as possible? In which situations could this support us locally? The idea of the researchers in the "Digital Villages" project was to create a digital ecosystem in which a wide variety of participants can act together and where all of them can benefit from added value. Specifically, the "Digital Villages" initially worked on an ordering and delivery service in their municipalities: Local traders could sell

their products in an online shop, and if the customers wanted, volunteers delivered their orders. Neighborhood Help 2.0, so to speak. And everyone benefitted: Regional trade was strengthened and elderly consumers were also able to order because they received support from those in the neighborhood who did not mind picking up something for others on their routine trips. Here, it was not profit that was primarily important, but rather the strengthening of solidarity for the purpose of bringing the community together, and thus the solution-oriented use of synergy effects.

"Smart Rural Regions" network rural areas

Since a critical mass must first be reached for many business ideas, solutions are frequently tested or introduced first in metropolitan areas and large cities. In rural areas, few people are usually spread over larger distances. This can be a dilemma if it means that innovative concepts are not introduced for this reason. This ultimately leads people to leaving their hometowns, as services of general interest and living comfort fall by the wayside in rural areas. This rural exodus, however, can be countered with appropriate measures, as Fraunhofer IESE has found out. Its "Digital Villages" project demonstrates how well one platform allows integrating different digital services that provide support for people living in less populated areas. Challenges in the areas of local supply, work, mobility, administration, and communication are addressed. In the meantime, it is not only the test municipalities of the project that are working with these services: Many other municipalities all over Germany have joined the "Digital Villages". Due to the Coronavirus pandemic, the DorfApps *(Village Apps)* were rolled out all over Rhineland-Palatinate and Schleswig-Holstein in April 2020. Negotiations are underway with other German states. The municipalities can decide individually which topic they want to start with and when and how they want to shape the digital transformation locally for themselves.

Fraunhofer IESE is now receiving funds from the German Federal Ministry of Food and Agriculture for another large project called "Smarte LandRegionen" (*Smart Rural Regions*). Similar as in the "Digital Villages", rural counties are invited to apply for the project with their ideas. Fraunhofer IESE will continue its vision of keeping life progressive and attractive even in rural areas with the help of Digital Ecosystems. Digitalization shall make life and work equally possible and attractive everywhere – whether in cities or in villages. By networking rural areas, an important step is being taken to keep all municipalities in Germany fit for the future. Just how important this is has been demonstrated drastically during the Coronavirus pandemic in 2020.

Steffen Hess – one of 70 Heads

70 years of the Fraunhofer-Gesellschaft are 70 years of the future – and 70 years of research spirit and diversity. In its anniversary year, the Fraunhofer-Gesellschaft asked 70 of its employees across different locations and disciplines about their vision for tomorrow and beyond.

One of these 70 heads is our colleague Steffen Hess, who was in charge of the research program "Smart Rural Areas" at Fraunhofer IESE and is now head of the department "Digital Society Ecosystems". There, he and his team are working on the digitalization of rural areas. The model for the program is the "Digital Villages" project in which apps are being developed that promote digitalization in rural areas.

More about this in our film:
http://s.fhg.de/hess

To see the portraits of the other 69 heads, go to:
http://s.fhg.de/koepfe

Digital Ecosystems

Setting the right course for new digital business models

The digital transformation leads to numerous new digital business models. A clear trend is emerging in this regard: Digital Ecosystems. Dr. Matthias Naab, Division Manager "Information Systems", and Dr. Marcus Trapp, Department Head "User Experience and Requirements Engineering", explain in this interview what Digital Ecosystems are all about and how Fraunhofer IESE supports its customers on the road towards successful Digital Ecosystems.

What characterizes a Digital Ecosystem?

Naab: In a Digital Ecosystem, companies and people collaborate who are independent, but expect mutual benefits from participating in it. At its core, a Digital Ecosystem has a digital platform that supports this cooperation particularly well.

Trapp: Good and successful examples of Digital Ecosystems have emerged around the platforms AirBnB, Uber, or Apple App Store. At the same time, it is important for us not to call everything a Digital Ecosystem now, which easily happens when a topic is highly visible.

How can the terms "Digital Ecosystem" and "Platform Economy" be delimited from each other?

Trapp: While a Digital Ecosystem is a very concrete network of organizations, people, and IT systems, platform economy is a fundamental economic principle. A Digital Ecosystem can be built with the intention of functioning according to the principles of the platform economy. This means that there are clear economic interests at stake in such a Digital Ecosystem and that there are typically multilateral markets where the participants conduct their transactions via the digital platform. There are, however, also Digital Ecosystems that are not part of the platform economy, but rather pursue other goals, such as Wikipedia.

Dr. Matthias Naab and Dr. Marcus Trapp have been working on the topic of Digital Ecosystems for years and support customers from a wide variety of industries.

"We accompany our customers on the path towards a Digital Ecosystem by collaborating intensively with them on ideation, design, and implementation."

Dr. Matthias Naab

What possibilities exist for companies to get involved in a Digital Ecosystem?

Naab: An organization must essentially decide in which role it wants to participate in a Digital Ecosystem. In the case of existing Digital Ecosystems, an organization can join as a partner and participate in the business being conducted via the corresponding digital platform.
If a domain does not have a successful Digital Ecosystem yet, or if an organization believes it can establish an even more successful Digital Ecosystem, it can take on the role of the ecosystem initiator. This is accompanied by a wide variety of challenging tasks aimed primarily at achieving a coordinated overall picture of the business model, the technical implementation on the platform, and the contractual arrangements between all ecosystem participants.

So the initiation of a Digital Ecosystem is very challenging: Which opportunities does it offer?

Trapp: The initiation of a Digital Ecosystem offers great opportunities because it enables changing the complete way business is done in a particular domain. It is possible to realize completely new business models and enormous increases in efficiency in a domain through harmonization in the business, technical, and legal sense. In this respect, the initiator of an ecosystem has considerable creative leeway and can earn a share of the profit by processing future business via their platform. This provides a great incentive for the ecosystem initiator to have the ecosystem grow and make it successful.

For which companies can it make sense to think about setting up a Digital Ecosystem?

Naab: First of all, there are no organizations per se that should not at least think about it, because Digital Ecosystems will influence the environment of all organizations, regardless of the role they choose to play. In order to master the initiation of a Digital Ecosystem, an organization needs to have a strong will to be creative and the urge to transform a domain despite many obstacles. In addition, significant financial resources are needed, as strong investments are required to build the platform and grow the partners.

Trapp: In Germany, there are many strong and traditional companies that have the necessary influence as well as the financial resources to establish successful Digital Ecosystems. Our focus in Germany should mainly be on B2B ecosystems, whereas many of the Digital Ecosystems already known tend to come from the US and focus on B2C.

How does Fraunhofer IESE help companies in the design of Digital Ecosystems?

Trapp: At the beginning, there is usually the question whether an organization should initiate a Digital Ecosystem at all. This question can only be answered soundly if concrete ideas for a Digital Ecosystem have been elaborated and if, in doing so, a certain depth has been reached in the areas of business model, ▸

technology, and legal aspects. We first support organizations in getting from an initial vison to a tangible idea, which can then be assessed.

The platforms and services of the large and successful Digital Ecosystems often appear directly convincing. What is the challenge of designing new ones?

Naab: Indeed, the end results of a business model of a Digital Ecosystem often look alarmingly simple. This is somewhat deceptive because it easily gives rise to the impression that one should be able to achieve a similarly convincing result with a manageable amount of effort.

At this point we can say from many experiences of our own that it is always similar: At the beginning, the ideas are not clear at all, and it often takes months of intensive creative work to achieve a result that looks simple. We accompany our customers on this journey and work with them intensively to design an emerging idea for a new Digital Ecosystem.

Together with the customer, you design new Digital Ecosystems in workshops using Playmobil®. What makes this method so valuable for the participants?

Trapp: The use of Playmobil® in TED, our "Tangible Ecosystem Design" method, makes designing an ecosystem literally tangible and experienceable. This leads to better discussions, more details are elaborated and reflected upon, the participants remember the result better. But this is only part of the success. We do not simply play with Playmobil®; rather, the procedure follows an extremely well designed process

that gradually sheds light on the essential aspects of Digital Ecosystems while always keeping in mind business, technical, and legal aspects. This very concrete approach allows the participants to identify and resolve potential problems early on.

How can IESE also help with the further development and the establishment of a Digital Ecosystem?

Naab: In addition to the initial design of the ecosystem, we have also gained a lot of experience regarding what is necessary during the development of the platform and the growth of the ecosystem. On the one hand, it is very much about the involvement of partners and an emerging community, which is what the Digital Ecosystem needs to thrive on. On the other hand, as a software and systems engineering institute, we can contribute the whole range of expertise needed to successfully build the core of the emerging Digital Ecosystem, that is, the digital platform. We have expanded our core competencies such as User Experience Design, Architecture Design, Safety and Security Engineering, or Data Science accordingly in order to provide our customers with the best possible support in the context of Digital Ecosystems.

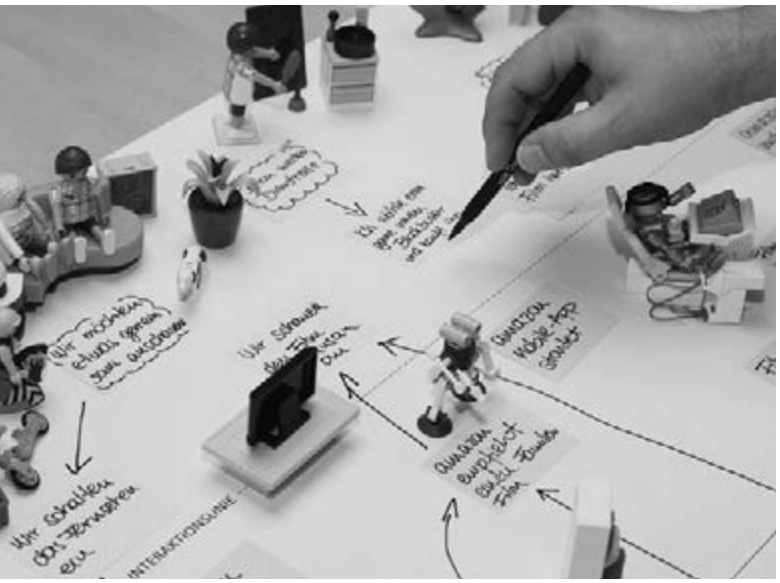
"In Germany, there are many strong and traditional companies that have the necessary influence as well as the financial resources to establish successful Digital Ecosystems."

Dr. Marcus Trapp

Which customers has Fraunhofer IESE already supported in the area of Digital Ecosystems? With which specific services?

Trapp: Fraunhofer IESE has supported companies across many industries in their decisions regarding Digital Ecosystems and in their design, e.g., Caruso GmbH, John Deere, and DATEV e.G.

Naab: Caruso is a very good example for illustrating possible support by Fraunhofer IESE. We accompanied Caruso from the initial design and orientation of the Digital Ecosystem and then repeatedly adjusted the focus to the needs over time. In this way, we made many contributions, from user experience design via the design of core concepts of the platform to the technical architecture and the safety concepts.



Using the TED method (see p. 40f.), Fraunhofer IESE gradually elaborates many different aspects of the Digital Ecosystem together with the customer.

More specifically, we helped them, for example, to design the processes for the GDPR-compliant handling of personal data during transmission via the central data exchange platform.

How can an organization ensure that a Digital Ecosystem they initiate will be successful?

Naab: Unfortunately, there is no recipe that could guarantee success. Still, we can of course learn from past mistakes (our own and those of others) and thus identify important success factors. One absolute factor for success is the integrated and properly coordinated consideration of business, technical, and legal aspects.

Trapp: The establishment of the partner network is another success factor. The partners must benefit from participating in the ecosystem; they must be compatible with each other because they need to interact, and their number must grow rapidly because only then can the necessary network effects occur and the attractiveness of the ecosystem can continue to grow. It is also important to look at the establishment of the Digital Ecosystem over a period of years and to have a vision of how to build it up, while always responding to lessons learned and adapting the plan. Companies also need to have financial perseverance because the commitment to Digital Ecosystems usually takes years to pay off. ■

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

Tangible Ecosystem Design

Mastering complexity with ease

Digital ecosystems are much more complex to understand than software systems that are under the exclusive control of a single organization. In more than twenty projects, Fraunhofer IESE has repeatedly encountered many challenges in the design and modeling of such Digital Ecosystems and their user experience. An independent method for the development of digital services and disruptive business models in the context of the digital transformation therefore appeared to make sense: the "Tangible Ecosystem Design" (TED) method.

What exactly is the TED method?

Traditional UCD (User Centered Design) methods focus on the design of high-quality services. Nevertheless, most of them are isolated solutions of individual companies. Today – in the midst of the digital transformation – the development of services requires additional methods in order to create an end-to-end user experience and sustainable business models that transcend the boundaries of individual companies and generate added value for the end user.

This is where Fraunhofer IESE comes in with its new workshop method. To make the design tangible for the participants, Playmobil® play figures are used.

In our workshops, the participants can model and describe a Digital Ecosystem with Playmobil® and appropriate templates. In this process, many of the challenges facing companies are addressed:

Diversity: Ecosystems consist of a variety of development organizations, heterogeneous technologies, a mix of technical methods, and different (partly contradictory) business and user goals. The modeling and prioritization effort for understanding and mastering the user and/or system requirements is huge.

End-to-end quality: In a Digital Ecosystem, many parts are no longer under the control of one software development organization that serves the ecosystem consumer, yet end-to-end quality must still be achieved. Although many organizations influence the system, users want to perceive and use it as one service.

Uncertainty: Ecosystems evolve dynamically and are driven by many independent actors at their own pace. Some decisions are based on incomplete requirements or on estimates regarding the evolution of user needs. But these must be systematically recorded and subsequently reviewed.

The main components of the method are strictly implemented by the experts of Fraunhofer IESE with the participants in the workshop and the various templates are developed. The first step is to define the goals, respectively the philosophy of the ecosystem.

Next, the workshop participants identify the different services and model them at various levels of abstraction. Then the different actors of an ecosystem are identified and described in detail. As part of the methodological guidance, the modeling elements have been defined in such a way that the workshop participants can always use the same Playmobil® element to represent different services and relations. At the end, all platform-specific aspects are recorded.

For Digital Ecosystems, the "TED" method promotes collaboration among the stakeholders in the following steps:
1. Definition | 2. Design | 3. Analysis

The benefits of the method

Within a short time, the companies get a good impression of whether the services they are considering have potential for success or how they can best position themselves in an ecosystem. Different variants of business relations can be tested in this respect to ensure that all stakeholders will benefit from participating in the modeled ecosystem.

The physical representation of concepts is an important tool in this context. Information such as colors and forms can be remembered better by our brain and can be associated with other unrelated aspects of information. To facilitate this, different metaphors for complex technical, business, and legal concepts are assigned to the Playmobil® toys. As symbols, they provide richer descriptions of reality and open a broader view of new possibilities. They are used to give a statement a strong effect and to convey a better idea of solutions and usage situations. In combination with a structured approach within the interactive workshop, this supports the constructive exchange between the stakeholders involved in a Digital Ecosystem.

Any organization concerned with its transformation through digital change can gain a better overview of its opportunities and potentials with the help of Fraunhofer IESE's creative approach. This applies to both its own business models and suitable other business models and new digital services. Together with Fraunhofer IESE as a consultant, the organization can thus work on innovative solutions in its own industry.

"What does the ecosystem do?" – It appears there is no easy answer to this question.

Each Playmobil® element represents, e.g., an actor or a platform service.

BaSys 4

A service-based Industrie 4.0 architecture

Nowadays, manufacturing plants are designed for the mass production of identical goods. Although manufacturing systems often have a certain flexibility, they are not completely changeable. Rather, changes are associated with high costs. Changeable production, on the other hand, allows manufacturers to react faster to changing demands and to efficiently produce small lot sizes. The Digital Twin is a key concept for the implementation of the required changeability. BaSys 4 defines a reference architecture for production systems that enables the transition to Industrie 4.0. Our open-source middleware Eclipse BaSyx is a reference implementation of the concepts of BaSys 4.

Changing markets require changeable production

The increasing demand for individualized products and the ever shorter product lifecycles open up new possibilities for manufacturing plants to differentiate themselves from their competitors. Traditionally, the sales arguments in manufacturing have been unit costs and quality, whereas today, the ability to manufacture individualized products is becoming increasingly important. Manufacturers that are capable of individualizing products can achieve much higher revenues per product already today. However, with individualized products, the challenge is that they are only in demand in small lot sizes. In traditional production lines, the costs for modification are too high to economically realize small lot sizes. On the other hand, a changeable manufacturing system could realize higher unit costs for individualized products at little or even no additional costs for changing the production lines. This brings competitive advantages, but also requires a new manufacturing architecture for production plants.

Changeable production requires changeability both in terms of the production resources of a production line and in terms of the production processes. Physical changeability includes, for example, the ability to change tools used by a robot, to add or remove production equipment, if necessary, and to train employees. Changes of the production processes require changes in the areas of process automation, adaptation of the process and quality documentation, and possibly the establishment of supply chains. In addition, production lines must be re-certified to ensure that they fulfill the customer requirements.

Current manufacturing processes are too rigid

Physical changeability is normally given in existing production lines. Changes in the areas of process automation and re-certification, on the other hand, are the main obstacles hampering changeable production. These cannot be achieved by simply exchanging a single device; rather, the manufacturing processes must be adapted to Industrie 4.0. Nowadays, process

automation is realized with the help of programmable logic controllers (PLC). These execute cyclic programs programmed in a standard language. A single PLC automates a production cell or one step of an automated manufacturing process. PLCs control workstations and robots and carry out the necessary production steps for each workpiece. The complete manufacturing process is distributed to all PLCs of the production line. Changes in the process automation therefore require reprogramming of the PLCs, which today often causes unwanted side effects in the process. These side effects lead to significantly longer downtimes and change times as well as to higher costs.

Enabling changeability with BaSys 4 architecture concepts

Changeable processes shorten the downtimes of production lines in the event of process changes. Ideally, the programming can be changed without side effects and without any downtimes. BaSys 4 defines a service-based manufacturing architecture that enables this changeability. It is no longer PLCs that implement the process steps, but rather callable services. PLC basic services implement real-time behavior that controls manufacturing steps, for example for drilling holes or for automated quality assessment. The services can be adapted using parameters that determine, for example, the position and size of drill holes.

Further information about the project can be found here: www.basys40.de

BaSys 4

BaSys 4 is also available with professional support.

Together with our partners NetApp and objective Partner AG, we will create a customized Industrie 4.0 solution for you in accordance with your wishes.

Your contact person: Thomas Kuhn, thomas.kuhn@iese.fraunhofer.de

Blockchain: yes or no?

Fraunhofer IESE can provide support for making the right decision

The topic of blockchain is currently on everyone's lips, also fueled by the hype around Bitcoin. Many companies are wondering whether it might be beneficial or promising for them to develop applications based on a blockchain technology, or at least experiment with this. Fraunhofer IESE supports companies in developing and building such applications.

What is blockchain anyway?

A blockchain is a database that is stored decentrally in a network of independent computer nodes. The data is stored in a linearly linked chain of blocks in the form of transactions that are connected with each other using cryptographic methods, and which are thereby secured against manipulation. The central advantages of a blockchain are the elimination of central brokerage instances and the manipulation-proof traceability of transactions. Frequently discussed disadvantages are the high costs of transactions and the associated energy consumption, as well as the low throughput of transactions.

The communication between the involved nodes, the cryptographic methods, and the voting on new transactions to be accepted into the network are implemented by means of a blockchain technology. The best-known blockchain technology is the cryptocurrency Bitcoin; another example of a blockchain technology is Ethereum. Based on blockchain technologies, IT applications can be developed that make use of the properties of the blockchain for data storage.

While on the one hand, there are great expectations regarding the disruptive potential of blockchain-based applications, on the other hand there is a growing number of voices massively deploring the lack of real applications that really benefit from blockchain.

The problem of blockchain in companies

Although there is a lot of talk and discussion about blockchain in the business world, a common language and a sufficiently deep understanding of the topic of blockchain are often missing. Moreover, the suitability of the blockchain technology is often only discussed superficially. There is also little methodological competence for developing highly distributed applications based on blockchain while at the same time realizing quality properties such as user experience and security. Many companies discuss this topic separately at the

management and technical level, but have often not developed a common level of knowledge or a common vision. In addition, many companies feel the pressure of time to get to market with decisions and possibly also solutions faster than their competitors.

So what do companies dealing with the topic of blockchain need now? Fraunhofer IESE offers methodological support for this purpose, which enables a structured approach to this topic. In this way, companies can develop a vision and are guided through the entire process all the way to the technological implementation.

Fraunhofer IESE offers a solution with solid support

The framework of our solution is a long-established and proven architecture and software engineering methodology and a corresponding project approach. The solution comprises, among others, the following components:

- **a uniform terminology,**
  which clearly defines frequently confused terms around blockchain.

- **support in the assessment**
  of the suitability of an application for the use of blockchain technology with a list of criteria.

- **support in the architecture design**
  of blockchain-based applications, especially through systematic architectural preparation of the applications and a list of questions to be asked and answered during the design process.

Together with the customer, Fraunhofer IESE either analyzes existing use cases that may be suitable for blockchain, or new use cases are created with the help of creativity techniques. The institute acts as a supporter and takes over the methodological guidance. The main objective is to understand and assess the planned usage context, the trust relationships between the parties involved in the application, and the required quality features of the application. Finally, it is discussed and determined whether there is a use case that could benefit from implementation using a blockchain technology and which the customer wants to implement as a prototype.
To implement the use case, Fraunhofer IESE and the customer work together on the architecture for the application, which is based on a blockchain. In doing so, Fraunhofer IESE contributes its experience in architecture definition and in specific issues related to blockchain. Furthermore, it provides support in the user experience design. This is about focusing on the users as well: What needs to be considered in blockchain projects to ensure that the user experience is as uncomplicated and satisfying as possible? Depending on what the customer wants, Fraunhofer IESE can also provide support for prototype implementation and prototype evaluation.

More information about this topic can also be found on our Blog: https://s.fhg.de/abba

Fraunhofer Blockchain Day

On 5 November 2019, the **"Fraunhofer Blockchain Day"** took place in Berlin. The exciting discussions ranged from current Fraunhofer work in the area of blockchain to the blockchain strategy of the German federal government. In the workshop "Blockchain as basic infrastructure for public services", the Fraunhofer Institutes IESE and FOKUS discussed with numerous participants what a "German federal blockchain" could look like and what it should be able to do in order to support meaningful use cases.

If you, too, are faced with the decision "Blockchain: yes or no?", get in touch with our expert Dr. Matthias Naab.
Mail: matthias.naab@iese.fraunhofer.de

Highlights

Project Kickoff BaSys 4.2

The success story continues

The BMBF-funded Industrie 4.0 project "BaSys 4.0 – Basic System Industrie 4.0" finished on 30 June 2019. The success story continues, however, because with BaSys 4.2, the BMBF project entered into another phase in July 2019: Under the leadership of Fraunhofer IESE, 20 partners from research and industry will conduct research into the continuous engineering of manufacturing processes and Industrie 4.0 for the process industry over the next three years. Which goals the project team has already achieved so far and where the journey with BaSys 4.2 is still headed is described by Dr. Thomas Kuhn, Division Manager at Fraunhofer IESE and project manager of BaSys 4, in this interview.

Dr. Kuhn, with which objectives did you start back then and with what results were you able to complete the first project period?

The goal of the BaSys 4.0 team was to develop an Industrie-4.0-capable middleware that enables changeable production. We implemented this project with our service-based manufacturing architecture. That is, we did not realize the manufacturing process in a distributed manner on programmable logic controllers (PLCs), as is common procedure today, but rather via services that are called by orchestrators based on product and process models. This allows defining different "recipes" for each product, which describe which services are necessary for manufacturing. Changing these recipes is much simpler than re-programming PLCs. Information about products and devices, such as the services offered and their costs, is stored uniformly in asset administration shells and their sub-models. These can be distributed and thus enable access to a wide variety of information via standardized interfaces.

Dr. Thomas Kuhn: "BaSys 4 is the enabler for Industrie 4.0".

In short – what makes the solution so unique?

The special feature of BaSys 4 is that the IT communicates with the devices on the shop floor, which no other Industrie 4.0 middleware has been able to do to date. Asset administration shells realize defined interfaces to devices, even enabling control of these devices.

What will happen next with BaSys 4?

Fortunately, BaSys 4.0 is succeeded directly by our follow-up project BaSys 4.2. BMBF will also fund this project for the next three years. Our goal is to expand BaSys 4 to the process industry. Moreover, we want to continue pursuing the continuous changeability of production processes and also provide tools for simplifying the configuration of BaSys 4.

Which benefits for industry does the BaSys 4 middleware offer?

BaSys 4 is a service-based manufacturing architecture. It offers enormous advantages for users. The key elements are the so-called asset administration shells. They enable continuous data access from the IT to the shop floor. The status of devices and orders is available at all times. Predictive maintenance, dashboards, and analyses can be realized at low cost thanks to BaSys 4. It is possible to document product quality in real time, which is demanded by more and more customers. This information is stored in a product's asset administration shell and is available for analyses at any time.

So BaSys 4 as an enabler for Industrie 4.0?

Yes, you could call it that. The service-based manufacturing architecture of BaSys 4 realizes enormous advantages for manufacturing companies. Workpieces can be produced efficiently even in small lot sizes; lot size 1 becomes reality.

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

Interested parties are cordially invited to download the open-source middleware: www.basys40.de

Hannover Messe with BaSys 4

Under the motto "Making networked production easy with Digital Twins!", we demonstrated with our model factory at Hannover Messe in April 2019 how the open-source middleware BaSys 4 networks and digitalizes manufacturing processes with Digital Twins.

Due to the Coronavirus pandemic in 2020, we will probably only be able to be back at Hannover Messe in 2021.

Prof. Liggesmeyer and BDI boss Kempf exchange views on the solutions of Fraunhofer IESE for Industrie 4.0 (top picture).

State Secretary of Economic Affairs Schmitt learns about BaSys 4 (bottom picture).

Secretary of State for Economic Affairs Schmitt Learns about Industrie 4.0 and Digital Agriculture

The Rhineland-Palatinate State Secretary for Economic Affairs Daniela Schmitt and Dr. Joe Weingarten, both from the Rhineland-Palatinate Ministry of Economic Affairs, Transport, Agriculture and Viniculture, visited the Fraunhofer Center on 16 July 2019. Among other things, they informed themselves about the research work of Fraunhofer IESE on the innovation topics "Industrie 4.0" and "Digital Agriculture".

State Secretary of Economic Affairs Daniela Schmitt was enthusiastic about the work being done at Fraunhofer IESE.

Production 4.0 with BaSys

On the basis of the project BaSys, Fraunhofer IESE showed its guests how Industrie 4.0 makes things easy even for small and medium-sized enterprises. The open-source middleware enables manufacturing companies to adapt their production more individually to the needs of their customers. That IESE is on the right path with this solution was also confirmed by State Secretary Schmitt: "It is our mission to remove obstacles and concerns and to make small and medium-sized manufacturing enterprises fit for the future."

Fraunhofer IESE conducts research on innovative solutions for the agricultural industry

How Fraunhofer IESE intends to contribute to shaping the agriculture of the future was also demonstrated with the lighthouse project "COGNAC" (Cognitive Agriculture). Here the goal is to use sensor-based data acquisition and digitalization and automation processes to make agricultural production both environmentally friendly and resource-saving on the one hand, and highly efficient on the other hand. According to State Secretary Schmitt, farmers today consider themselves to be entrepreneurs who must be competitive. In the future, even greater focus should therefore be placed on efficiency in conjunction with ecological aspects. In this context, "Agricultural Data Spaces" (see page 32f.), as an ecosystem of networked data and services, can support decision-making in the highly complex interaction between biosphere and production.

ELIV 2019

Fraunhofer IESE validates autonomous systems

Under this motto, Fraunhofer IESE demonstrated at ELIV, which was held at the World Conference Center in Bonn from 16 to 17 October 2019, how autonomous systems can be validated using dynamic risk assessment.

The presentation by Dr.-Ing. Rasmus Adler focused on the topic of safety for highly automated driving.

When cooperative and highly automated systems are introduced to the market, providing evidence of their functional safety still presents major difficulties for manufacturers. At the biennial automotive trade show ELIV, Fraunhofer IESE therefore presented ConSerts (Conditional Safety Certificates) at the joint Fraunhofer booth: modular and formally defined safety concepts that can be integrated fully automatically at runtime. After successful integration, the safety properties of the cooperating systems as well as their environment are monitored dynamically so that if safety-relevant events occurs, the systems can be reconfigured in such a way that the safety of the overall system is guaranteed at all times.

Interested trade show visitors could get first-hand information about these enablers for highly automated and cooperative functionality from our safety experts.

Our truck platooning exhibit served as an illustrative demonstration. Another highlight was the presentation given by our Program Manager "Autonomous Systems", Dr.-Ing. Rasmus Adler, on "Engineering and hardening of functional fail-operational architectures for highly automated driving".

Jan Reich (left) and Dr. Daniel Schneider introduced interested visitors to dynamic risk assessment for the validation of autonomous systems.

Dynamic validation of cooperative systems with ConSerts

Traditional validation methods at development time are not enough to master the challenges posed by cooperative systems. The Conditional Safety Certificates (ConSerts) developed at Fraunhofer IESE are modular and formally defined safety concepts that can be integrated fully automatically at runtime. With ConSerts, worst-case considerations and the associated loss of performance can be avoided. The variability present in cooperative scenarios is formalized by ConSerts and is resolved at runtime in terms of safety and maximum performance. Furthermore, ConSerts enable cooperative, dynamic risk management, where the risk of the current situation is measured and dynamically controlled at runtime. This makes it possible to limit the behavior scope of autonomous systems to the safe area.

Coding for sustainability, energy efficiency, and an eco-friendly community – these and ther topics kept the more than 50 participants of the 2nd PFAFF HACK busy.

"To the computers – ready, set, go…"

The PFAFF HACK as a think tank for the urban district of the future

More than 50 participants gathered at the Fraunhofer Center in Kaiserslautern on 25 October 2019 to face a 24-hour challenge. During that time, they developed ideas for prototypes for the digital implementation of sustainable concepts and innovative solutions for the urban life of the future.

Under the motto "Renewable. Efficient. Digital", Fraunhofer IESE and seven other partners are working on the development of innovative ideas and solutions for sustainable urban districts of tomorrow. On the former factory premises of the sewing machine manufacturer PFAFF, a new, climate-neutral urban district will be built, offering services on a district platform that integrates information and communications technology solutions. The focus will be especially on sustainable energy generation and usage as well as on future-oriented mobility concepts and digital-based possibilities for strengthening the community. The project "EnStadt:Pfaff" is funded by the German Federal Ministry of Education and Research (BMBF) and the German Federal Ministry of Economic Affairs and Energy (BMWi) as one of six nationwide lighthouse projects. The declared goal is to strongly involve the citizens in the development process of new digital solutions.

PFAFF HACK as think tank

With hackathons it is possible to involve a young target group in the project idea and to take into account the ideas and visions of young people and university students as well. At this second PFAFF HACK, the teams were once again very creative in the concrete implementation of their concepts around the topics of climate protection and sustainability. Once again they had a unique opportunity to find ideas in the dialog between research and people, to think ahead, and to directly implement their ideas.

In the final round, the eleven teams presented their proposals in the form of entertaining, yet substantial and technically convincing pitches in front of a jury consisting of representatives of KL.digital, the Founders' Office, and Fraunhofer IESE. They presented user interfaces with a wide variety of functions, sensors for measuring and monitoring one's own energy consumption, online platforms for sustainably organized ride-sharing, recycling- and sharing platforms for an eco-friendly community, or IoT-based (Internet of Things) compost management. In some cases, approaches from the fields of AR (Augmented Reality) and Gamification were implemented and funding models (e.g., crowdsourcing) to implement the presented ideas were shown. The series of PFAFF HACKs will be continued in 2020.

More information at www.pfaffhack.iese.de

ICT Concepts PFAFF 2029

As part of the transformation of an industrial wasteland into a modern urban district, especially the aspect of climate-friendliness is being addressed in the research project "EnStadt: PFAFF". The former factory premises of the sewing machine manufacturer PFAFF in the middle of the city of Kaiserslautern are being transformed into a new urban district. In the context of this project, eight partners are conducting research on how to realize the vision of a "climate-neutral urban district".

In the concept paper "ICT Concepts 2029", the research team of Fraunhofer IESE describes what the digitalization of our lives could look like in the year 2029 and what possibilities it offers for influencing climate-friendly human behavior. It shows how information and communication technology (IKT) can be embedded into the everyday lives of the district's residents, neighbors, visitors, workers, commuters, and other stakeholders in the future.

Which services are conceivable

In general, the digital services for the climate-neutral urban district can be divided into three groups: mobility, energy, and community. Examples from each one of these areas are presented in the concept paper.

A service in the field of mobility could, for example, be an assistance system that plans and coordinates routes with public transportation, rental services, or ride shares for its users (Lina, the smart mobility assistant). The idea of a Parcel Café addresses the issue of well-organized, comfortable participatory logistics. Here the idea of a "Packstation" is combined with the idea of participatory logistics. With its central location in the district, a café offers not only its core benefits, but also the possibility to drop off packages centrally, respectively to pick these up at a suitable time or possibly have someone bring them to the recipient.

This concept already reaches into the field of community services. With a strong sense of unity in the district, the commitment to work for a common cause – here: climate protection – also increases. The first step in this direction is the PFAFF-Funk app: a platform for sharing news, events, etc. that can support community life in the district in all aspects of life and keeps its users constantly up to date. Furthermore, a marketplace for swap offers will be established with the app "MeDeTe" (Mine – Yours – Share): Resources can be offered or used by private individuals or by companies. Finally, a service is also being planned that will playfully provide users in the district with additional advice and tips based on data on their own climate behavior. The app "Fish n' Tips" will offer personal hints and tips customized to one's own life and experience that are aimed at making one's own actions more eco- and climate-friendly. The app will be connected to other platform apps and will analyze the actions undertaken there in terms of their significance for the climate, respectively the environment (e.g., if a carsharing vehicle is rented, if the energy consumption of one's own household is checked via the Smart Home app, or if tools are borrowed via MeDeTe).

In an efficiency-by-transparency app, households will be able to challenge each other to an energy-saving challenge and compare who achieves the highest relative energy savings compared to the normal consumption of the households or the entire district. In addition to being represented in the app, the consumption will also be made visible for everyone on the large square in front of the real lab. An art installation – the energy column – will display the energy consumption of the district and will thus create identification of all residents with the community. Joint efforts to save energy will thus become externally visible to everyone.

70 years of Fraunhofer – a reason to celebrate, also for the employees of Fraunhofer IESE.

70 Years of Fraunhofer

"We shape the future together"

#WHATSNEXT: On 6 November 2019, the Fraunhofer Institutes in Rhineland-Palatinate (IESE and ITWM from Kaiserslautern, IMM from Mainz) celebrated 70 Years of Fraunhofer at the Fraunhofer Center in Kaiserslautern with a joint celebration followed by a Career Night for students.

In the spring of 1949, the Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. was founded in Munich to help rebuild Germany's de-industrialized post-war economy. Today, 70 years later, it is Europe's largest applied research organization, with 72 institutes. Three of these institutes that do research on topics related to the digital future are located in Rhineland-Palatinate: the Fraunhofer Institutes for Experimental Software Engineering IESE and for Industrial Mathematics ITWM in Kaiserslautern as well as the Fraunhofer Institute for Microengineering and Microsystems IMM in Mainz. They celebrated the anniversary on 6 November 2019 under the title "Fraunhofer is shaping the digital future in Rhineland-Palatinate", together with numerous representatives from government, industry, and research. After the official celebration, the second Career Night, an information and networking event for MINT students, took place, also at the Fraunhofer Center in Kaiserslautern.

Venturing a look into the future

The motto of the Fraunhofer anniversary year is "70 Years of Fraunhofer, 70 Years of Future, WHATSNEXT". In line with this motto, the directors of the three Fraunhofer Institutes Prof. Anita Schöbel, Prof. Peter Liggesmeyer, and Prof. Michael Maskos together with their guests and keynote speakers reflected on what has been achieved and, above all, looked ahead to the future. The welcoming address was given by Prof. Dr. Konrad Wolf, Minister for Science, Continuing Education and Culture of the State of Rhineland-Palatinate: "I warmly congratulate the

Fraunhofer-Gesellschaft on its 70-year history of success to date, and look forward to its continuance", said Minister Wolf. "This anniversary is also a nice occasion for the three Rhineland-Palatinate Fraunhofer Institutes to present themselves with their research. The research done by Fraunhofer in Rhineland-Palatinate makes an outstanding contribution to linking the great topics of the future, such as health, resource efficiency, or agriculture, to the opportunities offered by digitalization."

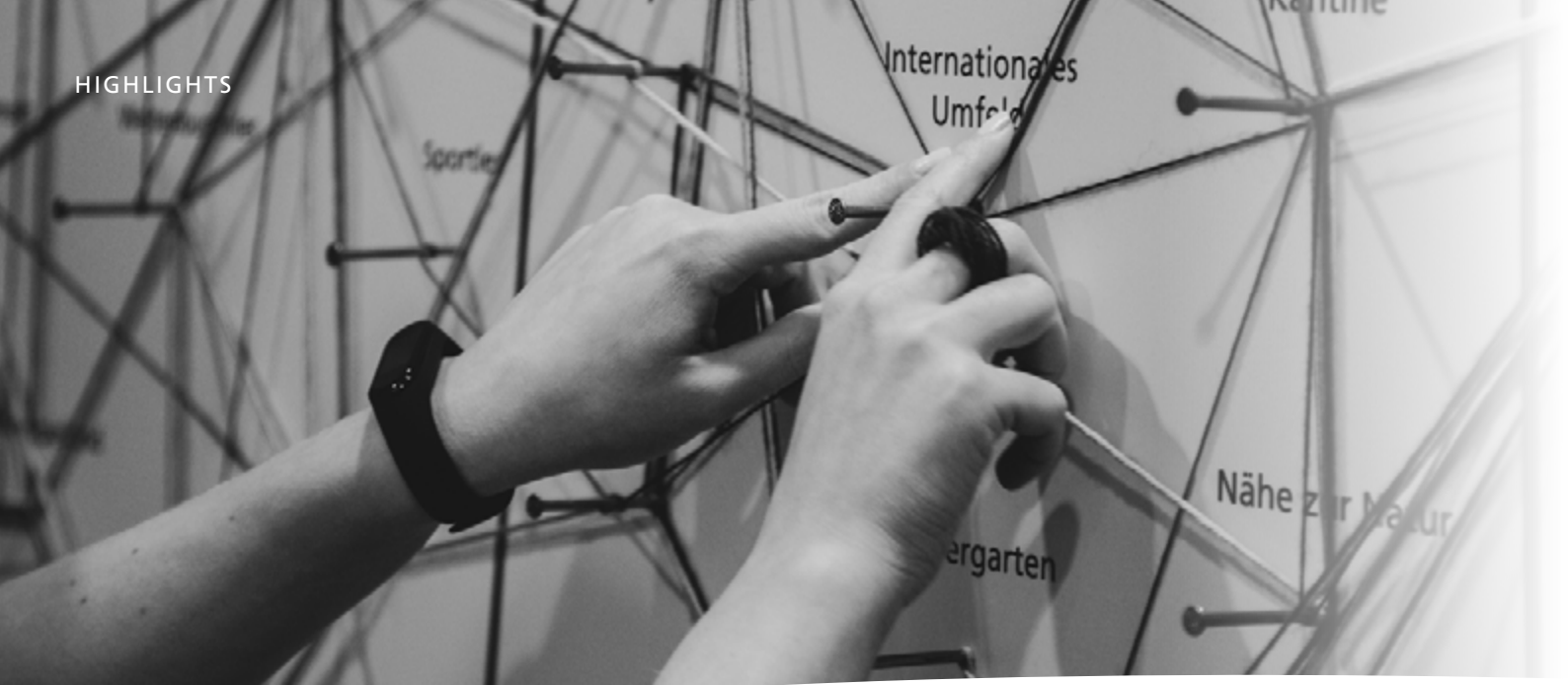
Digital solutions make agriculture, chemistry, and medicine fit for the future

From the perspective of industry, August Altherr, director of the John Deere European Technology Innovation Center, presented his vision of a digital agriculture with a focus on balancing sustainability and efficiency: "Digitalization in agriculture will take us from autonomous vehicles via autonomous work in the field to autonomous, process-driven agriculture. Just as in Industrie 4.0, each field will get a "Digital Twin", which will enable us to optimize agricultural processes both economically and ecologically."

Dr. Christoph Großmann, Director Smart Manufacturing at BASF SE, explained how Fraunhofer supports the chemical company in exploiting the potential of digitalization: "With the help of digital solutions, we can understand complex interrelationships among processes in our plants even better and optimize them. This helps us lift our production to a new level. We rely on intensive collaboration with Fraunhofer to further strengthen our leading role in the digitalization of the chemical industry. Interdisciplinary exchange helps us to expand our know-how and to develop new, innovative digital solutions."
Prof. Dr. Wolfgang Kaminski, medical director at the Bioscientia Institute for Medical Diagnostics, pointed out which new opportunities digitalization offers in health care. "In the future, the use of the health data available in laboratory medicine will make it possible to detect diseases earlier and more reliably. Bioscientia has already started with that."

Representatives from government and research also ventured a look into the digital future, including Univ.-Prof. Dr. Georg Krausch (President of Johannes Gutenberg University in Mainz), Prof. Dr. Hans-Joachim Schmidt (President of the Kaiserslautern University of Applied Sciences), and Member of the German Parliament Johannes Klomann (Chairman of the Committee for Science, Continuing Education and Culture of the State of Rhineland-Palatinate).

Prof. Kurz, Fraunhofer-Gesellschaft, presented the medal of honor of the Fraunhofer-Gesellschaft to Prof. Wolf, Minister for Science, Continuing Education and Culture of the State of Rhineland-Palatinate.



In the thread game, applicants could map their individual path at Fraunhofer.

A Career with Fraunhofer

Second Career Night at the Fraunhofer Center in Kaiserslautern

In the anniversary year "70 Years of Fraunhofer", the three Rhineland-Palatinate Fraunhofer Institutes – the Fraunhofer Institute for Experimental Software Engineering IESE and the Fraunhofer Institute for Industrial Mathematics ITWM in Kaiserslautern as well as the Fraunhofer Institute for Microengineering and Microsystems IMM in Mainz – jointly hosted a career night that included the Fraunhofer Escape Game.

Following the positive response and the great popularity in 2018, this information and networking event aimed at MINT (mathematics, informatics, natural sciences, and technology) students took place for the second time at the Fraunhofer Center in Kaiserslautern on 6 November 2019.

The response in the anniversary year was great: From 5 p.m. to 10 p.m., about 100 students had the opportunity to get to know the three Rhineland-Palatinate institutes during a varied program and find out about career opportunities at Fraunhofer. A very special highlight of the evening was the Fraunhofer Escape Game: In four groups with a maximum of eight people, the participants had 45 minutes in the fictitious office of a Fraunhofer researcher to solve puzzles, combine clues, and crack codes together. A challenge that called for knowledge, technical skills, and a strong team spirit! For example, clues had to be found on the Augmented-Reality level with the help of smartphone cameras, and Virtual-Reality glasses were also part of the game.

Many interesting program items

In addition, there were other exciting items on the program, such as the presentation of various research projects and exhibits from the institutes. Fraunhofer IESE showed with its BaSys 4 demonstrator what Factory 4.0 and customized production with lot size 1 can look like with the help of the BaSys middleware developed in-house and with Digital Twins.

In exciting and well-attended presentations held in the "Rapid Innovation Lab", the researchers shared their knowledge and expertise with the participants, for example on the topic of "Safety in autonomous driving".

In addition, there was a check of application documents and the possibility to shoot an application video or have a professional portrait photo taken. Students could also find out about current job vacancies at the Job Wall and even apply for these directly. The entire event was accompanied by a Meet and Greet with Fraunhofer employees over snacks and drinks. The second Career Night also proved to be a complete success for the organizers and will be back on the agenda as soon as possible.

Selina Sperber and Petra Wulff from Fraunhofer IESE presented the job offers of Fraunhofer IESE to interested visitors of the Career Night.

Playfully experiencing research with the Fraunhofer Escape Game

Agricultural Data Platform

Fraunhofer IESE conducts feasibility study

Digital solutions are used in agriculture along the entire value chain. Agricultural machinery, for example, applies seeds, fertilizers, and pesticides in a satellite-controlled and precisely targeted manner; animal welfare is accurately monitored and increased; transportation and storage processes are optimized in this way. Digital solutions also play a role in the recording of harvest-related figures and the entire farm management process, all the way to tax returns. In all this, farmers expect that smooth data exchange without loss of time is guaranteed between the products of different manufacturers. This is why data platforms are becoming increasingly important in this area.

What can such a data platform look like?

As part of a feasibility study funded by the German Federal Ministry of Food and Agriculture (BMEL), Fraunhofer IESE is investigating the following questions:

- How does a digital platform need to be set up in a meaningful way so that the government can provide farmers with the best possible support?
- Which relevant data can be made available to the farmer by the government free of charge and in a practical (machine-readable) form?
- What must digital data for agriculture look like so that it can be easily used for different requirements (standards for data formats, respectively open interfaces)?
- What potential does opening up interfaces, for example to the digital application systems of the federal states, offer?
- Which measures regarding data privacy must be guaranteed for state-run platforms?

Farmers to actively participate in shaping digital offers

Fraunhofer IESE is currently conducting a survey to determine the individual needs, requirements, and concerns of a wide variety of stakeholders regarding the provision of agricultural data by government agencies.

The survey is aimed at employees of agricultural enterprises; upstream and downstream enterprises in agriculture; agriculture-related departments, public agencies, and institutes; as well as members of federations and associations in agriculture and representatives of major public projects in agriculture. Participation in this survey offers participants the opportunity to help shape possible future digital services at a very early stage.

First results of the study are expected to be available in the fall of 2020.

Interim Conclusions of the "Digital Villages"

The vision of connecting people in rural areas better with the help of digitalization and creating new, innovative perspectives for an attractive life in rural areas became a success story with the project of the "Digital Villages". Today, numerous municipalities all over Germany are participating in the platform solution developed by Fraunhofer IESE, which has even been rolled out statewide in Rhineland-Palatinate and Schleswig-Holstein in the meantime.

Together with the Rhineland-Palatinate Ministry of the Interior and the Rhineland-Palatinate Development Agency, Fraunhofer IESE launched the project "Digital Villages" in 2015. An idea contest resulted in three municipalities in which the opportunities and possibilities of a digital platform were tested: with different services for the population, but also for the municipal administrations themselves. Betzdorf-Gebhardshain, Eisenberg, and Göllheim were the first "Digital Villages" to start as Living labs. Practicable solutions were devised and discussed in numerous citizen workshops and then implemented technically through user-friendly apps developed by Fraunhofer IESE that address various solutions for the topics of local supply, volunteering, and communication. In the meantime, more and more municipalities throughout Germany are taking advantage of this digital platform.

Both the Fraunhofer researchers, above all program manager Steffen Hess and the head of the Fraunhofer IESE Liaison Office in Berlin, Gerald Swarat, and representatives of the municipalities acted as facilitators and ambassadors at numerous events, conferences, and trade fairs in Germany and abroad. With custom-tailored digital solutions for the local needs, the project strengthens rural areas for the long term and revitalizes villages. The municipalities cooperating in the project received further funding notices for the years 2020 and 2021, while Fraunhofer IESE received the funding notice for the third project phase during the event "Nachhaltig digital unterwegs" (*Sustainably digital)* on 13 February 2020.

More information at
www.digitale-doerfer.de

Dr. Marcus Trapp interviews the pioneers of the Digital Villages: Steffen Hess from Fraunhofer IESE and the mayors of the municipalities Göllheim, Eisenberg, and Betzdorf-Gebhardshain (from left to right).

Smart City Atlas

A collaboration between Bitkom, Fraunhofer IESE, and other partners

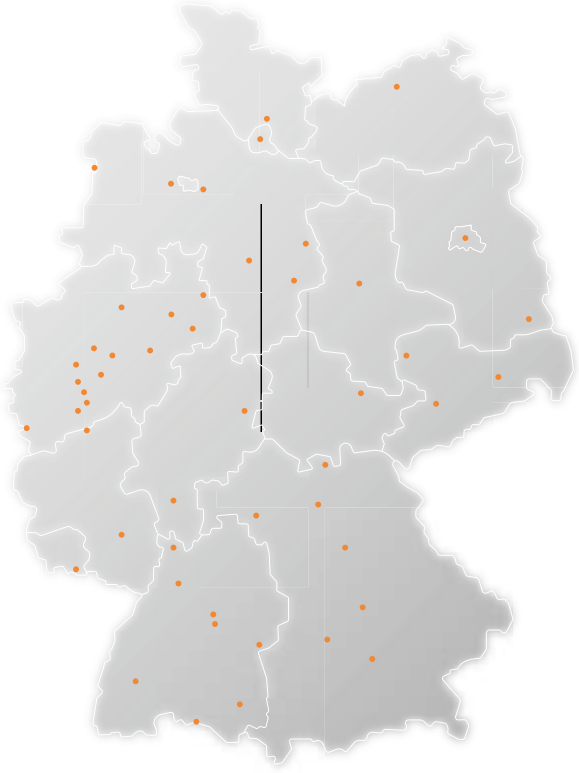
The Smart City Atlas by Bitkom, Fraunhofer IESE, and 13 other partners is the first to systematically focus on those cities that pursue an integrated Smart City approach in the sense of cross-thematic cooperation. By using new technologies, networked infrastructures are to be created in order to address urban challenges such as the energy and transportation transition. Digital services geared to the needs of the citizens are intended to improve the local quality of life and the attractiveness of the city.

The study provides a structured overview of the 50 pioneer cities in Germany, including Kaiserslautern, and outlines their respective strategic and organizational approach to local digitalization. In addition, the involvement of citizens, stakeholder groups, and local partners is shown, and projects from each municipality that deserve special mention are presented. The results are based on preliminary research as well as on expert interviews with the cities' digital officers. They represent a snapshot reflecting the situation in March 2019 in a rapidly evolving topic.

Urgency of the topic of digitalization

The results of the Smart City Atlas demonstrate that cities have widely recognized the need to actively address the challenges of the digital transformation of all areas of life and the economy and to shape these challenges together with local stakeholder groups. Metropolitan areas and large cities, in particular, are on a solid path and are setting a good example. Inspired by this, medium-sized cities are increasingly starting to develop and implement a Digital Agenda as well.

More than half of the cities reviewed are in the midst of the process of formulating their Digital Agenda. For the pioneering municipalities, it can also be seen that the need for a certain amount of resources to be provided and the adaptation of (administrative) structures is being recognized.



Overview map of the 50 cities examined in the study

One of the digital pioneer cities: Kaiserslautern

Challenges and recommendations for action

The fact that digitalization is not a foregone conclusion even among the "big ones" is demonstrated by the challenges that local authorities are facing and dealing with. The greatest challenges on the way to the Smart City are therefore digital participation, the qualification of administrative staff, and dealing with issues of data privacy, data security, and IT security. Central recommendations for action are the clarification of responsibilities and the provision of resources in order to create overall cross-cutting roles that address the digitalization of municipalities. Professional communication work, both internally and externally, and opportunities for participation by the urban community are also of great importance.

More information at
www.digitalestadt.org/de/smart-city-atlas

BY THE WAY...

Kaiserslautern is pursuing the goal of becoming a digital model city for the state of Rhineland-Palatinate. At the center of its Digital Agenda are the people, whose quality of life is to be increased, for example by technical systems supporting them in their tasks and accelerating processes. This is intended to achieve efficiency gains in public administration and facilitate contact between public agencies and citizens. Overall, the city strives to increase its attractiveness as a place to live and to become even more interesting for companies as a business location.

The study was carried out in cooperation between Bitkom and Fraunhofer IESE as well as the following 13 partners:
bee smart city GmbH, Capgemini Deutschland GmbH, Dell EMC (Dell GmbH), Deutsche Telekom AG, Ernst & Young GmbH Wirtschaftsprüfungsgesellschaft, Esri Deutschland GmbH, FIWARE Foundation e.V., Fujitsu Technology Solutions GmbH, Hewlett-Packard Enterprise, MasterCard Europe SA, PricewaterhouseCoopers GmbH Wirtschaftsprüfungsgesellschaft, Robert Bosch GmbH, and Stadtwerke München GmbH.


PROJECTS

Bosch Chassis Systems Control

Fraunhofer IESE has been cooperating with **Bosch Chassis Systems Control (CC)** on various aspects regarding agility since 2016. These include, for example, the degree of agility used, agile scaling approaches, agile transition, and concrete project support (e.g., coaching) for these topics. In 2019, the focus of the work was on the search for and adaptation of suitable attractive knowledge transfer concepts for teaching classic engineering topics. The role of a traditional test manager was considered as the use case for which the necessary adaptations for working in an agile context were developed. For the changed role of the agile test manager, suitable knowledge transfer concepts were then selected and adapted. The cooperation will also continue in 2020 to find knowledge transfer concepts for teaching topics from the area of Continuous Integration.

DATEV

DATEV e.G. from Nuremberg is the largest provider of software solutions for tax offices, lawyers, and auditors. As an innovative company, DATEV recognized the opportunities offered by Digital Ecosystems to establish new business models early on. The organizational unit at DATEV founded specifically for this purpose closely cooperated with Fraunhofer IESE in this context. The Fraunhofer Ecosystem Shaping Method was used to explore a wide variety of design possibilities for a Digital Ecosystem. Business, technical, and contractual aspects and their interrelations were considered. On this solid basis, Fraunhofer IESE and DATEV are working together on the design and development of this Digital Ecosystem.

T-Systems International

With the Data Intelligence Hub (DIH), the Deutsche Telekom subsidiary **T-Systems International GmbH** is creating the foundation for a secure and trustworthy data economy. The online platform offers a marketplace for trading data as well as tools for the analysis and refinement of this data. DIH's vision is to enable innovative, data-driven services, using Machine Learning and Artificial Intelligence to create value. Particular attention is being paid to respecting data sovereignty for all stakeholders. T-Systems has therefore opted for MYDATA Control Technologies, a technology developed by Fraunhofer IESE for the technical implementation of data usage control. The technology has been integrated into a joint project with DIH, where it ensures data sovereignty for different stakeholders.

FibuNet

FibuNet GmbH from Kaltenkirchen has been offering its customers financial accounting software very successfully for many years. In order to continue keeping their software up to date and powerful, FibuNet wants to complement their existing desktop application with a web application. FibuNet therefore decided to renew its cooperation with Fraunhofer IESE to get support for this challenging migration project. To this end, Fraunhofer IESE conducted user tests, designed a state-of-the-art user experience concept, and supported the development of the architecture concepts and the selection of web technologies. Based on this solid foundation, FibuNet is realizing the intended future web application in order to continue offering its customers a high-performance and easy-to-use system.

Siemens Gas and Power

The Data Science team of Fraunhofer IESE supports **Siemens Gas and Power** in making their current approach to optimizing power plant controls in terms of availability, efficiency, flexibility, and emission values more flexible and economically attractive through data-based components. To this end, methods and processes were identified and presented that make it possible to extract new insights from the data that go beyond existing knowledge, or that are impossible to obtain with conventional data analysis methods. Fraunhofer IESE was able to show how state-of-the-art technologies can be leveraged for the quality assurance, visualization, descriptive analysis, and exploratory investigation of data regarding new insights, in order to improve process operation even more through continuous, optimizing interventions.

Robert Bosch

FERAL is a co-simulation platform for the virtual testing of ECUs. In addition to the functions of the ECU, the influences of the bus communication and the target platform can also be tested. Various buses, processors, and gateways are supported for this purpose. **Robert Bosch GmbH** has commissioned an interface to FERAL from Fraunhofer IESE in order to use this platform in future tests during ECU development.

Volkswagen

The Konzern Grundanforderungen Software (KGAS; *Group Basic Requirements Software*) define for the entire Volkswagen Group requirements that must be observed in the development of software. The desire for agile development goes hand in hand with the question of compliance with the KGAS. For this reason, in 2019 Fraunhofer IESE investigated for the Group Software Quality Assurance department of **Volkswagen AG** how fulfillment of the KGAS is possible with agile methods. In consultation with the KGAS managers and agile experts from VW, a mapping of agile practices to KGAS requirements was drawn up first. The final result was a Pocket Guide, which, for a selection of requirements, provides an overview of which requirements are independent of the approach used and which are supported by agile practices. For these supported requirements, an agile implementation was demonstrated.

Debeka

With the Debeka Performance app, the insurance company **Debeka** has an application software in use for which there are a five-digit number of app store reviews. These contain an enormous amount of information, but it is no longer possible to manually review this efficiently. The "Debeka Innovation Center" therefore initiated a cooperation with Fraunhofer IESE to introduce automated analyses with the "User Echo Service", the CrowdRE tool of Fraunhofer IESE. The analysis covered different perspectives, such as the frequency of emotions, topics, and commented quality features, which enable a detailed and in-depth picture of the users' perception of the app. On the one hand, the results confirmed the assumptions of the Debeka staff, but on the other hand, assumptions could be substantiated with figures and new insights could be provided. The information obtained on suggestions for improvement, ideas for innovations, and popular functions can thus be taken into account in further development. As an innovative company, Debeka will now be able to respond even better to customer wishes, as these can be combined efficiently.

IAV

To solve control engineering tasks more effectively, more and more products contain components based on Machine Learning methods and Artificial Intelligence (AI). Since such methods are used, in particular, when correlations cannot be fully specified in advance, but must be learned from data, a residual uncertainty regarding the occurrence of faulty events in particular situations remains even after intensive testing of such components. The "Uncertainty Wrapper" architecture and analysis methodology developed at Fraunhofer IESE allows reliable estimation of this situation-specific degree of uncertainty and thus provides a dependable basis for decisions at both development time and runtime. The architecture addresses all three types of uncertainty in the corresponding shell model. Currently, the methodology is being applied to an existing AI component within the framework of a bilateral project together with **IAV GmbH**, whereby corresponding know-how is transferred into industrial practice.

John Deere European Technology Innovation Center

Data Science and Artificial Intelligence (AI) are high on everyone's agenda and offer great potential for novel business models in conjunction with Digital Ecosystems. Most companies already possess a great amount of data, and it is therefore only natural to exploit this data treasure. With Insights Collaboration Space (ICSpace), the **John Deere European Technology Innovation Center (ETIC)** and Fraunhofer IESE have developed the first collaboration app for interdisciplinary teams working together on data-driven digital services in the area of Smart Farming. The app runs in the cloud and is easy and intuitive to use thanks to state-of-the-art web technology. This is especially true for experts with a less pronounced technical background. The app offers a very simple graphical notation that supports the user in structuring the data processing pipeline conceptually in such a way that the so-called "Data Science Significant Requirements" can be derived very easily.

DEIS

The open, cooperative nature of cyber-physical systems (CPS) creates new challenges in ensuring their dependability. In the project **DEIS (Dependability Engineering Innovation for CPS)**, Fraunhofer IESE was in charge of the work package "Model Concepts", where the core concept of the project, the Digital Dependability Identity, was defined. In addition, it was responsible for planning the evaluations in labs and in industrial environments. Concrete goals of the project were the introduction of the concept of Digital Dependability Identities (DDI), which enables safe system integration: efficient synthesis of information on the dependability of components and system via the supply chain and effective evaluation of this information in the field to ensure safe composition of CPS configurations. The use of DDI was evaluated in 2019 using industrial use cases from different domains (Truck Platooning, European Train Control System, Driver Monitoring System, Medical Apps), and significant benefits could be shown in each case.

www.deis-project.eu/

MInD

The project **MInD (Machine Intelligence and Deep Learning)** is concerned with the identification and use of Deep Learning technologies for the socio-technical shaping of the digital transformation. To this end, the competencies and potentials of Fraunhofer IESE, Fraunhofer ITWM, and the German Research Center for Artificial Intelligence (DFKI) are being bundled. The project, which is intended as a long-term cooperation (> 4 years), started in 2018 with a preliminary project in which Fraunhofer IESE prepared an overview of published methods for the use of neural networks in safety-critical applications by means of a Systematic Mapping Study. In 2019, these were transferred into a reference process for the development of systems with Machine Learning components, which was partly evaluated using an example system (pedestrian detection system).

FabOS

Within the framework of the innovation competition "Artificial Intelligence as a Driver for Economically Relevant Ecosystems", funding is being provided for projects that focus on the digital transformation of the economy with regard to Artificial Intelligence. These projects also include **FabOS**, whose goal it is to develop an open and distributed as well as real-time-capable operating system for production. It is intended to form the IT backbone for the changeable automation of the factory of the future and the basis of an ecosystem for data-driven services and AI applications. Hybrid cloud platforms and IoT applications are core elements of cyber-physical architectures and will be the basis of future production solutions. FabOS is a platform modeled on an operating system that provides components that link machines, infrastructure, and services the way an operating system does with user programs and the hardware in the form of an abstraction layer. The previous preliminary work of the partners involved, such as our open-source middleware BaSys 4, is seen as key components that are combined to form an overall concept. This makes it possible to develop real-time-capable, cross-domain value networks for the AI-supported autonomous production of the future.

www.fab-os.org

DESIGNETZ

The challenge in the project **DESIGNETZ** is how to increase the share of renewable energies in the gross electricity consumption, taking into account all energy sources. Specifically, Fraunhofer IESE provides support in the design of the distributed system architecture of the integrated data and services platform for energy grid management as well as in the elicitation of data privacy requirements and the development of data usage control components for the integrated platform. In addition, it is performing smart data analyses for modeling, predicting, and diagnosing flexibility potentials in energy grids, and evaluating the architecture of the SESAM farm demonstrator for the networking of Smart Energy and Smart Farming. The end result will be a holistic view of the energy system across all stakeholders and energy sources: Finer control down to the distribution grids is to be developed, and existing isolated ICT solutions are to be combined to create a smart, resource-efficient energy supply of the future.

www.designetz.de

Digital Teams

"It's time to live and work where and how you want!" This is what Fraunhofer IESE has been working on since 2017 in the project **Digital Teams**: The overall goal of this project is to counteract the rural exodus in Germany by improving employment opportunities in rural areas. A consortium consisting of Fraunhofer IESE, Microsoft Germany, Insiders Technologies, Welance, and the Institute for Technology and Work (ITA) sees the solution in the use of "Digital Teams", i.e., working groups that are virtually connected to each other. Specifically, an ecosystem platform is to be developed to enable virtual collaboration. It is to be shown that working in virtual teams is possible with the support of modern ICT, without any loss of job satisfaction or productivity compared to local teams.

www.digitale-teams.de

Demeter

Within the framework of the European project **Demeter**, since September 2019 a total of 60 project partners have been working on solutions for easy data exchange in the context of digitalization in agriculture. The project, which is funded under the EU's "Horizon 2020" program, focuses on the interoperability and comparability of data-based services. In this project, Fraunhofer IESE is developing and testing which standards and methods can be used to assess data quality as uniformly, consistently, and automatically as possible. Only with the appropriate data quality can meaningfulness and accuracy – for example for forecasts – be guaranteed. Information on data quality can then be used by methods at the decision level to apply alternative strategies for assessing the data, if necessary. Our researchers are developing a service for automated quality assessment for this purpose.

http://h2020-demeter.eu

Smart tau Hus

With the model project **Digital Rural Life in Mecklenburg-Vorpommern "Smart tau Hus"**, digitalization is to lead the potential of rural areas successfully into the future. The model project is divided into three phases. In the first phase, a state-wide competition was held in which the association of municipalities led by the municipality of Hohenkirchen was chosen as the model region, which can now implement its digitalization concept. The idea is to develop and implement digital showcases to improve the exchange of information between the local public administration, residents, and visitors. The focus of Fraunhofer IESE is on the conception (phase 2) as well as on the technical development and implementation (phase 3) of the digital showcase, which is intended to improve the exchange of information between the local public administration, residents, and visitors.

www.smart-tau-hus.de

TrUSD

In the joint project **"TrUSD – Transparent and self-determined design of data usage in companies"**, a practice-oriented and legally compliant approach for technology-supported employee data privacy is being developed. In this way, a bridge is being built between the potential offered by data analytics and the employees' right to privacy. Privacy dashboards enable companies to provide their employees with both transparency about company data processing procedures and self-determination possibilities regarding data processing. In addition, companies are supported by a participatory process model developed in TrUSD. This enables them to strengthen the organization-wide trust and work culture and at the same time benefit from business-enhancing analyses with personal data released by employees in a self-determined manner.

www.trusd-projekt.de

AI in Medium-sized Cities

Research into the digital transformation in the municipal context focuses mainly on larger structures (Smart Cities). Increasingly, Smart Regions and rural communities are also coming into focus. Medium-sized cities, on the other hand, are not the focus of attention, with the result that especially the (small) medium-sized cities that are relevant for Rhineland-Palatinate – and their potentials – tend to be left out of consideration. The aim of the project **KI in Mittelstädten** (*AI in Medium-sized Cities*) is to take stock of the concepts and strategies for the use of AI and for innovative ideas in medium-sized cities. To this end, the current conditions for as well as potentials and limits of the use of AI-supported services in public administration of medium-sized cities in Rhineland-Palatinate are to be examined. The project is a continuation of the cooperation of Fraunhofer IESE with the Department of Urban Sociology at the Technical University of Kaiserslautern and DFKI, which resulted in the expert opinion "Effects of digitalization in general and artificial systems in particular on municipal life in Rhineland-Palatinate in the year 2050".

Co:Lab

KoKI

Even municipalities are dependent on innovative technological possibilities such as Artificial Intelligence (KI) in order to effectively and sustainably improve the quality of life, location, and work for people. The question of a political, legal, and social regulatory framework for AI has become a central issue of our time. Gerald Swarat, head of the Fraunhofer IESE Liaison Office in Berlin, together with the Kommunale Gemeinschaftsstelle für Verwaltungsmanagement (KGSt, *Municipal Collective Agency for Administrative Management*) and the Innovators Club of the German Association of Towns and Municipalities (DStGB) has therefore founded the open initiative **KoKI**, which addresses the issue of AI in municipalities. After the kick-off of the initiative in Berlin on 19 December 2019, experts from civil society, business, research, as well as public administration and government will meet repeatedly in classic think tank fashion until May 2020 to discuss the challenges and opportunities of AI in the municipal sector. The aim of KoKI is to develop strategies on how the approx. 12,000 municipalities in Germany can use Artificial Intelligence in a meaningful way and for the benefit of the people, so that this technology becomes an opportunity for our country.

www.colab-digital.de/koki/

ViTAWiN

Cardiovascular and respiratory diseases are responsible for almost every second death in Germany. Patients suffering from these groups of diseases are also among the most frequent reasons for the deployment of emergency medical services and for visits to hospital emergency rooms. A national consortium consisting of media didactics experts, technology experts, and partners from the professional practice of emergency medical services and emergency care is researching innovative solutions for vocational training in the project **ViTAWiN (*Virtual-augmented training for education and training in inter-professional emergency care*)**. In a sub-project, Fraunhofer IESE is responsible for the target group analysis, the development of the medical didactic design, as well as the development of the evaluation design and management of the evaluations of the transfer into practice. The goals are, on the one hand, to increase the degree of reality and the effectiveness of emergency medical training and to open up the market for VR-/AR-supported training in medicine and, on the other hand, to expand our own expertise and competencies in the development and implementation of VR-/AR-supported simulation environments.

www.vitawin.info

IESE AT A GLANCE

Mission

Applied research on innovative solutions for the design of dependable digital ecosystems

Vision

A better life, sustainability, and economic success through dependable digital ecosystems

Engineering the Digital Future

The Fraunhofer Institute for Experimental Software Engineering IESE in Kaiserslautern has been one of the leading research institutes in the area of software and systems engineering methods for more than 20 years. With its applied research, the institute develops innovative solutions for the design of dependable digital ecosystems, thereby accelerating the economic and social benefits for its customers. The focus of Fraunhofer IESE is on topics such as "Autonomous Systems", "Industrie 4.0", and "Smart Farming", as well as on digital solutions for rural and urban areas. In more than 1,500 customer projects, the institute has already transferred cutting-edge research into sustainable business practices, successfully contributing its competencies in the areas of Processes, Architecture, Data, Security, Safety, Requirements Engineering, and User Experience.

Fraunhofer IESE is one of 74 institutes and research units of the Fraunhofer-Gesellschaft. Together they have a major impact on shaping applied research in Europe and worldwide, and contribute to Germany's competitiveness in international markets.

Future-oriented competencies for digital innovations

SCALABLE ENGINEERING

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

PROCESSES

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

DATA

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

ARCHITECTURE

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

REQUIREMENTS

Knowing what is important: By systematically eliciting, specifying, and evaluating a company's requirements, we assure the quality of their systems right from the start and help them to avoid one of the most frequent and most expensive sources of errors.

GUARANTEED QUALITY

Validated methods, quality assurance, and fact-based proofs guarantee the highest possible quality for products and systems – in all phases of development.

SAFETY

Defects and failures can jeopardize human lives – functional safety is thus essential! We use innovative, model-based methods to make 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 companies to control and protect the dissemination and usage of their data beyond the initial access.

UX

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

ENGINEERING + QUALITY = INNOVATION

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 excellent know-how for information systems.

EMBEDDED SYSTEMS

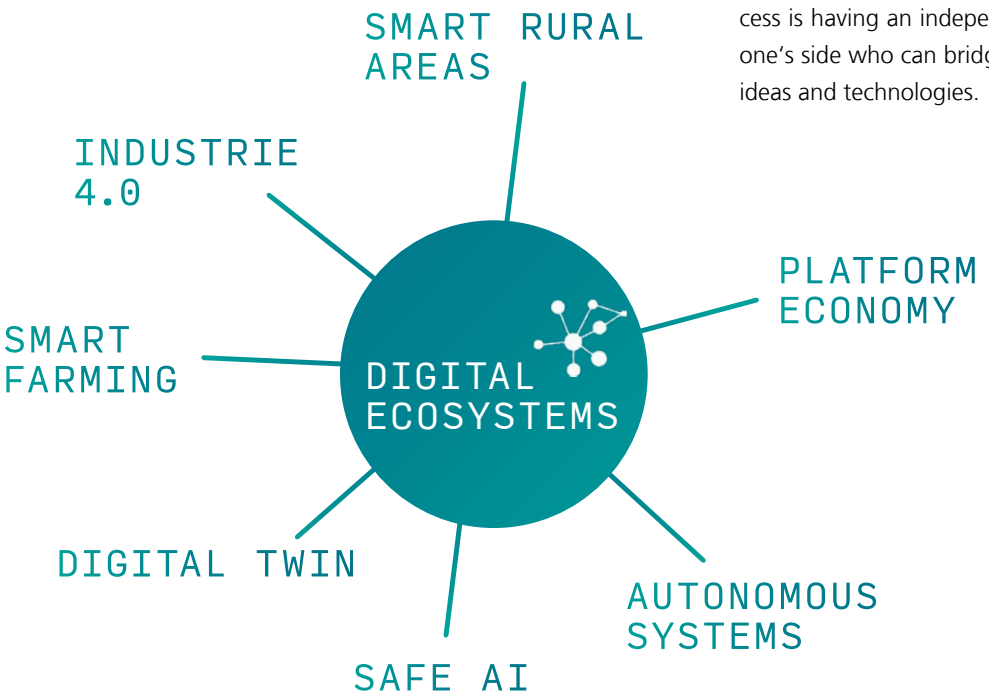
must be safe and reliable! They greatly contribute to functionality, innovation, and value creation in the domains Automotive and Transportation Systems, Automation and Plant Engineering, as well as Medical Technology. During product development, our primary focus is on implementing model-based systems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

DIGITAL ECOSYSTEMS

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

STRATEGIES FOR INNOVATIVE PRODUCTS

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



Fraunhofer IESE bridges the gap between research and industry

STRONG PARTNERS FROM THE FIRST IDEA TO THE SUCCESSFUL PRODUCT

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

WORKING TOGETHER

Strong partners stick together until the goal has been achieved. This is why the software engineers at Fraunhofer IESE do not let their customers down when it comes to development. Based on innovative methods and tools, the institute offers engineering support from the very beginning, for example also in the implementation of optimization recommendations. From user experience concepts to the validation and verification of systems: engineers from Fraunhofer IESE join forces with the experts of their customers to develop innovative products. In doing so, they rely on state-of-the-art systems and software engineering approaches, which they tailor to the needs of the customer. Upon demand, they also make the development platform including the entire tool chain available to their customers. This allows increasing innovative power as well as efficiency in the current development. And through joint work in combination with accompanying training and coaching, the know-how is transferred effectively and sustainably. Joint engineering with Fraunhofer IESE is therefore not only an investment into the quality and success of the current product or system: rather, it is a long-term investment into the success and added value of the organization. With its more than 150 employees, Fraunhofer IESE offers companies from any domain and of any size expertise and application competence in all issues of the Digital Transformation regarding autonomous and cyber-physical systems as well as digital services.

In the last years, Fraunhofer IESE has evolved into a world-leading competence center in software & systems engineering. This is also reflected in the participation of the institute in many publicly funded projects and industry projects in Europe and far beyond. These include, among many others:

Ecopetrol, Colombia
ELCA Informatik AG, Switzerland
John Deere, Germany & USA
Fujitsu, Japan
Hitachi, Japan
Hospital Alemao Oswaldo Cruz, Brazil
Schindler, Switzerland
Toyota, Belgium
Toyota, Japan

Project CrEST, EU
Project DEIS, EU
Project DEMETER, EU
Project PROPHESY, EU
Project Q-Rapids, EU
Project SECREDAS, EU

AUTOMATION IN PRODUCTION AND PLANT ENGINEERING

Ralf Pfreundschuh | Business Area Manager
Phone +49 631 6800-2270
ralf.pfreundschuh@iese.fraunhofer.de

In this business area, we offer you numerous solutions with regard to the automation of your production and your production processes:

- Digitalization of your manufacturing processes to enable automated production
- Changeable production up to lot size 1
- Documentation of products and processes
- Shorter manufacturing times through optimized automation
- Cost reduction and quality increase in production and plant engineering
- Live streaming of manufacturing data
- Efficient process monitoring
- Increase in productivity
- Holistic overview of manufacturing processes (shop floor and office floor)
- Optimization of coordination and efficiency between IT and manufacturing
- Virtual commissioning in mechanical and plant engineering

AUTOMOTIVE AND COMMERCIAL VEHICLES

Ralf Kalmar | Business Area Manager
Phone +49 631 6800-1603
ralf.kalmar@iese.fraunhofer.de
Oliver Bleisinger | Business Area Manager
Phone +49 631 6800-2257
oliver.bleisinger@iese.fraunhofer.de

In this business area, we offer you comprehensive solutions with regard to software systems for the automotive and commercial vehicle industry:

- Independent quality analyses and quality assessments of embedded automotive software and architectures
- (Joint) Development of system architectures and innovative products for automotive and commercial vehicles
- Controlled evaluation and piloting of new technologies in automotive software engineering
- Customer-specific process and tool consulting, empirical validation of methods and tool chains
- Training, workshops, coaching for software methods in the systems context, such as safety engineering

SOFTWARE & PLATFORM BUSINESS

Michael Ochs | Business Area Manager
Phone +49 631 6800-1604
michael.ochs@iese.fraunhofer.de

In this business area, we support you in the development and implementation of digital business models, from digital services via Digital Ecosystems all the way to a platform for your digital business:

- Innovation & Strategy – design of your Digital Ecosystem
- Diagnostics & Optimization – optimization of your IT- and software processes, revision of your software architectures, and improvement of your user experience
- Engineering Support – support in the conception of your software and services and in the modernization of your software systems

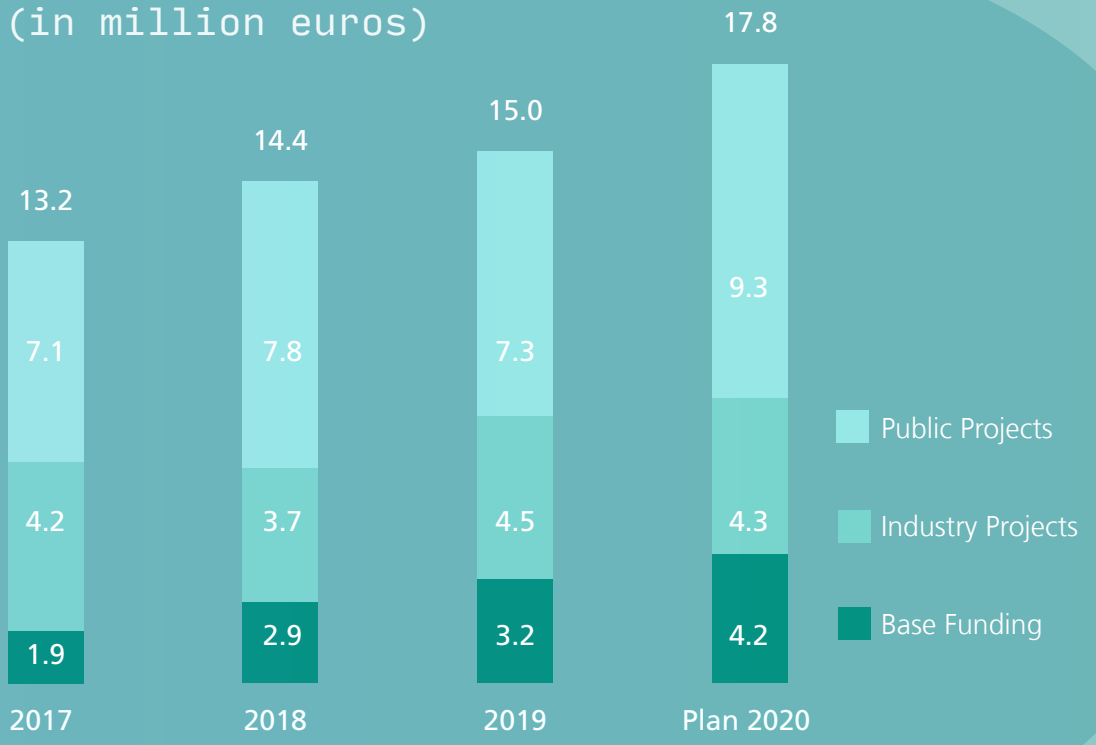
HEALTH CARE

Rolf van Lengen | Business Area Manager
Phone +49 631 6800-2103
rolf.van.lengen@iese.fraunhofer.de

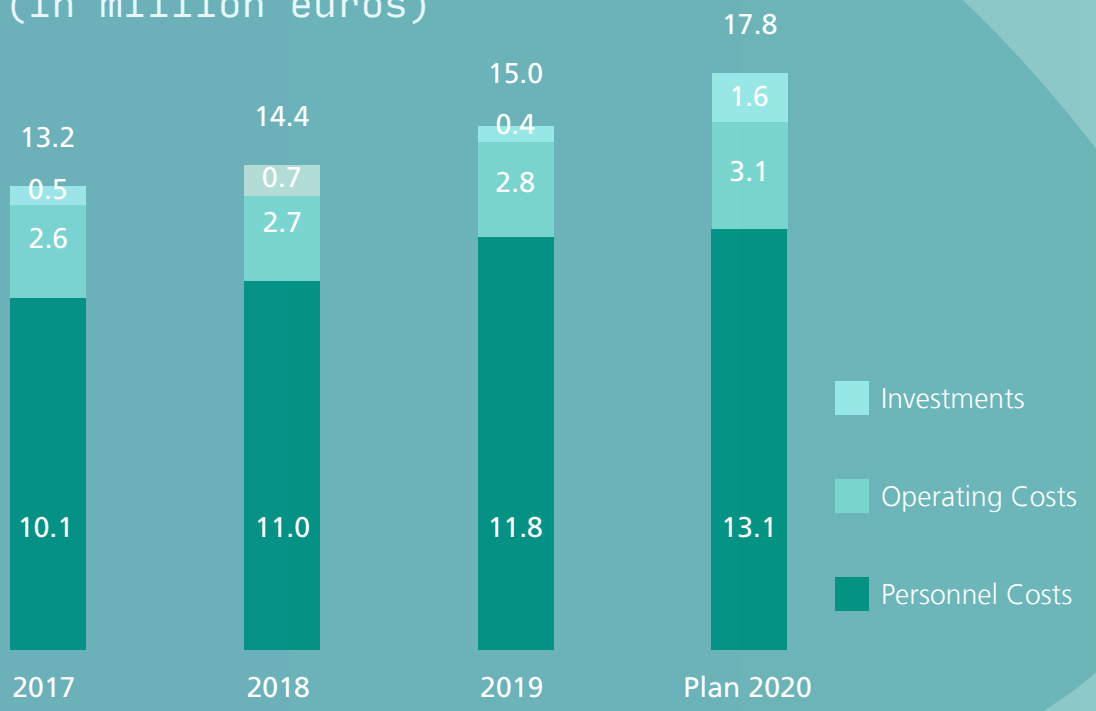
In this business area, we design your Digital Ecosystem in the health care sector for you and with you. The aim is to maximize the quality of treatment for your patients by using networked devices and services and to ensure the long-term success of your business:

- Diagnostics & Optimization – optimization of your software processes, architectures, and user experience
- Engineering Support – innovative software engineering solutions and systematic implementation in everyday practice

DEVELOPMENT OF BUDGET
(in million euros)



DEVELOPMENT OF COSTS
(in million euros)

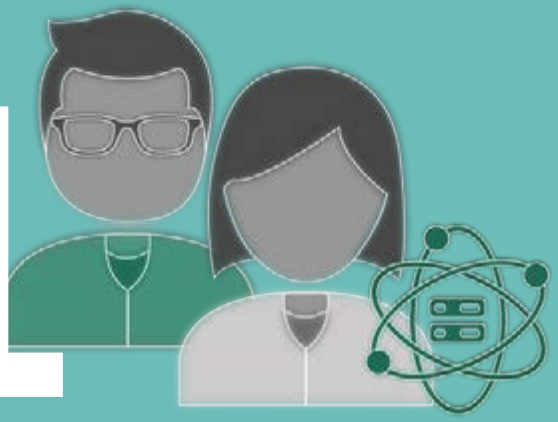


PERSONNEL
(as of 31 Dec 2019)

58
STUDENT RESEARCH ASSISTANTS

38
STAFF CENTRAL AREAS

121
RESEARCHERS



7
APPRENTICES

2
GUEST SCIENTISTS

LOCATIONS OF FRAUNHOFER IESE

KAISERSLAUTERN

Fraunhofer Institute for Experimental
Software Engineering IESE
Fraunhofer-Platz 1
67663 Kaiserslautern
Germany
Phone +49 631 6800-0
www.iese.fraunhofer.de
http://blog.iese.fraunhofer.de

BERLIN LIAISON OFFICE

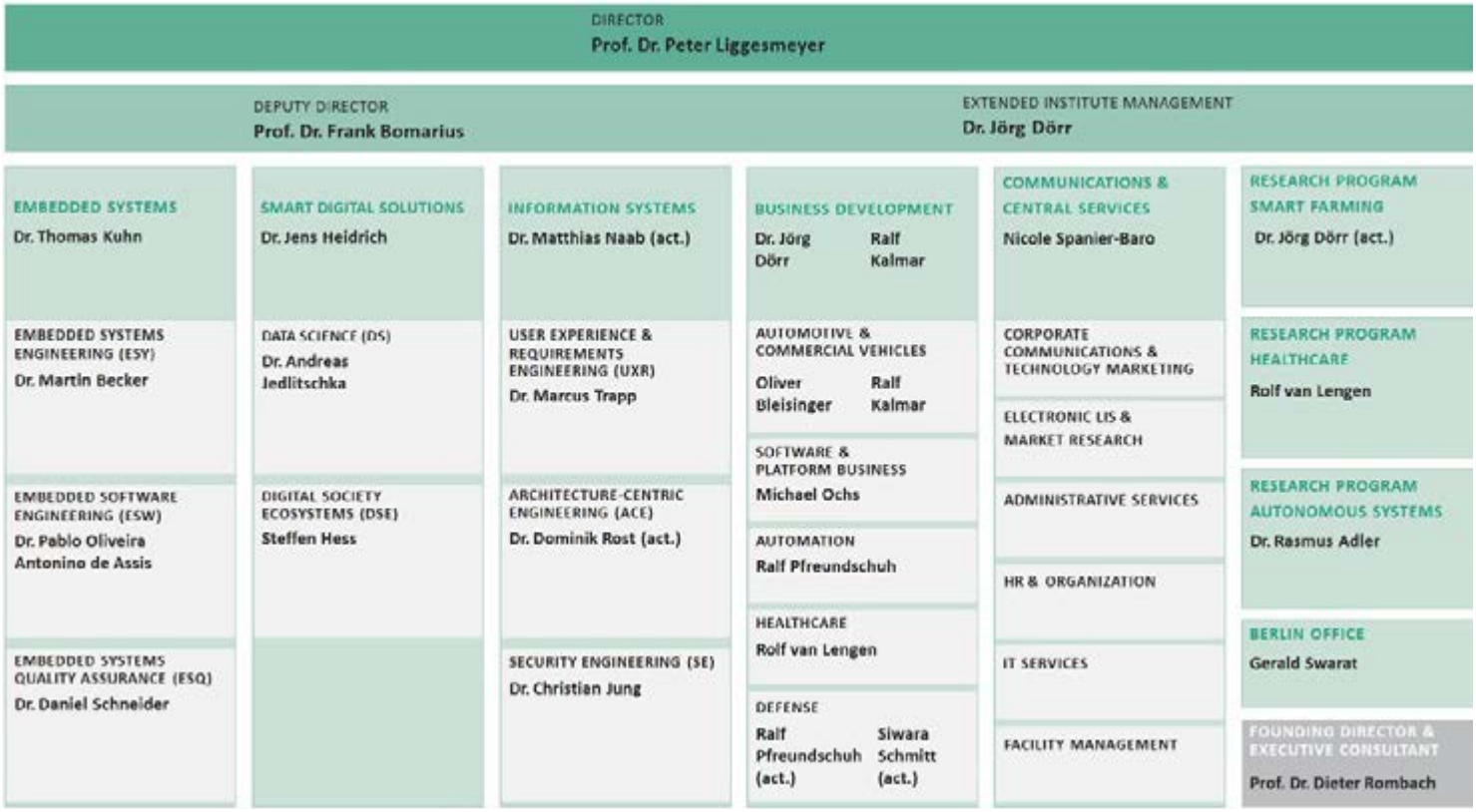
Fraunhofer Institute for Experimental
Software Engineering IESE – Berlin Liaison Office
Spreepalais, Anna-Louisa-Karsch-Straße 2
10178 Berlin
Germany

Your contact person: Gerald Swarat
Phone +49 171 3344883
berlin@iese.fraunhofer.de

SELECTED MEMBERSHIPS / ALLIANCES / NETWORKS

- bitkom e.V.
  www.bitkom.org
  Working groups: Arbeit 4.0, Projektmanagement, Qualitätsmanagement, Plattformen, Smart City/ Smart Region, Digitale Landwirtschaft, Digital Design, Open Data/Open API
- DLG e.V. (Deutsche Landwirtschafts-Gesellschaft)
  www.dlg.org
- Fraunhofer Big Data and Artificial Intelligence Alliance
  www.bigdata.fraunhofer.de
- Gesellschaft für Systems Engineering e.V. (GfSE)
  www.gfse.de
  Arbeitsgruppe System Architecture Framework
- GI e.V. – Gesellschaft für Informatik
  www.gi.de
  Different groups, incl. Board Task Force "Data Science/Data Literacy":
  www.gi.de/datascience
- Fachgruppe Software-Messung und -Bewertung:
  https://fg-metriken.gi.de/
- ISERN – International Software Engineering Research Network
  https://isern.iese.de
- Plattform Industrie 4.0
  www.plattform-i40.de
- ProSTEP ivip e.V.
  www.prostep.org
- SIAK – Science & Innovation Alliance Kaiserslautern
  www.science-alliance.de
- Softwareforen Leipzig
  www.softwareforen.de
  User Group Requirements Engineering
- VDI – Verein Deutscher Ingenieure e.V.
  www.vdi.de
- ZD.B (Zentrum Digitalisierung Bayern) – Plattform Digitales Landmanagement
  www.zentrum-digitalisierung.bayern

ORGANIZATIONAL CHART



ADVISORY BOARD

RESEARCH

Prof. Dr. John A. McDermid | University of York, York, UK
Prof. Dr. Jürgen Nehmer | Fraunhofer IESE, Kaiserslautern
Linda M. Northrop | Carnegie Mellon University | Pittsburgh, USA
Prof. Dr. Helmut Schmidt | Technische Universität Kaiserslautern, Kaiserslautern

INDUSTRY

Dr.-Ing. Reinhold E. Achatz | ThyssenKrupp AG, Essen
Gerd Höfner | Siemens Healthcare Pvt. Ltd., Bangalore, India
Harald Hönninger | Robert-Bosch GmbH, Renningen
Dr. Ian Thomas | FUJITSU RunMyProcess, Paris, France

GOVERNMENT

RDin Stefanie Nauel | Ministry of Economic Affairs, Transport, Agriculture and Viticulture
Land Rhineland-Palatinate, Mainz
Dr. Carola Zimmermann | Ministry of Science, Continuing Education and Culture
Land Rhineland-Palatinate, Mainz

PRIVATE MEMBER

Renate Radon | Landau

GUESTS

Dr. Matthias Nachtmann | BASF SE, AP/IS, Limburgerhof
Prof. Dr. Adam Porter | Fraunhofer USA Center for Experimental Software Engineering CESE Maryland, Riverdale, USA

The Fraunhofer-Gesellschaft

The Fraunhofer-Gesellschaft is the world's leading applied research organization. With its focus on developing key technologies that are vital for the future and enabling the commercial exploitation of this work by business and industry, Fraunhofer plays a central role in the innovation process. Based in Germany, Fraunhofer is an innovator and catalyst for groundbreaking developments and a model of scientific excellence. By generating inspirational ideas and spearheading sustainable scientific and technological solutions, Fraunhofer provides science and industry with a vital base and helps shape society now and in the future.

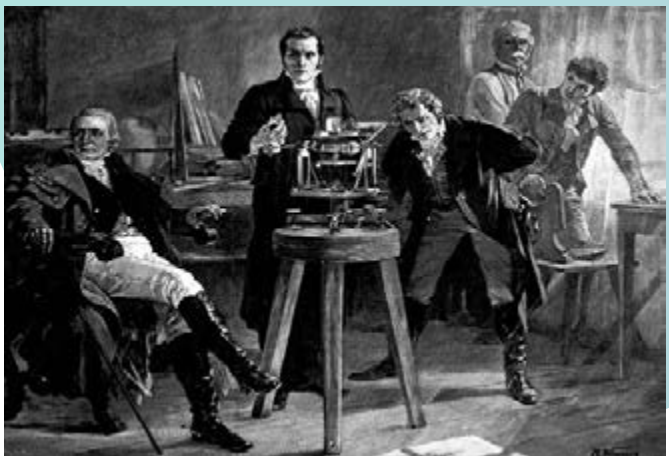
At the Fraunhofer-Gesellschaft, interdisciplinary research teams work together with partners from industry and government in order to transform novel ideas into innovative technologies, to coordinate and realize key research projects with a systematic relevance, and to strengthen the German and the European economy with a commitment to creating value that is based on human values. International collaboration with outstanding research partners and companies from around the world brings Fraunhofer into direct contact with the key regions that drive scientific progress and economic development.

Founded in 1949, the Fraunhofer-Gesellschaft currently operates 74 institutes and research institutions. The majority of our 28,000 staff are qualified scientists and engineers, who work with an annual research budget of 2.8 billion euros. Of this sum, 2.3 billion euros is generated through contract research. Around 70 percent of Fraunhofer's contract research revenue is derived from contracts with industry and publicly funded research projects. The remaining 30 percent comes from the German federal and state governments in the form of base funding. This enables the institutes to work on solutions to problems that are likely to become crucial for industry and society within the not-too-distant future.

Applied research also has a knock-on effect that is felt way beyond the direct benefits experienced by the customer: our institutes boost industry's performance and efficiency, promote the acceptance of new technologies within society, and help train the future generation of scientists and engineers the economy so urgently requires.

Our highly motivated staff, working at the cutting edge of research, are the key factor in our success as a scientific organization. Fraunhofer offers researchers the opportunity for independent, creative and, at the same time, targeted work. We therefore provide our employees with the chance to develop the professional and personal skills that will enable them to take up positions of responsibility at Fraunhofer, at universities, in industry and within society. Students who work on projects at Fraunhofer Institutes have excellent career prospects in industry by virtue of the practical training they enjoy and the early experience they acquire of dealing with contract partners.

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur.



The man behind the name: Joseph von Fraunhofer

Project Grant Numbers

BaSys 4.2 | www.basys40.de
Grant number 01IS19022A (BMBF)

DEIS | www.deis-project.eu
Grant number 732242 (EU Horizon 2020)

Demeter | http://h2020-demeter.eu
Grant number 857202 (EU Horizon 2020)

Designetz | www.designetz.de
Grant number 03SIN231 (BMWi)

Digitale Dörfer | www.digitale-doerfer.de
Grant number 56:382 Digitale Dörfer
(Ministry of the Interior, for Sport and Infrastructure of the *Land* Rhineland-Palatinate)

Digitale Teams | www.digitale-teams.de
Grant number 01MD18007C (BMBF)

FabOS | www.fab-os.org
Grant number 01MK20010A (BMWi)

KI in Mittelstädten |
Grant number 20192793/9110541
(TU Kaiserslautern)

MInD
Grant number 15414 – 52 207 – 2/43
(Ministry for Science, Continuing Education and Culture of the *Land* Rhineland-Palatinate

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

SECREDAS | www.ecsel.eu/projects/secredas
Grant number 16ESE0318 (VDI), 783119 (EU ECSEL)

Smart tau Hus | www.smart-tau-hus.de
Grant number 221-029-Hi-19 (Ministry for Agriculture and Environment of the *Land* Mecklenburg-Vorpommern)

TrUSD | www.trusd-projekt.de
Grant number 16KIS0898 (BMBF)

ViTAWiN | www.vitawin.info
Grant number 01PV18006P (BMBF)

Image Credits / Photographers

Fraunhofer IESE: Jasmin Awan | Birgit Buck | Andrea Hufen | David Kurz

Others:
P. 19: ©iStock.com/Diy13 | p. 20: Robert Bosch GmbH | p 23: ©iStock.com/Melpomenem | p. 24: Sick AG | p. 28: ©iStock.com/abadonian | p. 32: ©iStock.com/wundervisuals | p. 44: ©iStock.com/Rick-Jo | p. 58: ©iStock.com/PrathanChorruangsak | p. 61: KL.digital | p. 84: Andreas Eitel | p. 86: Fraunhofer-Gesellschaft

Editorial Board
Dipl.-Kauffrau Claudia Reis (responsible)
Nina Hahnel, M.A.
Larissa Theis, M.A.

Proofreading and Translation
Dipl.-Dolm. Sonnhild Namingha

Layout and Setting
Julia Kirch, M.A.
David Kurz
Berit Rickes
Dipl.-Betriebswirt (BA) Stephan Thiel

Printed by
Kerker Druck GmbH, Kaiserslautern

Your contact person for PR and Marketing

Claudia Reis
Team Leader Corporate Communications | Technology Marketing
Phone +49 631 6800-0
presse@iese.fraunhofer.de

www.iese.fraunhofer.de

This Annual Report is also available in German.

#STAYCONNECTED

Fraunhofer IESE | Fraunhofer-Platz 1 | 67663 Kaiserslautern | Germany
www.iese.fraunhofer.de | www.blog.iese.fraunhofer.de