ABSTRACT
In this paper, we describe a technology transfer case study with Siemens Corporate Technology, Systems and Engineering in Munich, Germany in which intelligent decision support was provided for road mapping of the services provided by this unit. The challenge was to provide roadmaps for optimal success in order to achieve maximum market competitiveness and customer satisfaction while simultaneously balancing the resources, business rules, risks, constraints and priorities of different stakeholders and customers around the world. The paper thus describes how ReleasePlanner, a cutting edge technology based on hybrid intelligence developed by the Laboratory for Software Engineering Decision Support at the University of Calgary was used to provide decision support. The technology transfer process and its impact at Siemens are reported.

Categories and Subject Descriptors
D.2.1 Requirements/Specifications (D.3.1)
D.2.9 Management (K.6.3, K.6.4)

General Terms
Management, Measurement

Keywords
Technology transfer, Road-mapping, Software engineering decision support, Lessons learned.

1. BACKGROUND
Despite an ongoing effort to facilitate the transfer of innovative technologies since the 80’s [6], the reality reflects that software related technology transfer is still far behind the potential possibilities. What are the reasons for this? Looking at the software systems life-cycle, there is typically a wide range of software and systems related technologies that are potentially available. However, two fundamental questions are still not understood well enough: First, what technology is most appropriate in a given context [2]? And second, how to perform a smooth transfer of an existing technology into a target environment having specific characteristics in terms of processes, products, existing technologies and personnel skills and expertise?

One of the first comprehensive studies of Software Engineering technology transfer was conducted by Redwine and Riddle [6], where they gathered case studies related to many concepts and technologies that were initially developed in the 1960s and 1970s. In this experience report we are addressing the question of technology transfer for strategic road-mapping. Intelligent road-mapping involves the assignment of deliverables to pre-defined time segments (e.g. years, release dates, milestones). The overall goal is to find an assignment that maximizes the sum of weighted priorities (reflecting satisfaction) of all the different stakeholders, while maintaining a good balance with the available, probably limited resources. Road-mapping enables an organization to plan and execute a path to achieve their objectives. Roadmaps link strategy to future actions and allow an organization to explicitly incorporate a plan so that necessary capabilities, resources and technologies will be in place at the right times. The quality of these early road-map decisions and their updates according to changed business priorities or available capacities is of pivotal importance for business success because failures at this early stage are hard to correct. However, strategic prioritization is inherently difficult primarily because of the computational and cognitive complexity of the uncertainties involved. The computational complexity has to do with the difficulty of determining a strategic roadmap once you have found an appropriate description of the problem. However, finding a formalized description alone is difficult as it relates to cognitive difficulty.
Evaluation and transfer of innovative technologies and their customization for the different business units is one of the key mandates of Siemens Corporate Technology. Siemens employs over 30,000 software developers—a fact that underscores the importance of software as a cross-sectional technology. With about 200 specialists in Munich and Erlangen, as well as partners in Bangalore, Beijing, Moscow and Princeton, the Software & Engineering Technology Division creates new processes, methods and tools to further enhance the quality and capabilities of the company’s software products [8].

How can the human expert be supported to make more qualified decisions? In case of complex decisions under uncertainty, human decision-making is supported by intelligent methods and techniques ranging from knowledge-based systems, simulation, optimization, analysis and reasoning. It is not intended to replace the human expert, but to facilitate understanding and structuring of the problem under investigation, bring relevant stakeholders together and allow them to co-tribute to decision-making, generate and evaluate solution alternatives, and explain those alternatives.

ReleasePlanner is a cutting-edge technology aimed at performing systematic road-mapping and resource planning based on computationally efficient optimization algorithms. The internet-based front end can be used by clients and all their stakeholders online. It allows determining the best possible prioritization, planning, and resource allocation strategies by taking into account the all key data of the planning problem. This includes effort and resource estimates, stated planning objectives, stakeholder priorities and capacities and budgets available to perform the tasks.

This paper is structured in five sections. The baseline situation at the target organization and the state-of-the-practice for road mapping in general are studied in Section 2. The actual technology transfer process is presented in Section 3. For that, we follow the five phase structure as introduced by Shari Lawrence Pfleeger [3]. The actual impact of the whole effort is presented in Section 4. A summary and conclusion are given in Section 5.

2. BASELINE: CHALLENGES OF ROAD-MAPPING

In today’s business climate, organizations are under constant pressure to increase efficiency and provide new services and products faster and in a more flexible manner. Road-mapping decisions have to be made to balance various conflicting objectives of the project stakeholders. These decisions are of high cognitive and computational complexity. Currently, most of these decisions are made in an ad-hoc manner and can have disastrous results leading to gaps and missed opportunities. Because of the high degree of uncertainty involved when making these decisions, it is extremely important to have a sound methodology for providing decision support when making such decisions.

Currently deficits in road-mapping of products/services include [4], [7]:

- Lack of stakeholder involvement, especially customer involvement in the process.
- Lack of meaningful estimates for the realization of the items to be road-mapped
- Lack of consensus in the description and understanding of the items to be prioritized
- Lack of a systematic process for performing planning and re-planning
- Excessive time to conduct meetings for negotiations of conflicting stakeholder opinions

Information technology (IT) resource management planning and coordination across projects is of pivotal importance for the business success of an organization. Siemens Corporate Technology Software and Engineering (CT SE) is a creator and early adopter of innovative technologies. Leading edge technologies in their early life-cycle stages are studied. IT products, services and solutions are evaluated, customized and transferred to the different Siemens Business Groups. With the great variety of emerging technologies and their dynamic change, strategic planning is of pivotal importance. The challenge is to determine best strategies to make the maximum business value out of the resources available.

The strategic planning at CT SE in the last few years was mainly supported by two tools:

- MS-EXCEL-based portfolio analysis with regard to market attractiveness and competitiveness of products or services
- MS-PROJECT for the scheduling and resource planning of pre-development projects per fiscal year
- The gap between these two solutions consisted of a lack of any support for prioritization of pre-development activities and their allocation to fiscal years. This gap was mainly, and inadequately filled by a common agreement between the department head and the Competence Centre management. The opinions of the Strategic Account Management and CT SE customers was regarded implicitly and tracked only by the success or failure of products and services. The planning contained a lot of “gut instinct” and the need for a more objective insight became apparent.

Siemens CT SE was looking for a solution to proactively evaluate the impact of alternative strategies under varying scenarios. They needed a transparent and rational approach to answer questions such as:

- What were the prioritized products, services, and solutions to concentrate on for the upcoming years to achieve maximum business success, given the available resources? If these resources were insufficient, what additional resources were necessary to obtain business objectives?
- How should different stakeholder expectations be balanced in the best possible way?
- What were possible scenarios in terms of adding resources needed to achieve predefined target levels of market share or customer satisfaction?
- Which strategy could be realized with minimum amounts of risk?
- How should re-planning be optimally performed under changing resource, budget, business rules or technological parameters?
3. TECHNOLOGY TRANSFER PROCESS

In our description of the technology transfer process, we will follow the five basic steps described in [3].

3.1 Technology creation

ReleasePlanner is a cutting edge technology that provides decision support for intelligent priority management (IPM). IPM comprises strategic planning (road-mapping) and implementation of items in incremental product or service development, as well as any kind of milestone planning such as annual or quarterly planning. The technology is relatively independent and can be installed on top of existing processes in different application domains. Most prominent applications scenarios include software release planning, product road-mapping, service planning, asset management, and project prioritization.

ReleasePlanner combines innovative ideas from computational intelligence, mathematical optimization, multi-criteria decision aid and intelligent decision support systems. It integrates and evaluates conflicting stakeholder priorities, resource consumptions and business value. As of January 2006, the IPM technology comprises 25 person years of research and development effort. A patent on the technology is pending. The technology provides intelligent decision support for road-mapping decisions. The technology is designed as an iterative and evolutionary procedure mediating between the real world problem of creating alternative roadmaps, the available tools of computational intelligence for handling explicit knowledge and crisp data, and the involvement of human expertise for tackling tacit knowledge and fuzzy data.

The overall process is illustrated in Figure 1. The goal is to provide optimized roadmaps for planning of services in iterations by using computational intelligence to reduce the solution space, create high value roadmaps that are feasible within budget and resource constraints, and that reflect maximized customer satisfaction and stakeholder priorities. For further information on the technology compare [7].

![Figure 1. Main steps of the ReleasePlanner-technology process.](image)

3.2 Preliminary evaluation

Initial evaluation of the technology was done in a controlled environment at the University of Calgary. Later, but still in an early stage of the technology development, a research prototype was developed that attracted interest from industry. We performed trial project road-mapping in an industrial environment. This helped substantially to develop a technology intended to match real-world expectations. Prioritization was refined into different criteria (urgency and value). Reporting functionality including the visualization of the road-mapping results was initiated. From running real-world road-mapping projects with several hundred requirements, we learned about the computational performance and the need to improve the optimization algorithms to provide sufficient usability. For the target organization, the main improvements were [1]:

- After using ReleasePlanner, stakeholders were more careful to accurately estimate implementation effort. A good effort estimate is now required because the effort parameters directly determines release contents. In addition, by defining all precedence and coupling constraints early in the planning process, the release plans are more certain and subject to fewer revisions.
Stakeholders were providing earlier and more valuable feedback. Before ReleasePlanner, stakeholders were asked for advice after the initial product plan was announced. Now, they are involved earlier and are more likely to endorse final release plans.

Program management can more easily identify and develop release themes that can later be used by Marketing.

Customers can be given a “road-map” of future plans extending beyond the next releases.

### 3.3 Advanced evaluation

Six pilot projects were conducted for advanced evaluation of the technology. The focus here will be on the key pilot project at Siemens CT that started in September 2004 and is ongoing. The collaboration was initiated by providing a customized demo of the technology to demonstrate the potential benefits of the technology to the organization. This included a kick-off meeting with the potential stakeholders. Stakeholder contributions are very important for the success of road-mapping. The proper understanding of stakeholders of ‘why’ and ‘how’ is necessary to encourage their meaningful contributions.

For Siemens CT SE, the first trials with ReleasePlanner showed that it was an easy tool to use, and the web based implementation strongly supported stakeholder involvement. Feedback on the tool’s usability and functionality were transmitted to the technology provider and have already led to product improvements. However, the first internal prioritization sessions did not show results that proved the advantage of a formalized and systematic approach over “gut instinct”. An analysis of the results pointed out the following reasons for this:

- All internal stakeholders had the same background, and their votes were mostly congruent
- The items to be prioritized were not balanced concerning their comparability (level of detail)
- The extensive application of prioritization constraints (predecessor and successor requirements) considerably narrowed the possible scenarios
- The strategic focus was not always kept in mind. The stakeholder experience of just the last few months was the main input for prioritization.

A couple of fundamental questions were raised to qualify the overall process at the target organization. This included the common understanding of the items to be prioritized. The given formulations of the services to be provided were ambiguous and needed further qualification to become concise, consistent and unambiguous. In the same vein, the resource estimates needed to be qualified. Without that, it is hard to establish a repeatable process and to obtain meaningful results. In addition to just planning in terms of effort, more specific planning considering different types of resources needed to be done.

Another key lesson learned was the need for more comprehensive stakeholder involvement. The quality of portfolio planning is strongly determined by including the conflicting perspectives of the key stakeholders, especially customers. For the next round of planning, external stakeholders were also considered. Their preferences were different from those of internal stakeholders, and trying to find the best possible compromises was the challenge of the planning effort.

### 3.4 Packaging and support

Packaging and support are key success factors for technology transfer. Despite the different locations, there is continuous interaction between the technology provider and the target organization. New releases of the system were demonstrated and broadly discussed in joint web sessions. The road-mapping technology provides decision support aimed at facilitating human decisions. A common understanding between stakeholders of the problem domain was important for defining different usage scenarios with varying problem parameters for a better understanding of the impact of those changes.

The technology transfer process was accompanied by ongoing support to clarify questions of data collection, import and export of data and the analysis and interpretation of results. In addition to that, the technology transfer helped to further qualify the technology development. Examples for this learning process were questions about the design and structure and the process of the data import, the usability of the system, reuse of stakeholder information, and reporting of results. This feedback from the advanced evaluation from Siemens and other trial projects helped to advance and package the technology. A process model for its usage was developed [Ruhe & Saliu 2005]. A stakeholder voting tutorial, FAQ’s (see http://www.releaseplanner.com/FAQs.htm) and usage scenarios were created (see http://www.releaseplanner.com/applicable.htm).

To package and promote a technology, champions in the target organization are needed. In our case, a proper collaboration framework was established with assigned responsibilities on both sides, with efforts explicitly defined and allocated.

### 3.5 Technology diffusion

The technology transfer reported here needs to be broadened. The experience gained from organizations such as Siemens CT SE3 is a key factor in encouraging other organizations to move from a more or less ad hoc and intuitive planning process to a more systematic procedure based on intelligent decision support as offered by ReleasePlanner. This process is ongoing. One lesson learned here is that the technology needs to be customized to the specifics of the target organization. Another lesson learned is that any technology is just part of a spectrum of means to qualify system development and evolution. This means that the specific technology under consideration always needs to be synchronized with other existing technologies and processes established in the organization. In the case of road-mapping, we need to look at the whole process of effort estimation as a prerequisite for performing qualified planning according to releases or milestones.

To encourage other organizations to add qualified decision support on top of their existing processes, we have added an automated utility to make comparisons between manually generated plans and plans with the same project parameters generated using the ReleasePlanner system. What became apparent from this utility is that many manual plans were partially infeasible in terms of resource constraint violations. In addition, the plans were only obtaining between 60 to 90% of the maximum possible value of the stated objective function.
expressing stakeholder satisfaction. This is one part of a broader ROI analysis as initially done in [5].

4. IMPACT OF TECHNOLOGY TRANSFER

The first results of applying ReleasePlanner at Siemens CT SE showed the need for improving the internal requirements process:

- A thorough preparation of items to be prioritized is crucial for the success of a project. A number of meetings were necessary to obtain a common understanding of terms and achieve comparability of items.

- For this purpose, a CT SE requirements engineering process was set up and applied. The inputs from an internal strategy workshop and from a broad variety of customer projects and contacts to all Siemens Business Units were analyzed and the requirements were described and documented comprehensively.

Overall, the introduction of the release planning technology had an impact not only on the actual planning process, but also on the accompanying processes to elicit and understand the requirements, the estimation of efforts needed to realize the services, and the understanding of dependencies between services.

Overall, it became clear that technology transfer is not happening in isolation of the surrounding processes. To enable technology transfer at the target organization, all the necessary associated pre-requisites need to be prepared as well.

The interpretation of first results was not as easy as was anticipated. But the close cooperation of Siemens and the University of Calgary showed its benefit for both sides: a quicker achievement of usable results and a comprehensive feedback for improving the usability and result analysis of ReleasePlanner. Different scenarios were performed to determine suggested strategies under different assumptions for the importance of the stakeholders and the human resource capacities available. This helped to better understand the inherent problem complexity and the impact of varying parameters. One important t scenario was the answer to the question: What amount of resources are necessary to achieve stated target goals in terms of services to be provided in certain time frames?

Siemens CT SE will continue the application of ReleasePlanner. The main steps planned are:

- Enlarging the circle of stakeholders to Account Management. The CT Strategic Account Managers will be involved in the short term. This will broaden the scope of planning considerably and hopefully show the benefit of the model-based approach for prioritization.

- Enlarging the circle of stakeholders to include selected internal customers.

When the involvement of CT Strategic Account Managers has proven its benefit a selected number of key customers will be invited to vote on the priority of CT SE services. This will finally provide the basis for deriving multiple planning scenarios and will give support for decisions on pre-development planning for the next two years.

Thus Siemens CT SE will apply a comprehensive and systematic approach to optimizing its strategic planning process.

5. SUMMARY AND CONCLUSIONS

This experience report presents highlights from the ongoing effort to transfer an intelligent road-mapping technology based on the concept of software engineering decision support to industrial practice. We are currently in the fourth year of this process. Key factors for progress achieved so far include:

- Early and ongoing collaboration between academia and industry to guide the direction of release planning research and development, in order to advance that technology.

- Early development of a technology prototype that enabled early evaluation and end-user feedback to us

- Early sponsoring of the research, development and transfer process

We are in the process of advanced evaluation and are performing packaging and support. Despite the encouraging results achieved so far, the hardest step is still in front of us: Technology diffusion. There is no silver bullet on how to be successful in regards to that. Understanding the key parameters of the technology (such as ROI, effort needed to introduce the technology, the degree of impact on existing processes) and how to adopt it into organizations is a prerequisite for success in the diffusion effort.

6. ACKNOWLEDGMENT

The authors would like to thank the Alberta Informatics Circle of Research Excellence (iCORE) for its financial support of this research. For the “Proof-of-Concept” and “Technology Enhancement” stages of the ReleasePlanner technology maturation, support provided by the Natural Sciences and Engineering Research Council of Canada (NSERC) was of key importance. In addition to that, we would like to thank both involved teams at University of Calgary and Siemens CT SE. Special thanks are due to Jim McElroy for his comments to improve the readability of the paper.

7. REFERENCES


