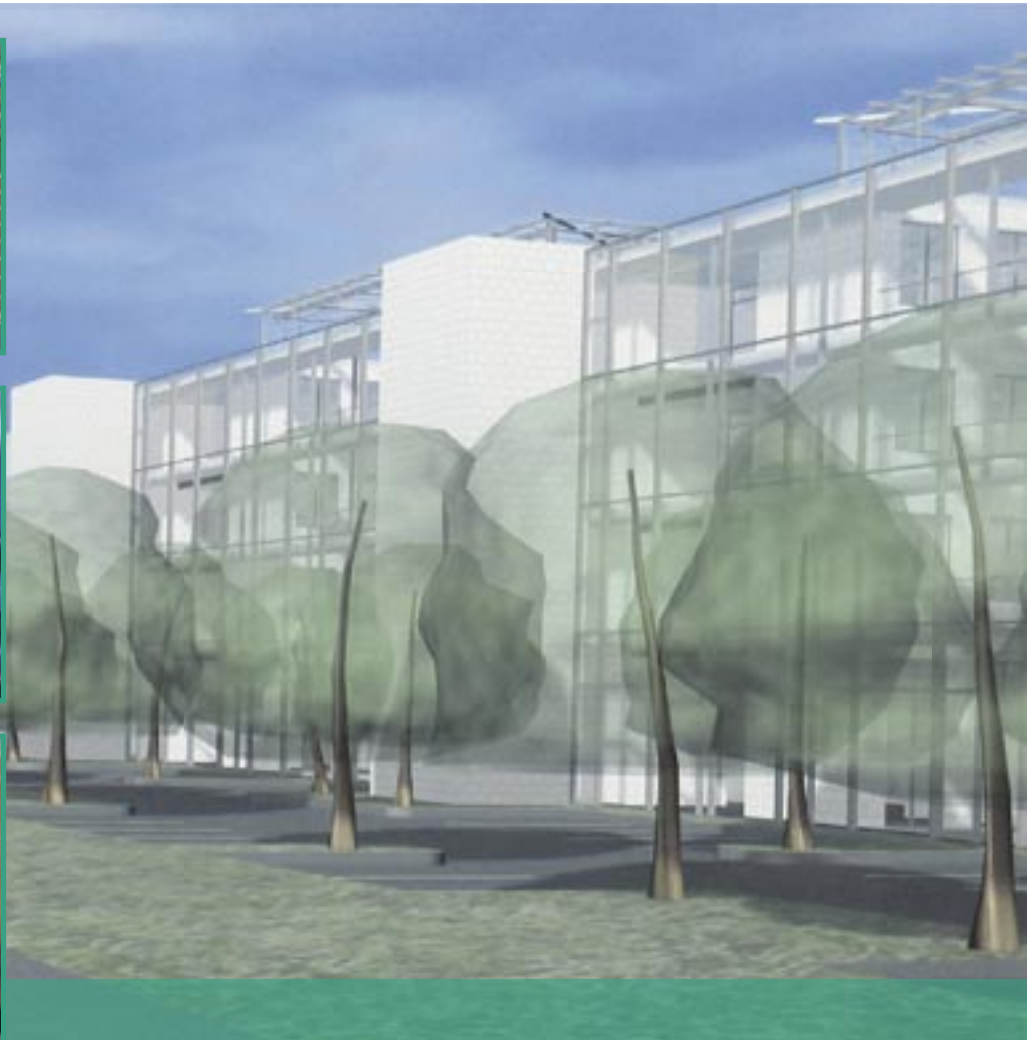
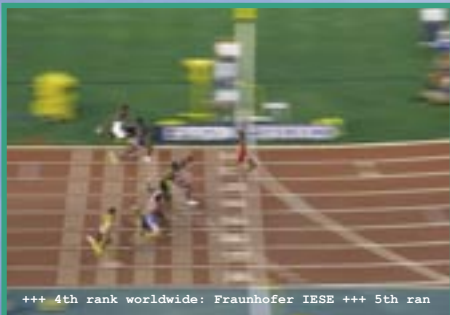




**Fraunhofer** Institut  
Experimentelles  
Software Engineering

# Annual Report 2004



# Fraunhofer Institute for Experimental Software Engineering

## Fraunhofer Institute for Experimental Software Engineering IESE

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### **Executive Director**

Prof. Dr. Dieter Rombach

### **Director**

Prof. Dr. Peter Liggesmeyer

The Fraunhofer Institute for Experimental Software Engineering IESE offers methodological instruments that make it possible to plan the design of development processes and make software-based products ready for the market in a more efficient manner by applying engineering-style principles.

Our research foci software engineering, project and quality management as well as experience management and human resource development are concentrating on typical problem areas such as quality defects, time and budget overruns as well as lack of sustainability of improvement measures taken.

Fraunhofer IESE's international customers come from domains where the quality of products and services is co-determined by the software used: automobile production, telecommunications, traffic and transportation, commerce, banks and insurance companies

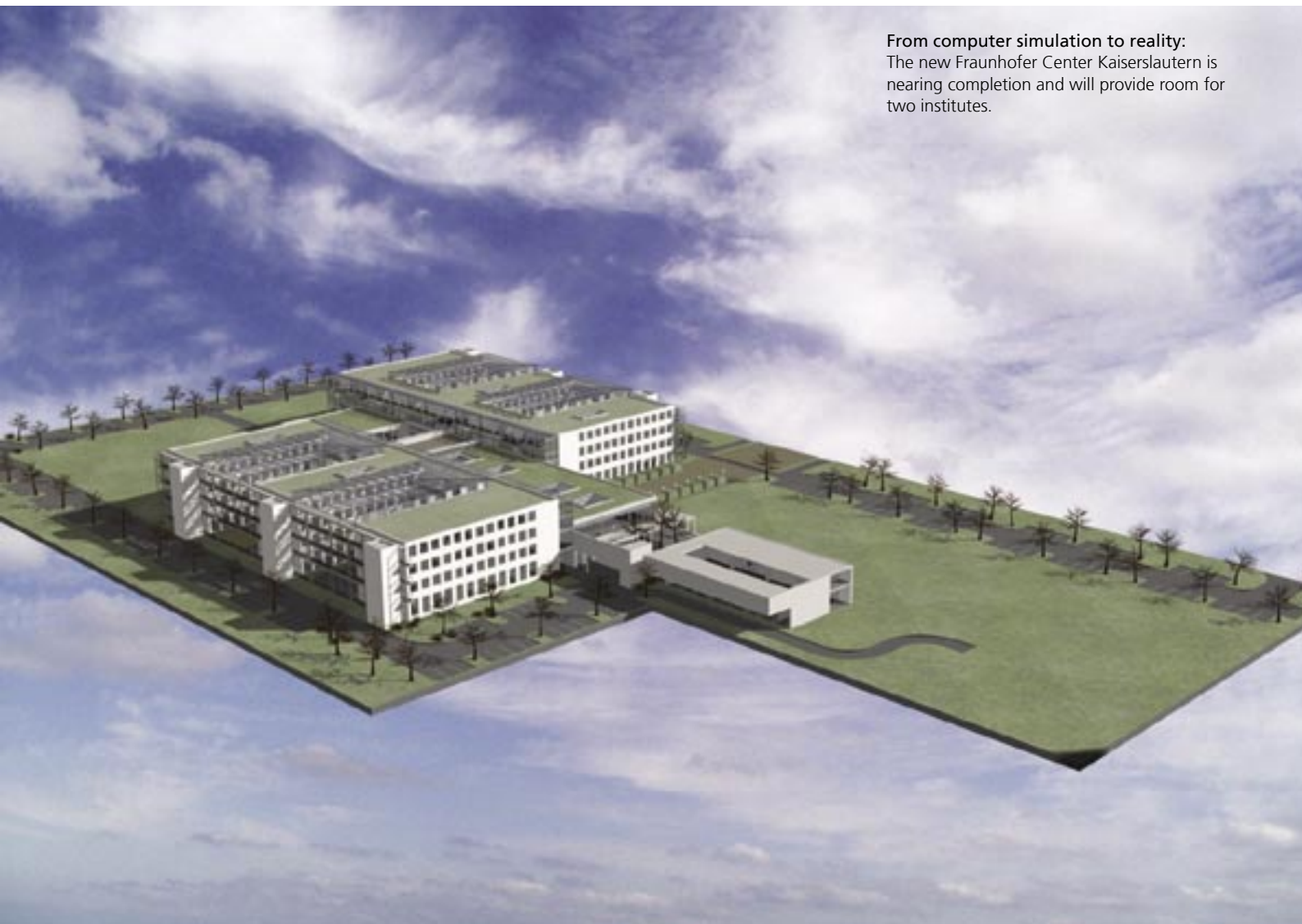
as well as software production. Government also plays an important role as a project partner in EU-, federal-, and state-funded projects. In particular, the institute has extensive experience in the context of developing reliable, secure, and flexible software for embedded systems, IT infrastructures and IT service providers, as well as support of IT-based business processes.

The services we offer range from consulting to building new structures and processes in software development. They include both the introduction of continuous improvement programs and the selection, adaptation, testing, and implementation of innovative approaches for software development. Companies of all sizes, to include especially small and medium-sized enterprises (SMEs), are supported in improving their software (development) competence through consulting, contract research, and technology transfer.

## Annual Report 2004

Fraunhofer Institute for  
Experimental Software  
Engineering IESE

**From computer simulation to reality:**  
The new Fraunhofer Center Kaiserslautern is  
nearing completion and will provide room for  
two institutes.



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Prof. Dr. Peter Liggesmeyer

*"Systems are certainly becoming more and more complex. But is this also necessary in every case? It must be one of the goals of software engineering not to increase complexity through unnecessary functions that nobody needs. The first step towards controlling complexity is therefore to concentrate on what is really essential."*

The complete interview with Prof. Dr. Peter Liggesmeyer can be found on page 12.

```
2 // BubbleSort.java
3 // This program sorts
4 // ascending order
5 import java.awt.Graph
6 import java.applet.Applet
7
8 public class BubbleSort {
9     int a[] = { 2, 8,
10
11     public void paint(
12     {
13         private a = new int[] { 25, 25 };
14
15         a = { 25, 25 };
16
17
18
19     public
20     {
21         s = 1; pass <
22         i = 0; i < a.l
23         i ] < a[ i +
24         = a[i];
25         = a[ i
26
27
28
29
30
31
32     pu
33
34
35
36     x = 15;
37     y = 15;
38
39     for ( int i = 0; i < a.length; i
40         g.drawString( String.valueOf(
41         x += 20;
42
43
44
45
46
```

## Editorial

2004 was a very successful year in our institute's short history. We continued sustained growths in personnel and in third-party revenues, broadened the leadership structure by hiring a second institute director, continued to expand our international research reputation, established a growing number of strategic collaborations with leading industries, became more involved in public policy making, and extended our international network of collaborations. We thank all our partners for their support in the past and hope to continue serving your needs in the future.

About 150 employees continue to maintain leading edge competencies in software engineering areas relevant to the future challenges of software-intensive industries. Based on a technology audit performed by an international team of representatives from academia and industry in 2004, our focus was sharpened even more. Our ability to combine leading expertise in software engineering methods, tools, and technologies with quantitative experiences regarding their effectiveness under specific company constraints represents a unique offering to industry. I refer you to pages 43 ff. in this report for more details about our range of services offered, and to pages 61 ff. for examples of successful collaborations.

The continued growth of our institute required broader leadership. In 2004, the decision was made to hire a second institute director. We were fortunate to attract Prof. Dr. Peter Liggesmeyer, who perfectly fits the overall direction of our institute while bringing with him complementary competencies in the areas of software testing, software safety, and software visualization. Prof. Liggesmeyer's professional career includes stays at Siemens AG Corporate Research and, most recently, a professorship with the Hasso-Plattner-Institute in Potsdam. We believe that with this new colleague in our directorate, Fraunhofer IESE is well prepared for its continuing growth – both internally and externally. For more details about Prof. Dr. Peter Liggesmeyer, please read the interview on page 12.

In our last annual report, we reported on the 6th place of our institute in an international ranking by the "Journal for Systems and Software" based on publications in the most prestigious international journals. We are proud to report today that we have improved our ranking to number 4! We are still rated the best organization in Europe and the only organization from Germany among the Top 15. Since last year we have by-passed such prestigious organizations as Bell Labs/Lucent Tech-



Prof. Dr. Dieter Rombach

nologies and the National University of Singapore. We view this ranking as a great compliment, as it shows that successful industry collaborations are based on top-rated basic research. It is also a great compliment to our scientists, who have achieved high marks on both sides – excellent research and successful industry projects.

The key measure of success for any Fraunhofer institute are successful projects with industry. In this regard, our institute's strategy for many years has been to establish a large number of strategic, long-term collaborations with industry. The concept of tight strategic collaborations has been accepted more broadly this past year. We now have long-term collaborations with Robert Bosch GmbH, Ricoh Co. Ltd., Siemens AG, Deutsche Telekom AG, and several smaller companies in the Kaiserslautern region. All of these collaborations are integrated into the strategic plans of the respective companies. Many of the companies (e.g., Bosch Blaupunkt GmbH, Ricoh Co. Ltd.) have even established physical collaborations between company experts and IESE scientists according to the "Research

Lab" concept. Such close collaborations between industry staff and Fraunhofer researchers may turn out to be a model for dealing more efficiently with the growing challenges in many software-intensive industries.

The reputation of our institute as a leading competence center for all software-related issues has attracted public decision makers to employ us as expert institute. Examples range from the German Ministry of Education and Research, BMBF (Broy M., Rombach D., Analyse und Evaluation der Software-Entwicklung in Deutschland, Studie für das BMBF, 2000) to the State of Rhineland-Palatinate (which, in 2004, outsourced to us the study "Regions and Domains in Flux" to analyze regional innovation potential), and other federal, state and local authorities who hire us as experts to monitor industry contracts in areas such as e-Government. Our reputation as an expert institute in software, software engineering, and IT enables us to fulfill our responsibilities to society and to provide impulses to government and society in our areas of work.

Fraunhofer IESE has always drawn on a large international network of scientific and industrial collaborators. The Fraunhofer Center Maryland FC-MD is one of the most successful engagements of Fraunhofer-Gesellschaft in the USA. Its involvement in leading American projects has significantly contributed to the reputation of IESE. In 2004, Professor Victor R. Basili retired as Executive Director, but will continue as a scientific staff member for special assignments. We are indebted to Prof. Basili for his contribution to the successful build-up of the Fraunhofer Center Maryland. We will most likely announce his successor in early 2005.

Beyond the traditional international collaborations with European companies with and without funding by the European Union, we have recently established very close international collaborations in Hungary, India, and Japan. The Hungarian collaboration involves the University of Budapest and the Technical University of Kaiserslautern, and is focused on "Ambient Intelligence". In India, we have established a joint research project on software measurement with Siemens Informa-

tion Systems Ltd. (SISL), a CMMI Level 5 company. Finally, in Japan, we have been chosen by METI, the Japanese Ministry of Economy, Trade and Industry, as the expert advisory institute for the build-up of the National Software Engineering Center (SEC), and have started collaborations with JAXA (Japan Aerospace Exploration Agency) and Hitachi Ltd. Based on the growing international engagement of IESE, we have summarized all international activities in a separate section (see page 113 ff.).

We are aware that your challenges are changing continuously. We take into account your time and cost constraints as well as your quality requirements. Our solutions are empirically validated in order to guarantee the full benefit of technology innovation. We sincerely believe we have positioned Fraunhofer IESE as a competent partner for solving your challenges.



Dieter Rombach,  
Executive Director,  
Fraunhofer IESE

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## Computers Controlling our Everyday Lives – "Embedded Systems" as a Challenge

Since 01 June 2004, Prof. Dr.-Ing. habil. Peter Liggesmeyer has been in charge of Fraunhofer IESE together with Prof. Dr. Dieter Rombach. In our Annual Report interview, this well-renowned expert in the areas of software quality and software testing, especially for embedded systems, responds to questions about the possibilities and limitations of embedded systems, about the economically feasible development of reliable programs, and about ways to escape the trap of complexity.



Prof. Dr. Peter Liggesmeyer

**?** *Today, we are constantly surrounded by computer-monitored equipment without ever paying special attention to it most of the time. Washing machine, car radio, or mobile phone: Often, we only notice how important computers integrated into everyday appliances are when they malfunction. Scientists in various departments at Fraunhofer IESE are focusing their current research on these so-called embedded systems. You want to consequently advance software engineering research in this context. How did you get into this field, what is it that particularly fascinates you about this field, and which perspectives do you see for its future development?*

**!** My first contact with embedded systems already took place while I was still a student at the university. I studied electrical engineering, but right from the start, I put an emphasis on information technology by focusing on data technology. From there, this aspect has been running through my entire career like a red thread. After my studies I obtained my Ph.D. at an electro-technical department at a Chair for Software Technology, which was followed by a job at Siemens. There, about 60% of the revenue is nowadays gained from software – normally for technical applications in embedded systems. Thus, I have been involved with embedded systems for many years; the fascination this field has had for me until today can certainly be attributed to a large extent to its interdisciplinary orientation. It includes, of course, computer science and especially software engineering, but also electrical engineering and other engineering disciplines.

? *Quality is a very far-reaching and central term in software development – with both developers and users equally desiring systems that are functional, reliable, and, at the same time, as cost-efficient as possible. The software engineer who develops embedded systems is often still subject to special constraints and requirements that are hard to reconcile. Engineering-style system development has its price – the costs of software development contribute a lot to the sale price of computer-controlled products. Which strategies do you consider to be particularly promising for producing high-quality systems that still remain within financial reach?*

! First of all, we should clearly define the term quality – there is no such thing as one quality that suits all areas of application. If you compare a typical consumer product such as a computer game with the control of a passenger jet, it becomes immediately clear that the term "quality" must be viewed in different ways for different products and application areas. In order to ensure a sufficient degree of system safety, higher costs will be accepted for software that controls a passenger jet. On the other hand, safety aspects will most likely be mainly irrelevant in the case of a computer game. Yet, cost limits exist even for those systems that must fulfill extremely high quality requirements. The prerequisite for market success is the right degree of quality in the right place, appropriate costs, and, of course, the required and desired functionality. Here is where Fraunhofer IESE comes in: It provides support in implementing mature processes that permit systematic development of products with the required properties.

? *Natural phenomena are recognized too late despite massive computer computations, space rockets and planes get out of control, and soldiers are fired upon by their own computer-controlled weapons systems: Malfunctions due to failure-prone software have had devastating effects in the past, sometimes even resulting in fatalities. Methods, techniques, and tools for developing safe systems do exist, however, and continue to evolve. How do you then explain the still significant number of accidents and near-catastrophes that are caused by software defects?*

! First of all, many malfunctions are unjustly attributed to software defects. Nevertheless: Even when we disregard these events, numerous other incidents remain that were clearly caused by software defects. For a long time, people tried to realize as many functions as possible through software, since this entails advantages, at least at first sight: High functionality at moderate costs with a flexibility that can hardly be achieved with hardware-based solutions. This has led to the fact that software-based solutions were able to encroach into certain application areas before people understood how the specific requirements in those areas could be fulfilled correctly. Incidents with far-reaching consequences, such as the crash of Ariane 5, were the consequence. But we should not overlook the many positive influences of software. When we look at how software is being used in the automotive domain, from airbag systems to safety electronics or electronic stabilizer programs, we clearly recognize that there is more safety. There are no benefits without drawbacks – in many modern systems, however, software does not only create major advantages, but even

enables their realization in the first place. The decisive point is that systems must not be the cause of unacceptably high potential jeopardy. Currently, research at Fraunhofer IESE in the area of "safety" is being further expanded. There we deal with techniques that help to prevent risks for people and for the environment.

**?** *For obvious reasons, computer programs for embedded systems with particularly high safety requirements are also designed and implemented with higher effort. Yet, users of process-controlled everyday products can tell a thing or two about these: Cheap mass products such as consumer electronics are more often than not characterized by annoying shortcomings caused by the software used in these products. Confusing menu structures of DVD players or mobile phone warning signals that are too loud are some of the more harmless problems in this area. Sometimes, however, defects occur even here that limit functionality or even create risks. How can modern software engineering also improve the cost/benefit relation on these markets, which are far from industrial special applications, in the medium term, and thus increase the competitiveness of the manufacturers?*

**!** I believe that it is exactly the cost pressure in certain application areas that promotes software engineering suitable for developing such systems correctly and with acceptable quality, in other words, easy to use and sufficiently safe. I would even claim that software engineering might have a greater potential in these areas than in the area of industrial goods mentioned before. Let us look at a modern rail vehicle, for example, or a passenger jet – industrial goods produced in relatively small numbers. Here, safety can be achieved fairly easily through hardware redundancy, for example, because it hardly matters whether you install a little more hardware in a product that is already quite expensive. The issue is different for those products that, as mass products, must be designed from the start with the price in mind. In this area, software engineering is therefore a particularly interesting solution, since you only have to think about the correct software solution once, namely at the start of development – even if you reproduce the product a million times. The costs for this initial investment can be apportioned to a very large number of products, making these only slightly more expensive. You also mentioned usability – at Fraunhofer IESE, we are working on the integration of usability-



and requirements engineering; I think that this is a central activity. I fail to see why usability should not be anticipated and dealt with at the start of development. This is the issue we are working on. Safety and availability are other properties that must be taken into account early on in system development.

**?** *Until recently, software was a product to be purchased and to be used by the user in the state it was delivered. With the advent of the Internet, minor updates of already delivered programs became possible – resulting in more and more software arriving at the customer in an immature, insufficiently tested state and being corrected later if necessary. This principle is also being employed with increasing frequency for products with embedded systems, and some manufacturers expect their customers to perform complex, not always risk-free update procedures or cumbersome shop visits. Will end users have to get used to the so-called "banana software" in the future, which matures at the customer's site and can only be used sensibly after its third Internet update?*

**!** Of course, it is not okay if manufacturers proceed in this way. However, experience shows that the time to market, in other words, the time from the start of development to the time when the product is introduced on the market, has by now become an extremely critical factor for success. Even if you enter the market as the second or third company with a comparable product, you will hardly have a chance to amortize development costs. Additionally, we are observing an enormous drop in prices in areas such as consumer electronics – DVD players are one example. There is an ever widening gap between decreasing prices and increasing development costs and development times, which are due to added functionalities. Actually, more development time would often be necessary in order to implement the desired functionality with high quality. It cannot be ruled out that the development of such systems gets completed after the product has already been delivered. Yet, it is also up to the market to decide about the acceptance of such products. Furthermore, the possibility of influencing systems and equipment after delivery, e.g., via the Internet, also offers great opportunities. One example would be long-distance maintenance in case of malfunctions, i.e., experts being able to make systems function again across a great distance.



**?** *Buzzwords such as "Ambient Intelligence", "Pervasive Computing", or "Ubiquitous Computing" have not only appeared in IT journals and magazines during the past few months – the general public is also discussing the pros and cons of life being permeated by omnipresent computer technology, and sometimes this discussion is definitely critical. How could and should, in your opinion, science influence future developments, and which aspects do you think are not being sufficiently taken into consideration yet?*

**!** Computers are practically everywhere already. It is known that over 90% of the microprocessors produced are integrated into embedded systems and usually perform their service there without being noticed. The computers on our desktops are a small, but visible minority. Another aspect that needs to be taken into account in the course of the development mentioned above and the buzzwords associated with it is the networking of such systems. People are quickly scared that data are collected, stored, and analyzed in a manner that is not very desirable for the individual. This leads to a key role for data protection, because it should certainly be transparent which personal data have been stored and how these are used. The importance of the issue of "security" will increase without any doubt.

**?** *It seems to me that so far, there has not been any complete legal clarification of these scenarios. Do legislation and legal practice still keep up with current developments in information and communications technology?*

**!** Some problems in this context are of a purely technical nature, but many of them also create legal issues. Who is liable for damages resulting from the use of distributed applications – with correspondingly unclear responsibilities? Legislation does not stay abreast of current developments; current legal practice seems to barely keep up with the technical progress. In some areas, however, there are already legal principles that fit well, e.g., the product liability law. I think that more needs to be done in this area.

**?** *The methods of software development must be oriented towards the requirements placed on the systems and on their technical circumstances. However, the increasing complexity of embedded systems and their continuing networking lead to more problems, for example in the form of inexplicable malfunctions. The capacity of modern embedded systems already allows extremely large programs, sometimes implemented in higher programming languages.*



*Will the limit of complexity that can be controlled with a reasonable amount of effort be reached in the near future, or is it already being exceeded by the ambitious plans with regard to "Ambient Intelligence"?*

! Systems are certainly becoming more and more complex. But is this also necessary in every case? It must be one of the goals of software engineering not to increase complexity through unnecessary functions that nobody needs. The first step towards controlling complexity is therefore to concentrate on what is really important.

However, systems are also becoming more and more complex in their central, really needed functions. But there is a way out of this dilemma: I think that all really complex systems – which certainly include the above-mentioned "Ambient Intelligence" systems – offer a natural form of partitioning. The proven principle of "Divide and conquer!" should also be applied here. A system does not necessarily need to be understood in its complex totality and, at the same time, in each of its details. The important issue is to anticipate interfaces between defined building blocks and thus make defined functionality with specific properties available. It must be possible to rely on these

properties in order to achieve smooth interaction of all building blocks in the overall system. This is achieved by employing various techniques, from suitable requirements and design processes via modern programming languages to specialized testing techniques for functionality, safety, and other quality characteristics. I am confident that even the development of complex systems will be controllable with a suitable combination of measures. The experienced expert – the software engineer – assesses different processes with regard to the problem and optimally combines the effective techniques. This is exactly what characterizes an engineering science, which includes software engineering.

The interview was conducted by Patrick Leibbrand.

## Highlights in 2004

### "Everything on track" – Fraunhofer IESE to move into its new domicile as scheduled

There was never any serious doubt regarding the date of the move – construction is right on schedule: In July 2005, Fraunhofer IESE is supposed to move into its new domicile on the grounds of the former railroad shunting yards on Trippstadter Straße.

The shell of the Fraunhofer IESE building has been completed; after an appropriate topping-out ceremony in early 2005, installation and operation of the building services were started. Extensive trial runs ensure that the sophisticated IT infrastructure as well as ventilation and building services will function properly upon move-in. The responsible officials are confident that work will be finished on time and within the scheduled budget.

Flashback: On 27 October 2003, the groundbreaking ceremony took place – and in the months since then, the vision of a second high-tech center in

Kaiserslautern has become a reality. The PRE-Uni-Park, as the area has been named, is expected to give new impulses to the development of Kaiserslautern. Here, even more so than in the PRE-Park on Mainzer Straße, applied research will drive economic development and attract further IT research competence centers.

This will be guaranteed by the Fraunhofer Institutes for Experimental Software Engineering IESE and for Applied Mathematics ITWM, who will form the first building blocks of the new science center. Synergy effects, which so far were sometimes made difficult by the physical separation of applied, industry-oriented research and university research, will then be able to unfold without restrictions.

Just like the construction work, preliminary scientific work is already in an advanced phase, too. Research labs are being established, where scientists and designated experts from industry cooperate on joint issues. Demo centers have also been designed, which specifically address small and medium-sized



**Approaching the finish line:**  
By the end of the year 2005, the Day Care Center being built here will offer 30 slots.



**Straight lines:**  
Numerous windows in the exposed concrete facade of the new institute building (currently still hidden by scaffolding) will make for well-lit, friendly offices.

enterprises and provide neutral and professional information on state-of-the-art software technologies.

Numerous challenges have to be met in the course of such a mammoth project, since new construction of a complete institute center is not a static process. Rather, it is a highly dynamic process, which will remain exciting to the end due to unexpected events and last-minute changes. The renowned architectural office AS Plan (Kaiserslautern), which is responsible for the planning of the project, has always been able to find an adequate solution in close collaboration with the coordinators of the institutes involved.

In the meantime, interior construction has been completed; all work is now concentrated on the upcoming move-in of Fraunhofer IESE in a few months. Only six months later, at the end of 2005, it will be joined by Fraunhofer ITWM, and the Day Care Center will start operation with slots for 30 children.

Despite the cumulative research and development competence of the newly created institute center, the area still offers room for more. In addition to plans for residential housing, commercial enterprises, and teaching institutions, there are also plans for expansion with another Fraunhofer institute. A lively exchange of ideas accompanied by an exchange of knowledge and people between science and industry can thus be expected for the future.



**More than a beautiful countryside:**

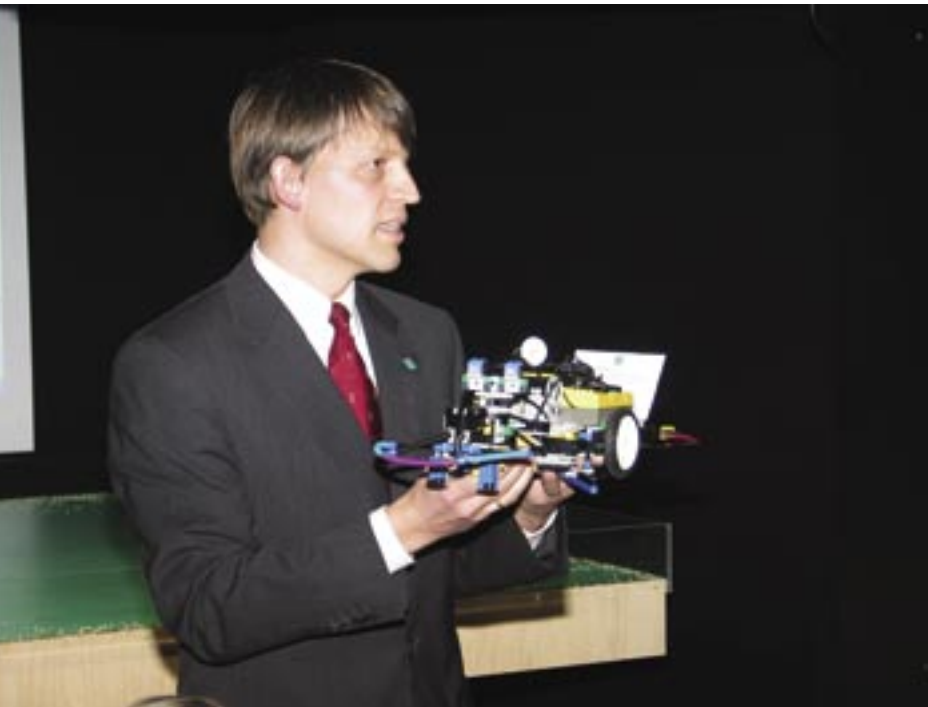
Rhineland-Palatinate must make systematic use of the opportunities that IT/media provide for education, employment, and growth.

**Presentation of expert report on "Regions and Domains in Flux"**

The Council of Ministers considers the expert report on "Regions and Domains in Flux" as an important basis for expanding the media site Rhineland-Palatinate. This view was emphasized by the director of the state chancellery, state secretary Martin Stadelmaier, when the expert report was presented at a press conference in Mainz. The study, which was performed by the Fraunhofer Institute for Experimental Software Engineering (IESE) and the Gesellschaft für Informations- und Kommunikationsmanagement Media Systems, qualified the accenture media report from the previous year under regional aspects. New content includes an analysis of all important domains in Rhineland-Palatinate from agriculture to chemical industry under the aspect of media and IT development as well as the Rhineland-Palatinate innovation

atlas, which documents the development of start-up centers, universities, and university research institutions. The results and conclusions shall become part of the state government's strategy on promoting employment and growth, said state secretary Stadelmaier. Information technology has initiated a giant change process in society; IT media competence is becoming increasingly important in the competition between domains, cities, and regions. Stadelmaier: "We will actively accompany this change process, which will have a major impact on the future of society in the age of information, so that Rhineland-Palatinate will remain an attractive economic location and will stay globally competitive."

"Regions and Domains in Flux" can be downloaded free of charge in a printer- and reader-friendly PDF version from the website of Fraunhofer IESE at [www.iese.fraunhofer.de](http://www.iese.fraunhofer.de).



**Hightech in a toy:**

At the opening of the Lego Show in Kaiserslautern, embedded systems expert Christan Peper explains the software engineering concepts implemented with the robot presented by IESE.

**Much more than just a toy: Computer-guided vehicles illustrate innovative software engineering**

Ever since the first time it took place as the State Garden Fair in the year 2000, the Kaiserslautern Garden Fair has had much more to offer than attractive garden architecture and a remarkable variety of plants. This fact has become well known far beyond Kaiserslautern. In the year 2004, the highlights that attracted many visitors included not only Europe's largest dinosaur exhibit, but also the Lego exhibit, which took place in cooperation with the Kammgarn Cultural Center Kaiserslautern in several buildings on the grounds of the Garden Fair.

Using a Lego robot as an example, the Fraunhofer IESE experts proved in the context of this exhibit that these building blocks known from childhood times could be much more than just a toy.

The microcontroller-guided vehicle of Fraunhofer's permanent presentation vividly demonstrated how embedded systems can be developed in a cost-efficient and reliable manner by using the software development method MARMOT, which was developed at Fraunhofer IESE. Automobile manufacturers, mechanical engineers, telecommunications manufacturers, in short: manufacturers of electronic equipment whose functionality largely depends on software, can gain particular benefits from this method, since the development techniques and processes currently in use for creating IT systems to be embedded into hardware are often unsatisfactory with regard to quality requirements. MARMOT has the potential of resolving a development impasse in embedded systems that is caused by the methods used, and to reduce frequently lamented software-based defects in everyday appliances.

**Germany displays software competence:**

**Competence network software-kompetenz.de presented to the public**

Participants in the kick-off event of the software engineering competence network found out just how explosive methodological issues in software development are in many domains. Experts from four core domains of the German economy presented their companies' special requirements regarding software quality and the software development process. To satisfy the demand of industrial software developers for technical know-how knowledge and practical experiences is the declared goal of the competence network software-kompetenz.de.

The competence network software-kompetenz.de, which is funded by the German Federal Ministry for Education and Research (BMBF), packages practice-relevant software development know-how, makes it available via an Internet portal, and promotes the exchange of experience between software developers from research and industry. It bundles practice-appropriate know-how on techniques, methods, and tools, and documents experiences from case studies and industrial practice. The knowledge database, which is the core of the portal, currently contains approx. 2,400 entries on central and current topics in software development. In addition to the online knowledge database, the competence network offers continuing education events as well as events for exchanging experience. Small and medium-sized enterprises, in particular, are addressed via regional networks, and networks with research partners and universities are promoted.



On 5 May 2004, software-kompetenz.de was presented to the public in Berlin. Representatives of industry from the domains of automobile technology, automation technology, finance, and telecommunications discussed trends and challenges from their fields. Prof. Bernd Hindel, scientific director of the International Software Quality Institute (ISQI) particularly emphasized the relevance of the competence network for qualification in software engineering: "The International Software Quality Institute (www.isqi.org) deals with personnel certification in the area of software engineering in more than 15 countries. The data basis of software-kompetenz.de represents an excellent collection of software technology knowledge for the German-speaking countries. We see our task in integrating this knowledge into modern forms of training, in including it into what we offer, and thus enlarging the circle of people using the competence network."

"The economic importance of the competence network will become evident once the knowledge transfer between research and industry is improved and accelerated through it", underlined Dr. Peter Broß, Managing Director of the

German Association for Information Technology, Telecommunications and New Media e.V. (BITKOM). "For this to happen, the software-relevant research results must be made available to those responsible for development in industry in an understandable and comprehensive manner that assures quality. In addition to making it easier to select a method, access to proven practices may support the reuse of solutions and avoid new sources of defects and thus, unnecessary potential costs."

The fact that the competence network will function as an important bridge between research and industry was stressed by Jörg Maas, Managing Director of the Gesellschaft für Informatik e. V. (GI). "Research institutions receive valuable information via the competence network about how to use new methods in practice. The most recent research results can be made available to a wide audience without losing any time."

The competence network software-kompetenz.de is currently being established and expanded by a consortium that includes the Fraunhofer institutes FIRST, FIT, IESE, IITB, ISST as well as the Technical Universities of Cottbus and Munich and the research institute OFFIS in Oldenburg. In the future, it is supposed to be run by an association. By the end of 2005, domain-specific contents and experience reports from practical use, in particular, will extend the portal.

#### **Innovative and practice-oriented: Hands-on software engineering at CeBIT 2004**

At the joint Fraunhofer-Gesellschaft booth at CeBIT 2004, Fraunhofer IESE presented itself with innovations in the area of software engineering. Using a Lego robot as an example, the institute's experts demonstrated how embedded systems could be developed cost-efficiently and reliably with the use of the software development method MARMOT designed by them. According to the software engineers, automobile manufacturers, mechanical engineers, telecommunications equipment manufacturers, in short: manufacturers of electronic equipment whose functionality depends to a large degree on software, can especially profit from this method, since the development techniques and processes currently being used for developing IT systems to be



embedded into hardware are often not satisfactory with regard to quality requirements. MARMOT has the potential of resolving a development impasse in embedded systems that is caused by the methods used, and to reduce frequently lamented defects in everyday appliances that are caused by software.

However, Fraunhofer IESE did not only offer solutions for the developers and users of embedded systems. The Rhineland-Palatinate Ministry of Economy, Transportation, Agriculture, and Viniculture has contracted Fraunhofer IESE to design the Internet-based geographic information system (GIS) "Area Information Online ('FLächeninformationen Online') – FLOrIp" in the context of a case study and to realize a prototype implementation of it. The demand is great: Every year, approx. 20,000 farmers in Rhineland-Palatinate apply for area-related subsidies. For this, the

farmer makes a list of his areas under cultivation, stating their size and the respective land parcel number. This information is given based in part on information from the land register obtained by the farmer from the corresponding land registry office, and in part based on measurements done by himself. With FLOrIp, obtaining this information becomes easier. The farmer can now

access the size and extension of his cultivated areas in the form of maps and aerial photographs via the Internet. He can also obtain area- and enterprise-related data online. The pilot operation of FLOrIp has been running since April 2004. Plans are to accomplish further development into a productive system by the beginning of 2005, to be presented at CeBIT 2005.

Minister President Kurt Beck gets information about the Internet-based Area Information System for Farmers "FLOrIp - Flächeninformationen Online" from Dirk Heidemeyer (ISB AG, center) and Petra Steffens (Fraunhofer IESE) at the joint booth of the state of Rhineland-Palatinate. Photo: Konrad Peil, CP-Mediengestaltung





**Cornerstone laid:**

Institute director Prof. Rombach (Fraunhofer IESE), BMBF state secretary Dr. Dudenhausen, Minister President Beck, institute director Prof. Prätzel-Wolters (Fraunhofer ITWM), mayor Dr. Oeckinghaus, Fraunhofer Executive Board member Dr. Gossner, and architect Prof. Ermel (from left to right) wish good luck and success for the future in the new research center.

Photo: Konrad Peil, CP-Mediengestaltung

**Fourth German Fraunhofer Center being built in Kaiserslautern – Politicians and scientists lay the cornerstone for a new research center in Kaiserslautern**

Documents that provide evidence of the extraordinary success story of two research institutes from the fields of computer science and mathematics were deposited on the occasion of the cornerstone being laid for the new Fraunhofer research center in Kaiserslautern on 30 April. Starting in mid-2005, the two Fraunhofer institutes in Rhineland-Palatinate, IESE (Institute for Experimental Software Engineering) and ITWM (Institute for Applied Mathematics) are to move into their new location on Trippstadter Straße. The event, which was moderated by the former director of Fraunhofer ITWM, Prof. Helmut Neunzert, brought

together a large number of individuals representing politics, business, and research, who – with a lot of commitment and determination – had pursued the idea of creating a competence center functioning as a scientific pace-maker, as a complement to the University and as a promotion for the city of Kaiserslautern. The center is being built in the immediate vicinity of and in close cooperation with the University of Kaiserslautern.

In his welcome address to the invited guests, Dr. Alfred Gossner, member of the Executive Board of Fraunhofer-Gesellschaft, spoke of a stroke of luck for research when he sketched the development of the two Kaiserslautern research institutes. Although the overall economic situation had deteriorated shortly after their founding, the institutes had managed to achieve their goals, to initiate new developments through international collaborations with renowned industrial companies, and to achieve significant success both scientifically and economically.

In his speech, Minister President Kurt Beck recalled the phase in the mid-1990s when the state government and Fraunhofer-Gesellschaft had agreed on identifying embryonic cells for potential Fraunhofer institutes in Rhineland-Palatinate. Without the significant start-up funding provided by the state, it would not have been possible to realize this plan, said Beck. But the result of this investment into information and communications technology and into applied mathematics was not only increased scientific and technological know-how, but also additional benefits. New jobs were created; Kaiserslautern

has evolved into a hot address for national and international companies.

Dr. Wolf-Dieter Dudenhausen, undersecretary in the Federal Ministry of Education and Research (BMBF), pointed out the significance of the two Fraunhofer institutes IESE and ITWM in the context of the innovation offensive initiated by the federal government. Both institutes, which are part of the IuK Group of FhG, are already in a good position. The topic of information technology constitutes an important research topic for both institutes. This serves as a crucial contribution to making Germany ready for the future and to securing jobs in the long term, stated Dr. Dudenhausen.

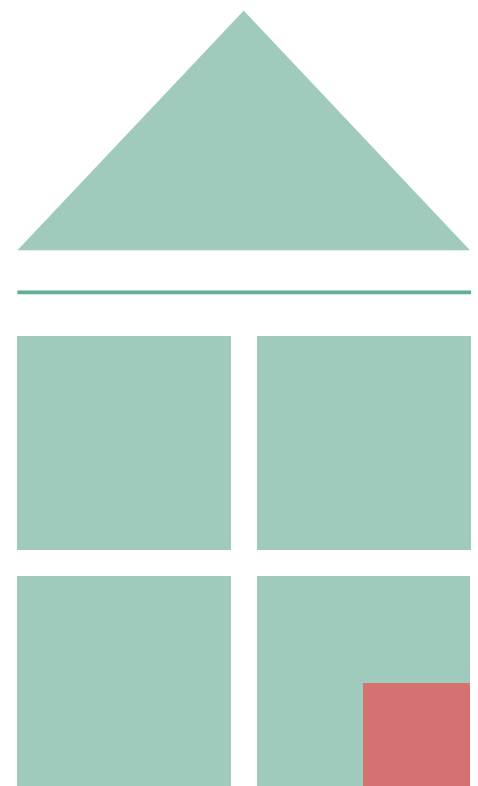
The great expectations regarding the model role of the research center were emphasized by mayor Dr. Arne Oeckinghaus. At the end of 1999, the city made a smart decision regarding its further development when it bought the area of the former railroad shunting yard. The founding of the PRE-Uni-Park in that location, in whose center the Fraunhofer Center is being built, will continue the trail of structural changes that the city has started on, and will advance the region technologically and economically.

The two institute directors, Prof. Dieter Rombach (IESE) und Prof. Dieter Prätzel-Wolters (ITWM), issued words of thanks to the friends and sponsors. Pride in what has been achieved and the perspective of new potentials that the Fraunhofer Center will offer were the main issues in the speeches of the two Fraunhofer directors. Rombach stressed that the generous new facilities

would improve the chances of winning companies of various sizes for application-oriented research collaborations. Research Labs will be created, generating new ideas and developments. Prätzel-Wolters emphasized that the vicinity to the university campus will have a major influence on injecting life into the interlacing of the Fraunhofer institutes with the University in the areas of research and academia. For many students of mathematics and computer science, the Fraunhofer Center will become the ideal interface between theory and practice. He expressed his special gratitude to the state government, since the planned realization of the research center was only made possible through the fast and non-bureaucratic way in which state and EU funds were made available.

Prof. Horst Ermel, who is in charge of the planning and design of the construction project with his architectural office ASPLAN, is confident that the envisioned move-in date in the second half of 2005 can be kept. The project that is expected to cost 47 million Euro is running according to schedule – as everyone could see. The overall project leadership is in the hands of the construction division of Fraunhofer-Gesellschaft.

Accompanied by the applause of the approx. 120 guests, the corner stone, which was filled with the Annual Reports of both institutes and with digital data carriers, was embedded into the foundation. The festivities were concluded with a small snack accompanied by the sounds of the "Viktor Loos Jazz Combo".



### Quality in e-Learning: Fraunhofer IESE's IntView method for designing high-quality learning software presented at Learntec 2004

A method for developing e-Learning applications that combines software engineering knowledge with development know-how, management experience, and pedagogical expertise was presented by Fraunhofer IESE at Learntec 2004 in Karlsruhe. On the basis of the method called IntView, the institute, together with partners from science and industry, has developed three sample online courses. They are directed in part at decision-makers from the software domain, and in part at software developers and technical writers. One of these examples for "engineered e-Learning" – an introduction and instruction for developing software with the UML Unified Modeling Language – has already been received very well in the domain. The other two examples – a course for technical writers in the area of software and a course that provides access to the secrets of component-based software development – are novelties and were presented for the first time at Learntec. This year, Fraunhofer IESE again presented itself at the joint booth of Fraunhofer-Gesellschaft in the Garden Hall of the Karlsruhe Fair Grounds.

E-Learning projects are too effort-intensive and too complex to be managed "on the fly". In addition to a lot of experience knowledge, a sophisticated work process is needed to regulate the interaction of all stakeholders. Just as important are instruments with which to obtain figures concerning the course of the project. These are indispensable for controlling time and costs. And last, but not least, it is essential to select the correct development methodology right from the start, so that the e-Learning product can be expanded and will not be surpassed by technical developments within a short time.

The e-Learning project manager is therefore faced with a lot of requirements, and so is his staff. In each phase of the project, they need the most up-to-date knowledge and clear instructions. This start-up situation is typical for every major development project. The commonalities with software development projects are particularly great. This realization caused the Fraunhofer Institute for Experimental Software Engineering to establish a special work focus on "e-Learning".

One thing was clear for the Fraunhofer experts: Even e-Learning can benefit from the insights of modern software engineering, since digital learning systems are set up in a way similar to

complex software systems. Thus, the IntView method was developed at the Fraunhofer Institute for Experimental Software Engineering.

The basis of the IntView method is a detailed analysis of all aspects that play a role in a learning software project. It represents a body of rules and regulations, which is unique in this extent, for all those involved in the development of learning software: project managers, programmers, authors, and designers. IntView thus helps to manage the entire project process, from the elicitation of requirements to the delivery of the final product. Factors such as cost and time effort, reusability, contents, functionality, and user friendliness are given the attention they deserve if the project participants follow the web-based IntView development guidelines. The main advantages of the IntView method – increase in quality, cost savings, and sustainability – could already be realized in several projects.

Three of these, the e-Learning products "UML interactive" in its variants for decision-makers and for design engineers, "Courseware for technical writers with the focus on software development", and "The Kobra Method for Technical Managers", were presented at Learn-  
tec.

"UML interactive for Decision Makers" is addressed at decision makers from the software domain; "UML interactive for Design Engineers" is addressed at software developers. The great feedback to these introductions to object-oriented software development, which have been online for about one year (<http://www.uml-kurs.de>), shows that there is a large demand for information in this area and that this type of knowledge presentation is highly appreciated.

The courseware "Creating Documentations for IT Technical Writers" was presented as a prototype at Learn-  
tec. The online course is based on many years of experiences gained in the context of the training measure "Technical Writer IT – Documentation Specialist in the area of Software". This qualification measure was designed in cooperation with SWA Software Akademie AG in Kaiserslautern and received the Rhineland-Palatinate Award for Continuing Education in 2002. In the future, the newly developed learning software shall be used for planning and executing future qualification measures for technical writers ("IT Technical Writer" in accordance with the new regulation on IT continuing education).



**Training programs according to the construction kit principle:**

Business information scientist Ines Grützner works on the scientific development of sophisticated blended-learning systems and advises decision-makers and software developers with regard to continuing education and training in the area of software engineering.

"The Kobra Method for Technical Managers" introduces software developers to the component-based software engineering approach in general and to the Kobra method developed for this approach in particular. The motto of this course is "Everything you always wanted to know about component development and the Kobra method", and in a learning period of four to five hours, it provides a well-founded introduction to this topic.

Course materials on other software engineering topics are currently being prepared. However, what Fraunhofer

IESE has to offer with regard to continuing education in software engineering is not only limited to online courses and development methods for learning software. The building kit "Object-oriented Software Development with UML" provides business customers with a complete blended learning program, which fulfills all continuing education wishes from knowledge acquisition via e-Learning, attendance seminars and project resp. team coaching to certification. For further information, see [www.iese.fraunhofer.de/Products\\_Services/uml/](http://www.iese.fraunhofer.de/Products_Services/uml/).



"This is a major contribution towards making Europe one of the most innovative regions in the world", stated German Federal Minister of Education and Research Edelgard Bulmahn on the occasion of the collaboration agreement being signed. Read the detailed project description on page 120.

**"It is fun when it finally works!" – Impressions from Girls' Day 2004**

The goal of Girls' Day as a Germany-wide campaign is to get girls interested in courses of study outside the "typically female" professions by offering practical experiences and personal conversations. Fraunhofer IESE was one of the organizations that opened its doors to seven girls aged 14 to 16 years and provided them with a varied program.

"Participate!" was the motto of the information event, which presented "typical male professions" to the enthusiastic students; professions such as IT specialist (system integration) or webmaster. In the workshops, operational personal computers were built from numerous electronic components, and the girls designed their first Internet pages. Of course, all participants had extensive opportunities to get the newest information on education and training and on professional practice in the IT domain.

"We were allowed to find out what is inside a computer. We added a hard drive, CD ROM drive, graphics card, and sound card", reported one of the young participants about her first experience with hands-on computer technology: "We could see whether

or not we had done things right when the computer actually did work afterwards", was the comment of one of her teammates about this successful experience.

Everyone agreed that their expectations with regard to fun and action were completely fulfilled on that day. During their brief visit, the participants were able to gain some insights into the daily practice of an IT job. "Together, we can reach the goal much faster", was how one student summarized the benefits of designing one's own Internet pages in a team. The future technicians discovered already that some problems do require a certain stubbornness: "Sometimes you need to mess with it quite a bit, but it is fun when it finally works."

The professional goals of the students, who are currently still attending the Goetheschule Integrierte Gesamtschule as well as the St. Franziskus-Realschule in Kaiserslautern, are very different, though. They range from biology lab technician to elementary school teacher, architect, occupational therapist and physician to actress. At the next Girls' Day, Fraunhofer IESE will again ensure that after that day, jobs from the IT domain will be added to the list of job wishes.



**"We did it – the computer is working!"**  
Pauline Schmitt and Irina Root are happy after successfully assembling a complete PC system from different components.

Rank	Institution	Journals	Score	Prev. rank
1	Carnegie Mellon/SEI	All	24.17	1
2	Korea Adv. Inst. Sci. & Tech.	All but TOSEM, TSE, SW	21.20	3
3	National Chiao Tung University	All but TOSEM, SW	17.50	2
<b>4</b>	<b>Fraunhofer IESE</b>	<b>All but TOSEM</b>	<b>16.74</b>	<b>6</b>
5	Bell Labs, Lucent	All	15.23	4
6	Seoul National University, Korea	All but TOSEM, SW	14.00	8
7	City University, Hong Kong	All but TOSEM	13.48	7
8	Iowa State University	All but TOSEM, SW	11.40	-
9	Microsoft	All but TOSEM, SW	11.28	-
10	National University of Singapore	All but TOSEM, SW	10.85	5
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**4th Place for Fraunhofer IESE!**  
Now the goal is to stay at the top.

**Fraunhofer IESE further improves international top position!**

According to the ranking performed by the internationally renowned "Journal of Systems and Software", Fraunhofer IESE continues to be the best European research institution in the area of software and system engineering. Globally, it is ranked in 4th place; only institutions with much more personnel are ranked higher than Fraunhofer IESE, such as Carnegie Mellon University / SEI in the United States, which is ranked first.

In last year's ranking, there was also no other European research institution in the area of software and system engineering that was ranked higher than Fraunhofer IESE. After the very good sixth place in the worldwide ranking

last year, Fraunhofer IESE's executive director, Professor Rombach, is particularly pleased with the new jump to fourth place: "We owe this superior position to our excellent researchers, who have made great scientific achievements during the past five years and published them. It was hard for us to imagine that we would be able to surpass much larger institutions such as Bell Labs. Now we must make every effort to maintain this position."

The index of the Journal of Systems and Software counts the scientific publications of the past five years in the six most renowned scientific journals in the area of software and system engineering. Fraunhofer IESE's publications led to a 15% improvement in this index, which enabled it to jump to a higher rank.

# Fraunhofer IESE and its Network Partners

## Collaborations

Fraunhofer IESE fulfills its mission of applied research and technology transfer through close collaboration with users of software engineering technology, providers of new technologies, and strategic partners in national and international collaborations. Thus, IESE actively promotes further development of software engineering technology and its transfer into industrial practice.



## International Research Networks

Fraunhofer IESE is a member in several international research associations. The **International Software Engineering Research Network (ISERN)** with approx. 35 members from science and industry plays an important role in Fraunhofer IESE's international research collaborations. ISERN is a forum for applied software engineering researchers for exchanging the latest research results and experiences. Leading research institutions within ISERN include the University of New South Wales, Australia; the Fraunhofer Center for Experimental Software Engineering, Maryland (FC-MD), USA; the University of Lund, Sweden; Tor Vergata University, Rome; the University of Bari, Italy; the University of Strathclyde, Scotland; the University of Hawaii; the University of Maryland; the Nara Institute of Science and Technology, Japan, and VTT in Oulu, Finland. Fraunhofer IESE is the coordinator

of the ISERN network. In addition, Fraunhofer IESE is affiliated with the Center for Empirically Based Software Engineering (CeBASE), a project of the National Science Foundation (NSF) in the United States. Other CeBASE members include FC-MD, the University of Maryland, the University of Southern California, Mississippi State University, and the University of Nebraska-Lincoln.

Bilateral research and exchange programs for students and scientists exist with renowned institutions such as the Experimental Software Engineering Group at the University of Maryland, the Center for Software Engineering at the University of Southern California, the Software Engineering Institute (SEI) of Carnegie Mellon University, Pittsburgh, Carleton University in Toronto, the University of Calgary, Canada, the National ICT Australia Ltd (NICTA), Sydney, and the Software Quality Institute at Griffith University in Australia.

International competence networks promote global scientific exchange – not only virtually.



### Publicly-funded Collaborations

Fraunhofer IESE is the coordinator of the national network [software-kompetenz.de](http://www.software-kompetenz.de), a project funded by the German Federal Ministry of Education and Research.

- Fraunhofer-Institut für Software und Systemtechnik ISST ("Fraunhofer Institute for Software and Systems Engineering"), Berlin



The partners are

- Brandenburgische Technische Universität ("Brandenburg University of Technology"), Cottbus
- Fraunhofer-Institut für Rechnerarchitektur und Softwaretechnik FIRST ("Fraunhofer Institute for Computer Architecture and Software Technology"), Berlin
- Fraunhofer-Institut für angewandte Informationstechnik FIT ("Fraunhofer Institute for Applied Information Technology"), St. Augustin
- Fraunhofer-Institut für Experimentale Software Engineering IESE, Kaiserslautern
- Fraunhofer-Institut für Informations- und Datenverarbeitung IITB ("Fraunhofer Institute for Information and Data Processing"), Karlsruhe

- Oldenburger Forschungs- und Entwicklungsinstitut für Informatik-Werkzeuge und -Systeme OFFIS ("Oldenburg Research and Development Institute for Computer Science Tools and Systems"), Oldenburg
- Institute for Computer Science IV, Technical University of Munich, Munich

The mission of ViSEK is to provide German software developing organizations with fast and simple access to the latest and most appropriate methods for developing software according to engineering principles. Its primary goals are the establishment of a community of software engineering experts and professional users as well as the creation of an Internet portal that makes the ViSEK partners' expert knowledge accessible to the more than 20,000

software developing companies in Germany. The portal or virtual competence center thus provides the basis for successful knowledge transfer between research and industry.

On the European level, Fraunhofer IESE is the coordinator of the **Experimental Software Engineering Research Network (ESERNET)**. The main objective of ESERNET is to establish and maintain Europe's leadership position in experimental software engineering as an essential catalyst for the rapid and sustained improvement of European software competencies. It is funded by the European Commission in the context of the 5th Framework's IST program.

Furthermore, there are collaborations with several other publicly-funded consortia. These either deal with further development of software engineering technology or with the dissemination of best practices and technology transfer. Often, these projects result in bilateral, industrially-funded collaborations. Public project sponsors include the state government of Rhineland-Palatinate, the German federal government, and the European Commission.

Further information:

[www.software-kompetenz.de](http://www.software-kompetenz.de)

[www.esernet.org](http://www.esernet.org)

### Industrially-funded Collaborations

Fraunhofer IESE's industrial cooperation partners range from global players to small regional companies. They can be grouped into four categories:



- Large national and international organizations looking for support in their mid- to long-term strive for quality improvement in software development.
- Large national and international organizations with their own R&D department, who are looking for competent research partners.
- Medium-sized enterprises, who want to establish improvement programs or that must implement technology changes under very tight budget- and schedule constraints.
- Small companies, who want to use proven technology that yields short-term return-on-investment.

In addition to the bilateral collaborations, Fraunhofer IESE and FC-MD are the organizers of a worldwide consortium consisting of globally operating organizations – the Software Experience Center (SEC). SEC is an association of organizations who want to expand their software engineering competencies on a global scale. In SEC, companies exchange experience across various locations and business areas, and in cooperation with other leading organizations from their own application domain as well as from other domains.

### Specialized Services for SMEs

The Competence Center for Software Technology and Training (KSTW) offers services that are custom-tailored to small and medium-sized enterprises. Services focus on fundamental software engineering practices such as requirements engineering, systematic testing, inspections, etc. KSTW's software competence kit ("Baukasten Software Kompetenz") allows for individual consultation, including self-assessment workshops, systematic business process modeling, problem analyses based on ISO 15504/SPICE, and customized continuing education measures for employees.

The recently founded Research Lab for SMEs (which was established with funds from the state of Rhineland-Palatinate and the European Commission/EFRE) offers clusters of SMEs an opportunity to jointly work on one software engineering research topic. The focus is on establishing an infrastructure for adapting software engineering topics to the special needs of SMEs, and also includes preparations for transferring such topics to SMEs.

# The Fraunhofer-Gesellschaft

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### Fraunhofer Locations in the USA

Boston, Massachusetts  
 College Park, Maryland  
 Newark, Delaware  
 Pittsburgh, Pennsylvania  
 Plymouth, Michigan  
 Providence, Rhode Island

### Fraunhofer Locations in Asia

Beijing, China  
 Jakarta, Indonesia  
 Singapore  
 Tokyo, Japan

### Fraunhofer Locations in Europe

Brussels, Belgium

The Fraunhofer-Gesellschaft undertakes applied research of direct utility to private and public enterprise and of wide benefit to society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration. The organization also accepts commissions and funding from German federal and Länder ministries and government departments to participate in future-oriented research projects with the aim of finding innovative solutions to issues concerning the industrial economy and society in general.

By developing technological innovations and novel systems solutions for their customers, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. Through their work, they aim to promote the successful economic development of our industrial society, with particular regard for social welfare and environmental compatibility.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their

institute, in other scientific domains, in industry and in society.

At present, the Fraunhofer-Gesellschaft maintains some 80 research units, including 58 Fraunhofer Institutes, at over 40 different locations in Germany. The majority of the roughly 12,500 staff are qualified scientists and engineers, who work with an annual research budget of over 1 billion euros. Of this sum, more than €900 million is generated through contract research. Roughly two thirds of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. The remaining one third is contributed by the German federal and Länder governments, partly as a means of enabling the institutes to pursue more fundamental research in areas that are likely to become relevant to industry and society in five or ten years' time.

Affiliated research centers and representative offices in Europe, the USA and Asia provide contact with the regions of greatest importance to present and future scientific progress and economic development.

The Fraunhofer-Gesellschaft was founded in 1949 and is a recognized non-profit organization. Its members include well-known companies and private patrons who help to shape the Fraunhofer-Gesellschaft's research policy and strategic development.

### Executive Board

(as of 31 December 2004)

Prof. Dr. Hans-Jörg Bullinger  
President, Corporate Policy and Research

Dr. Alfred Gossner  
Finances and Controlling (incl. Business Management, Purchasing, Real Estate)

Dr. Dirk-Meints Polter  
Human Resources and Legal Affairs

Prof. Dr. Dennis Tschritzis  
Chief Information Officer (CIO),  
International Business Development



The man behind the name:

#### Joseph von Fraunhofer

The Fraunhofer-Gesellschaft owes its name to Joseph von Fraunhofer (1787-1826), the successful Munich researcher, inventor and entrepreneur.

Born of a family of modest means, the glass-grinding apprentice Joseph von Fraunhofer joined the institute for optics headed by privy councillor Joseph von Utzschneider, who put the young researcher in charge of glass manufacturing at the early age of 22. Joseph von Fraunhofer's major developments include new methods of glass production and processing.

The optical instruments he himself developed, such as the spectrometer and the diffraction grid, enabled Fraunhofer to conduct fundamental research in the fields of light and optics. He was the first scientist to measure the spectrum of sunlight and characterize the appearance of the dark absorption strips: the "Fraunhofer lines".

## Fraunhofer IESE Alliances



### Fraunhofer eGovernment Center

The Fraunhofer eGovernment Center consists of seven Fraunhofer institutes offering services for e-Government in Germany and Europe on the basis of the synergies of their individual competencies, which range from application knowledge and technology know-how to solution development.

Each institute involved has many years of experience in the areas of technology and application, and collaborates in various e-Government application projects. As regional representative of the eGovernment Center in Rhineland-Palatinate, Fraunhofer IESE supports government agencies as well as software developing organizations in establishing, expanding, and improving their e-Government services. In particular, the following services are offered: support in strategy determination and execution of feasibility analyses, quality assurance and support of realization projects (with special consideration of

system architecture, usability, and IT security issues) as well as support in establishing e-Government know-how. In order to guarantee optimal coverage of the technological and application-related issues, the projects are performed in cooperation with other institutes of the Fraunhofer eGovernment Center on a case-by-case basis.

The Fraunhofer eGovernment Center is manufacturer-independent. The services offered range from consulting and assessment services to technology evaluation, re-organization of business processes, software development and implementation, evaluation and development of security solutions, to project performance, quality assurance, standardization support, and know-how transfer.

#### Contact at Fraunhofer IESE

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### Fraunhofer Group Information and Communication Technology

The Fraunhofer Group Information & Communication Technology consists of fourteen Fraunhofer institutes with more than 3,000 employees, and has an annual budget of over €190 million. This makes it the largest research association for information and communication technology in Europe and one of the largest in the world.

The value-creating chain of the information and communication technology domain is covered broadly by the complementary foci of the member institutes (New Generation Internet, multi-modal dialogs and new media, knowledge and content engineering, IT security, computing and biology, simulation and virtual engineering, innovative applications and I&C-based services).

Within the Fraunhofer Group Information & Communication Technology, Fraunhofer IESE is particularly active in the areas of e-Government, IT security (e.g., in the context of the E-Security Network) and software engineering (systematization of requirements; modeling and design of distributed, parallel,

and embedded systems; development of methods and tools, structural assessment of organizations regarding I&C). In addition, Fraunhofer IESE, together with the Virtual Software Engineering Competence Center (which can be accessed on the Internet via [www.software-kompetenz.de](http://www.software-kompetenz.de)), bundles the know-how of more than 500 experts who implement new technologies in practice in a sustainable manner.

The Fraunhofer Group Information & Communication Technology makes its competence portfolio available to partners from industry and government. The range of services offered includes custom-tailored IT solutions, competent technology consulting as well as advance research for new products and services. Through international research programs, the member institutes are part of a worldwide network of business and research organizations in the information & communication technology domain.

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**Fraunhofer Traffic and Transportation Alliance**

Since March 2003, the Fraunhofer Traffic and Transportation Alliance has brought together sixteen Fraunhofer institutes with various competencies for coping with traffic- and transportation-related issues. In March 2004, this alliance was strengthened further through the addition of five more Fraunhofer institutes.

The members of the alliance aim at developing and implementing suitable technical and conceptual solutions for public and industrial customers through interdisciplinary research.

By cooperating closely on related issues, holistic and demand-oriented system

and alliance solutions as well as new application areas can be developed in the area of traffic and transportation through know-how transfer.

Fraunhofer IESE's contribution to the alliance consists of its competencies in planning and designing complex systems, which are needed, for example, for distributed traffic management solutions. In addition, there are various application possibilities for solutions originating from the Ambient Intelligence research focus, particularly in the areas of freight transport and logistics.

**Contact at Fraunhofer IESE**

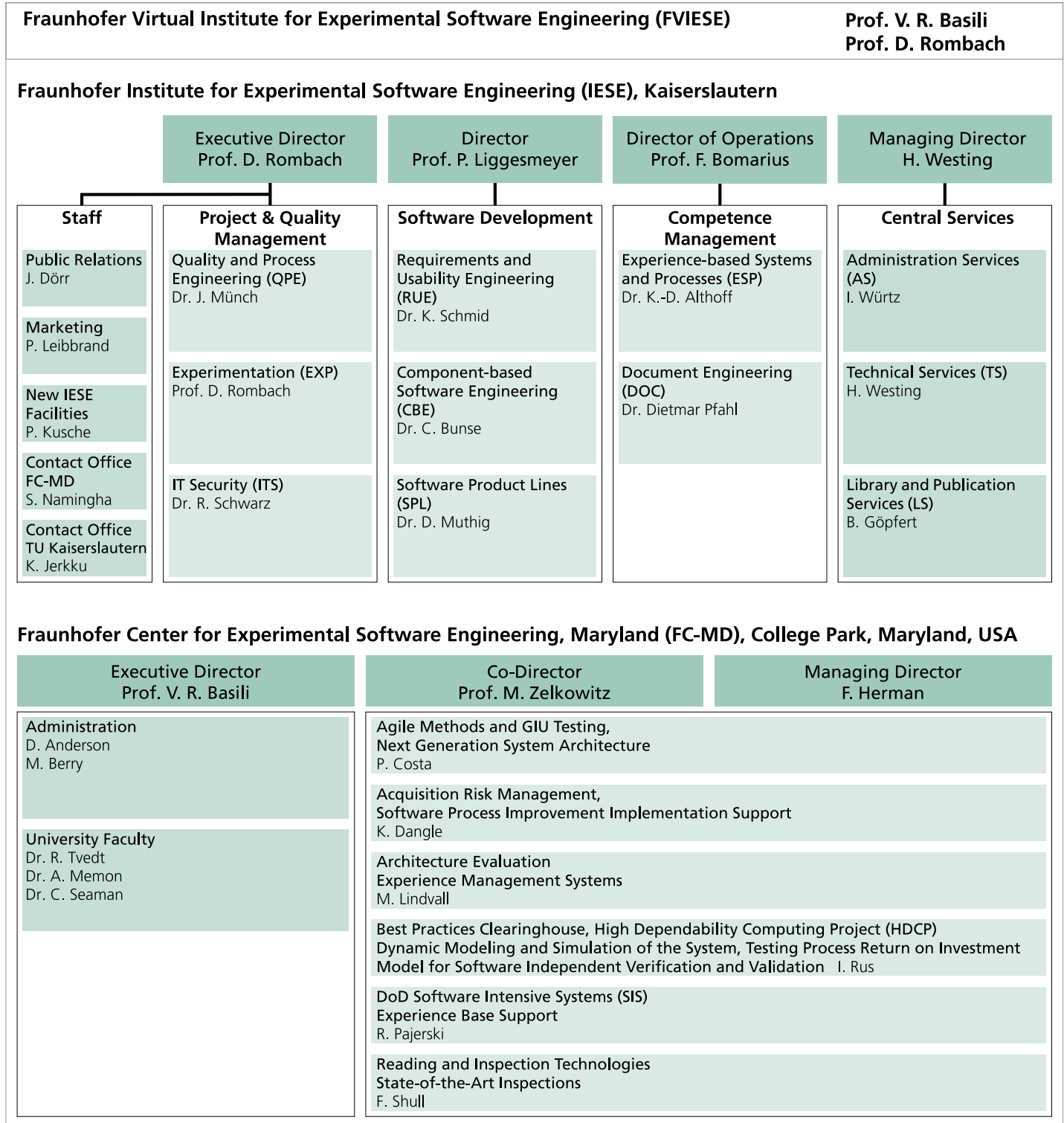
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**On the dot:**  
Punctuality as the result of the right traffic and mobility strategies.

# Organizational Structure



## The Fraunhofer Virtual Institute for Experimental Software Engineering

The Fraunhofer Virtual Institute for Experimental Software Engineering, FVIESE, includes two partner institutions: the Fraunhofer Institute for Experimental Software Engineering (IESE) in Kaiserslautern and the Fraunhofer Center for Experimental Software Engineering, Maryland (FC-MD) in College Park, Maryland, USA. Both institutions are legally independent entities of Fraunhofer-Gesellschaft e. V. and Fraunhofer USA, Inc., respectively. The institute directors of Fraunhofer IESE and Fraunhofer Center Maryland FC-MD jointly coordinate FVIESE.

## Departments and Business Areas

To ensure efficient execution of daily operations, the FVIESE institutes – Fraunhofer IESE and FC-MD – are organized into four departmental units plus staff functions, which constitute the institutes' line structures. The Fraunhofer IESE line structure is complemented by a two-dimensional matrix structure. One dimension is assigned to the "Departments", each of which focuses on a cluster of research themes. The other dimension of the matrix is allocated to so-called "Business Areas", each of which is motivated by a group of related customer problems. The departments are dedicated to developing innovative software engineering methods, technologies, and tools, to proving their benefit, and to systematically packaging their research results. Research is typically carried out within public or Fraunhofer base-funded projects. While the departments thus prepare the ground for technology transfer, the business areas are devoted to applying the technologies in industrial practice and to initiating their large-scale roll-out:

- Reliable Software for Embedded Systems
- Secure Software for IT-Infrastructures and -Providers
- Flexible Software for IT-supported Business Processes
- Software-based Products and Services

The business areas are thus responsible for acquiring, setting up, and monitoring industrial projects, for continuously observing and analyzing market needs, for spotting new business opportunities, and for feeding market requirements back to the departments. Each Fraunhofer IESE scientist belongs to one department and is dynamically assigned to business area projects. Business areas are thus virtual units with no personnel resources of their own (apart from the Business Area Managers), which draw upon the departments for staffing customer projects. One member of the IESE Advisory Board is assigned to each department and to each business area, in order to provide continuous advice and guidance on strategic research and market-related issues.

Due to expanded requirements on flexibility voiced by the business areas, the so-called Competence Development Teams (CDTs) were created. Established for three years at a time, they are under the direction of a business area and are staffed with researchers from at least two departments. CDTs are funded through public projects and free research capacity of the staff (e.g., in the context of Ph.D. projects).

Competence Development Teams currently exist with a focus on Secure Systems, Safety, Ambient Intelligence Applications, Application-oriented Software Quality, Process Documentation, and Visualization of Software Systems.

## The Fraunhofer IESE Advisory Board

The Advisory Board consists of representatives of research, industry, and government. The board members support the Institute Directors with advice and counsel.

### Research

**Prof. Dr. Victor Basili**

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Department of Computer Science  
University of Maryland  
College Park, MD  
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**Prof. Manfred Broy**

Institute for Computer Science  
Technical University of Munich  
Munich

**Dr. Paul C. Clements**

Software Engineering Institute (SEI)  
Pittsburgh, PA  
USA

**Prof. Michael A. Cusumano**

Massachusetts Institute of Technology  
Sloan School of Management  
Cambridge, MA  
USA

**Prof. Dr. Werner Mellis**

Department of Information Systems  
System Development  
University of Cologne  
Cologne

**Prof. Jürgen Nehmer**

Department of Computer Science  
University of Kaiserslautern  
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**Prof. Helmut Schmidt**

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Carnegie Mellon University  
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Vice President Corporate Technology  
Siemens AG  
Munich

**Dr. Matthias Berg**

CEO, Pfaff Industrie Maschinen AG  
Kaiserslautern

**Dr. Klaus Grimm**

Director Software Technology  
DaimlerChrysler AG  
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**Wolfgang Jung**

Head of Development Center West  
T-Systems NOVA  
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**Dr. Michael Strugala**

Robert-Bosch GmbH  
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**Dr. Martin Verlage**

Director Online Products  
MARKET MAKER Software AG  
Kaiserslautern

**Dr. Thomas Wagner**

Head of the Advisory Board  
Executive Vice President, Corporate  
Robert-Bosch GmbH  
Stuttgart

**Dr. Hans-Ulrich Wiese**

Former member of the Executive Board  
of Fraunhofer-Gesellschaft e. V.  
Gräfelfing

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Director, Department of Research and  
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Mainz

**Dr. Ulrich Müller**

Director, Department of Research,  
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Ministry of Economy, Transportation,  
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**Dr. Bernd Reuse**

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### Fraunhofer-Gesellschaft

**Dr. Alfred Gossner**

Member of the Executive Board  
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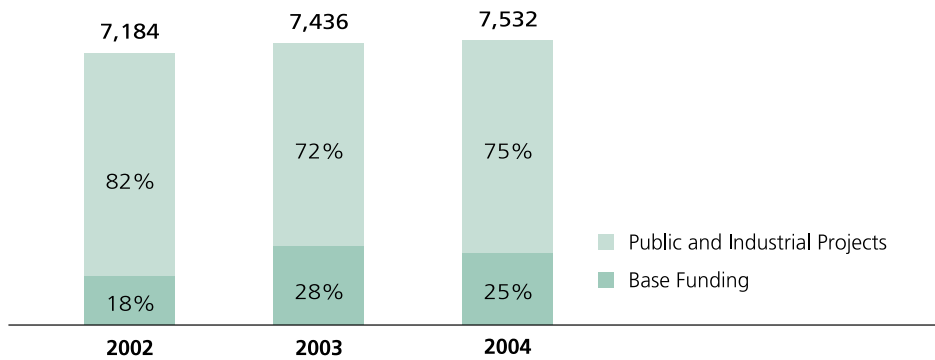
**Dr. Dirk-Meints Polter**

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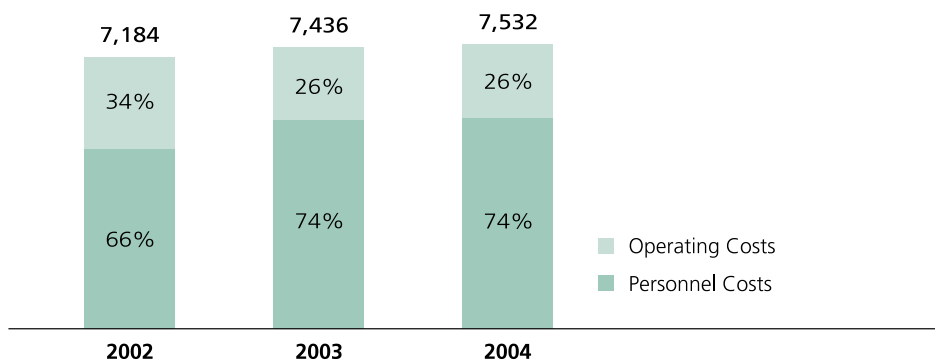
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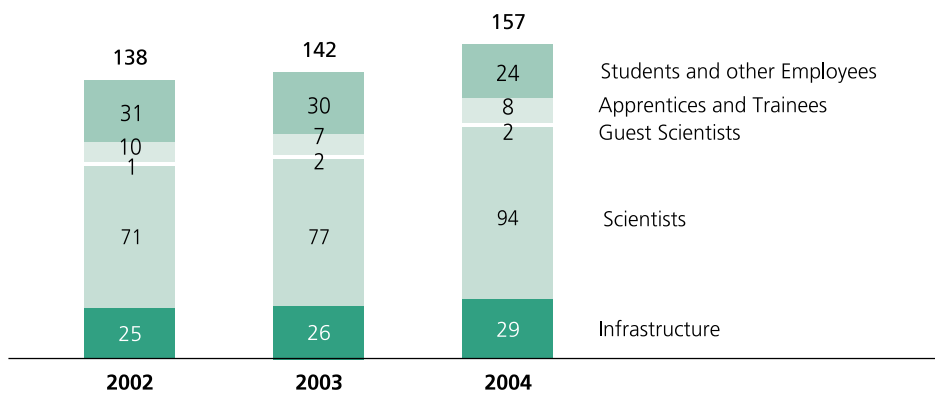
## Development of Personnel and Budget



Development of Budget (in T euro).



Development of Costs (in T euro).



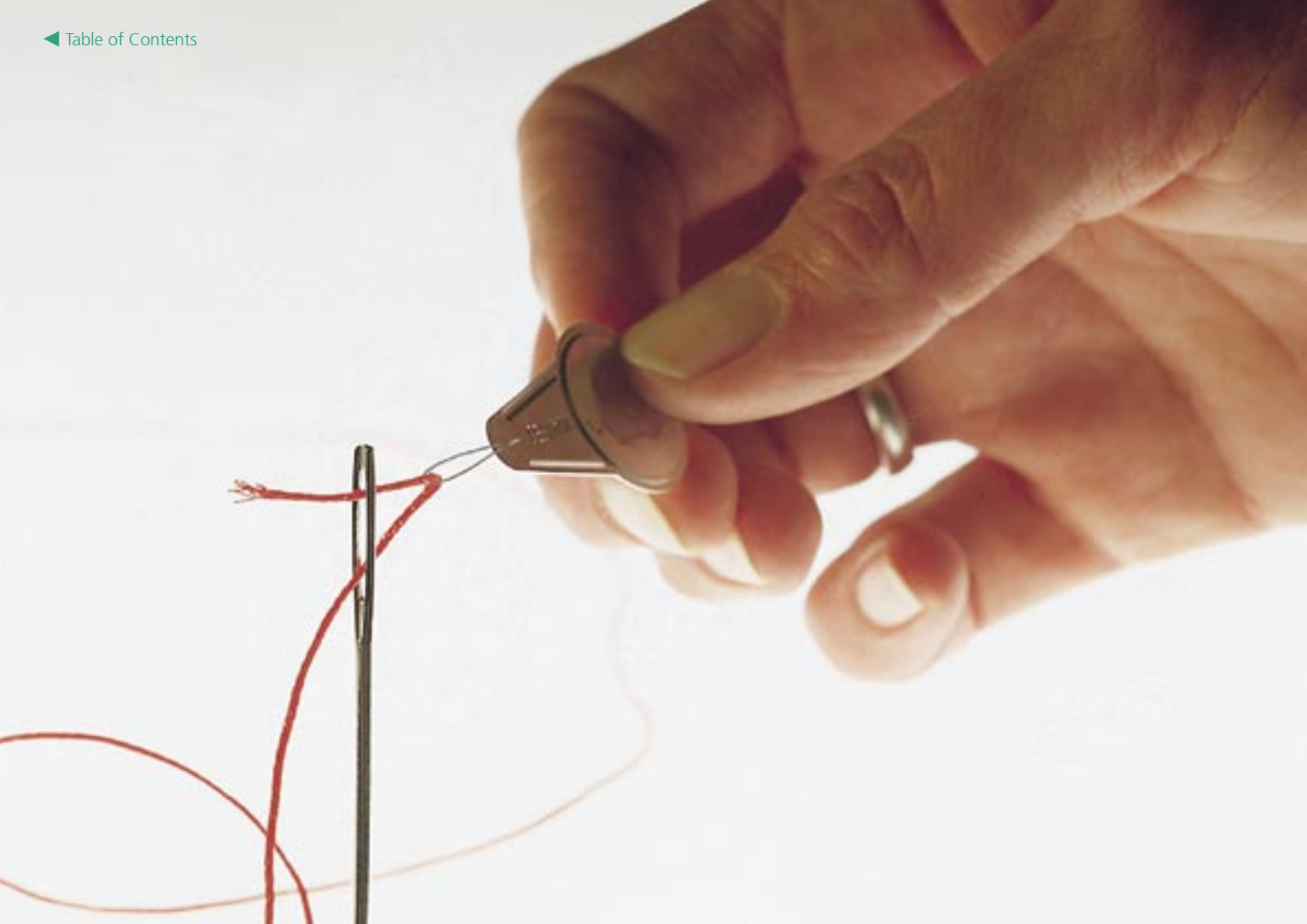
Development of IESE Personnel.

### Personnel and Budget Development

In the year 2004, IESE continued to pursue its strategy of moderate personnel growth regarding scientist positions. During the course of the year, IESE employed 157 people, including 94 scientists, 2 guest scientists, 24 student research assistants as well as 8 trainees and interns, with 11% of the employees coming from abroad. The percentage of female employees was 35%.

In 2005, the institute plans to further increase its scientific personnel in the course of reorganizing its departments.

The breakdown of overall costs into operational costs and personnel costs remained on the level of the previous year. It lies in the nature of a service-oriented institute that the majority (74%) of its expenses was spent on personnel.



# Departments

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## Experimentation (EXP)

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Prof. Dieter Rombach

**The systematic-experimental approach is one of the fundamental pillars of this institute. The added value of innovative techniques and methods becomes measurable when they are applied in industrial practice. This added value is often reflected in cost savings, higher quality, or faster time to market of new products.**

How software development methods and processes influence product quality, costs, and time depends on a multitude of human and organizational factors, which include experience, motivation, and the specific product life cycle. Empirical studies – from controlled experiments in research environments to case studies in industrial practice – are necessary for building reliable models of the mutual dependency of processes and products. Such models make it possible to select suitable methods and processes for a given project context. In addition, explicit process-product models can be optimized on the basis of project feedback that is based on measurement data. Numerous software engineering projects have benefited from such a data-based approach: examples include NASA's Software

Engineering Laboratory (50% reduction in costs, a prediction precision of  $\pm 5\%$  and zero defect delivery quality), Allianz and Bosch, where significant quality improvements were achieved. There are, however, also examples from small and medium-sized companies, such as MARKET MAKER Software AG, where the application of product line technology helped to significantly shorten development cycles.

The empirical work conducted at Fraunhofer IESE is based on central approaches: the "Goal/Question/Metric" method (GQM) for measurement, the "Quality Improvement" method (QIP) for project-based learning and improvement, as well as the "Experience Factory" method (EF) for experience management. All of these methods were originally developed together with our sister institute, the Fraunhofer Center Maryland. Later, the methods were refined and supporting tools and domain-specific technology transfer plans were added. In the meantime, the Fraunhofer IESE approach has evolved into the de facto standard for the introduction of innovative software engineering methods in industry. The competence team Experimentation (EXP) cooperates

with all other competence areas in preliminary empirical testing of innovative software engineering methods as well as their transfer into industrial practice. With its empirical approach, Fraunhofer IESE has become a globally competent partner in the areas of software engineering. It is, for example, a partner in the EASE (Empirical Approach to Software Engineering) project of the Japanese Ministry of Education (MEXT) as well as a consultant to the Japanese

Ministry of Economy, Trade and Industry (METI) on establishing a Software Engineering Center (SEC). Fraunhofer IESE's internationally renowned experimental competence is also reflected in the fact that it is in charge of the ISERN competence network, which consists approx. 35 globally leading research institutions, and which aims at furthering empirical methods and promoting empirical studies.

**We help you get started:**

Empirical studies for reliable models of the mutual dependency of processes and products.



## Requirements and Usability Engineering (RUE)

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Dr. Klaus Schmid

**If you want a wish to come true, you must say what you want. Sounds simple – in practice, however, software products often do not fulfill the expectations of customers and users. Requirements engineering with Fraunhofer IESE creates the basis for ensuring that software really does what it is intended to do.**

The correct and timely implementation of customer wishes is crucial for any organization's business success. Especially in the area of software development, however, the systematic elicitation, management, and tracing of requirements for the later product is often given too little consideration – with far-reaching consequences: If not enough investments are made during the requirements phase, problems will occur sooner or later, the latest when the customer has to accept the product. If the user's or the customer's expectations are not (completely) fulfilled, time- and cost-intensive rework on an already finished product becomes unavoidable. Experience has shown that correcting defects or failures in a delivered system costs 10 to 100 times more than recognizing them during the requirements phase. If requirements were properly elicited, these costs can be avoided in the subsequent implementation; costly corrections are unnecessary.

The department Requirements and Usability Engineering (RUE) at Fraunhofer IESE develops solutions in the areas of software requirements and usability and supports their transfer into industrial practice. The focus is on both user requirements and technical innovations; this helps to increase the satisfaction of all stakeholders in the product and process. At the same time, costs for development and rework, as well as user support and training are reduced. Systematic requirements and usability engineering with the cooperation of Fraunhofer IESE therefore pays off for an organization in multiple ways and results in a significant competitive edge.

The requirements engineering method RE-KIT (Requirements Engineering with Emphasis on Knowledge Management, Interface Specification, and Traceability) developed at Fraunhofer IESE supports communication and knowledge management in software projects and products during the requirements engineering phase. It provides proven techniques for elicitation, specification, validation, and management of functional and non-functional requirements as well as a tailorable procedure for the assessment and improvement of requirements processes.

Despite all technical correctness of a software, one must not forget the user – quality is also reflected in the usability



**Don't worry about what to choose:**  
 Rigorous requirements engineering gets software projects on the right track from the start.

of a program or a software-based technical product. In order to provide optimal support for the developer in creating user-friendly systems, Fraunhofer IESE offers special usability engineering techniques, which focus in particular on the elicitation and definition of usable processes and tasks.

Customized variants of these techniques have been successfully applied in different domains and in companies of various sizes. Examples include projects in the area of e-Government, automotive systems, and telecommunications.

Another focus of the department RUE is on innovative areas such as systems that can recognize user needs on their own and adapt to them ("Ambient Intelligence"). In addition, this Fraunhofer IESE department evaluates, improves, and packages experiences and techniques with new software engineering trends such as agile processes.

Further information:

RE-KIT  
[www.iese.fraunhofer.de/re-kit/](http://www.iese.fraunhofer.de/re-kit/)

## Component-based Software Engineering (CBE)

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Dr. Christian Bunse

**You want modular software development, increased performance, and safety, and still save on development costs? Fraunhofer IESE's modern component technology makes it possible – even for embedded systems!**

The functionality of technical products increasingly depends upon control software embedded in these products, which is almost completely responsible for the behavior of these products. In addition to functional requirements, embedded control systems must fulfill stringent non-functional requirements such as performance, safety, and reliability.

The department "Component-based Software Engineering" (CBE) offers a portfolio of synergistic software engineering techniques that individually, or collectively, help to systematically develop component-based software systems, with a specific focus on embedded and real-time systems.

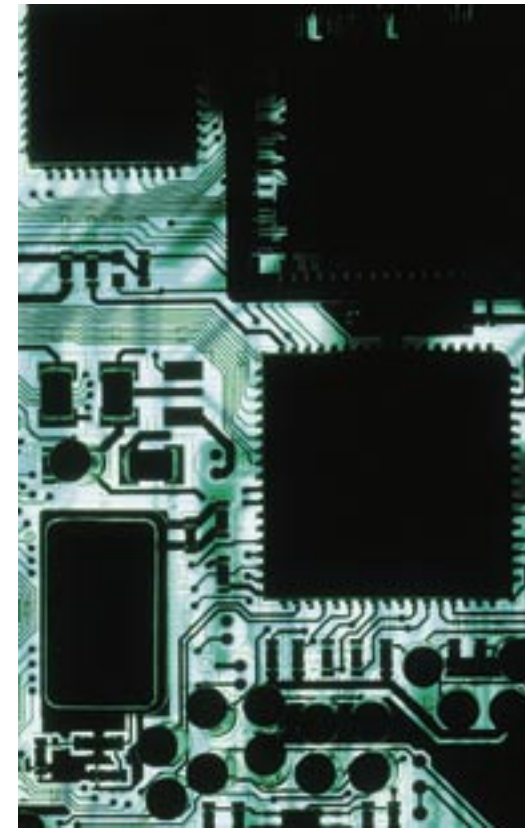
Through its model-driven, UML-based representation of software components, the Kobra method developed

at IESE offers systematic support for component-based principles during the entire software life cycle – including the reuse of components that are needed multiple times. Based on the Kobra method and on the principles of component-based software engineering, the CBR department aims at supporting IT organizations in systematically building embedded systems and real-time systems. This includes all aspects with regard to strategy, organization, management, methodology, and implementation.

Building on the Kobra method, Fraunhofer IESE's department CBE has developed the MARMOT approach especially for embedded systems. MARMOT is completely based upon the Kobra method, and fully subsumes all Kobra principles and artifacts. However, MARMOT places strong emphasis on embedded and real-time concepts in object and component technologies such as software/hardware integration, response-time requirements, safety, and efficiency of the programs with regard to storage and computing power requirements. Furthermore, MARMOT allows such systems to be developed in an aspect-oriented way, whereby

**Building blocks for success:**

Individual chips complement each other to create a functioning system. The necessary software can also be efficiently developed from components.



non-functional characteristics such as timing or performance are regarded as aspects.

In the area of embedded systems, high software quality is vital, since defects can only be corrected with a disproportionate amount of effort – if at all – once the product has been shipped. Systematic quality assurance is needed for ensuring high-quality, reliable components. Therefore, MARMOT provides state-of-the-art inspection- and testing techniques. Examples are "Architecture Centric Inspections" (ACI), "Built-In Testing" (BIT-Composite), and evolutionary and genetic algorithms (timing and performance analysis).

To demonstrate the practical applicability of these techniques, the department CBE has started an embedded system laboratory, which allows students and practitioners from research and industry to develop embedded systems (both hard- and software) under conditions that are as realistic as possible.

Further information:

Marmot  
[www.marmot-project.de](http://www.marmot-project.de)

KobrA method:  
[www.iese.fraunhofer.de/KobrA\\_Method/](http://www.iese.fraunhofer.de/KobrA_Method/)

BIT-Composite  
[www.component-plus.org](http://www.component-plus.org)

## Software Product Lines (SPL)

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Dr. Dirk Muthig

**Today, systematic reuse is an issue wherever complex systems are to be produced in large numbers. Product line approaches show their strengths where product portfolios with numerous variants obstruct the implementation of conventional reuse concepts.**

Product line development is currently seen as the most efficient answer to the challenges faced by many companies that develop software-intensive products: They must bring more and more products to market in increasingly shorter time intervals, with increasing complexity and at decreasing costs. Product line development enables an organization to make optimal use of its resources by establishing a strategic platform for software development. Such a platform deals with those properties that are common to several products, and offers a means for systematically managing product-specific characteristics. Therefore, product line development allows efficient development and maintenance of a large variety of products. This has proven to be extremely successful in many companies of various sizes and in various application domains.

The transition from single system development to product line development makes it necessary to change various aspects of the software life cycle. The solutions offered by the department Software Product Lines (SPL) at Fraunhofer IESE is PuLSE® (Product Line Software Engineering) – an approach that supports all product line-related activities, including all introductory transfer activities.

PuLSE® supports three orthogonal perspectives:

- Optimization of the product line with regard to an organization's economic goals
- Selection and implementation of suitable methods, techniques, and tools for implementing, using, and maintaining a product line platform
- Definition and evolution of a future-oriented (product line) architecture with systematic inclusion and integration of existing values

During the design of PuLSE®, attention was paid to developing the approach in an adaptable and modular way, in order to deal with various organizational contexts and constraints. Thus, the

introduction and application of product line technology can be done in the right places at the right times – flexibility as the result of practical experiences since 1998.

Fraunhofer IESE supports organizations in migrating their single system development to an optimal product line approach, i.e., suitable organizational and technical measures are identified and planned, and active support is provided for implementing them.

Further information:

PuLSE®

[www.iese.fraunhofer.de/PuLSE/](http://www.iese.fraunhofer.de/PuLSE/)

PuLSE® is a registered trademark of Fraunhofer-Gesellschaft.



**Similar – but not the same.**

Software product lines make systematic use of existing commonalities in order to efficiently develop families of products with numerous variants.

## Quality and Process Engineering (QPE)

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[www.iese.fraunhofer.de/Core\\_Compencies/](http://www.iese.fraunhofer.de/Core_Compencies/)



Dr. Jürgen Münch

**Innovative research results in the areas of project and quality management, optimization of organizational development processes, transparent project representation, and far-reaching safeguarding against risks characterize the areas of work of Fraunhofer IESE's department "Quality and Process Engineering" (QPE).**

We use model-supported project and quality management – based on quality centered measurements, systematic processes, and mathematically-based methods – to support software developing organizations in determining their improvement potentials and provide assistance both in the development of ratio systems and quantitative models and in the sustained implementation of improvements.

In order to perform a "Health Check" of your organization as well as of your projects and products, we offer the following services:

- Performance of ISO/IEC 15504 (SPICE)-conformant process assessments with our proven FAME approach and training/coaching of SPICE assessors
- Performance of customer-specific software product assessments with our adaptive M-System-Tool and the evaluation approach MORE
- Support in preparing for process assessments (e.g., IAW CMMI, SPICE)

Measurements of important ratios within a software process make the development more transparent, allow recognizing problems on time, and show ways for improvement. Quantitative models permit controlling of or even predicting software product and process characteristics. We develop and test such models and introduce them to organizations. Applied research for your benefit:

- Development and introduction of ratio systems with our established GQM (Goal-Question-Metric) approach
- Development of quality models for defining a QA strategy that enables quality assurance right from the start and that optimally coordinates software evaluation processes
- Size estimation of software systems with function points (IAW IFPUG or COSMIC-FFP) and cost estimation with our experience- and data-based CoBRA method
- Safeguarding against software development risks with the RISK-IT method
- Definition, performance, and analysis of benchmarking studies as well as performance of software engineering data analyses, e.g., with the OSR method (Optimized Set Reduction)

The sustained implementation of improvements is based on the Quality Improvement Paradigm (QIP), which helps to establish efficient processes and systematically support their evolution. We elicit, model, define, analyze, and optimize processes and process standards. In addition, we also offer the following range of services:

- Generation of consistent and current process documentation with customer-specific layout (handbooks, web guides, training materials, etc.)
- Establishment of effective and low-risk near- and offshoring processes through our Buy-IT Framework

Further information:

Process Assessments  
[www.iese.fraunhofer.de/fame/](http://www.iese.fraunhofer.de/fame/)

Product Assessments  
[www.iese.fraunhofer.de/more/](http://www.iese.fraunhofer.de/more/)

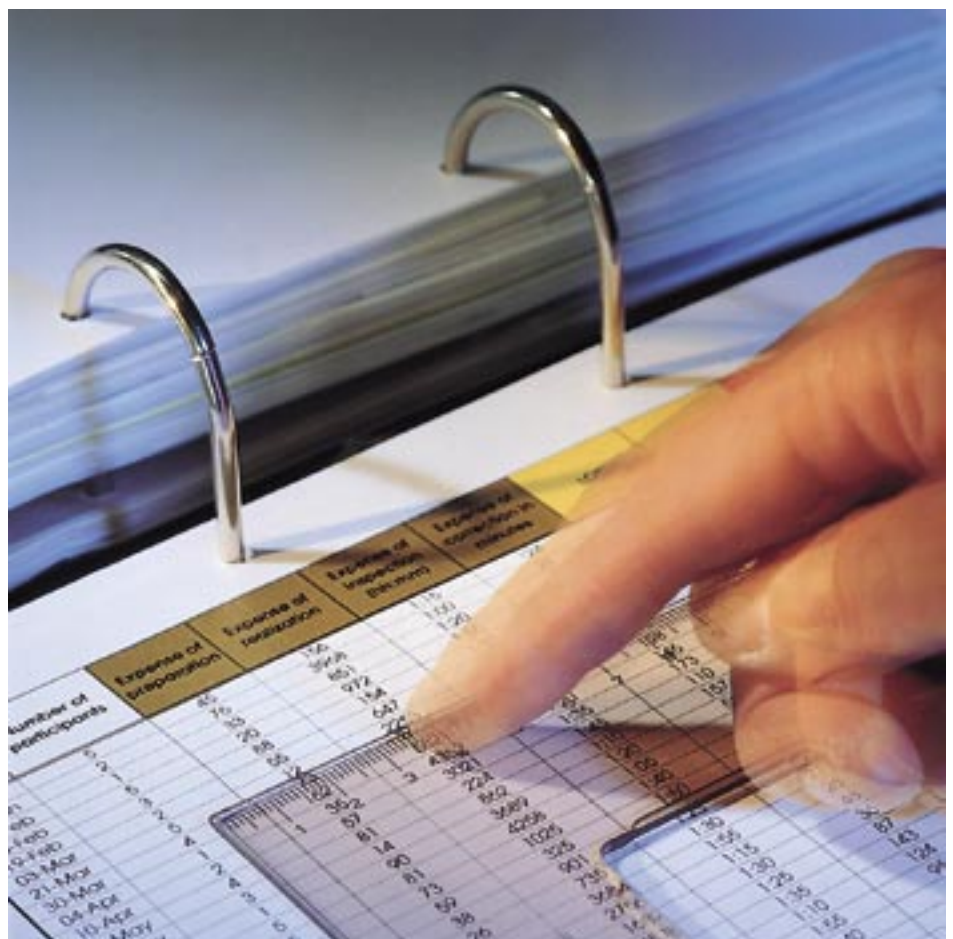
Cost estimation, risk management, risk analysis, benchmarking  
[www.iese.fraunhofer.de/COBRA/](http://www.iese.fraunhofer.de/COBRA/)

Data analysis  
[www.iese.fraunhofer.de/osr/](http://www.iese.fraunhofer.de/osr/)

Process documentation and management  
[www.iese.fraunhofer.de/vincent/](http://www.iese.fraunhofer.de/vincent/)

Nearshoring, offshoring, COTS selection  
[www.iese.fraunhofer.de/buyit/](http://www.iese.fraunhofer.de/buyit/)

**Exact measurements** of ratio systems with the GQM (Goal-Question-Metric) approach.



## Experience-based Systems and Processes (ESP)

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[www.iese.fraunhofer.de/Core\\_Compencies/](http://www.iese.fraunhofer.de/Core_Compencies/)



Dr. Klaus-Dieter Althoff

**Suitable processes and tools are necessary to turn experiences accumulated in an organization's daily work into knowledge that can be accessed at any time. Initiating professional experience management does not, however, need to be expensive or complicated – with Fraunhofer IESE you will find the optimal solution.**

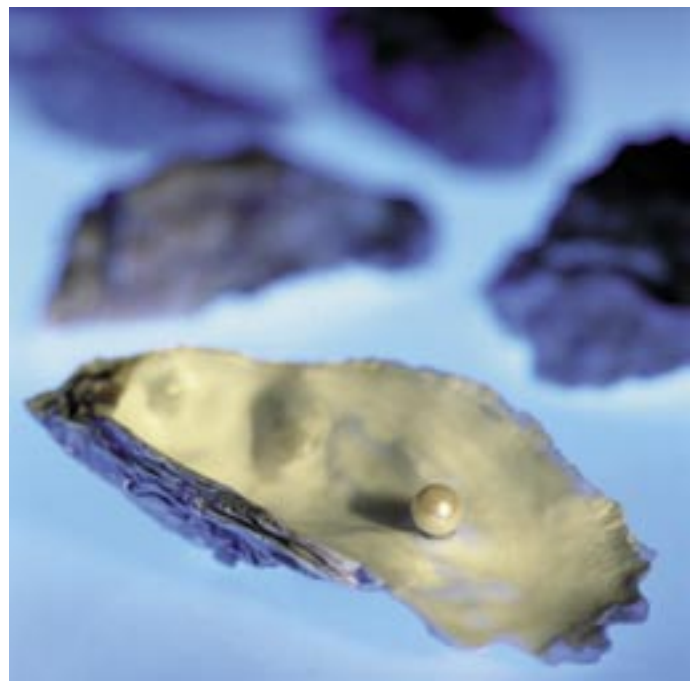
Experience is an important resource for the competent handling of challenging software development and maintenance tasks, as well as for making well-founded decisions. A software organization's competitiveness can only be assured if experience is packaged systematically.

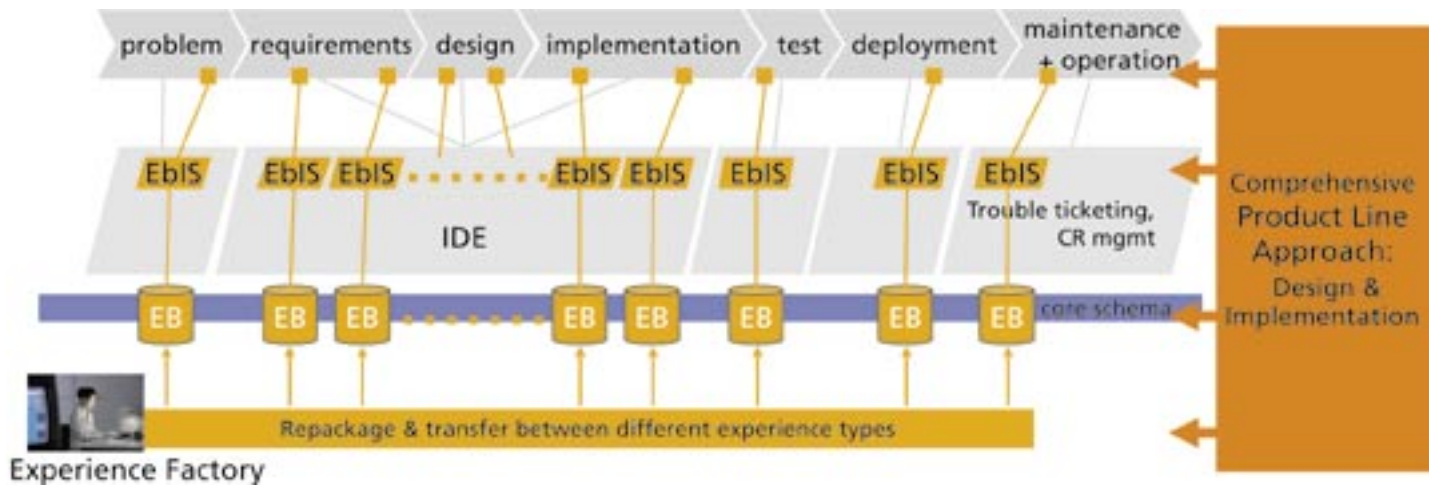
Experience management is an approach to distribute experience (that is, knowledge gained in a practical context) in the organization on demand, to prevent important steps from being forgotten in complex tasks, or to support a gentle path towards appropriate partial automation for frequently recurring tasks.

Experience-based Information Systems (EbIS) have a great usage potential, but even today, they still have to face problems regarding acceptance and costs. Current studies show that this is often related to the fact that knowledge management processes and tools are not sufficiently integrated with the business processes and tools. This leads to the impression that experience knowledge "is too far away by one click."

These problems are the subject of research and development in the department Experience-based Systems and Processes (ESP) at Fraunhofer IESE. The basic concepts include the Experience Factory and the Experience Feedback Loop. Whereas the Experience Factory looks mainly at the organizational aspects, the Experience Feedback Loop ensures close integration of business processes and experience management tools. Thus, experiences are introduced into daily work processes as automatically as possible and are actually being used. In addition, systematic evaluation and maintenance are closely interconnected with the use of experiences, in order to always keep these as up to date and consistent as possible.

**As valuable for an organization as a pearl –** the experience of its employees. With the right know-how, this experience optimally supports the workflows of an organization.





Connecting business processes with the Experience Factory.

This is the basis on which the department ESP offers a development methodology for Experience Factories (see illustration), which systematically considers all aspects from requirements via design and implementation to evaluation and maintenance, all based on a product line for EbIS solutions.

An important factor for the technical and economic success of experience management systems is the selection of appropriate and practice-proven processes and products, including those from the areas of Artificial Intelligence and Information Retrieval. Inappropriate processes and tools, on the other hand, easily lead to an increase in costs and a decrease in the success of a system. Our solution approach: Start off small and cost-efficiently, then scale up according to demand along our process and product portfolio.

The Experience Factory product line permits us to efficiently develop scalable and interoperable experience management systems and to act as competent consultants in setting up, evaluating, and operating such systems.

On the one hand, we concentrate on supporting software engineering (SE) processes and tools through close integration of experience management, SE processes, and SE tools (e.g., IDEs, CASE tools). The department ESP offers ready-made Experience Factory products for the software process, such as intelligent support for software inspections or the experience-based IT- / Software Failure Control Center.

On the other hand, we offer know-how in integrating experience-based features into software end products that offer intelligent user support.

Further information:

More information on the DISER methodology (Design and Implementation of Software Engineering Repositories) and INTERESTS (product lines for organizational information systems) can be found at

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

## Document Engineering (DOC)

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Dr. Dietmar Pfahl

**Knowledge means power! Get the all-decisive competitive edge with continuing education and training courses and learning software development methods made by Fraunhofer, a global player for applied research and development.**

Although software is extremely important for market success in all high-tech and service domains, competence development in the area of Software Engineering (SE) is often neglected. Concurrently, however, the demand for on-the-job- and on-demand qualification of people working in the area of SE is rising constantly, due to the increasingly shorter innovation cycles of software technology. One way of meeting this challenge is the establishment of effective and efficient SE learning systems that combine innovative e-Learning techniques with traditional ways of teaching ("Blended Learning" resp. "Dual Mode Learning"). In order to improve their effectiveness, SE learning systems must be tailored to the business processes, software application domains, individual SE competence profiles, and qualification requirements of a software organization. For controlling the efficiency of SE learning systems, measures must be taken for evaluating the success of e-Learning, assuring the quality of e-Learning products, and systematically reusing

continuing education content. Furthermore, the integration of e-Learning processes and infrastructures with current knowledge management solutions is a necessity if sustainable success is desired.

In its e-Learning laboratory, the department Document Engineering (DOC) performs research in several of these important areas and offers related services to software development organizations, providers of continuing education courses in the area of SE, and providers of SE content in general, for example in the context of the products IntView and QUALISEM.

The IntView product offers methods, techniques, and tools for efficiently developing high-quality learning software. What makes IntView special is the systematic, comprehensive, and continuous interweaving of relevant professional knowledge from the area of media didactics and media pedagogics with engineering-style processes in the development of software. In addition to the introduction of an integrated learning software development methodology, IntView also includes individual services such as the analysis and custom-tailored adaptation of methods, techniques, and tools already in use, as well as support in requirements engineering and quality assurance.

With the QUALISEM product, a "tool kit" for competence development, the DOC department offers a package of coordinated methods and techniques for efficiently analyzing the demand for continuing education in the area of SE, for evaluating learning software and learning infrastructures, as well as for assessing planned or previously introduced e-Learning and/or Blended Learning solutions.

Building on the methods of the products IntView and QUALISEM, the department DOC has started approx. one year ago to adapt or newly develop methods and techniques to support software developers in the generation, representation, consistency upkeep, maintenance, and evaluation of service and user documentation for software products. Service and user documentation does not only include instruction and installation manuals, but also help texts, mini-tutorials as well as all types of contents such as those appearing on the display of a software-based product.

Further information:

IntView – Systematic development of learning software  
[www.iese.fraunhofer.de/IntView/](http://www.iese.fraunhofer.de/IntView/)

Building Kit "Object-oriented Software Development with UML"  
[www.iese.fraunhofer.de/uml/](http://www.iese.fraunhofer.de/uml/)

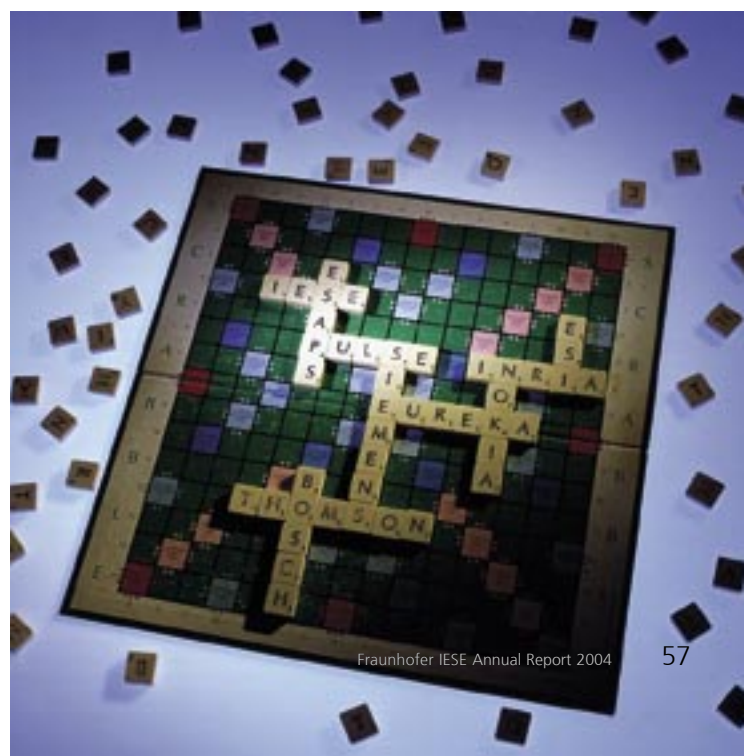
The Kobra-Method for Technical Managers  
[www.iese.fraunhofer.de/Products\\_Services/kobra\\_online/](http://www.iese.fraunhofer.de/Products_Services/kobra_online/)

ITW – IT Technical Writer  
[www.iese.fraunhofer.de/ITW/](http://www.iese.fraunhofer.de/ITW/)

Learning tour V-Model XT  
[www.kbst.bund.de/statisch/Lerntour\\_1.0/](http://www.kbst.bund.de/statisch/Lerntour_1.0/)

Please request information on QUALISEM directly from Fraunhofer IESE.

**Everything fits:**  
 Fraunhofer IESE's SE learning systems are custom-tailored to the business processes, software application domains, individual SE competence profiles, and qualification needs of a software organization.



## IT Security (ITS)

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[www.iese.fraunhofer.de/Core\\_Compencies/](http://www.iese.fraunhofer.de/Core_Compencies/)



Dr. Reinhard Schwarz

**Are you secure? Fraunhofer IESE will help you not to worry about this question. Whether you need consulting, checking, tool support, or strategy development: With our experts, you will always be on the safe side!**

IT security is an important issue for anyone who depends on information technology (IT). The department IT Security (ITS) at Fraunhofer IESE supports organizations in determining their long-term security strategy, in identifying and closing possible security gaps, and in maintaining secure IT operations. The services offered by the department ITS include methodology, tool support, and technical expertise, all aimed at fulfilling customer-specific security requirements.

Making IT infrastructures secure is a complex, time-consuming task – and experienced security personnel are rare. Fraunhofer IESE provides suitable tool support for improving the efficiency and effectiveness of security analyses and for using existing resources in an optimal manner.

One of the tools developed at Fraunhofer IESE is NIXE®, a flexible tool for performing cost-effective security audits on UNIX systems. The audit criteria can be individually set. If necessary, the tool can also derive these automatically from a secure reference system.

Another innovative tool for the systematic checking and improvement ("hardening") of router configurations is CROCODILE®. Further development of this interactive tool continues in close cooperation with our customers, such as Deutsche Telekom. CROCODILE® possesses a series of analysis and representation capabilities that are unprecedented so far. The tool is also suitable for larger evaluation campaigns in batch processing mode in accordance with freely configurable evaluation criteria.

Fraunhofer IESE supports its customers in the development of security-sensitive software by providing Secure Software Engineering methods and best practices. The objective is "Security by Design". We help developers to systematically capture security requirements and implement them in a reliable manner. Our test and audit methods contribute to quality assurance and help to recognize security risks and correct defects early on, before they can become a threat.

Fraunhofer IESE helps organizations in product areas where conformity with mandatory safety standards is essential, such as in the food or pharmaceutical industry. For instance, we support our customers in performing computer validation in accordance with relevant laboratory standards, or in dealing correctly with electronic data sets and signatures in accordance with FDA regulations.

**Risk recognized:**

The goal of Fraunhofer IESE is "Security by Design".

One general focus of our research is on reducing the dependency on the implicit knowledge and the intuitive skills of a small number of security experts. Fraunhofer IESE is working on providing decision-making support in key areas such as e-Government security or baseline IT protection. Techniques from the area of knowledge management make security know-how available to a larger group of employees through tools. On this issue, the department Experience-based Systems and Processes (ESP) is cooperating with ITS in developing system solutions for large municipalities.

**Further information:**

NIXE®  
[www.iese.fraunhofer.de/NiXE/](http://www.iese.fraunhofer.de/NiXE/)

CROCODILE®  
[www.iese.fraunhofer.de/crocodile/](http://www.iese.fraunhofer.de/crocodile/)

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# Reliable Software for Embedded Systems

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Ralf Kalmar

Advanced, high-quality software for embedded systems is one of the strengths of both German and European industry. Today, the use of software for competitive products is indispensable in many traditional engineering disciplines. Quality, reliability, and economic feasibility, in particular, are important quality aspects in this area.

The activities of the business area "Reliable Software for Embedded Systems" center around the special requirements of the following application domains:

- Automobile industry
- Mechanical engineering and Industrial Machines
- Industrial and Consumer Electronics

Furthermore, this Business Area also offers support to customers from the areas of

- Aerospace and defense industries
- Chemical and pharmaceutical industry
- Medical technology

All these domains are characterized by their need for high-quality software embedded in large heterogeneous systems. Standard conformant and cost efficient methods are necessary for producing secure, reliable, and easily expandable and/or adaptable software components.

The business area provides customer-specific solutions from the IESE portfolio for typical problems. This includes the following services:

- Support for the systematic, tool-supported elicitation of requirements. Specification of requirements documents.
- Introduction of product line software engineering. This makes it possible to shorten release cycles and reduce costs by improving the reuse of software components across the products of a product family. Furthermore, better synchronization of software and hardware development is facilitated.
- Security analysis of embedded systems with the new fault tree analysis methods as well as constructive quality measures to achieve high standards of security.
- Performance of software engineering process assessments (e.g., in accordance with ISO 15504).
- Preparation for external assessments according to the CMMI standard by means of document and process analysis, as well as support in necessary adaptations.
- Creation of prerequisites for outsourcing and offshoring. Technical support for subcontractor management and integration of current technologies such as Web Services, enabling an organization to concentrate on its core competencies and facilitating time- and cost-optimized product development.
- Development of company-specific ratio systems on the basis of software metrics in order to trace the projected quality goals for processes and products.

Further information:

[www.iese.fraunhofer.de/Business\\_Areas/](http://www.iese.fraunhofer.de/Business_Areas/)



### High-quality software for diagnosis and therapy:

Computer systems in medical technology must be reliable.

## Secure Software for IT-Infrastructures and -Providers

Flawless information processing has become vital for the fast, smooth progress of business and production processes. Today, one critical basis for nearly all organizations is the availability and correct functioning of their IT infrastructure. The growing use of telecommunication services and the increasing importance of e-Commerce applications will lead to an even higher dependency on IT in the future. Against this background, the business area "Secure Software for IT Infrastructures and Service Providers" deals with the special requirements of the following application domains:

- Telecommunications
- Telematics
- Infrastructure services (providers)

It is characteristic of these domains that they require a system environment that is not only highly scalable, available, maintainable, and flexible, but also extremely secure. For many of the typical problems associated with these critical requirements, we offer customer-specific solutions, such as:

- IT Security Audits: Performing IT security audits to identify security vulnerabilities and threats in the areas of network configuration, network workload, and server configuration. Support in defining adequate security goals and in implementing appropriate security measures.

- Evaluation of the development process through assessments of the (sub-)processes in an organization's software resp. system development.
- Constructive development support already in early phases: Definition of testable and measurable functional and, especially, also non-functional requirements. This includes, in particular, the areas of safety, reliability, performance, and maintainability – but also usability.
- Risk management: Introduction of risk management procedures aimed at continuous assessment of development risks and at the implementation of appropriate strategies and countermeasures in software development projects.
- Product lines: Introduction of product lines for the cost-efficient safeguarding of a stable and maintainable platform for current and future products.

Further information:

[www.iese.fraunhofer.de/Business\\_Areas/](http://www.iese.fraunhofer.de/Business_Areas/)



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Jörg Dörr

**Paying by card –**  
 comfortable for sure, but is it also secure?  
 Software engineering helps prevent bad surprises.

# Flexible Software for IT-supported Business Processes

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Michael Ochs

The Business Area "Flexible Software for IT-based Business Processes" mainly addresses three business domains:

- Banks and insurance companies, who want to enforce higher cost efficiency, maintain and improve product quality, and shorten development cycles, e.g., by harmonizing heterogeneous IT landscapes and architectures;
- Suppliers and their business partners, who want to optimize their workflow processes along the supply chain by making full use of the potential of Internet-based technologies (e-Business);
- Public and government institutions and their development partners, who want to optimize the efficiency and quality of administrative processes as well as the government services offered by using modern IT technologies (e-Government).

The services offered by Fraunhofer IESE include support for owners, developers, and users of software for banks and insurance companies as well as for e-Business and e-Government solutions in the following areas: IT security, usability engineering, process optimization, reuse-based software design and architecture, software project management, competence management, quality assurance, software acquisition, and business strategies

The services of the Business Area include:

- IT security audits and design of security strategies; architecture-centric software design, combining the benefits of software product line technology, model-driven architectures, and component-based development
- Design and implementation of technology-based learning environments and sustainable competence management
- Consulting with regard to outsourcing strategies as well as analysis and improvement of outsourcing scenarios
- Support in subcontractor management and COTS acquisition
- Integrated software project risk management; software process optimization
- Assessments and improvement of user interfaces.

Further information:

[www.iese.fraunhofer.de/Business\\_Areas/](http://www.iese.fraunhofer.de/Business_Areas/)



**Commerce, banks, insurance companies –**  
 Modern software engineering ensures smooth processes "behind the scenes".

## Software-based Products and Services

This business area deals with the special requirements of software organizations manufacturing software-based products or offering custom-tailored software solutions. The extended target group also includes IT consulting companies as well as companies that provide continuing education and training measures on these issues.

The customers of this business area are mostly small and medium-sized enterprises that do not maintain their own research departments, but expect an immediate return-on-investment at the same time. Fraunhofer IESE offers such companies innovation and research services in project-related collaborations and acts as a technology partner in customer projects.

The typical issues include:

- Requirements Analysis and traceable documentation of requirements
- Usability Engineering, i.e., for example, usability assessments of user programs or websites, including the design of systematic improvement programs

- Techniques and methods for the verification and validation of software systems, e.g., (semi-) automated testing of software resp. planning and execution of inspections in the context of the software development process
- Quality management, control, and assurance in connection with software development projects of various sizes
- Assessment and improvement of software processes, e.g., in accordance with ISO 15504 (SPICE), adapted to the special requirements of small and medium-sized enterprises (SMEs)
- Assessment and design of improvement measures for software products
- Expert reports, certification, evaluation of tools and technologies
- Software project management, individually supported by risk management and knowledge management
- Methods and techniques for technology-supported learning (e-Learning, Blended Learning), especially in the area of software engineering

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Dr. Volker Hübsch

- Evaluation of learning modules and learning platforms according to technological, functional, and content-related criteria resp. under the aspect of usability and human-machine-interface
- Skill Analysis and demand-oriented establishment of curricula for continuing education and training "on-the-job" resp. "near-the-job" in the area of software engineering

Further information:

[www.iese.fraunhofer.de/Business\\_Areas/](http://www.iese.fraunhofer.de/Business_Areas/)



**Success is not a question of size** – small and medium-sized enterprises, in particular, gain a significant competitive edge from engineering-style processes.



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## Technical Writer IT – Documentation Specialist in the area of Software

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Sonja Trapp



Ines Grützner

Fraunhofer IESE has been active in the area of web-based learning for quite some time. It focuses on providing software engineering-related special knowledge in the context of continuing qualification of IT professionals, who thus receive first-hand knowledge. This allows optimal use of the internal synergies of the institute through the interaction of content experts, multimedia instructional designers, and implementers. After various target group-specific offers on the Unified Modeling Language (UML) and the learning course on the KobrA methodology, a learning software has now been developed in the context of the project "Development and testing of modularized learning units for the profile 'Technical Writer IT – Documentation Specialist in the area of Software'", which is to be used especially for continuing education and training on the job.

The job profile "IT Technical Writer" is a specialized occupation that is already very much in demand: It describes an IT-oriented specialist for technical documentation in the widest sense. By the end of the project in October 2004, Fraunhofer IESE and its partner, the Software-Akademie AG Kaiserslautern (SWA AG), had designed and implemented 30 web-based learning units of 15-30 minutes processing time each. These learning units were then evaluated together with SWA AG in the context of a 6-week online evaluation, which included a detailed survey of more than 80 participating technical editors from industry and continuing

education institutions, and were then optimized on the basis of the lessons learned.

The development of the learning software was supported by the Federal Ministry of Education and Research (BMBF) in the context of the program "New Media in Education". This program especially promotes the development of learning programs and educational concepts following the methodology of work process-oriented continuing education and training. This methodology overcomes the separation between work and learning, which is often unavoidable in classic continuing education measures offered by companies. Learning is achieved by performing the work processes required for a specific job profile as well as by reflecting on and documenting the learning processes. With the support of so-called learning process tutors, the learners largely organize their learning processes themselves. This type of continuing education with interactive media supports the individualization of company-internal continuing education in accordance with the needs of individual employees and the requirements of their jobs. Maximal efficiency of the continuing education measure is achieved through the close relationship between working and learning.

Self-organized learning does not necessarily carry the negative connotation that the learner is left on his or her own. Being able to learn in a self-organized manner is a request often



**Technical Writer IT** – software documentation specialists receive comprehensive training in how to write professionally.

voiced by learners: One can determine the learning location, the time, the duration of learning, and the depth of learning by oneself, which is particularly important in the case of on-the-job qualification activities. However, this does not necessarily exclude group processes. Virtual team work and information exchange must be designed and organized with pedagogical care, as even virtual learning groups ("Communities") require structured processes. The use of qualified tutors has proven to be useful in this area. These tutors moderate the collaborative processes and encourage motivation for learning. In work process-oriented continuing education, this task can be assumed by

the learning process tutors. They are responsible for the optimal progress of the qualification measure and provide assistance in the individual design of the qualification process.

One of the central goals of the project is the orientation of the learning software towards use in self-organized learning on the job. Therefore, the contents to be taught were, for example, divided into a relatively large number of modules, and the required processing time per learning unit was strictly limited. This limitation takes into account internal and external studies of online learning courses, according to which individual sessions should not last for



IT Technical Writers are professionals in demand.

more than 30 minutes maximum, if they are to be integrated without problems into the learners' job environment. The learning contents are embedded into the realistic scenario of a project for developing a technical documentation. In numerous instructions, the learners receive many practical hints, which they can directly transfer into their everyday work. This is complemented by interactive exercises that allow the learners to assess and expand their knowledge. In addition, the learning units contain extensive examples from the field of technical writing as well as further information on how to study relevant topics on one's own.

The use of learning software (e-Learning) in work process-oriented continuing education offers major benefits: It can be designed in such a way that its contents perfectly match the work that needs to be done. The methodological learning arrangement for the use of learning software is designed in such a way that both the advantages of self-

organized learning and those of social learning can be optimally used. All of these factors were already recorded in detail before development began, and were continuously verified and validated during development.

The learning software was designed, implemented, and evaluated in close cooperation between Fraunhofer IESE and SWA AG according to the integrative method IntView for the development of systematic learning software, which was developed at Fraunhofer IESE. IntView takes into account technical, didactical, design-oriented, and organizational aspects of such an endeavor to the same extent, and is thus able, in particular, to correctly implement the dependencies that exist between these sub-areas.

By means of IntView, the learning arrangement in which the learning software is to be used can also be integrated into the development of the learning software. Therefore, it should be determined from the start, in detail, for which target group and for which usage purpose the software is to be developed, in order to avoid unnecessary costs and loss of time. The selection of the optimal didactical strategy for the use of the learning software is not only paramount for the design of the contents, but also for setting up navigation and planning community activities.

Further information:

IT Technical Writer  
[www.iese.fraunhofer.de/itw/](http://www.iese.fraunhofer.de/itw/)

IntView  
[www.iese.fraunhofer.de/IntView/](http://www.iese.fraunhofer.de/IntView/)

## The Regional Software Engineering Transfer Platform in Rhineland-Palatinate

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Dirk Hamann

The economic structure in Rhineland-Palatinate is strongly shaped by small and medium-sized enterprises (SMEs). More and more of these companies are turning into service companies and making their money from software-intensive services. Others produce products with a value adding proportion of embedded software of 50% and more – not counting those organizations who produce application programs for the primary software market. Faced with intensive competition, only companies using the newest methods, technologies, and tools in software engineering can operate with economic efficiency. But SMEs, in particular, generally lack the financial and personnel resources to adapt state-of-the-art research results to their own requirements and use them – let alone perform their own research activities. The personnel required for these activities would have to be withdrawn from current projects, or newly hired and trained – neither is feasible considering the high project pressure, tense financial situation, and low staffing levels of many companies in the region. Essentially concentrated in the universities and in application-oriented research institutes, the knowledge so urgently needed by IT SMEs often does not find its way into these companies' everyday operations.

In order to accelerate and intensify the technology transfer into these organizations and thus eliminate the competitive disadvantage of regional SMEs, funds were made available for building the infrastructure of a regional research platform for small and medium-sized enterprises in the western Palatinate region. These funds are provided in the context of the Goal 2 Program 2000 – 2006 by the Ministry of Economy, Transportation, Agriculture, and Vini-culture (MWVLW) of the state of Rhineland-Palatinate and the European Fund for Regional Development (EFRE). This research laboratory platform, which is to be created by the end of 2005, provides the physical and technical infrastructure, including the necessary personnel, for paving the way for quick, cost-efficient, and sustainable technology transfer within a limited topic area, ahead of future economic use. In such research labs, employees from different companies collaborate closely with Fraunhofer IESE researchers. The company representatives contribute the necessary application knowledge, while the software experts from Fraunhofer IESE contribute the technological know-how. Via the research lab platform, the knowledge from the research institutions that is needed for the technology transfer is made available for the development of innovative and marketable solutions in an uncomplicated manner, and in a way that is very cost efficient for the companies.

The platform consists of several research labs, each dealing with one concrete problem from the area of software engineering in long-term collaborations with regional companies. The results achieved are also being made available via a Web portal: Thus, even organizations who did not directly collaborate in the labs also benefit from the possibilities of technology transfer.

The research lab "Software Product Line Development and Usability", which has been in existence since mid-2003, deals with software product lines that decrease development costs through consistent reuse of existing components.

Since the adaptation of individual products to a customer's requirements can still be a complicated process, the user's business processes are used as a basis for the adaptation. Thus, a significant simplification can be achieved. This approach is essential for many organizations, since the ultimate goal of their software development is to provide support for business processes.

Business-based software adaptation is particularly efficient if easy-to-use and specialized modeling environments are available. This research lab serves to develop such modeling and adaptation environments – ideally, the user himself can then adapt the individual product from the product line to his own requirements.

Research is performed with a focus on selected SMEs. The results obtained provide the technological basis upon which a multitude of SMEs can be supported in the future.

The industrial partners collaborating on these issues include DCON Software & Service AG (Kaiserslautern), a3 systems GmbH (Zweibrücken) as well as m2k Informationsmanagement GmbH (Kaiserslautern).

A second research lab that was initiated at the beginning of 2004 is dedicated to the issues of "testing and test automation". An online survey on software tests in the industrial practice, combined with real interviews and performed mainly among small and

medium-sized enterprises, revealed significant demand with regard to methodological and technological support in this area.

After baselining the current state of the art, the goals of the industrial partners involved with respect to improvement of the processes used for software tests resp. test automation will be made more concrete during the course of the project, and concrete requirements for different test procedures (e.g., regression- or partial regression tests) and their automation will be worked out. At the same time, ratios will be determined to allow for future monitoring of the success of the improvement measures that were implemented.

During the subsequent realization phase, the participating organizations together with Fraunhofer IESE experts will develop methods and technologies resp. select appropriate tools for achieving fundamental improvement and optimization of the organization's own testing processes and, ultimately, an increase in the quality of the tested software products.

On the basis of the ratios defined together with the requirements, a very detailed statement on the future applicability of the results for SMEs from different perspectives can be given when the work in the SME Research Lab "Testing and Test Automation" is wrapped up. In addition to technical realization issues, economic aspects are particularly interesting. On the one hand, manual software tests cause significant effort, on the other hand, processes for automating them must also first be worked out and implemented.

Under which circumstances and in which periods of time is it worth to invest in automated testing procedures? Which optimization possibilities exist? These and similar questions are issues for the participants in the SME Research Lab "Testing and Test Automation": MARKET MAKER Software AG, verit Informationssysteme GmbH, and Wikon Kommunikationstechnik GmbH from Kaiserslautern together with the Fraunhofer IESE software experts.

In order to enable technology transfer before competition, the results of all SME Research Labs are made available via the project's Internet platform at <http://www.kmu.rlp-labs.de>. This platform will also offer a Community area, which can be used especially by regional small and medium-sized enterprises for exchanging information and experiences. Furthermore, lectures on SME-related topics with subsequent discussion are offered on a regular basis; the dates are published via the platform.

More software engineering research labs in the context of the Rhineland-Palatinate SME Research Platform are being planned. Representatives of regional organizations can submit topic proposals to the project office.

The SME Research Lab is being funded by the European Fund for Regional Development and by the State of Rhineland-Palatinate. Grant number MWVLW; Az.: 8315 38 51 04 IESE; chapter 0877 title 892 02.



## From Project-specific Development of Single Systems to the Reuse of Generic Components – Experiences with Software Product Lines at Robert Bosch GmbH

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Dr. Martin Becker

The control units for automobile manufacturing developed by Robert Bosch GmbH are so-called embedded systems, consisting of hardware and software. Just like the entire software developing industry, Robert Bosch GmbH can also only continue to keep up its competitiveness in the long term if they manage to further reduce costs, efforts, and time-to-market in software development. At the same time, equipment is becoming more and more complex, since it fulfills increasingly complex tasks in modern automobiles – with continuously high quality requirements. In addition, there is an increasing demand for customized products: More and more variants of these embedded systems must be produced for different control units. In order to be able to face these challenges, Robert Bosch GmbH has decided on using a product line approach.

Switching from project-specific development of single systems to product line development can normally not be accomplished in a single step. Therefore, Bosch has also pursued a step-wise migration strategy.

After a reference architecture for control units had been developed together with experts from the various project teams, the migration towards product line-oriented software development was performed. This included three steps: selection of suitable components, determination of the extent of the product line ("scoping") as well as modeling and implementation of the selected components according to the product line method PuLSE® developed at Fraunhofer IESE. In this process, the selected components were viewed sequentially and adaptations of the PuLSE® method to the specific development situation at Bosch were performed if needed.

In order to prove the applicability of the approach, it was first applied to two components that are required for all types of equipment and hardware platforms. Variability was thus motivated by technical as well as by application-specific aspects. Another advantage of the selected components was the fact that they consisted of a relatively small amount of code, and that they were well understood.



**Efficient:** Software development for the multitude of modern control units is made significantly easier thanks to the product line approach.

Scoping determined which "members" the product line should comprise and which properties the individual variants would have. For this, the set of existing variants of the two components, which were being used in already existing products, was analyzed. On the basis of this analysis, the software components of the planned product line were modeled and implemented in accordance with the product line method PuLSE® developed at Fraunhofer IESE. The components were designed generically, i.e., they contained explicit variation points according to the variable properties that had been identified. The resulting software variants did not only include code, but also a variant-specific

specification and a matching software design. Concentrating on particularly common and manageable components allowed realistically demonstrating the use of product line technology in all its aspects, examining the potential of the product line approach in the organization, and bringing as many employees as possible in contact with product line technology.

This planning and implementation of a product line based on two components was the first step towards product line-oriented development. It was shown that all variants demanded by the project partner could be generated, which proves the success of this project.



**Many variants:**

Practically all modern vehicles are equipped with electronic steering systems. Despite their variety, they are characterized by common functionalities, which can be systematically reused.

In addition to demonstrating technical feasibility, the adaptation of the PuLSE® method to the specific requirements of the organization was also validated. This was done in the following manner: In parallel to the implementation work at Fraunhofer IESE, software variants were also realized at Bosch on the basis of the generic specifications generated by Fraunhofer IESE, and the resulting artifacts and implementations were compared. In both cases, the specific product line components had been realized correctly. However, there was a difference in the quality of the technical implementation of the different solutions. Thus it seemed advisable to improve the technical product line capabilities in the customer organization in the context of further migration towards product line-oriented software development.

Encouraged by the positive experiences with the feasibility study, work towards a component-based product line covering all variants and components of the reference architecture was pursued consistently. Next, a component was selected that provides a significantly higher degree of functionality when compared to the first two components and that is crucial for the systems.

Due to the stringent resource constraints in the control units to be developed, this component had a very large number of variabilities. Thus, the development of this component turned into a practical test for the variability concepts of the PuLSE® method, which was passed well after minor modifications. After completion of the component, several component instances for various control units could be successfully derived within a short period of time.

In the next step, the approach is to be widely disseminated and applied at Robert Bosch GmbH. In the coming year, twenty reusable components are to be developed.

Further information:

PuLSE®  
[www.iese.fraunhofer.de/PuLSE/](http://www.iese.fraunhofer.de/PuLSE/)

# Software Engineering in e-Government: Development of a Web-based Geographic Information System (GIS) for Farmers in Rhineland-Palatinate

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## Situation

Every year, about 20,000 farmers in Rhineland-Palatinate apply for area-related subsidies. For this, the farmer lists his cultivated areas with their respective size and land parcel number. This information is provided partially on the basis of land register information obtained by the farmer from the appropriate land registry office, and partially on the basis of measurements performed by himself. The 2004 application year was the first time that the farmer received printouts of aerial photographs, where his areas under cultivation and the land register boundaries are marked. But he still can neither access the electronic geo-basis data of the Database of Agricultural Enterprises ('Landwirtschaftliche Betriebsdatenbank') of the state of Rhineland-Palatinate, which is the basis of these printouts, nor can he view his currently stored application data. Administration thus still has a major information advantage compared to the farmer.

## Goals

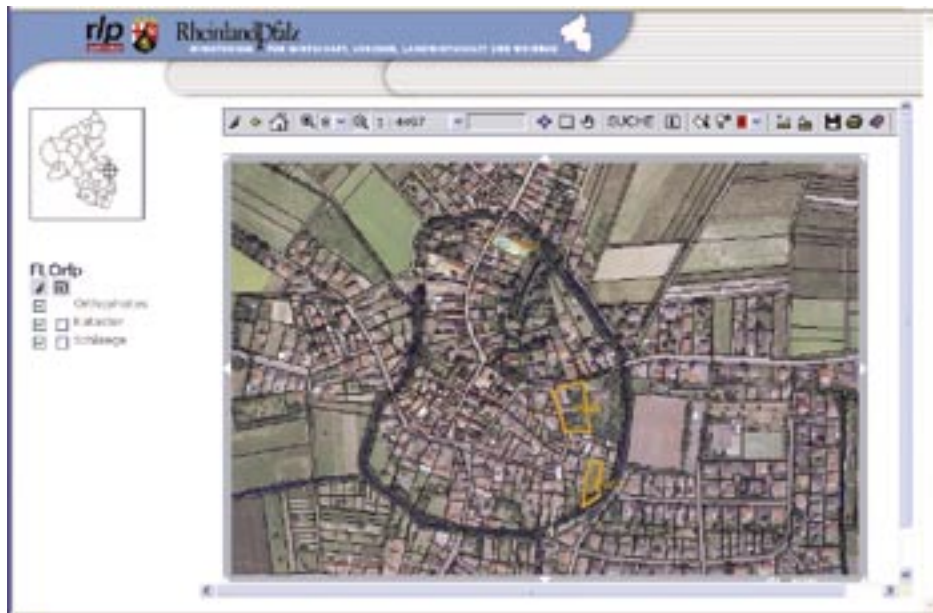
In order to enable farmers to access the state's GIS-based geo-basis data, the Ministry of Economy, Transportation, Agriculture, and Viniculture of Rhineland-Palatinate has initiated a project in the context of the implemen-

tation of the Integrated Administration and Monitoring System ('Integriertes Verwaltungs- und Kontrollsystem (InVeKoS)') for joint subsidy regulations. The goal of this project is to develop a web-based GIS for farmers. The farmer is to be given the opportunity to access maps and other data about his areas under cultivation via the Internet, without the need for proprietary software and solely by using browser functions. At the same time, administrative staff should be able to use the system at those workstations where only GIS information functions are required.

## Procedure

In an initial step, the Ministry of Economy, Transportation, Agriculture, and Viniculture of Rhineland-Palatinate has tasked Fraunhofer IESE with performing a case study. The subject of the case study was the design, prototypical implementation, and evaluation of a web-based GIS to support area-related applications. Furthermore, a design for the expansion and future phases of the system were to be developed.

By involving Fraunhofer IESE in a step-wise development project early on, it was to be ensured that software engineering best practices would be used right from the start.



**Just point-and-click to get area information:**  
With FLOrIp, the farmer can get information about cultivated areas online.

### FLOrIp – Area Information Online

In the context of this case study, the web-based GIS "FLOrIp – Area Information Online" was developed. In combination with land registry maps and aerial photographs, the areas are visualized with their exact locations. In addition to these GIS data, area-related and enterprise-related data are available. Important tools include not only the measurement of distances and areas, but also search capabilities for areas under cultivation and land parcels. The farmer can download the geometries of his areas under cultivation in the GML format (GML – Geography Markup Language) and further process it with his own special software. By means of a print function, he can create either documentation for his own records or an attachment to an application.

FLOrIp accesses the same information basis as the Administration's own GIS applications. In this way, all data are available to the user in an up-to-date and comprehensive way, without replication of data.

### Fraunhofer IESE Contribution

In the context of the case study, Fraunhofer IESE's job was the management and quality assurance of the prototype development. Both were done in close cooperation with representatives from the Ministry. In detail, the contributions made by Fraunhofer IESE included the following tasks:

**Requirements Analysis.** Representatives of the system's main target groups, farmers and administrative staff, were surveyed in on-site interviews and workshops regarding their requirements and expectations for a GIS-based area information system. This resulted in a requirements specification document that describes the system requirements via Use Cases. This requirements specification document formed the basis for the detailed data processing concept, which was developed by the development partner ISB AG in cooperation with Fraunhofer IESE.

**Architecture Evaluation and Design.** In order to enable the farmer to access the same information basis as the Administration's own GIS programs, data replication was to be avoided. The online access to productive systems from the Internet led to high system design requirements regarding data safety and

performance. A two-step process was selected for eliciting the optimal architecture: In a test application, an initial architecture design was implemented in the context of the state's e-Government infrastructure, the *rlpService24* of the State Agency for Data and Information ('Landesbetrieb für Daten und Information (LDI)'); in a second step, the design was evaluated and refined with regard to performance and security aspects in coordination with the contractor, the development partner, LDI, and other project partners.

**Evaluation and Selection of Map Server.** For generating the maps presented to the user, a GIS uses so-called Map Servers. In cooperation with the development partners, a decision matrix was developed for selecting a suitable Map Server. The following products were compared: UMN (Open-Source), deegree (OpenSource), MapXtreme (MapInfo), and ArcIMS (ESRI). After preliminary selection on the basis of the defined required criteria, a decision had to be made between UMN and ArcIMS, which resulted in the UMN Map Server being picked.

**Project Management.** The design and development of *FLOr/p* was done in close coordination and cooperation with representatives from the Ministry,

from state and county administration offices as well as with the following technology and development partners: ISB AG, which collaborated in developing the technical system design of *FLOr/p* and implemented the system, LDI as operator of *rlpService24*, CCGIS, which performed adaptations of the UMN Map Server, and Fraunhofer AIS, which contributed its long-time application experience and competence in the area of Open-Source Map Servers. In the context of project management, Fraunhofer IESE was responsible for coordinating the partners, moderating the coordination processes, developing project plans and controlling them with regard to time and budget, contracting and monitoring the development partners, as well as continuously performing quality assurance measures.

**Pilot Tests.** As a starting point for developing *FLOr/p* into a production system, pilot tests were performed with selected farmers and administrative staff. The goal of the pilot tests was to evaluate the prototype's user friendliness with regard to the further extension of the system, and to identify requirements for this. The pilot tests confirm that the functionality of the prototype appropriately supports the tasks identified in the context of the requirements analysis.

### Result and future outlook

*FLOr/p* is the first Internet application that provides online access to the geo-data and subsidy-relevant enterprise data of the state of Rhineland-Palatinate. Thus, by using Internet technology, the farmer can access precise information about the location and size of his cultivated areas at any time and use this information for his application. This increases the correctness of the information provided in the applications. The risk of the farmer suffering financial drawbacks due to incorrect or insufficient information on his areas is thus significantly reduced. It can also be assumed that there will be less correction and control effort (administrative effort and on-site controls) necessary on the part of Administration. Furthermore, *FLOr/p* enables the farmer to view any application data obtained about him and stored by Administration, during the entire period of application processing. This will lead to more transparency in the administrative system.

The following issues should be considered the project's central development results:

- Proof of the technical feasibility of Internet access to the geo-data and enterprise data of the state of

Rhineland-Palatinate by using the e-Government platform *r/pService24*, without data replication

- A replicable method for the presentation of all state geo-information on the Web
- A prototype system for evaluating user requirements and system properties, on the basis of which requirements for a productive system can be formulated

*FLOr/p* was chosen as the e-Government lead project of the Ministry of Economy, Transportation, Agriculture, and Viniculture of Rhineland-Palatinate and first presented to the public at CeBIT in March 2004. Until the beginning of 2005, it will be extended into a productive system. This includes especially improvements in the areas of usability, security, and performance. The results of the pilot tests are an important basis for this. The system is intended to be available to the farmers and the administrative staff in the state of Rhineland-Palatinate for the application year 2005. *FLOr/p* represents the first step towards an interactive online solution for agricultural subsidy application. A corresponding technical and organizational concept is currently being developed.

# Experience-based IT Failure Control Center for Software Maintenance and Operation

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Modern business workflows in service industries and administrative organizations are strongly dependent on information and communications technology, which makes it necessary to minimize failures and quickly deal with them should they occur. A simple example, which is, nonetheless, not far from reality at all: While importing sets of accounting data into the central accounting system, the system crashes. How to react in order not to (a) generate duplicate sets of accounting data and (b) lose any sets of accounting data? In such a case, the service employee normally relies on system literature, on his own personal experiences, or on the advice of colleagues who have the appropriate knowledge or experience.

This apparently reasonable procedure is inadequate in several ways: Neither one's own personal experience nor that of individual colleagues can be up-to-date and comprehensive at all times; there is no central storage, maintenance, and combination of experience knowledge. In addition, looking for information requires interrupting one's work and thus delays reaction to the failure. Systematic IT failure management, on the other hand, makes individual experiences in an organization generally accessible and directly makes them available within the work process – a special advantage not only in the case of large teams, changing responsibilities, and high personnel fluctuation. Conventional trouble ticket systems, which are often used to support the capture of failures, do not sufficiently

satisfy these requirements. Although they take the organizational aspects into account, they do not make use of the employees' experience.

At this point, Fraunhofer IESE's IT Failure Control Center comes in: By means of the IT Failure Control Center, the IT support process is supported in all aspects related to content and organization; experience is recorded automatically and is made available for specific situations.

## Functional principle

Fraunhofer IESE's experience-based IT Failure Control Center is based on two major aspects: On the one hand, a simple workflow with "To-Do lists" supports the organizational process of operation and maintenance. On the other hand, an experience base integrated into this workflow offers intelligent support in case of failures and exceptional circumstances. This is based on Case-Based Reasoning methods proven in practice as well as on Information Retrieval processes, which are integrated into the workflow in an unobtrusive manner. Search requests are automatically generated from the current work context – which significantly facilitates the practical application of such an "intelligent help function" when compared to traditional knowledge-based systems without workflow integration.

In the everyday practice of failure management, all relevant phases are supported by the IT Failure Control Center:

- During Status Monitoring, incidents (problems or tasks) are detected automatically or reported manually, and a corresponding entry is made into the Control Center. Each incident is assigned to one employee.
- During the phases Diagnosis & Decision Support as well as Reaction, intelligent support is provided by such means as suggestions for problem solution paths, alternative causes, contact persons, etc. During processing of the incident, the work status and deviations from the suggestions are recorded. Thus, the current work status can always be accessed by the employees and by the IT Manager.
- During the Experience Recording phase, the solution path taken is analyzed and appropriate additions are made to the experience base. This is how the IT Failure Control Center learns from daily practice – automatically, in the background, without additional effort for the users.



In addition to its routine operation, the IT Failure Control Center also supports a continuous improvement process: The systematic recording of incidents and reactions thereto forms the basis for medium- and long-term decisions regarding IT-related improvement measures. These may be of both an organizational nature and a technical nature. Analyses of the experience collected make it possible, for instance, to recognize where automation would be beneficial. Furthermore, the system offers help regarding the proactive adaptation of the solution paths in case of modifications made to the software.

**What to do when everything fails?**

In case of a failure, all depends on the knowledge and the experience of the IT support staff. Experience-based support systems lead to faster solutions by using innovative information retrieval processes.

### **Adaptation and introduction illustrated by the case of the city of Cologne Finance and Tax Office**

The usage area of the Control Center was focused for the Finance and Tax Office ('Stadtkasse') of the city of Cologne in close cooperation with the managers and employees of the department of information processing. Suitable knowledge representations were also selected systematically.

In order to quickly set up the system with tight workflow integration and scalable implementation, the Experience Factory Product Line of Fraunhofer IESE's Department of Experience-based Systems and Processes (ESP) was used. An accompanying evaluation of the usage and the user satisfaction served to analyze acceptance of the Failure Control Center in real use.

#### **Benefit from the user's point of view**

The benefit of the experience-based IT Failure Control Center was characterized by the Finance and Tax Office of the city of Cologne as follows:

- Comfortable build-up of experience without extra effort for the user

- Faster and professional elimination of failures
- Significantly improved information retrieval through intelligent search and additional statistical statements
- Step-wise and systematic automation of failure elimination, e.g., in case of frequently occurring and time-consuming reactions

Since its introduction, the experience-based IT Failure Control Center has now been productively used in real operation by the Finance and Tax Office of the city of Cologne.

Funding information: Part of the work was performed within the publicly-funded project SKe. The focus here was on IT security failures. After completion of the SKe project, the experience-based IT Security Control Center was already generalized into an experience-based IT Failure Control Center.

Further information:

SKe – Comprehensive Security Design with Dynamic Control Mechanisms for e-Service Processes

[www.ske-projekt.de](http://www.ske-projekt.de)

## The Virtual Office of the Future

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Dr. Dirk Muthig

The future will fundamentally change our office world. Systems will not necessarily need to be activated by people anymore, but will react on their own to situations they recognize. "Ambient Applications" is the name for such applications, which are characterized by situation-caused, proactive reactions and dynamic system configuration.

During the past few years, scenarios were developed in many application domains that benefit from the idea of "ambience". One of these is the "Virtual Office of the Future", in which diverse pieces of end user equipment interact on their own – either because certain persons are identified, messages are received from other equipment, or based on the status of higher-level business workflows. According to current prognoses, the market for such "intelligent" office applications, which also include e-Government applications, will experience strong mid-term growth.

In the competence center "Virtual Office of the Future", which is funded by the state of Rhineland-Palatinate, Fraunhofer IESE is establishing fundamental research competencies for demonstrating the visions of a Virtual Office, and is developing future software-based products and services for this domain in cooperation with industrial partners.

In the context of this project, comprehensive competence is being built up in the area of flexible software architectures, which will be a decisive factor for the efficient technical realization of office environments. Beyond that, research is necessary regarding (semi-) automated support of the workflows and processes in an organization. It

takes these to provide office end equipment with the context information needed to support the user in a proactive and "intelligent" manner.

In light of these prospects, the work of the research partners and the collaborating industrial companies from the office application systems domain has focused on requirements, reference architectures, and quality assurance. Work concentrated on system- and software engineering aspects dealing with the development and adaptation of IT-based office services and their support through flexibly adaptable office end equipment.

After an analysis of the application domain and after identification of the services, functionalities, and properties of office infrastructure and end equipment that are typical today, the requirements on future infrastructures were exemplarily juxtaposed to these results. This enabled precise identification of the central new aspects of the approach for the competence center "Virtual Office of the Future". The crucial difference to previous applications – in addition to efficient and maximal adaptability of all system components and office equipment – is that the office infrastructure is informed about the current workflows and thus offers context-sensitive services that can be reasonably combined with parallel or subsequent workflows. For example, a telephone "thinks" by interpreting the meaning of its quick-dial buttons depending on the appointment schedules that have been installed. Depending on whether a colleague is in the office, at home, or on the road, the telephone will dial the appropriate number.

The reference architecture designed in the subsequent step should fulfill the requirements of future office infrastructures and office systems, while allowing as much flexibility as necessary in order to be efficiently adaptable to the individual needs of different office organizations. This resulted in a generic solution for realizing a product line for office environments.

The resultant reference architecture is also an initial fixed point for all companies that want to develop, install, and operate future office infrastructures in cooperation with the competence center. It defines a framework for the different roles, such as office organizations (i.e., end customers), smaller and large suppliers (i.e., partners who provide individual system components), system integrators as well as maintenance companies or other service providers.

For the reference architecture, suitable quality assuring measures were identified and assessed with regard to their usability and usefulness in the area of office applications. Taken together, these result in a generic quality strategy, which is an inherent part of the reference architecture. In order to do justice to the highly flexible reference architecture, static and dynamic quality assurance techniques were developed, which can be used in various contexts.



**Like power from an outlet:**

In the future, organizations will not necessarily need to have their own office space. It will be possible to order typical office services from external suppliers and integrate them seamlessly into planned workflows and business processes.

## RTLOpen – An Open Platform for Realtime Applications in Mechanical Engineering

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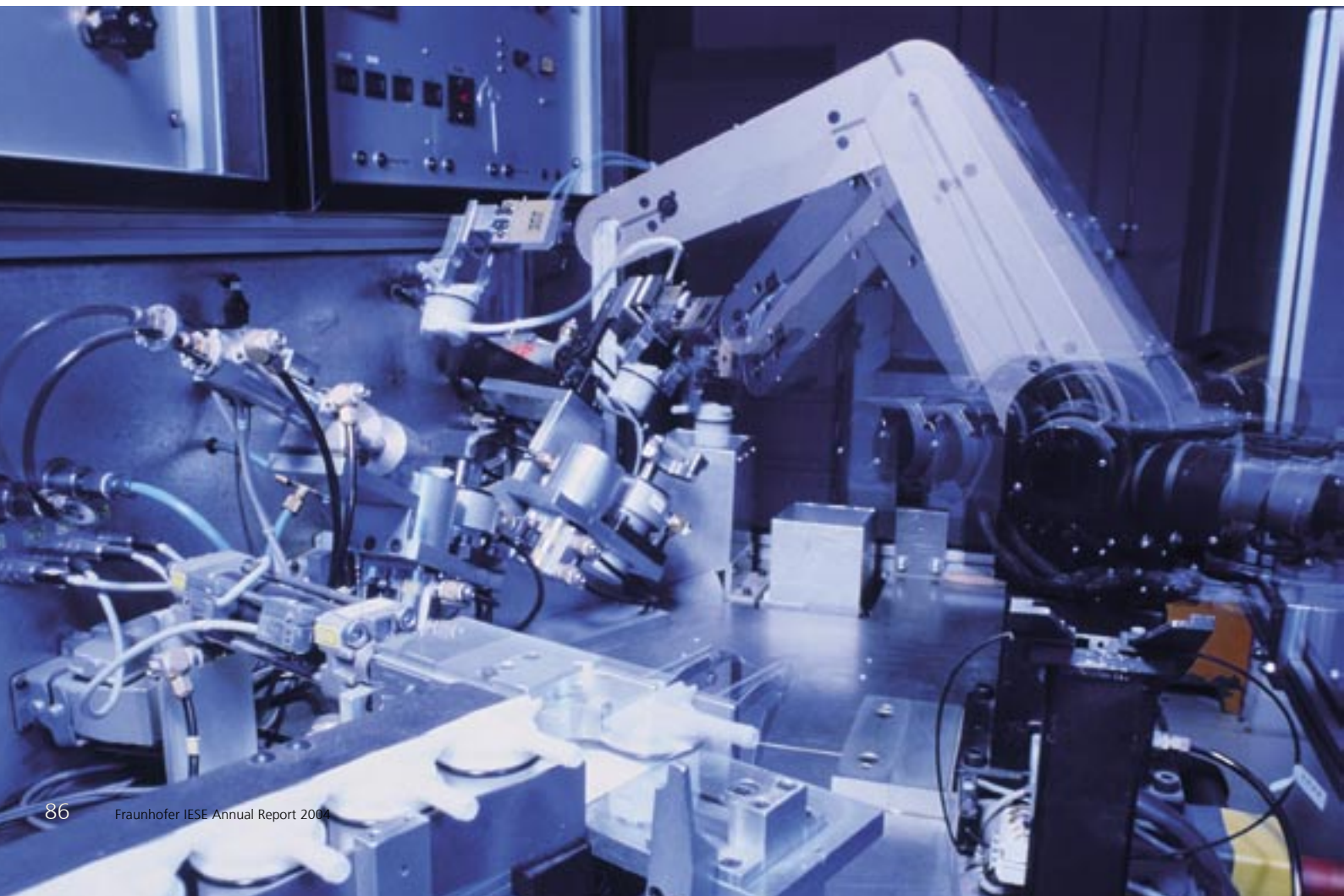
Ralf Kalmar

In the cooperative project *RTLOpen* (Open Reference Platform for Realtime Linux in Mechanical Engineering), a flexible, performant, future-oriented, and cost-efficient reference platform for mechanical engineering in small and medium-sized enterprises is being developed on the basis of the Open Source operating system Linux. This takes into account the special requirements of the application domain such as real-time requirements, complex computations, interoperability, safety, quality, long life, and failure safety. Results include a freely available reference architecture based on one or several variants of embedded or real-time Linux kernels, interface specifications, communication- and exchange formats as well as the corresponding development methods, techniques, and tools. The project started at the beginning of 2004 and will be completed by the end of 2006.

### Situation

The mechanical engineering industry in Germany has maintained its competitive edge on the international market until today mainly due to the excellent quality of the mechatronic solutions it offers. The technique used for this is optimized for control systems and is very productive and efficient in this regard. The introduction of software-controlled systems has led to increasingly efficient products and has strengthened the position of the German mechanical engineering industry in international competition. Even today, the greatest value is added by using information technology in some application areas of this domain.

Compared to process control with personal computers, programmable control systems, which are currently still



very widely used in mechanical engineering, increasingly lead to disadvantages regarding interoperability (e.g., the machines' Intranet connection), modern user interfaces as well as the increasingly important implementation of complex measurement data evaluations. Furthermore, specialized hardware is up to ten times as expensive as solutions based on standard industrial PCs. Considering the high value adding portion of information technology, significant cost reductions of the overall system accompanied by increased technical performance can be expected if PC technology is used.

However, cost-efficient PC solutions running under desktop operating systems, like those already in use in mechanical engineering for user interfaces and data evaluation, lack the real-time capability that is absolutely mandatory for safety- and time-critical control systems. In the area of PC real-time operating systems, proprietary solutions are currently available that are based on Linux or Windows NT environments. Despite the licensing costs of commercial applications, which are sometimes very high, technical difficulties regarding their use in mechanical engineering are not generally excluded.

**As if operated by ghosts:**

Automated production processes often work with complex, proprietary control systems. Open Source software promises to deliver improved system performance and more interoperability at lower costs.

**Project goals**

In the context of the research project, which is being funded by the German Federal Ministry of Education and Research (BMBF), the reference platform *RTLOpen* is being developed, which contains not only the operating system as such and a collection of free software tools, but also a suitable software development process. This platform is customized for the requirements of the industrial goods industry. It enables especially smaller and medium-sized companies to develop high-quality real-time solutions on a cost-efficient Open Source basis. The reference platform is made available free of charge to interested parties on the Internet.

**Procedure**

Fraunhofer IESE is responsible for the selection, integration, and description of a comprehensive software development methodology for use with the reference platform *RTLOpen*. In addition, the *RTLOpen* platform is being empirically validated by Fraunhofer IESE in the context of the development of a demonstrator. This demonstrator has the characteristics of typical real-time applications and serves as both an evaluation object and a teaching example for the use of the platform.



**Innovation in stock:**

RTLOpen is tailored to the requirements of the industrial goods industry. This enables especially smaller and medium-sized enterprises to develop high-quality real-time solutions on the basis of low-cost Open Source software.

**Project results**

Due to the research approach aimed at achieving optimal competitiveness, different groups of users will benefit from the reference platform *RTLOpen*. These benefits include:

- As a reference platform, *RTLOpen* can be used for mechanical engineering without extensive adaptation.
- The consistent use of Open Source software results in cost savings compared to proprietary solutions.
- The user is not dependent on a specific provider.
- The openness of the platform makes available a multitude of various add-on modules of different origin.
- GNU/Linux as the most important Open Source operating system is known as a secure, stable, and robust system.
- The general trend towards Open Source-based systems facilitates acceptance and increases demand.

With the *RTLOpen* platform, the user gets a reference solution that has been scientifically validated and tested under industry conditions, and that covers various aspects of Linux-based computer technology including software and corresponding tools in automation systems. Since the *RTLOpen* reference

architecture will be freely available, significantly lower product costs will be incurred. For these reasons, the consortia partners expect a good response from mechanical engineering manufacturers in Germany. The use of the *RTLOpen* platform will enable them to reduce their costs per unit, increase the degree of innovation of their products, and thus enable them to improve their competitiveness on the market.

Current project results and links to further information can be found at <http://open-realtime-linux.de>.

The *RTLOpen* consortium consists of four project partners (including three from mechanical engineering):

- BERGHOF Automationstechnik GmbH (Eningen)
- Hofmann Maschinen- und Anlagenbau GmbH (Worms)
- VisionTools GmbH (Waghäusel)
- Fraunhofer Institute for Experimental Software Engineering (Kaiserslautern, project management).

The project is being funded by the German Federal Ministry of Education and Research (BMBF) in the context of the research initiative "Software-Engineering 2006" under grant number 01ISC 14; the amount of funding is 1.125 million euros.

## UseLine – The Synergy of Usability and Reuse

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Sometimes everyday situations turn into problems when computers are involved: The video recorder refuses to record and instead displays cryptic messages; after a wrong key is pressed, the word processing software ruins the text that was written with so much effort; the computer just does not do what it is supposed to do. Often, these everyday glitches are neither the fault of the user nor of missing or defective functions of the software as such. Instead, the central obstacle is the lack of usability: User expectations, on the one hand, do not correspond to the actual behavior of the system; the system, on the other hand, does not provide any sensible clues as to how the desired objective might be achieved.

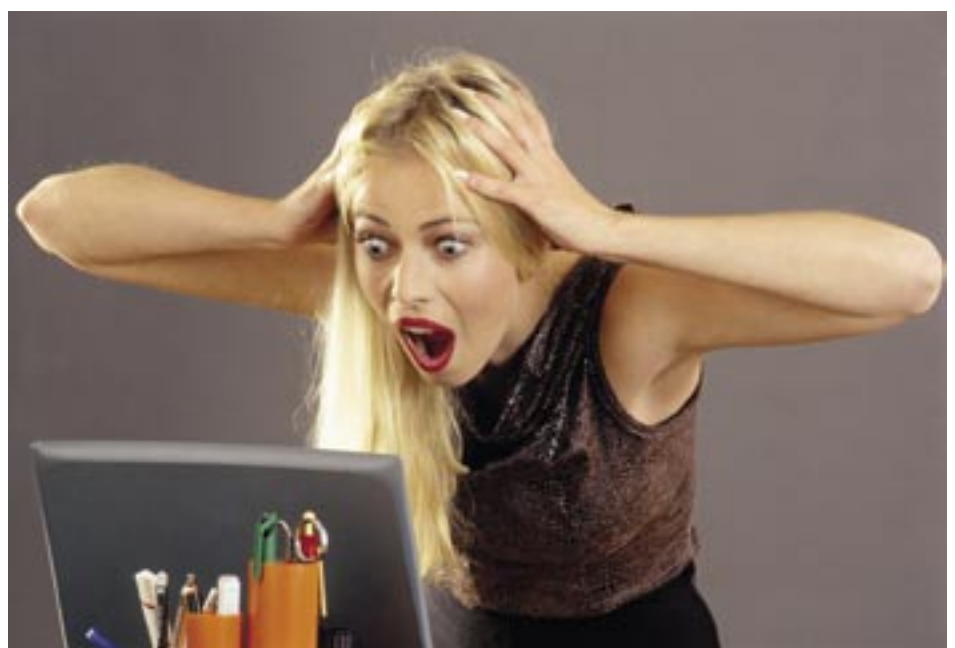
Particularly for small and medium-sized enterprises (SMEs) with their strong customer ties, good usability of their software-based products is of paramount importance. Only software that is understood by the customer and can be used in accordance with his expectations can be considered "good" and can be marketed successfully. In addition, good usability can save training

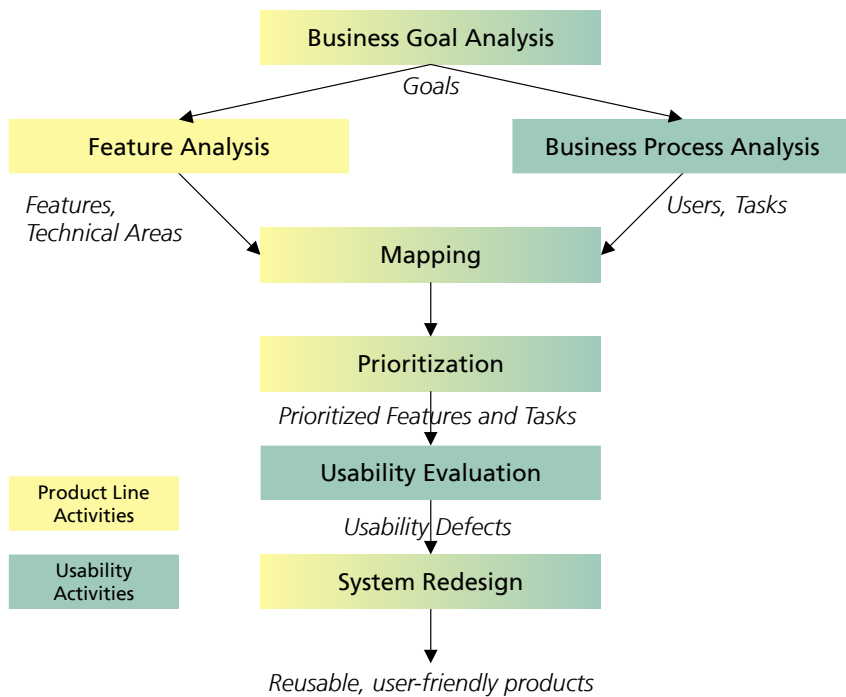
and support costs – a self-explanatory, simple program or software-controlled appliance does not require training and raises fewer questions. Often, however, small organizations neither have the time nor the means to make major investments into improving their products' usability; instead, they use their own solutions, which often do not completely fulfill user expectations.

Consequent reuse is considered a fundamental prerequisite for the rational development of software. The efficiency of development processes can be systematically improved through product line approaches or the purchase resp. reuse of already existing components. But more often than not, these measures collide with usability aspects: The same components in different usage scenarios are not necessarily appropriate for optimally fulfilling individual user requirements. It is in this area of conflict between usability, product-oriented reuse (Product Line Engineering), and the tight budget constraints of small and medium-sized enterprises where the project UseLine comes in.

### What happened now?

User-unfriendly software is not only unpleasant to handle. It contains significant risks and can cause consequential damage such as loss of data.





**Useline Process:** The basis of products that can be produced cost-efficiently and user-friendly at the same time is the analysis of the manufacturer’s business goals.

**Analysis, design, redesign – steps to success**

In the UseLine project, which is funded by the Stiftung Rheinland-Pfalz für Innovation (‘Rhineland-Palatinate Foundation for Innovation’), Fraunhofer IESE has developed a process for integrated usability- and product line analysis. It is based on the proven processes of corresponding analysis methodologies and was developed in particular for smaller and medium-sized enterprises that do not possess sufficient time and funds for separate product line- and usability analyses and the resulting combination of results. The entire process is presented schematically in the illustration and includes the following individual steps:

- Business goal analysis: The company’s business goals are elicited and the subsequent process is oriented towards these business goals. Possible business goals in the context

of SMEs might be, for example, reduction of a product’s time-to-market, reduction of support effort, or increase of product quality.

- Business process analysis: Starting from the existing and planned systems, the processes and detailed tasks of the potential users are captured. Variations of tasks in different systems are taken into account. It is essential to consider both the system and the user in order to optimize the necessary system support required by the user.
- Feature analysis: Starting with the results of the business process analysis, the system features that are common to all the products of a product line and those that are individually different are captured and combined with the user activities.
- Mapping and prioritization: The features and tasks are mapped to each other, i.e., they are checked and prioritized with regard to completeness and correctness.
- Usability evaluation: Based on these results, the usability of the system under consideration is evaluated; especially those (prioritized) user activities that were recognized as being of particular importance serve as test scenarios.
- Redesign: In conclusion, the results are consolidated, and an integration of the recommendations regarding usability- and reuse considerations into the architecture and implementation is performed.

The result of these steps is a product line of systems that is not only oriented towards optimal reuse, but also offers optimal usability for various user groups and application scenarios.

### UseLine in practice

The UseLine approach has been successfully applied at Sieda GmbH (Kaiserslautern), a medium-sized enterprise for roster planning systems. The existing systems of Sieda GmbH were analyzed in accordance with the UseLine process and systematically improved on the basis of the lessons learned. On the one hand, a "light" product with limited functionality was derived with the help of product line methods without major new development of components already available. On the other hand, usability of both the existing and the newly derived systems was increased; support and training effort required so far could be reduced.

In further projects, such as the SME Research Laboratory Platform, which is funded by the state of Rhineland-Palatinate, and the "UseKit" project, which is funded by the Federal Ministry of Education and Research (BMBF), Fraunhofer IESE will further advance the interaction of usability aspects with product line methods and other software engineering techniques.



**The ideal software** is not only functional and correct, but also unambiguous and easy to use. UseLine integrates the systematic reuse aspect and thus combines benefits with usefulness – both for the user and for the manufacturer.

Further information:

UseLine:  
[www.software-kompetenz.de/?22922/](http://www.software-kompetenz.de/?22922/)

UseKit:  
[www.usekit.de](http://www.usekit.de)

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## NeMoS – Network Monitoring Station

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The increasing use of intelligent, self-organizing networks does not only entail continuously increasing complexity and inhomogeneity, but also a constantly growing dependence on a perfectly functioning network infrastructure. It is therefore the job of IT managers to ensure a high degree of availability of all systems and services. In order to recognize emerging problems as soon as possible, or even prevent them before they happen, centralized monitoring of all components involved is necessary.

### OpenSource tools as an alternative

Although commercial system management tools exist on the market, they are quite expensive to buy, especially for small and medium-sized enterprises. OpenSource tools are a cost-efficient alternative. Unfortunately, many of the freely available products only cover single aspects of network monitoring, so that a functionality that is comparable to commercial applications can only be achieved by using several single tools in parallel. The main problem with this: installation, configuration, operation, and result presentation of the different tools are not uniform. This does not only make it significantly more difficult to use these tools in practice, but also includes the risk of problems being overlooked although they are displayed.

### Modularity and integration

This is where NeMoS, a tool developed by Fraunhofer IESE, comes into play: a modular tool integrating various Open Source tools for network monitoring under UNIX/Linux in a uniform platform. Installation and configuration are simplified even more by the fact that all necessary parameters are summarized in a single file. The time-consuming and defect-prone editing of very different configuration files thus becomes a thing of the past!

Currently, NeMoS consists of six modules. The Network Plan module offers a graphical overview of the entire network monitored. From there, one can branch off to the next hierarchy level, where detailed information is presented. For example, server and network components can be listed there with their IP addresses. With a simple mouse click on one of the components displayed, more information on the availability of the appliance and the services installed are displayed.

With the Availability module, NeMoS determines the reachability of network components and checks the availability of the previously configured services. To do this, regular queries are started via common IP protocols and the status of the respective servers and services is

determined based upon the answers. The lessons learned are packaged graphically and presented in an easy-to-understand way. Components that create problems during evaluation or that cannot be reached are marked in color, and particularly serious defects are marked separately. In addition, the responsible IT manager is notified via email. Through the display of the history, a server's behavior and its services during the past seven days can also be traced.

The Utilization module retrieves various operating parameters of network components by means of the standard protocol SNMP and presents them with graphics. In this way, the utilization of all SNMP-capable network components can be monitored continuously. Normally, parameters such as CPU usage, memory usage or interface utilization are captured and displayed. Diagrams are available with daily, weekly, monthly, or yearly views.

The IP-Accounting module was developed additionally specifically for Cisco routers. After activation of the respective mechanism on the router in question, the captured accounting data are also elicited by NeMoS via SNMP and stored. Afterwards, a daily and monthly summary is created for each monitored component.

The Logging module collects Syslog messages from the previously defined network components. Similar pieces of equipment store their information in separate files, which enables simple interpretation of the messages. Furthermore, the log files for each component can be displayed separately. In addition, filter rules can be set for isolating important information or hiding unimportant information.

An optional NetFlow module receives the data transmitted from the monitored equipment and creates statistics of the entire network traffic, which can be freely parameterized. Similar to the Utilization module, information on various protocols, services, or sending and receiving equipment can be displayed for different periods of time in the form of diagrams.

### Benefits

NeMoS is characterized by low purchase costs and high flexibility. Through its modular design and the central configuration possibilities, adaptations to various networks can be performed simply and easily. NeMoS is already being used successfully in the telecommunications domain and within Fraunhofer-Gesellschaft.

### Availability, reliability, security:

Almost every industrial organization is very much dependent on a functioning IT infrastructure. A system administrator must keep an eye on many functions at the same time – integrated diagnosis tools provide support.





# Fraunhofer Center for Experimental Software Engineering, Maryland (FC-MD)

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## Profile of Fraunhofer Center Maryland (FC-MD)

### Mission and Vision

In 1994, Fraunhofer-Gesellschaft e. V. (FhG) established Fraunhofer USA (FUSA), headquartered in Plymouth, Michigan, to foster collaboration between research institutions and industries in the United States. The Fraunhofer Center for Experimental Software Engineering, Maryland (FC-MD) began operations in 1998 as the only FUSA center to specialize in software and related engineering fields, focusing on the use of experimental approaches to introduce innovative techniques into industry.

Affiliated with the University of Maryland (UM) and the Fraunhofer Institute for Experimental Software Engineering (IESE) in Kaiserslautern, Germany, FC-MD is the leading competence center for applied research and technology transfer in experimental software engineering.

FC-MD's mission is to advance the state-of-the-practice in software development and acquisition organizations by applying state-of-the-art research results. The FC-MD approach is based on the following fundamental principles:

- applying empirical methods to evaluate processes and products,
- identifying improvement areas and proposing changes,
- understanding the impact of changes on measures of success,
- utilizing experience to guide technical and management choices,
- tailoring solutions for specific customer contexts,
- transferring proven technologies into practice.

FC-MD envisions an ever-increasing need for both technology and research organizations to better integrate their efforts to understand software and the impact that it has in the world. FC-MD has positioned itself to be the recognized leader in this endeavor among industry, government, and academia. Emphasizing software engineering, software development practices and software processes, FC-MD relies on application development, feedback, and learning in order to improve our client organizations' software development technologies.

### Business Areas and Competencies

FC-MD supports research and development in the discipline of software engineering and its enabling technology. It facilitates collaboration between private-sector companies, government agencies, and academic institutions, in order to develop innovative, actionable approaches.

The core competencies that FC-MD offers are based upon the application of the Experience Factory concept to a broad spectrum of software engineering issues. This approach has been successfully applied to software development at NASA for more than 25 years and recently at other organizations. This concept enables organizational learning based on lessons learned and acknowledges the need for a separate support organization (the Experience Factory) that works with the project organization in order to manage and learn from its own experience. The support organization helps the project organization observe itself, collect data about itself, build models and draw

conclusions based on the data, package the experience for further reuse, and most importantly: feed the experience back for future projects' usage.



**Core Competencies**

**Learning Organizations**

- Experience Factory
- Experience Base
- Knowledge Management
- Visual Query Interface
- eWorkshop

The Experience Factory (EF) approach defines a framework for building Learning Organizations. A concrete manifestation of knowledge management concepts and tools, the EF content and structure are often referred to as the Experience Base. FC-MD has developed support tools to manage content and structure and execute the needed procedures, as well as to help capture, store, integrate, analyze, synthesize, and retrieve experience. The Visual Query Interface and eWorkshop are examples of tools that support the analysis and synthesis of organizational experience.

**Technology Evaluation**

- Technology Maturity
- Goal Question Metric
- Project Measurement and Data Collection
- Empirical Studies
- Model Building
- Management by Data

Technology Evaluation involves experimenting with various technologies to determine their maturity and suitability for use in specific environments. Any evaluation begins with setting

study goals and objectives, and defining the context data and measures to be collected. Empirical studies can be performed as part of the evaluation process to quantitatively assess technologies and build models to enable better management and technical practices.

**Process Improvement**

- Assessments
- Process Modeling
- Risk Management
- CMM(I)
- Consortium Management
- Training and Education

FC-MD helps organizations to achieve their software process improvement goals through baseline assessments, process modeling, action planning assistance, periodic consulting support, and auditing services. Staff expertise in risk management and lessons learned for process improvement in small organizations and non-traditional software environments plays a significant role in the delivery of these services. Staff are certified by the Software Engineering Institute in performing Software Capability Evaluations and are experienced in assisting organizations to achieve compliance with the Capability Maturity Model® (CMM) and Capability Maturity Model-Integration® (CMMI).

We also coordinate and manage several software-related consortia to provide a software engineering resource to member companies in advancing the practices of system and software engineering and improving the quality of their software-related products and services. These consortia integrate research and experience into practical improvement, create opportunities to develop and disseminate improvement practices, enhance the competitiveness of mem-

ber companies, accelerate new software technology adaptation, leverage member company experience, promote inter-corporate cooperation of member organizations, and provide training and education.

#### **Product Quality**

- Dependability
- Reliability
- Security
- Architectural Evaluation

There are many aspects to evaluating product quality. One approach is to model a system's dependability from a user perspective. This involves defining a methodology for characterizing software systems' dependability and an iterative approach for defining and quantifying dependability attributes, such as reliability. This methodology takes into account the multiple facets of dependability and the system's different stakeholders. We are developing an experience base of models that describe, assess, and predict software's dependability properties.

In the information security area, there are many techniques that improve specific aspects of security, but there is little empirical evidence of their effectiveness with respect to various classes of vulnerabilities in different contexts. We are developing a cost-benefit function to model how much security a given level of investment can provide.

Product quality is also affected by design degeneration. Programmers working within time and budget constraints sometimes add and change code without fully understanding the architecture of the system they are modifying. The changes that they make are often magnified when developers who were

not part of the original design team further alter the system. Re-engineering is costly and time consuming and also delays the implementation of new features. Architecture evaluation is a form of defect reduction that addresses this problem, facilitating maintenance and evolution by detecting unnecessary complexity, incorrectly implemented software solutions, and dead code. FC-MD's process for architecture evaluation reveals architecture violations in a clear, systemic way, making it easier to address problems and incorporate implementations according to the original architecture. Our systematic process, supported by a software tool, is flexible, cost-efficient and can be tailored to meet different levels of design constraints.

#### **Emerging Technologies**

- Reading/Inspections
- Agile Technology
- Using COTS in Development
- Product Line Development

Software inspections ensure that software artifacts created during the software life cycle possess the required quality characteristics. For instance, inspections improve design and code quality by increasing defect removal during development in a cost efficient manner, thus ensuring that the software artifacts necessary for its construction correctly reflect the needs of stakeholders.

FC-MD has continued its work on the research and application of "software reading techniques," which increase the effectiveness of software inspections by providing guidelines that inspectors can use to examine (or "read") a given software artifact and identify defects. Empirical evidence demon-

strates that software reading is a promising technique for increasing software quality for different situations and document types and is not just limited to source code. Software reading can be performed on all documents associated with the software process and is an especially useful method for detecting defects, since it can be applied as soon as documents are written. FC-MD is engaged in a number of collaborations for the purpose of refining reading techniques for different stages of the life cycle.

Agile Software Development Methods are software development practices designed to efficiently produce software and reduce overhead costs. Although interest in Agile Methods is increasing, very little empirical evidence exists to support anecdotal evidence about its usefulness and effectiveness. FC-MD collaborates with experts and practitioners to characterize Agile practices by

- conducting a series of eWorkshops
- designing and conducting experiments
- developing a measurement framework to help practitioners and experimenters collect metrics and better understand these practices.

The COTS Lesson Learned Repository (CLLR) is part of the Center for Empirically-Based Software Engineering (CeBASE) and provides support for the software development community in using COTS products. The CLLR allows practitioners to share insights and solutions that can reduce risk and improve the industry's quality and productivity. It contains descriptions of the lesson (summary, risk, or issue addressed, type of data supplied – qualitative or quan-

titative), recommended audience (program or project manager, developer), and the story behind the lesson. The context where the lesson was learned is also incorporated, with reference to details regarding the type of system, organization, number and types of COTS products, and life cycle plans. Many of the lessons learned are also relevant for product line developers.

**Development Technologies**

- Project Management
- Software Acquisition
- System Development
- Requirements Management
- Configurations Management
- Dynamic Simulation

FC-MD supports all aspects of software engineering activities and processes, from system acquisition and project management to development and maintenance, including requirements management and configuration management.

FC-MD's modeling capabilities feature both static and dynamic simulation models, which are calibrated specifically to meet the needs of different organizations and their projects, taking into account their specific problems, questions, and decisions. By focusing on relevant variables that must be monitored and controlled, FC-MD identifies significant factors inherent in the development process and tailors metrics collections to improve tracking and planning.

## Projects in Progress

### Best Practices Clearinghouse

To overcome the challenges of developing large, software-intensive systems, many organizations consider adopting "best practices," but often choose not to implement them for various reasons: there are too many lists and no basis to select practices, no clear proof of effectiveness, no connection of practices to specific program risks or problems, limited resources that offer no evidence of the return on investment in the best practices, and inadequate implementation guidance. The goal of the Best Practices Clearinghouse is to promote the adoption and effective utilization of "best practices" within the Department of Defense software acquisition and development community by providing central access to validated, actionable best practice information that can be used to apply lessons that have already been learned. The target audience for the Clearinghouse is software acquisition professionals who provide technical support to acquisition decision makers, including program and project managers involved in developing software-intensive systems.

This Clearinghouse project is being developed as a joint effort between FC-MD, the Office of the Secretary of Defense (OSD), and the Defense Acquisition University (DAU). Begun in mid-2003, the initial steps of the project have been focused on defining a feasible concept for the Clearinghouse, including a "vetting" process for each identified practice that will measure the

maturity and benefits of each practice through the use of empirical data. This process would allow Clearinghouse users to understand the robustness of the best practice and how it applies within their own context. Each best practice is accompanied by implementation guidance, characteristics of the environment(s) in which it was considered a best practice, dependencies on other practices, and experience stories. Activities for the initial phase of the project include designing approaches for overcoming problems with traditional best practices lists, framing the overall Clearinghouse methodology, defining the requirements gathering process, prototyping the vetting process, and investigating various repository technologies.

### Cooperation Project with the Institute for Experimental Software Engineering (IESE)

Both FC-MD and IESE conduct applied research in software engineering on similar topics. However, since each of the research projects has different customer needs and goals, the knowledge gained is somewhat different, but strongly related. In order to leverage expertise and utilize assets as much as possible, the two organizations have begun a FhG-funded cooperation project to align and integrate competencies. A joint workshop was held at FC-MD in August with a dozen participants, led by Dr. Dirk Muthig, IESE, and Dr. Mikael Lindvall, FC-MD.

The foundation of the cooperation project is the integration of two well-established technology areas into one unified model: Quality Assurance (QA) (including inspection and testing techniques) and Software Product Lines (SPL) (including architecture and reverse engineering) under the theme of "dependable software engineering" (DSE). Beyond the important task of sharing knowledge by integrating and enhancing existing technologies, the cooperation project will produce concrete deliverables that will set the basis for future common activities:

- Define a methodology to support IESE and FC-MD personnel in designing and analyzing SPL architectures for clients and in deciding what QA techniques to apply to client organizations. The method will take clients' goals and organizational profiles into account and will be based on previous experience gained from applying existing technologies.
- Produce a shared tool platform, which will enable research and project tools to be used together. The first step is to define a common architecture, including programming guidelines on building tool plugins, and then to port the first tools to the infrastructure. The goal is to integrate measurement, reverse engineering, and software architecture tools, as well as tools to support QA.

A unified Inspection Technique is one of the first QA techniques being packaged in this way. Christian Denger, IESE, and Dr. Forrest Shull, FC-MD, have begun by defining the discrete components of a unified service offering:

- A common template used to define inspection procedures ("reading techniques") for customers;
- A process for tailoring the instantiated procedures to a given team;
- A start-to-finish method that describes how Fraunhofer personnel should work with customers to tailor and train the procedures;
- A set of requirements for tool support that can be used to support the interaction between Fraunhofer personnel and customers.

Over the next year, they and others here and at IESE will be turning these concepts into reality.

### **DataStream Conversion Services**

Since 1994, DataStream Content Solutions, LLC (DSCS) has provided the full spectrum of data conversion and data management services to a premier group of customers, including the U.S. House and Senate, LexisNexis, Congressional Quarterly, GuideStar, and others. The company recognizes the need to implement industry best practices to support and manage the rapid growth

of the company's operations and to position the company for several large government procurements.

DSCS, working with FC-MD, has undertaken a three-staged Capability Maturity Model (CMM) Implementation effort designed to overcome process improvement implementation hurdles by understanding, tailoring and implementing software engineering best practices that fit the culture and specific environment of a very small software development organization. The expected outcomes of the project include the improvement of internal operations to support growth, improvement of the company's market position and the creation of a major competitive "discriminator," through successful compliance with CMM Level 3.

The initial stage of the CMM Implementation involved preparing DSCS for change by analyzing the DSCS organization to determine if the CMM best practices model made sound business sense and was applicable to existing and future DSCS business. This also included training the workforce on the model. The second stage entailed the creation of a process improvement infrastructure and defined the initial practices. A process asset library was created that included guidelines, templates, and process definitions for the standard set of practices. Each practice was piloted in a software development project. The goal of the third stage is to

institutionalize the practices throughout the DSCS organization, then develop, refine, and implement other practices as needed. In addition, success criteria measures that were established during the second stage will be captured and analyzed. The results of the three stage effort will be published for industry benefit.

### eWorkshops on Assurance Cases

FC-MD is conducting a series of eWorkshops sponsored by MITRE ([www.mitre.org](http://www.mitre.org)) with the goal of formulating a research agenda and related issues for assurance cases. These are a follow-up to a workshop on this topic held at the 2004 International Conference on Dependable Systems and Networks (DSN 2004). Defining assurance cases requires gathering both a compelling argument and a documented body of evidence that a system meets some property (or set of properties). Assurance cases are constructed because a stakeholder (the customer of the assurance case) requires evidence that some property(ies) must be met (and is willing to pay for and/or trade-off other properties).

The eWorkshops cover issues such as:

- Can an assurance case cover multiple properties?
- What attributes should an assurance case have?

- Does the property addressed by an assurance case have to be "critical"?
- Is assurance the same as certification?

Problems in practice identified so far include:

Problem 1: No clear sense of what constitutes "compelling" evidence.

Problem 2: How do we get people to express their concerns about quality properties in a tangible way?

Problem 3: How do you motivate people to support the development of assurance cases?

Problem 4: Can assurance cases address multiple properties simultaneously? If so, how?

Problem 5: How to maintain assurance cases?

Problem 6: How do assurance cases vary depending on what is being assured? For example, assurance cases for process vs. product?

A group of experts in the field meet in the eWorkshop discussion space to explore these issues and questions. Results are summarized and then made available on customer and/or FC-MD web sites.

### Future Combat Systems Project Management Support

The U.S. Army is aggressively pursuing emerging technologies in numerous areas to apply to the construction of the Future Combat System (FCS). Software technologies play a central role in FCS, which is a networked system of systems that uses advanced communications and technologies to integrate the soldier with "families" of manned and unmanned platforms and sensors.

Now completing our second year of support, FC-MD continues to provide assistance to the Army's Program Management Office in the areas of program management, risk assessment and issue identification, software measurement, software acquisition processes, source selection, decision support, and lessons learned. In collaboration with the University of Southern California's Center for Software Engineering and Carnegie Mellon University's Software Engineering Institute, FC-MD is combining facilitated workshops, industry-recognized experts, best-of-breed software engineering practices, and focused measurement to address the issues identified. FC-MD first applies our experience factory concepts to support the specific programmatic needs of FCS and then leverages these experiences for the benefit of the Department of Defense overall.

### Effort Estimation Process Model

The objective of this project is to define a sizing, effort, and schedule estimation process that an independent group (government or contractor) could follow for planning and tracking new development and maintenance efforts at NASA's Goddard Space Flight Center. The estimation process is a multi-step process. The process framework is being tailored based upon the organization's development life cycle and products. The process description is being developed as a set of linked Web pages, an electronic process guide (EPG), that can be easily integrated into the organization.

Using the initial software requirements as the basis, function point analysis (FPA) is used to measure the size of software systems under development at key points in the development process (e.g., selected major reviews) to refine the size estimates. We are using this information as well as industry productivity benchmark data to further analyze and refine the new effort estimation model. Additional case study data from other FPA can be added as appropriate to update/evolve the model.

## High Dependability Computing Project

The High Dependability Computing Project (HDCCP) investigates the use of experimental methods to evaluate new design and development approaches and technologies in order to improve NASA's capability to create highly dependable software. The incremental, five-year, cooperative agreement is part of a broad strategy for dependable computing that links NASA, corporate partners, universities, and research centers.

FC-MD has developed a methodology for characterizing software systems' dependability that it has prototyped for a small size system. This methodology takes into account the multiple facets of dependability and the system's different stakeholders. We are developing an experience base of models that describe, assess, and predict software's dependability properties. We have also analyzed the dependability of operational NASA systems such as the Mars Science Laboratory and the Center-TRACON Automation System (CTAS).

## High Performance Computing Systems (HPC)

The development of High-Performance Computing (HPC) programs (codes) is crucial to progress in many fields of scientific endeavor. However, HPC machines are difficult to program. Effective programmers are rare because HPC code development requires individuals who are both experts in the HPC architecture and in the application domain. These problems will only increase in the future as tougher problems are attacked and more powerful (and likely more difficult to program) HPC machines are created.

Current activity is mostly focused on better execution performance of HPC codes. However, to avoid potential problems in the future, insight is needed into the process by which codes are created in the first place. We need to investigate effective development of HPC codes and to identify problems and bottlenecks that impact development. This would not only allow future research into improving development of the high-payoff problems and provide the most useful support, but may also improve our knowledge of good practices for HPC development that can be passed along to novices.

In order to investigate these questions, the Defense Advanced Research Projects Agency (DARPA, [www.darpa.mil/](http://www.darpa.mil/)) has funded the High Productivity Computing Systems (HPCS) project. This project is a collaboration among researchers experienced in empirical studies of software engineering (i.e., the work practices required for production of quality software so far studied in non-HPC domains) and researchers in the area of HPC itself.

## State of the Art Software Inspections

FC-MD is working with NASA's Goddard Space Flight Center (GSFC) and Johnson Space Center (JSC) to improve their processes for inspecting software work products for defects. A unique outcome of this research will be an assessment of advanced reading techniques that promise to detect a greater number of faults in a more cost effective manner, and the integration of a well-proven process for inspections across the software engineering life cycle.

The final product of this work will be an updated inspection process, supported by a training course and train-the-trainer materials developed with input from NASA developers and based upon the constraints faced by typical NASA projects. The development of this process will build upon previous results obtained, including:

- recent experiences elicited from across NASA with regards to inspections.
- an existing and effective set of inspection training materials that have been updated and tailored for use in particular NASA development environments.
- results of pilot applications and case studies with NASA projects showing the effectiveness of the updated inspection approach.

### NASA Metrics Support

NASA is currently implementing an agency-wide metrics program to understand and improve its software systems. In supporting this program, FC-MD is developing project-level processes and focused guidance for NASA project managers. In order to establish this guidance, common goals across NASA centers and system domains as well as project-specific goals and risk areas need to be considered. The creation of an agency-wide metrics program is a key objective within the NASA Software Engineering Initiative Implementation Plan. However, for a broad-based program like this to succeed, it must be perceived as valuable by project managers and program offices and also minimize any impact on projects. The measurement process is being piloted

on several projects at several NASA centers. The resultant goal-metric sets will be categorized into classes of metrics and usage scenarios that provide metrics selection guidance at the project level. Reporting examples are being developed that will assist both project and agency-level analysis.

Since motivation is vital, a key task will be to show project managers both the short-term benefit of using data to effectively manage their projects and the longer-term benefits of measuring improvements in their software products and processes. Tying performance measures to internal and external goals provides strong motivation for managers to rely on data to understand project performance.

### Software Engineering for Information Security

FC-MD has a Fraunhofer USA-funded project to measure information security. There are many techniques that improve specific aspects of security, but there is little empirical evidence of their effectiveness with respect to various classes of vulnerabilities in different contexts. The long-range goal of this project is to provide a cost-benefit

function of how much security a given level of investment can provide.

Security of a system is often discussed in the context of the "CIA" attributes – confidentiality, integrity and availability of a system. But these are not necessarily the best attributes to use in measuring the "amount" of security a system has. In the FC-MD approach being developed, the security of a system is viewed in terms of "AAA" dimensions – architecture, attackers, avoidance. Vulnerabilities, or the lack of security, are due to the security of the underlying software architecture, the effort of outside attackers to bypass a system's security, and the level of effort employed by users of a system to avoid break-ins. A breakdown in any one of these dimensions makes a system insecure. By measuring each dimension for a given system over time, we can generate a combined measure of how security of a system progresses over time. In our initial phase of this work, we are installing various intrusion detection systems (IDS) and vulnerability tools to determine the 3 As of our model over time. By monitoring our internal network first, and later other organizations that wish to cooperate with us, we can develop a measurement model of how security evolves.

**Absolutely reliable:**  
Aerospace software is subject to special quality requirements.



### Software Process Implementation Support

FC-MD helps private industry companies to achieve their software process improvement goals through baseline assessments, action planning assistance, periodic consulting support, and auditing services. Staff expertise in lessons learned for process improvement in small organizations and non-traditional software environments plays a significant role in the delivery of these projects. Staff are certified by the Software Engineering Institute in performing Software Capability Evaluations and are experienced in assisting organizations to achieve compliance with the Capability Maturity Model® (CMM) and Capability Maturity Model-Integration® (CMMI).

Organizations served include: Creative Computing Solutions, Inc., Bethesda, Maryland; DataStream Conversion Services, LLC, College Park, Maryland; ManTech Systems Engineering Corporation, Lexington Park, Maryland; QSS Group, Inc., Lanham, Maryland; AC Technologies, Fairfax, Virginia; Keymind, A Division of Axiom, Falls Church, Virginia.

### Technologies and Experience Base Developments

FC-MD develops various support tools and technologies as part of our competence infrastructure.

### Agile Methods

Agile Software Development Methods are software development practices designed to efficiently produce software and reduce overhead costs. Although interest in Agile Methods is increasing, very little empirical evidence exists to support anecdotal evidence about its usefulness and effectiveness. FC-MD collaborates with experts and practitioners to characterize Agile practices by

- conducting a series of eWorkshops
- designing and conducting experiments
- developing a measurement framework to help practitioners and experimenters collect metrics and better understand these practices.

The testing practices of Agile Methods are of particular interest to us. In Agile Methods, testing occurs early and forms one of the cornerstones of the development process. One of the main principles of Agile Methods is to embrace change, even late in the de-

velopment cycle, in order to improve the customer's competitive advantage. In environments applying this principle, testing and re-testing become crucial to assure the system's quality as it evolves.

## Architecture Evaluation

Programmers under time and budget pressures sometimes add and change code without fully understanding the system's architecture. This behavior is often accelerated when developers who were not part of the original design alter the system. Once a system is damaged by architectural mismatches, significant effort may be required to stop and reverse this degeneration. Re-engineering is costly and time consuming and also delays the implementation of new features.

Architecture evaluation is a form of defect reduction that addresses this problem and makes maintenance and evolution easier by detecting unnecessary complexity, incorrectly implemented software solutions, and dead code. FC-MD's process for architecture evaluation reveals architecture violations in a clear, systemic way, making it easier to address problems and incorporate implementation according to the original architecture. This also helps preserve the system's maintainability over time.

The FC-MD approach actively and systematically detects and corrects deviations based on the analysis of couplings between components. Visual inspection of the architecture might not be systematic enough to detect deviations. Our systematic process, supported by a software tool, is flexible, cost-efficient and can be tailored to meet different levels of design constraints.

## Reading/Inspection Technologies

Software inspections ensure that software artifacts created during the software life cycle possess the required quality characteristics. For instance, inspections improve design and code quality by increasing defect removal during development in a cost efficient manner, thus ensuring that the software artifacts necessary for its construction correctly reflect the needs of stakeholders.

FC-MD has continued its work on the research and application of "software reading techniques," which increase the effectiveness of software inspections by providing guidelines that inspectors can use to examine (or "read") a given software artifact and identify defects. Empirical evidence demonstrates that software reading is a promising technique for increasing software

quality for different situations and document types and is not just limited to source code. Software reading can be performed on all documents associated with the software process and is an especially useful method for detecting defects, since it can be applied as soon as documents are written. FC-MD is engaged in a number of collaborations for the purpose of refining reading techniques for different stages of the life cycle.

Unlike other inspection methods, the FC-MD inspection methodology analyzes the stakeholders in the software product and provides each reviewer with a targeted quality focus. This analysis makes inspections possible even during early phases of software development (for example, requirements and high-level design creation), where the cost savings from avoiding defects is highest.

## Software Measurement Service

Software Measurement provides a means of interpreting and preserving data in a form that facilitates making decisions and recognizing goal achievement. It also allows more useful data integration and enables data to be consolidated and used to fulfill long and short-term measurement

goals. For example, most organizations utilize measurement data to manage productivity performance. Typically, the software component of an organization does a poor job relating their performance to business goals.

FC-MD's software measurement framework is based on the following components:

- **Method:** The FC-MD method draws the best components from existing approaches, including our own Goal-Question-Metrics™ approach.
- **Experience Base:** Effective software measurement programs are based on experience. An experience base helps select the best metrics for any given situation.
- **Experts:** FC-MD measurement experts rely on our method and experience base to analyze an organization's needs and design effective measurement programs.

Software Measurement is implemented in stages. First, goals and currently collected data are analyzed to build an individualized measurement program. The program lays the groundwork by starting with selected key metrics that can be incrementally complemented with additional metrics over time, to create an immediately useful program that gradually matures measurement capability.

## Software Process Simulation

Software Process Simulation provides a level of confidence in the planning and control of the technical and human factors involved with software development. It enables users to simulate parameters, factoring in different decisions and strategies along the way. Process simulation enables users to:

- Match the best technologies and strategies for a specific project.
- Estimate the effect of technology infusion and process changes before implementation.
- Increase understanding and communication throughout development.
- Examine process structure, relations and behavior that affect engineering and management decisions.
- Use customized experimentation tools.
- Predict trends in the dynamic evolution of project parameters, including defect prediction, dynamic control, and more.

FC-MD's project simulation models are calibrated specifically to meet the needs of different organizations and their projects, taking into account their specific problems, questions, and decisions. By focusing on relevant variables that must be monitored and controlled, FC-MD identifies significant factors inherent in the development process and tailors metrics collections to improve tracking and planning.

## Consortia

### The Center for Empirically Based Software Engineering (CeBASE)

The Center for Empirically Based Software Engineering (CeBASE) was formed in order to reach the goal of building more reliable software systems, on time and within budget. CeBASE proposes an institutionalized empirical discipline for understanding causal relationships among the processes, components, and technologies that affect the building of systems. As in the physical and natural sciences, experimentation in software engineering requires a community in which

- proposed experimental designs can be critiqued by multiple researchers.
- experimenters access the resources they need to perform experiments.
- the results of experiments replicated at different locations can be analyzed for what they say about the “big picture.”

For these reasons, FC-MD cooperates with four universities across the country in the development of CeBASE. Through CeBASE, FC-MD undertakes original empirical research and is developing a prototype system for sharing and evolving the results of such research with a community of affiliated researchers and practitioners. CeBASE develops and refines techniques to increase the descriptive and predictive power of empirical models, and studies specific software development technologies to enable industrial organizations to understand the benefits and disad-

vantages of those technologies in their specific context. FC-MD also provides courses and symposia on empirical methodologies and results, and encourages the use of empirical knowledge in software engineering education.

On its website, [www.cebase.org](http://www.cebase.org), CeBASE maintains a repository of tools, reports, data, and experimental results related to empirical studies, for use by empirical researchers and practitioners. Some examples include:

- Links to publicly available tools that can be downloaded to assist in empirical studies or data collection.
- A comprehensive repository of all studies on a particular family of defect reduction technologies, i.e., reading techniques for improved software inspections. CeBASE collaborators can access materials and data for reuse in their own work.
- Results of expert workshops that were held to discuss important software engineering phenomena across organizations and industries, such as defect reduction, COTS-based software development, and Agile methodologies.
- A repository of lessons learned on COTS-based system development, accessible via keyword search or a prototype visualization interface.

All of the above features are interactive, and users of the website are encouraged to submit their own experiences and data as well as review what is already offered.

## Software Experience Center

The goal of the Software Experience Center (SEC) Consortium, a joint project between FC-MD and Fraunhofer IESE, is to improve member companies' software competencies and development practices. To achieve this goal, member companies share past and ongoing experiences in software process improvement and particular development technologies. The Fraunhofer organizations contribute their expertise to help analyze, package, and disseminate the lessons to be learned from these experiences.

The Fraunhofer organizations provide a number of services to member companies: Twice-yearly workshops present a forum for the discussion of software development experience. The Fraunhofer organizations produce a series of experience reports addressing specific technologies of interest to the Consortium that are gathered and stored in the Fraunhofer-operated SEC Experience Base for use and feedback by all

members. The Fraunhofer organizations have developed an extensive network of software experts, both within the organizations and externally, that can be made available to SEC member companies.

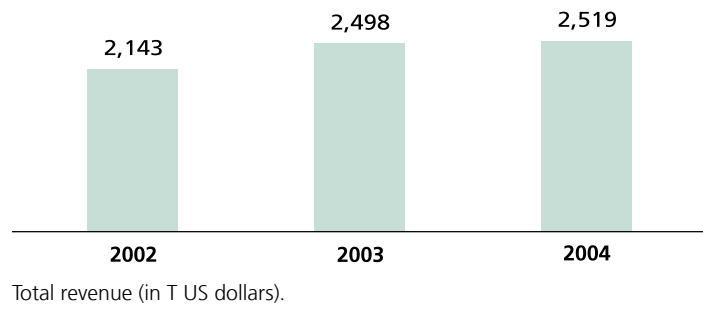
The Consortium is currently composed of five international corporations with significant investments in software development: ABB, Boeing, DaimlerChrysler, Motorola, and Nokia. The latest Consortium workshop was held in April 2004, in Seattle, and sessions ranged from in-depth working groups to presentations of experience reports. Session topics selected by the member companies included Design for six sigma, Usability, and Product-Line Architectures.

In a series of past meetings on Agile software development, a significant amount of experience has been shared. This experience was collected, refined, and packaged by the Fraunhofer scientists and will be made official so that other large organizations can take part in the lessons learned.

## FC-MD in Figures

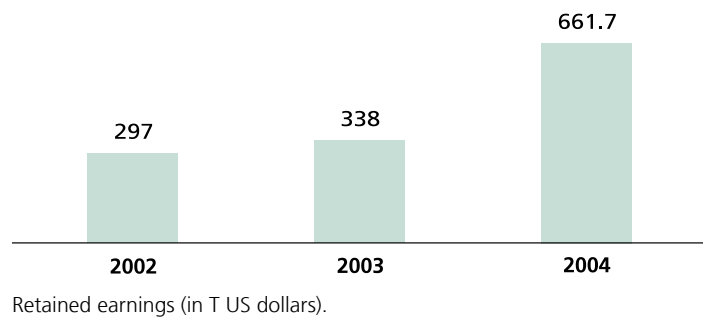
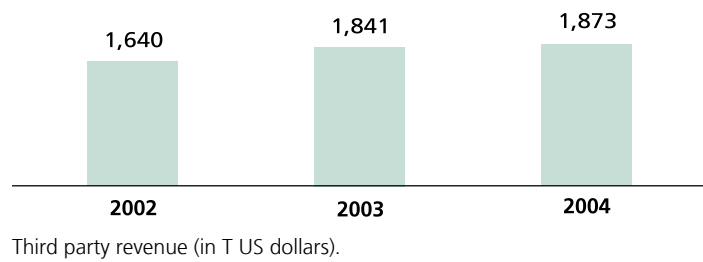
### Development of Revenues

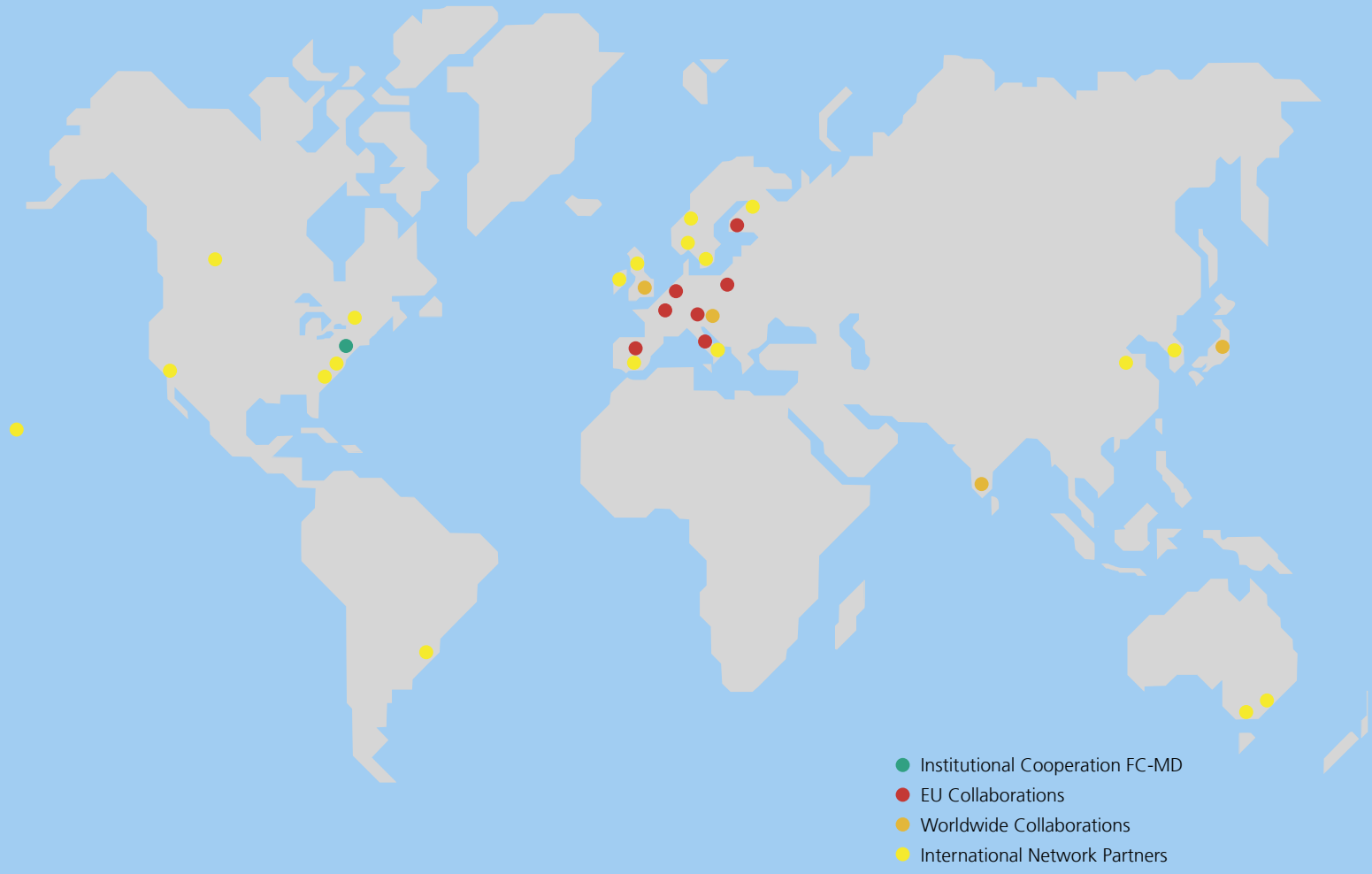
The Center is on track to increase its retained earnings in 2004 based on small increases in both total and third-party revenues and reduced costs from the previous year. Third party revenue accounts for 76% of the total revenue.



### People

Dr. Basili retired as Executive Director in mid-year and a search committee is actively seeking a Science Director. Our technical staff increased by 2 early this year and we are planning additional hires towards the end of 2004 or early 2005.





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## Research and Globalization

Fraunhofer IESE is one of the leading research institutions in the area of software engineering. A recently published study lists the institute as the best institution in Europe, and in fourth place internationally (The Journal of Systems & Software 76, 2005, pp. 91-97). To a large extent, Fraunhofer IESE owes its worldwide reputation to the international cooperation with other research institutions and project partners, which by now comprises five continents:

- North America, with our sister organization "Fraunhofer Center Maryland FC-MD", in close cooperation with the University of Maryland and many partners from the International Software Engineering Research Network (ISERN) in the U.S. and Canada
- Europe, with numerous strategic projects (e.g., with Hungary in the area of "Ambient Intelligence")
- Asia, with the focus on Japan, China, and India
- Australia, with our close cooperation with the National ICT Center of Australia (NICTA)
- South America, with our partners within ISERN

In all regions of the world mentioned, projects with industrial companies and public institutions have been initiated. In the following section, some examples of our participation in international collaborations as well as in global networks will be presented.

# Institutional Cooperation FC-MD

In 1994, Fraunhofer-Gesellschaft e.V. (FhG) established Fraunhofer USA (FUSA), headquartered in Plymouth, Michigan, to foster collaboration between research institutions and industries in the United States of America. The Fraunhofer Center for Experimental Software Engineering, Maryland (FC-MD) began operations in 1998 as the only FUSA center to specialize in software and related engineering fields, focusing on the use of experimental approaches to introduce innovative techniques into industry.

Affiliated with the University of Maryland (UM) and the Fraunhofer Institute for Experimental Software Engineering (IESE) in Kaiserslautern, Germany, FC-MD is the leading competence center for applied research and technology transfer in experimental software engineering.

To keep this overview short, only a few sample descriptions of FC-MD projects are listed here. Detailed descriptions of current projects of Fraunhofer Center Maryland can be found starting on page 95.

## Current Projects of Fraunhofer Center Maryland

### Best Practices Clearinghouse

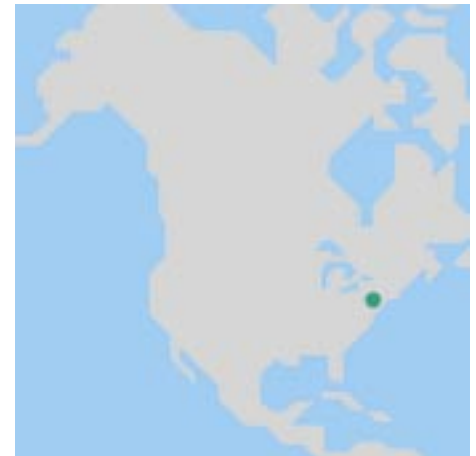
**Project Topic:** Acceptance and effective use of best practices by organizations from the areas of software development and acquisition

**Results / Goals:** Definition of the Clearinghouse concept, definition of an empirically based vetting process for each practice, definition of a requirements process, study of various repository technologies

**Keywords:** best practices, data-based process modeling, software acquisition

**Cooperation partners:** U.S. Department of Defense (DoD); Defense Acquisition University (DAU)

**Contact:** Dr. Ioana Rus  
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### Cooperation Project with the Institute for Experimental Software Engineering (IESE), Germany

**Project Topic:** Integration of the technology areas quality assurance and software product lines

**Results / Goals:** Method definition for the design and analysis of SPL architectures in connection with applicable QS techniques; development of a tool platform for the joint use of research and project tools

**Keywords:** software quality, inspections, test techniques, software product lines, reverse engineering, dependable software engineering

**Cooperation partner:** Fraunhofer IESE, Germany

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Dr. Mikael Lindvall  
mikli@fc-md.umd.edu



**Close cooperation:**  
Fraunhofer IESE collaborates with the Fraunhofer Center in Maryland

### Effort Estimation Process Model

**Project Topic:** Definition of a process to estimate project parameters

**Results / Goals:** Process description as hypertext (EPG), measurement of project size via FPA, model refinement via benchmarks and data from case studies

**Keywords:** process modeling, Electronic Process Guide (EPG), Function Point Analysis (FPA)

**Cooperation partner:** Goddard Space Flight Center, NASA, USA

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### High Dependability Computing Project

**Project Topic:** New design and development approaches for highly dependable software

**Results / Goals:** Methods for the characterization of high dependability systems, prototype implementation; development of an experience base for models of dependability properties

**Keywords:** high dependability systems, software for aerospace industries

**Cooperation partners:** U.S. Space Agency NASA; University of Maryland, Maryland, USA; Carnegie Mellon University; University of Southern California; Massachusetts Institute of Technology; University of Washington; University of Wisconsin

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### High Performance Computing Systems

**Project Topic:** Software development processes for high performance computers

**Results / Goals:** Analysis of the creation process of high performance code, optimization of development processes

**Keywords:** high performance computing, high performance computers, process modeling, process optimization

**Cooperation partner:** Defense Advanced Research Projects Agency (DARPA)

**Contact:** Patricia Costa  
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### Partners of Fraunhofer Center Maryland

- U.S. Department of Defense (DoD)
- U.S. Space Agency NASA
- Defense Advanced Research Projects Agency (DARPA)
- Creative Computing Solutions, Inc., Bethesda, Maryland
- DataStream Conversion Services, LLC, College Park, Maryland
- ManTech Systems Engineering Corporation, Lexington Park, Maryland
- QSS Group, Inc., Lanham, Maryland
- AC Technologies, Fairfax, Virginia
- Keymind, A Division of Axiom, Falls Church, Virginia

and many others

## Multinational European Collaborations



Since the founding of Fraunhofer IESE in 1996, cooperation projects that are funded by the European Union have created not only international visibility, but also extensive synergy effects by establishing research networks on a European level. These projects with considerably varying amounts of funding primarily serve to market new products and methods and also support the research community with numerous publications at meetings and conferences, in professional journals and books. Scientific research in the context of European consortia increases competitiveness and improves the market opportunities of industry in Europe through up-to-date and demand-oriented research results. At the same time, existing resources can be optimally used in research activities that are coordinated on the European level, and the unavoidable risks for the individual consortium partners can be kept to a manageable level. In the following, the current ITEA project Families as well as the project ProLearn, both funded by the European Union, will be described as examples of these multinational collaborations.

### **FAMILIES – Software Product Lines for more Efficiency and Productivity**

**Project Topic:** Further development of the state of the art and dissemination of software product lines

**Results / Goals:** Methods for analyzing, identifying, and packaging components; methods for the systematic, quality-oriented definition of architectures; methods for determining the investment value of product line development; tool for modeling product lines; tool for identifying variable requirements from existing documentations

**Keywords:** software product lines, strategic alliances

**Cooperation partners:** Siemens AG, Munich (Germany); Robert Bosch GmbH, Stuttgart (Germany); MARKET MAKER AG, Kaiserslautern (Germany); University of Duisburg-Essen (Germany); Nokia (Finland); University of Helsinki (Finland); VTT Electronics (Finland); MetaCase (Finland); Thales (France); INRIA (France); Ivorium Software S.A.

(France); Objecteering Software S.A. (France); Laboratoire d’Intégration des Systèmes et des Technologies CEA List (France); Technical University of Vienna (Austria); Koninklijke Philips Electronics N.V. (Netherlands); Rijks Universiteit Groningen (Netherlands); IKT-Norge (Norway); SINTEF (Norway); DNV Software (Norway); EDB Telesciences AS (Norway); Ericsson AVS (Norway); SuperOffice ASA (Norway); Visma Software Norge AS (Norway); European Software Institute ESI (Spain); TELVENT (Spain), Universidad Politécnica de Madrid UPM (Spain).

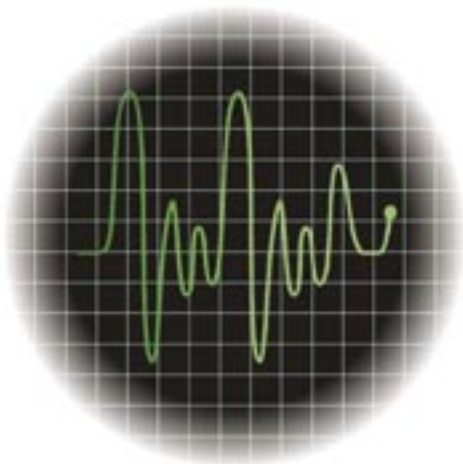
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**Grant number:** Eureka Σ 2023 Programme, ITEA project ip02009, German BMBF grant no. 01 IS 002 B

The international project FAMILIES (FAct-based Maturity through Institutionalisation of Lessons-learned and Involved Exploration of System-family engineering) is the third in a series of projects aimed at further developing the state of the art and disseminating

software product lines. The two previous projects ESAPS (1999-2001) and Cafe (2001-2003) created the basis for the European head start in the area of product line development. It is now one of the tasks of the project FAMILIES (2003-2005) to consolidate the achieved results and thus facilitate and advance dissemination into other interested organizations.

Major results from the FAMILIES project and the two previous projects have been integrated into Fraunhofer IESE's PuLSE® method (Product Line Software Engineering). The PuLSE® method and the product line competence gained in the FAMILIES project were successfully used in numerous projects, even with non-consortium partners, and continue to be used. Part of the experiences made by the German sub-consortium has recently been published in a book (Böckle, Knauber, Pohl, Schmid: Software-Produktlinien; Dpunkt-Verlag, 2004).



**Sound competence made by Fraunhofer:**

PuLSE® simplifies the transfer from project-specific development of single systems to the reuse of generic components.

**International Projects Funded by the European Union**

**ProLearn – Networks of Excellence**

**Project Topic:** In the ProLearn (Professional Learning) network, a total of 19 research institutions from 13 different European countries are combined under the leadership of the Learning Lab Lower Saxony, Hanover, Germany, with the purpose of coordinating their own research in important areas of technology-supported professional training.

**Results / Goals:** Build-up of a competence network; development of simulation-based learning environments; identification of best practices

**Keywords:** competence networks, continuing education and training, adaptive learning, e-Learning

**Cooperation partner:** European research institutions

**Contact:** Dr. Dietmar Pfahl  
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**Grant number:** FP6-IST-507310

The areas of work within the project ProLearn include personalized adaptive learning, interactive media, online experiments, learning objects, metadata and standardization, brokerage systems and learning management, business models and market analysis as well as work-related knowledge management.

Fraunhofer IESE focuses its activities on the area of “online experiments”, primarily contributing its competencies and research interests in connection with the creation of virtual, simulation-based learning environments (Virtual Laboratories) for continuing education in the area of software development. The goal of the research is to examine the effectiveness of virtual laboratories for specific areas of usage in job-related continuing education and training and also to identify and disseminate related best practices.

Further information:

[www.prolearn-project.org](http://www.prolearn-project.org)

### Wireless Services Internet Engineering (WISE)

**Project Topic:** Developing an engineering-style method und a generic architecture for the realization of Wireless Internet Services and testing it in industrial environments

**Results / Goals:** Software development methodologies for wireless services as well as their quantitative (GQM-based) and qualitative testing; descriptive process modeling with SPEARMINT®

**Keywords:** wireless communication, process engineering

**Cooperation partners:** InvestNet Italia SpA (Italy); Motorola Global Software Group (Italy), Sodalia SpA (Italy), Solid EMEA Headquarters (Finland); Telia-Sonera (Finland); Politecnico di Torino (Italy); VTT Electronics (Finland)

**Contact:** Dr. Jürgen Münch  
juergen.muench@iese.fraunhofer.de

**Grant number:** IST-2000-30028

### Adaptive Service Grids (ASG)

**Project Topic:** Development of an open platform for the adaptive identification, development, combination, and execution of software-based services

**Results / Goals:** Coordination of platform development; development of an ASG-application development method on the basis of the methods PuLSE® and KobrA developed by Fraunhofer IESE

**Keywords:** Grid Computing, service-oriented applications

**Cooperation partners:** Hasso Plattner Institute (HPI) at the University of Potsdam (Germany); University of Leipzig (Germany); University of Innsbruck (Austria), DaimlerChrysler Research (Germany); National University of Ireland (Ireland); TranSIT GmbH (Germany); NIWA (Austria), Telenor (Norway); Siemens AG (Germany); Rodan Systems (Poland); University of Jyväskylä (Finland); Telekomunikacja Polska (Poland); Marketplanet (Poland); University

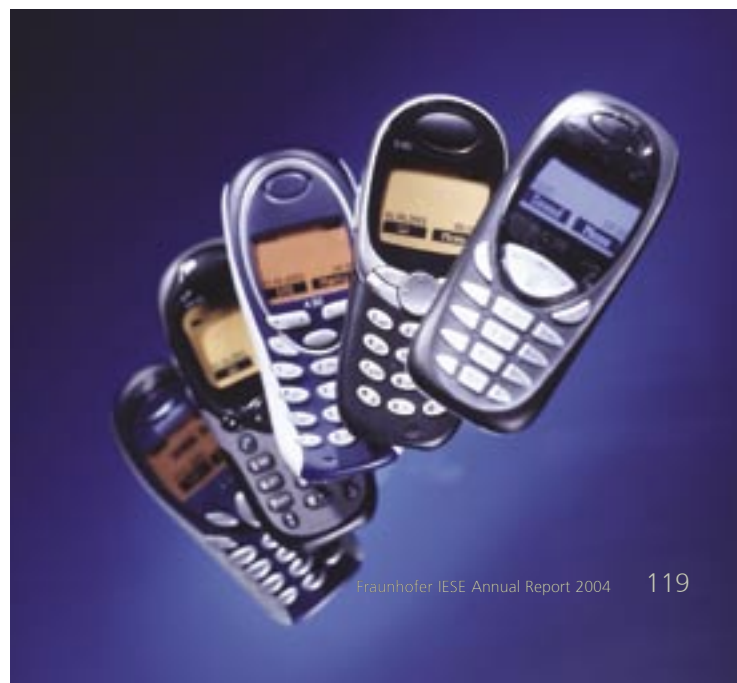


of Karlsruhe (Germany); ASTEC Group (Poland); Poznan University of Economics (Poland); University of Applied Sciences Furtwangen (Germany); Polska Telefonia Cyfrowa (Poland); University of Potsdam (Germany).

**Contact:** Dr. Joachim Bayer  
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**Grant number:** FP6-IST-004617

**Wireless communication is "in" –**  
Software Engineering ensures reliable services.  
(photo reprinted with permission of Siemens AG.)



## Fraunhofer IESE in Worldwide Projects



**Omnipresent micro-processors:**  
With Ambient Intelligence, the number of computer systems that are almost invisibly integrated into our daily lives will increase even more.



Top research thrives on international cooperation and competition – preferably in worldwide research projects. Fraunhofer IESE has been pursuing this strategy for many years, with great success in numerous countries worldwide. The following pages present some of our more extensive international collaborations.

### Cooperation with Hungary in the area of Ambient Intelligence

**Project Topic:** Technologies for improving energy efficiency, architectures & platforms for Aml systems as well as quality assuring development methods

**Keywords:** strategic networks, ambient intelligence, ubiquitous computing, pervasive computing

**Cooperation partners:** Inter-University Centre for Telecommunications and Informatics ETIK, Budapest (Hungary); Technical University of Kaiserslautern (Germany)

**Contact:** Prof. Dieter Rombach  
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Since one of the declared goals of the University of Kaiserslautern is to increasingly expand its collaborations towards Eastern Europe, Professor Nehmer and Professor Rombach (Department of Computer Science) visited the Technical University of Budapest in March of this year. It turned out to be a competent cooperation partner, and since matching research foci already existed on both sides, it did not take long to identify the topic of the cooperation – Ambient Intelligence.

In Kaiserslautern, the work of the German-Hungarian research team is integrated into the research focus “Ambient Intelligence” of the University of Kaiserslautern. In October 2004, the first of a series of planned workshops on joint scientific model topics and projects already took place in Budapest. The workshop participants from Kaiserslautern included the research groups of the following professors: Litz, Wehn, Tielert, Urbansky, Zühlke, Berns, Gotzhein, Rausch, and Rombach (University of Kaiserslautern), as well as experts from Fraunhofer IESE (Prof. Rombach, Dr. Schmid). The scientific model projects will deal with technologies for improving energy efficiency, architectures & platforms for Aml systems as well as with quality assuring development methods.

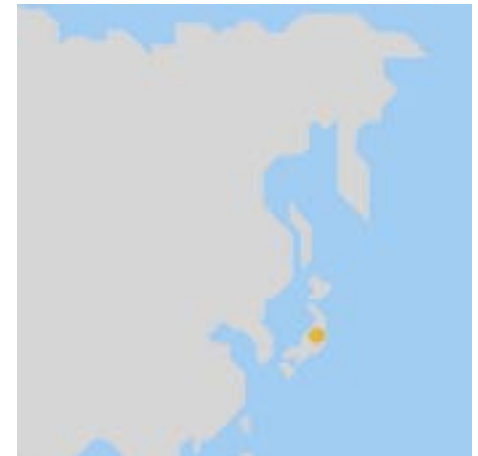
In the meantime, the collaboration with Budapest was selected by the Office of the German Chancellor as a pilot project for future-oriented research collaboration with Hungary. The pilot project – under the leadership of the Fraunhofer Institute for Experimental Software Engineering (IESE) in Germany and the Inter-University Centre for Telecommunications and Informatics (ETIK) in Hungary – was presented to the public in Budapest by the Office of the Chancellor, on the occasion of the 15th anniversary of the day that East German citizens were granted permission to leave the country via the German embassy. In the context of a visit to Hungary by German Chancellor Gerhard Schröder, German Federal Research Minister Edelgard Bulmahn and the Hungarian Minister of Education Magyar Bálint signed a joint agreement in Budapest on 15 September 2004 to further develop and intensify their collaboration in scientific research and technological development. The start-up investments for the pilot project in the amount of six million euros will be born in equal parts by the two countries. On the German side, the funds are provided by the German Federal Ministry of Education and Research (BMBF), the state of Rhineland-Palatinate as well as the Fraunhofer-Gesellschaft.

## Collaborations with Japan

The close scientific relationships between Fraunhofer IESE and top Japanese universities in Osaka and Nara, which have existed for many years, and recently also our relationship with the Japanese Ministry of Economy, Trade and Industry METI on the issue of software engineering, have already led to intensive collaborations in the past, such as contract research with companies such as Ricoh Co., Ltd. and Fujitsu.

After Fraunhofer IESE signed a collaboration agreement with the Japanese Ministry of Economy, Trade and Industry (METI) in November, more industrial collaborations on various software engineering topics are now getting established.

This intensified cooperation with Japanese research institutes and companies – complemented by the exchange of scientists and students – will strengthen the international reputation of Fraunhofer IESE as a leading software engineering competence center even more. For more than 10 years, there has existed close scientific cooperation with the Nara Institute of Science and Technology NAIST in Nara. Fraunhofer IESE is involved as a partner in the EASE project of the Japanese Ministry of Education (MEXT) under the leadership of Prof. Koji Torii.



## The Virtual Office of the Future

**Project Topic:** Development of future software-based products and services for the virtual office

**Keywords:** strategic alliances, ambient intelligence, ubiquitous computing, pervasive computing, intelligent office applications, reference architectures

**Cooperation partners:** Ricoh Co., Ltd. (Japan); German Research Center for Artificial Intelligence (DFKI); and others

**Contact:** Dr. Dirk Muthig  
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During the past few years, scenarios were developed in many application domains that benefit from the idea of "ambience". One of these is the "Virtual Office of the Future", in which diverse pieces of end user equipment interact on their own – either because certain persons are identified, messages are received from other equipment, or based on the status of higher-level business workflows. According to current prognoses, the market for such "intelligent" office applications, which also include e-Government applications, will experience strong mid-term growth.

In the competence center "Virtual Office of the Future", which is funded by the state of Rhineland-Palatinate, Fraunhofer IESE is establishing fundamental research competencies for demonstrating the visions of a Virtual Office, and is developing future software-based products and services for this domain in cooperation with industrial partners.

In the context of this project, comprehensive competence is being built up in the area of flexible software architectures, which will be a decisive factor for the efficient technical realization of office environments. Beyond that, research is necessary regarding (semi-) automated support of the workflows and processes in an organization. It takes these to provide office end equipment with the context information needed to support the user in a proactive and "intelligent" manner.

In light of these prospects, the work of the research partners and the collaborating industrial companies from the office application systems domain focused on requirements, reference architectures, and quality assurance. Work concentrated on system- and software engineering aspects dealing with the development and adaptation of IT-based office services and their sup-

port through flexibly adaptable office end equipment.

After an analysis of the application domain and after identification of the services, functionalities, and properties of office infrastructure and end equipment that are typical today, the requirements on future infrastructures were exemplarily juxtaposed to these results. This enabled precise identification of the central new aspects of the approach for the competence center "Virtual Office of the Future". The crucial difference to previous applications – in addition to efficient and maximal adaptability of all system components and office equipment – is that the office infrastructure is informed about the current workflows and thus offers context-sensitive services that can be reasonably combined with parallel or subsequent workflows. For example, a telephone "thinks" by interpreting the meaning of its quick-dial buttons depending on the appointment schedules that have been installed. Depending on whether a colleague is in the office, at home, or on the road, the telephone will dial the appropriate number.

The reference architecture designed in the subsequent step should fulfill the requirements of future office infrastructures and office systems, while

allowing as much flexibility as necessary in order to be efficiently adaptable to the individual needs of different office organizations. This resulted in a generic solution for realizing a product line for office environments.

The resultant reference architecture is also an initial fixed point for all companies that want to develop, install, and operate future office infrastructures in cooperation with the competence center. It defines a framework for the different roles, such as office organizations (i.e., end customers), smaller and large suppliers (i.e., partners who provide individual system components), system integrators as well as maintenance companies or other service providers.

For the reference architecture, suitable quality assuring measures were identified and assessed with regard to their usability and usefulness in the area of office applications. Taken together, these result in a generic quality strategy, which is an inherent part of the reference architecture. In order to do justice to the highly flexible reference architecture, static and dynamic quality assurance techniques were developed, which can be used in various contexts.

**Strategic Cooperation with the Japanese Space Agency JAXA**

**Project Topic:** Providing and optimizing highly efficient development processes for software-intensive aerospace systems

**Keywords:** strategic alliances, international competence networks, aerospace

**Cooperation partner:** Japan Aerospace Exploration Agency JAXA, Tokyo (Japan)

**Contact:** Dr. Jürgen Münch  
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In the context of this cooperation, Fraunhofer IESE will perform tasks both in Germany and in Japan. Together, we will analyze software development procedures and processes at JAXA and determine their improvement potential. Fraunhofer IESE supports JAXA in organizing internal process assessments and designing an improvement program for the development of safety-critical aerospace applications. Additionally, this cooperation is further intensified through training sessions and workshops. In this context, Fraunhofer IESE can make valuable experiences regarding the use of established methods in a sensitive and critical context. The know-how created together with the Japanese development experts will also benefit other Fraunhofer IESE projects in the context of the European aerospace domain.

**Information-technology Promotion Agency (IPA) / Software Engineering Center (SEC) in Japan**

**Project Topic:** Support of the Japanese Software Engineering Center (SEC)

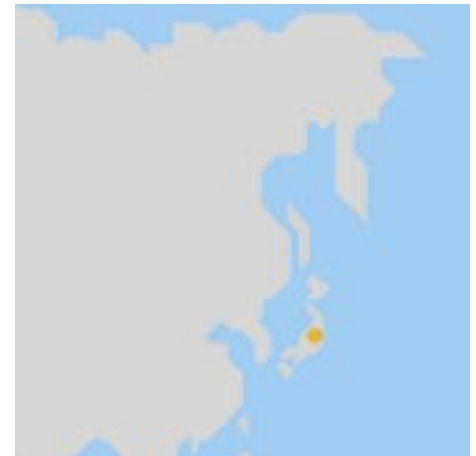
**Keywords:** strategic alliances, international competence networks

**Cooperation partner:** Japanese Ministry of Economy, Trade and Industry METI, Tokyo (Japan); Universities of Osaka and Nara (Japan)

**Contact:** Prof. Dieter Rombach  
dieter.rombach@iese.fraunhofer.de

The Japanese Ministry of Economy, Trade and Industry (METI) has signed a long-term collaboration agreement with the Fraunhofer Institute for Experimental Software Engineering (IESE) located in Kaiserslautern. The topic of the cooperation is support for the Japanese Software Engineering Center (SEC). The SEC was presented to the public in Tokyo on the day the collaboration agreement was signed and is intended as a Japanese research and technology transfer platform for the promotion of industrial software engineering.

In the context of this cooperation, Fraunhofer IESE together with the universities in Osaka and Nara will perform research into software development methods and further develop these; it will also support technology transfer into Japanese companies. From



the perspective of Fraunhofer IESE, the agreement with the Japanese ministry of trade serves the goal of further strengthening our own competencies in the exchange with the best scientists in Japan and establishing more industrial collaborations with Japanese companies. One initial concrete project was started on the topic of "Project Effort Estimation". The methods and tools OSR (Optimised Set Reduction) and CoBRA (Cost Estimation, Benchmarking, and Risk Assessment) on measurement-based development of effort estimation models, which were developed by Fraunhofer IESE, will be used here.

Various pilot projects with Japanese IT service providers in the financial sector as well as with automotive companies are already envisioned; further industrial collaborations with Toyota Motor Corporation and Hitachi Ltd. are being prepared.



**COMPAS: What comes after capability level 5?**

(Cooperation on Measurement-based quantified Processes for Activities in Software Engineering)

**Project Topic:** Identification of quantitative relationships between software processes and software products

**Keywords:** data-based project management, business intelligence for software organizations

**Cooperation partner:** Siemens Information System Ltd. (SISL), Bangalore (India)

**Contact:** Prof. Peter Liggesmeyer  
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 Michael Ochs  
 michael.ochs@iese.fraunhofer.de

One characteristic feature of mature software development processes is the enrichment of the process steps, which are initially merely defined qualitatively, through quantitative data (metrics) and, finally, the control and optimization of the development process on the basis of measurements.

Siemens Information System Ltd. (SISL) in Bangalore has achieved CMMI Level 5, the highest capability level. The prerequisites for an effective measurement system have been fulfilled; quantitative tracking of all process steps is deeply rooted in the entire organization. Measurement data are not only being elicited continuously during development, but they are also used to influence the process in the sense of a feedback loop.

However, even such mature processes have a potential for optimization that is interesting in both a technical and an economic sense – in the sense of efficiency and effectiveness. The wish of the cooperation partner to optimize the measurement program itself based on the measurement data elicited and to make predictions that are on target regarding properties that cannot be measured directly by using existing data is the basis of the cooperation with Fraunhofer IESE.

In the context of the collaboration with Siemens Information System Ltd. (SISL) the issue is to develop suitable prediction models for quantitatively controlling the operative products by combining empirical measurement processes and analyzing the resulting data. How will the effort for the employees change when the development process is performed differently than so far in certain areas? Which defect rate will occur after clearance has been given? How will cost and quality be changed when there is more or less project management?

In the past, these questions were the subject of speculations and merely qualitative estimations. In the context of COMPAS they shall now be answered quantitatively and based on traceable, numerical facts. The transfer of the corresponding competence in these methods through Fraunhofer IESE enables Siemens Information System Ltd. (SISL) to draw conclusions from existing measurement processes and data in order to optimize both its own measurement programs and products and development processes, which will go far beyond the definition of CMMI Level 5.

**Collaborations with India**

The still young IT industry on the Indian subcontinent has achieved very high maturity since it came into being. Many software companies are categorized as CMMI Level 5, which includes, in particular, quantitative, i.e., measurable tracking of all process steps. In India, companies can choose from a large reservoir of highly motivated and well trained professionals, who develop software at an interesting cost-/performance ratio. One of the outstanding characteristics of the emerging software industry in India is its constant ambition to maintain its own high standards and elevate these even more with the help of modern software engineering processes. Fraunhofer IESE currently provides support for CMMI Level 5-certified Siemens Information System Ltd. SISL in Bangalore to further optimize its development processes, which are all characterized quantitatively.

## Other Collaborations

In addition to the collaborations mentioned above, Fraunhofer IESE has contacts to other research and industry partners in various software engineering contexts. To provide a complete list of all collaboration projects would go beyond the scope of this report; however, upon demand, we will be glad to inform you about our worldwide activities. Below you will find a sample list of running or recently concluded projects in Europe.

### Software Development for Access Control Systems

**Project Topic:** Risk management and data-based optimization programs

**Keywords:** access control, ticketing, security, GQM, Risk-IT

**Cooperation partner:** AXESS AG (Austria)

**Contact:** Christian Denger; christian.denger@iese.fraunhofer.de

### Software Inspections Guarantee Quality in Bioinformatics

**Project Topic:** Definition of customer- and application-specific inspection processes

**Keywords:** life sciences, software inspections, process engineering

**Cooperation partner:** LION bioscience Ltd., Cambridge (Great Britain)

**Contact:** Ralf Kalmar; ralf.kalmar@iese.fraunhofer.de

### International Exchange of Experience via the Software Experience Center (SEC)

**Project Topic:** International exchange of experience while protecting corporate interests

**Keywords:** international competence networks

**Cooperation partners:** ABB Asea Brown Boveri Ltd. (Switzerland); The Boeing Company (USA); DaimlerChrysler Corporation (Germany / USA); Motorola, Inc. (USA); and Nokia (Finland).

**Contact:** Dr. Dirk Muthig; dirk.muthig@iese.fraunhofer.de

### ForPICS – Formal Methods Solve Critical Problems

**Project Topic:** Seamless integration of formal methods into existing software development processes of critical industrial applications

**Keywords:** formal methods, critical systems, safety, software tests

**Cooperation partners:** Istituto Trentino di Cultura ITC, Trento (Italy); Istituto per la Ricerca Scientifica e Tecnologica IRST, Trento (Italy)

**Contact:** Thomas Olsson; thomas.olsson@iese.fraunhofer.de



## Fraunhofer IESE in International Networks



Fraunhofer IESE is active in various international research networks. The objective of these activities is to promote an intensive worldwide exchange of experience in the area of software engineering and to obtain and consolidate statements about the effects of software engineering methods through empirical research. The most important software engineering network is the International Software Engineering Research Network (ISERN), which is under the direction of Fraunhofer IESE. Furthermore, Fraunhofer IESE is engaged in NICTA (National ICT Australia), JSEC (Japanese Software Engineering Competence Center), in the EASE project (Empirical Approach to Software Engineering) in Japan, in ISERC (International Software Engineering Research Center) in Ireland, and in additional collaborations with SEI in the USA, as well as with partners in Korea and China. Within these collaborations, there is a lively exchange of scientists and students. Within the ISERN network, in particular, Fraunhofer IESE is engaged in an intensive mutual exchange of experience with the following partners: Prof. Dr. Lionel Briand (Carlton University, Canada), Dr. Frank Houdek (Daimler Chrysler, Germany),



Prof. Dr. Marvin Zelkowitz (University of Maryland / Fraunhofer Center Maryland, USA), Prof. Dr. Jyrki Kontio (Helsinki University of Technology, Finland), Prof. Dr. Koji Torii (NAIST, Japan), Mr. Masafumi Katahira (JAXA, Japan), Prof. Dr. Natalia Juristo (Politechnico Madrid, Spain), Prof. Dr. Victor Basili (University of Maryland, USA), Prof. Dr. Ross Jeffery (University of New South Wales, Australia), Prof. Philip Johnson (University of Hawaii, USA), Prof. Dr. Guenther Ruhe (University of Calgary, Canada), Prof. Dr. Dag Sjøberg (University of Oslo, Norway), Prof. Dr. Markku Oivo (University of Oulu, Finland), Prof. Dr. Barry Boehm (University of Southern California, USA). A list of all ISERN partners completes this overview.

### International Software Engineering Network (ISERN)

**Project Topic:** Exchange of experience and personnel between internationally operating software engineering research groups

**Keywords:** international competence networks

### Collaboration Partners:

- Blekinge Institute of Technology (BTH)  
<http://www.bth.se/eng/>  
Sweden
- Carleton University  
<http://www.carleton.ca/>  
Department of System and Computer Engineering  
Canada
- Central Research Institute of Electric Power Industry  
<http://criepi.denken.or.jp/>  
Japan
- COPPE  
<http://www.cos.ufrj.br/english/>  
Brazil
- DaimlerChrysler Research Center  
<http://www.daimlerchrysler.com>  
Germany
- Fraunhofer Center Maryland  
<http://fc-md.umd.edu/>  
USA
- Fraunhofer Institute for Experimental Software Engineering  
<http://www.iese.fraunhofer.de/>  
Germany
- Helsinki University of Technology  
<http://www.hut.fi/English/>  
Finland
- Lucent Technologies – Bell Laboratories  
<http://www.lucent.com/>  
USA
- Lund University  
<http://www.tts.lth.se/>  
Sweden
- Nara Institute of Science and Technology  
[http://www.naist.jp/index\\_en.html](http://www.naist.jp/index_en.html)  
Japan
- National ICT Australia (NICTA)  
<http://nicta.com.au/>  
Australia
- Japan Aerospace Exploration Agency (JAXA)  
[http://www.jaxa.jp/index\\_e.html](http://www.jaxa.jp/index_e.html)  
Japan
- North Carolina State University  
<http://www.ncsu.edu/>  
USA
- Norwegian University of Technology & Science  
<http://www.idi.ntnu.no/english/>  
Norway

- NTT Data Corporation  
<http://www.nttdata.co.jp/en/index.html>  
Japan
- Politecnico Madrid  
<http://www.upm.es/>  
Spain
- SINTEF, Norway  
<http://www.sintef.no/>  
Norway
- Solid Information Technologies  
<http://www.solidtech.com/>  
Finland
- SUN Microsystems  
<http://www.sun.com>  
USA
- Technical University of Vienna  
<http://www.tuwien.ac.at/>  
Austria
- University of Maryland, Baltimore County  
UMBC  
<http://www.umbc.edu/>  
USA
- University of Technology Sydney  
<http://www.uts.edu.au/>  
Australia
- University of Castilla-La Mancha  
<http://www.uclm.es/>  
Spain
- University of Maryland at College Park  
<http://www.cs.umd.edu/>  
USA
- University of Kaiserslautern  
<http://www.uni-kl.de/>  
Germany
- University of New South Wales  
<http://www.unsw.edu.au/>  
Australia
- Università degli Studi di Roma "Tor Vergata"  
<http://www.uniroma2.it/>  
Italy
- University of Bari  
[http://www.uniba.it/index\\_n.php](http://www.uniba.it/index_n.php)  
Italy
- University of Strathclyde  
<http://www.cis.strath.ac.uk/>  
Scotland  
U.K.
- University of Hawaii  
<http://www.ics.hawaii.edu/>  
USA
- University of Calgary  
<http://www.ucalgary.ca/>  
Canada
- University of Alberta  
<http://www.ualberta.ca/>  
Canada
- University of Oslo  
<http://www.uio.no/english/>  
Norway
- University of Oulu  
<http://www.tol.oulu.fi/english/>  
Finland
- University of Southern California (USC)  
<http://www.usc.edu/>  
USA
- University of São Paulo (USP)  
<http://www2.usp.br/ingles>  
Brazil
- VTT Electronics  
<http://www.vtt.fi/ele/indexe.htm>  
Finland

**Contact:** Dr. Christian Bunse  
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**ISERN on the Internet:**  
[www.iese.fraunhofer.de/ISERN](http://www.iese.fraunhofer.de/ISERN)

As a community, ISERN has begun to recognize that software cannot be produced with one standard technology, but needs to be developed with technologies tailored to the goals and characteristics of particular projects. Consequently, software engineering research needs to be performed in an experimental context that allows us to observe and experiment with the technologies in use, understand their weaknesses and strengths, tailor the technologies for the goals and characteristics of particular projects, and package them together with empirically gained experience to enhance their reuse potential in future projects.

Several software engineering research groups have made the paradigm shift to an experimental software engineering view. The purpose of this

network is to encourage and support the exchange of results and personnel between these groups. Specific emphasis is placed on experimentation with development technologies in different environments; the repetition of experiments across environments; and the development and exchange of methods and tools for model building, experimentation, and assessment. The long-term expectation is that such cooperation will enable the abstraction and unification of environment-specific results and knowledge with the objective of generating the basic components of our discipline.

The founding ISERN members chose the Quality Improvement Paradigm as the reference model to provide a common terminology for their cooperation. The QIP is an experimental framework for software development, based on the scientific method and instantiated in the TAME project at the University of Maryland. It views measurement as essential to the capture and effective reuse of software experience, and assumes that the process is a variable based on the characteristics and goals of the project and organization. This framework views software engineering as a laboratory science, which must be supported by the effective cooperation between academia and industry in order to achieve significant improvements.

ISERN is open to other academic and industrial groups worldwide that are active in experimental software engineering research and are willing to adopt the experimental framework. There is no membership fee. The individual network members are responsible for funding the collaboration through existing local or future joint grants.



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# Fraunhofer IESE Locations

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67661 Kaiserslautern  
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Fax: +49 (0) 6301/707-200  
info@iese.fraunhofer.de  
www.iese.fraunhofer.de

### How to reach us:

**By car**  
Arriving on highway A6 from either the west (Saarbrücken) or the east (Mannheim), take the exit *Kaiserslautern-West* and follow the signs that read *Lauterecken*. About 500 m after exiting the highway, make a left towards *Siegelbach*. Follow the road leading through a forest. Right after entering *Siegelbach*, turn right at the first junction into the street *Sauerwiesen*. After about 100 m you find IESE on your right-hand side.

**By train**  
After arriving at the Kaiserslautern railway station, take either a taxi (ca. 8 km) or the bus (line RSW 6510, departs from bus stop AV2 at the railway station, destination: Siegelbach) to Siegelbach. Get off at the bus stop *Siegelbach Sand*, which is about 100 m from the Institute.

**By airplane**  
After arriving at Frankfurt/Main airport, take either the train (about 2 hours) or rent a car (about 1.5 hours).

## Contact Office at PRE-Park Competence Center for Software Technology and Continuing Education

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67657 Kaiserslautern  
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volker.huebsch@iese.fraunhofer.de

### How to reach us:

**By car**  
Arriving on highway A6 from either the west (Saarbrücken) or the east (Mannheim) at the Autobahn Interchange ("*Autobahn-Dreieck*") *Kaiserslautern*, take the exit *Kaiserslautern-Centrum*. After 500 m turn left into PRE-Park, until the priority road makes a sharp left turn. There, continue straight into *Luxemburger Straße*. The Fraunhofer IESE Contact Office is located in the 2nd white building on the left-hand side.

**By train**  
After arriving at the Kaiserslautern railway station, take the bus (# 2, 5, or 7) to *Schillerplatz* stop. Change into bus # 4. Get off at the *PRE-Park* stop.  
Attention: Not every bus stops at PRE-Park!

## Contact Office at the University of Kaiserslautern

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### How to reach us:

**By car**  
Arriving on highway A6 from the west (Saarbrücken), take the exit *Kaiserslautern-West* and follow the signs to Pirmasens on B270. After approx. 1 km (1/2 mile) turn right onto *Pariser Straße*, following the signs *Universität* and *Stadtmitte*. After approx. 1.5 km (1 mile), you will see a white sign *Universität* on your right. Continue straight until you get to the traffic light. There, turn left following the sign to *Universität*. The Fraunhofer IESE Contact Office is located in Building 57 on the fifth floor.

Arriving on highway A6 from the east (Mannheim) at the Autobahn Interchange ("*Autobahn-Dreieck*") *Kaiserslautern*, take the exit *Kaiserslautern-Centrum* and follow the signs to *Stadtmitte* on *Mainzer Straße*. Then follow the signs *Universität*. The Fraunhofer IESE Contact Office is located in Building 57 on the fifth floor.

**By train**  
After arriving at the Kaiserslautern railway station, take either a taxi or bus # 5, destination *Uni-Wohngebiet*. Get off at the *Uni-Ost* stop. After walking approx. 300 m in the opposite direction, you will see signs to Bldg. 57. The Fraunhofer IESE Contact Office is located on the fifth floor.



**Fraunhofer USA Center for Experimental Software Engineering University of Maryland**

4321 Hartwick Road, Suite 500  
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 Fax (301) 403-8976  
 info@fc-md.umd.edu  
 http://fc-md.umd.edu/fcmd/index.html



**How to reach us:**

**By car**

**Directions from Points North:**

Follow I-95 South to the point where it merges with I-495. Follow the signs for Exit No. 27-Richmond (I-95/495 South). Then follow the Exit 27 signs staying to the left so you can take the special Rt.1/College Park exit lane. This will briefly put you back on I-95. Stay to the right and take Exit No. 25 onto Route 1 South (towards College Park).

For directions from this point on, see "Further directions" on this page!

**Directions from Points South:**

Follow I-95 North to the point where it merges with I-495. Follow the signs for Baltimore (I-95/495 North). Take Exit No 25 onto Route 1 South (towards College Park).

For directions from this point on, see "Further directions" on this page!

**By train (15 minute walk)**

Exit College Park Metro station by turning right after you exit the turnstile and going through a tunnel to Calvert Rd. Take Calvert Rd. for 4-5 blocks to Rt. 1. (Calvert ends there). Cross Rt. 1 and go right a block to Hartwick Rd. Turn right (there's a Kinko's Copy sign on the corner). Our building (4321) is on the left.

**By plane**

B.W.I. airport (about 45 minutes by car): Exit the airport on I-195 (main road out of airport). After a few miles, take I-95 South towards Washington.

From this point, follow directions from Points North.

National Airport (about 90 minutes by car; also a stop on the Yellow Metro line):

Exit the airport towards I-395 North towards Washington, D.C. Continue on I-395 North to New York Avenue. Turn right onto New York Avenue (US Rt. 50 East) to MD Rt. 295/Baltimore-Washington Parkway for approximately six miles. Stay on BWI Parkway to the exit for Maryland Rt. 193. This is Greenbelt Road/Rt. 193. Take Rt. 193 East to Rt. 1 South.

For directions from this point on, see "Further directions" below!

**Further directions:**

Stay on Rt.1 South, going past the University of Maryland. After passing the University, you will encounter 2 stop lights – the 2nd one being Knox Rd. Take the next right after Knox onto Hartwick Rd (there's a Kinko's Copy sign on the corner). Our building (4321) is on the left – turn left past the building into the parking lot and park anywhere.

We're on the 5th floor – directly opposite the elevator.



Map of Kaiserslautern

## Fraunhofer IESE Contact Persons

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121 Dr. Reinhard Schwarz  
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Technology and Continuing  
Education**

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223 Jörg Dörr  
Secure Software for IT-Infrastructures and -Providers  
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135 Michael Ochs  
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Software-based Products and Services  
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## Information Service

Fraunhofer-Institut für  
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Sauerwiesen 6

67661 Kaiserslautern  
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New address presumably starting from  
August 2005:  
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Germany

To receive further information, please  
fax us a copy of this page.

Fax: +49 (0) 6301/707-200

### Further Information

- Annual Report 2004 of Fraunhofer IESE, print version (German)
- Annual Report 2004 of Fraunhofer IESE, print version (English)
- Annual Report 2004 of Fraunhofer IESE, CD-ROM version (German & English)
- Fraunhofer IESE: Overview
- The Fraunhofer-Gesellschaft from A-Z
- Annual Report of Fraunhofer-Gesellschaft
- STI Software Technology Initiative Kaiserslautern e.V.
- Please add my address to your information distribution list.

A pdf file of the Fraunhofer IESE Annual Report 2004 and other publications (e.g., technical reports, press releases, previous Annual Reports) are available at

[www.iese.fraunhofer.de](http://www.iese.fraunhofer.de)

#### Fraunhofer IESE Point of Contact:

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[info@iese.fraunhofer.de](mailto:info@iese.fraunhofer.de)

### Return Address

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Title

---

Last Name, First Name

---

Company

---

Position

---

Department

---

Address

---

Zip Code / City

---

Phone

---

Fax

---

E-mail

---

Date and Signature

