Please cite as:
Müller-Prothmann, Tobias & Susan Pinternagel (2010): Give Lead Users the Lead. Integration of Requirements Engineering into Innovation Processes, XXI ISPIM Conference 2010: The Dynamics of Innovation, June 6-9, 2010, Bilbao/Spain

Give Lead Users the Lead. Integration of Requirements Engineering into Innovation Processes

Tobias Müller-Prothmann*

Pumacy Technologies AG, Bartningallee 27, 10557 Berlin, Germany.
E-mail: tobias.mueller-prothmann@pumacy.de

Susan Pinternagel

Pumacy Technologies AG, Bartningallee 27, 10557 Berlin, Germany.
E-mail: susan.pinternagel@pumacy.de

* Corresponding author

Abstract: The paper presents a requirements engineering integrated innovation process (REI²P) as a systematic approach for user integration along the whole innovation management process. Based on the ISYPROM reference process for innovation management, the authors identify ways of integrating requirements engineering into the innovation process. This is achieved by drawing analogies between the two processes and linking relevant aspects to each other. This approach aims at supplementing existing market-oriented approaches by a combined process that provides an outline of integrated activities. The implementation of a requirements engineering integrated innovation process provides opportunities and risks for companies; however, a domination of realistic chances for sustainable improvement of innovative capacities can be concluded.[1]

Keywords: Requirements Engineering; Innovation Process; Customer Integration; Lead User; Product Life Cycle; Process Integration.

1 Background

Motivation

Successful innovation capabilities are an essential asset for companies to compete in globalising markets. However, development activities always imply high costs and risks. Various approaches in academic publications and management literature deal with design of the innovation process under constraints of time, money, quality, and competition. Especially experiences from innovation management practice have shown that listening to the customers' voice and considering their demands are the most vital ingredients for successful innovation.[2]

While recent innovation management approaches such as open innovation or lead user approaches strongly emphasise the customers' pivotal role for innovation activities, reference processes rarely provide a systematic integration of the different stakeholder

perspectives. From a business point of view, innovation activities are often not continuously aligned with market requirements and thus, strongly imply the risk of failure in terms of commercialisation or at least significant delays of market introduction. Change requests in product design, especially during the testing phase, lead to an unnecessary waste of time and money. Even companies running an innovation process with systematic lead user integration during the early stages of idea and innovation development often lack a systematic and methodological customer requirements management across the entire innovation process. Requirements gathered at the beginning of the development process are often not properly kept track of until the final implementation.[3] Therefore, it is strongly proposed that an approach toward a clear market orientation during all stages of the innovation process should be developed.

In addition to the above mentioned problem there are two more aspects of the innovation process that have to be considered. Firstly, companies need to consider how to manage the complexity of new products while, at the same time, they are facing short innovation cycles.[4] Constraints on innovation regarding time and money provide little room for trial-and-error methods. Secondly, geographical distribution of research laboratories makes informal communication among scientists, developers, customers, and other stakeholders difficult.

As this paper will demonstrate, methods of requirement engineering as used in software development projects may provide new insights and a useful approach for practical implementation to elicit customer needs during the innovation process, i.e. to give lead users the lead! Approaches for the integration of requirements engineering in innovation management processes are presented as the requirements engineering integrated innovation process (REI²P).

Lead User Approach and its Shortcomings

A prominent approach to integrate users into entrepreneurial innovation activities is the lead user method by Eric von Hippel.[5] Many companies develop new products with focus on short-time success. Existing products are improved and enhanced by new features. Line extensions and other incremental innovations dominate innovation efforts. Motivated by utility expectations it is often not the company, but the customer who develops or co-develops an innovation.[6] Thus, from a company's perspective the user integration in product development may ensure that the final product meets the customers' needs. As von Hippel discovered, these user needs are often 'at the leading edge' of market trends.[7] The users are therefore called 'lead users'. It can be very appealing for companies to work together with lead users instead of generating new product ideas by collecting market research data.

In combination with the open innovation paradigm the lead user theory postulates a vivid outflow and inflow of ideas from and to companies.[8] Nevertheless, there is little advice on practical implementation of this concept. The lead user theory provides a basic approach to integrate external ideas into the innovation process. Current research on customer integration widely agrees on the importance of lead users since many studies have confirmed the high relevance of their contribution to new product success. However, research on integration beyond the first stages of innovation processes is rare. The close collaboration is rather exception than standard. Starting-points and process descriptions remain vague and leave practitioners with few methods ready for application. This shortcoming needs to be resolved if lead users were to be integrated into

the innovation process on a regular basis. In this paper, the authors provide an approach of user integration based on requirements engineering as widely used in software development. Integration of requirements engineering in innovation processes is outlined by using an innovation reference process developed in the ISYPROM research project.

ISYPROM Innovation Process

The approach of a requirements engineering integrated innovation process (REI²P) as presented in this paper is based on an innovation reference process developed in the ISYPROM research project by the authors. ISYPROM is a joint research project on Acceleration of Innovation through Model-based Process and Systems Design. The project is co-funded by the German Federal Ministry for Research and Education (BMBF) with 12 partners from industry, research, and education.[1]

The ISYPROM innovation process describes how companies can face up to the challenge of developing new and successful products. Figure 1 shows the different phases of the ISYPROM process. With each phase complexity and knowledge about a project increase. The ISYPROM innovation process is unique in that it presents a best practice of innovation processes from literature and additionally emphasises the early innovation phases (especially idea management related processes) that are mostly neglected by common other innovation processes (like stage gate).[9]

The innovation process consists of five phases. After each phase the information gathered is reviewed by the management which then decides whether the project is continued or not:

Phase 0. ‘Discovery/Problem Analysis’ defines fields of interest that set up the basis for new ideas. Scenario analysis and other strategic management tools can be used to define the scope of the subject area.

Phase 1. During the ‘Idea Generation’ phase a wide range of ideas is collected. Ideas may be taken from different fields of interest as well as from inside and outside the company. Stakeholders and lead users of products as well as from other related ares are identified and consulted.

Phase 2. ‘Idea Selection’ covers evaluation and analysis of ideas according to predefined methods such as cost-utility and profitability analysis. This step is followed by a management review. In this phase, ideas are evaluated, and promising ideas proceed to the next phase whereas others are stopped or halted.

Phase 3. ‘Idea Specification’ further specifies the ideas that have passed the previous gate according to their general scope and user-specific needs. A business case and strategic decisions lead to a project kick-off or, alternatively, to external exploitation of the idea through outsourcing/licensing etc.

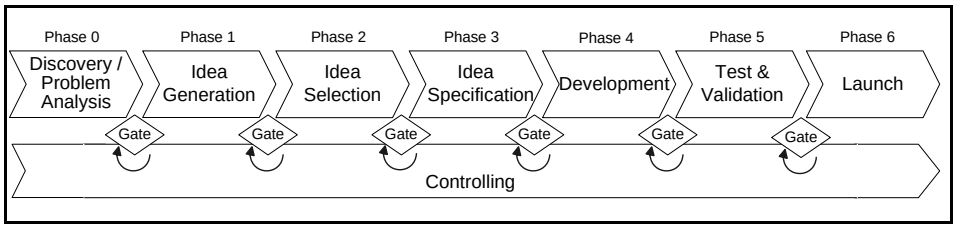
Phase 4. ‘Development’ covers the product development including design alternatives, technical specification, and user integration by early change requests. A successful prototype leads to series development.

Phase 5. ‘Test & Validation’ includes final change requests, product optimisation as well as roll-out preparation and production planning. Pre-launch market tests reveal first reactions of customers and last changes need to be implemented for a market ready product/production.

Phase 6. ‘Launch’ is the final phase where the new product is introduced to the market. The whole process is accompanied by controlling measures which act as a support to the management decision at the gates.

If a product is successfully launched at the market further changes and improvements will be necessary within a product's lifetime. New ideas can be applied to out of date products. A close contact between customer service and development team helps to identify new functions and extend the usage of a product. Loops within the innovation process help to stay up-to-date during new product development, realise user/review feedback in a timely manner and include new ideas at later phases of the process.

Figure 1 ISYPROM Innovation Process



Source: The ISYPROM Innovation Process is work in progress and part of the ISYPROM joint research project developed by Pumacy Technologies AG (www.pumacy.de) and the Institute of Industrial Science/Ergonomics (IfA), University of Kassel (www.ifa.uni-kassel.de)

Requirements Engineering

Identification and specification of stakeholder requirements is a major challenge faced by all involved in software development processes. To enable exchange of knowledge and opinions on a formal level, modelling languages have been developed. A method to elicit, analyse, validate, and manage requirements for complex systems is called requirements engineering. As defined by the IEEE, requirements are 'a condition or capability needed by a user to solve a problem or achieve on objective […]'.[10]

A requirement can describe functional or non-functional aspects of a product. It needs to be formulated clearly and without ambiguity. Within the specification document requirements need to be prioritised and distinguished between mandatory and nice-to-have components based on a classification scheme of 'must/need/nice to have'. In the formulation of the requirement it is important to describe 'what' has to be done rather than 'how' it has to be done and not to give too narrow guidelines for the developers.

Requirements are defined at an early stage of product development. The requirements engineering process ensures that all stakeholders can contribute their views. The resulting requirements document describes functions, constraints and overall definitions of the product that have to be kept track of until the final implementation and validation.

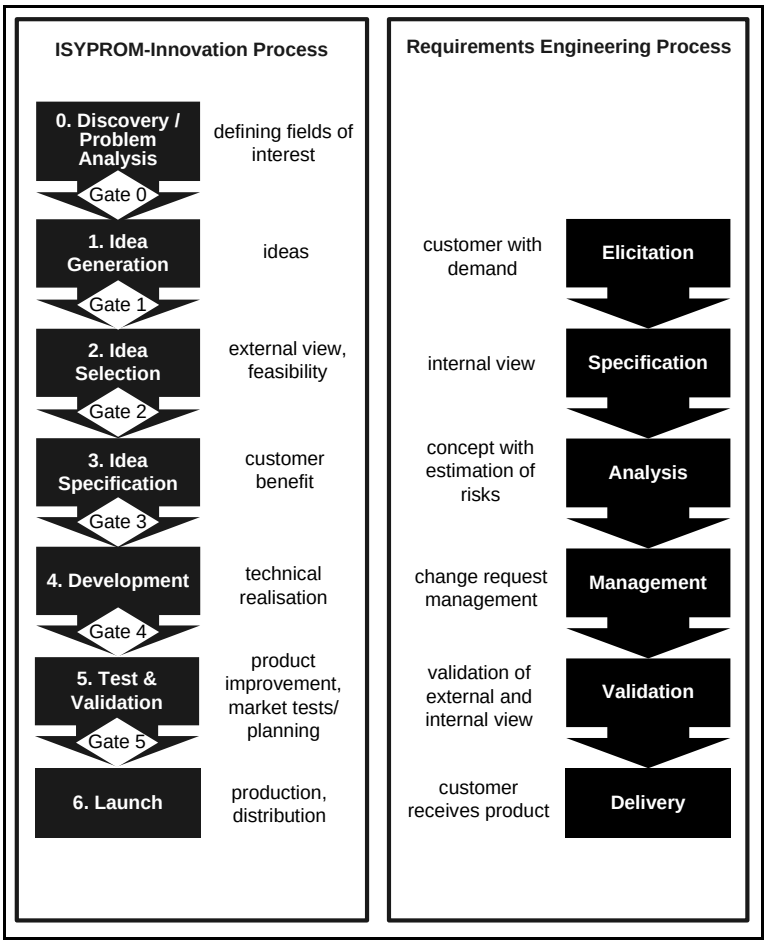
2 Approach

Innovation vs. Requirements Engineering Processes

This paper aims at providing an approach for the integration of external ideas and lead users into the innovation process based on the methods of requirements engineering.

Integration of innovation management and requirements engineering helps to reduce the above mentioned shortcomings of systematic user integration into the whole innovation process. It seems reasonable to conclude that the considered methods used in requirements engineering can support the fuzzy front of innovation management.

Figure 2: Innovation vs. Requirements Engineering Processes



The innovation process has its origin in the industrial development of new products. The requirements engineering stems from the software development industry and is an attempt to manage the complexity of systems as outlined above. Both processes have different review phases to ensure progress and quality of the implementation. Figure 2 illustrates the two processes and highlights possible starting points for integration:

- Gates of the innovation process include management involvement, i.e. reviews to decide whether ideas or projects pass on in the innovation funnel. Reviews take place according to predetermined criteria. In the realm of requirements engineering it is rather the customer and involved stakeholders than the management who decide on the project. Whereas reviews in innovation management aim at selecting the most promising ideas, requirements engineering

generally demands a successful outcome since only in this case the assignment has been completed.

- The innovation process starts with an idea that is usually vague and possibly visionary. Sometimes, the idea is not even a real product so it is hardly possible to compare it to existing products or estimate its potential. Requirements engineering has its origin in customer demand. Under this aspect, a product is clearly focused on user requirements and needs. The product does not need to suit any general market demands but those of the actual client. As a result, successful development of a product is dependent on good communication and close collaboration between software provider and customer. Requirements engineering concentrates on the internal view and conceptions about feasibility whereas the innovation process points at marketability of a product.
- Besides customer input at the very early stage of a vague idea, feedback of potential customers usually is collected not before the late stages of the innovation process. Here, it may be possible that the innovation team discovers completely new demands or that the customers reject the product. At this point the requirements engineering is a better means to evaluate customer needs and adjust design and functions of the product accordingly. Frequent feedback from the customer supports the homogeneity of demand and reality. Both the innovation and the requirements engineering process are able to result in complex products and systems; however, requirements engineering is more suited to manage the complexity of the product development process.

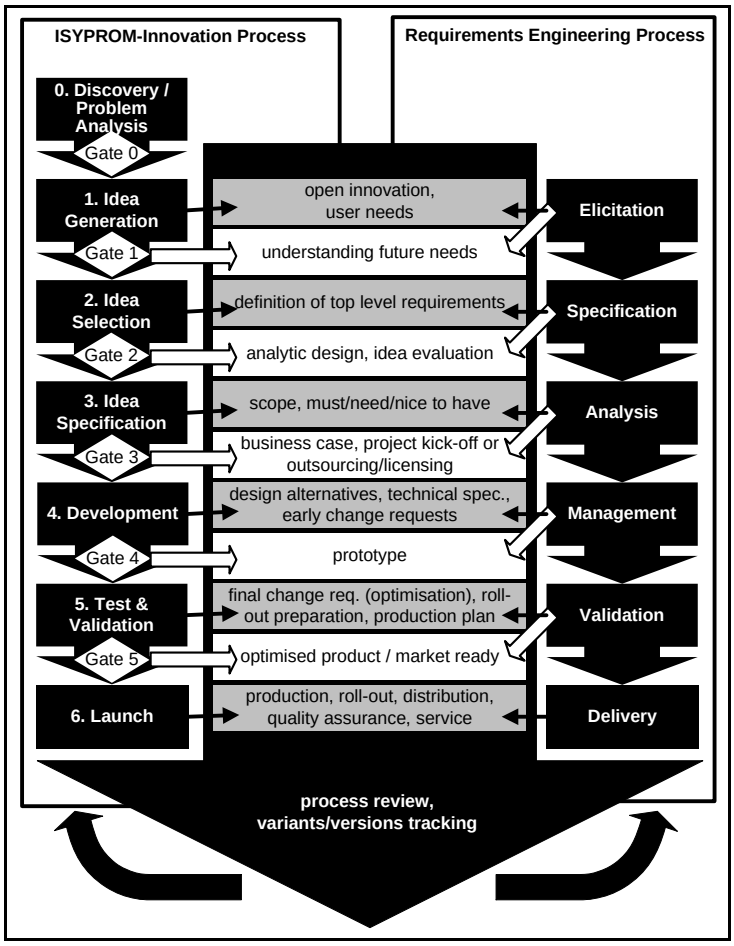
Requirements Engineering Integrated Innovation Process (REI²P)

Based on the previously outlined phases of the innovation process on the one hand and the requirements engineering process on the other, the requirements engineering integrated innovation process (REI²P) combines joint activities in the respective phases of both process (see Figure 3). This approach aims at an integrated process model that provides match-making information of product ideas/specifications with user requirements on every step of the innovation process and thus, reduces uncertainties about customer demands from early innovation activities to market launch. In the REI²P process, idea formulation and product design is guided by user/customer requirements and helps to ensure a future-related thinking for all research and development (R&D) activities.

After setting the frame for discovery or problem analysis *phase 0*, first ideas are developed or collected in the idea generation *phase 1*. Lead users and other stakeholders can air their demands and ideas and contribute to the stock of ideas. In order to comprehend ideas properly, methods of requirements engineering can be used to capture the most important facts and make sure that engineers in the development team do not alter the ideas according to their understanding or wishes. The goal of phase 1 is to understand the aim behind a product idea. The innovation team, stakeholders, and customers should develop the same understanding about this aim. If all partners involved start from the same point only then will they be able to produce a product that takes all necessary facts into account. Phase 1 should therefore result in a common document that clearly states the goal of the product and the customers' benefit.

In *phase 2* the requirements of the stakeholders need to be further investigated, since these should match the goals of the projects as described in phase 1. Later the development of the product is pursued according to the set of requirements. After elicitation the requirements are sorted and prioritised. Here, interdependencies and constraints become visible. This part of phase 2 already concentrates on internal aspects of product development. The innovation process itself rather aims at external factors and marketing activities. At the transition to the next phase ideas are selected according to how promising they are in respect to the company's goals for innovative products.

Figure 3: Requirements Engineering Integrated Innovation Process (REI²P)



The subsequent *phase 3* is dominated by market research which will help to confirm the accuracy of the stakeholders' requirements. New requirements will be elicited, analysed, and added to the existing document. At this point, analysis allows for a ranking of the already listed requirements. This allows a distinction between 'must/need/nice to have' requirements. It becomes visible which kind of product features are must criteria required to develop the most basic version of the product. This information at such an early point of the development process can provide decision support for the project and assigned resources. If a must criterion can only be fulfilled with a high amount of resources, then it

might not be worth developing. Market analysis and statements from stakeholders should additionally include a possible distinction between features for different regional markets. If a product will be sold worldwide or to different customers, it can be useful to respond to diverse needs.

Product development in *phase 4* leads from the technical specification, design alternatives and the implementation of major changes, all with a close user integration, to functional prototype that can be reviewed at the gate.

In *phase 5* market tests with customers are carried out. It is the first test whether the 'visionary' ideas of lead users and stakeholders are suitable for the market. Furthermore, the design of alternative product versions and aspects of regional markets may improve the evaluation. If all changes and demands of the customers are implemented and production and marketing plans are approved, the product can be launched.

Innovation activities are not finished with the new product launch in *phase 6*. Lessons learned from the innovation project as well as from experiences over the whole product life cycle are a valuable source for future service support and product improvements. Therefore, knowledge and experiences should be documented and made available to all involved in the development process of subsequent product versions. Unused requirements and further specifications should be checked against market research conclusions after the launch and either used for product enhancements, product line extensions or new products.

3 Findings

Opportunities

Companies can improve their innovation activities and strengthen their competitiveness based on REI²P. The development of different components of a new product can be distributed among departments without losing track of features and functions. Especially for global companies, it becomes easier to elicit a product's requirements for local markets and adjust the product accordingly. Companies stay close to the market and to customer needs and the complexity of products, e.g., a high amount of software components, can be managed systematically.

The integration holds several advantages for the management of innovation. Within the idea development the integration of all stakeholders can be emphasised. Different stakeholders have different, specific views on a new idea due to their background and individual relation to the envisioned product. Systematic accumulation of all diverse opinions reduces the risk of discounted requirements. From the beginning, a common view of the project and its goals can be achieved. Throughout the process the consistency implementation of a project's requirements can be monitored. References and connections between the specified requirements allow for tracking. The knowledge about this interconnectedness provides more flexibility for the handling of the requirements. During the implementation process of a product idea, customers stay in close contact to the development team through communicating their requirements. Integration of customers and their ideas is leveraged. Modern products are usually complex and a well-functioning communication between stakeholders and producer is vital to the process.

Furthermore, REI²P reduces the risk of misunderstandings between customer and producer as well as within intra-organisational communication. A world-wide distribution of one product becomes more attractive if alternative versions for differing market demands are already designed in primary development stages. At the same time it keeps a tight rein on engineers who will then not get distracted by unnecessary functions. A thorough description of all the requirements makes it possible to estimate the resources and development steps more adequately. Uncertainties about the implementation and required time can be reduced. REI²P allows a scaling of the development into appropriate steps that can be managed and verified one by one.

Risks

Integration of requirements management into innovation processes as presented in this paper indicates significant advantages for the design of innovation processes. However, the practical implementation of the requirements engineering poses great challenges for companies. Requirements engineering is not yet an established methodology outside of software development projects. Nevertheless, the authors come to the conclusion that it can be beneficial to other sectors as well and become a means of managing the complexity of new product development. Considering the relevance of software for the majority of innovations, it becomes clear that a more systematic approach is overdue. It seems to be apparent that companies better face up to the international competition and manage complex developments with requirements engineering. Communication difficulties between stakeholders and amongst international research staff can be alleviated by a clear and concise description of necessary requirements. Companies can keep innovation cycles sufficiently short and ensure marketability through requirements management.

The approach bares the risk of getting influenced by people's own point of views. Possibly, this could lead the project into a wrong direction and a concentration upon niche areas of the market. Companies should therefore check how representative the requirements of a lead user or stakeholder are.[11] Expectations of lead users towards the product can differ very much from the company's aim.[12] The company might get itself into dependency from stakeholders if it wants to please everybody. It depends on the knowledge and experience of lead users hence it does not want to annoy its assistants. The introduction of the new method can lead to a bias in the selection of new ideas if not all projects are evaluated like that. The search for innovative ideas is a process driven by creativity and coincidence. In the early phases it is not always possible to detect and evaluate the potential of an idea. Innovations with a high degree of novelty are difficult to assess since the process of bringing a product to market would require new technologies.

The approach presented in this paper does not necessarily help to identify unspecific features and complex models for the future. For this reason, creativity and methods that help to detect latent requirements should play a role in the process so that they can be included in the list of requirements as well as more general approaches to develop robust innovation strategies.[4] Success cannot be generated through requirements engineering alone since the search for new ideas is influenced by many factors. Lead users help to identify new demands for products in their capacity as being 'ahead of the market'. However, not all of their ideas can be generalised as being the demand for a whole market or market section. For the company this raises the question of whom to trust in their judgement. The thorough description of requirements for the product and the

consultation of the stakeholders take time and effort and may even slow-down the progress of the development, especially if customers and stakeholders express contradicting ideas. This can be a sign of different development directions for innovations and requires a thorough investigation. Evolving conflicts should be addressed to make sure that the most plausible idea gets put through and not a less promising compromise. Laid down decisions about a project are not unchangeable. The assessment of requirements is based on the decision under uncertainties, and therefore modifications are part of the process. Requirements engineering increases the ability to plan ahead only up to a certain level.

4 Conclusion

The REI²P design, as outlined in this paper, provides a new way of thinking about systematical requirements management in the development process. Starting points for the integration are outlined and a first description of the joint process is given. Stakeholders are integrated in order to give an insight into future market needs and trends. REI²P will therefore enhance the understanding of market and customer requirements. This way, companies can systematically improve their innovation capabilities by identifying the value a customer sees in a new product. This may prevent expensive erroneous product developments and misconceptions about customer needs. Innovative activities can be speeded up and long-term potentials are more visible then without requirements engineering. The method may alleviate the portfolio decisions at the gates and help to opt for a certain project.

There are limitations to the concept; some of them were already pointed out when describing the risks. The thorough elicitation of requirements engineering and close collaboration with lead users can only be carried out by companies that already have a functioning innovation process implemented. The question of how to find appropriate lead users and stakeholders still remains to be solved. Although the goal-oriented communication between customer and producer is improved, the dependency of the company on the user's will to cooperate still is a challenge. An implementation of this concept will tie up resources and requires training of the involved staff.

In order to verify the approach of this paper it will be necessary to conduct case studies and test whether REI²P can be further supported by practical findings.

References and Notes

[1] ISYPROM is funded by the German Federal Ministry of Education and Research (BMBF) within the Framework Concept 'Research for Tomorrow's Production' (funding number 02PC105x) and managed by the Project Management Agency Karlsruhe (PTKA); see also http://www.isyprom.de. The authors are responsible for the contents of this publication.

[2] Cf., e.g., Selma Borovac, Joanna Golata, Tobias Müller-Prothmann, and Edda Behnken (2009) Integration of Customer Knowledge for the Generation of Service Innovation in the Music Industry in *Supporting Service Innovation Through Knowledge Management. Practical Insights & Case Studies*, eds. A. S. Kazi, P. Wolf, and P. Troxler (eds.) (KnowledgeBoard & Swiss Knowledge Management Forum), pp. 62-81.

[3] Ellen Enkel, Javier Perez-Freije, and Oliver Gassmann "Minimizing Market Risks Through Customer Integration in New Product Development: Learning from Bad Practice" *Creativity and Innovation Management*, Vol. 14, No. 4 (December 2005): 434.

[4] For approaches toward a robust innovation management, i.e. systematic evaluation and integration of disruptive factors in innovation processes, cf. Tobias Müller-Prothmann, Edda Behnken, and Selma Borovac "'Innovation Management Devils' - A Disruptive Factor Based Analysis of Innovation Processes" in *Proceedings of the XIX ISPIM Conference: Open Innovation*, Tours, France, June 15-18, 2008; Tobias Müller-Prothmann and Holger Rhinow "'Innovation Profiler' – Identification and Prioritisation of Innovation Factors Based on Social Network Analysis" in *Proceedings of the XX ISPIM Conference 2009: The Future of Innovation*, Vienna, Austria, June 21-24, 2009.

[5] Eric von Hippel, *The sources of innovation* (Oxford University Press: New York, 1988).

[6] Eric von Hippel, *Democratizing Innovation* (The MIT Press: Cambridge, 2005), p. 25.

[7] Eric von Hippel, *Democratizing Innovation* (The MIT Press: Cambridge, 2005), p. 22.

[8] Henry Chesbrough, *Open Innovation, The New Imperative for Creating and Profiting from Technology* (Boston: Harvard Business School Publishing Corporation, 2006).

[9] For an introduction to basic innovation process designs cf., e.g., Tobias Müller-Prothmann and Nora Dörr, *Innovationsmanagement. Strategien, Methoden und Werkzeuge für systematische Innovationsprozesse* (Hanser: München, Wien, 2009), pp. 25-50.

[10] IEEE, *Standard Glossary of Software Engineering Terminology* (New York, 1990), 610.12-1990.

[11] Klaus Brockhoff *Der Kunde im Innovationsprozess* (Vandenhoeck & Ruprecht: Göttingen, 1998), p. 21.

[12] Ellen Enkel "Chancen und Risiken der Kundenintegration" in *Management von Innovation und Risiko, Quantensprünge in der Entwicklung erfolgreich managen*, eds. O. Gassmann and C. Kobe (Berlin Heidelberg: Springer-Verlag, 2006), p. 176.