ALBERTA INFORMATICS CIRCLE OF RESEARCH EXCELLENCE

# 2005 Research Report

GUENTHER RUHE

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*This document is an excerpt from the 2005 iCORE Annual Research Report. For information or copies, please contact iCORE.*

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# SOFTWARE ENGINEERING DECISION SUPPORT

Decisions are hard to understand and far from being optimal in terms of their quality. What can be expected from decision support in the area of software engineering is higher decision quality, improved communication between all involved parties, increased productivity, time savings, and improved customer satisfaction.

# GUENTHER RUHE

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Qualified decisions related to software and system technologies, resources, processes and products are the drivers of an efficient economy. The main achievements of the laboratory of Software Engineering Decision Support (SEDS) over the last year have been breakthrough results in the area of intelligent support for strategic and early stage decisions in software and system development. We are following a multi-disciplinary research approach and have integrated concepts and approaches from software engineering, decision science, artificial intelligence, knowledge management, and computational intelligence to achieve innovative results. Research in the reporting year has resulted in four journal publications with 3 more in preparation, 18 publications at conferences or workshops, 6 book chapters, preparation of a special issue of the IJSEKE, and further progress on the book titled "Software Engineering Decision Support – Methodology, Tools and Applications" (to be published at CRC Press in 2007).

## EXECUTIVE SUMMARY

Progress has been achieved in creating a core team of researchers and in establishing and enhancing national and international collaboration. The team attracted another iCORE International Award student. The former Post Doctoral Fellow and visitor Dr Pfahl successfully applied for a position at the University of Calgary, Department of Electrical and Computer Engineering. He joined the team in July 1, 2005.

Four NSERC related project initiatives have been launched. One NSERC CRD grant, Simulation-based Decision Support for Software Quality Assurance started in Fall 2004. Another grant, Intelligent Support for Release and Design Decisions for Evolvable Software-Intensive Systems, was conditionally approved pending finalization of IP agreement. An NSERC Strategic Research Grant proposal "Towards the Next Generation of IT Resource Management Systems – A Hybrid Intelligence Approach" was prepared with the City of Calgary as a non-academic partner. Additional financial support was launched in the NSERC "Idea to Innovation (I2I)" program for the proof-of concept project titled "Web-based Decision Support for Release Planning and Prioritization".

Further progress was made in pre-commercialization of the ReleasePlanner® decision support system. Successful trial projects were performed with Siemens Corporate Technology (Muenich), Trema Laboratories (Calgary), Nortel Networks (Calgary), Autodesk (Calgary), SoldiTech (Helsinki), and Ericsson Canada (Montreal). The technology was successfully presented at CeBIT'2005, the world's largest computer trade show.

The 16th International Conference on Software Engineering and Knowledge Engineering (SEKE'2004) was held in Banff in June 2004. It brought together leading researchers and industrial representatives. The program committee was chaired together with Dr Frank Maurer. The conference attracted the largest number of submissions in history. Thanks to additional iCORE support, outstanding keynote speakers could be invited; Shari Lawrence-Pfleeger, Dieter Rombach, and Lotfi Zadeh. Two follow-up workshop events have been approved for 2005/2006.

## RESEARCH PROGRAM OVERVIEW

### Objectives

The current maturity of software and systems engineering decision-making is low. Decisions are made ad hoc, not relying on validated models and sound methodology. Decisions are hard to understand and far from being optimal in terms of their quality. What can be expected from decision support in the area of software engineering is higher decision

quality, improved communication between all involved parties, increased productivity, time savings, and improved customer satisfaction. Our related research can be structured into three main areas.

- Advancing Software Engineering Decision Support (SEDS) methodology by multidisciplinary research
- Developing intelligence-based support methods and techniques for specific software engineering decision problems
- Tool development and empirical evaluation of its impact

### Main Achievements

Technically, we have achieved the following main results:

*Advancing SEDS Methodology*

The paradigm of hybrid intelligence was further developed and refined. The advantage of the human intelligence based approach is that it is able to better handle soft and implicit objectives and constraints. The advantage of computer-based approach is exactly where the human based approach fails: to cover a large portion of the solutions space. Our hybrid approach is designed to combine the strength of both human and computational intelligence. The methodology of SEDS was further enhanced by creating synergy between decision-making and the contributions of simulation, e-assistants, explanation and different optimization techniques (genetic algorithms, integer programming, branch and bound, heuristics).

Uncertainty is an important issue in decision support. This is particularly true in software engineering where uncertainty is one of its key characteristic. We are particularly interested in decision problems that are not completely understood, have a large solution space and/or uncertain data, such as planning problems. We have developed the diversification principle to facilitate the participation of human expertise into the decision process without explicitly integrating it into formal models.

*Intelligence-Based Decision Support for Specific Problems*

We have further qualified and enhanced intelligent support in the area of release planning. This was done by providing explanations about 'why' certain alternatives were proposed. This issue is the most critical limitation of current decision support. We have designed a dialog approach that is applicable not only to release planning, but also to the more general class of "wicked" planning problems. In addition to that, we have enhanced the scope of release planning by allowing a flexible number of releases, by considering system characteristics for evolving systems, and by taking more flexible prioritization criteria into consideration.

After having designed and applied the paradigm of hybrid intelligence to the wicked problem of release planning (with successful development and application of a decision support system based on this idea), we have transferred these principles to three more classes of decision problems:

- Selection of Commercial Off The Shelf (COTS) software components
- Decisions about quality and how it affects time-to-market
- Value-based prioritization and planning

*Decision Support System Development and Empirical Evaluation*

Further progress was made in the development and evaluation of the ReleasePlanner® decision support system; a tool suite that provides flexible, web-based tool support for assigning requirements or features to releases such that the most important risk, resource, and budget constraints are fulfilled. It can be used in different user modes and provides intelligent decision support for any kind of iterative development. US and Canada patent protection is pending.

Successful trial ReleasePlanner® projects were undertaken with Siemens Corporate Technology (Muenich), SoldiTech (Helsinki), Trema Laboratories (Calgary), Nortel Networks (Calgary), Autodesk (Calgary), and Ericsson Canada (Montreal). The technology was presented at CeBIT'2005, the world's largest computer trade show. A series of promising new contacts were obtained from this event, including Verizon Information Services (US), Applied Biosystems (US), Hyperwave (Austria), Schlund+Partner (Germany), ELCON (Germany), Tranzeo (Vancouver), SmartTechnologies (Calgary), and Wi-Lan (Calgary).

## RESEARCH PROJECTS

*Diversification of Solution Alternatives*

In this research, as mentioned above, we propose the diversification principle to facilitate the participation of human expertise into the decision process without explicitly integrating it into formal models. Instead of just one optimal solution, the diversification principle suggests the consideration of a small set of qualified solution alternatives that are as diversified as possible. This diversification can help the decision maker obtain more insight and detect new aspects of the problem. The diversification principle is materialized by a meta-model consisting of a core optimization model, a metric in the solution space, and a strategy

to obtain diversification. Though the diversification principle arose in our research in software engineering, it can also be applied in any decision problem having a large solution space where optimization is indispensable but never sufficient.

*Comprehensive Software Release Planning (CSRP)*
Very often, release planning is handled informally and in an ad hoc manner. Recently, we introduced the EVOLVE* method, which incorporates an evolutionary framework of performing successive steps of modeling, generation and exploration of solution alternatives and evaluation and consolidation. In our research, we have extended the applicability of the approach to software release planning of systems with maintenance considerations. By exploiting a specialized problem formulation allowing the application of mixed integer programming, we achieve better results from a more flexible allocation of involved resources. The comprehensive approach called CSRP allows planning for a flexible number of releases under different types of resource and technological constraints.

*Supporting Software Release Planning Decisions for Evolving Systems*
Large-scale software systems constantly change during system evolution involving feature enhancement. Most of the features originate from diverse stakeholders that require their needs to be met despite resource and risk constraints. In such large systems, the number of features requested during the different releases of the system typically exceeds the available resources. Release planning involves decision making about which new features or changes should be implemented during which release of the software. Existing release planning techniques are not targeted at evolving systems; in this case, knowledge about the existing software product is core to making meaningful release decisions.

We have described ten key technical and non-technical aspects impacting release planning. Based on these aspects, we evaluated seven existing release planning techniques. We have also proposed a new release planning framework that considers the effect of existing system characteristics on release planning decisions. Initial realization of this framework focuses on historical defect data to characterize the health of system components. This proposed approach extends the existing solution method called EVOLVE* by the proactive analysis of the risk involved in integrating new features into existing components of the system and identifying the importance of estimating the integration effort for each feature based on system characteristics.

*Decision Support for the Customization of the COTS Selection Process*
Software technologies need to be customized to make them effective and efficient for a specific context. We have considered customization of the COTS selection process. We have developed a methodology which customizes the selection process based on the actual project domain characteristics, including attributes such as available effort or project criticality. The customization of the process is done at both the process level and the activity level. We suggest a hybrid approach that integrates formalized knowledge

Guenther Ruhe and some research team members at the 2005 Banff Informatics Summit

(From left to right)
Thamer Al Boura'e, Sebastian Maurice, Pankaj Bhawnani, Jim McElroy, Ahmed Al-Emran, Abdallah Mohamed, Omolade Saliu, Guenther Ruhe, Kornelia Streb, Gensheng Du, Eric Bauld, Jingzhou Liv

with human expertise. This principle has already been successfully used in the context of software release planning. The advantage is two-fold: First, we exploit the existing empirical results related to different stages of the COTS selection process. Second, we facilitate involvement of human judgment to determine the most appropriate decisions among the ones proposed by the formalized and knowledge-based solution techniques.

*Uncertainty Handling in Tabular-based Requirements Using Rough Sets*

Software requirements management is an essential process to better understand, identify, derive, control and improve system requirements. Typically, requirements are unclear at the beginning and evolve over time. Uncertainties usually result in conflicts among requirements. Rough set analysis (RSA) is a promising technique of granular computing. The emphasis of this research is on formally defining three software requirements uncertainty problems and applying RSA to solve these problems. A systematic approach called MATARS was developed for this purpose. We use a modification of a real world software requirements specification (SRS) benchmark example to illustrate the main concepts and ideas of the approach.

*Reliability Driven Decision Support for Incremental Software Development*

In the 2002 Standish Group report it was observed that 84 percent of software projects are incomplete and erroneous when released, so deciding on whether a software version should be released remains a big challenge. This becomes even more difficult in the case of incremental software development where the requirements keep changing frequently. A reliability driven decision support approach was proposed to study the effects of defect repository patterns on software release decisions. We have evaluated the suitability of existing reliability models in guiding release decisions. The case study presented reveals the impact of project and domain specific uncertainty factors such as risk, testing effort and target reliability on time to market decisions for the software release when the underlying assumptions made by existing reliability models are violated.

Guenther Ruhe

*Effort Estimation for Release Planning*

A hybrid method is proposed for effort estimation at the requirement/feature level as well as the project level by combining experience reuse, expert judgment and analogy-based approaches. After discussing the organization of the experience base, qualitative similarity measures for attributes were defined based on a categorization of attribute values. Analogy-based effort estimates are provided based on local similarity measurements between attributes and global similarity measurements between objects. The final effort estimates are aggregated from the analogy-based estimates and expert judgment. Experience maintenance and organizational learning activities are also proposed to keep the experience up to date. Two data sets are used for the validation of our method; one is from a student project, another one from the International Software Benchmarking Standard Group (ISBSG).

*Decision Support for Software Release Planning Using e-Assistants*

In this research, uncertainty and incompleteness of available information is addressed by a more flexible planning procedure including e-assistants. We are proposing a hybrid approach called e-release planning combining the strengths of computational intelligence with human intelligence. The e-assistants provide support to generate the most promising sequence of problem instances to be solved. They interact with the human stakeholder and the project manager to elicit their implicit preferences based on their individual evaluation of the proposed solutions. During the iterative approach, we incrementally fix requirements to their most favorable assignment to a release. This decision is based on analyzing concordance and non-discordance of assignments of requirements to releases between the candidate solutions. The intelligent decision support tool ReleasePlanner® is used as the underlying 'solution generation engine'.

*Evaluation of Operational Feasibility of Strategic Release Plans*

Strategic planning needs to be supplemented by the more fine-grained operational release planning typically performed in project management. Operational

planning, as a refinement of strategic planning, is performed for the next immediate release. In this research, we present the improvements in software development processes and products by performing the evaluation of the operational feasibility of strategic software planning. We also present the use of the research prototype ReleasePlanner® in a real-world situation through a case study at Trema Laboratories Inc. and report on the improvements achieved.

*Decision Support for Value-Based Software Release Planning*

Incremental software development replaces monolithic-type development by offering a series of releases with additive functionality. In this research, we have extended the existing hybrid intelligence based release planning method called EVOLVE* to accommodate financial value in the form of net present value estimates of proposed features. This extension enables us to perform financial value-based software release planning. The results show that the F-EVOLVE* model may be used to decide which features to produce when based on their financial contributions. Specifically, F-EVOLVE* may be used to determine which features generate the highest returns, with shortest development times.

*Staffing for Software Inspections – An Empirical Study*

Software inspection is an important means to verify and ensure high quality in software development projects. Many proposals have been suggested and used to improve Fagan's inspection method. Various publicly published data have already clearly demonstrated the effectiveness and efficiency of software inspection. However, few empirical studies are currently available to guide the appropriate selection of inspectors based on their experience and skills. This research has been devoted to an exploratory empirical study to address this open question. The empirical study reveals the cause-effect relationship between certain observable experience levels and skills of inspectors, and the number of defects actually found in the requirement document.

The results indicated that software design and testing experience had the strongest influence on the reading effectiveness of software requirement documents. On the other hand, coding experience has the least effect. These results provided further insight for the design of a subsequent study. Rough-set based data analysis provided production rules to help decision makers on future projects better choose their inspectors.

*A Dialogue Approach for Solving Wicked Planning Problems*

In this research we have considered an interactive and explanation supported approach to planning problems that are not only wicked but also complex. In our approach we concentrate on the communications between agents. These are organized in the form of a dialogue between agents of an explanatory character. This explanation method differs essentially from the methods used in traditional expert systems. During the dialogues stakeholder opinions can be changed or withdrawn, even if they are formulated as hard constraints (that is, the constraints that cannot change). This method is generic enough to be applied to any wicked and complex planning problems. Therefore, we also present one of the applications of this method in release planning.

*An Explanation Component for Software Release Planning*

Acceptance of decision support solutions offered by software systems is largely determined by the degree of trust and understanding of the results by the end-users. The generation of explanations can be regarded as running a sequence of coordinated problem instances and making sense out of the related results. This research has provided a taxonomy for identification of question-types and answer-types for an explanation component called EXPLAIN-RP that provides decision support for software release planning. Release planning is a very complex optimization process by which a set of requirements are assigned to different releases of software development to maximize technological, effort, time and budget utilities. Explaining results arising from such complex process is very necessary for end-user understanding and trust. The question-types and answer-types identified within this context are meaningful and interesting to EXPLAIN-RP users.

## OBJECTIVES FOR NEXT YEAR

### Intelligent Support for Release and Design Decisions of Evolvable Software-Intensive Systems

Hybrid Intelligent Systems (HIS) are a promising area of research due to the applicability of HIS to many complex and real world problems. HIS combine and integrate the strengths of multiple automated and semi-automated approaches to collect and analyze both qualitative and quantitative data. Such integration is necessary as neither human nor computational

intelligence alone are able to provide sufficient release planning and software design decision support to achieve cost-effective evolvable systems. Humans are better able to handle soft and implicit objectives and constraints; computational intelligence is better able to handle a wide search through a large solution space. We will create and apply HIS in two innovative directions:

- As the foundation of a methodology to support decision-making for release and design decisions
- As a new paradigm to generate, activate, and exploit knowledge for generating, evaluating, and explaining alternatives for release and design decisions.

We are working on a hybrid methodology for generating qualified solution alternatives for release and design problems under risk and resource constraints. The methodology will be based on the hybrid and customized use of modelling and simulation, genetic algorithms, and integer programming. It will overcome the limitations of current solution approaches in terms of its scope and its proactive decision support capability. No comparative results for this research question are currently available.

## Dynamic Release Planning and Software Project Monitoring

Current planning is static in the sense that is does not consider any aspect of execution of the plans other than estimates of the resources required. However, software development and evolution is a dynamic process with a large number of impacting factors. To better accommodate this dynamic character including feedback loops within the process, we will investigate software process simulation for modeling and executing the individual tasks related to the features to be assigned to releases. This will result in a better validity of the proposed plans. If done for the different types of resources involved, this will further allow project monitoring by comparing the planned tasks and their comparison with actual performance.

## Open Scope Release Planning

Releases may also be arranged according to open scope release planning, where release times are not predefined. If this approach is used, the definitions of the release times and the requirements or features assigned to the respective releases are obtained as results. In this case, a solution may be sought that minimizes the time between releases, since the earlier a release is issued, the earlier it generates value such as money. Another point to consider is whether there is any sub, or otherwise related, products. In this case, each may have its own release planning goals, however, for the overall products the different cycles have to be synchronized. This can be modeled and solved using integer programming. The notion of "open scope planning" can be extended to address synchronization of releases as requested in any kind of embedded product development where you have to address planning of different parts (hardware, software, middleware). Each of these components is an open scope problem. However, for the final product, planning for all the components has to be synchronized because of the mutual dependency between the components. The solution is approached through a formal description of the problem that uses binary variables and applying genetic and integer programming optimization algorithms.

## Fast Heuristics and Integer Programming Solution Algorithms

Current solution algorithms for release planning are based on genetic algorithms. These algorithms cannot guarantee optimality. We are working on fast (knapsack-type) heuristics able to generate good solutions for large-scale and complex problems in very short time. We will further analyze and fine-tune parameters for genetic algorithms and comparative analysis between heuristic, exact (integer programming) and evolutionary optimization algorithms. The results will be used to extend the functionality of ReleasePlanner® by providing features for handling uncertainty of data, fuzzy effort, and risk and dependency constraints. This includes the development of on-line user support to optimally customize the algorithms in dependence of the problem parameters.

## Explanation Component for Release Planning Decision Support

Explanation is intended to increase acceptance of the tool, to improve understanding of the results, and to increase applicability and acceptance of suggested solutions. The ReleasePlanner® explanation scenario involves three types of agents (participants): the system that provides the solution to the problem. In our context a software agent; the user who obtains the solution for further treatment, in our context a human agent; and the explainer who explains the system's solution to the user, in our context a software agent.

We are mainly interested in the explainer agent. The explanation agent needs knowledge about the other agents. More precisely, the explainer needs an understanding of how the system obtains the solution, and a model of the user. A user model in general describes

- What the user knows and
- What the user wants or needs to know. In some way, one can think of an explanation as an answer to (yet) unexpressed questions of the customer;

therefore somehow the concept of a dialog enters the scenario. In particular, two types of explanations must be distinguished:

a) One-step explanations, provided only once, and

b) Dialog-type explanations that proceed in several steps. Both types contain a communication aspect, for a) it is degenerated.

### Decision Support for Value-Based Software Technologies

A value-based approach to software engineering involves a different focus and approach to developing software. Meeting the needs of customers is as important as justifying the development efforts needed to meet those needs. In today's world with rapidly changing consumer demands, informational technology, and marketplaces, the requirements are changing rapidly requiring quicker adaptability by market participants. The critical success factor in this world for software developers is responding to changing requirements quickly while maintaining a focus on their value proposition which may be a quicker return on investments or an improvement in a public service like health, education, and defense.

### Modeling and Implementation of Software Agents Decision Making

Software agents are knowledgeable, autonomous, situated and interactive software entities. Agents' interactions are of special importance when a group of agents interact with each other to solve a problem that is beyond the capability and knowledge of each individual. Efficiency, performance and overall quality of the multi-agent applications depend mainly on how the agents interact with each other effectively. In this chapter, we suggest an agent model by which we can clearly distinguish different agent's interaction scenarios. The model has five attributes: goal, control, interface, identity and knowledge base. Using the model, we analyze and describe possible scenarios, devise the appropriate reasoning and decision making techniques for each scenario, and build a library of reasoning and decision making modules that can be used readily in the design and implementation of multi-agent systems.

## RESEARCH TEAM MEMBERS AND CONTRIBUTIONS

### Faculty Team Members

| NAME | |
|---|---|
| Dr Maurer | Department of Computer Science |
| Dr Denzinger | Department of Computer Science |
| Dr Walker | Department of Computer Science |
| Dr Far | Department of Electrical and Computer Engineering |
| Dr Wang | Department of Electrical and Computer Engineering |

### Postdoctoral Fellows

| NAME | ROLE/TOPIC |
|---|---|
| Dr An Ngo-The | Soft Computing in Software Engineering Decision Support |
| Dr Dietmar Pfahl | Fraunhofer Institute for Experimental Software Engineering: Simulation-based Decision Support |
| Dr Michael M. Richter | Professor emeritus, Department of Computer Science, University of Kaiserslautern: Reasoning and explanation in decision support systems |

## PhD Students

| NAME | ROLE/TOPIC |
|---|---|
| Gensheng Du | Intelligent Explanation Component for Software Release Planning |
| Jingzhou Li | Effort Prediction for Release Planning Using Collaborative Filtering |
| Jim McElroy | Use-case Driven Planning of Software Releases |
| Abdallah Mohamed | COTS Software Product Selection |
| Michael Ochs | Fraunhofer IESE, Co-Supervisor: Efficient and Effective Management of COTS Assessment and Selection |
| Omolade Saliu | iCORE International Graduate Student Scholarship Award: Supporting Software Release Planning Decisions for Evolving Systems |
| Tom Watanaya | Co-Supervisor: Agent-based COTS Product Selection Method |

## MSc Students

| NAME | ROLE/TOPIC |
|---|---|
| Pankaj Bhawnani | iCORE International Graduate Student Scholarship Award: Quality-based Software Release Decisions |
| Thamer Al Boura'e | Impact Analysis for Parametric Release Planning |
| Ahmed Raihan Al-Emran | Intelligent Tool Support for Decisions in Software Engineering |
| Zhizhong Li | Management of Tabular-based Requirements Using Rough Sets |
| Sebastian Maurice | Decision Support for Value-Based Software Engineering Release Planning |
| Yuhang Wang | Machine Learning for Improving Performance of Software Inspections |

## Undergraduate Students

| NAME | ROLE/TOPIC |
|---|---|
| Erik Bauld | Database Management for ReleasePlanner® |
| Brad Cossette | Import and Export Functionality for ReleasePlanner® |
| David Goodlad | Back-end Algorithms for ReleasePlanner® |
| Gregory Spiers | User Interface for ReleasePlanner® |
| Kenny Tsang | Analysis Wizard for ReleasePlanner® |

## Support and technical staff

| NAME | ROLE/TOPIC |
|---|---|
| Kornelia Streb | Assistant |

| INTERNATIONAL |
| --- |
| FRAUNHODER IESE AND FRAUNHOFER-CENTER MARYLAND |
| In accordance to the Academic Cooperation Research Exchange between the University of Calgary and the Fraunhofer Institute for Experimental Software Engineering (Fh IESE), the Laboratory for Software Engineering Decision Support and Fh IESE agreed to a collaborative research and personnel exchange. On this basis, Dr Dietmar Pfahl has visited the laboratory for three months. |
| UNIVERSITY OF NEW SOUTH WALES |
| A similar agreement as signed with Fh IESE is in preparation to be signed with the research group of Dr Ross Jeffrey at University of New South Wales. Based on this agreement, the intention is to conduct joint research and exchange PhD students. |
| UNIVERSITY OF SANNIO, ITALY |
| A collaboration agreement between Research Center for Software Technologies and the Laboratory for Software Engineering Decision Support is in preparation. It covers joint research in the area of soft computing for decision support and the exchange of researchers. |
| INFORMAL COLLABORATIONS |
| Informal collaborations were launched, especially with the groups of Dr Lionel Briand (Carleton University, Canada), Dr Jens Jahnke (University of Victoria, Canada), Dr David Raffo (University of Portland, USA), and Dr Shari Pfleeger (RAND Corporation). |
| INDUSTRIAL COLLABORATION |
| SIEMENS CORPORATE TECHNOLOGY |
| Siemens Corporate Technology (SE3) is performing strategic planning of IT services to their business units. For that purpose, ReleasePlanner® is used. At a first stage, the road-mapping process is performed internally. At a second stage, external stakeholders will be integrated into the prioritization process. The prioritization will be done accordijng to urgency and risk considerations. |
| CITY OF CALGARY |
| An NSERC Strategic Research grant was prepared with the City of Calgary. It is devoted to a new generation of Information Technology (IT) resource management planning systems. The IT business unit at the City of Calgary is a multi-disciplinary organization that works with different divisions in building IT solutions, and then supporting these solutions for The City of Calgary. The IT department currently has over 100 projects in development. Another 200+ potential projects have been identified for development consideration. IT also supports over 600 systems currently in production, including their affiliated infrastructure requirements. The resource management function in this environment is very difficult. When building systems, resources from across the IT discipline are required at different times during the systems' development life cycles to bring a solution from inception to production and into support. |
| CHARTWELL TECHNOLOGIES |
| Chartwell Technology Inc. develops online games for the Web, PC and mobile phones. The approximately 30 games are delivered to approximately 20 clients world wide and include single player (for example: blackjack) and multiplayer games (for example: poker). Chartwell also produces a set of back-office tools for monitoring and reporting on game play and for collection of royalties. The medium-term goal is to provide decision support for Chartwell's release planning that incorporates risks associated with changing specific modules within the system. The long-term goal is to automate the determination of risk based on historical data collected in Chartwell's source code management system and to use these measures to augment the release planning and decision support systems. |
| SECURAC AND WESTJET |
| There are ongoing meeting to include WestJet as trial partner into the CSER project described in section 6.3. The idea is to use their measurement data and process models as input for the decision support system development. WestJet also articulated strong interest in using ReleasePlanner® for their strategic and operational planning of projects. The prioritization will be done according to the defined strategic business goals and to what extend these projects would match them. |
| TREMA LABORATORIES |
| Trema Group is a provider of strategic software solutions for the financial industry. The software development focus is on providing a fully integrated cash and treasury management product suite designed to support front to back office treasury operations, as well as specific applications for cash management and accounting. Requirements are added to the product incrementally. So, planning for future releases becomes extremely important for the business.<br><br>At the end of the trial of using the intelligent decision support for both strategic and operational release planning at Trema Laboratories Inc., the general agreement is that ReleasePlannerTM provides benefits to the organization. Some of these benefits are tangible and some are intangible. The intangible benefits are difficult to realistically evaluate but the good thing in this study is that most of the intangible benefits are generally positive. |
| TRIAL APPLICATIONS OF RELEASEPLANNER® |
| Further progress was made in pre-commercialization of the ReleasePlanner® decision support system. Successful trial projects were performed with Siemens Corporate Technology (Muenich), Trema Laboratories (Calgary), Nortel Networks (Calgary), Autodesk (Calgary), SoldiTech (Helsinki), and Ericsson Canada (Montreal). The technology was presented at CeBIT'2005, the world's largest computer trade show. A number of promising new contacts and statements of interest were launched. |

| MULTIDISCIPLINE OR MULTI-INSTITUTIONAL PARTNERSHIPS |
|---|
| CSER |
| An NSERC CRD proposal titled "Simulation-Based Decision Support Software Quality Assurance" was conditionally approved. The project is part of the (Canadian) Consortium for Software Engineering Research. Created in 1996, CSER is a multi-party, industry-led research program, geared toward solving selected industrial problems in software engineering. The project called SimQuali aims to benefit the collaborators, their students and the Canadian economy in various ways. As a small company, Securac cannot afford to support a research department. This project provides opportunity for Securac to benefit from the collaborative research results embedded in an interaction/argumentation device when discussing trade-offs in software quality improvements and outcomes. The intelligent decision support tool will provide the capability to evaluate the outcomes of feasibility alternatives based on standard variables for verification and validation techniques. |
| INTERNATIONAL SOFTWARE ENGINEERING RESEARCH NETWORK (ISERN) |
| The Software Engineering research group at the University of Calgary successfully applied to become a member of the International Software Engineering Research Network ISERN. This gives us excellent opportunities to further extend collaboration with leading researchers and research institutions all over the world. For a list of the 33 member organizations, see http://www.iese.fhg.de/network/ISERN/pub/isern.list_of_members.html. |
| SECCO |
| The Software Engineering Consulting Consortium (SECCO) was formed with the objective of fostering and encouraging links between the industry and graduate students in the Software Engineering discipline engaged in research activities. SECCO is an organization operated by Software Engineering graduate students under the direction of the Software Engineering Decision Support (SEDS) lab (http://www.seng-decisionsupport.ucalgary.ca/). The objectives of SECCO are to be run not for profit, grow at a challenging and manageable rate, and to provide avenues for interaction between software engineering graduate students and industry. The mission of SECCO is to provide industry access to cutting edge technologies in the area of SEDS and promote applied research and empirical validation of new technologies as part of the graduate education. |

## INTELLECTUAL PROPERTY

### ReleasePlanner®

While the release planner technology builds on a web-based approach, it has also been designed and developed to be easily customizable for the different types of users and different application scenarios. University Technology Inc. (UTI) has evaluated the technology for patent protection and determined that the objective function and consolidation process is both novel and patentable and has initiated the patent application process. UTI is actively involved in managing this process. Due to the fact that this technology can service a broad horizontal market, the potential for securing multiple follow-up patents is also a positive opportunity. US and Canada patent protection is pending. The research will also produce additional, valuable intellectual property such as the know-how generated through broad-ranging applications of the technology.

## FUNDING

This year Guenther Ruhe received funding from NSERC (~$160K) which was added to his iCORE Professorship award ($350K/year). He also received $25K from industry and is pursuing other sources of industry funding for potential commercial spin-offs of his ReleasePlanner® software.

# PUBLICATIONS

REFEREED JOURNAL PUBLICATIONS

G. Ruhe, O. Saliu: The Art and Science of Software Release Planning. Appears in: *IEEE Software,* Issue 6/2005.

J. Denzinger, G. Ruhe: Decision Support for Software Release Planning Using e-Assistants. *Journal of Decision Support Systems*, Vol 13 (2004), pp 399-421.

O. Saliu, G. Ruhe: Software Release Planning for Evolving Systems. *Innovations in Systems and Software Engineering - A NASA Journal*, Vol 1 (2005), Issue 2.

A. Ngo-The, G. Ruhe: Diversification of Solution Alternatives: An Approach to Handle Uncertainty in Software Engineering (submitted to *Journal of Decision Support Systems*).

A. Ngo-The, G. Ruhe: Optimized Resource Allocation for Incremental Software Development (in preparation for *IEEE Transactions on Software Engineering*).

G. Ruhe, A. Ngo-The: Hybrid Intelligence in Software Release Planning. *International Journal of Hybrid Intelligent Systems*, Vol 1(2004), pp 99-110.

D. Greer, G. Ruhe: Software Release Planning: An Evolutionary and Iterative Approach. *Information and Software Technology,* Vol 46 (2004), pp 243-253.

CONFERENCES AND WORKSHOPS

Ngo-The, A. and Saliu, M. O.: Measuring Dependency Constraint Satisfaction in Software Release Planning using Dissimilarity of Fuzzy Graphs. *4th IEEE International Conference on Cognitive Informatics* ICCI'05, Irvine, California, USA, August 2005. Accepted.

Ngo-The, A. and Saliu, M. O.: Fuzzy Structural Dependency Constraints in Software Release Planning. *2005 IEEE International Conference on Fuzzy Systems*, Reno, Nevada, USA. May 2005. Accepted.

Y. Wang, G. Ruhe: Staffing for Software Inspections. *Proceedings of IASTED Conference on Software Engineering and Applications* (Innsbruck, February 2005), pp 400-407.

G. Ruhe, J. Momoh: Strategic release planning and evaluation of operational feasibility. *Proceedings HICSS-38* (Mini-Track on Strategic Software Engineering), IEEE Computer Society.

A. Mohamed, G. Ruhe, A. Eberlein: Decision Support for Customization of the COTS Selection Process, Accepted paper for *2nd International Workshop on Models and Processes for the Evaluation of off-the-shelf Components, 27th International Conference on Software Engineering*, ICSE'2005.

Z. Li, G. Ruhe: Uncertainty Handling in Tabular-based Requirements Using Rough Sets. Accepted paper for *The Tenth International Conference on Rough Sets, Fuzzy Sets, Data Mining, and Granular Computing*, RSFDGrC 2005, September 1-3, 2005.

P. Bhawnani, B. Far, G. Ruhe: Reliability Driven Decision Support for Incremental Software Development. Submitted to *IEEE International Conference on Software Maintenance* ICSM'2005.

J. Momoh, G. Ruhe: Process Improvement through Evaluation of Operational Feasibility of Strategeic Release Plans. Submitted to *European Software Process Improvement and Innovation Conference 2005.*

G. Du, M. M. Richter, G. Ruhe: A Dialogue Approach for Solving Wicked Planning Problems, Accepted for *International Symposium on Explanation-aware Computing*, Washington, D.C., November 3-6, 2005.

G. Du, M. M. Richter, G. Ruhe: Identification of Question/ Answer Types for an Explanation Component in Software Release Planning". Accepted for *3rd International Conference on Knowledge Capture*, October 2-5, 2005, The Banff Centre, Banff.

O. Saliu and G. Ruhe: Supporting Software Release Planning Decisions for Evolving Systems, *Proceedings of the 29th IEEE/NASA Software Engineering Workshop*, Greenbelt, MD, USA, April 2005.

G. Ruhe, J. Li: Software Process Improvement Education from an Industrial Perspective. *Proceedings Canadian Conference on Computer and Software Engineering Education*, Calgary, March 2004, pp 117-122.

A. Mohamed, T. Watanaya, G. Ruhe, A. Eberlein, B. Far: COTS Evaluation Supported by *Knowledge Proceedings International Workshop on Learning Software Organizations.* Banff, June 21, 2004, LNCS Vol. 3096, pp 43-54.

G. Ruhe, G. Du: Strategic Planning of Enterprise Application Integration. Banff Summit on *Enterprise Application Integration,* Banff, Canada, May 2004. pp 193-203.

Y. Wang, D. Liu, G. Ruhe: Formal Description of the Cognitive Process of Decision Making, *Proceedings 3rd IEEE International Conference on Cognitive Informatics* ICCI'04, August 2004, pp 124-130.

An Ngo-The, G. Ruhe, W. Shen: Release Planning under Fuzzy Effort Constraint, *Proceedings 3rd IEEE International Conference on Cognitive Informatics* ICCI'04, August 2004, pp 168-175.

S. Maurice, G. Ruhe, A. Mohamed, A. Amandeep, J. Momoh: How to create a Win-Win Relationship between Industry and Software Engineering Graduate Education, *Proceedings Canadian Conference on Computer and Software Engineering Education*, Calgary, March 2004, pp 147-154.

A. Amandeep, G. Ruhe, M. Stanford: Intelligent Support for Software Release Planning, *5th International Conference on Product Focused Software Process Improvement* (PROFES'2004), April 5 - 8, Kansai Science City, LNCS Vol. 3009, pp 248-262.

BOOKS, BOOK CHAPTERS AND SPECIAL ISSUE EDITOR

D. Pfahl, G. Ruhe, K. Lebsanft, M. Stubberich: Software *Process Simulation with System Dynamics. Appears in: People-ware and Software Process* (N. Juristo, S.T. Acuna, eds.), World Scientific 2005.

S. Maurice, G. Ruhe, A. Ngo-The, O. Saliu, R. Brassard: Value-based Software Release Planning. Appears in: *Value-based Software Engineering* (S. Biffl et al., eds.), Springer 2005.

B. H. Far, G. Ruhe: Prescriptive Decision Support based on Software Agent Interaction, Decision Support in Agent Mediated Environments (G. Phillips-Wren and L. Jain, Eds..), *Knowledge-Based Intelligent Engineering Systems Series*, 2005, Chapter 7, pp. 161-186.

G. Ruhe: Software Release Planning. Appears In: *Handbook of Software Engineering and Knowledge Engineering* (S.K. Chang, Ed.), Vol. 3, World Scientific.

D. Pfahl, G. Ruhe: System Dynamics and Goal-Oriented Measurement. Appears in: *Handbook of Software Engineering and Knowledge Engineering* (S.K. Chang, Ed.), Vol. 3, World Scientific.

Special Issue "Best Papers SEKE 2004", *International Journal for Software Engineering and Knowledge Engineering*, Issue 6/2005.