A Successful Model of Technology Transfer in Germany

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ABSTRACT

The Fraunhofer Gesellschaft e.V. is the leading organization for applied research in Germany. The text presents its goals, finance model, and topics addressed by research. As example of an institute with its paradigm, products, and business areas, the Fraunhofer Institute for Experimental Software Engineering (IESE) is described. IESE is a relatively new institute working in the fast evolving field of information technology.

Based on this example, the chances of establishing a similar model in Bosnia-Hercegovina can be discussed.

1 INTRODUCTION

1.1 The Situation

In Germany, universities concentrate mainly on basic research. The positive aspect of basic research is that development of new ideas, concepts, tools etc. does not focus from the beginning on (potential) requirements for their use in specific products. This way, new ideas and concepts can be developed, tried out, and evaluated without actual market pressure. The drawback of basic research is that typically its results are not easy to transfer to industrial environments nor to apply them there.

Industrial organizations, on the other hand, need external research cooperations in order to speed up innovation. That holds especially for small and medium-sized companies that can not afford to pay for their own corporate research organization. These companies can not use results from universities directly.

This setting results in a large gap between state-of-the-art and state-of-the-practice in new technologies (like software engineering, see Section 3). Thus, a kind of 'bridge' or 'link' organization between universities and industry is needed. Mission of the Fraunhofer Gesellschaft is to provide that link.

1.2 The Fraunhofer Gesellschaft

The Fraunhofer Gesellschaft has a close link with basic research (always the director of a Fraunhofer institute is professor at a university) and a strong application orientation (about 70 percent of an institute's income have to be acquired through projects). The link to a university and about 30 percent income from base funding (shared 90:10 between Federal and State Government) allow to do some basic research. On the other hand, the need to acquire 70 percent of an institute's income via industrial and public projects guarantee that only those research threads are followed that over time show enough return on investment.

1.3 Overview

The Fraunhofer Gesellschaft is described in more detail in Section 2; as example of a Fraunhofer institute Fraunhofer IESE is presented in Section 3. Some lessons learned from its short history are given in Section 3.5.

Section 4 discusses the chances to establish a model similar to Fraunhofer in Bosnia-Hercegovina and concludes the paper.

2 THE FRAUNHOFER GESELLSCHAFT E.V.

The Fraunhofer Gesellschaft is the leading organization for applied research in Germany. It operates 47 research institutes in Germany (see Figure 1) with about 9,000 employees, about the half of them scientists and engineers. The Fraunhofer Gesellschaft expands to a worldwide

Organization, especially in USA and Asia. Home of the Fraunhofer-Gesellschaft is Munich, Germany.

One of the goals of the Fraunhofer company policy is a rapid transfer of innovations.

The total expenditure for 1996 reached the level of about 1.3 billion DM; more than two-thirds of this amount is earned through contracts from industry and the public sector (>50% of the industrial earnings come from small- and medium- sized enterprises). International activities are increasingly important. Apart from the collaboration with numerous companies and research establishments within Europe the Fraunhofer Gesellschaft operates resource centers and research units in the United States. The Fraunhofer-Management-Gesellschaft mbH (FhM) was founded as a subsidiary company in 1990.

The name Fraunhofer Gesellschaft was chosen in reference to the researcher, inventor, and entrepreneur Joseph von Fraunhofer (1787-1826, see Section 2.5), who won high acclaim for his scientific and commercial achievements.

Figure 1: Locations of Fraunhofer Institutes in Germany

2.1 Research fields of Fraunhofer Gesellschaft

Eight fields form the core of Fraunhofer research:

- Materials and Components
- Production Technology
- Information and Communication
- Microelectronics and Microsystems
- Sensor Systems, Testing Technologies
- Process Engineering
- Energy, Environment, Health
- Technical Economic Studies

Apart from research services, certified test beds and other facilities can also be provided.

2.2 Contract research with Fraunhofer Gesellschaft

More than 2,600 experts are available for the development of complete systems. All developments are based on profitability considerations. The Fraunhofer Gesellschaft collaborates with various renowned companies whose research contracts have resulted in successful products. Modern laboratory equipment and scientific aids such as project management and internationally linked communications systems enhance the quality of the research work. Detailed project reports, instructions for use, staff training and complete introduction strategies for new technologies round off the contract research services. Reliability, continuity and service of a large organization are available to all companies.

2.3 Collaboration with Fraunhofer Gesellschaft

Contract research with the Fraunhofer Gesellschaft has advantages for all companies. Orders come from all branches of industry and companies of all sizes. The institutes' facilities are particularly recommended for small businesses who can take advantage of Fraunhofer research when their own capacities are not sufficient to make the technical innovations necessary to stay competitive.

2.4 More Principles of Fraunhofer Gesellschaft

In Section 1.2, the two underlying principles of all Fraunhofer institutes, a close link to basic research at universities on one hand and focus on

application of research results in projects on the other hand, have been motivated.

Industry prefers Fraunhofer over universities for several reasons:

- Typically, Fraunhofer employees are more experienced in technology transfer (because they do that more often) and sometimes even in some application domains (because they have worked with companies dealing with the same or a similar domain).
- Due to more customer interaction, staff at Fraunhofer institutes is often more "professional" (than many university researchers).
- Fraunhofer institutes can provide a better continuity over more than one project because of the (compared to universities) less high personnel turnover. The line management and some key people of Fraunhofer institutes guarantee enough critical mass to manage the introduction of new people.
- Fraunhofer can offer more confidentiality than typical university environments.

Possible collaboration modes with industry include contract research, transfer projects, common consortia (e.g., moderating a group of companies interested in similar domains or applying for European funded projects), strategic collaborations and industry research laboratories, training and education for company employees, as well as studies and evaluations.

Fraunhofer institutes are attractive for their employees in various ways: by working at an institute, employees acquire research and project management skills. That opens the opportunity for careers in academia or industry. For example, one can work on a Ph.D. thesis and in parallel validate the concepts/methods/tools proposed in that thesis in research projects or industrial collaborations. Using the knowledge and experience acquired afterwards it is possible to stay at Fraunhofer and focus on technology transfer projects, to apply for a position at a university, to apply for a leading position in industry, or to start a spin-off company.

2.5 Joseph von Fraunhofer

The Fraunhofer Gesellschaft was founded in Munich in 1949. Its aim was to contribute to the reconstruction of Germany after the Second World War through its promotion of applied research. The name of Joseph von Fraunhofer (1787-1826) was chosen as the 'guiding light' of the association.

Joseph von Fraunhofer was the first to observe the *dark absorption lines* in the spectrum of sunlight, which where later named Fraunhofer Lines.

He developed a *new method of melting glass* that made the manufacture of high-precision optical equipment possible, a process that paved the way for Germany's dominant role in the optics industry.

The *telescopes* manufactured by Joseph von Fraunhofer in Munich and Benediktbeuern were highly regarded throughout Europe. His crowning achievement, a telescope with a lens of 24 cm in diameter and a focal length of 4.5 m, was ordered by the Russian Tsar for the Dorpater Observatory

Figure 2: The 9-inch refractor in the Deutsches Museum, Munich, Germany

located in today's Estonia. With the identical 9-inch refractor on exhibit today in the Deutsches Museum in Munich (see Figure 2), the astronomer Johann Gottfried Galle succeeded in discovering the planet Neptune in 1846.

At the same time *maritime navigatio*n and *land surveying* benefitted greatly from the new optical equipment.

Application-oriented research is the guiding principle underlying the activities of the Fraunhofer Gesellschaft to this day.

3 FRAUNHOFER INSTITUTE FOR EXPERIMENTAL SOFTWARE ENGINEERING (IESE)

3.1 History

In early 1996, the Fraunhofer Institute for Experimental Software Engineering (IESE) was founded in Kaiserslautern (see Figure 1) and funded for five years initially. 1999 marked the fourth year of continuous growth in industrial and public project income. On 26 October 1999, the Fraunhofer Senate voted to make IESE a permanent member of the Fraunhofer Gesellschaft e.V., effective immediately. This "promotion" was based on a very successful external review of IESE's research competencies and business orientation by a panel of highly renowned experts in 1998, almost four years of successful industry collaborations, and the conviction that the market for software engineering expertise will continue to grow in the future. This decision enables IESE to continue to foster its high-quality international personnel, to become a long-term strategic partner for industrial firms, and to play a growing synergetic role with other Fraunhofer institutes as software increasingly permeates all other Fraunhofer business domains.

The institute grew out of the successful Software Transfer Initiative at the University of Kaiserslautern (STTI-KL), which was founded as a "Transfer Group" under the sponsorship of the Ministry of Economic Affairs, Transportation, Agriculture and Viniculture of the State of Rhineland-Palatinate in 1993. Within four years, IESE has established itself as one of the leading international competence centers for applied research and has established strategic collaborations with major companies within the telecommunication, automotive and aerospace, banking, insurance, and trade sectors. Special attention is given to small and medium-size companies within the State of Rhineland-Palatinate.

Experimental Software Engineering employs experiments of different kinds as instruments for effective software technology transfer. Based on the recognition that well-understood and quantitatively manageable software development and maintenance processes need to be customized to a company's specific business goals and characteristics, new and innovative software technologies need to be carefully evaluated before being transferred into practice. After transfer, they need to be continuously tracked and optimized based on feedback from measurement.

3.2 Cooperation Modes

Fraunhofer IESE provides the following products to industrial customers:

- contract research in key software engineering areas
- transfer of innovative software engineering technologies (techniques, methods, and tools) into business practice (including their customization)
- build-up of industrial improvement programs
- consulting
- education and training

Major highlights in 1999 (besides IESE's promotion to permanent institute) included the continued build-up and maturation of personnel, including about 20% international scientists, a strong presence at major international conferences (e.g., ICSE'99 and SEKE'99) and workshops in core competence areas of the institute, the continued growth and renewal rate of industrial projects, the growth and integration of IESE' U.S. sister organization (FC-MD) through joint projects such as the SEC project, and the extensive use of Software Akademie AG (SWA) for professionalizing IESE's education and training offerings to industry. The IESE "Competence Center for Software Technology and Continuing Education" located in the Kaiserslautern Industrial Park (PRE Park) has supported the local efforts to establish a sound software and information technology industry in Kaiserslautern and has resulted in numerous collaborations with local firms. Overall, one can see a strong infrastructure for software and IT developing in Kaiserslautern.

3.3 The Experimental Approach

Fraunhofer IESE's mission is to promote experimental software engineering - the best approach for introducing engineering style rigor into business practice. This way of working provides customers with measurable facts about their development practices and enables informed decision making. Measurable facts, analysis, and continuous feedback of findings are the engine for goal-oriented continuous improvement and for risk-controlled innovation.

Software development in particular is a human-based engineering activity, that is, all major tasks and decisions are taken by humans. In such human-based environments technology transfer, that is, the introduction of new innovative development practices is hard and credible evidence must be given in order for them to persist, for example, under project pressure. The best way to achieve this is to produce empirical evidence in the target organization itself. For example, a measurement program can be installed and development effort spent for a certain task can be measured and compared before and after the introduction of a new technique or tool.

Technology transfer can use empirical studies at many different stages:

- To test initial basic research results (e.g., controlled experiment on inspections with students).
- To test scale-up of new practices (e.g., controlled experiment replication with industrial personnel).
- To motivate sustained use of practice under project pressure (e.g., convince developers through semi-controlled experiments during training that a new inspection technique works better than the old approach).
- To continuously optimize practice in operation.

Through experimental software process engineering software product engineering becomes more predictable. The experimentation approach corresponds to prototyping for process engineers (to manage risk in technology transfer). It underlies all technology transfer activities performed by IESE, being its unique selling proposition.

3.4 Business Areas

The following topic areas represent IESE's main business areas:

- Predictable and certifiable software development:
  IESE helps to select, tailor, and continuously improve the software development practices best suited for an organization's needs.
- Comprehensive software reuse:
  IESE experts in re-engineering and product line development show the most economical way of carrying legacy systems into the future and help to evolve existing systems into product lines.
- Software project management by data:
  IESE helps to implement lean practices for planning, tracking, and predicting cost and quality, integrating goal-oriented measurement, assessment, and benchmarking.
- Software process and product assessment:
  IESE experts perform efficient, reliable, and reproducible assessments of an organization's practices and products and help to implement an action plan that meets the respective business goals. IESE helps to detect vulnerabilities that may become targets of deliberate as well as accidental threats, define security goals for the organization, and determine action plans for achieving and sustaining them.
- Accelerating corporate-wide learning:
  IESE helps to continuously identify and capture valuable information from processes, products, and people, to assess, manage, and maintain knowledge, and to supply it to a whole organization. When the market demands a technological quantum leap, IESE helps to assess associated risks, evaluate alternatives, and make a smooth transition.
- Education & training for software professionals:
  IESE helps to respond to the demands of technological and organizational evolution. Training and education programs are built to support essential core competencies and products of the institute. A system of modules is offered allowing the tailoring towards intended job profiles as well as existing background.

3.5 Lessons Learned

In the almost five years of its existence, IESE has gained a lot of experience in technology transfer. The following are some key lessons learned:

- Entering companies at problem-solving level creates trust and thus enables higher-level contacts (sometimes leading to long-term relations) later on.
- It is important to have positive references in order to create trust in customer organizations. For that purpose, it helps to start small (as an institute) and then grow carefully.
- Employees are the main capital in this kind of business with many customer interactions and lots of experience that are extremely hard to write down explicitly. Successful Fraunhofer employees should combine problem solving and research intelligently; at IESE the option to do a Ph.D. is one of their major incentives. Especially for young scientists it proves to be hard to do research and at the same time keep an eye on (sometimes low-level) problems and try to solve them.
- Overlap between industrial projects and major research threads is important. Over time that leads to rejection of projects if they are not in the institute's focus.
  If research and project work drifts into different directions, research has to be refocused (Fraunhofer mission is to do applied research). On the other hand, Fraunhofer should seeks to drive state-of-the-art in research in order to influence and improve the current state-of-the-practise.
- It is important to build up a network with external research groups and to set up strategic research collaborations. Especially in a new and fast-moving field like software engineering a direct connection to the international community is essential.

4 CONCLUSION

The paper presents the underlying principles of the Fraunhofer Gesellschaft e.V., Germany's leading organization for applied research. The history, paradigm, and business areas of Fraunhofer Institute for Experimental Software Engineering (IESE) are presented in more detail.

Given the experience in Germany, it can be expected that a model similar to the Fraunhofer Gesellschaft in Germany would work in Bosnia-Hercegovina as well (the Fraunhofer Gesellschaft was founded shortly after the second world war).

Taking into account the experience from building up IESE, as a relatively new institute, the recommendation for Bosnia-Hercegovina would be to:

- start to create a small core center of knowledge in a new and fast-evolving field, like information technology, where it is relatively easy to catch up with current practices.
- try from the beginning to go for a combination of public and industrial money (at least some IT services can be offered independent from the location, e.g., to companies in other countries),
- try to find some highly motivated people with incentives different from salary,
- build up a network of international contacts or join an existing one in order to participate in state-of-the-art research and to have support in not-yet-owned knowledge areas.

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