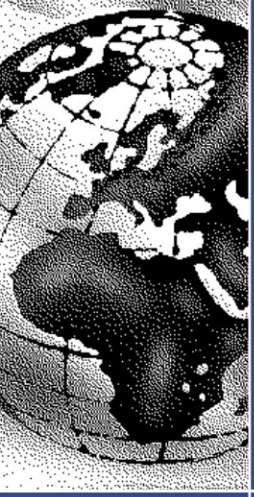


Patricia Sandmeier

# Customer Integration in Industrial Innovation Projects

GABLER EDITION WISSENSCHAFT

Patricia Sandmeier

# Customer Integration in Industrial Innovation Projects

GABLER EDITION WISSENSCHAFT

Patricia Sandmeier

# Customer Integration in Industrial Innovation Projects

With a foreword by Prof. Dr. Oliver Gassmann

GABLER EDITION WISSENSCHAFT

Bibliographic information published by the Deutsche Nationalbibliothek
The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at http://dnb.d-nb.de.

Dissertation Universität St. Gallen, 2006

1st Edition 2008

All rights reserved
© Betriebswirtschaftlicher Verlag Dr. Th. Gabler | GWV Fachverlage GmbH, Wiesbaden 2008

Editorial Office: Frauke Schindler / Anita Wilke

Gabler Verlag is part of the specialist publishing group Springer Science+Business Media.
www.gabler.de


No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the copyright holder.

Registered and/or industrial names, trade names, trade descriptions etc. cited in this publication are part of the law for trade-mark protection and may not be used free in any form or by any means even if this is not specifically marked.

Cover design: Regine Zimmer, Dipl.-Designerin, Frankfurt/Main
Printed on acid-free paper
Printed in Germany

ISBN 978-3-8349-1035-6

# Foreword

The fact that customers can be a major source of innovation is well known. Research traditions on user-driven innovation have received a lot of attention since the first research attempts in the early 80s. With today's trend of opening up the internal innovation process, innovation actors are no longer restricted to R&D or cross-functional internal teams but include external partners as well. Open innovation and open R&D models are means to manage the increased technological complexity and customer demands in the global market place. The roles of customers are no longer restricted to passive consumers whose latent requirements need to be identified. Instead they have become an active and important part of the innovation process. Von Hippel's 'Democratizing innovation' is today's mantra, but how are we to integrate customers in the innovation process and how can such a process be managed?

Patricia Sandmeier analyzes how companies can establish a continuing transfer of customer knowledge to the innovator. She draws on more than 22 European companies and her analytical framework for the case analysis is based on the rather new approach of Extreme Programming (XP) in the software industry. While this approach and the underlying agile project management practices have received a high acceptance among software engineers, the concept is less known in the 'hardware world' of new product creation.

The in-depth analyses of industrial firms, Hilti and Buechi, and technical service firms, IDEO and Tribecraft, demonstrate how such a process works in practice. The approach of this work is new and has many implications for R&D management: Derived from the XP approach, Patricia Sandmeier proposes decentralized customer-centered innovation cells as a new form of organizing an industrial R&D department. This kind of management includes bottom-up resource attraction instead of the traditional functional top-down resource allocation in R&D. R&D becomes more of a knowledge broker where creativity of customers are used and multiplied for new product creation.

This is a convincing book for reflective practitioners and scholars in the field of user innovation. The proposed framework shows how the democratization of innovation (von Hippel, 2005) can be managed by integrating customers in industrial product innovation. I hope for a wide distribution of Sandmeier's work and wish all companies employing these concepts the best of success.

Prof. Dr. Oliver Gassmann
Institute of Technology Management
University of St. Gallen

# Preface

This book—based on my doctoral thesis—is a result of my work at the Institute of Technology Management at the University of St. Gallen (ITEM-HSG), Switzerland and the University of New South Wales (UNSW), Australia where I had the opportunity to broaden my professional and academic experience.

With the completion of the thesis, there are many people to whom I owe a great deal of thanks. My first and foremost gratitude goes to Prof. Dr. Oliver Gassmann, Director of the ITEM-HSG, for supervising my thesis, constantly providing me with constructive feedback and freedom of action. Furthermore, I would like to thank Prof. Dr. Roman Boutellier from the Swiss Federal Institute of Technology Zurich (ETHZ) for the co-supervision and his valuable contributions and advice. I wish to extend thanks to Prof. Dr. Pam D. Morrison for making my research experience at UNSW possible and enjoyable. I also owe a great debt to the Swiss National Science Foundation which provided me with generous financial support during my time in Sydney.

The foundation for this book are approximately 150 interviews and discussions I had with experts from practice and academia. In this context, I would like to thank Dr. Christoph H. Wecht, Nadia Jamali, Patrick Widler, Dr. Carmen Kobe, Rafael García, Dr. Andreas Bong, Dr. Ernst Freydl, Daniel Irányi, Sabine Vögler, Dr. Martin Jud, Prof. Dr. Ian F. Wilkinson, Richard Wenk, Peter Frank, Peter Schleiffer, Esther von Ziegler and Dr. Ellen Enkel. I also would like to thank my student researcher, Michael Vogel, for assisting my work.

I thank my colleagues and friends with whom I had a very good time. I am especially grateful to Dr. Javier Perez-Freije, Dr. Emma Po Yee Wong, Yimin Huang, Dr. Vinh Q. La, Stefan Leuenberger, Patricia Deflorin, Dr. Maike Rathje, and Alexander Conreder for their joyful support at various stages and their creative ideas. Special thanks go to Torsten von Bartenwerffer for his endeavors supporting my work all the way. I would also like to express my gratitude to Sophie Haag for her friendship and for providing cheerful emotional encouragement.

Last but certainly not least, I am sincerely grateful to my parents, Isabelle and Walter Sandmeier, for supporting me during this great journey.

Patricia Sandmeier

# Index

# Contents

# List of Figures

# List of Tables

# List of Abbreviations

| | |
|---|---|
| A&QC | Analysis and Quality Control |
| AG | Public company (German: *Aktiengesellschaft*) |
| B2B | Business-to-business |
| BU | Business unit |
| CAD | Computer-aided design |
| cf. | Compare (Latin: *confer*) |
| CMM | Capability Maturity Model |
| CTO | Chief Technology Officer |
| Ed. | Editor |
| Eds. | Editors |
| e.g. | For example, for instance (Latin: *exempli gratia*) |
| et al. | And others (Latin : *et alii/alia*) |
| ETH | Swiss Federal Institute of Technology Zurich (German: *Eidgenössische Technische Hochschule*) |
| FEM | Finite element method |
| IC | Integrated circuit |
| i.e. | That is to say, in other words (Latin: *id est*) |
| ISO | International Standards Organization |
| MIT | Massachusetts Institute of Technology |
| MLP | Market and performance profile (German: *Markt-Leistungs-Profil*) |
| NASA | National Aeronautics and Space Administration |
| NB&T | New Business and Technology |
| NIH | Not invented here |
| NIR | Near infra red |
| No. | Number |
| NPD | New product development |
| qtd. | Quoted |
| R&D | Research and Development |
| R&Di | Research and Discovery |
| TQM | Total Quality Management |
| TTM | Time to money |
| U.S. | United States |
| XP | Extreme Programming |

# 1 Introduction

## 1.1 Motivation and research goal

### 1.1.1 Relevance of research subject

Managing the development of their product innovations confronts industrial firms with a severe challenge. Nearly two-thirds of new products fail after their launch, largely because companies are under pressure to address rapidly evolving customer demand (Lempres 2003). The basic assumption that companies can anticipate demand and mobilize their scarce development resources in previously specified ways simply does not hold true anymore. Due to customers' fast changing product requirements, which result from rapidly evolving markets and technologies and shortened product life cycles, product innovation projects must hit moving targets and change their focus continually during the course of a project. These demands have become especially challenging in the competitive markets for technology-intensive industrial products, which require huge investments and long development times.

The simultaneous pressures of deep budget cutbacks and escalating industrial research and development (R&D) costs have forced companies to come to the understanding that they must better exploit the innovation capabilities they can derive from the market. European executives rank "understanding their customers better" as the most important element for increasing the value of innovations created during the product development process (Wharton 2005: 1). Because a significant fraction of innovative products are directly initiated or significantly influenced by customers, practitioners concomitantly recommend that firms should align their key innovation activities with actual and potential customers to reduce the risk of failure and target their resource spending more precisely (Seely Brown and Hagel 2005).

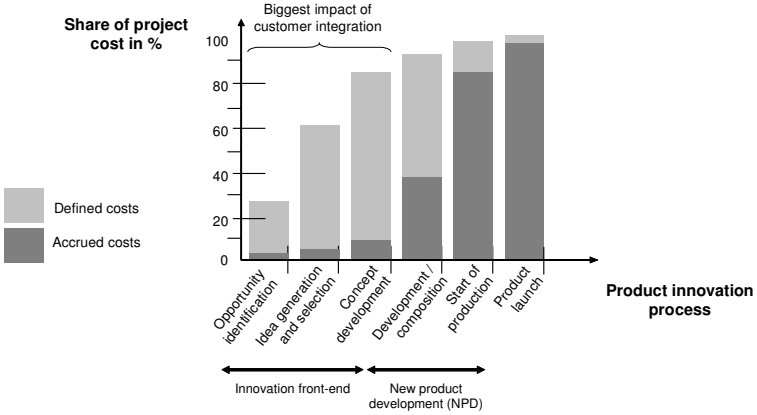
As a result, companies have recognized that they need to inject more customer know-how into their product innovation processes. In many 'leading-edge' companies, R&D managers encourage the direct interaction of the development team with customers, in contrast with traditional practices in which the marketing department would undertake customer research and throw the results 'over the wall' to R&D. For example, IBM researchers now spend approximately 25 percent of their time with customers, in contrast

with the company's policies in the early 1990s, when only 2–5 percent of the research division's work was dedicated to interaction with IBM customers (Larson 1998; Times 1998).

However, modern attempts to integrate customers' contributions into new product innovation activities remain focused on single tasks, such as idea generation workshops or testing of final prototypes and pilot series. These activities help improve innovation tasks in a piecemeal fashion, but a consistent procedure that integrates customers' contributions continually throughout the course of an innovation project and thereby promotes it to a new level of innovativeness simply does not exist. Furthermore, companies have difficulty adopting sophisticated customer integration methods, such as the lead user concept developed in the 1970s and 1980s (von Hippel 1976, 1988) and which continues to be improved upon (e.g., von Hippel and Katz 2002). This concept has been widely discussed in practice and literature, but practitioners assert they do not know who their lead users are and therefore find it difficult to identify appropriate customer innovators in a cost-effective manner. Overall, existing methods represent striking instruments to support customer integration efforts, but unused potential to profit from customers' contributions still exists. Companies therefore need a product innovation approach that will enable them to interact closely with the right customers throughout the entire innovation process, which will give them the means to identify real product innovation needs and respond to fast changing information from the market.

Successful customer integration further requires that customers have a chance to influence a product innovation project when the development team has the flexibility to respond (see figure 1-1). The biggest impact of customer integration lies in the early phases of the product innovation process, the so-called *innovation front-end* or *product definition phase* (Kim and Wilemon 2002).

Figure 1-1 Impact of customer integration on project costs




Source: adapted from Gebhardt (1996: 9).

The innovation front-end determines up to 85 percent of the total development cost (Buergel and Zeller 1997; Herstatt and Verworn 2002) and comprises several activities: identifying new opportunities for future products, generating and selecting new product ideas, and developing new product concepts. However, though this phase typically is the least expensive part of the overall innovation project in terms of accrued costs, product developers from most companies spend little time in this stage for fear of duplicating the efforts of marketing or R&D, or because they lack the know-how to manage this early innovation phase effectively.

In product innovation processes in general, product-developing companies have concentrated on the actual new product development (NPD) phase, during which performance improvements have hit a plateau. During the past 15 years, most firms have adopted standard NPD processes with disciplined planning and timelines, strict design reviews, *stages* and *gates* for decision making, and cross-functional development teams. These practices have made the development of new products more efficient, but because they tend to be inflexible, they cannot respond to new contributions from customers, which often are released only when the company presents a first prototype to the customer. The inevitable result is expensive changes at late stages in the innovation project.

Raising product innovation activities to a new level by better integrating customers requires turning sequential and predefined processes into flexible ones, which react to contributions from customers continually rather than at specific intervals and in batches. Such flexible product innovation processes embrace actual NPD as well as the innovation front-end. Furthermore, they are built on first-hand customer contributions from the very beginning of the process, combine new findings frequently, and result in optimal product solutions for the customer. This development practice thus can empower firms to improve the quality, timing, and synthesis of product and process know-how throughout their development cycles, keep their product options open longer, and act on new contributions from customers later in the product innovation process (Holman, Kaas, and Keeling 2003).

In the search for analogies to flexible product innovation approaches that successfully manage the intersection of customers and R&D, a solution emerges from *Extreme Programming* (XP) in the software engineering context. In XP's product development methodology, the product innovation process is organized to ensure a continual flow of high-quality contributions from customers to the development activities surrounding a new product. Customers are considered continuously and from the very first development activity, which provides for the full integration of their contributions into the new product. The XP method first determines, together with the customer, the product needs and critical attributes for the new product's success. Then, the development team reconfigures its product development activities around these needs, thereby ensuring that the right know-how is gathered at the right time and flows to the right people. Customer know-how collection is facilitated by 'quick-and-dirty' engineered product releases or prototypes demonstrated to the customers. The physical presence of the evolving prototypes enables both customer and developer to discover real requirements for a new product and even new product needs and solutions.

In the *industrial* products sector, the question arises whether XP's flexible approach to customer integration can be beneficial for traditional product innovation projects. Organizing customer integration in product innovation processes in the way that XP has been successful in software engineering might seem simple, but it represents a radical departure from the common practices of most industrial companies. Therefore, the application of XP's customer integration and product innovation practices appears to be a potentially promising approach to reduce the risks of product failures, target resource spend-

ing more precisely, and respond to the challenges caused by changing customer requirements throughout industrial product innovation projects.

### 1.1.2 Deficits in current research

Integrating customers into industrial product innovation processes resides within the context of R&D and innovation management. It also aggregates the research fields of product innovation processes and customer integration. Identifying deficits in current research thus requires a consideration of publications from two literature streams: (1) that pertaining to product innovation processes, which comprises literature on NPD and innovation front-end management (see figure 1), and (2) that related to customer integration management, including research in the field of lead users. Furthermore, customer integration aspects covered by marketing research also must be considered. A brief overview of these literature streams is presented in the following sections.

***Product innovation processes***

Literature on NPD shows that a product development process that encourages explicit and deep consideration of customer needs likely stands a better chance of producing a successful product outcome (Zirger and Maidique 1990). The resulting imperative to open the NPD process to absorb innovations from the company's broader environment recently has been discussed under the term 'open innovation' (Chesbrough 2003; Gassmann and Enkel 2004, 2006). This openness should enable organizations to react to the significant changes in both customer needs and technological potential that occur in rapidly changing markets during the development of a product innovation.

However, the effective structuring and management of such a NPD process, which enables an organization to respond to changing information during a development project, imposes several implementation challenges (Boutellier and Gassmann 2001). Commonly used and predefined NPD processes do not offer the required flexibility to respond to evolving customer requirements or new technologies in high-velocity industries (MacCormack, Verganti, and Iansiti 2001). Their inherent, extensive upfront planning simply wastes time and may even slow the pace of the process when the available know-how is incomplete or obsolete. In contrast, more effective product development approaches are experiential strategies based on probing and learning, which means they require frequent iterations, short times between milestones, and minimal project planning (Allen 1966; Clark and Fujimoto 1991; Wheelwright and Clark 1992; Eisenhardt and Tabrizi 1995; Lynn, Morone, and Paulson 1996).

Focusing on the newer area of innovation front-end management, some authors have referred to the 'mysterious' portion of the innovation process (Koen, Ajamian, Burkart, Clamen, Davidson, D'Amore, Elkins, Herald, Incorvia, Johnson, Karol, Seibert, Slavejkov, and Wagner 2001), which resembles an uncertain search (Dahan and Hauser 2001). Even though this early phase of the innovation process has been addressed by man authors, the existing research still reflects the difficulty of recognizing and explaining activities that are similar to iterative learning cycles, as well as the lack of common terms and definitions for early innovation phases. Current research suggests some theoretical models that attempt to map front-end activities (Khurana and Rosenthal 1997; Kim and Wilemon 2002; Koen, Ajamian, Boyce, Clamen, Fisher, Fountoulakis, Johnson, Puri, and Seibert 2002), but practitioners have criticized these models as difficult to apply due to their abstract nature.

***Customer integration***

Empirical studies from the research field of customer integration show that the integration of customer know-how into the development of new products leads to a higher degree of product innovativeness, reduced innovation risks, and more precise resource spending (Kohli and Jaworski 1990; Bacon, Beckman, Mowery, and Wilson 1994; Atuahene-Gima 1995; Griffin and Hauser 1996; Brockhoff 2003). Most work in this field focuses on approaches in which customer integration stands for a better understanding of customers' product requirements. Authors tend to refer to their approaches as 'market orientation' (Kohli and Jaworski 1990; Atuahene-Gima 1996), the 'voice of the customer' (Griffin and Hauser 1993), the 'virtual customer' (Paustian 2001; Dahan and Hauser 2002), 'customer driven innovation' (Billington 1998), or 'consumers as co-developers' (Jeppesen and Molin 2003). With this understanding, the customers' contributions can be brought into R&D directly or through the marketing department to develop new products that fit customers' real needs and wishes (von Hippel 1978; Biemans 1991; Ciccantelli and Magidson 1993; Griffin and Hauser 1993; Griffin and Page 1996; Berry and Parasuraman 1997; Gruner and Homburg 2000; Thomke and Fujimoto 2000; Fritsch and Lukas 2001; Dahan and Hauser 2002; Nambisan 2002; von Hippel and Katz 2002; Jeppesen and Molin 2003).

The value of considering so-called lead users—users who recognize their product needs in advance of other customers and who significantly benefit from a new product solution—in the early stages of the innovation process has been demonstrated by von Hippel (1976; 1978; 1988) and various other researchers. Specifically, the value of a product

innovation increases when users bring their specialized need and preference know-how into the NPD process, which thereby leads to new products that provide true value for customers (Herstatt and von Hippel 1992; Lilien, Morrison, Searls, Sonnack, and von Hippel 2002; Morrison, Roberts, and Midgley 2004; Lüthje, Herstatt, and von Hippel 2005).

Ultimately, know-how flows from customers can result in the transmutation or evolution of the entire NPD challenge because they redefine the *problem* and reorient approaches for addressing it (Clark and Fujimoto 1990). Therefore, a customer-integrated approach can elevate understanding of a design challenge to a higher level, one that will result in a design solution that better serves the needs of the intended product users (Veryzer and Borja de Mozota 2005). Furthermore, customers will be more receptive to a new system if they contribute to its design (Coch and French 1948).

However, the blank spaces in the field of customer integration become obvious in the context of a specific, continuous embodiment of R&D collaboration with the customer. According to Bidault and Cummings (1994), the rewards of cooperative relations with customers may not always be realized in practice because of the fundamental tension that exists between the dynamics of innovation and the logic of partnering. This tension may arise as a result of the dangers of opportunism, the reduction of direct control over the NPD process, the additional financial and time costs associated with managing the customer relationships, the generation of inaccurate or unrepresentative know-how due to the limited domain of customer expertise, the internal denial of inputs from outside the company (known as the 'not-invented-here (NIH) syndrome'), the leakage of proprietary information, or the allocation of property rights (Katz and Allen 1982; Dolan and Matthews 1993; Littler, Leverick, and Bruce 1995; von Hippel and Katz 2002). Additional uncertainties associated with customer integration in NPD emerge through increased dependency, lack of partner commitment, partner selection, timing and intensity of customer involvement, uncertainty about the customer's ability to express his or her know-how, and damaged relationships (Biemans 1991, 1992; Dolan and Matthews 1993; von Hippel 1994; Leonard-Barton 1995; Li and Calantone 1998; Enkel, Kausch, and Gassmann 2005). As a consequence and to overcome these uncertainties, new methods for obtaining contributions from customers and building these contributions into commercially viable new products are needed desperately (Lilien et al. 2002).

In summary, the literature review unveils a research deficit in the synthesis of insights from customer integration and product innovation process literature, which comprise the

NPD and the innovation front-end phase. Although there is extensive literature available across the customer integration and product innovation process literature streams, no publications provide a synthesized product innovation approach that continuously builds on customer contributions throughout the product innovation process. In contrast, existing research concentrates on piecemeal approaches to including customer know-how in product innovation, leaving unexploited the potential for optimization that could be achieved by a continuous approach that builds on an intensive interaction between R&D and the customer. As a result, the questions of how customers can contribute to product innovation activities and how and where their contributions should be integrated into the product innovation process have not been addressed sufficiently. Therefore, it is justified to assert that this intended research targets a blank spot in management research.

### 1.1.3 Research objective

This research addresses both a major practical issue currently under discussion in product innovation management and a corresponding gap in R&D and innovation research. Against this background, the purpose of this study is to respond to the gap by extending theory on integrating customers into product innovation processes. Furthermore, the study aims to serve as a guideline for R&D managers. Therefore, it strives primarily to provide an answer to the following research question:

> *How can companies establish a continuous transfer of customer know-how into the product innovation process?*

Thus, the research focuses on companies that develop industrial products. Because an analogy to the subject exists as a method in software engineering, this study explores the product innovation process of XP to attain new insights on how successful customer integration in product innovation projects can be managed from a perspective external to the industry. Its highly flexible product innovation process and collaborative approach between developers and customers synthesizes the recommended practices from both customer integration and product innovation process literature. Therefore, XP promises to yield insights into how industrial companies can improve their integration practices in product innovation processes. This consideration of XP in turn raises the following subquestion:

- What elements of Extreme Programming make its customer integration and product innovation process effective?

By answering this question, the study aims to create a foundation for investigating the possibility of transferring these elements to industrial product innovation processes. Overall, the research should contribute to theory on customer integration by developing a conceptual model. This conceptual model in turn relies on insights from XP and brings forward, in particular, research on accessing, unsticking, and implementing customer know-how for product innovation. It aims to answer a second subquestion:

- How can customer contributions be effectively accessed, unstuck, and implemented throughout the phases of the product innovation process?

To provide guidelines for R&D managers regarding how to structure, organize, and manage customer integration into product innovation processes, the study also aims to develop a decision model that translates the theoretical insights from the conceptual model into management practices. This decision model is designed to address the following aspects:

- How should the early product innovation process be organized to integrate contributions from customers continuously?
- Which customers should contribute to product innovations in what phases of the product innovation process?
- What type of projects are suited for a flexible product innovation process, designed for the continuous integration of customer contributions?

## 1.2 Research concept

### 1.2.1 Research classification

This research is based on *inductive field research* that will lead to a contribution to existing theory by constructing representations of observable elements and their interrelations. Inductive field research sometimes is accompanied by some form of interpretive or anti-positivist paradigm that rejects the pursuit of scientific laws in favor of the *Verstehen* of socially constructed realities (Prasad and Prasad 2002). Theory building occurs through connecting and disconnecting data and existing theory, or as Mintzberg describes (2005),

> You have to get as close to the phenomena as possible in digging out the inputs (data, stories, and lots more), but then be able to step back to make something interesting out of them. (Mintzberg 2005: 365)

This inductive procedure attempts "to 'come to terms' with the meaning, not the frequency, of a phenomenon" by studying it in its social context (van Maanen 1983: 9). Compared with deductive methods, inductive research takes a more holistic approach to the research object by capturing dynamics occurring within the interrelations (D'Iribarne 1997). To do so, empirical data and existing theory both are employed throughout the whole research process to achieve the depth required for an understanding of these interrelations and dynamics.

As a result, this process leads to statements of research *propositions* that represent new theory on the subject of customer integration into product innovation processes. This result differs from the outcomes of testing preliminarily formulated hypotheses, which are then accepted or rejected on a broad scale to generalize findings (Eisenhardt 1989). In contrast, the study at hand tests the propositions with the present data of selected companies and rather tries to bring forward new insights and results and thereby extend existing theory on customer integration.

### 1.2.2 Research methodology

A qualitative case study design was selected as most suited to the objectives of this particular enquiry. This qualitative method of exploring XP to obtain insights that may be transferable to industrial product innovation offers a thorough understanding of the system (Stake 1988; Yin 1994). Current research provides little information regarding the continuous integration of customer contributions into product development activities, but the analogy to XP provides a new perspective. Therefore, several cases are studied in detail to gain an in-depth understanding of their natural setting, complexity, and context (Punch 1998).

#### *Sample selection*

The research was carried out between 2003 and 2005 and consisted of three phases. The first phase attempted to explore product innovation processes and customer integration practices on a broad scale. It led to case studies about some success factors and challenges in managerial practice among 17 product-developing companies that participated in expert workshops and contracted research projects. The companies were *Bayer Mate-*

*rialSciences*, *Buechi Labortechnik, Endress+Hauser*, *Hilti*, *IVF Hartmann*, *Leica Geosystems*, *Mammut Sports Group*, *Model*, *MTU Aero Engines*, *Nestlé*, *Philips Lighting*, *Qiagen*, *Schindler*, *Sefar*, *Siemens Building Technologies*, *SIG Combibloc*, and *Zumtobel*. These companies focus on generating a considerable portion of their turnover from products that have been on the market for no longer than three years and are experienced with integrating their customers into their product innovation practices. All companies are based in Germany, Liechtenstein, Switzerland, or the Netherlands but are spread across different industries, range from small enterprises to large multinationals, and represent all technology categories (high-tech, medium-high-tech, medium-low-tech, and low-tech, OECD 2005). The sample was constructed to maximize the heterogeneity of customer integration practices.

In the second phase, existing literature was analyzed to explore the XP method from software engineering. Because little is known about this method in innovation research (the scarce literature is limited to practical guidelines), interviews were conducted with experienced software engineers. These software engineers work in the software departments of the companies considered in the first phase (*Schindler*) or software institutions that specialize in the application of XP (*Object XP*, *Lifeware*, *Fachhochschule Zentralschweiz*).

In phase three, an in-depth analysis of companies with *advanced customer integration practices* was carried out to gain new insights. The criterion for selecting the firms for these in-depth case studies was their potential for learning, rather than representativeness: to build theory from case studies, case selection should use replication logic rather than sampling logic (Stake 1988; Eisenhardt 1989; Yin 1994). Although there is no ideal number of cases for such research, between four and ten cases usually works well (Eisenhardt 1989). For this research, a sample of four cases, in which the process of interest is transparently observable, was chosen (Eisenhardt 1989). The companies are *Buechi Labortechnik* (hereafter referred to simply as *Buechi*), *Hilti*, *IDEO*, and *Tribecraft*. The selection criteria for the case studies include the companies' pioneering efforts in customer integration: *Hilti* has long been known and studied as a company that successfully practices the lead user approach, and *Buechi* excels in its closeness to distributors and selected end-customers throughout its product innovation process. *IDEO* and *Tribecraft* both work in very tight collaboration with their customers and, as a result, have developed product innovations that stand out due to their superior design. Regarding the companies' technology intensity, they cover the spectrum from low- to high-

tech. As an additional selection criterion, to permit a comparison to XP, the company cases were chosen according to a *modular product structure*, such that most of the modules can be upgraded independently with minor release costs. This structure results in relatively low costs for introducing a product enhancement or adding new functionality.

*Hilti* and *Buechi* were selected from the sample of companies in phase 1. *IDEO* and *Tribecraft* also were chosen to fill theoretical categories (Eisenhardt 1989) in terms of different business models for industrial product development: both companies are development contractors, that is, professional technical service firms that develop product innovations with their clients on a project basis. This difference is significant because of its potential impact on the analysis of customer integration practices that relies on an identification of similar patterns between the XP method and industrial product development. An overview of the companies involved in the three research stages appears in table 1-1.

Table 1-1 Overview of empirical data set

| *Research Phase* | *Number of Interviews* | *Companies and Institutions* |
|---|---|---|
| **Phase one**<br>Exploration of product innovation processes and customer integration practices on a broad scale | 33 | Bayer, Buechi, Endress+Hauser, Hilti, IVF Hartmann, Leica, Mammut, Model, MTU, Nestlé, Philips, Qiagen, Schindler, Sefar, Siemens, SIG, Zumtobel |
| **Phase two**<br>Investigation of Extreme Programming within software industry | 5 | Schindler, Object XP, Lifeware, Fachhochschule Zentralschweiz |
| **Phase three**<br>In-depth case studies with product developers, selected according to greatest learning potentials regarding innovation processes and customer integration practices | 33 | Hilti, Buechi, IDEO, Tribecraft |
| **Total number of interviews** | **71** | |
| **Total number of companies and institutions** | | **22** |

***Data collection***

In all phases, data were collected through personal, face-to-face interviews of 30–90 minutes in length with Chief Technology Officers (CTOs), R&D directors, R&D managers, developers, engineers, and product managers. In 33 interviews, a total of 26 interview hours were recorded in phase one; 13 interview hours in 5 interviews were recorded in phase two; and in phase three, 62 interview hours were recorded in 33 interviews (see table 1-1). Participants were selected so that different levels of customer contact and product innovation responsibilities were represented. Most informants had personally participated in customer integration activities, and they were asked to focus on a specific project from the preceding 18 months. Some informants were interviewed more than once. An interview guideline was used to maintain the coherence of the data collection throughout the research phases, and when possible, this guideline was sent to the interviewees in advance. The analyzed aspects were the product innovation process, customer integration activities, and the specific customer contributions incorporated into the development of a new product during different innovation phases. Interview data were augmented by desk research, namely, analyses of company publications (internal journals, annual reports, Internet Web pages), internal memos, and presentations. Site visits and workshops enabled complementary personal observations as well. In phase three, follow-up sessions with the interview partners confirmed the case study interpretations from the interview data. This triangulation through combining multiple sources of evidence helped confirm the validity and reliability of the research data (Yin 1994; Voss, Tsikriktsis, and Frohlich 2002).

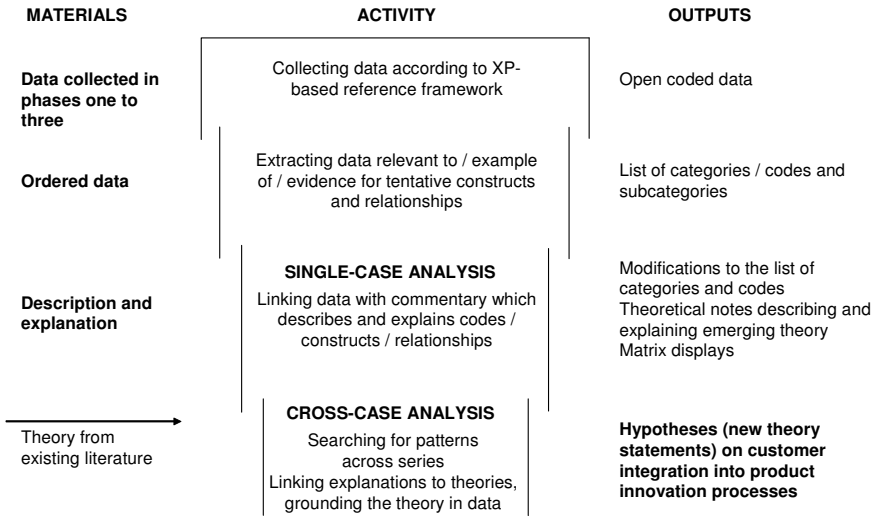
***Data analysis and theory building***

In a qualitative research project, the analytical process is an iterative one, involving constant alternations between data collection and analysis. In this study, data analysis was guided by Eisenhardt's (1989) approach to building theory from case study research. First, a reference framework was constructed that underlies the exploration of the phenomenon under investigation (Eisenhardt 1989; Miles and Huberman 1994). This framework selects and explains the main aspects to be studied within the case studies (Voss et al. 2002). The framework was developed from literature and using insights from the XP method from software engineering, which served as a 'filter' for the abundant theoretical insights from literature on customer integration and the product innovation processes of industrial products. In addition, XP helped structure and select those theoretical aspects from the literature that were relevant from the perspective of XP. The

resulting *XP-based reference framework* enabled a focus on the subsequent case data collection, such that the determining elements of customer integration in product innovation processes could be acquired and analyzed.

Second, the in-depth case studies conducted with the XP-based reference framework revealed how customer integration takes place among four industrial product developing companies. Figure 1-2 shows the process of how the case data were coded and analyzed for building theory: in a first step, data were fragmented by open coding, an analytic process by which tentative constructs can be identified and developed in terms of their properties and dimensions. Therefore, observations, sentences, ideas, and events were given names and then regrouped into subcategories, which in turn could be grouped as categories. In the second step, data were combined in new ways with the objective of regrouping and linking categories with one another in a rational manner. In the final step, core categories were selected and related to other categories. This data coding led to the identifications of some tentative constructs for a conceptual model, as well as linkages among the constructs and why such relationships exist (Voss et al. 2002). The subsequent *single-case analysis* provided descriptions and explanations of the constructs and relationships by refining them for each case. Using matrix displays, information was presented systematically, which allowed the unique patterns of each case to emerge before generalization was sought across cases (Eisenhardt 1989). Finally, the *cross-case analysis* led to research propositions that extended theory on customer integration into product innovation. The propositions, which represent new theory statements, were built through the embodiment of the constructs and relationships in existing literature and a grounding of the emerging theory in the new data.

Figure 1-2 Process of data coding and analysis for theory building




Source: adapted from Zalan and Lewis (2004: 517).

Third, the theoretical propositions were translated into a new approach toward customer integration for management practice. This approach was developed from the understanding gained during the exploration of product innovation processes and customer integration practices in the first data collection phase, as well as from the insights of the in-depth case studies (see table 1-1).

Summarizing the outcomes of the *overall process* of data analysis, theory building, and translation to management practice, three concepts have been developed:

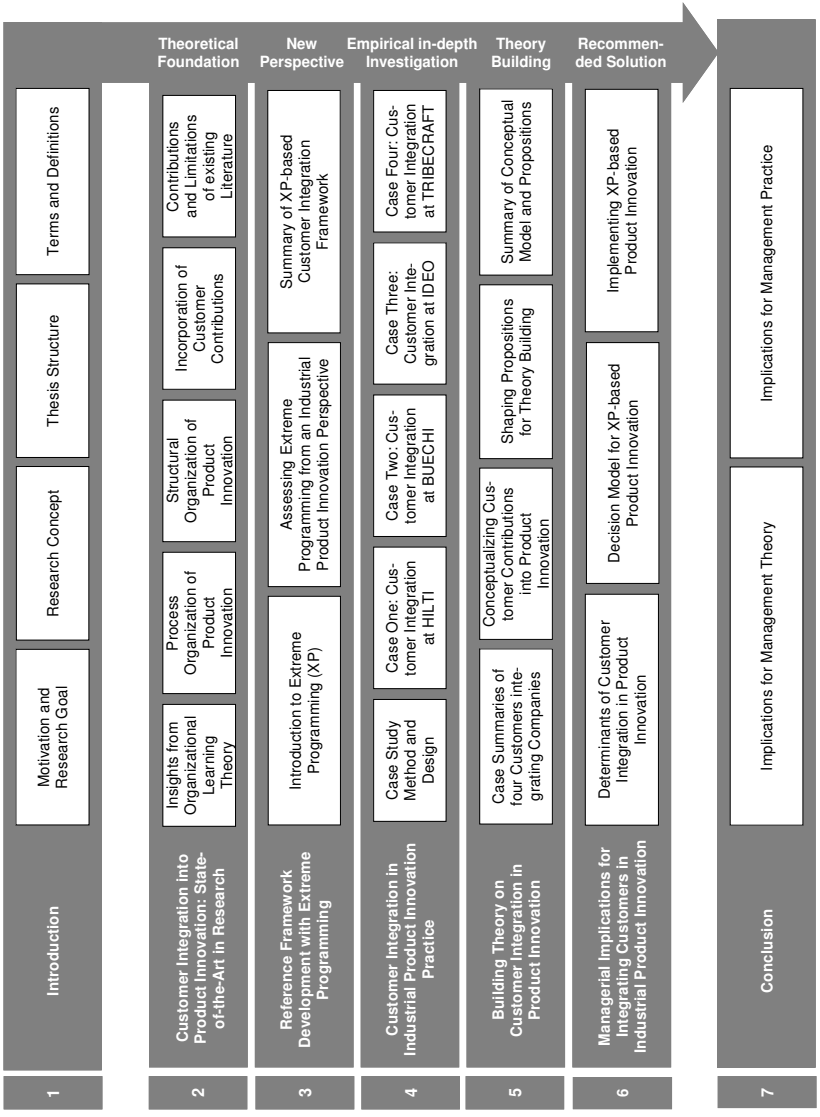
- The *XP-based reference framework* was built on the basis of insights from existing literature and XP and used for the collection of data in the in-depth case studies.
- The *conceptual model* was built on the basis of data from the in-depth case studies and existing literature. It highlights research propositions and contributes to existing theory on customer integration into product innovation processes.
- The *decision model* was derived from the conceptual model and proposes a new solution for customer integration into product innovation processes from a managerial point of view.

## 1.3 Thesis structure

The thesis is structured as follows (see also figure 1-3):

- Chapter 2 presents the theoretical foundation of this research. It first explicates customer integration into product innovation from the perspective of organizational learning theory, then presents an overview of the state-of-the art in research pertaining to product innovation processes, organizing customer integration, and the incorporation of customer contributions into product innovation.
- Chapter 3 introduces Extreme Programming (XP) as a new perspective to customer integration into product innovation processes. By assessing XP from the perspective of the literature discussed in chapter 2, an XP-based customer integration framework is developed.
- Building on the XP-based reference framework, chapter 4 provides an empirical, in-depth investigation in the form of four case studies of industrial product-developing companies.
- Chapter 5 presents the results of the cross-case analysis. First, it summarizes the four case studies from the perspective of the results of the analysis process. Second, it conceptualizes customer contributions by referring back to the existing literature presented in chapter 2. Third, it presents new research propositions that extend existing theory on customer integration into product innovation processes, which result from the integration of existing theory and new case data. Fourth, the conceptual model and propositions are summarized.
- Using the theoretical propositions in chapter 5, chapter 6 derives some determinants of customer integration, as well as an XP-based decision model that serves as a recommended practical solution for managing customer integration into product innovation processes. It also gives an overview of implementing this new solution in organizational practice.
- Finally, chapter 7 summarizes the research results and concludes with implications for management theory and practice.

Figure 1-3 Thesis structure



## 1.4 Terms and definitions

### 1.4.1 Product innovation processes, new product development, and innovation front-end

*Innovation* is the use of a new or old technology to meet an old or new need for improving the performance of a process, product, or service that is sufficiently valuable by potential customers that they will adopt it. Innovation begins with this connection between a need and the technology to address that need—these combine to form an idea, which in turn is screened, tested developed, scaled up, and then used and diffused (Paap and Katz 2004).

Broadly speaking, *product innovations* are new products and can be differentiated from both process innovations and social innovations (Thom 1992), and from services (Meyer and DeTore 1999). A product innovation can be specified by a new product's degree of novelty and the perspective from which the degree of novelty is determined (Verworn 2005), which is provided by either the developer or the customer of the product innovation. Referring to the degree of novelty, product innovations are distinguished from other new product categories, such as product variations (products differ in secondary attributes) or product upgrades (improved versions of an existing product), for which the overall degree of novelty is lower (Vahs and Burmester 1999). The boarders between the categories are not well-defined and the transition between the categories therefore is continuous.

Product innovations are realized through *product innovation projects*, which attempt to reduce uncertainty, especially in terms of technology and the market by applying new problem-solving methods to deliver improved solutions. According to Wolpert (2002), the term product innovation project applies to pursuing fundamentally new business opportunities, exploiting new technologies and applications, and introducing changes into the concept of the business through the introduction of a new product. This definition differentiates innovations from *inventions*. Whereas invention describes the key moment of insight and the concept it evokes, innovation refers to the process of transforming an invention into something that is commercially useful and valuable to a customer. Invention occurs apparently and unpredictably at random; innovation is manageable—and must be managed—as a business process (Miller and Langdon 1999).

Therefore, product innovation projects proceed according to a defined process, referred to as the *product innovation process*. This process is the development course defined by

the company's organization and has attracted the interest of various researchers. However, prior use of the term product innovation process is not consistent and has been confounded with the process of *new product development* (NPD). Whereas NPD has evolved as a literature stream within the R&D management and marketing discipline, the borders of literature on product innovations and innovation management are difficult to capture, because they extend into disciplines such as organizational behavior and strategic management (von Stamm 2005).

In addition to NPD, the newer research stream of *innovation front-end* management also must be considered to complete the range of product innovation processes. Research in the field of the innovation front-end focuses on the phases that precede actual NPD activities, which take place before and during the realization of a product concept or an early prototype and before extensive resources are allocated (Murphy and Kumar 1997; Khurana and Rosenthal 1998; Kim and Wilemon 2002; Kim and Wilemon 2002; Gassmann and von Zedtwitz 2003; Herstatt and Verworn 2003). A consistent differentiation in the literature does not exist, because front-end activities have been addressed only partially in NPD research before, without explicit references to them as the front-end (Eisenhardt and Tabrizi 1995; Lynn et al. 1996).

To distinguish the fundamental terms of the product innovation process, NPD, and the innovation front-end as they are used in this research, the following definitions are presented:

The **product innovation process** is the overall process of developing a product innovation. It consists of an earlier innovation front-end phase and a sequencing new product development phase. The transition between the innovation front-end phase and the NPD phase in practice is mostly blended.

**New product development (NPD)** is defined as the phase in the product innovation process during which actual product development activities take place. These activities are usually based on a product concept, as provided by the innovation front-end phase.

The **innovation front-end** is the phase in the product innovation process preceding actual NPD activities. It consists of opportunity identification, idea generation and selection, and product concept generation.

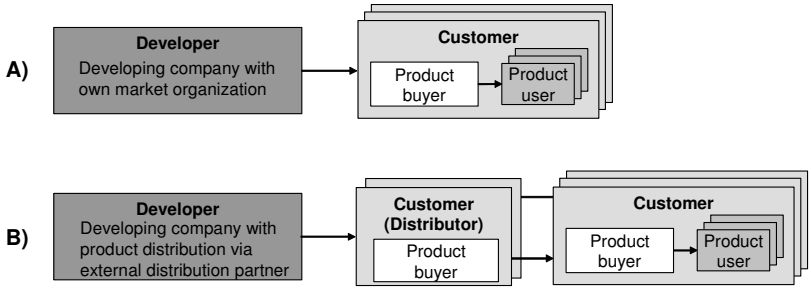
### 1.4.2 Customers, product users, and product buyers

Definitions of the term *customer* vary throughout the existing literature. The customer can refer to an individual level (Shaw 1985; Herstatt 1991; von Hippel, Thomke, and Sonnack 2000) or an organizational level (Gemuenden 1981; Kirchmann 1994; Karle-Komes 1997). Furthermore, the term can include both current (established) and future (potential) customers, which can be differentiated according to their characteristics and the nature of their contributions to product development activities (Nambisan 2002).

The term *user* usually refers to an individual level, specifically, to the person applying, consuming, utilizing, or working with a product. In particular, the *lead user* has attracted significant research interest and been defined by von Hippel (1976; 1986; 1988) according to two characteristics: first, the lead user expects attractive, innovation-related benefits from a solution to his or her needs and therefore is motivated to innovate, and second, he or she experiences needs for a given innovation before the majority of the target market does.

In *business-to-business* (B2B) constellations, a developing company (the *developer*) sells a new product to a buying company (the *customer*). In this situation, the product user usually is a different person than the person who 'buys' the product on the basis of the investment decision by the customer organization. Whereas the person buying the product usually is a member of a buying center or a project or R&D manager, the product user is a developer, researcher, laboratory assistant, or engineer who uses the product in his or her work environment. This differentiation between the product user and the person buying the product does not appear in the relevant literature so far; authors usually do not differentiate among specific persons within the customer organization (cf. Vredenburg, Isensee, and Righi 2002). However, this differentiation is fundamental for this research, which requires the introduction of a new term for the latter: the person deciding if the customer company will invest in a product from the developing company is referred to as the *product buyer* (see figure 1-4). Depending on whether the developing company has its own market organization, one customer with one product buyer may be involved (see figure 1-4 A), or more than one customer and product buyers may need to be considered before the product reaches the product user (see figure 1-4 B).

Figure 1-4 Overview of developer, customer, product user, and product buyer




To distinguish the 'customer,' 'product user,' and 'product buyer' within this research, the following definitions are needed:

The **customer** is an organization buying products from the developer. The customer can be a distributor (also referred to as distribution partner) or another product-developing company that uses the product for its operations.

The **product user** is the person using and working with the new product in the customer organization.

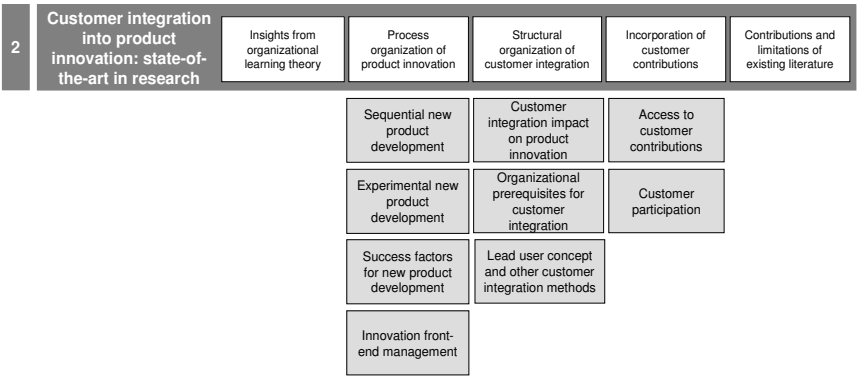
The **product buyer** is the person within a customer organization (distributor or developing company) who decides if the new product will be acquired from the developer. The product buyer can be a team member of the buying center or a project or R&D manager within the customer organization.

# 2 Customer integration into product innovation: state-of-the-art in research

Customer integration into product innovation requires the aggregation of the research fields pertaining to customer integration and product innovation processes. Whereas product innovation process research emphasizes how companies manage the course of developing a new product, customer integration literature is dominated by the question of how to organize structurally the integration of customers into various product development activities.

The following sections present the state-of the art of the relevant literature (see also figure 2-1), including insights into customer integration in product innovation processes from the perspective of the organizational learning theory (2.1). In addition, this chapter provides an overview of research pertaining to the organization of product innovation processes, including literature on new product development (NPD) and innovation front-end management (2.2). Furthermore, the literature on the structural organization of customer integration into product development activities is presented (2.3), as is literature at the interface of product innovation processes and the structural organization of customer integration, namely, the incorporation of customer contributions into product innovations (2.4). Finally, chapter 2 concludes by summarizing the contributions and limitations of existing literature that is relevant to this study (2.5).

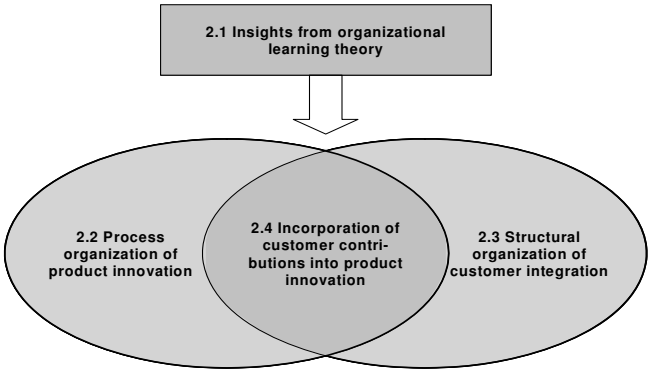
Figure 2-1 Outline of chapter 2



Theorists have been studying innovation since the late 1930 (e.g. Schumpeter 1937; Schumpeter 1939), with a focus on innovation as a source of competitive advantage and sustainability, which has led to more and more research in this topic area. Most commonly, these explanations refer to the linkages between actions and organizational structure as determinants of the innovation process (van de Ven and Ferry 1979; Clark and Staunton 1989; Schroeder, Gopinath, and Congden 1989; Edwards 1999).

For this study, *organizational learning theory* serves as the central perspective because of its valuable contribution to the dynamic aspects of customer integration and product innovation processes (Imai, Ikujiro, and Takeuchi 1985; Kanter 1988; Dodgson 1991; Kok, Hillebrand, and Biemans 2003): whereas traditional economics perspectives, such as the transaction cost theory (Coase 1937; Williamson 1981), consider innovation primarily as a result of a rational planning process, theories from the resource-based view tradition instead suggest that firms design their processes to gain access to additional resources from the company's environment (Das and Teng 2000). Thus, resource rejuvenation for continuous development and adaptation is vital for firms in their quest for innovation. In this context, *learning* characterizes an adaptive organization that is able to sense changes in its market environment and adapt accordingly (Cyert and March 1963). Organizational learning theory also helps explain how companies learn from their market; they incorporate customer contributions into their product innovation activities to bring their development capabilities to new levels. An overview, showing the interplay of the theory selected and the relevant literature streams discussed in this chapter, is presented by figure 2-2.

Figure 2-2 Overview of the interplay of the relevant literature streams



## 2.1 Insights on customer integration from organizational learning theory

Organizational learning theory is multidisciplinary (Dodgson 1993). In the literature, researchers note the relevance of fields as varied as psychology, organizational theory, innovation management, strategic management, economics, organizational behavior, sociology, political science, information systems, anthropology, and production / industrial management (Argyris and Schön 1978; Shrivastava 1983; Perrow 1986; Dodgson 1993; Leibenstein and Maital 1994). For this research, organizational learning theory is considered from the perspective of its contribution to the understanding of how companies profit from market know-how by integrating customer contributions into their product innovation processes.

*Organizational learning* is defined as the process of improving actions through better knowledge and understanding (Fiol and Lyles 1985). Individuals are able to learn, and organizations are composed of such individuals (Kok et al. 2003). The organizational learning process thus can be described as sequential information processing activities. The theory in turn builds on the assumption that any process of knowledge socialization and collective learning is based on relationships that consist of meaning building and sharing. Such relationships cannot be enacted in the absence of a context of co-participation, which indicates the importance of creating a 'cognitive minimum common denominator' for all the individuals and groups participating in knowledge creation. This context promotes the development of shared values, reciprocity, and mutual trust (Taylor 1987; Sawhney and Prandelli 2000).

Focusing on *customer integration*, an organization learns about its market through a series of sequential information processing activities undertaken with its customers (Kok et al. 2003). Learning about markets for new products can be understood as an organizational learning process that involves the *acquisition, dissemination, and utilization* of information (Fiol and Lyles 1985; Imai et al. 1985; Huber 1991; March 1991; Moorman and Miner 1997).

First, *acquiring market information* consists of the collection of information about the needs and behavior of customers. Some of this information can be obtained from data banks and the results of past actions, whereas some needs to be collected anew through quantitative (e.g., market surveys) or qualitative (e.g., customer visits) methods (Adams, Day, and Dougherty 1998). However, market know-how related to new products is inherently ambiguous, because customers may not be able to articulate their needs clearly

(von Hippel 1986), and their needs may change as they learn to use the product (Veryzer and Borja de Mozota 2005).

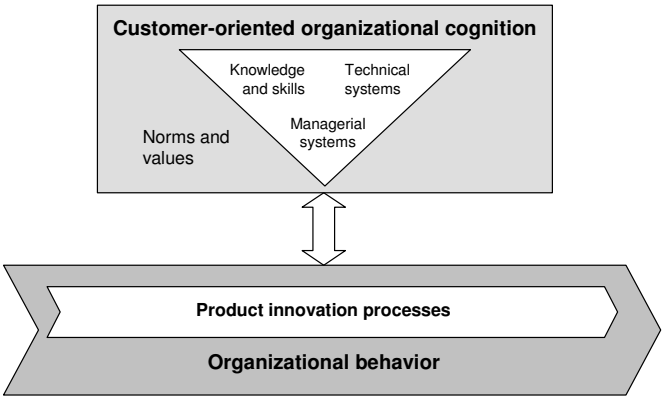
For information to be useful, it must be shared quickly and efficiently among the relevant users (Kohli and Jaworski 1990). Therefore, second, market information has to be *disseminated* across functions, phases of the innovation process, geographic boundaries, and organization levels (Adams et al. 1998). Distribution is not enough. Before information can be used, people must classify, sort, and simplify it into coherent patterns—that is, make sense of it. Shared mental models influence the lessons and insights people extract about their appropriate actions (Porac and Thomas 1990) and can help them process ambiguous, multidimensional, and fine-grained market data (Adams et al. 1998).

Third, *using market information* occurs in the process of learning about the market for decision making, the implementation of decisions, or evaluations of a new product (Menon and Varadarajan 1992). Organizations develop routines for using certain information in certain ways as they work with customers and technology regimes (Adams et al. 1998).

Learning about markets therefore is the result of a series of *organizational* activities that can be embedded in the *product innovation process* (Adams et al. 1998). Although on the surface these activities may seem to be the same as those used by individuals, organizational learning is both more complex and more encompassing than the sum of individual learning (McKee 1992). For product innovations, a firm must make various decisions to create a new product. Each decision triggers an information inquiry that leads to information acquisition, dissemination, and utilization activities, which follow the procedures and decision rules of existing knowledge systems and shared mental models. Through organizational learning activities, a firm gathers and combines market and technical know-how into knowledge about product specifications, product concepts, and prototypes. The evaluation of these activities contributes to the knowledge and skills required to improve these activities and also may result in a search for missing know-how to improve the activities.

According to Kok and colleges (2003), organizational learning theory integrates *cognitive and behavioral perspectives* and therefore offers a holistic approach to customer integration in product innovation (see figure 2-3).

Figure 2-3 Cognitive and behavioral perspectives on product innovations




Source: adapted from Kok and Hillebrand (2003).

The firm's cognitive elements comprise customer-oriented values and norms, knowledge and skills (i.e., the ability to translate knowledge into action), technical systems (formalizations of knowledge and skills), and managerial systems (formal and informal ways to control and create knowledge and skills that enable market learning). The behavioral elements of a product development capability consist of information processing activities during each stage of the product development process.

The three stages of learning about markets—acquisition, dissemination, and utilization of information—constitute an integral part of the behavioral definition of a market orientation. Kohli and Jaworski (1990) define it as the organization-wide generation of market intelligence, dissemination of that intelligence across departments, and organization-wide responsiveness to the intelligence.

Further work on learning and innovation in a strategic context has argued that *collaboration* can facilitate learning in terms of both contribution sharing and the transfer of existing knowledge, as well as the creation of new knowledge that neither collaborator previously possessed (Anand and Khanna 2000; Dyer and Nobeoka 2000; Kale, Singh, and Perlmutter 2000; Kale, Dyer, and Singh 2002). Collaboration among organizations and individuals thus enables firms to acquire resources and skills that they cannot produce internally and jointly develop new products and processes that they need to survive in a highly competitive environment, the costs of which are often beyond the financial and human resources of any single company (Lei, Slocum, and Pitts 1997). Such col-

laboration might include the direct transfer of assets; sharing of key equipment, intellectual property, or personnel; and/or the transfer of organizational knowledge (Dyer and Singh 1998).

## 2.2 Literature on the process organization of product innovation

The product innovation process has been depicted and discussed by many researchers. The following section first provides an overview of the field of sequential NPD models, which have long dominated product innovation management (2.2.1). It then presents experimental product innovation processes, as they evolved subsequently (2.2.2). Next, this section shows an overview of the success factors for new product development (2.2.3), and finally illustrates the research in the area of innovation front-end management, including the challenges surrounding organizing the early phases of the product innovation process (2.2.4).

### 2.2.1 Sequential new product development

Research on NPD has been driven by the question of how companies can structure their product development activities most efficiently. The rudiments of such a NPD structure stem from NASA's work in the 1960s: by breaking the product development process into single steps, the so-called *Phased Review Process* represented an elaborated, detailed scheme for working with contractors and suppliers on various space projects (Cooper 1994). The following section describes how research on NPD evolved from a rational plan approach to a communication web approach and finally to a disciplined problem-solving approach. Furthermore, an overview of NPD success factors is presented.

***Rational plan approach***

The rational plan approach to NPD was built on the assumption that a product that is well planned, implemented, and appropriately supported will be a success. It was initiated by Myers and Marquis (1969) and focused on a broad range of determinants of a product's financial performance. Promoted by several authors who concentrated on the companies' NPD organization, subsequent research brought forward a *compression* strategy (Rothwell 1972, 1974; Rubenstein, Chakrabarti, O'Keefe, Souder, and Young 1976; Maidique and Zirger 1985; Zirger and Maidique 1990) with its underlying assumption that product development is a predictable or certain process that can be planned as a series of discrete steps that then can be compressed to reduce development

time. Cooper (1979; 1990; 1994; 2001), the most established author in this field, also developed the Stage-Gate™ process, which has been credited with speeding products to markets in a variety of industries: every step, or 'stage,' necessary to complete a project task was linked to the next by a 'gate' at which the decisions regarding the continuation of the project were made.

As a result, internal NPD process organization was conceptualized as carefully planned activities, executed by competent and well-coordinated cross-functional teams that relied on the synergies of the firm and significant support from top management. Criticism of stage models arose from their sequential design, which excluded any consideration that know-how relevant to a NPD project might emerge only during later development stages (Herstatt and Verworn 2003; Verworn 2005).

***Communication web approach***

This second research stream evolved from Allen's (1971; 1977) pioneering work at the Massachusetts Institute of Technology (MIT). The underlying premise was that communication among project team members and with outsiders could stimulate performance by development teams. Thus, the more members are connected to one another and key outsiders, the more successful the development process would be (Brown and Eisenhardt 1995). Investigations highlighted how communication affects teams' performance over time (Katz and Allen 1982), specifically, the effect of *gatekeepers*, those high-performing individuals who communicate more often and with more people outside their specialty. Gatekeepers not only gather and translate external know-how to the organization but also facilitate external communication by their fellow team members (Allen 1971; Katz and Tushman 1981; Brown and Eisenhardt 1995).

Following Brown and Eisenhardt (1995), this literature stream emphasized that frequent and appropriately structured task communication (both internal and external) would lead to more comprehensive and varied knowledge flows to team members and, thus, to better development processes. The principal shortcoming of this perspective was its focus on communication by project team members, such that other factors, including the organization of the work, product attributes, and market attractiveness, were neglected (Brown and Eisenhardt 1995).

***Disciplined problem-solving approach***

The third literature stream evolved from studies of Japanese product development practices in the mid-1980s (Imai et al. 1985; Quinn 1985), which regarded product develop-

ment as a balancing act between relatively autonomous problem solving by the project team and the discipline imposed by a dominant, heavyweight leader, strong top management, and an overarching product vision. The results were a fast, productive development process and a high-quality product concept (Brown and Eisenhardt 1995).

Hayes and colleagues (1988) added an emphasis on *predevelopment activities* and argued that bringing conflicts to the surface early in the development process was an important factor in successful development projects. Thomke and Fujimoto (2000) introduced the concept of *front-loading*, which they defined as a strategy that seeks to improve development performance by shifting the identification and solution of development problems to earlier phases of a product development process. Also emphasizing predevelopment activities, the *loose–tight concept* (Wilson 1966; Albers and Eggers 1991) suggested that the success of a project was determined by the degree of organization experienced during the development process. In the early stage of a project, the organization should be designed loosely; near the conclusion of the project, it should become more rigid and tight. The varying degrees of R&D project organization were imposed by time constraints: although creativity and idea generation were highly important in the early stage, management concerns shifted to efficiency and on-time implementation in the later stages.

In summary, this research stream envisioned successful product development as disciplined problem solving: successful product development involved relatively autonomous problem solving by cross-functional teams with high levels of communication and an organization that depended on the demands of the development task. Shortcomings of this research stream relate to its lack of political and psychological realism, as well as its extensive reliance on a Japanese viewpoint (Brown and Eisenhardt 1995).

### 2.2.2 Experimental new product development

Research on NPD always has been driven by the question of how to reduce time to market. Although rational plan models promised to improve innovation speed, different thinking emerged in NPD literature in the mid-1990s. These new approaches emphasized that rather than a sequential process, NPD may be more successful if guided by an ‘evolutionary’ process of experimentation, which enables it to handle a rapidly changing market environment. These approaches, which are based on experiential models and prototyping, are presented in the following sections.

***Experiential models***

Still searching for a means to speed up product development activities, researchers found that in uncertain product development environments, people engaged in more experiential, flexible, and even improvisational activities (Scott 1987). As a result, quick adaptation had to be recognized as a central, competitive capability that could contribute to development speed (Eisenhardt and Tabrizi 1995). The emerging *experiential strategies*, however, demonstrated that moving faster simply by accelerating an existing, albeit streamlined, process was not always realistic. Comparing compression and experiential strategies, Eisenhardt and Tabrizi (1995) found that if NPD were a predictable path through well-known markets and technologies, a compression strategy would be relevant. However, if the path was more uncertain, an experiential strategy should be followed. In the case of the experiential strategy, more design iterations, longer product testing, reduced time between project milestones, and project leader power are all associated with faster development times (see table 2-1).

Table 2-1 Compression versus experiential models

| *Characteristic* | *Compression Strategy* | *Experiential Strategy* |
|---|---|---|
| Key assumption | Certainty | Uncertainty |
| Image of product innovation | Predictable series of well-defined steps | Uncertain path through foggy and shifting markets and technologies |
| Strategy for speed | Rationalize, then squeeze the process | Quickly build understanding and options while maintaining focus and motivation |
| Tactics for speed | ▪ Planning<br>▪ Supplier involvement<br>▪ Overlapping of project steps<br>▪ Reward for meeting schedule | ▪ Multiple iterations<br>▪ Extensive testing<br>▪ Frequent milestones<br>▪ Powerful leader |

Source: adapted from Eisenhardt and Tabrizi (1995).

These results suggested a more real-time, hands-on approach to fast product development for uncertain product environments. Eisenhardt and Tabrizi (1995) found, especially in the case of high-velocity industries, that extensive planning simply wasted time. They stated:

> In this setting, product development is well characterized as a process of navigating through unclear and shifting markets and technologies using experiential and improvisational tactics. Fast product development emerges as more uncertain than

> predictable, more experiential than planned, and more iterative than linear. (Eisenhardt and Tabrizi 1995: 104)

Thomke and collegues (Thomke, von Hippel, and Franke 1998; Thomke 1998; Thomke 2001, 2001) found that experimentation for development problem solving had a fundamental impact on the total innovation time and cost. Problem-solving studies showed iterative *'trial-and-error' activities* (more precisely, trial, failure, learning, correction, and retrial) represented a significant feature of product development (Simon 1969; Wheelwright and Clark 1992). The effect of trial-and-error already had been pointed out by Alchian (1950), who compared the process of seeking the best solution during NPD to the exploration of a 'value landscape's topography': a value landscapes can be visualized as a flat plain with one or more hills rising from it. The total landscape represents the area that the experimenter plans to search to identify an acceptable solution to its problem. The probability of finding a solution increases by ascending the 'hills' in the landscape, so the experimenter's goal is to devise a series of experiments that will enable him or her to identify and explore those hills in an efficient manner. According to Alchian (1950), real-world experimenters may not have much information regarding the value landscape they plan to explore when they begin their work and may even abandon one landscape for another as their work changes.

Building on trial-and-error activities, the *probe-and-learn processes* approach was described from several angles, including marketing and discontinuous innovations (Lynn et al. 1996), product development and experimentation (Wheelwright and Clark 1992; Thomke 1995, 2001), and technology strategy (Iansiti 1998). The probe-and-learn process model offered by Lynn and colleges demonstrated how successful companies developed their products by probing potential markets with early versions of the products, learning from those probes, and then probing again (Lynn et al. 1996). They found that:

> The initial product was not the culmination of the development process but rather the first step, and the first step in the development process was in and of itself less important than the learning and the subsequent, better-informed steps that followed. (Lynn et al. 1996: 15)

The challenge in managing a probe-and-learn process lies in preventing unproductive chaos due to unplanned trial-and-error development (Gassmann and von Zedtwitz 2003)

***Prototyping***

Beginning with Simon (1969), various innovation researchers began to study the role prototyping plays during the NPD process (Simon 1969; Allen 1977; Wheelwright and Clark 1992; Iansiti 1998; Thomke 1998). The notion of prototyping has been theoretically established for software engineering, but it also became a fundamental practice in industrial NPD (Berblinger 1988; Hallbauer 1997). Recent work in NPD has addressed economic trade-offs of prototyping, including when to build prototypes (Thomke 1998), how many to build (Dahan and Mendelson 2001), how much development time to devote to it (Terwiesch and Loch 1999), and what search strategies to pursue (Loch, Terwiesch, and Thomke 2001).

The effort of conducting a prototyping cycle typically involves the cost and time associated with using equipment, material, faciltities, and engineering resources (Thomke 1998). The benefit of experimentation with prototypes lies in its ability to identify and eliminate errors early in the process. Furthermore, it represents the emerging product in reasonably neutral language, and prototypes serve as visible, accessible symbols of the finished product, which can help unify the development team. Prototypes also give a holistic perspective to the project that can help build consensus (Leonard-Barton, Wilson, and Doyle 1993; Veryzer and Borja de Mozota 2005), as well as excite and energize the product team. When prototypes are available, team members' discussions tend to become more focused and concrete, and decisions are made more quickly (Tabrizi and Walleigh 1997).

The literature has shown that valuable prototypes can be physical in nature or represented in other forms (Simon 1969; Thomke et al. 1998). They also might not be part of the development itself but merely representations that can be discarded after they fulfill their function (MacCormack 2001). The following list provides an overview of the modes of prototyping:

- *Computer simulation* substitutes for 'real experimentation' in fields ranging from the design of drugs (e.g., rational drug design), mechanical products (e.g., finite element method), and electronic products (e.g., simulations of digital circuitry) to analyses of global warming (e.g., climate modeling) (Thomke 1998). The useful substitution of a simulation for a 'real' experiment requires a simulation model that is accurate from the point of view of the given experimentation purpose.

- *Rapid prototyping* is used by developers to generate quickly an inexpensive, easy-to-modify (and often physical) prototypes that can be tested against the actual use environment and allow 'real' experimentation (Thomke 1998). It involves creating a working model of various parts of the system at a very early stage after a relatively short investigation. The method used to build it is usually quite informal, and the most important factor is the speed with which the model is provided. The model then becomes the starting point from which customers can reexamine their expectations and clarify their requirements (Crinnion 1991). Such rapid prototyping techniques have resulted in significant improvements in development times and costs.
- *Evolutionary prototyping* takes place after a more careful investigation, and the methods used to build the prototype are more structured because an evolutionary prototype forms the heart of the new system, and any improvements or further requirements will be built into it. Therefore, it is not 'thrown away,' as is the rapid version (Crinnion 1991).

### 2.2.3 Success factors for new product development

Across these streams of NPD literature, extensive work has been carried out to identify the success factors for product innovation management. In his comprehensive study, Ernst (2002) presented an overview of the NPD success factors from research streams in the product innovation literature. He grouped these success factors into five categories: (1) process structure, (2) organization, (3) culture, (4) senior management involvement, and (5) strategy. Table 2-2 presents an overview of Ernst's literature categories, complemented by findings from this study.

Table 2-2 Success factors for new product development

| | *Success Factor* | *Managerial Aspects* | *Authors* |
|---|---|---|---|
| Process structure | Firm's understanding of its customers' needs | ▪ Orientation of the NPD process to the needs of the market<br>▪ Importance of identifying and understanding the user's needs<br>▪ External integrity<br>▪ Update of market information during the course of the entire NPD process | (Myers and Marquis 1969; Rothwell 1974; Clark and Fujimoto 1990; Zirger and Maidique 1990; Atuahene-Gima 1995; Veryzer and Borja de Mozota 2005) |
| | Assessment during all phases of the NPD process | ▪ Timely and consequent termination of unprofitable NPD projects<br>▪ Decisive initial project selection before entering the development | (Rothwell 1974; Parry and Song 1994; Cooper and Kleinschmidt 1995) |
| | Quality of planning before entry into the development phase | ▪ Includes first broad evaluation of ideas, execution of technical and market-directed feasibility studies, and commercial evaluation of the NPD project<br>▪ Provides a description of the product concept, target market, relative utility gained by the customer in using the new product opposed to a competing product | (Rothwell 1974; Maidique and Zirger 1985; Parry and Song 1994; Sicotte, Préfontaine, Ricard, and Bourgault 2004) |
| Organization | Interfaces between functional departments | ▪ Defined interfaces between functional groups, providing the mechanisms for transferring know-how (e.g., customer needs and wants, product pricing points, market timing and positioning)<br>▪ Cross-functionality of the NPD process | (Clark and Fujimoto 1990; Zirger and Maidique 1990; Veryzer and Borja de Mozota 2005) |
| | Cross-functional teams | ▪ Project team should comprise members from several areas of expertise who can make substantial contributions to the development of a new product<br>▪ Team includes, in particular, members from R&D, marketing, and production | (Maidique and Zirger 1985; Eisenhardt and Tabrizi 1995; Griffin 1997; Brockhoff 1998; Song, Thieme, and Jinhong 1998) |
| | Powerful project team leaders | ▪ Must demonstrate the necessary qualifications and command sufficient authority<br>▪ Must be able to pay sufficient attention to the project<br>▪ Authority is reflected especially in the success with which the team leader commands individuals from various areas of expertise and the manner in which the responsibility for decision making is delegated to the project | (Quinn 1985; Gold 1987; Gupta and Wilemon 1990; Clark and Fujimoto 1991; Cooper and Kleinschmidt 1995; Sicotte et al. 2004) |
| Culture | Organizational communi-cation | ▪ Ensuring strong internal communication<br>▪ Ensuring strong external communication<br>▪ Support of a gatekeeper: a high-performing individual who communicates more often overall and with people outside his or her specialty | (Allen 1971; Clark and Fujimoto 1990; Thamhain 1990; Griffin and Hauser 1993; Griffin and Page 1996; Sicotte et al. 2004) |

| | | | |
|---|---|---|---|
| | Promoters and product champions | ▪ Establishment of promoter models<br>▪ Appointment of a product champion | (Rothwell 1974; Hauschildt and Kirchmann 2001) |
| Senior mgmt. involv. | Key sponsors | ▪ Ensuring strong top management support | (Zirger and Maidique 1990) |
| Strategy | Building upon firm's existing competencies | ▪ Building NPD projects for products with existing technological and market strengths<br>▪ Best chance for success if established teams enter markets that are closely related to their organizations' current business | (Cooper 1979; Zirger and Maidique 1990) |
| | Collaboration with externals | ▪ Early supplier involvement | (Ragatz, Handfield, and Scannell 1997; Wynstra and Pierick 2000) |

Source: adapted and extended from Ernst (2002).

### 2.2.4 Innovation front-end management

The terms 'front-end' or 'fuzzy front-end' have been shaped by Wheelwright and Clark's (1992) use and constitute a relatively new research field in the area of product innovation. The front-end focuses on the organization of activities that precede the actual NPD phase and aims to provide evidence about market relevance and technical feasibility as early as possible and thereby reduce uncertainties at the beginning of a NPD project. Although front-end activities have been addressed partially by NPD literature, researchers have realized that their structuring imposes new managerial challenges. The following section describes the characteristics of the innovation front-end, as well as an overview of different models developed to manage it.

#### *Front-end characteristics*

Research in innovation front-end management evolved out of NPD literature. Since the late 1970s, several studies have demonstrated that innovation processes are partially linear in nature, triggered by either technological potentials or market needs, but also consist of random processes that are more complex and uncertain than those the linear model assumes (Cohen, March, and Olsen 1972; Tushman and Anderson 1986). In their research on innovation processes, Kline and Rosenberg (1968) introduced the chain-linked model, which describes five paths of early innovation activities. Some of these paths were linear and followed an idea → development → production → marketing sequence, whereas others were based on several feedback loops that suggest reiteration to early-stage innovative activity (Gassmann and von Zedtwitz 2003).

Quantitative research results from Cheng and Van de Ven (1996) showed that the nature of an innovation process changes over time. According to their results, an innovation process starts in a chaotic fashion, then gains a periodic pattern, and finally attains order. These authors suggested that an underlying system that regulates transitions from 'chaotic' to 'ordered' phases of the innovation process also may exist, though they unfortunately could not provide an equation for predicting the transition from chaos to order. However, Cheng and Van de Ven's research described the varying nature of learning throughout the innovation process and provided evidence that learning in chaotic conditions represents an expanding, diverging process of discovering possible action alternatives, outcome preferences, and contextual settings. Learning during more stable periodic conditions consists of a narrowing, converging process of testing how actions relate to outcomes (Cheng and van de Ven 1996). Table 2-3 shows an overview of research on the nature of innovation and the characteristics that shape the innovation front-end.

Table 2-3 Literature pertaining to the innovation front-end

| *Research Areas* | *Key Issues/Managerial Challenges* | *Authors* |
|---|---|---|
| Nature of innovation | ▪ Randomness of the innovation process, instead of linearity<br>▪ Changing nature of innovation process over time<br>▪ Differentiation between processes based on feedback loops and processes that follow linear development or production sequences<br>▪ Evidence of learning processes in the early phases<br>▪ Phase segmentation through stage-gate processes | (Kline and Rosenberg 1968; Cohen et al. 1972; Cooper and Kleinschmidt 1986; Tushman and Anderson 1986; Cooper and Kleinschmidt 1988; Cooper and Kleinschmidt 1991; Cheng and van de Ven 1996; Gassmann and von Zedtwitz 2003) |
| Front-end characteristics | ▪ Nature of work: experimental, often chaotic, can schedule work but not invention<br>▪ Creativity: high<br>▪ Tasks: highly individual by engineers and developers, necessity of adjustment with other departments<br>▪ Interfaces between tasks and departments: fuzzy responsibilities, different objectives, highly interdisciplinary<br>▪ Top management commitment: low<br>▪ Type of knowledge: mainly implicit<br>▪ Commercialization date: unpredictable and uncertain<br>▪ Revenue expectations: uncertain, speculation | (Souder and Moenaert 1992; Verganti 1997; Khurana and Rosenthal 1998; Nottrodt 1999; Koen et al. 2001; Kim and Wilemon 2002; Kim and Wilemon 2002; Koen et al. 2002) |

***Front-end management models***

The literature presents a multitude of approaches to structuring the innovation front-end. Normative stage models were shaped by Cooper and Kleinschmidt's (Cooper and Kleinschmidt 1988) market-driven stage-gate model for the overall innovation process, which also referred to innovation front-end activities. The deficits of this model included that it did not consider the iterative learning processes of individuals, which occur in a random way.

Trying to provide a solution that could overcome the imposed rigidity of the stage-gate model, theoretical circular models attempted to picture the actual course of action during the innovation front-end and lessen the rigidity of a sequence of tasks by depicting them in a circle (Khurana and Rosenthal 1997; Kim and Wilemon 2002; Koen et al. 2002). These models recognized that an overly strong management focus on resource efficiency, process structure, and a rigorous orientation toward customers' demands could endanger the creativity of engineers, because these characteristics would stabilize the innovation process to the point that every activity would become a bureaucratic routine and lead to the loss of an inventive spirit. The model's weakness stemmed from the difficulties that arose when implementing the circular approach in practice (Sandmeier, von Ziegler, and Jamali 2006). Because the model exists only on an abstract level, its implementation into company practice became a significant issue.

## 2.3 Literature on the structural organization of customer integration

After having presented the literature on the process organization of product innovation, this analysis now focuses on how companies organize to integrate customers into their product innovation activities. In the 1970s, companies grew more aware that being technology-driven—that is, creating new technologies and then trying to find markets for them—was an inefficient approach to managing innovation and led to many failed efforts (Ulwick 2003). As a result, momentum shifted to market-driven innovation models, which instructed firms to align their internal processes according to a measurable output in the market. To achieve this alignment, companies came to recognize the fundamental role of customer integration into product innovation (Gassmann and von Zedtwitz 2003).

Customer *integration* must be differentiated from customer *involvement*. In the case of customer involvement, the customer provides insights about *needs* which should be addressed by a new product, which typically happens via the marketing or sales depart-

ment. In contrast, customer integration *also* tries to capture the *solution know-how*, in the form of customers' technical or application expertise, by involving customers in product development and its direct interaction with R&D (Haman 1996; Gruner 1997; Reichwald and Piller 2005). This study focuses specifically on customer integration. The following section presents the relevant literature in this field by first discussing the impact of customer integration on product innovation (2.3.1), then the prerequisites for the structural organization of customer integration (2.3.2), and finally the lead user concept and an overview of other customer integration methods (2.3.3).

### 2.3.1 Customer integration impact on product innovation

The vast literature on customer integration has discussed both the benefits and the risks of customers' impact on product innovation, as are presented in the following sections.

***Benefits of customer integration***

In his research, von Hippel (1988) showed that the value of a product innovation increases when qualified customers bring their specialized know-how to the R&D process. Additional studies by Zirger and Maidique (1990) and Veryzer and Borja de Mozota (2005) showed that customer integration into R&D leads to a better understanding by the firm of customer needs and wants and, consequently, to products that respond to these needs and wants. In addition, Bacon and Beckman (1994) agreed that direct, timely, and reliable information about customer preferences and requirements represents the most critical information for successful product development. Finally, Boland (1987) stated, from a product quality perspective, that the quality of the product or process being developed may be improved by incorporating users' 'mental schemas.'

Considering the concept of *risk*, Helten (1994) found that integrating customers can help a manufacturer overcome its know-how deficit in relation to the market. Consequently, customer integration had a positive impact on product success because it enabled the firm to explore innovative opportunities created by emerging market demand and thereby reduce the potential that it would misfit buyer needs (Li and Calantone 1998) by enhancing product–market fit (Brown and Eisenhardt 1995). Coch and French (1948) also suggested that customers would be more receptive to a new system if they had contributed to its design, which also would reduce market risks.

When customers have been considered *development resources*, they also have been found to participate in or take over activities that traditionally have been the responsibility of manufacturers. As a result, they act as an extension of the R&D unit. In this con-

text, Leonard-Barton (1995) and Christensen (1997) have clarified that the utility of customers varies with the maturity of the technology and the alignment of the product line with the existing customer base. When both aspects were low (i.e., evolving technologies, emerging markets), the resource value of current customers was limited, though customers provided an excellent innovation resource when both aspects were high. In this latter scenario, various studies have demonstrated that customers, rather than manufactures, often serve as the idea generators and initial developers of products that later become commercially significant (Enos 1962; Freeman 1968; Shaw 1985; von Hippel 1988; Lilien et al. 2002).

Therefore, an effect of integrating customers into product innovation pertains to the increase of *creativity*: the integration of customers introduces different, typically unfamiliar perspectives into the approach undertaken to develop innovative products and thus leads to a higher level of 'collective creativity' (Maltz, Souder, and Kumar 2001). This creativity spurs the generation of creative solutions that range beyond the possibilities likely to be generated without customers' input (Veryzer and Borja de Mozota 2005). Ultimately, involving know-how obtained from the market (Clark and Fujimoto 1990) could result in the transmutation or evolution of the entire NPD challenge because it can redefine the 'problem' and reorient approaches directed toward addressing it. A possible outcome of this shifted approach is a greater understanding of the design challenge, which could result in a product solution that better serves the needs of the intended product users (Veryzer and Borja de Mozota 2005).

Other benefits of the integration of customers, especially in a B2B context, include the facilitation of interfunctional relationships, such as between marketing and R&D. Customers can stimulate communication and often adopt the meditating role of a conflict reducer (Li and Calantone 1998). Customer integration also encourages intensive, precocious communication among the players involved in the NPD effort; such cross-communication can challenge assumptions or shatter conventions (Veryzer and Borja de Mozota 2005).

***Risks of customer integration***

However, the integration of customers into product innovation activities also reveals certain challenges and controversies.

- Constant pressure from the customer can interfere with the engineer's creativity during the idea generation stage, forcing the engineer to develop fea-

tures that, technically, he or she might not prefer (Kohn and Niethammer 2002).

- As a result of the cultural differences between the customer and R&D employees, their interface can cause high friction losses. There is no guarantee that the customer's requirements will be understood or that the customer can articulate what he or she really wants (von Hippel and Katz 2002).
- Early customer integration into the product innovation process may lead only to incremental improvements of existing solutions instead of radically new 'breakthrough' products (Kohn and Niethammer 2002).
- A strong focus on the customer organization perilously can alienate the manufacturer from its inherent core competencies (Lilien et al. 2002).
- In most cases, the integration of customers into the innovation process means a greater demand for resources in terms of time and effort (Lilien et al. 2002).
- The selection of customers that actually are able to contribute to NPD is, in practice, very challenging (Brockhoff 2003). There is no guarantee of finding the right partner, and the consequences of a poor collaboration can be both harmful and dangerous.

With regard to this last point, Lynch and O'Toole (2003) noted the dangers of opportunism, leaking proprietary information, the allocation of property rights, inaccurate or unrepresentative know-how generated due to the limited domain of customer expertise, and the internal denial of inputs that come from outside the company (Katz and Allen 1982; Dolan and Matthews 1993; Littler et al. 1995; von Hippel and Katz 2002). Additional uncertainties associated with customer integration into NPD might revolve around increased dependency, lack of partner commitment, timing and intensity of customer involvement, uncertainty about the customer's ability to express its know-how, and damaged relationships (Biemans 1991, 1992; Dolan and Matthews 1993; von Hippel 1994; Leonard-Barton 1995; Li and Calantone 1998; Lilien et al. 2002).

### 2.3.2 Organizational prerequisites for customer integration

To avoid uncertainties and limit the risks of customer integration, an impressive number of studies have described the prerequisite organizational measures for successful customer integration. The literature overview presented in the following section first suggests some intercompany prerequisites, which focus on the interaction between the

developing company and the customer, and then discusses intracompany prerequisites, which focus on management practices internal to the developing company.

***Intercompany prerequisites for customer integration***

Intercompany prerequisites for customer integration are defined as organizational aspects that facilitate the interaction between a developing company and the customer. An overview of these aspects appears in table 2-4, which shows that, other than the reciprocity of the connection between the developer and the customer and the need to set clear collaboration objectives, the prerequisites predominantly relate to team structure and organization culture, as have been discussed in the literature.

Table 2-4 Literature on intercompany prerequisites for customer integration

| *Aspects* | *Organizational Measures* | *Authors* |
|---|---|---|
| Reciprocity of connection with the external environment | ▪ Consideration of partner's activity to include effectively in a business network<br>▪ Establishing measures to avoid a loss of proprietary information, dependency, and a lack of commitment | (Håkansson 1987; Johnsen and Ford 2000; McLoughlin and Horan 2000) |
| Clear collaboration objectives | ▪ Definition of collaboration objectives at the beginning of the collaboration<br>▪ Joint participation in goals setting and roles definition | (Biemans 1992; Millson and Raj 1996; Mohr and Spekman 1996) |
| Compatibility of culture | ▪ Imperative to embrace common goals, values, policies, and managerial procedures | (Bruce, Leverick, Littler, and Wilson 1995; Maron and VanBremen 1999; Hutt and Stafford 2000) |
| Communication | ▪ Creation of an atmosphere conductive to frequent and timely communication, both internally and externally<br>▪ Reduction of uncertainty and ambiguity through shared understating of goals and objectives | (Håkansson 1987; Biemans 1992; Bruce et al. 1995; Mohr and Spekman 1996; Hutt and Stafford 2000) |
| Building and maintaining trust | ▪ Insurance of partner's reliability and integrity through frequent communication among parties<br>▪ Emphasizing value consistency, competence, honesty, fairness, responsibility, willingness to act, helpfulness, and benevolence | (Anderson and Narus 1990; Morgan and Hunt 1994; Buttle 1996; Hutt and Stafford 2000; Rindfleisch and Moorman 2001) |

***Intracompany prerequisites for customer integration***

In addition to intercompany prerequisites for customer integration, literature also highlights intracompany prerequisites, which focus on how the product-developing company should organize to integrate customers successfully. These intracompany prerequisites, shown in table 2-5, center around defining appropriate project structures, ensuring a fit

with the business strategy, selecting and motivating the right people, managing the marketing–R&D interface, and building customer knowledge competence.

Table 2-5 Literature on intracompany prerequisites for customer integration

| *Aspects* | *Organizational Measures* | *Authors* |
|---|---|---|
| Appropriate project structures and priorities | ▪ Imperative to melt internal cross-functional teams and externals into one organizational boundary-spanning team<br>▪ Selecting customers on the basis of characteristics and commitment that contribute to the solution<br>▪ Establishing flexible management to adapt and respond to changes quickly | (Pitta, Franzak, and Katsanis 1996; Tidd, Bessant, and Pavitt 2001) |
| Fit with business strategy | ▪ Creating a shared vision about external focus<br>▪ Ensuring the ability to respond to external inputs<br>▪ Allocation of sufficient NPD resources<br>▪ Organization-wide orientation to new stimuli from outside<br>▪ Establishment of support and commitment of top management | (Biemans 1992; Johne 1994; Campbell and Cooper 1999; Tidd et al. 2001) |
| Identification and motivation of the right people | ▪ Definition of clear roles and objectives<br>▪ Identification of key enabling figures, such as organizational sponsors, team members, and business innovators | (Biemans 1992; Bruce et al. 1995; Markham and Griffin 1998; Hauschildt and Kirchmann 2001; Tidd et al. 2001) |
| Management of the marketing–R&D interface | ▪ Bundling of different firm competencies through cross-functional teams<br>▪ Emphasizing the relevance of the quality of internal cross-functional interfaces, which shape the quality of external collaborations | (Souder 1988; Biemans 1991; Song, Montoya-Weiss, and Schmidt 1997; Jassawalla and Sashittal 1998; Li and Calantone 1998; Song et al. 1998; Kahn 2001; Olson and Bakke 2001) |
| Customer knowledge competence | ▪ Consideration of customer knowledge as a strategic firm asset<br>▪ Establishment of knowledge management to support the exploration of emerging market demands | (Glazer 1991; Adams et al. 1998; Li and Calantone 1998; Lukas and Ferrell 2000) |

### 2.3.3 The lead user concept and other customer integration methods

The organization of customer integration also requires specific methods to capture and build a customer's know-how into product innovation activities. For example, von Hippel (1976; 1977; 1978) provided a new research impulse in the late 1970s when he demonstrated the value of customer integration in the idea-generation stage of the product innovation process through his customer active paradigm, out of which he built the *lead user concept*. The following section presents the lead user concept, which remains the

most prominent method of integrating customers into product innovation activities. A short overview of other methods for customer integration is presented subsequently.

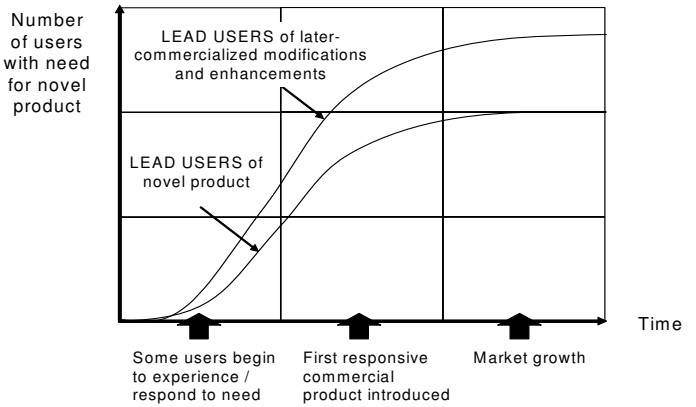
***Lead user concept***

The lead user concept by von Hippel (1986) remains the most important, empirically validated method for customer integration into product innovation; advancements in the field still build on it (Urban and von Hippel 1988; Kotler 1999; Morrison, Roberts, and von Hippel 2000; Dahan and Hauser 2001; Kohn and Niethammer 2002; Lilien et al. 2002; Thomke and von Hippel 2002; Ulwick 2002; von Hippel and Katz 2002). The concept's basic assumption is that innovation by customers tends to be concentrated among the lead users of products and processes:

> When new product needs are evolving rapidly, as in many high-technology product categories, only users at the 'front-trend' will presently have the real-world experience that manufacturers must analyze if they are to understand accurately the needs that the bulk of the market will soon face. (Herstatt and von Hippel 1992: 214)

Therefore, the lead user role usually is played by selected customers who differ from typical, 'average,' or mass customers. The lead user concept relies on a sample of existing or potential customers whose present needs are expected to become general in the marketplace months or years in the future. They can be employed to generate new product ideas that have the potential of becoming 'breakthroughs' in the broader market (see figure 2-4).

Figure 2-4 Schematic of lead users' position in the life cycle of a new product




Source: adapted from von Hippel (1986: 797).

Von Hippel (1986) defined lead users according to two characteristics: they expect attractive innovation-related benefits from a solution to their needs and therefore are motivated to innovate, and they experience needs for a given innovation before the majority of the target market does. The first characteristic identifies users with a higher likelihood of innovating because of the positive associations between their profit expectations and innovative activity (Schmookler 1966). The second characteristic filters user innovations that developing companies would be likely to find commercially attractive, namely, those that foreshadow general demand in a target marketplace (Morrison et al. 2000).

Comparing product idea generation according to the lead user concept with traditional marketing methods reveals two major points of difference: the kind of respondents from whom information is collected and the type of information collected. Whereas traditional marketing methods obtain need information from representative users that reside in the center of the intended target market, the lead user approach collects both need and solution know-how from lead users (Haman 1996; Eliashberg, Lilien, and Rao 1997; Griffin 1997; Lilien et al. 2002). In addition, lead users are mostly found outside a target market and often encounter more extreme conditions of trends relevant to the target market. They are technologically savvy customers with an urgent need for improved products who could serve as trendsetters in an emerging market (Gassmann and von Zedtwitz 2003). They therefore may be forced to develop solutions that are novel enough to represent 'breakthroughs' for the target market (Lilien et al. 2002).

The course of a lead user project involves five major phases (von Hippel 1988; Herstatt and von Hippel 1992; Lilien et al. 2002):

- *Phase 1: goal generation and team formation.* The firm provides an ideation-goal for the project and forms a lead user project team.
- *Phase 2: trend research.* Lead user teams focus on identifying and deeply understanding important market and technical trends in the field.
- *Phase 3: lead user pyramid networking.* The project team engages in a 'pyramid' networking exercise to identify and learn from users at the leading edge of the important trends selected as the focus of study.
- *Phase 4: lead user workshop and idea improvement.* In a lead user workshop, invited lead users work with company personnel to improve the preliminary concepts.

- *Phase 5: concept testing.* The final phase involves testing whether typical users in a marketplace find the product or service concept developed by lead users attractive.

The last phase, the testing of the generated solutions, attempts to reduce the biggest risk associated with the integration of lead users; namely, products developed with input from lead users can be of limited appeal to typical users or applicable only to other lead users (Ulwick 2002; Lettl 2004; van Kleef, van Trijp, and Luning 2005). Therefore, the test of new product concepts with typical users is highly relevant.

***Other customer integration methods***

In addition to von Hippel's lead user approach, current literature offers a rich body of methods for integrating the customer into the product innovation process. A fundamental distinction can be made between methods that integrate customers' self-articulated needs and solutions (directly derived) and those that derive customer needs and solutions indirectly (e.g., statistically, through observation). In *direct approaches*, the customer is asked about and often guided to give his or her ideas and reasons for preferences. The lead user concept belongs to this category of direct approaches. In applying direct approaches, however, several premises must be considered (van Kleef et al. 2005):

- Letting consumers articulate their needs implies that consumers are able to *fully understand* their own needs.
- By directly deriving consumer needs, it is implicitly assumed that consumers are *able to express their needs and wants correctly* during personal and group interviews.
- Participants are assumed to be prepared to *tell their needs and wants* to researchers.

In *indirect approaches*, participants are not asked directly whether they prefer a product or about which attributes determine their choice, which helps eliminate the issues inherent to direct approaches (van Kleef et al. 2005). Direct and indirect approaches also often are combined to obtain a broad spectrum of customer know-how. Various studies explicate customer integration methods in an industrial product innovation context from both an R&D and a marketing perspective. The following overview presents a selection of these methods.

- ***User toolkits*** are based on integrated circuit (IC) development, in which context customers develop their circuitry designs with innovation toolkits. The Internet's low transaction costs, short feedback loops, and the capacity of broadband connection make user toolkits efficient. Online toolkits allow customers to customize products according to their needs and offer them the opportunity to get what they want on the basis of their own experimental inputs. Developers profit from this approach because they can capture must of their customers' know-how in their product (Seybold 2001; von Hippel 2001; Thomke and von Hippel 2002; von Hippel and Katz 2002).
- ***Quality function deployment (QFD)*** is the dominant approach in total quality management (TQM) organizations. The basic idea behind this concept is to capture the desires and values of the customer and estimate the performance of competitors' products. Subsequently, the key characteristics for successful commercialization of the product can be identified and transferred into its construction and attributes, as well as required processes and production requirements. (Akao 1988; Hauser and Clausing 1988; Akao 1990; Eureka and Ryan 1994; Herrmann 1998).
- ***Conjoint analysis*** is a product-driven approach in which products or concepts are represented by their attributes, which can have two or more alternative levels. This method attempts to find out which attribute and attribute levels consumers prefer and how much they value those attributes. A characteristic of conjoint analysis is that the products and features are primarily hypothetical and hence more or less unfamiliar to respondents. The method is popular in research and practice pertaining to the conception of a new product or differentiation of an already existing good (Green, Rao, and Desarbo 1978; Herrmann 1998; Lilien and Rangaswamy 1998; van Kleef et al. 2005).
- ***Laddering*** is a personal interviewing technique used to understand customers' knowledge structure about a particular product. It is rooted in means-end theory, which examines the types of concrete product characteristics, benefits, and values perceived by customers. A means-end chain reflects a knowledge structure that links a customer's knowledge about product attributes to his or her knowledge about consequences and values. In the interview, a product-driven stimulus is employed to elicit customer needs. The task format of laddering can be characterized by the evaluation of multiple products, after which the interviewer obtains the customer's needs by directly and repeatedly issuing probing, 'why' question to the participant

(Gutman 1982; Reynolds and Gutman 1988; Herrmann 1998; Nielsen, Bech-Larsen, and Grunert 1998).

- ***User-oriented product development*** is a human factor or ergonomic engineering approach to product design. It focuses on usage requirements rather than product features related to a specific engineering solution. Beginning with a problem analysis of user requirements, with its starting point in the usage situation, the approach then leads to the formulation of 'user requirements' and transformation of these requirements into measurable engineering requirements. It results in iterative design work; prototypes are tested by users and modified by designers (Rosenblad-Wallin 1985; Dahlman 1986; Rosenblad-Wallin 1988).
- ***Empathic design*** is rooted in theories of anthropological investigation and tacit knowledge. It is a form of observational research in which researchers watch customers as they use products in their own environment. The key premise of empathic design is that new product concepts are based on a deep (empathic) understanding of unarticulated customer needs. By spending time with customers, the developer develops empathy for the problems customers encounter in their daily life. This process also helps overcome the challenges that arise from customers' limited ability to imagine and describe possible innovations (Leonard 1995; Leonard and Rayport 1997; Leonard and Sensiper 1998; Ulwick 2002; van Kleef et al. 2005).

Techniques from the field of anthropology other than empathic design also have been employed to support customer integration into product design: *traditional ethnography* refers to the art and science of describing a group or culture. A form of cultural anthropology that uses fieldwork to observe a group and derive patterns of behavior, beliefs, and activities (Cagan and Vogel 2002), it includes *observation* (physically observing an event or using video and sound recording for subsequent analysis), *interviews* (collecting deep stories that detail the way people think about products and relate them to their lifestyles), and *visual stories* (narratives created through the use of disposable cameras and journals by the target customers, who record what they think is important in a defined setting). The data collected through such techniques are shared among all innovation team members and provide a better sense of the customer's intent from a marketing as well as from an R&D perspective.

More recently, a new type of actively focused customer research has begun to emerge in the design community, specifically *video observations* of user interactions and *video*

*ethnography* (Kumar and Whitney 2003). Such research provides databases that are relevant for many types of design projects. Digital ethnography indicates a technologically driven evolution of traditional ethnographic methods that employs wired and wireless technologies to extend ethnographic methods, like participant observation, beyond geographic and temporal boundaries (Masten and Plowman 2003). Hypermedia ethnography, which draws heavily on electronically based media to infer meaning, and 'cybersociology,' which involves the study of Internet-based interactions, also show potential for increasing insights into user experiences, interactions between customers and products, and brand transformations (Moore 2002).

## 2.4 Literature on the incorporation of customer contributions into product innovation

The previous two sections highlighted literature on the process organization of product innovation and the structural organization of customer integration. The following section in turn analyzes literature focused on the intersection of the two literature streams. It specifically points to research on the interaction between the developer and the customer, which tends to focus on contributions of customers built into product innovation activities. Therefore, the following section pertains to findings about how to access customer contributions (2.4.1), and the subsequent section refers to the participation of customers in the product innovation process (2.4.2).

### 2.4.1 Access to customer contributions

The incorporation of customer contributions depends on the access that a developing company can attain to capture its customers' know-how. Therefore, the accessibility of customer contributions, as well as the different types of customer contributions, are discussed next.

#### *Accessibility of customer contributions*

The extent to which customers' know-how is accessible depends on factors such as the customers' articulation capabilities and awareness of the overall problem situation, as was already discussed in the section pertaining to methods for customer integration (2.2.3). Empirical research on decision making has stated that customers frequently are unaware of their problem situations, underlying preferences, problems, and choice criteria (Simonson 1993; van Kleef et al. 2005). Von Hippel (1994) revealed in this context that much of the information useful for product innovation is 'sticky'—meaning it is

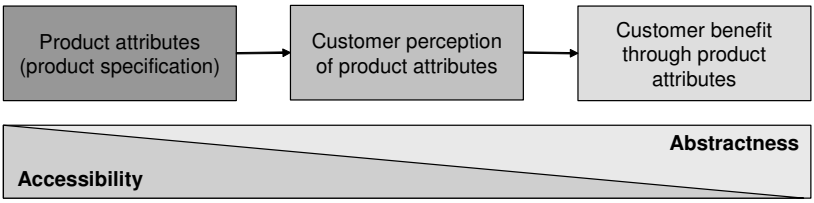
complex to acquire, transfer, and use in a new location. Stickiness has also been investigated from the perspective of knowledge management in the context of cross-boarder knowledge transfer (Jensen and Szulanski 2004). *Information stickiness* refers to attributes of not only the information itself but also the information seekers and information providers.

Information stickiness might be high because organizations typically must acquire related information and skills before they can release and understand the potentially beneficial and transferable new contributions (von Hippel 1994). Furthermore, information may be sticky depending on the nature of the information that has to be transferred. Some information is encoded in explicit terms, but some is tacit. Polanyi's (1958) work noted that many human skills and human expertise employed extensively in product innovation tend to be tacit; as he stated:

> The aim of a skillful performance is achieved by the observance of a set of rules which are not known as such to the person following them. (Polanyi 1958: 49)

In addition to its stickiness, the accessibility of customer contributions also varies according to the level of abstractness. The more abstract are the customer needs elicited, the more difficult it is to transfer them to product innovations. For example, though it is relatively easy to access product attributes and characteristics, customers' perceptions of those attributes and the benefits the customer perceives as arising from the attributes are more difficult to access (Shocker and Srinivasan 1979; van Kleef et al. 2005). Figure 2-5 illustrates how accessibility relates to the abstractness of customer contributions.

Figure 2-5 Accessibility and abstractness of customer contributions

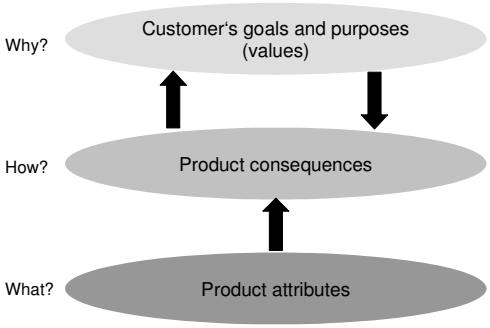



Source: adapted from van Kleef, van Trijp, et al. (2005: 6).

The accessibility of customer contributions also can be explored according to the *customer-value concept* which turned out to be a powerful idea for marketing strategy and research (Jensen 2001). According to Stahl and colleagues (1999), the value of products is generated not through their innate attributes but on the basis of their consequences in a

specific usage situation, as illustrated by the customer value hierarchy (see figure 2-6). This hierarchy has been repeatedly validated in consumer goods industries, as well as in a B2B context. At the bottom of the hierarchy sit the physical attributes of a product. Higher up the hierarchy are the consequences; at the top rest the goals and purposes that make these attributes relevant to the customer (Woodruff and Gardial 1996). These consequences and goals help explain the customer's motivation for wanting specific attributes.

Figure 2-6 Customer value hierarchy




Source: adapted from Woodruff and Gardial (1996: 65).

In moving up in the hierarchy from product attributes to customer goals, the contributions become increasingly abstract (Stahl et al. 1999) and therefore more and more difficult to access. This progression is especially true for customers' 'latent needs,' which are the goals and values that they are not aware of but promise the biggest rewards if developers can address them. Customers do not ask developers to fulfill their latent needs and may not even have the ability to articulate them; the products that might fulfill them probably do not exist yet (van Kleef et al. 2005). Identifying and understanding these latent needs is of crucial importance, because fulfilling such needs would delight and surprise the customer (Griffin and Hauser 1993).

***Types of customer contributions***

The types of customer contributions also vary according to the *intensity* of customer integration. The level at which customers are integrated into product innovation tasks can fall anywhere on a spectrum ranging from purely unilateral information provision to the bilateral, active participation of the customer in the innovation process. Athaide and Stump (1999) stated that partnerships with customers can be managed solely from the

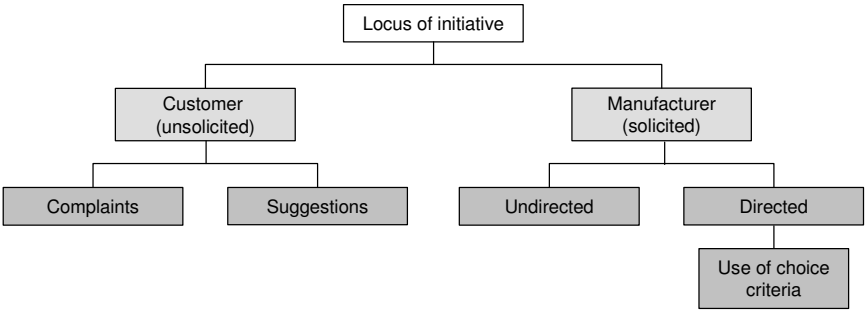
developer's side (unilateral) with low commitment from both partners or through a bilateral collaboration that involves more intense bidirectional flows. Damodaran (1996) regarded levels of customer integration as lying somewhere on a continuum from informative through consultative to participative. Eason (1992) and Kaulio (1998) differentiated among three customer categories—'design for,' 'design with,' and 'design by'—to capture the depth of customer engagement in the development process. Referring to the difficulty of identifying the adequate level of customer integration, Brockhoff (2003) stated:

> It can be assumed that higher degrees of involvement lead to higher costs, and consequently can be considered rational only if these costs are at least matched by the expected results. (Brockhoff 2003: 471)

Going further into questions pertaining to customers' contributions to the product innovation process, Brockhoff (2003) pointed out the relevance of the *initiative* behind a collaboration with the customer. Usually, market power determines the so-called *locus of initiative* for cooperation; if customers take the initiative, it may lead to *unsolicited* cooperation, whereas if the developer does so, it may lead to *solicited* cooperation (see figure 2-7).

Developers receive *unsolicited* information about potential new products through complaints and suggestions in particular (Brockhoff 2003). *Complaints* are a common way for customers to offer their feedback about product characteristics, and complaint management might consider this information a valuable and inexpensive source of potential product improvements. However, complaints commonly are viewed as quality control inputs rather than sources of ideas for new product development, an activity generally mentioned only in passing (Hansen, Jeschke, and Schöber 1995; Brockhoff 2003). *Suggestions*, in contrast, are offered by satisfied or potential customers. With respect to the representativeness of these customers and the generally very low degree of newness involved in their suggestions, the point of criticism is the same as that regarding the usefulness of complaints.

Figure 2-7 Locus of initiative of customer integration




Source: adapted from Brockhoff (2003: 471).

Solicited customer cooperation can be *undirected*, such that the developer takes the initiative but is unable to influence which customers will respond. In the case of *directed* solicitation, the manufacturer selects potential respondents, at least in principal. Certainly, customers cannot be forced to answer, but the developer can control its information gathering much better than with undirected solicitation.

Another differentiation with regard to the types of customer contribution also comes from marketing literature, namely, customer *needs* and *wants*: needs are more general and refer to basic requirements, whereas wants are much more specific and specify objects that might satisfy the need. Needs can originate from either an internally perceived state of discomfort or an external source (van Kleef et al. 2005) and remain at a higher levels of abstraction than wants, which can activate specific ideas for new products or product improvements.

Finally, Ulwick's (2003) differentiation regarding customer contributions appears in table 2-6. He differentiated among the solutions, specifications, needs, and benefits expressed by the customer to the developer. These different contributions impose different managerial challenges, as shown in table 2-6.

Table 2-6 Customers' contributions and resulting managerial challenges

| *Type of Contribution* | *Description* | *Managerial Challenge* |
|---|---|---|
| Solutions | Statements of ideas, new concepts, or suggestions for product features from the customer. | Accepting suggested customer solutions as requirements is common but leads to drawbacks because few customers are technologists, engineers, or scientists. The result of giving customers the solutions they request often is disappointing. |
| Specifications | Inputs from the customer about the desired size, weight, color, shape, look, feel, or other product performance characteristic in attempt to shape a solution. | Considering specifications from the customer again assumes that the customer knows the best solution, which often is not the case.<br>Accepting specifications as customer inputs inherently prevents engineers and designers from using their creative skill to devise superior solutions. |
| Needs | Universal forms of customer input typically stated as a high-level descriptor of quality. It is common, for example, for a customer to say that he or she wants a product to be 'reliable,' 'effective,' 'robust,' 'stable,' 'resilient,' 'consistent,' or 'powerful'. | Needs are characteristically stated in the form of an adjective and inherently do not state a specific benefit to the customer. Although these statements provide some indication about what customers are looking for, they are often vague and ambiguous.<br>Although such statements may be useful for marketing, communication, and positioning purposes, they are nearly impossible to measure or control and, as a result, present designers, developers, and engineers with the impossible task of trying to figure out just what customers mean by their statements. |
| Benefits | Statements such as 'easy to use,' 'faster,' 'better,' or 'cheaper' that customers use to describe what value they would like a new feature or solution to deliver. | Similar to needs, these statements present designers and engineers with information that is often ambiguous, immeasurable, and inactionable. |

Source: adapted from Ulwick (2003).

### 2.4.2 Customer participation

The incorporation of customer contributions into product innovation also varies with the participation of the customer in the development process. This participation is explored in the following section through considering the motives of customers to contribute to product innovation and the roles customers play in the product innovation process.

#### *Customer motives to contribute*

Because of different customer motives, the information developers receive from customers should not be expected to be identical (Brockhoff 2003). Empirical research has indicated that the rank order of motives that drive customers to make their contributions available during product development processes varies among product categories and

includes ego-enhancing as well as extrinsic motives, such as monetary rewards (Hansen and Raabe 1991; Brockhoff 2003). Possible customer motives include the following:

- Reimbursements that reflect the value of the contribution.
- Price reductions on a limited number of future new products.
- Early access to future new products, which may hold the promise of generating higher returns or lowering production costs.
- Extra services during use of the new product (e.g., extended warranties, repair work, availability of help lines).
- Private or public honorable mentions as the originator of a product idea, which may be of value to the customer because it impresses his or her peer group.
- Demonstration of creativity to the concerned customer.

The organization and communication of the processes of customer selection also can influence this motivation, as can customers' expectations with respect to the outcome of the product development process. Customers may derive value from knowing the selection procedure and feel honored if chosen (Brockhoff 2003). However, the value of the *reward* could spoil customer behavior, should the customers be promised high rewards for new product ideas. As a result, customers might generate suggestions not because of their interest in better new products but because of their interest in winning the reward. To balance this behavior, the reward should either be low, which can be problematic because it may not represent a motivation for customers to participate, or be tied to the intensity of future orders of the resulting new product. However, because few customer contributions lead to entirely new products, it is rather difficult to determine their contribution to the total value of a particular innovation based partly on their input (Brockhoff 2003).

***Customer roles***

Searching for the characteristics of appropriate customers for product innovation involvement, Gruner and Homburg (2000) showed that their representativeness of the target markets and their reputation in those markets provide discriminating criteria that can lead to better or worse products. This finding is in line with Brockhoff's (2003) suggestion that it is not just customer creativity that counts but also customers' demand potential. Furthermore, authors have pointed to the relevance of the customer organization, its financial attractiveness, its technological expertise, and its past experience with co-

development. Further relevant characteristics include objectivity, willingness to cooperate, market position, ability to maintain confidential information, and competitor ties (Shaw 1985; von Hippel 1986; Håkansson 1987; Urban and von Hippel 1988; Biemans 1992; Herstatt and von Hippel 1992; Ganesan 1994; Bruce et al. 1995; Millson and Raj 1996; Gruner and Homburg 2000; Lettl 2004). In addition, Scott, Rivera, and Tate (Scott, Rivera, and Tate 2003) noted that customers should have something specific to offer, such as significant revenue potential or other interesting products (whether from the developer or a third party) that can be integrated for product innovation. Other authors found that especially unhappy customers can make valuable contributions to the development of new products (Morrison et al. 2004).

Depending on the contribution required for product innovation, the identity of the customers employed typically varies with the stage of the product innovation process, similar to the extent and intensity of customer integration (Biemans 1992; Gruner and Homburg 2000). Overall, companies must ensure that the most appropriate customer is integrated at the right time, with the right intensity of involvement, and following the most appropriate form of governance (von Hippel 1977, 1986; Wynstra and Pierick 2000; Lynch and O' Toole 2003). As a result, researchers have identified different roles that customers can play in the product innovation process, and their contributions vary according to their role. Table 2-7 gives an overview of the roles and contributions that have been highlighted in the literature.

Table 2-7 Literature review on customer roles and contributions in product innovations

| *Author* | *Roles* | *Customer contribution* | *Role characteristics* |
|---|---|---|---|
| (von Hippel 1986, 1988) | Lead user | ▪ Problem statements<br>▪ Solution statements<br>▪ New product ideas related to a trend/ topic selected by the manufacturer | Has needs in an early stage that become relevant for mass customers later<br>Expects benefits of the innovation<br>Differs from the representative customer who has no inventive ideas |
| (Brockhoff 2003) | Launching customer | Active co-designer of NPD<br>▪ designs<br>▪ provides ideas<br>▪ is problem solver | Crucial if subsystems with interdependencies must be developed |
| | Innovator | Finished or quasi-finished problem solutions are changed into a product<br>Producer of quasi-prototypes<br>Accords with the lead user | Identification of creative potentials is difficult to recognize for manufacturer |

| | | | |
|---|---|---|---|
| | Reference customer | Source of know-how about the application of a product | Interesting customers are those who not only test but also buy a product |
| | First orderer | Helps overcome resistance within the manufacturer company<br>Reduces uncertainty about market failure | Customer influence not empirically demonstrated, is based on practical experience |
| (Lengnick-Hall 1996; Nambisan 2002) | Customer as resource | Supplier of information<br>▪ capital<br>▪ natural resources<br>▪ ideas<br>▪ any tangible or intangible contribution to production activities | Input side<br>Need to ensure that customer input meets quality requirements<br>Need for varied customer incentives |
| | Customer as co-creator | Direct participation in transformation activities:<br>▪ is involved in a wide range of design and development tasks<br>▪ validates product architectural choices<br>▪ designs and prioritizes product features<br>▪ specifies product interface requirements<br>▪ establishes development process priorities and metrics<br>Indirect participation in:<br>▪ managerial decision making<br>▪ personnel selection and performance appraisal<br>▪ policy development<br>▪ measurement of accountability | Input side<br>Customers become 'partial employees'<br>Coproduction is not cost free because of increase of uncertainty in production activities<br>Tight coupling with internal NPD teams<br>Enhancement of customers' product /technology know-how<br>More evident in industrial products than in consumer products |
| | Customer as user | Product testing, reveals<br>▪ product design needs<br>▪ maintenance requirements, repair demands, replacement expectations<br>▪ product support | Output side<br>Troubleshooting in case of product design flaws<br>Time-bound activity<br>Ensuring customer diversity |

## 2.5 Overall contributions and limitations of the existing literature

In this discussion of innovation process literature and works pertaining to customer integration into product innovation, many contributions have been identified. In addition, the course of this discussion reveals some of the limitations of existing work that has relevance for this study.

First, this chapter shows that learning about markets is the result of a series of organizational activities that can be embedded in the product innovation process (Fiol and Lyles 1985; Taylor 1987; Adams et al. 1998; Sawhney and Prandelli 2000). In this context, organizational learning theory explains that a firm must acquire, disseminate, and utilize customer knowledge to gather and combine market and technical know-how into knowledge about product specifications, product concepts, and prototypes. Organizational learning theory integrates cognitive and behavioral perspectives and therefore offers a holistic approach to customer integration into product innovation (Kok et al. 2003).

The review of the literature on the process organization of product innovation (Myers and Marquis 1969; Cooper 1979; Maidique and Zirger 1985; Cooper 1990; Eisenhardt and Tabrizi 1995; Lynn et al. 1996; Khurana and Rosenthal 1997; Thomke and Fujimoto 2000; Koen et al. 2001; Ernst 2002) crystallizes the following main contributions relevant for the present research: starting with sequential approaches to structure the product innovation process, the relevance of experiential models has been recognized as a superior strategy for product development in uncertain environments. In this context of uncertain environments, the importance of early prototyping has been emphasized. The shortcomings of research about product innovation processes pertain mainly to the early phase of product innovation management, specifically how to improve clarity for the innovation front-end process by 'defuzzying' its inherent creative and disordered innovation tasks.

The review of the literature on the structural organization of customer integration (von Hippel 1976, 1977; Urban and von Hippel 1988; von Hippel 1988; Biemans 1991; Griffin and Hauser 1993; Leonard-Barton 1995; Dahan and Hauser 2002; Lilien et al. 2002; Reichwald and Piller 2005; Veryzer and Borja de Mozota 2005) shows the relevance of not only approaching customers from the perspective of the marketing department but also integrating them into R&D to capture their need and solution information in the form of their technical or application know-how. In this context, the literature highlights the benefits and risks of customer integration, the inter- and intracompany prerequisites for customer integration, and methods for customer integration into product innovation, such as the lead user concept, QFD, or conjoint analysis. Even though these methods provide a structure for the embodiment of customers in R&D, they focus on single development tasks and lack a process perspective of continuous interaction between customers and R&D. Therefore, new methods for obtaining contributions from customers

and building these contributions into commercially viable new products are needed desperately.

Concentrating on the incorporation of customer contributions into product innovation, researchers have investigated the accessibility of customer contributions, the different types of customer contributions, and aspects of customer participation in product innovation, pointing to the different motives of customers to contribute and the various roles customers play in the development of product innovations (Shaw 1985; von Hippel 1986; Urban and von Hippel 1988; von Hippel 1988; Biemans 1992; Herstatt and von Hippel 1992; Ganesan 1994; Lengnick-Hall 1996; Gruner and Homburg 2000; Nambisan 2002; Brockhoff 2003; Scott et al. 2003; Lettl 2004; Morrison et al. 2004). However, literature in this field does not tackle the integration of customer contributions throughout the different phases of the product innovation or address the specific embodiment of customer contributions for the different tasks of the product innovation process.

In conclusion, there are significant works in the fields of product innovation processes, customer integration, and the incorporation of customer contributions into product innovations. Yet, though these areas have a significant impact on the resulting product innovations, researchers have largely neglected an integrative approach. Existing research concentrates on punctual approaches of building customer know-how into the product innovation process, but does not address the potential of continuous customer contribution incorporation: no publications provide a synthesized product innovation approach that continuously builds on customer contributions throughout the different phases of the product innovation process and builds on an intensive interaction between R&D and the customer. This lack of integration has resulted in disjointed knowledge building in isolated areas without synthesis to the process of continually integrating customers throughout the product innovation process as a specific area of research. This gap in existing research provides the opportunity to integrate and adapt research streams that address the process organization of product innovation, as well as the structural organization of customer integration, to provide a more comprehensive framework.

# 3 Reference framework development based on Extreme Programming

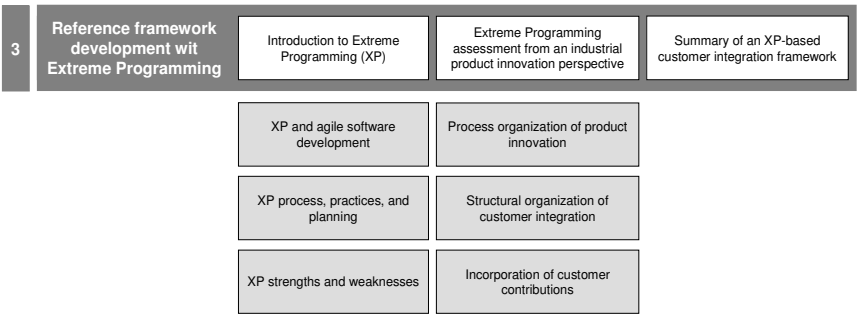
The goal of this study is to contribute to theory on customer integration into product innovation using case study research. To achieve this goal, a *reference framework*, based on the practical exploration of the phenomenon under investigation, must be constructed (Miles and Huberman 1994). The framework helps indicate and explain the main aspects that the case studies should investigate and thereby builds the foundation for the data collection (Voss et al. 2002).

The reference framework is based on literature pertaining to product innovation processes and customer integration. Furthermore, to achieve new insights and extend the state-of-the-art in research, a method from software engineering, *Extreme Programming* (XP), is introduced for framework development. As a software development method, XP represents an innovative, dynamic approach to product innovation that integrates the customer intensively during the entire innovation process.

With regard to the reference framework, XP helps identify the elements that render XP's customer integration and product innovation practices successful. Because this study aims to contribute to research on *industrial product development*, these identified elements then are analyzed from the perspective of existing customer integration and product innovation literature, as presented in chapter 2. This procedure arises from the question of whether those elements that determine XP's success can be transferred to the development of industrial products.

This chapter explains the development of the reference framework, including an introduction to XP's processes, practices, strengths, and weaknesses (3.1). Next, it investigates XP from the perspective of existing customer integration literature related to industrial products. This assessment enables the identification of the elements that make XP's customer integration and product innovation processes successful (3.2). These elements then are summarized into an XP-based reference framework (3.3), which underlies the subsequent data collection for the case studies. An outline of chapter 3 appears in figure 3-1.

Figure 3-1 Outline of chapter 3




## 3.1 Introduction to Extreme Programming

Changing customer requirements have become the standard in fast developing business environments—a standard that industrial product developers and software engineers have been forced to face. As a result, new product innovation methods to manage these changes have become highly relevant. Whereas traditional software development methods tried to plan product requirements well in advance, which frequently led to unsuccessful developments, new agile development methods, of which XP is the most popular, have tried to make software development more adaptive to customers' evolving needs and therefore more successful.

The following section first gives an overview of the modus operandi of XP and agile software development (3.1.1). Subsequently, XP's process, planning, and development practices are explained (3.1.2), followed by a discussion of XP's strengths and weaknesses (3.1.3).

### 3.1.1 Extreme Programming and agile software development

Traditional software engineering emerged 30 years ago out of efforts to gain control over the management of large customized software development projects, such as those for the U.S. military. In these classic methodologies, software originally was considered a predicable process with a fixed project devolution that could be planned from start to finish and for which all phases could be controlled and documented (Dornberger and Habegger 2004). This conceptualization of the planning process was heavily challenged by customers' tendency to change their minds frequently about product requirements, as well as by developers' mistakes with regard to technical issues. As a consequence, soft-

ware in most cases grew more expensive than originally planned, and customers did not receive what they hoped to get. Furthermore, the requirements that a new product was designed to address changed quickly, which meant the product no longer truly fit customer requirements.

The 'Extreme Programming' software development method was developed around 1998 by Kent Beck in an attempt to find a new approach that would simplify the existing methods to which developers were accustomed (Acebal and Cueva Lovelle 2002). This was motivated by gaps in the required adaptability of software, necessary in the context of rapid and constantly changing product requirements.

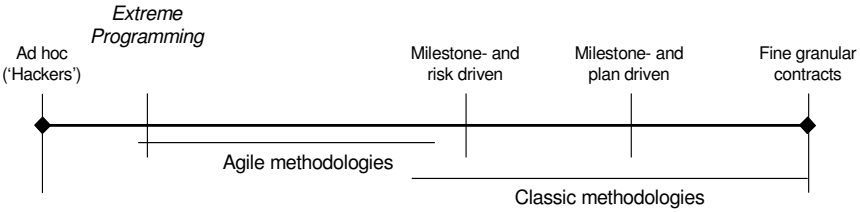
Eventually, as an answer to this unsatisfying situation, XP became one of the most popular disciplines of a group of new procedures that might be categorized as agile software development. Agile software evolved in the mid-1990s as part of a reaction against resource-heavy organization models, such as ISO 9000 or the Capability Maturity Model (CMM), which were perceived as bureaucratic, slow, demanding, and divergent from the actual path that software engineers tended to follow (Nawrocki, Jasinski, Walter, and Wojciechowski 2002). Unlike plan-oriented classic software development, agile methodologies were built on the idea that, in environments characterized by rapidly changing requirements, software development was difficult to plan. Therefore, the overall goal of agile methodologies was to provide benefits for the customer as soon as possible (Dornberger and Habegger 2004). By ensuring that software engineers focused on smaller units of work, these methods attempted to minimize risk as well. Working with the agile methodologies required engineers to collaborate with the customer, which was considered much more important than defining a development contract in advance.

Figure 3-2 demonstrates how classic and agile development methodologies might be placed on a spectrum of increasing planning orientation. The left end represents the extreme of unplanned, undisciplined 'hacking,' whereas the right extreme indicates the disciplined, process-oriented, classic methodologies that require highly detailed contracts. Between these extremes lie agile development methods. As this figure highlights, XP cannot be compared to an unplanned, ad-hoc procedure because it contains some forecasting, but it also falls on the low structured end of agile development methods (Dornberger and Habegger 2004).

In addition to a categorization of 'classic' and 'agile' development methodologies, two process categories—'heavyweight' and 'light'—also can be distinguished. Developing with lightweight methodologies means that every activity not relevant to the project is

left alone; developing that uses heavyweight processes conducts every activity as planned (Dicke 2002).

Figure 3-2 Classic versus agile software development methodologies




Source: adapted from Dornberger and Habegger (2004: 6).

### 3.1.2 Extreme Programming process, practices, and planning

Many computer programmers consider XP the first established agile software development method that emerged from their common tactics. The defining characteristic of an XP method, compared with other agile methodologies, is that some of its practices must be executed in a more absolute or extreme way; whereas common practices in other agile methodologies postulate that testing is important, XP demands continual testing. The traditional practice of 'seeking for simplicity' becomes 'everything as simple as possible' in XP. These examples clarify that the idea of XP is not new, but the strictness of its practices and their constellation is far more intense than in traditional approaches (Beck 2003).

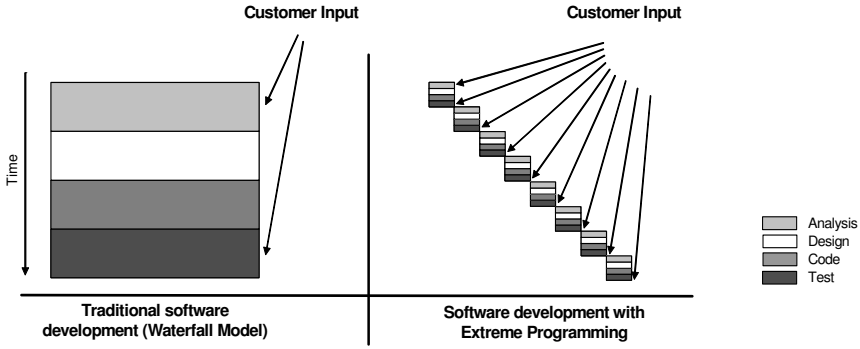
The following section gives an overview of XP's product development process and illustrates how it performs the central aspect of development planning. Finally, it explains the development practices that make the method work.

***Product development process***

The XP method is shaped by the development of significant preproduct iterations, driven by continuous customer input. This procedure minimizes the length of the feedback cycles between developers and the customer. Most design activities take place on the fly and incrementally, starting with the simplest solution that might work and continuing by adding complexity as necessary (Acebal and Cueva Lovelle 2002). As a result, the new product evolves together with the customer's needs, iteration by iteration.

Figure 3-3 contrasts this XP development process with a classic methodology, the Waterfall Model. Classic methodologies generally feature a highly structured, sequential process geared toward maintaining a document trail of the significant design decisions made during development. A project proceeds through specific stages—requirement analysis, specification, design, coding, integration and testing—with sign-off points at the end of each stage (MacCormack 2001). Customers are considered at the beginning and end of the overall process. Such classic methodologies are best for an environment in which customer requirements (and the technologies required to meet those requirements) are understood well. Their application in more uncertain environments, however, is problematic because uncertain environments call for interactivity that lets the customer evaluate the design before the specification is finally implemented; otherwise, the resulting product will not correspond to customers' needs (Dornberger and Habegger 2004).

Figure 3-3 Classic software development process versus Extreme Programming process




Source: adapted from Dronberger and Habegger (2004: 16).

In XP, customers still are considered at the beginning of the process, but instead of an overall requirement analysis, an XP project starts with an identification of the customer's basic need for a new product. A solution that covers this basic need determines the scope of the first preproduct *release*, and its implementation may take up to several weeks. As soon as it is finished, the already valuable preproduct is presented to the customer for feedback. From this basic product, the customer helps define further product functions and features through so-called 'user stories,' which describe refinements to the evolving product that accord with the customer's needs. On the basis of the most relevant user story, the engineers improve the original solution through changes or add-ons

and present the altered product to the customer as the second release. The same procedure takes place for the next release, and so on (Beck 2000; Beck and Fowler 2001).

Software development through XP ends when the customer is satisfied, meaning that he or she does not perceive value for any more added functions or features. The final product may not look like the product the customer imagined at the beginning, but it perfectly fits his or her needs. The following example of a software project conducted with the XP method illustrates XP's process of developing a new product.

> The information technology department of *Schindler*, a Swiss elevator company, has successfully applied XP to develop complementary software for several product innovation projects. The main reason for its application of the XP method was rapidly changing, difficult-to-implement requirements from customers. As a consequence, changes in the actual implementation phase caused difficulties in terms of keeping to the project plan. Traditionally, *Schindler* had been characterized by rigid process management, such that changes in customer requirements were not considered enough to alter development plans.
>
> In one particular project, XP has been applied to develop a Remote Monitoring System for elevator surveillance in office buildings. The project was executed together with a small software company, *Object XP*. Discussions with *Schindler* customers highlighted their basic need for regulated access of employees to certain floors in the building. The solution, in the form of a simple pin code system, was defined as a first release and sold to the customer. In examining this release, the customer discovered its need for visitor access control, which was implemented in the second release. After several releases, the final product emerged as a sophisticated access system that fit the customer's needs exactly, including not only those needs that originally led to the product development but also new ones that stemmed from the increasing importance of security systems in large buildings. The innovative Remote Monitoring System could be applied to new elevator markets and sold as a software update for already installed elevators.

To make the discovery of new and valuable product solutions for the customer work, XP's development process is shaped by four values: communication, simplicity, feedback, and courage (Beck 2000; Beck and Fowler 2001). First, excellent communication is crucial; even with XP, developing without excellent communicators is not possible (Beck 2003). Second, simplicity refers to an orientation toward the simplest design solution that is sufficient to solve a problem. As a consequence, developers are not handi-

capped with questions that will be relevant only in the future and can implement those parts that are immediately relevant. In general, XP developers are convinced that it is better to realize something simple immediately and possibly pay more for changes required tomorrow than to develop complexities that might never be of use (Dornberger and Habegger 2004). Third, feedback must be received from the customer through the frequent releases. The developer also receives additional feedback from a pair programming partner through automated module tests and, at the end of each day, integration tests (Beck 2003). Fourth, courage is important in terms of the responsibility of each project member for recognized problems. Each member solves only those problems that are relevant at the given moment, instead of those that might appear in the future. Courage is further required to eliminate complicated programming code and start completely at the beginning to resolve the problem (Beck 2003).

***Development practices***

To make this somewhat chaotic process involving releases work, Beck (2000), the creator of XP, described 12 core practices. Although Beck did not invent these practices, XP combines them in a new method that attempts to compensate reciprocally for each individual practice's inherent weaknesses. The practices assembled by Beck (2000) are as follows:

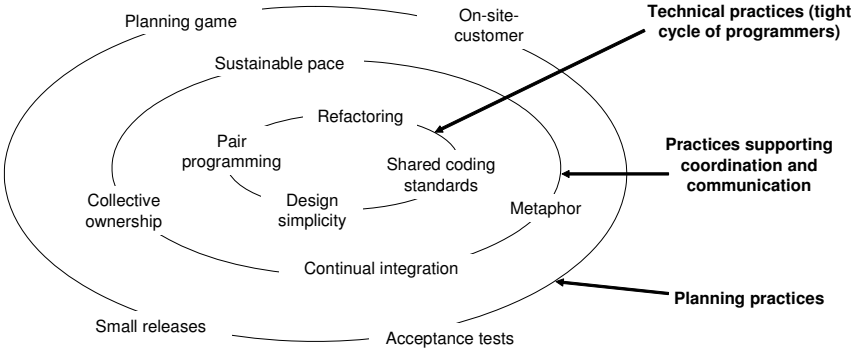
1. *Planning game*: The development team engages in a planning meeting together with the customer. This meeting determines which user stories will be implemented in the next release or prototype. As an outcome, this procedure delivers a short-term schedule, with the full commitment of every person concerned, for when the next step in the development will be completed.
2. *Small releases*: An XP project delivers a series of fully functional, completely tested releases leading up to the final delivery of the product under development. This process is useful because, first, it keeps the releases small and functional and thereby enables the development team to avoid the 'big bang' syndrome, which forces the team to attempt to integrate several large subsystems near the end of the project. Second, the development team always has a functional version of the programming code in the hands of the customer after the completion of the first release. The customer uses these small releases to give feedback on the project's progress, and this feedback can inspire additional user stories for the development team to work on in future releases.

3. *Metaphor*: To ensure the design of the system under development remains as simple as possible, an alternative, metaphorical description of the system also is developed. The metaphor serves to inspire development and design and provide a common vocabulary of terms among the system stakeholders.
4. *Simplicity in design*: The only code under development should be the code that is absolutely necessary to implement the latest user stories, and no more. The drive for simplicity leads to continual refactoring of the code (described subsequently).
5. *Testing*: In each collected user story, developers can find paths of programming operation, some of which model successful operations and some unsuccessful operations. These paths through each story are used to generate the system test cases before any code is written. Tests thus become part of the natural design of the system under consideration instead of afterthoughts. No system release is permitted until it has passed all tests.
6. *Continual integration*: After some subtask within a particular user story is completed, the implementation code is released into a shared development environment. Other programmers may refactor the code and use it within the context of their own particular assigned user story under development.
7. *Pair programming*: No person codes alone in an XP project; indeed, XP explicitly rejects any coding done by fewer than a pair of programmers working together at the same machine. One member of the pair writes code while another programmer critiques the work at hand, offers insight about the next step, and exposes trivial defects with the code.
8. *Collective ownership*: Working hand-in-hand with the principle of continual integration, the idea of collective ownership rejects any notion that a solo programmer (or single group of programmers) bears the full burden of responsibility for any one subsystem under development. Any code in the shared development environment is open to viewing and modification, and any member of the team may work on any subsystem (provided that the modification passes all applicable tests for that subsystem). The idea is to spread know-how to the entire development team to counteract the danger of a system depending on individual experts.
9. *Refactoring*: When it becomes apparent to the development team that the system design is too complex, the code is refactored, which means that system functionality remains stationary, to ensure that the refactored code still passes all tests it had passed prior to the refactoring, but the code base gets greatly simplified.

10. *Sustainable pace*: A 40-hour work week with no overtime is rigidly adhered to, based on the belief that development teams are able to produce high-quality products when they are comfortable and not overly exerted.
11. *Onsite customer*: It is not enough to have occasional access to a customer; a customer representative must be continuously present in the development area.
12. *Shared coding standards*: The entire development team agrees to maintain a common set of rules regarding the maintenance and creation of new code.

An overview of XP practices appears in figure 3-4, which divides them into three categories, represented as circles in the figure. The inner circle describes the technical practices, primarily relevant for the tight cycle of the programmers. The middle loop indicates practices that help the development team communicate and coordinate the delivery of quality software. Finally, the outer loop describes the planning practices that enable and facilitate the collaboration that occurs between the customers and programmers (Lindstrom and Jeffries 2004).

Figure 3-4 Categories of Extreme Programming practices




Source: adapted from Linstrom and Jeffries (2004: 46).

Practitioners who are experienced in working with XP agree that not every XP practice is imperative for a successful development. The metaphor, for example, is difficult to apply to many projects because shared stories may not fit the project sufficiently. Instead, a practicable rule is to use simple, nontechnical language that can be understood by everyone, including the customer, and thereby avoid misunderstandings and ambi-

guities. In addition, the onsite customer imperative often is difficult to fulfill in practice because the customer will not always be the product user, even though only the product user has the necessary know-how about relevant user stories. Furthermore, the customer will not always invest the required amount of resources to be present throughout the project. In these cases, the product manager usually plays the role of the customer. Furthermore, Beck (2000) has stated that it is imperative that development teams imagine a pseudo-customer by asking themselves, for every piece of code they produce, "Am I working on something that could be sold to a customer?"

***Development planning***

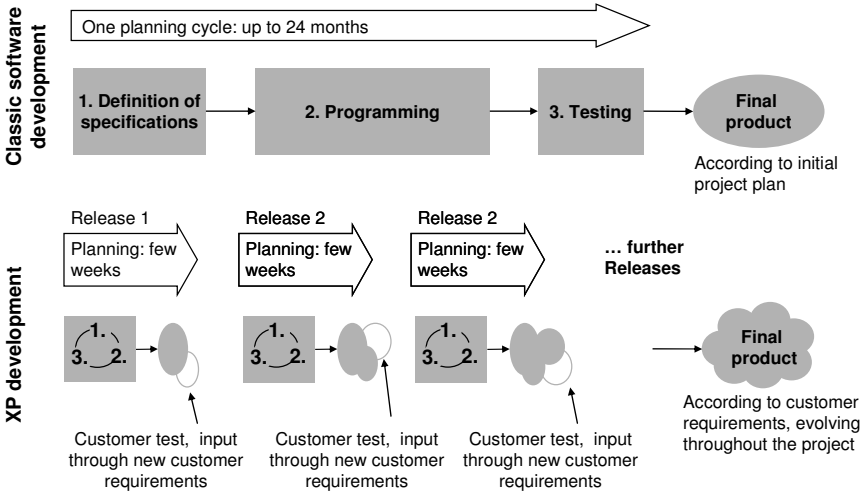
An XP project is planned according to four variables: cost, quality, time, and scope. Because there is a fundamental relationship among these parameters in every project, their scope is determined as soon as three first variables are defined. If a variable changes, the change in the other three variables usually does not occur in a linear manner. Therefore, it is not possible to, for example, double the costs, halve the time, and keep the other two factors constant. This relationship among the planning variables is also called the '3 + 1 rule' (Beck 2000). As a result of this rule, the customer is allowed to influence only three of the four variables.

To set the parameters for the first release, a *planning game* is performed by the developing team and representatives of the customer organization. The same cyclical procedure takes place for the second release. The customer can introduce its changing requirements every time a planning game is performed, no matter how far the project has evolved (see figure 3-5). The procedure enables programmers, managers, and the customer to communicate in a transparent way about changes and their implications. In turn, realistic decisions about the variables' cost, quality, time, and scope can be made and continuously adjusted. If a certain value set held by the customer or managers is unrealistic, the other variables' values must be changed.

This practice of project planning just for the next release, instead planning upfront for the whole project, renders the development process adaptive to the evolving requirements of the customer, which get discovered and implemented during the course of the project. A process guideline as a steering element emerges only through continuous tests with the customer. As a result of these small releases, planning accuracy is guaranteed, even though the customer may change its mind during the development if it discovers new product potentials. The new product that results at the end of the cyclical XP proc-

ess differs from a new product planned upfront because it corresponds perfectly to the evolving customer requirements discovered during the course of the project.

Figure 3-5 Planning cycles within Extreme Programming




### 3.1.3 Extreme Programming strengths and weaknesses

Of the new generation of agile software development methodologies, XP is the most prominent. Observers of the XP method tend to fall into two main groups: fascinated programmers working according to the method and those who consider XP an ideology or marketing trend that is difficult to realize in practice (Dornberger and Habegger 2004). However, the applicability of XP in a software context is not the subject of discussion here, this study introduces XP simply to provide a new perspective on customer integration and product innovation in the context of industrial product development.

It remains difficult to find objective commentary about XP's successes and failures. In general, positive opinions dominate, but a lack of measurable facts prevents any real conclusions about the overall performance of XP projects (Dornberger and Habegger 2004). However, the following section lists some of the strengths in product development that can be achieved through an XP application, as well as some of its weaknesses. The section concludes by listing some the project requirements that should be considered prerequisites for a successful application of the XP method.

***Strengths of Extreme Programming***

Rumpe and Schröder (2002) conducted a survey to assess the benefits of applying the XP method, using 45 questionnaires. With only one exception, all of the projects were evaluated as development successes. Each team's primary goals for the application of XP, including on-time delivery of the software and having fun at work, were considered achieved. The teams used most of the practices and guidelines prescribed by the XP method and believed them helpful (Rumpe and Schröder 2002).

Overall, XP proponents state that the method helped them consider customer needs better, improve the quality of the evolving software, and significantly reduce the development resource demands (Beck 2000; Beck and Fowler 2001). Resource investments decrease because risk-avoidance measures, such as those common to the early specification phase in regular software development projects, are no longer necessary. An additional advantage of XP lies in the likelihood that it will improve project profitability because of its frequent cost and return controls. In addition and as a result of the short planning horizon for each development portion, developers are aware of the overall project goal, which contributes significantly to their motivation and proximity to the markets' needs.

In listing the advantages of software development through XP, Dornberger and Habegger (2004) showed that

- The project direction (i.e., project goal) can be adjusted to the project environment. Therefore, the project can grow and adjust to market growth, and new business cases can be integrated continually.
- Open issues relevant for the development can be ignored until the project's environment provides the necessary information. As a consequence, insecure investments can be reduced and project productivity increased.
- The project can be finished with any release, and the customer still owns a product (a software package) based on the work that has been completed. Because the customer has chosen and prioritized its functionalities, it does not necessarily matter if not all the system's functionalities have been implemented.

***Weaknesses of Extreme Programming***

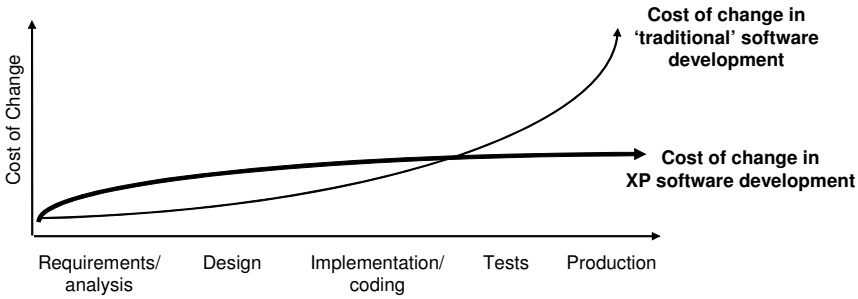
The study by Rumpe and Schröder (2002) reported that problems with XP projects arise mainly from customers who were not onsite, as the method requires. Missing customers was considered by 30 percent of those involved as the biggest risk factor pertaining to

an XP project's success (Rumpe and Schröder 2002). Accordingly, the customer's role is a demanding one: someone must be onsite to answer any questions from the developers or set development goals. That person has to be able to formulate requirements in the form of simple user stories and explain them clearly to the developers. The customer also prioritizes its user stories to help determine the sequence of their implementation. Furthermore, the customer must formulate appropriate acceptance tests to evaluate the results the developers offer. Most difficult for the customer is that it can influence the project but not control it (Beck 2003). An investigation by Martin (2003; 2004) showed that the customer representative often is overloaded with the task he or she is expected to perform in addition to his or her daily responsibilities. The time required to represent many diverse users and cover broad project activities, including implementation and coordination, is significant and diminishes the time the customer could spend with programmers. In turn, the impact of this diminished time affects the quality of the product and may increase both the cost and the duration of the project due to the resultant prolonged feedback loops.

Another aspect that has been regarded from a critical angle is that the XP method claims to be able to reverse the project cost curve. As illustrated by figure 3-6, the development cost for changes at the beginning of a project are higher with XP than with classic methodologies, but they do not significantly increase during the course of the project. Classic methodologies cannot afford to allow for changes during later project stages, because the cost of changes during project development increases exponentially with time.

With regard to this cost curve within XP, design improvements are achieved through continuous changes of the software architecture. These improvements grow smaller and smaller—and in the end incremental—as the software gets increasingly complex. For a small project, XP allows a complete revision of the whole project design, but such is not the case for bigger projects due to the time restraints. Therefore, software is optimized toward a local optimum, which is not necessarily the global optimum. The XP method thus leads to a software architecture that fits customer's current needs but may be inappropriate for future product features that need to be implemented (Dornberger and Habegger 2004).

Figure 3-6 Extreme Programming cost of change




Source: adapted from (Beck 2003: 21).

In terms of documentation, critics charge that XP fails to provide an adequate level of structure and necessary documentation; according to XP, the source code offers enough. Some authors have argued that, as a consequence of this documentation gap, new team members require a longer time span to be integrated into the project. Undocumented but important design decisions can lead to recurring discussions about already determined issues (Rumpe and Schröder 2002; Dornberger and Habegger 2004).

Other critics mention issues that pertain to resource planning with developers, in that problems arise if developers work on different projects. Therefore, XP has difficulties in dealing with adjustments, which inevitably are required within firms. The more projects depend on the input from other departments, the more difficult become estimations of investments, rapid implementation of requirements, and the achievement of customer satisfaction (Lappe 2002). Few companies have organizational structures appropriate for the application of XP, which means that significant changes are needed to adopt these practices effectively. To establish an XP environment, a massive reorganization of the firm's processes and cultural issues is needed.

Finally, the XP method does not suit every project; its applicability for product development projects is limited to certain types of customer needs. Specifically, XP can be applied to development projects that do not consist of complex technical constructs but demand developments that occur close to the interface with the user of the system. At *Schindler*, for example, XP could not assist in developing the technology for a new elevator concept in which the basic needs still consist of going up and down in a building and opening the doors. However, it could be used successfully to develop new functionalities that directly affect the user.

***Requirements for Extreme Programming projects***

The most commonly debated question regarding XP is whether it can be used successfully for a particular type of project. Experience is proving that, as with other approaches to software development, limitations often relate to team, individual, and organizational characteristics. Consequently, to evaluate whether the XP practices can help a team achieve greater success for its project, consideration must be given to the project characteristics, the people on the team, and the cultures of the organizations involved in the project (Lindstrom and Jeffries 2004). In turn, there are certain requirements and preconditions that influence the successful application of the XP method for software development. These requirements address project participants, as well as necessary environmental conditions. An overview of these requirements appears in table 3-1.

Table 3-1 Requirements for working with Extreme Programming

| *Aspects* | *Requirements* |
|---|---|
| Culture | Must be informal and open to new and unconventional methodologies. Employees should be accustomed to high degrees of personal freedom. |
| Project type | Not appropriate for high-risk projects, for which dangers must be avoided from the very beginning (e.g., air and space projects). The process of realizing some functionality first cannot be followed for security reasons. As a consequence, a flat curve of cost changes does not occur in these cases. |
| Teams | Only appropriate for small teams (up to 12 developers); with bigger teams, problems of coordination and communication increase significantly. Furthermore, developers must be close to one another to guarantee an optimal communication. |
| Project power | XP postulates the acceptance of a separation of powers: customers make business decisions and developers make technical decisions. If this rule is not accepted by both sides, XP should not be applied. |
| Personality profile of developers | Developers must meet demanding requirements of their social competence. The collective success must be prioritized over personal success. Developers have to be self-disciplined, intrinsically motivated, and able to question their ways of working, as well as their results, critically. Further required characteristics include process reflection and the ability to adapt the process to current events. |
| Experience | Developers should bring with them a high degree of experience. The introduction of XP to a team of beginners is not recommended. |
| Discipline | Maintaining a high degree of discipline among stakeholders is important. With the exception of a project manager and a coach, XP has no further instruments to balance a defect of discipline. |
| Automated tests | XP assumes that the technique and development environment enable the automation of tests with minimal investments. |
| Computing environment | Daily integration and change of platforms (from development to test and production) should not be complicated through costly processes. |

Source: adapted from Dornberger and Habegger (2004: 22-23).

## 3.2 Extreme Programming assessment from an industrial product innovation perspective

The preceding introduction to Extreme Programming demonstrated that XP represents a powerful method for developing new products under conditions in which customer needs constantly evolve and product requirements change. In the next sections, XP is assessed from the perspective of the theoretical insights on customer integration into product innovation described in chapter 2. This assessment of XP according to existing product innovation and customer integration literature aims to identify and select those elements that constitute a dynamic process of customer integration, as it is provided by XP. Therefore, the investigation focus shifts from software engineering to new product development activities in the context of industrial products.

This assessment will lead to an XP-based customer integration framework, which underlies the subsequent collection of relevant case study data needed to build case study research. Within this research, XP is not investigated from a technical perspective; this study does not dig deep into the architecture of software development. Rather, the XP method is considered from a conceptual point of view. The assessment process first considers XP's process organization of product innovation (3.2.1), then XP's customer integration organization (3.2.2), and finally XP's incorporation of customer contributions (3.2.3).

### 3.2.1 Process organization of product innovation

The literature review in chapter 2 displayed the different findings in the field of product innovation process research, which has evolved from a stage-gate emphasis to evolutionary approaches based on experimentation and excessive prototyping. Further insights can be gained from research on product innovation success factors and the innovation front-end. Using insights from the literature, the product development process within XP is investigated, with a concentration on product innovation phases, experimentation practices, and team composition.

***Product innovation phases***

The foundation of XP's product development process—which at the same time is the product innovation process—is provided by short, highly efficient development cycles. Customers assess the results of these cycles continuously and enrich them with their feedback. The striking element in the process is the planning activity, which is reduced to a minimum for each release and seems absent in terms of the overall project. Conse-

quently, explanations of XP's process can be found in the research field of *disciplined problem solving* rather than in the stream pertaining to rational planning (see chapter 2.2.1).

Taking the perspective of disciplined problem solving, an explanation for the profitability of XP's process cycles can be found in the *loose–tight concept* developed by Wilson (1966) and Albers and Eggers (1991). Within each XP release, in which chaotic trial-and-error development is allowed, engineers can deploy their full creativity, introduce new ideas, and focus on developments that are technically possible. The degree of organization within releases remains loose. Customers provide their feedback for each release and thereby adjust the product development project to meet their requirements. However, the procedure of collecting customer feedback occurs with a tight degree of organization. This separation between the tightly organized collection of customer requirements and rather loosely organized technical implementation is valuable, because it enables engineers to deploy their creativity and introduce new ideas and customers to provide subtle process control by steering the development of the next release in a particular direction. Whereas Wilson (1966) and Albers and Eggers (1991) promote a loosely organized development at the beginning of the project and a tightly organized one near the end, 'loose' and 'tight' phases occur repeatedly in the XP process.

From the perspective of *experimental new product development approaches* (see chapter 2.2.2), XP's product development process responds to Eisenhardt and Tabrizi's (1995) experiential model and its demands for multiple iterations and frequent milestones. Even as XP enables developers to quickly build an understanding of different solution options, it maintains their focus and motivation. *Project planning* adjusts continuously to the project development. Consequently, rapid product development can be achieved through experiential and improvisational tactics and "navigation through unclear and shifting markets and technologies" (Eisenhardt and Tabrizi 1995: 104).

With regard to the *innovation front-end* perspective (see chapter 2.2.3), the maintained flexibility to realize new discoveries, especially in the early development stages, becomes extremely valuable. Developing a new product with XP does not require control over the exact course of a project in the early phase through a sequential stage model. Instead, only some activities are fixed, and developers can make decisions over the course of their sequence and adoption, depending on the specific situation and variables (Dornberger and Habegger 2004). The flexible procedure inherent in XP is enabled by the number of planning practices (shown in figure 3-4). The *planning game* among the parties involved, the *onsite customer* used to test implemented user stories and think of

new ones, the *continuous acceptance tests* that generate tests for every user story before the code is written, and the *small release practice* all lead to a product development procedure that involves creativity and discipline from the first development steps. As a consequence, the front-end's inherent dilemma, between developers' creativity and the required discipline imposed by the customer, is diminished.

In summary, the deciding characteristics of XP's development process structure retain the following elements for the reference framework:

- Degree of process control.
- Adoption of development iterations.
- Planning flexibility.

***Experimentation practices***

In terms of the *experimental approaches to NPD* (chapter 2.2.2), research on experimentation modes has highlighted the role of testing and experimentation during the product innovation process (Simon 1969; Allen 1977; Wheelwright and Clark 1992; Iansiti 1998; Thomke 1998). Prototypes help overcome many uncertainties about technical feasibility but also uncover the relevant elements needed to make the product fit customers' needs. Boehm and his colleagues (Boehm, Gray, and Seewaldt 1984) found that a prototyping process, which allows for changes late in the design process according to new know-how from and about customers, resulted in products that were not only judged superior from a customer perspective but also developed with fewer resources. This benefit falls in line with XP's product innovation approach.

First, XP's multiple releases (comparable to prototypes) help overcome the customer's design uncertainty and eliminate potential ex post regrets. Second, the increased number of releases provides the customer with more options from which to choose and thus leads to higher expected design quality, as has been shown by Terwiesch and Loch (2004) in a prototyping context. Furthermore, the releases help reduce the customer's uncertainty about its own preferences and insecurity about the producer's ability to meet its specific needs. The resultant evolutionary process of *sequencing prototyping cycles* emphasizes both the management of a rigid development process and the people involved (Terwiesch and Loch 2004). Developers and customers are both stimulated by the evolving product, visible as a release or prototype every few weeks. This early material presence catalyzes new ideas and know-how that can be integrated into the product and, in turn, may cause the exploration of novel customer needs.

This phenomenon also has been addressed in the literature by Lynn, Morone, and Paulson's (1996) *probe-and-learn cycles* (see chapter 2.2.2). These authors state that probing and learning help build new know-how, which leads to a superior new product that has been optimized in terms of technical feasibility and fit with customer needs. The concept also emphasizes that creative elements, through which new know-how is generated, are separate from disciplined elements, which focus on critical reflection about the relevance of the new findings.

The deciding characteristics of XP's experimentation and prototyping practice thus retain the following two elements for the reference framework:

- Acquaintance with development uncertainty.
- Intensity of prototype adoption.

***Product innovation team***

Another effect of prototyping stems from the integrating function of prototype models for development teams, including 'nonspecialists' from other affected departments and customers (Wheelwright and Clark 1992). The relevance of the team integration aspect has been noted within the literature pertaining to the *communication web approach* (see chapter 2.2.1), which states that the greater the connection among development team members and key outsiders, the more successful the development process will be (Brown and Eisenhardt 1995). With its unconventional and spontaneous teamwork, XP emphasizes direct and unbureaucratic interaction among team members, management, and the customer. The positive effect of structuring communication around concrete tasks, novel routines, and fluid job descriptions also has been pointed out by Brown and Eisenhardt (1995).

Moreover, XP developers must be strongly team oriented; for example, the pair programming practice requires a significant amount of social competence. The high relevance of a team orientation also arises because developers, in addition to their programming activities, are responsible for estimating the expenses required and providing tests. These activities must be coordinated with other persons involved in the development. Appropriately, XP's team composition is characterized by the cross-functionality of the developers, product managers, and customers involved. Because one of the most important facets is that everybody maintains a long view of the project, XP projects require generalists, not developers who specialize in a dedicated topic.

Evidence for the positive impact of *cross-functional teams* on NPD has been offered by many authors in disciplined problem-solving literature and especially in research on *NPD success factors* (see chapter 2.2.3). Such authors have revealed that project teams should comprise members from several areas of expertise who can make substantial contributions to the development of a new product. Above all, members from R&D, sales and marketing, and production should be part of the team.

Extreme Programming emphasizes the team aspect with its varied *coordination and communication practices* (see figure 3-4). Through *collective ownership*, every developer is responsible for the overall system; therefore, the development of isolated applications can be avoided. In addition, *continual integration*, which demands the immediate implementation of every subtask into the shared development environment, guarantees that the overall system coordination cannot be lost. The *metaphor* practice facilitates communication because every project stakeholder can comprehend even highly technical discussions. Finally, the *sustainable pace* practice, over time, should result in good communication and coordination practices.

Finally, XP project managers can be seen as *gatekeepers*, or high-performing individuals who communicate more often overall and with people outside their area of expertise (Katz and Tushman 1981; Brown and Eisenhardt 1995). However, because important decisions in XP are made by the team and the customer directly, the project manager's role is not as prominent as in classic product development. The manager has an important function with regard to the team climate, which should be free of fear and regard errors as chances for learning (Beck 2003). In addition to the project manager, a *coach* is responsible for the process and discipline during the project. This coach must know if a person involved in the project tends to proceed in the wrong direction and share this information with the team.

Thus, in terms of the deciding characteristics for XP's development team, the following elements should be retained for the reference framework:

- Communication (un-)bureaucracy.
- Team cross-functionality.
- Gatekeeping functions.

### 3.2.2 Structural organization of customer integration

The review of customer integration literature in chapter 2 brought out the difference between *involving* and *integrating* the customer (see chapter 2.3). As a method that strongly focuses on the latter, XP emphasizes customer integration into the development process through direct interactions with the development team. The following section emphasizes and assesses the organizational aspects of customer integration, which leads to the deciding characteristics of the success of customer integration into the product innovation process. It depicts the impact of customer integration, the intracompany prerequisites, and the intercompany prerequisites for customer integration into product innovation.

***Customer integration impact***

In XP, the customer is integrated into the development process so that the new product is designed to fulfill its needs. Therefore, the goal of customer integration is to identify the relevant product requirements and overriding product needs, which reveal major innovation potentials. To achieve this goal, the customer's market know-how enters directly into the product development project and can be regarded as an *extended R&D resource*, as has been pointed out by Leonard-Barton (1995) and Christensen (1997) (see chapter 2.3.1).

The goal of integrating the customer as an extended R&D resource in XP comprises two aspects: the development of a specialized innovative product solution for the principal customer and the multiplication of the resulting innovative product for other customers. The latter aspect is especially valuable because development resource investments are much lower if the product can be sold to more than one customer. Illustrating this aspect with the example of the XP application at *Schindler*, the product innovation developed together with one customer could be sold successfully to a much broader market. This highly innovative product was a market success that could have been achieved only with the customer's input; it was not possible to use solely the in-house developers' perspective to create a product that perfectly suited customers' needs.

These elements of the XP method also point to a second impact of customer integration, namely, the increase in new product creativity. This aspect has been discussed by Clark and Fujimoto (1990), Malz, Souder, and Kumar (2001), and Veryzer and Borja de Mozota (2005) (see chapter 2.3.1): the interaction between the developers and the customer introduces unfamiliar perspectives to both parties, which leads to creative product solutions that move beyond the status quo.

From these insights on the impact of customer integration into the development of new products, the following elements are retained for the reference framework:

- Customer impact on development resources.
- Customer impact on development creativity.

***Intercompany prerequisites***

As stated previously, XP's product development process can be regarded as a vehicle for identifying the final product target through constant interactions with the customer. The XP team, working iteratively between releases, needs a constant flow of information to steer the project according to the customer's input and to implement its requirements. The team's continuous small adjustments keep the project on track, on time, and on budget (Crispin, House, and Wade 2002). This required flow of information points to the relevance of *communication* in XP's development method, as has also been addressed by the four XP values.

The literature regarding industrial product development has discussed the relevance of communication for customer integration in terms of intercompany prerequisites (see chapter 2.3.2.). Authors such as Biemens (1992), Bruce and colleagues (1995), and Mohr and Spekman (1996) have emphasized the need to create an atmosphere conductive to frequent and timely communication, both internally and externally, and reduce uncertainty and ambiguity through a shared understating of goals and objectives. Also, a new product under development can be integrated more easily into people's minds and lives when it is based on a shared experimental vocabulary and preexisting understandings (Veryzer and Borja de Mozota 2005).

This necessary communication intensity leads to a requirement of *closeness of the partnership.* Closeness is crucial in XP, because every finished release gets presented to the customer in the form of a prototype. This procedure may be viewed as a method for rapidly building and disseminating both explicit and implicit, or tacit, market and technology know-how among members of the development team and the customer, which advances the project. Furthermore, the customer has a fixed role in the product development team, which also supports the closeness between developers and the customer. In the literature, the closeness factor has been mentioned as a means to build and maintain trust (Anderson and Narus 1990; Morgan and Hunt 1994; Buttle 1996; Hutt and Stafford 2000; Rindfleisch and Moorman 2001). Therefore, developers and the customer

should interact as closely as possible and possibly even transfer the development project to the customer site (von Hippel 1994).

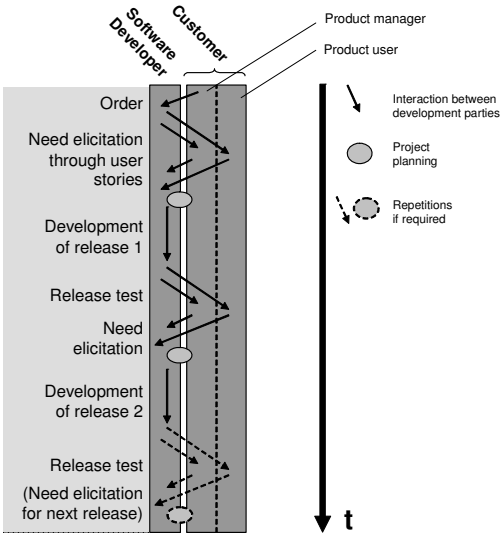
The deciding characteristics of XP's intercompany prerequisites for customer integration thus suggest that the following elements be retained for the reference framework:

- Communication in development team.
- Closeness to the customer.

***Intracompany prerequisites of customer integration***

Literature on the intracompany prerequisites for customer integration emphasizes the appropriate *project and customer integration structure*. The process for integrating customers in the XP method follows a highly regulated approach, as depicted in figure 3-7. The figure shows the course of customer integration activities throughout a software development project. The parties involved in customer integration activities, as illustrated by two pillars, are the software developer and the customer. Within the customer organization, there are two actors involved: the product manager and the product user. The arrows indicate the activities among the parties throughout the project. During product development, the tasks that must be performed by the customer (i.e., need elicitation through writing user stories, testing implemented user stories) are fixed for each release. This structured approach does not conflict with the method's inherent planning flexibility, because only the next release is planned at a particular time, not the whole project. The customer repeatedly gets integrated during the product development process in the same manner, which leads to many customer integration activities that serve as guidelines for developing a product that suits customers' needs. A description of the activities appears on the left side of the figure, and the circles indicate where the project planning parameters are set, adjusted, and refined.

Figure 3-7 Structure of customer integration within Extreme Programming




Structured approaches to customer integration, such that the tasks performed together with the customer occur according to a defined procedure, appear in literature describing *customer integration methods* (see chapter 2.3.3). The most prominent one, the lead user approach (von Hippel 1986, 1988), prescribes five steps performed together with the customer during the early innovation project stages. However, in contrast to XP, the lead user method does not involve any iterations of these steps during the course of the product development project, and therefore, there is no continuous process of creating a product together with the customer.

In summary, the deciding characteristics of XP's intracompany prerequisites for customer integration retain the following elements for the reference framework:

- Structuredness of customer integration practice.
- Number of customer integration cycles.

### 3.2.3 Incorporation of customer contributions into product innovation

Chapter 2.4 discussed research that has been carried out in the field of incorporating customer contributions into innovation activities, which has investigated the specific

contributions the customer can make for product innovation and pointed to the know-how exchanged between the developer and the customer. Within the XP method, these aspects, as investigated subsequently, include access to customer contributions and customer participation in the development of a new product.

***Access to customer contributions***

In XP's product development process, the customer becomes part of the product development team. It contributes to the planning process through regular feedback after every release, which allows more precise estimations about the resources required. These improved estimations reduce the risk that relevant functionalities might not be considered. Another customer contribution comes from the evaluation of the value of each user story, so that the functionalities may be prioritized according to their relevance. If the scope of the project must be reduced, those decisions are made together with the customer. This procedure ensures that only less relevant functionalities get discarded (Beck and Fowler 2001).

Using literature that addresses the *types of customer contributions* (see chapter 2.4.1), Brockhoff (2003) differentiates between solicited customer input, in which case the developer takes the initiative to get know-how from the customer, and unsolicited customer input, where the customer addresses the developer according to its own initiative. For XP, the developer continuously seeks the customer's input into the new product under development to systematically fill the know-how gaps that occur throughout the course of the project. However, once the customer gets used to the process of being contacted on a regular basis, the input flows to the developer in an unsolicited way as well when the customer calls the developer's attention to a new development potential or issue. This solicited and unsolicited know-how flow positively contributes to the incorporation of customer contributions.

Ulwick (2003) categorized customer input as solutions, specification, needs, and benefits. With XP's direct interaction of developers and customers, the whole spectrum of different input types can be accessed. In the software context, the customer usually is technically experienced and therefore can contribute to technical solutions and specifications. However, XP tries to avoid this type of input because technical implementation remains the responsibility of the developers. In contrast, the customer's task is to write user stories that focus on the product application, not the technical implementation. Furthermore, by beginning with the customer's basic need for a new product, XP projects try to uncover real customer benefits. Van Kleef, van Trijp, and Luning (2005) stated in

this context that the more abstract the customer needs are, the more creative freedom is involved. Information about the benefits customers are seeking from a particular product enlarges the solution space and prevents 'thinking inside the box' of current product deliveries.

Extreme Programming succeeds in discovering customer needs and values by collecting customer contributions *at the customer's site* and getting a low-functionality version of the product into customers' hands at the earliest opportunity. Through early prototypes, customers and members of other departments such as marketing and sales—that is, the people generally without deep technical know-how—can constantly investigate the usability, strengths, and weaknesses of a new product. These parties realize the meaning of a new product only when they see evidence that it works. Referring to prototyping and 'materialized' evidence in the context of industrial product development, MacCormack (2001) suggested the relevance of the *medium* through which the customer's contribution is triggered and noted that this medium plays a crucial role in the customer integration process.

With regard to the deciding characteristics of XP's action for accessing customer contributions, the following elements are retained for the reference framework:

- Type of customer contribution.
- Place of accessing customer contribution.
- Media used.

***Customer participation***

Literature on customer integration into product innovation often emphasizes the characteristics of the customer involved, particularly in research on the lead user concept (Herstatt and von Hippel 1992; Lilien et al. 2002; Morrison et al. 2004). Other authors, such as Gruner and Homburg (2000), showed that in addition to lead users characteristics, criteria such as the representativeness of customers for the target markets and their reputation in those markets, as well as the intensity of the interaction between the manufacturer and customer beyond a particular project, can significantly discriminate between better or worse performing products (see chapter 2.4.2).

In typical XP projects, customer criteria, such as those for lead users, do not apply; the customers involved are the project clients who 'ordered' the new product. Therefore, sophisticated customer selection mechanisms are not relevant to XP. The involved customers typically do not have a high degree of innovativeness but rather contribute by

providing insights into what the 'typical' customer needs and values. However, the customer and its role have been discussed intensively in literature. Martin and colleagues (Martin et al. 2003; Martin et al. 2004) emphasized in their work on the role of the customer that identifying the *individual within the customer organization* with the ability to fulfill the customer role in the XP process represents a success factor. Therefore, the specific person who contributes to the new product under development is an important factor, because he or she determines the role played by the customer.

In addition, literature on the development of industrial products has indicated the relevance of the customer's role and corresponding customer contributions (see chapter 2.5.2). Authors such as von Hippel (1988), Lengnick-Hall (1996), Nambisan (2002), and Brockhoff (2003) have stated that, depending on the contribution required for an innovation project, the identity of the users typically varies according to the extent and intensity to which the user is involved, as well as with the stage of the NPD process.

Furthermore, the different *involvement levels*, which depend on the goals developers want to achieve with the customers, have been considered by several authors (Ives and Olson 1984; Kaulio 1998; Brockhoff 2003; Reichwald and Piller 2005). In XP, the intensity of customer involvement remains constant and high. The customer does not participate merely at the beginning of the project to define the specification and at the end to test the final product but instead is part of every development step, in which the project's cost, time, quality, and scope parameters are set anew.

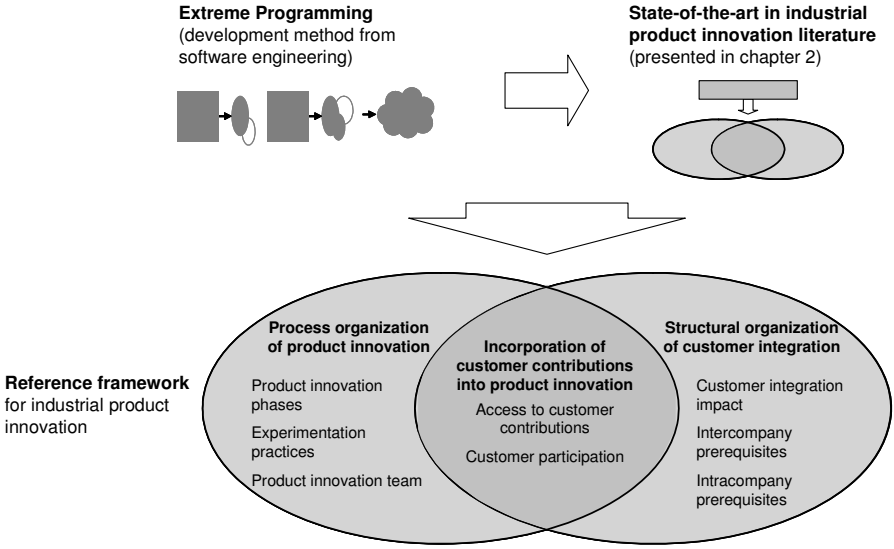
Of the deciding characteristics of XP's customer participation throughout product development projects, the following elements are retained for the reference framework:

- Considered individuals from customer organization.
- Customer involvement level.

## 3.3 Summary of an XP-based customer integration framework

To develop a reference framework for the case study data collection, the *Extreme Programming* (XP) method from software engineering is introduced and assessed from the perspective of both industrial product innovation and customer integration literature. This procedure identifies those elements of customer integration into product innovation that constitute successful development practices in the dynamic context of changing customer requirements. Figure 3-8 shows a general overview of the developed framework.

Figure 3-8 Overview of reference framework development




In the XP assessment, the first aspect was the process organization of the product innovation (chapter 3.2.1), which showed that product innovation phases, experimentation practices, and the product innovation team represent critical elements. The assessment of the second aspect, XP's structural organization of customer integration (chapter 3.2.2), indicated that the impact of customer integration, intercompany prerequisites, and intracompany prerequisites for customer integration all must be considered. Finally, the third assessment aspect, the incorporation of customer contributions (chapter 3.2.3), focused on the development tasks and activities undertaken together with the customer to identify the critical elements of accessing customer contributions and customer participation in the development process. Table 3-2 provides an overview of the overall framework developed, which will be referred to hereafter as the 'XP-based reference framework.' This framework serves as the basis for the case study investigations presented subsequently.

Table 3-2 Summary of XP-based reference framework

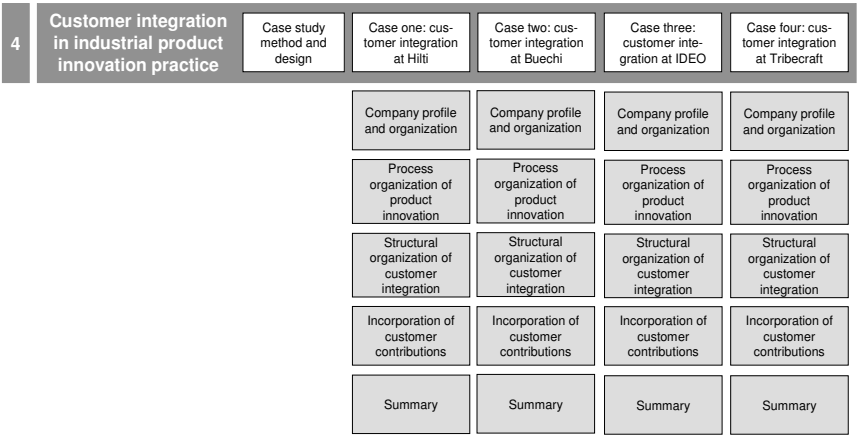
| *Investigation Level* | *Process Organization of Product Innovation* | *Incorporation of Customer Contributions* | *Structural Organization of Customer Integration* |
|---|---|---|---|
| Elements for case study investigation | **Product innovation phases**<br>▪ Degree of process control<br>▪ Adoption of development iterations<br>▪ Planning flexibility<br><br>**Experimentation practices**<br>▪ Acquaintance with development uncertainty<br>▪ Intensity of prototype adoption<br><br>**Product innovation team**<br>▪ Communication (un-) bureaucracy<br>▪ Team cross-functionality<br>▪ Gatekeeping functions | **Access to customer contributions**<br>▪ Type of customer contribution<br>▪ Place to access customer contribution<br>▪ Media used<br><br>**Customer participation**<br>▪ Considered individuals from customer organization<br>▪ Customer involvement level | **Customer integration impact**<br>▪ Customer impact on development resources<br>▪ Customer impact on development creativity<br><br>**Intercompany prerequisites**<br>▪ Communication in development team<br>▪ Closeness to customer<br><br>**Intracompany prerequisites**<br>▪ Structure of customer integration practice<br>▪ Number of customer integration cycles |

# 4 Customer integration in industrial product innovation practice

This chapter presents case studies of four industrial companies that integrate customers into their product innovation activities. The case studies result from the empirical, in-depth investigation phase of this research (see chapter 1.2.2). The presentation of the research cases relies on the XP-based reference framework and provides an empirical basis for cross-case analysis for theory building (chapter 5) and the development of a decision model (chapter 6).

The following section first presents an overview of the case study method and the design of the individual cases. The four single case studies are presented subsequently (see figure 4-1).

Figure 4-1 Outline of chapter 4




## 4.1 Case study method and design

The companies selected for the in-depth case studies all take successful measures to profit from their customers' know-how through their new product development activities. They actively attempt to integrate customer contributions directly into their R&D, address new customer requirements, and uncover underlying customer needs. The identified similarities among the cases in their management practices across their diverse

customer integration activities indicate that a relationship exists between practice and outcomes (Lynn et al. 1996).

As described in chapter 1.2.2, those cases with the greatest identified learning potential were selected (Glaser and Strauss 1967; Eisenhardt 1989). The companies were chosen due to their pioneering efforts in customer integration and a focus on a modular product structure within their product innovation activities. Most of the modules can be upgraded independently with minor release costs. The companies all operate within the technology spectrum from low- to high-tech. Additionally and in line with Eisenhardt's (1989) recommendation to fill theoretical categories, companies from different industries with different business models and sizes were considered: two companies can be categorized as *in-house developers* because of their in-house product development activity. The other two represent *development contractors*, that is, professional technical service firms that develop product innovations with their principals (i.e., in-house developing companies) on a project basis. Whereas one in-house developer (*Hilti*) and one development contractor (*IDEO*) can be regarded as *big enterprises* in relation to their industry average, the other two (in-house developer *Buechi* and development contractor *Tribecraft*) are *small enterprises.* From the perspective of an interindustry analysis, the ratio of the big to the small company in terms of their employees is comparable for both industries. Table 4-1 offers an overview of the empirical data set.

Table 4-1 Overview of the companies selected for in-depth case studies

| | *Industry* | *Staff* | *Headquarters* | *R&D from Turnover* | *Technology Intensity* |
|---|---|---|---|---|---|
| HILTI | In-house developer for construction and building maintenance | 15,000 | Schaan, Principality of Liechtenstein | 4% | Whole spectrum from low- to high-tech |
| BÜCHI | In-house developer of laboratory equipment | 300 | Flawil, Switzerland | 10% | Whole spectrum from low- to high-tech |
| IDEO | Development contractor for industrial and consumer goods | 450 | Palo Alto, California, United States | 85% | Whole spectrum from low- to high-tech |
| TRIBECRAFT konzeption design engineering | Development contractor for industrial and consumer goods | 7 | Zurich, Switzerland | 85% | Whole spectrum from low- to high-tech |

The unit of analysis for this investigation is the product innovation process for a representative industrial product innovation project into which customers were actively integrated. Case data were collected according to the XP-based reference framework (chapter 3.3) and as described in the research methodology (chapter 1.2.2). The case studies pertaining to the in-house developers *Hilti* and *Buechi* present a specific project to illustrate the customer integration structure. Because specific product innovation projects for development contractors involve secrecy agreements, *IDEO's* and *Tribecraft's* practices are presented as neutral descriptions of representative projects.

The cases are structured according to the XP-based reference framework developed in chapter 3. To provide consistent case studies and avoid repetition, however, the presentation of company information may not rigidly follow the framework but instead prioritizes the companies' characteristics. In general, the presentation of each case proceeds along the following organization:

1. *Company profile and R&D organization*. A short introduction to the company and its environment, key figures, products, customers, markets, organizational structure, and R&D clarifies the company's customer integration activities and implementation.

2. *Process organization of product innovation.* This section presents the company's product innovation focus and strategy; the phases of the innovation process, including experimentation and prototyping activities; and the team composition for product innovation projects.

3. *Structural organization of customer integration.* This section discusses the impact of customer integration, as well as the companies' inter- and intracompany prerequisites for customer integration into product innovation projects.

4. *Incorporation of customer contributions.* This section explores the specific access to customer contributions and the customer's participation in a product innovation project.

5. *Summary.* The last section summarizes the findings by mapping the companies' activities of customer integration into product innovation on an illustrative display.

## 4.2 Case one: customer integration at Hilti

> See? The structural steelworkers in America have been wishing for exactly what we developed!
>
> —Project Manager Business Area Direct Fastening, Hilti, reviewing a videotape with his development team, making a comment regarding a steelworker's smile after testing a prototype

### 4.2.1 Company profile and organization

***Introduction and key figures***

*Hilti* is a world leader in developing, manufacturing, and marketing added-value, top-quality products and services for professional customers in the construction and building maintenance industries. As a group, *Hilti* maintains a presence in more than 120 countries worldwide and employs more than 15,000 people, of whom two-thirds interact directly with customers through sales, engineering, and customer services (see table 4-2). Approximately 1,500 people are employed at the company's headquarters in Schaan, Principality of Liechtenstein.

Table 4-2 Hilti at a glance

| | |
|---|---|
| *Headquarters* | *Schaan, Principality of Liechtenstein* |
| *No. of sites* | *135—127 are sales locations* |
| *No. of employees* | *15,000* |
| *Industry* | *Construction and building maintenance* |
| *Products* | *Drilling and demolition, direct fastening, diamond and anchoring systems, fire stop and foam systems, positioning and screw fastening systems, cutting and sanding systems* |
| *Technology intensity / dynamics* | *Whole spectrum, from low to high tech* |
| *Positioning in the market* | *Innovation leader* |
| *Turnover 2004* | *About 3.3 Bio CHF* |
| *Innovation cycles* | *3–15 years* |
| *Employees in R&D* | *About 450* |
| *Investments in R&D from turnover* | *4%* |

Since its founding in 1941, *Hilti* had been profoundly influenced by the values, tradition, and spirit of its founder, Martin Hilti. *Hilti*'s executive management draws from his principles and core beliefs and keeps the company in a state of constant evolution in

which people always remain the focus, utmost quality is a must, and *Hilti* products are sold via direct sales. 'Sustain that which has sustained' is its motto, according to which executive management constantly realigns the company (Hilti 2003). However, it remains controlled by the Hilti family, and since 2000, all registered shares of the *Hilti* Corporation have been held by the Martin Hilti Family Trust (nonvoting participation certificates have been listed on the stock exchange since 1986). Finally, it was one of the first companies in the world to receive an ISO 9001 certificate in 1996.

***Products, customers, and markets***

*Hilti* delivers high added value in the premium construction segment through a product range that covers drilling and demolition, direct fastening, diamond and anchoring systems, fire stop and foam systems, installation, positioning and screw fastening systems, and cutting and sanding systems (for examples, see figure 4-2). Its service offerings include devices with corresponding tools and consumables, consulting, application instruction and training, technical documentation, and customer-oriented service after sales.

Figure 4-2 Examples of Hilti technology: breaking and direct fastening

Source: Hilti (2005a).

*Hilti* serves worldwide professional customers in the construction industry, including construction experts, electricians, fitters of sanitary facilities and elevators, metal workers, carpenters, general entrepreneurs, and civil construction authorities. The company also recognizes engineers and architects as important influences and experts in terms of their know-how about customer behavior and competitive performance. Products, services, sales, and consulting all are tailored to different customer segments, from inde-

pendent construction workers to building (sub)contractors. This differentiation leads to an extremely broad assortment of premium-quality and -priced products (Drenth 2002).

Martin Hilti's belief that "market share is more important than factories" led to a significant emphasis on understanding and answering customer needs. Recognizing that customers would value knowledgeable advice on how to best use *Hilti* tools, the company established a direct sales force rather than using distributors or dealers (Hilti 1997). Almost without exception, *Hilti* products offer the highest quality and highest price in each product category in which the firm competes. Such price premiums have been justified by not only the enhanced durability and productivity of *Hilti* equipment but also the reliability of *Hilti* services.

> Hilti successfully sells its products at a price which is 20 up to 40 percent above competitors' prices. (Project Manager Business Area Direct Fastening)

*Hilti's* competitors include both worldwide businesses and national and local companies that function within core and related construction industries. Its important global competitors are Atlas Copco, Black & Decker, Bosch, EJOT, Fischerwerke, ITW, and Würth.

> We know that with competitors like Bosch, Würth, and the Japanese, we will be hard pressed to maintain a conventional competitive advantage. They too will find ways to reduce their time to money cycle, lower costs, improve logistics, and so on. Our uniqueness, which they will have very great difficulty in copying, because you cannot buy it off the shelf or get it from a consultant, is our culture. We are fast, flexible, and constantly open to change. (Pius Baschera, CEO of the Hilti Corporation, qtd. in Hilti 1997: 5)

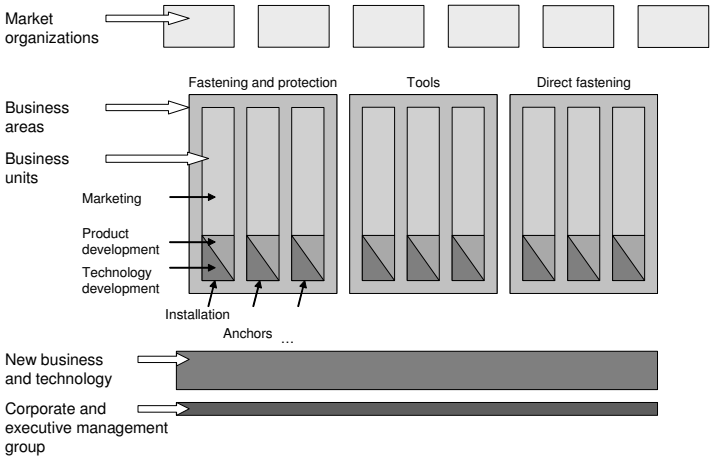
The company strategy focuses on increasing profitability on the basis of innovations, operational performance, and direct market sales. At the heart of *Hilti*'s strategy lie the 'three Cs,' strategic guidelines systematically promoted throughout the company (Hilti 2003):

- *Customer:* potential-oriented sales, market coverage and penetration, share of wallet and relative market share.
- *Concentration:* focus on products and markets with leadership potential.
- *Competence:* quality, innovation, direct access to customers, brand management.

***Organizational structure and R&D***

*Hilti* maintains several manufacturing facilities in Europe, America, and Asia. The research and development functions are situated in the Principality of Liechtenstein and Germany. The company is organized into three business areas (Fastening and Protection, Tools, and Direct Fastening), all of which are located in Schaan, Principality of Liechtenstein, but are independent in their operational activities. The business areas are further organized into business units, each of which has its own marketing and development division. As a consequence, business units have a high degree of autonomy (see figure 4-3).

Figure 4-3 Hilti organizational structure




Source: adapted from Hilti, Electric Tools & Accessories business area, Hilti (2005a).

Development activities within the business units further are separated into product and technology development. The role of technology development is to determine whether new technologies can be realized by a marketable *Hilti* product. To make this determination, it receives input from New Business & Technology (NB&T), the corporate technology department, which focuses on identifying new trends, technologies, and technology predevelopments to serve the business units. Corporate management takes responsibility for companywide strategic decision alignment, including strategy formulation, organizational change, and overlapping projects in marketing and technology.

As a result of *Hilti*'s direct selling approach, more than two-thirds of its employees work in the market organization (i.e., sales, consulting, or service) and are in direct contact with customers, which virtually guarantees a very strong customer orientation. *Hilti* has its own market organizations at its disposal in approximately 50 countries that produce 90 percent of its turnover. In another 70 countries, *Hilti* is represented by sales partners and agents. *Hilti* headquarters aspire to realize close cooperation among the market organizations to combine experiences and facilitate the extensive exchange of know-how.

Corresponding with the business area structure, the market organizations are structured according to their business focus: most salespeople concentrate on one of the three market areas. In each major country organization, a senior manager runs an area. Furthermore, each country has a central customer service operation that can be reached by telephone at all times, as well as *Hilti* Centers, small stores where *Hilti* customers can pick up commonly used, fast moving *Hilti* products, such as drill bits. Supported by the e-business channel and shop-in-shop concept, *Hilti* can service both large and small customers (Hilti 2003).

### 4.2.2 Process organization of product innovation

***Product innovation focus and strategy***

In the early 1970s, Martin Hilti shifted the company focus from a technology to a market orientation. The basis for this change was the 'Hilti Market Value System,' which included assessments of customer needs, close collaboration of marketing with development and production, and market supply grounded in in-depth analysis (Hilti 2003). Today, the company's strategic orientation toward innovation is considered market as well as technology based. The main strategic objective related to innovation is to increase the percentage of new product sales on turnover. Most projects are initiated by *Hilti* customers and arrive at the development department through the market organization.

> Most new product developments, in particular short-term–oriented projects, are driven from the business area side, based on an identified and specific customer need. In the NB&T department, projects are often initiated through the identification of new technological trends and completely new application fields. Therefore, our projects have a rather long-term orientation to ensure innovative product solutions in the mid- and long-term. (Senior Vice President New Business & Technology, Hilti)

In order of the different degrees of new product innovativeness, *Hilti* differentiates among new generation projects, product advancements, and radically new projects.

***Product innovation phases and prototyping practice***

*Hilti*'s innovation process can be split into three categories: research process, technology and platform development, and product development. The product care and phase-out process follows these three categories. The overall innovation procedure—called the 'time to money' (TTM) process—reflects a stage-gate process with six gates. At every gate, the company makes a 'go' or 'no-go' decision. The TTM process is planned in detail for every project, and significant efforts are undertaken to meet the planned deadlines.

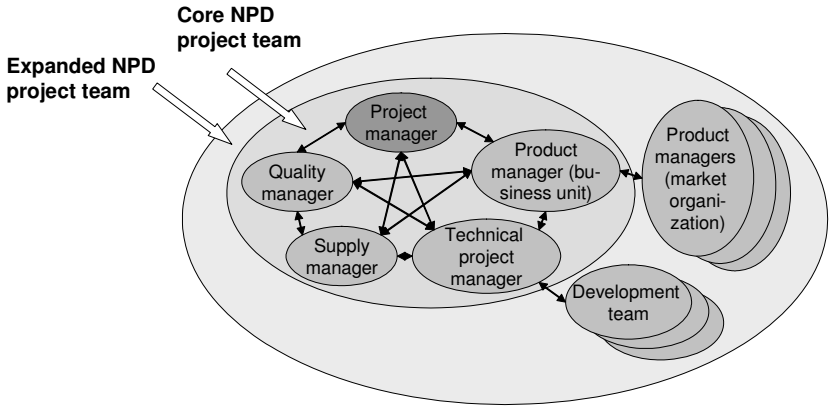
The early innovation phase, the front-end, includes Gate 1 (opportunity, providing detailed information about whether the subject investigated represents a business opportunity) and Gate 2 (task, providing the product concept and a project plan). The stage between the gates is referred to as the 'product definition' phase. After Gate 2 comes the 'concept' phase, which leads to Gate 3 (targets, providing key results in the form of a product solution and marketing concept). At Gate 3, the product board, which consists of a committee of executive managers, reviews the final product concept and makes the final 'go' project decision. After the sequencing 'design' phase, Gate 4 requires a tested system, from which the 'launch preparation' phase initiates. Gate 5 aims to initiate the market introduction.

Prototyping is a fundamental element in *Hilti*'s product innovation activity and is employed throughout the whole innovation process. Highly formalized prototype testing by customers represents a specific activity in the TTM process. Details about the specific development activities within the process and prototypes are presented in section 4.2.3, illustrated by a specific product innovation project.

***Product innovation team***

In line with *Hilti*'s market focus, the market organization is strongly integrated into new product development. A development team consists of the project leader; a product manager from the business unit responsible for the potential market analysis and the marketing concept, as well as for the selected product managers in the market organization; a technical product manager; a quality manager; and a supply manager who focuses on strategic sourcing and resource planning (see figure 4-4). Whereas the core project team consists of 4–6 people, the expanded project team includes 10–30.

Figure 4-4 Overview of Hilti project teams




Source: Hilti (2005b).

The project manager from the specific business unit visits the responsible product manager from the market in which the product will be sold first (i.e., the lead market) on a regular basis. To ensure the developer team understands actual customer needs, the team also visits customers during prototype testing.

### 4.2.3 Structural organization of customer integration

***Customer integration impact***

With its focus on customer integration, *Hilti*'s distinctive direct sales policy has remained a company mainstay. It grew out of technological necessity in 1957, as illustrated by the following example: the 'DX piston principle' developed by *Hilti* represented such an innovative technology that it had to be explained to customers. Therefore, Martin Hilti arranged for the product to be demonstrated in an active, hands-on situation, directly on the construction site. This measure ensured close contact with the customer and thus immediate feedback about customers' needs and desires (Hilti 2003). As the principle continued, the intense consideration of customer feedback, collected early in product innovation projects, became routine. The company also adopted practices such as the lead user approach (see chapter 2.3.3). As a result, *Hilti* has long been known for its successful lead user projects and served many authors as a subject for in-depth case study data (Herstatt 1991; Herstatt and von Hippel 1992). In addition to the lead user concept, *Hilti* employs a broad set of market research techniques, provided mainly by the market organizations.

***Intercompany prerequisites for customer integration***

*Hilti* has excellent know-how about market and customer structures because of its direct selling approach and sophisticated market research, as well as the active customer integration tools it applies. However, the conversion of this market know-how into innovative product opportunities remains challenging, especially because of the distance between the market organizations and the development departments of the business units. To overcome this situation in the development of new products, the project manager from the business unit communicates with the future product manager from the main or selected market organizations as early as the first step in the TTM process.

Furthermore, regular exchange with customers represents a fixed element in *Hilti*'s product innovation process. The project leader, the product manager and local product managers, and the technical project leader (for highly technical projects) serve as contact partners for the customers, which are integrated during concept generation and testing.

> Also developers participate when we observe focus groups of construction workers testing first functional prototypes. Developers' profound technical comprehension provides valuable insights which could not be understand and absorbed by product managers, even though they also are technically versed. (Project Manager Business Area Direct Fastening, Hilti)

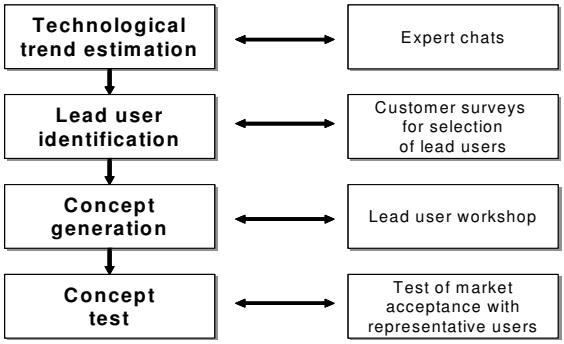
The general interaction of *Hilti* with its customers can be exemplified according to the steps of the lead user approach, which are also illustrated by figure 4-5:

- *Technological trend estimation through chats with experts*. With the experts, the trends and opportunities relevant for the development of a new product are identified.
- *Lead user identification through customer surveys in the specific market*. Those customers who see a significant benefit in the new product being developed are especially relevant. The market organization is integrated for lead user identification, because of its profound know-how about customers and its ability to contribute to product innovations (e.g., articulate needs). Customer surveys generally are conducted by telephone. External companies can be considered for attaining copious data.
- *Concept generation in workshops together with lead users*. A workshop can take up to three days. The participants from *Hilti*'s side include engineers, product

managers, and marketing managers, complemented by experts who already have contributed to the trend estimation.

- *Test of market acceptance in a concept test with representative users*. The aim of this last step is to ensure the relevance of the future new product to a broad market segment.

Figure 4-5 Customer integration structure at Hilti—lead user approach




Source: Hilti (2005a).

The lead user approach is not enforced as rigorously as the methodology prescribes, because the applicability of the steps strongly depends on the character of the project. However, all product innovation projects consider these four steps in one way or another, as the following demonstrates.

***Intracompany prerequisites of customer integration***

Within *Hilti*, the integration of customers follows a highly structured approach. A specific but typical product innovation project offers an illustration of this structure as a means to achieve a profound understanding of the situation. The analyzed business area, one of the traditional business areas active in a mature market, develops and manufactures tools for setting bolts and nails efficiently and safely.

The product development being considered is a stand-up tool for direct fastening. The device had appeared in the European market but required a complete reconceptualization for its introduction to the U.S. market. The project was initiated after a customer request from the U.S. market. The idea behind the new device was to enable the user to fix corrugated metal onto steel, a common practice in the U.S. construction

business, especially in the building of production plants and warehouses. In the United States, this task was usually completed by welding, but the *Hilti* solution would shoot a nail into the corrugated metal. This application is faster, simpler to use, and more cost effective than the traditional welding solution.

> The stand-up tool offers the North American market an alternative, especially for large roof areas and thin girder profiles. One single worker is able to make up to 1,000 fastenings per hour, thanks to our innovation. He moves four to six times as fast as he would weld—and doesn't even have to bend his back. (Project Manager Business Area Direct Fastening, Hilti)

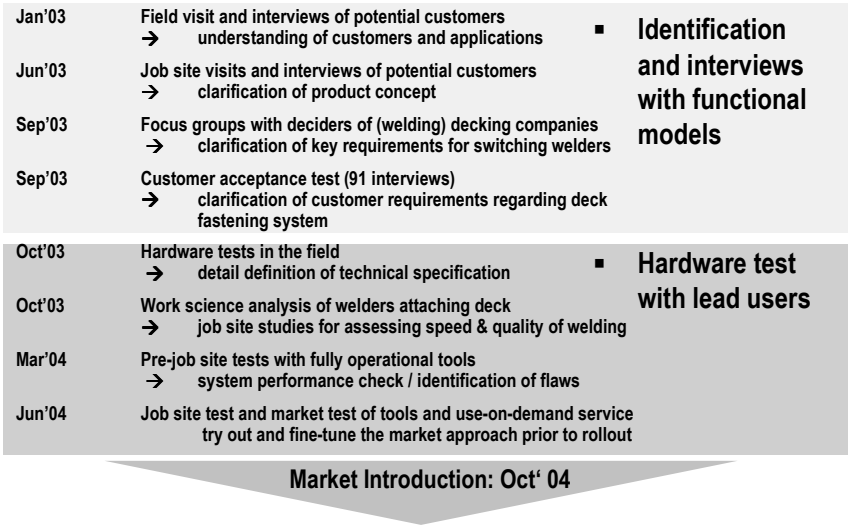
Even though a similar product existed in Europe, the project represents a product innovation because its performance requirements demand completely different handling. Therefore, it was not possible simply to transfer the already existing European product to the American market. For 10 years, *Hilti* had not succeeded in increasing its share in the U.S. market with the mechanical fastening method, but from its experience in the European market, *Hilti* knew about the potential of the new product, which would use new technology that corresponded better to customer needs. After its completion, the new product was released successfully in the U.S. market, and since its introduction, *Hilti*'s market share has increased significantly.

To identify high potential customers from the U.S. market to participate in the development of the new product, current customers were mapped according to their salary costs, which indicate the relevance of performance improvement devices to the customer and thereby cross all relevant geographical areas.

In the definition stage of the product development (based on a business opportunity description and project plan that covered the time prior to Gate 2), *Hilti* attempted to gather more know-how about its customers and the relevant product applications in the selected salary cost areas. Therefore, a questionnaire was prepared and sent to selected customers. The questions contained in it focused more on getting insights into the customers' perspectives about future themes and developments than on specific aspects of the new product. Additional questions asked how much a customer was willing to pay for a needed fastening application. Because *Hilti* products are expendable goods that amount to a maximum of 2 percent of the construction budget, customers (e.g., building contractors) do not consider them a primary focus. To complement the questionnaires, the project leader and product manager from the business unit and the product manager from the U.S. market organization conducted 20 field interviews with selected customers (see figure 4-6).

In the concept stage, starting in June 2003, the product concept was clarified through additional site visits and interviews with potential customers. The discussions were conducted with decision-making management level employees of pertinent general contractors and subcontractors. At this stage, the product buyer (managers from the customer company who are responsible to take investment decisions) traditionally would not be considered, because the precise cost parameters are unknown, but because this new project represented the introduction of a new application to a new market, the product buyer was contacted in this case. With this meeting, *Hilti* tried to verify the customers' product acceptance and willingness to buy the completely new fastening concept and therefore presented them with early functional prototypes. Customers again were selected so that they covered the spectrum of known customer needs.

Figure 4-6 Project plan of the fastening project




Source: Hilti, Electric Tools & Accessories business area, Hilti (2005a).

With the assistance of the U.S. market organization, a focus group of three to five professional welders was organized in September 2003 to present the fastening method. This event took place three months after the concept test. To avoid product perception bias, the fact that the new fastener was a *Hilti* product was withheld from the focus group members. Welders represented the relevant users because, at that time, approxi-

mately 80 percent of fastening occurred through welding, which made them the right people to convince about a new product solution.

Subsequent to the focus group interviews, further customer acceptance tests were conducted, for which interviewees filled in a five-page questionnaire that addressed critical issues pertaining to product specifications. The questionnaire, which accompanied the prototype, asked about their contentment with its technical product attributes, such as performance and reliability. Further questions queried whether the person would buy or recommend the new product. In total, 91 interviews were conducted with about 65 companies, which allowed large-scale verification of the results. In addition to this customer acceptance test, internal lifetime tests also were employed to test the technical characteristics. A lifetime test at this early stage is necessary because manufacturing of the required production tools had to start by this point to avoid a production delay.

During the design stage, intensive testing of the final prototypes with customers took place for several days at the customers' construction sites. Marginal changes initiated by the customer could still be built into the product, because serial production had not started yet. These changes did not pertain to technical modifications but instead to ergonomic elements relevant for product design and handling.

Finally, in the market introduction stage, 'check-up tests' were conducted at the customer's site, as well as internally at *Hilti*, to prepare the marketing organization for the product launch and link customers with the initial sales activities.

### 4.2.4 Incorporation of customer contributions

***Access to customer contributions***

As this project example shows, *Hilti* collects insights about future trends and themes from its product buyers and users, clarifies the relevance of the product concept with users, and conducts various product tests to ensure customers' product acceptance and adjust the product's ergonomics and handling. To obtain its required contributions from customers, *Hilti's* project managers recognize it is crucial to invest continuously in motivating customers to contribute during the entire innovation process. For customers, it must be evident that they can get something in return for their efforts to contribute to the product innovation project. The best input from the customer comes when the same individuals are integrated throughout all development steps. Financial commitment from the customer to buy the new product under development usually occurs at the end of the design phase and is needed to start the production stage. Because the new product repre-

sents an expendable good (2 percent of the construction project budget), customers make investment decisions about it only at a late stage. As a consequence, *Hilti* must have a clear understanding of the perceived added value for the customer to guarantee a successful market introduction of the new product, as well as sustainable business.

Customer contributions usually are accessed at the customer's site, whether in the office buildings in which those who make the buying decisions work or at construction sites where product users can offer their own contributions. The media used to provoke these contributions usually are mature, functional prototypes. During the construction site visits, the *Hilti* project manager and accompanying developers try to catch both articulated customer contributions and unarticulated areas for improvement that may become evident from the observed difficulties the customer encounters while answering questions or handling a prototype.

***Customer participation***

It is important for *Hilti* to consider the market nuances in the customer selection process, so that it may capture the requirements relevant for the whole market segment. *Hilti* counts on its contact with a few customers it has collaborated with for many years. This relationship ensures excellent understanding between them and facilitates the communication process. For their customers, *Hilti* differentiates between product buyers (managers who make the investment decision) and product users. Both groups are considered in product innovation projects. Furthermore, in addition to direct customers that buy *Hilti* products (mostly large general contractors and subcontractors), the company also considers architects and civil engineers, who can set important parameters relevant to the new product development, influence construction projects, and determine the use of construction materials—all decisive aspects for the application of *Hilti's* technology.

Different customers can be selected and contacted by project leaders autonomously, meaning there is no specific policy for a general customer database. Overall, *Hilti* communicates with a few long-term customer partners to ensure high-quality feedback. These customers must have lead user characteristics (von Hippel 1977, 1988): they significantly profit from the new product to be developed, and they already have needs that will be representative of the broader market later. Regarding this second aspect, *Hilti* emphasizes that overly innovative customers (e.g., anticipate needs 10 years before they will be relevant to the larger market) are not helpful, because the inert construction industry could not accept their innovations immediately.

> We know the definition of lead users from theory. But a further characteristic that we consider being crucial as regards lead users is that they are only valuable for *Hilti* if they are still within the traditional construction applications. Applications from other industries lack relevance for the *Hilti* business. Furthermore, the market power of the customer considered is a most relevant aspect which positively contributes to a project's input-output ratio from a resource perspective. (Project Manager Business Area Direct Fastening, Hilti)

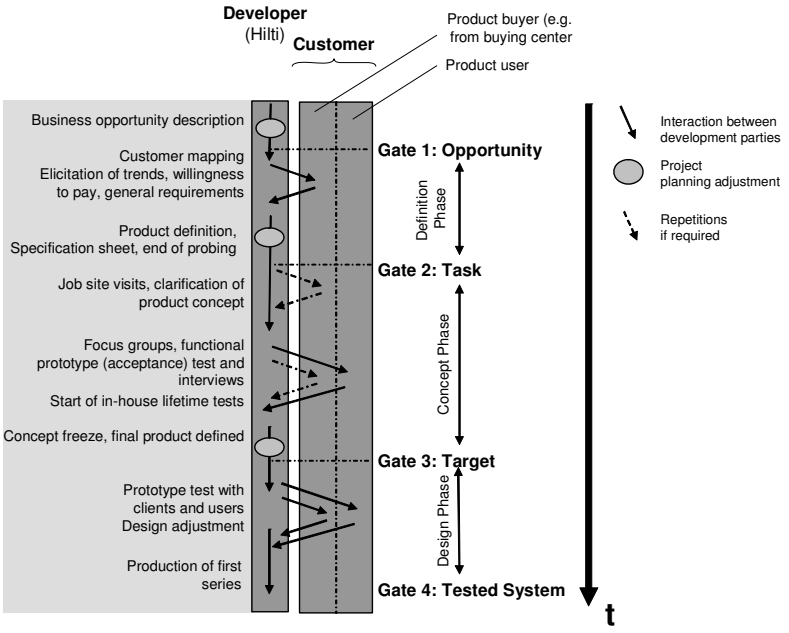
In addition to this restriction of potential lead users to the construction industry, other selection mechanisms are employed: after the initial market survey, only those customers with positive attitudes toward the project are considered further, because it is very difficult to convince customers about the new product if they have a negative attitude from the start. *Hilti* contacts these customers, however, for specific orders after the product has been finished.

In terms of the involvement level, customers are considered during the definition and concept phase to obtain profound insights into their needs. Focusing on the person who makes the product buying decision (management level in the customer's organization), he or she is predominantly interested in the investments required for a product innovation and therefore rarely contacted during the concept phase. This buyer becomes involved again during the design phase, when the exact product parameters are fixed and the precise product cost can be calculated. As a consequence, he or she might be considered an *advocatus diaboli* who sets the project challenge, whereas the product users represent critical testers who provide genuine, unbiased feedback.

### 4.2.5 Summary

*Hilti*'s product innovation activities are summarized in figure 4-7, which depicts the course of the customer integration activities in a product innovation project. The product innovation process with its stages and gates appears on the right side of the figure. The parties involved in the customer integration activities, illustrated by two pillars, are the developer (*Hilti*) and the customer. Within the customer organization, two actors are involved: the product buyer, a representative from the buying center of a general contractor or a facility manager, and the product user, who belongs to the general contractor's company. The arrows indicate the activities among the parties throughout the project. A description of the activities appears on the left side of the figure, and the circles indicate where project planning parameters are set, adjusted, and refined.

Figure 4-7 Summary of customer integration into product innovation at Hilti



## 4.3 Case two: customer integration at Buechi

The reason why we integrate customers into innovation projects is simple: success.

—Head Business Unit Research & Discovery, Buechi

### 4.3.1 Company profile and organization

***Introduction and key figures***

*Buechi* Labortechnik AG (hereafter referred to as *Buechi*) is a global leader in providing laboratory equipment for the chemical, pharmaceutical, and food and feed industries, as well as to universities. With its headquarters in Flawil, Switzerland, *Buechi* products support laboratory processes for the discovery of new chemical compounds in research and development laboratories, from optimization through scale-up and including quality control in production processes for raw materials and end products (see table 4-3). *Buechi* emerged from a Swiss glassblowing enterprise in 1939, and nonautomated precision glassblowing remains the differentiating competence required in this industry. The company is still family owned.

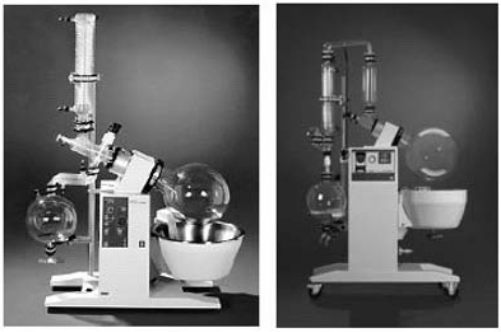
Table 4-3 Buechi at a glance

| | |
|---|---|
| *Headquarters* | *Flawil, Switzerland* |
| *No. of sites* | *8—7 are distribution organizations* |
| *No. of employees* | *300 worldwide* |
| *Industry* | *Laboratory equipment* |
| *Products* | *Instruments for pharmaceutical and chemical research and quality control* |
| *Technology intensity / dynamics* | *Whole spectrum from low to high tech* |
| *Positioning in the market* | *Fast follower/innovation leader (depending on the product)* |
| *Turnover 2004* | *About 50 Mio Euro* |
| *Innovation cycles* | *6–9 years* |
| *Employees in R&D* | *38* |
| *Investments in R&D from turnover* | *About 10%* |
| *Ambition for sales growth* | *10% annually* |
| *Strategic goals* | *Retaining independence and providing a product-sets approach for laboratory product portfolio* |

***Products, customers, and markets***

The Swiss company is world market leader in the production of rotary evaporators, serving research laboratories in both industrial and university research. *Buechi* generates most of its turnover with its rotary evaporator product line, widely considered the standard laboratory evaporator (Rotavapor®, see figure 4-8 for examples). In its remaining product spectrum, *Buechi* faces a wide scope of possible laboratory applications from which the company must choose the most profitable ones. It also covers the fields of nutrition analysis and products for protein and fat extraction. *Buechi* further focuses on occupying a growing market position with its NIR (near infrared) instruments for industrial process control and quality assurance and therefore has developed leading, software-enabled products for chemometric analysis of spectral data.

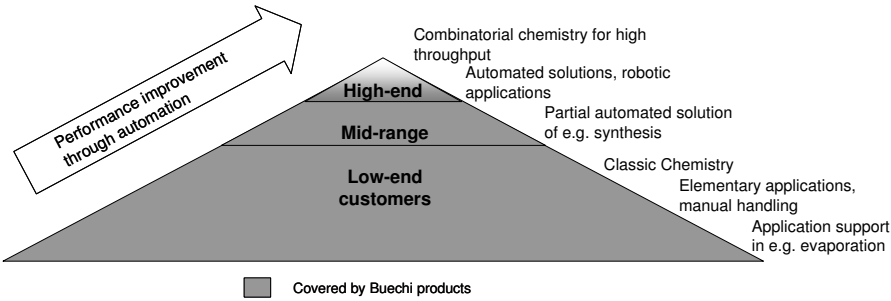
Figure 4-8 Examples of Buechi products: rotary evaporators



Source: Buechi (2004).

The diverse application fields for laboratory equipment in research range from low-end, mainly manual processes at universities and research laboratories to high-end, automated laboratory processes in the pharmaceutical industry, which tries to increase productivity through automated screening and synthesis processes (see figure 4-9). For low-end product solutions, competition is mainly cost driven, whereas high-end customers prioritize performance. Products from the quality control segment are developed mostly for pharmaceutical mass production.

Figure 4-9 Range of Buechi products




Source: adapted from Buechi (2004).

*Buechi* covers low-end to high-end customers but ignores fully automated, high-throughput applications for combinatory chemistry, as well as classical manual chemistry applications. The university segment in the lower end constitutes 25 percent of the overall turnover. The company aims at incrementally improving its customer processes through automated and partially automated product solutions for a broad customer segment.

Although it sells its products to Asia, Europe, and the United States, the 'flagship market' for top-range products is Japan, with a turnover share of 9 percent. However, the Chinese and American markets offer the biggest growth potentials.

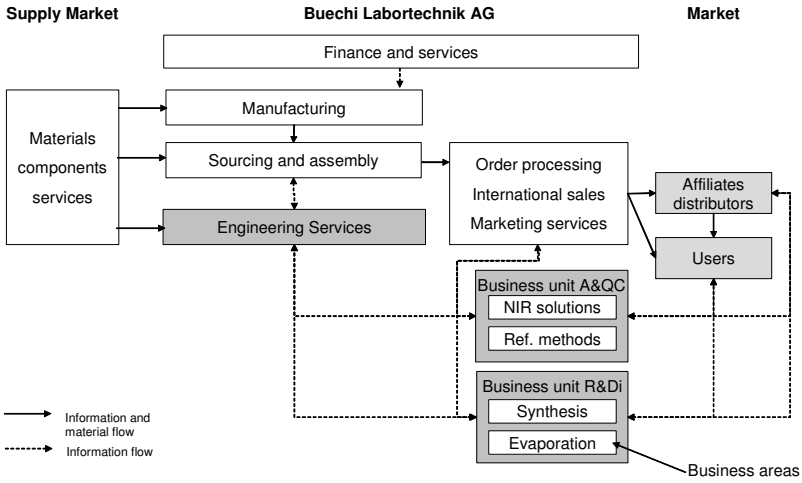
> The U.S. market is still dominated by very simple, non-automated laboratory processes—one person manually accomplishes one task at a time. Simple product solutions enabling a partial automation promise a significant performance improvement." (Head Business Unit Research & Discovery, Buechi)

*Buechi's* products are sold through its own affiliates and laboratory distribution partners. Depending on the market's specificity, distribution partners sell laboratory products to other distribution organizations or directly to customers. Due to increasingly complex products and market situations, *Buechi* has strengthened its efforts to found new affiliates in important markets, such as China, and thereby get closer to its products' customers. Distance from the customer has been identified as a possible reason that *Buechi* missed several trends and innovation potentials in the 1980s and 1990s.

***Organizational structure and R&D***

*Buechi* follows a functional organization. At its core lie two business units: Research and Discovery (R&Di) and Analysis and Quality Control (A&QC). Both of these are divided further into two areas: R&Di into Evaporation and Synthesis and A&QC into NIR Solutions and Reference Methods. The approximately 15 employees in each business unit are responsible for perfective maintenance across product life cycles and to introduce new product concepts and preprototypes for innovation projects. Another department, Engineering Services, realizes these product innovations through construction design, software, and electronics. This business unit generally is regarded as a service function for R&Di and A&QC. Figure 4-10 provides an overview of *Buechi's* organizational structure.

Figure 4-10 Buechi organizational structure




Source: adapted from Buechi (2004).

Products are manufactured on the basis of the product development provided by Engineering Services. The entire value chain pertaining to product development and manufacturing is located in Flawil, Switzerland.

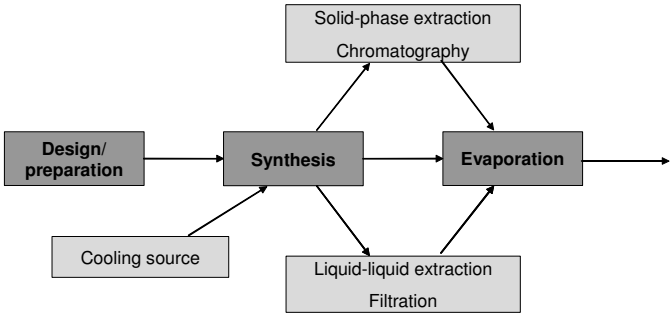
### 4.3.2 Process organization of product innovation

***Product innovation focus and strategy***

*Buechi* needs to remain strongly market oriented. Because the laboratory equipment market is saturated, it is difficult to achieve growth or maintain market shares in the face of strong competition. With the exception of the small segment of performance-oriented combinatorial chemistry, laboratory automation cannot be the predominant remedy for performance improvements. Because chemistry is at its core diverse, automated processes impose too many restrictions on research and discovery. As a result, *Buechi* focuses on developing simpler, partially automated devices with highly reliable processes, which can provide flexibility for laboratory work without narrowing it. Sales arguments for new products—especially for customers in the partial automation segment, for whom cost criteria count—involve product handling convenience, the lack of time investments needed to familiarize employees with the device, usability for different applications, reliability, and potential productivity increases. Because both design and ergonomics play mayor roles, *Buechi* collaborates with external designers in their product innovation projects. Strategically, it hopes to achieve 20 percent of it sales from products less than a year old.

This case study concentrates on the R&Di business unit, within which *Buechi* positions itself as a provider of systems solutions in the laboratory equipment market. Its products in the laboratory environment concentrate on three core processes: (1) synthesis, (2) evaporation, and (3) separation, which involves processes such as chromatography and extraction (see figure 4-11).

Figure 4-11 Product focus of R&Di business unit




Source: adapted from Buechi (2004).

As highlighted in the introduction to this case study, *Buechi* maintains a significant presence with its Rotavapor®, a laboratory evaporation device. *Buechi* introduced the first automated evaporation device to the market in 1957, but the market has matured and now offers few prospects for growth. In addition, *Buechi* successfully functions in the chromatography field. With regard to synthesis, *Buechi* strategically concentrates its forces on introducing promising product innovations.

> Our goal is to support our customers along their laboratory process chain. If we succeed, Rotavapor customers also buy Buechi products for chromatography and synthesis. But therefore, we now have to develop a good product solution for the area of synthesis (Head Business Unit Research & Discovery, Buechi)

***Product innovation phases and prototyping practice***

Product innovations at *Buechi* start with a strategy and vision, which is formulated for every business unit. The product innovation process includes six phases: (1) idea generation, (2) market and technical analysis, (3) functional model development, (4) prototype development, (5) pilot production, and (6) market introduction. The company conducts a phase review after every development phase.

Product ideas either emerge in a 'bottom-up' fashion from employees in the business units or are collected from product users and distributors. The heads of the business units collect new product ideas and select them according to the R&D strategy. In addition to this continual approach, the company offers initiatives for systematic searches for new solutions and ideas for specifically identified strategic fields, such as synthesis. The subsequent profound market and technical analysis of the selected ideas usually is conducted (phase 2) by product managers. Because of the scope of competences that product managers must maintain, they can be considered generalists rather than highly specialized experts.

> According to our product managers' application background in chemistry, they collect data from the pharmaceutical industry and universities, always focussing on the customer need which underlies the potential new product. Relevant parameters which have to be analyzed are market potential, technical realizability, as well as costs and profitability. (Head Business Unit Research & Discovery, Buechi)

If the analysis reveals that an idea's potential is high, a project application is submitted to the executive board and company management. After project assignment, functional model development begins (phase 3), which means that the product's functionalities are developed and checked in line with the overall system. If the development pertains to a

new product, an alpha test is conducted with customers. At this stage, the budget responsibility for the product moves from R&Di or A&QC to Engineering Services.

In the fourth phase, Engineering Services develops a prototype to present to customers. Input from the market becomes relevant, especially for handling, ergonomic, and design aspects. Before pilot production can be realized at the end of this phase, another decision from the executive board and company management is required. Overall, the product innovation process is highly formalized, a result of the market's strong competition and price dominance. Furthermore, the company's size does not allow for the expenditure of resources that have not been adopted carefully: staff is always working to full capacity.

At *Buechi*, it is not the prototype itself that must be in place for the next development step but rather 'feedback from the customer.' Only when the relevance of the project for users has become evident will the innovation project advance; without test results, the next development phase cannot be initiated. As a result, early prototypes can be regarded as catalysts that provoke the required market feedback. For prototyping in general, these prototypes must present a convincing solution that gives a realistic picture of the new product in which customers are investing.

> If a concept or prototype presented to customers is poorly conceived as regards look and feel, customers usually decline a new product. Therefore, design and interfaces have to be at an appealing level for user visits. (Head Business Unit Research & Discovery, Buechi)

During project planning, *Buechi* calculates the product's price, its manufacturing costs, the number of items that could be sold, and the project's cost and resulting profitability from the very first moment of the product innovation process. Although these calculations represent rough estimates during the idea stage, they must be based on applicable data if the project is to be assigned by the executive board and company management. At the point that the project moves to Engineering Services for the development of the functional model, the parameters are calculated anew with the greatest possible precision.

Details about the specific development activities during the process and the use of prototypes appear in chapter 4.3.3, illustrated with a specific product innovation project.

***Product innovation team***

A product innovation team consists of five to seven people, including a project leader from the R&Di, A&QC, or Engineering Services business units; a product manager

from R&Di or A&QC; and a production representative (i.e., sourcing and assembly, glass, or mechanical production, depending on the technical product focus). Project leaders may be either line responsible, such that they come from the head laboratory or electronics, or full-time project leaders from the business units. The primary qualifications are a good comprehension of customer needs and technical know-how.

The overall driver of the product innovation process is the head of Engineering Services, who represents the interface between the supply of new product concepts and their realization in manufacturing and simultaneously ensures the care and consideration of product platforms. In addition to their product responsibilities, product managers control distribution partner training. For totally new products, distribution partners learn about product functionalities and the appropriate market (i.e., where customers are located) to guarantee a proper product introduction and ensure the inclusion of service offerings. Distribution partners do not directly influence product innovation projects but are considered early to ensure their commitment.

### 4.3.3 Structural organization of customer integration

***Customer integration impact***

*Buechi's* product innovations are driven by its product users; however, distribution partners also play an important role. Historically, distribution partners have been involved when the specific value proposition of *Buechi* products, compared with those of competitors, is relatively simple to communicate to the customer. As a result, most know-how about the market arrives at *Buechi* from these distribution partners. Due to its long tradition of high-quality goods, *Buechi* generally finds that selected distribution partners are strongly interested in being associated with its products. The challenge, however, is that these partners make their own determination of which products to accept in their product portfolio and which they will not list in their catalogues. As a consequence, distribution partners can become a hurdle if they fail to cooperate, especially when new markets first must be developed to realize innovation potentials. *Buechi* therefore actively works to build its network of owned affiliates, which enables it to decide which products receive active sales efforts and get direct access to its product users.

***Intercompany prerequisites for customer integration***

*Buechi* generally maintains good relationships with its distribution partners, which are valuable providers of local market know-how. However, they also can be reserved in communicating their data about product users. Furthermore, if *Buechi* receives user in-

formation from distributors, the information usually must be 'decoded' because of the differences in language, culture, and focus toward product users. On the one hand, distribution partners offer another perspective on users that may lead to further insights about the project. On the other hand, distribution partners follow their own interest—to sell as much as possible from the shelf—which often causes them to demand 'one-size-fits-all' devices. Therefore, statements from distribution partners must be analyzed carefully to gather accurate and realistic user information that has been cleaned of codes and 'political intentions.' Still, these collected contributions can provide valuable ideas; as parameter setters for quality, they can serve a controlling function.

In addition to its collaboration with distribution partners, *Buechi* emphasizes visits to product users to collect direct, unbiased user feedback. The product manager and other members of the project team are present at the users' sites during alpha and beta tests. Contact persons are defined according to the product's inherent technical characteristics; for example, if it offers a strong focus on software, the *Buechi* software specialist attends along with the product manager. *Buechi* also attempts to ensure that both the decision makers (e.g., laboratory leaders, who also are product users) and individual users (e.g., laboratory assistants) are considered during site visits. In most cases, the distribution partners arrange for and join the user site visits, though they are less involved if an established partnership exists already among *Buechi*, the distributor, and the user.

***Intracompany prerequisites of customer integration***

To present the structure of customer integration into innovation projects at *Buechi*, this case study presents a specific but typical project and thereby offers a profound understanding of the situation. For this example, the Synthesis business area within R&Di is investigating a project that attempts to find an automated solution for a synthesis subprocess, in line with the established company strategy.

The first product idea that underlies this innovation project aims to develop a simple synthesis station to cover the unexplored area of low-end synthesis. A market research study revealed that such simple solutions for synthesis already exist en masse; as a result, differentiation in the market through a new device would be difficult. The market research for the project also revealed that customers perceive process bottlenecks not in synthesis overall but in one of the subprocesses of synthesis. As a consequence, the project's orientation changed to a device to automate this problematic subprocess. The resulting product would be sold as catalogue product via the traditional distribution

channel. Consequently, the new device needed to (1) address an obvious customer issue, (2) fall in line with the process of evaporation and sustain the process chain in laboratories, and (3) provide a process automation solution at the broad mid-range price level.

The first customer visits took place after the initial market research survey, which led to the shift in project focus. Because the new product aimed at the U.S. market, in which significant growth potentials can be realized, it became the context for user site visits: 18 persons from 11 laboratories were selected by the responsible distribution partner for these interviews. During the site visits, the project leader (head of R&Di business unit), the business manager from the distribution partner (product manager and coordinator of sales representatives), and the sales representative for the specific customers participated.

For these site visits that took place during the market and technology analysis phase, *Buechi's* project leader presented a handout with the project concept that pictured the system components. The distribution partner and sales representatives observed all interviews. *Buechi* and the distribution partner had agreed that the latter would write a report or summary of insights and observations after all visits. The following statement gives an idea about some sample insights from the distribution partner:

> Customers could easily understand the function of the product and see its application in the laboratory. The physical size of the unit was acceptable and met most criteria for performing synthesis. (Sales representative of Buechi distribution partner)

However, the report from the distribution partner representative bore the strong stamp of his own sales ambitions. Therefore, the product requirements detailed from his perspective were far too broad to be realized.

*Buechi's* project leader came away with some different insights; he perceived that the product user's statements confirmed the device's relevance. At least nine users claimed to be interested in testing the device as soon as a prototype was ready. The *Buechi* project leader also collected a long list of customer requirements, including extending the volume spectrum covered, simplified cleaning, contamination avoidance methods, pollution resistance, and compatibility with standard glassware, as well as customer wishes, such as a device for parallel or automated processing. Furthermore, the visits led to the conclusion that a demonstrated prototype would be a condition *sine qua non* for further clarifications.

On the basis of these results, the team began to develop a prefunctional model. To test the required functionalities of the new device in a pre-alpha test, the team held intense discussions with an external consultant who previously had served as a laboratory leader in the pharmaceutical industry. In this pre-alpha test, which occurred during the phase of technical and market analyses of innovation projects, *Buechi* brought a functional model to the sites of a few customers and tried to consider the various market characteristics. The functional model focused on technical feasibility and contained the requisite product functionalities.

In the next step, an improved functional model was presented and demonstrated to selected customers in the alpha test to obtain reliable and conclusive feedback about the new product's market relevance, as well as to verify its functionalities. This testing process did not take place as a single activity but rather as an iterative event that continued until the market feedback was sufficient to allow *Buechi* to proceed with its innovation process. The distribution partner was intensely involved in these visits too. On the basis of the information garnered during this alpha test, the project assignment occurred. Then, during another alpha test in the prototype phase, a prototype was presented to a broader number of customers: *Buechi* aimed to get feedback about the relevance and sales potential of its new product from approximately 5–10 customers that stood out because of their innovative thinking. Most of these users already had been considered during the market and technical analysis. To ensure the reliability of the feedback, the project manager also contacted customers with a critical attitude toward the new product concept.

Finally, during pilot production, the beta test provided assurance about the components used to verify that the required quality could be delivered. This last test led to marginal new product adjustments.

### 4.3.4 Incorporation of customer contributions

***Access to customer contributions***

Product managers and developers systematically visit the customer to obtain their precise feedback about an existing or a planned new product, as shown in the preceding project example. For access to product users, the distribution partners are involved throughout all development steps. In customer visits—usually together with the responsible distribution partner who provides the customer contact—*Buechi* developers may present product concepts, early functional models, or prototypes to the persons respon-

sible for a laboratory, as well as to the laboratory assistants who use the devices in their daily work. During these visits, customers offer input about product improvements in the areas of (1) new accessories, (2) potential new applications and functionalities, (3) quality, or (4) quality overshooting.

During the specific user visits, *Buechi* and the distribution partner representatives try to uncover both articulated customer comments and unarticulated areas of improvement that may become evident from the observed difficulties the customer encounters while answering questions or handling a prototype. This early presentation of a concept or functional model can positively influence the customer's confidence in the development project. Customer know-how is often difficult to understand and decode but is necessary before real innovation potentials can be determined.

> Usually, ideas and information from the customer have to be adjusted to Buechi's know-how and own product innovation ideas to minimize failure risks. Only then, the realization of product innovations can take place. (Head Business Unit Research & Discovery, Buechi)

Even though the distribution partners are present during user visits, it can be a challenge to convince them of the overall benefits of a new product that *Buechi* wants to introduce to the market, because market development for a new product means an investment by the distribution partner as well. Therefore, prototypes also are presented to distribution partners during the development process, even though *Buechi* can access the user directly after an initial visit. This practice of continuously considering the distributors facilitates and accelerates market introduction, because it enables the distributor to prepare and plan any necessary tasks or adjustments. Finally, financial commitment from the distribution partner or directly from the user may be allocated with the alpha test but usually occurs with the beta test.

***Customer participation***

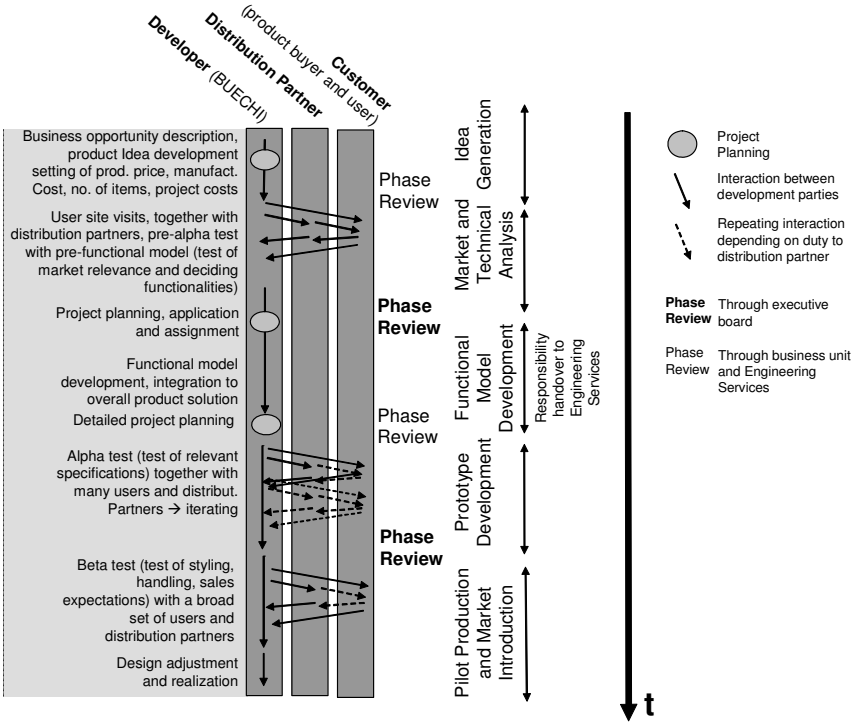
Market relevance for the required investments occurs when a specific amount of turnover is guaranteed for the product innovation project. Because the quantity of turnover it requires is relatively high, *Buechi* mainly selects larger players among its customers (e.g., those from the pharmaceutical industry) whenever possible. These big players generally also represent the customers which *Buechi* refers to as lead users. *Buechi* contacts the person within the customer organization who decides whether to buy the product for the laboratory but also tries to interview other users who may not be involved in the buying decision.

Usually, the same customers remain involved with a project during its whole development process. However, *Buechi* recognizes that it must also collect opinions and requirements from customers whose ideas have not been biased by their know-how of the project's history or their tight relationship with *Buechi*. Furthermore, *Buechi* does not consider solely those customers that are enthusiastic about a new product idea during the development process. If during the analysis, customers in the appropriate customer segment have a negative attitude toward the product, they are contacted again later in the process. If they have negative attitudes but obviously do not correspond to the market segment being addressed, they will not be contacted again.

### 4.3.5 Summary

*Buechi's* product innovations activities are summarized in figure 4-12, which demonstrates the course of customer integration activities throughout a product innovation project. The five phases of the product innovation process appear on the right side of the figure, and the parties involved in the customer integration activities, illustrated by the three pillars, are the developer (*Buechi*), the distribution partner, and the customer. Within the customer organization, the product buyer often is a product user who works with the *Buechi* device in a laboratory. The arrows indicate the activities undertaken among parties throughout the project, and a description of the activities appears on the left side of the figure. Circles indicate where project planning parameters are set, adjusted, and refined.

Figure 4-12 Summary of customer integration into product innovation at Buechi



## 4.4 Case three: customer integration at IDEO

It's a delicate balance between process and innovation

—Tim Brown, European director of IDEO, London, (qtd. in Dearlove 1998: 3)

### 4.4.1 Company profile and organization

***Introduction and key figures***

Created in 1991 when founder David Kelley merged his engineering firm with two industrial design firms, *IDEO* is the largest industrial product design firm in the world (IDEO 2003). The pioneering design company not only focuses on actual design aspects but also includes product development disciplines. The resulting R&D service offered to customers is driven by design, provides innovative solutions for progressive and changing customer requirements, and still includes all aspects of technical competence that are crucial for rapid product realization. An overview of the company shows table 4-4.

Table 4-4 IDEO at a glance

| | |
|---|---|
| *Headquarters* | *Palo Alto, USA* |
| *No. of sites* | *8* |
| *No. of employees* | *Worldwide 450* |
| *Industry* | *Product development (design and engineering) and innovation consulting* |
| *Products* | *Every industry* |
| *Technology intensity / dynamics* | *Low-tech to high-tech, whole spectrum* |
| *Positioning in the market* | *Innovation leader* |
| *Turnover 2004* | *About 70 Mio US$* |
| *Employees in R&D* | *About 85% (development contractor characteristic)* |
| *Ambition for sales growth* | *Yes, but not as an existential need* |
| *Strategic goals* | *Improve the image and value of design as a defining force in product development* |

> IDEO is developing on the moving cutting edge in a rapidly changing environment. (Head IDEO Germany)

*IDEO* always aims to consider products not from a technical perspective but by focusing on customers' overall emotional product and service experiences. The company ad-

dresses the design of every touch point with the customer, including services and maintenance.

In past years, *IDEO* has won more Industrial Design Excellence Awards than any other company (Perry 1995). It remains privately owned and autonomous in its strategy, although Steelcase Inc., a U.S. office furniture manufacturer, has equity in the company.

***Products, customers, and markets***

Clients who order a product development typically hire *IDEO* to design parts or an entire new product that they want to manufacture and sell but lack the expertise or staff to design. Major *IDEO* clients include Proctor & Gamble, Pepsi Co., AT&T, Samsung, Philips, and Steelcase. Famous *IDEO* projects are the original Apple computer mouse, the Palm V, the mechanical whale in the *Free Willy* films, and a remote control device for Lufthansa (see figure 4-13). *IDEO* creates approximately 90 new products a year.

Figure 4-13 Example of IDEO products: remote control 'nice' for VVIP (very, very important persons) jets

Source: IDEO (2005a).

*IDEO* offers its know-how for design and environmental studies, product development and transformations, and consulting services for companies that need help to become more innovative. For its product development activities, revenues stem from approximately 30 percent each in medical, consumer, and telecommunication/computer industries, with an additional 10 percent from industrial products (IDEO 2000).

When a client approaches *IDEO* with a mandate, it usually has a clear image of the market position it wants to achieve or the market segment it wants to address with the new product. Client requests also can be motivated by an existing product or technology for

which the client needs an ideal channel to bring it to market. Product development projects last from a few weeks to three years, with an average of about one year. The results range from sketches of product concepts to crude working models to complete new product designs (Hargadon and Sutton 1997). *IDEO's* fees for product development run from US$100,000 to more than $1 million, depending on the scope of the project (IDEO 2000).

***Organizational structure and R&D***

In addition to its headquarters in Palo Alto, California, *IDEO* maintains design centers in Boston, Chicago, San Francisco, London, Munich, and Shanghai. These sites were chosen for their stimulating locations; they dynamically evolve according to market trends and environmental changes. Although all centers operate independently and seek business locally, they exchange a high volume of e-mail and often share talent as needed.

*IDEO's* organization is flat to an extreme. All work is organized into project teams, which form only for the life of a project. As a result, there are no permanent job assignments, job titles, or organizational charts. Project leaders often emerge on the basis of an employee's personal excitement about a project. An individual can work on one large project as a principal or as many as four projects as a contributor. Anyone in the company can be a project leader; the person must simply be 'presentable to the client' (Perry 1995). Most employees have engineering educational backgrounds, but employees come from every discipline. As a consequence of *IDEO's* business model, which relies on selling a product development service, approximately 85 percent of the staff can be considered part of R&D; the remaining 15 percent are responsible for bureaucratic functions such as purchasing or tracking bills and payments.

To realize this team-based approach, IDEO is organized into a matrix of practices and locations. Practices pertain to the fields of expertise inherent to employees at the different sites and involve autonomous units ranging from 5 to 15 members. These units are supervised by management, but every location is responsible for and recruits its own employees: it chooses the right team for a project and offers support and coaching to maintain quality but virtually no specific direction and no intrusive monitoring. Each practice functions as a profit center whose incentive compensation is based on company performance (IDEO 2003). Motivation through peer pressure spurs employees to put in 50- to 60-hour work weeks in their creative endeavours (Perry 1995). As a project evolves, the project leader recruits an appropriately sized team to handle the necessary

tasks, rarely more than a dozen people. When the project is over, the team disburses after a closure ceremony (Perry 1995).

A goal of *IDEO's* founders has been to keep each unit small and thereby maintain the firm's informal and creative culture. Following an 'amoeboid' growth strategy, the company headquarters reflects the desire to keep operations small, as the company spreads among seven buildings.

> We are small enough so that everybody here knows all the projects that are happening in this office and feels a part of them. Employees have a sense of ownership and significance. (Craig Sampson, IDEO Chicago, qtd. in Perry 1995: 16)

The hiring process at *IDEO* is particularly rigorous; the company does not look for people who want to become experts on a certain subject but rather tries to recruit those who are always interested in doing something new and moving on to the next thing (Perry 1995). Prospective *IDEO* employees go through a dozen or more interviews, in which both their personalities and their technical qualifications are scrutinized. Money and salaries, taboo subjects, are not the principal motivation of *IDEO* employees, who instead are attracted by *IDEO's* combination of a constantly stimulating environment and serious fun (IDEO 2003). Because David Kelly, the founder, is a tenured professor in Stanford University's Design Division of the Mechanical Engineering Department and many of its engineers graduated from the university, *IDEO* maintains a tight relationship with Stanford, which in turn guarantees a constant flow of high-level technological know-how.

### 4.4.2 Process organization of product innovation

***Product innovation focus and strategy***

*IDEO* pioneered the design version of 'concurrent engineering'—a fusion of art and engineering to produce aesthetically pleasing products that were also technically competent (IDEO 2000). The strategic focus for every project is to develop a highly innovative new product that fulfills users' needs both functionally and emotionally. Regarding the way to realize these products, founder Kelley states:

> We pick the things each client does well, and assimilate them into our methodology. We're not good at innovation because of our flawless intellects, but because we've done thousands of products, and we've been mindful. (Tom Kelley, IDEO founder, qtd. in Perry 1995: 17)

As a consequence, *IDEO* counts cross-fertilization as a key catalyst for its innovation internally: all design teams are interdisciplinary and combine staffers trained in engineering, art and industrial design, psychology, and other fields (Perry 1995).

***Product innovation phases, experimentation, and prototyping practice***

As the company gained experience, Kelley and his original team developed the *IDEO* methodology, which serves as a centerpiece of its design efforts. The methodology has the following steps: understand, visualize, evaluate, and implement. Some steps are iterated many times in a single project and 'aerated' through brainstorming sessions with the entire crew.

***Phase 0 (Understand/Observe).*** This phase requires that the team understand the market, the client, the technology, and the perceived constraints as they exist at present. The team seeks to understand the client's business and immerses itself in finding out about the feasibility of a product. This immersion involves taking in everything ever written about the planned product and potential users. The team researches all aspects, from the cost structure to product use.

> The project leader must immerse himself in the product. To design a new chair, he studies the history of chairs, and the companies that make chairs. He researches the cost structure of chairs and the ergonomics of chairs. And he gets every different kind of chair he can find and rips them apart. He also tries to understand the client, meeting representatives from marketing, manufacturing, and other key departments. (Perry 1995: 17)

To gather local specialities for a certain product, contact persons around the world buy items from different markets and send them to the team that needs them for the project. By the end of this process, team members have tacked pictures and diagrams summarizing major discoveries about the marketplace and users to the walls and created a feasibility record that indicates their major discoveries about the marketplace and users.

***Phase I (Visualize/Realize).*** At this point, the team goes out into the real world to observe people in real situations: how do they use similar products? Do they like them? What are their needs and desires, particularly those they cannot quite express? User observations are overseen by human factors experts—mostly trained psychologists who develop a questionnaire, go into the field, and watch others.

The team eventually chooses a product direction on the basis of its gathered ideas, technologies, and market perceptions. It also gains an understanding of the product context

through the gallery of consumers using the product in their daily lives. By the end of phase I, through close coordination with the client, the team has rough, three-dimensional models of the product and a general idea about the manufacturing strategy.

***Phase II (Evaluate/Refine).*** Here, the team visualizes new concepts, as well as the product users who will work with the product in the future. This phase involves brainstorming as well as simulations, whether in the form of a specific prototype or virtual video scenarios, sketched vignettes, or role playing.

The purpose of this stage is to develop functional prototypes and resolve technical problems and the problems users may face. The team enhances design prototypes by testing functional prototypes. The emphasis shifts over the course of this stage from human factors and ergonomics to engineering. Concurrent engineering often occurs, in which previously unspecified features get filled in using an iterative process. By the end of phase II, both a functional model and a 'looks-like' design model is delivered. The industrial design solutions eventually get documented using computer-aided design (CAD) tools.

***Phase III (Implement/Detailed Engineering).*** To provide a series of improvements to the original idea, this phase involves evaluating and refining the prototypes in quick iterations. The team completes the product design and verifies that the final product works and can be manufactured. Although engineering efforts predominate, continuous low-level involvement with design team members also occurs. By the end of this phase, the team delivers a fully functional design model, tooling databases, and technical documentation. Testing also can be undertaken during this phase to meet government regulations, and the team starts selecting vendors.

***Phase IV (Implement/Manufacturing Liaison).*** This phase focuses on implementing the concept by taking it through all design, engineering, and manufacturing stages. If product release is *IDEO's* responsibility, this phase also requires that the team ensure a smooth movement of the product from the shop floor to the client's factory lines. The team still supervises production of tooling, regulatory approvals, and construction of pilot runs of the manufacturing line. By the end of this phase, the product is formally handed over to the client. However, in many cases, the client performs the product implementation itself to keep its project costs down.

These described development steps provide a rough overview of *IDEO's* product innovation process. However, development phases 0–III still occur within each of the single phases.

> Already in phase 0, we observe the relevant product users—also called stakeholders—in their environment, visualize what we find, and build rough prototypes, which we discuss with the client. These prototypes build the fundament to realize the next project step. (Business Developer, IDEO Germany)

For project planning, the cost and time parameters are quite unclear in phase 0, because the quality of the product feature remains very flexible. When it comes to the first prototypes in phase I, these variables grow more evident. Due to their many years of experience, *IDEO* employees can estimate quite precisely the project parameters, but for complex technical features or unclear physical requirements, the parameters remain open, get determined only at a later stage, and are discussed with the client.

Throughout the process, *IDEO* seeks to generate as many ideas as possible early in the design process through frequent brainstorming sessions. To ensure the best results, the firm's five principles of brainstorming remain on display on the walls: stay focused on the topic, encourage wild ideas, defer judgment, build on the ideas of others, and one conversation at a time. In addition to regular brainstorming, which is central to *IDEO's* methodology, prototyping is fundamental. Prototyping and brainstorming go hand in hand, such that brainstorming sessions lead to rapid prototyping and vice versa (see figure 4-14). The goal is to create a whirlwind of activity and ideas, with the most promising ideas developed into prototypes in just days (IDEO 2000). 'Fail often to succeed sooner' is one of *IDEO's* mottos.

According to Kelley, researchers at larger companies are afraid of looking bad to management, so they create an expensive, sleek prototype but then become committed to it before they really know any answers. At *IDEO*, the process of creating quick and dirty prototypes, which get repeatedly knocked down, is referred to as 'enlightened trial and error' (Perry 1995).

Figure 4-14 Early prototype and final product result of the Gyrus-Diego Surgical System


Source: IDEO (2005a).

Each *IDEO* office has a shop in which employees can build their own prototypes out of various materials (e.g., cardboard, Legos). *IDEO* also has large central shops staffed by machinists and model makers to which engineers can send CAD drawings and from which they receive more sophisticated prototypes quickly (Perry 1995). Each prototype relates to a specific decision necessary to advance a project:

> Every prototype is built for one specific purpose—not to simulate the entire new product which will be built. The prototype has to fully concentrate on this aspect and to avoid confusions regarding other aspects. (Head IDEO Germany)

People at *IDEO* are convinced that models often surprise, thereby helping people change their minds and accept new ideas (Kelley, Littman, and Peters 2001). A report sent to the management team likely will not lead to a crisp decision; presenting a prototype gives them a spokes-object for a particular point of view, crystallizes the group's feedback, and keeps things moving.

> Never go to a client meeting without a prototype. ('Boyle's Law' by Dennis Boyle, IDEO Palo Alto, qtd. in IDEO 2000: 8)

***Product innovation team***

An *IDEO* project team consists of a project leader, a team member responsible for 'human factors' (involved mainly in the early phases), the design team (usually one engineer and one designer), and, depending on the project, a client representative as a full-time project member. If the client is a regular customer, a business development representative, the 'key account manager,' also becomes part of the team. Project team members may change during the project if additional competences are required, but designers

and engineers are constant team partners. When a project is finished, the team disbands as the members go on to new constellations, depending on their new projects.

If the project requires the profound technical expertise held by the client, engineers from the client firm join the development team and participate throughout the whole project. This inclusion ensures that the skills needed to determine technical feasibility exist within the team. Furthermore, the transfer of the project to the client after its completion gets facilitated because client's R&D employees are already familiar with it. The project leader plays a gatekeeping role, as does a member from the practice side who has profound expertise with the product. The latter is responsible to ensure the quality required and that the project does not deviate from the original project scope.

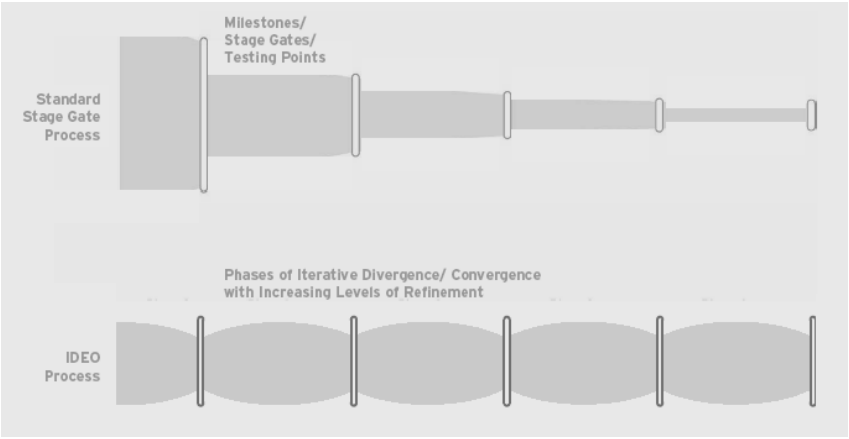
### 4.4.3 Structural organization of customer integration

***Customer integration impact***

Customer integration at *IDEO* means overall that a few good ideas get elaborated and developed together with the client. For such development, *IDEO* seeks not only input from the client but also any relevant input from the user. Therefore, a broad set of activities with users leads to a representative depiction of the product's market.

As a result of continuous prototyping, the number of ideas considered to realize a product remain more or less stable: ideas from clients and users evolve continually through iterative phases of divergence/convergence and result in a product that fits the client's and users' needs exactly. This procedure contrasts with a traditional sequential development procedure, in which the client filters ideas and chooses among many at the very end instead of developing them throughout the project (see figure 4-15). The advantages of such an evolutionary process relate to the greater motivation for both employees and clients: ideas are not 'thrown away' but used to enrich existing ones. The process also is valuable from a resource perspective, because the risk of wasted efforts for ideas that never get considered is far lower.

Figure 4-15 Product evolution versus sequential development




Source: IDEO (2005b).

***Intercompany prerequisites for customer integration***

The inherent inability to predict the innovation process's outcome, time, and cost precisely make it extremely important to keep clients involved during the entire innovation process. Meetings with the client's division take place weekly to support communication and ensure a constant stream of feedback through discussions of project progress. Therefore, closeness to the customer is crucial. Furthermore, *IDEO* strongly emphasizes meeting all the deadlines fixed with the customer through its expertise in professional project management.

> I do not remember one single client presentation where we did not meet the deadline. (Business Developer, IDEO Germany)

At the beginning of a new project, after creating a collective rough description of the project's goal, *IDEO* evaluates the cost and time estimates together with clients. The project parameters (schedule, costs, and product features) can be adjusted regularly, together with the client, if, in the course of the project, the parameters cannot be retained.

Setting the product features at an early stage is only possible for projects for which clients have a clear idea about the product specifications. As a project unfolds and designers come up with innovative ideas and concepts, project managers must ensure that these concepts fit the budgets and timelines. Because designers often aim for perfection, which can lead to cost and time overruns, clients must be sensitized about the ideas they

want to have implemented by the actual project and the cost and time involved versus the opportunities that might be considered for further innovative projects.

***Intracompany prerequisites of customer integration***

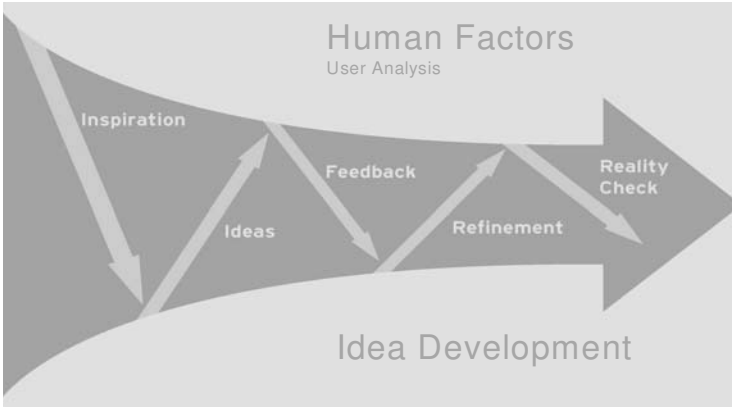
Because clients are part of the project team, they are continually considered throughout the product innovation process. In addition to these meetings with clients, *IDEO* conducts extensive studies with product users during phases 0 and I.

> The data we need is highly qualitative in nature, not aiming at validating market research results, but focussing on getting inspiration for new ideas. (Business Developer, IDEO Germany)

Human factors experts, who generally have psychological, sociological, or anthropological backgrounds, run these investigations by designing a framework to obtain relevant data about a potential product's use situation (see figure 4-16). The result is an evolutionary product innovation process guided by requirements voiced by clients and users, as well as the technical possibilities of the developers.

Using these frameworks, *IDEO* team members visit single users and observe and interview them in their habitual environments with a questionnaire developed specifically for the project. These qualitative data complement the quantitative data gathered from traditional market research.

Figure 4-16 IDEO product innovation process between developer and customers




Source: IDEO (2005a).

The evolutionary process of improving and focusing finishes when the client considers the product 'good enough' to bring it out to the market. Further deciding parameters for ending the process include timelines and budgets, which are continuously negotiated with the client.

### 4.4.4 Incorporation of customer contributions

***Access to customer contributions***

The client is a provider of know-how crucial for the development of an innovative new product. Its know-how about the market environment, business models, and competitors and expertise as a developer, manufacturer, or seller complements the know-how needed to develop a new product. For complex projects, for which *IDEO* does not have the required expertise, the client's researchers or engineers can be members of the development team, in which case the client participates in every development step.

For decisions about the next development step, the team members draw a list of the possible product features based on the insights generated by the human factors study of users. From this list, so-called 'make or break' features, fundamental for the realization of the product in terms of risk assessment, are identified and prioritized with the client's input. After such a decision, *IDEO* can continue with the project according to these client priorities. Overall, this development and decision-making tactic is possible only because of its highly modular structure, in which product features are developed and implemented sequentially, starting with the most fundamental and riskiest one.

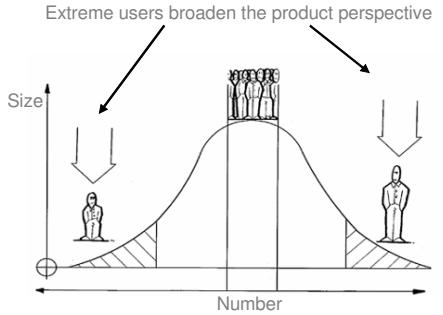
With regard to contributions from product users, interviews are usually conducted by two persons at the users' location. The *IDEO* team members carefully document their findings with notes and/or video records. Furthermore, users experience various prototypes, which enables the *IDEO* observers to collect insights about their application and handling. These interviews are arranged for every project step, so the teams require new inspiration from the user environment.

***Customer participation***

Because *IDEO* focuses on the product use situation, it must select the persons who can provide the know-how it needs carefully. *IDEO* gains its required product application know-how from different users, but to find the best product solution, the company looks not only for *average* but also *extreme* users (see figure 4-17). Potential users are identi-

fied by *IDEO's* human factors experts and asked whether they know others who might be even 'more extreme' in their use.

Figure 4-17 Consideration of 'average' and 'extreme' users



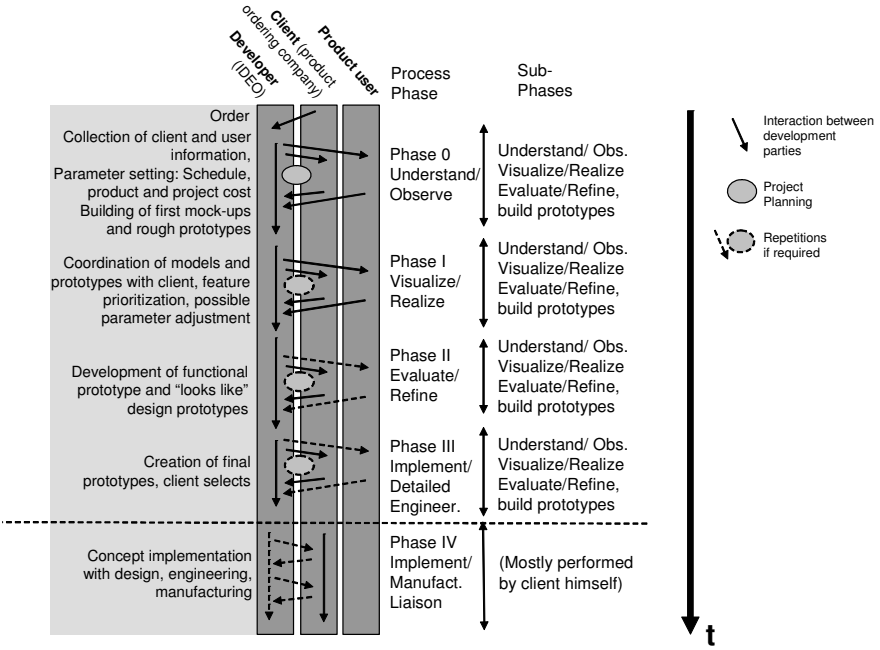

Source: IDEO (2005b).

*IDEO* discovered that the more emotional people get, the more profound is the feedback they provide about an evolving product. With regard to the customers' role, users are seen as a source of inspiration, whereas clients are considered team members.

### 4.4.5 Summary

*IDEO's* product innovation activities are summarized in figure 4-18, which indicates the course of customer integration activities for a product innovation project. The product innovation process with five phases appears on the right side of the figure. The parties involved in the customer integration activities, illustrated by three pillars, are the developer (*IDEO*), the client company that orders the new product, and the product user. The arrows indicate the activities among the parties throughout the project, and a description of these activities appears on the left side of the figure. The circles indicate where project planning parameters are set, adjusted, and refined.

Figure 4-18 Summary of customer integration into product innovation at IDEO



## 4.5 Case four: customer integration at Tribecraft

Die Hände denken mit.

—"The hands think ahead." Tribecraft philosophy, expressed by Uwe Werner, Tribecraft founder and partner (qtd. in Wuersten 2003: 20)

### 4.5.1 Company profile and organization

***Introduction and key figures***

*Tribecraft* is a product development company that offers total development of a product from start to finish. Its offerings include analysis, seeing the product through to the market, developing the product concept and design, and engineering. *Tribecraft* was founded in 1999 as a spin-off of the Swiss Federal Institute of Technology (ETH) in Zurich. Its combination of traditional product development disciplines with a strong design orientation, which comes from the design and mechanical engineering backgrounds of the company founders, makes the company's R&D service special. An overview of the company shows table 4-5.

Table 4-5 Tribecraft at a glance

| | |
|---|---|
| *Headquarters* | *Zurich, Switzerland* |
| *No. of sites* | *1* |
| *No. of employees* | *7* |
| *Industry* | *Product development (design and engineering)* |
| *Products* | *Developments in almost every industry* |
| *Technology intensity / dynamics* | *Low-tech to high-tech, whole spectrum* |
| *Positioning in the market* | *Innovation leader, special emphasis on design aspects* |
| *Employees in R&D* | *About 85% (development contractor characteristics)* |
| *Ambition for (sales) growth* | *Marginal, because the company is convinced that its methods would not work with a bigger team* |
| *Strategic goals* | *Establishing the company's reputation in the Swiss core market, expanding activity to other European countries.* |

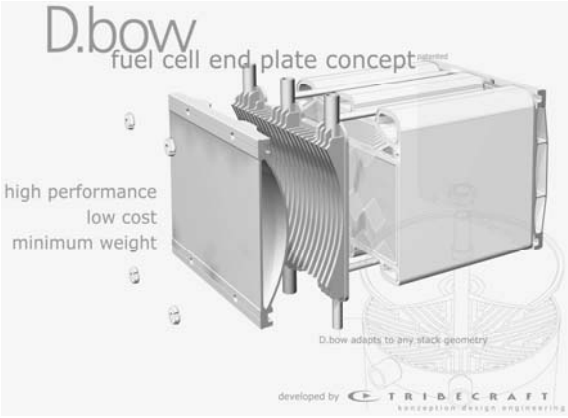
The company bases its work on methodically structured scientific, ergonomic, and aesthetic foundations, with a particular emphasis on the early phases of the innovation process, where *Tribecraft* creates true added value. *Tribecraft* follows a holistic approach to product innovation and considers every product not only from a technical or

design perspective but also from a strategic and emotional point of view. This conceptualization is made possible by the very interdisciplinary development teams and their diverse abilities. The productive combination of design and engineering capabilities does not exist in isolation; *Tribecraft* employees see themselves as intermediaries who connect specialists from all relevant sectors.

***Products, customers, and markets***

*Tribecraft*'s clients, companies that order the development of a new product, represent various industries. Client examples include Schindler, Geberit, or Coop, a Swiss retailer. Products range from daily use items like shopping carts, cubes to light fires, sink siphons, and spraying devices for professional or leisure gardeners to high-tech developments, such as head lamps for medical use, new conceptions of bicycle frames and their suspension, a fuel cell enclosure (see figure 4-19), and linear engines for elevators. *Tribecraft* also is engaged in trend studies to discover an industry's future developments. As an example, a universal toilet, functional for every culture and with water consumption of only one liter, was investigated and designed together with Geberit, the European market leader in sanitary technology.

Figure 4-19 Example of Tribecraft products: fuel cell development




Source: Tribecraft (2005).

Client companies that involve *Tribecraft* in the development of new products are, in some cases, strongly technically driven and want to place their in-house technology in a new application field. In other cases, clients may be market driven in their search for a provider of new ideas and products to realize a desired market position. A third possibil-

ity pertains to companies searching intensively for their next big innovation step because the innovation potential of their established products has been realized and does not allow for further improvements. These companies, according to *Tribecraft*, need a kind of an 'innovative revolution' to demonstrate to their environment, as well as to themselves, their ability to introduce the next blockbuster product.

> Working with a highly dynamic and innovative company such as Tribecraft provides new ideas but also new methodologies for and approaches to product innovation. (Tribecraft founder and partner)

***Organizational structure and R&D***

At present, the company consists of the four founding members, two employees (all with design and mechanical engineering backgrounds), and one assistant. In turn, the organization is extremely flat and made up entirely of R&D, with the exception of the assistant. The team constellation arose out of the personal contact of the company founders. Furthermore, the company views the maximum team size as 12 employees:

> More than 12 people should not work in the company; otherwise our methods of operation would not work any more. (Tribecraft founder and partner)

If a project starts with a client initiative, a project leader is assigned to function as the contact person for the client and assemble the in-house team resources to realize the project. Consequently, employees work on different projects in a flexible way, joining the team for any task for which they are needed and focusing on other projects when their competences are required elsewhere. *Tribecraft* sells its project on the basis of a fixed salary, predetermined amount, or detailed time accounts.

In addition to the offices, which are all located on one floor to optimize communication among team members, *Tribecraft*'s working space consists of a group room for brainstorming and team meetings and an 'implementation room' or shop floor to realize prototypes and employ sophisticated CAD tools. Furthermore, the company cultivates strong relationships with scientific institutions, such as the Swiss Federal Institute of Technology (ETH) in Zurich, to attain access to the latest trends and technologies.

### 4.5.2 Process organization of product innovation

***Product innovation focus and strategy***

*Tribecraft*'s innovativeness is based on a different way of thinking, enabled by a specific methodology for developing a new product. The resulting work process would be difficult to realize in a traditional developing company environment, because highly innovative tasks are inseparable from the daily business tasks of an engineer. A core aspect of *Tribecraft*'s methodology is strategic foresight regarding the future positioning of a product, which the company considers for every project: the market position that the client hopes to achieve with the product is part of its very conception and means that the development of the new product is based on a product vision for its anticipated life cycle.

***Product innovation phases, experimentation, and prototyping practices***

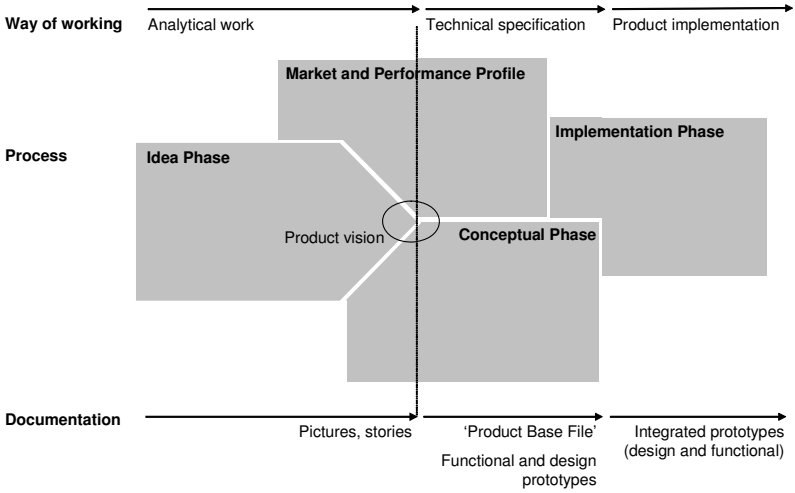
A crucial aspect of *Tribecraft*'s innovation process is to work in a highly analytical, abstract way for a long time instead of providing specific ideas or product concepts in early stages. This approach allows a profound analysis and consideration of the market environment and avoids the possibility of neglecting important information (e.g., ideas are realized with suboptimal materials because other materials were not considered).

> In our work we remain on an abstract level for a long time. This means that we do not immediately lay any specific suggestions on the client's table, but scrutinize the basic thought again and again. (Tribecraft founder and partner)

Because the technical specification occurs only at a relatively late stage—at the end of the conceptual phase—the product's ideal application field or technical scope evolves first, without the restraint of overly hasty ideas or their intuitive implementation. To solidify this approach, *Tribecraft* works with pictures and stories to make a project's progress explicit, even though that progress may be difficult to articulate. The resulting final product does not always look like the initial projections. This openness to changes stems from the early emphasis on the product's market environment to determine its application.

*Tribecraft*'s product innovation process differs for every project as a consequence of the different requirements determined by the client. However, a basic structure of the process exists, consisting of an idea phase, a conceptual phase, a market and performance profile, and an implementation phase (see figure 4-20).

Figure 4-20 Tribecraft's product innovation process




Source: adapted from Tribecraft (2005).

***Idea Phase.*** In the idea phase, the use of the product is considered and broken down to 'come to fundamental grips' with it. Consequently, activities center on getting all the information required to create an overall picture of what will be achieved with the product. This phase's duration can take weeks to months, depending on the time horizon. A project starts with brainstorming and data collection to elaborate a product vision; overly hasty functional specifications of existing ideas must be avoided. Creative tools and specific methods help retain difficult-to-express but key aspects at this project stage. The early conceptualizations about the product's 'character' can offer a guideline for the whole innovation process, as well as an idea of the long-term objective to be achieved with the product: to realize the effect the final product will have on its stakeholders, *Tribecraft* applies the 'Moodboard' method, well known in design disciplines. A board consists of a collage of pictures or colors that simulate an emotional state of mind and depicts the final emotional effect or sentiment to be associated with the future product. A brainstorming library of materials, gadgets, items, and other tools sustains these creative methods.

Such approaches toward exhaustive product 'character' and design studies are fundamental to *Tribecraft*'s innovative potential. They also are considered enablers that constantly remind designers of users' physiological and psychological needs.

> As a matter of principle we ask: what is, in fact, the story behind the product? And where does our client position itself on the market? (Uwe Werner, Tribecraft founder and partner, qtd. in Wuersten 2003: 20)

*Tribecraft* describes its activities as playing with the mechanisms, proportions, and shapes of evolving products, which then result in the desired development and parallel evolution of the design during the entire process, even to the finished data set for the toolmaker and beyond. In that process, it investigates the intrinsic meaning and specific character of the object itself, as well as its relationship to the client's brand.

Because *Tribecraft* has strong inherent engineering and implementation competences, the relevance of its idea process is better than that of companies that arrest their activity after the idea phase. As a consequence, project costs decrease, because *Tribecraft* employees' background helps them approach new ideas with their realization in mind (Donath 2003). In turn, impossible-to-implement ideas are immediately excluded, but not in such a way as to restrain creativity. The idea phase eventually leads to a product vision that clarifies which customer needs the product will satisfy. This vision is depicted with pictures, statements, or mock-ups.

***Conceptual phase.*** The aim of the conceptual phase is to compare the evolving product concepts that have emerged. During this phase, up to ten mock-ups and early prototypes are developed; these visualizations indicate the relevance of the considered know-how and provide a means for the client to make a relative evaluation of the different possible solutions. Through the visualization, the client's decisions about these solution possibilities become comprehensible and transparent instead of unconscious or politically biased. This evaluation also provides a basis for future product cost estimations and performance evaluations.

To enable these decisions, evaluation criteria are fixed in conjunction with the client before the evaluation starts. These criteria help clarify the client's preferences: it is possible that the client commits itself to an option that objectively is not the best one but is legitimized by the client's gut feeling. These decisions are made explicit and are visible to all project stakeholders. To ensure this visibility, criteria provide a good basis for a discussion.

The conceptual phase, similar to the idea phase, does not occur in a stepwise, systematic manner. Designers receive significant analytical freedom for experimentation; otherwise, important information that is only visible as the future product evolves would get

neglected. This growing body of know-how is recorded in a 'base file' that evolves from visual to functional specifications.

A standard approach at *Tribecraft* is to apply stress with CAD models. Unusual in the early stage of innovation projects, *Tribecraft* also applies the finite element method (FEM), a computer simulation technique. In its application, the object or system is represented by a geometrically similar model consisting of multiple, linked, simplified representations of discrete regions—i.e., finite elements—to sketch structural concepts in cases of strong deformation, contact-friction, or when orthotropic materials (e.g., rubber) are used. This analysis of physical edges and prediction of nonlinear behavior can lead to new insights about possible product applications and solutions. For example, the applicability of an angular rather than a traditional round body could be verified with FEM at a very early stage.

***Market and Performance Profile** (Markt-Leistungs-Profil—**MLP**).* In parallel with the idea and conceptual phases, the MLP continuously provides the required data. Although existing market surveys from the client are considered, *Tribecraft* also conducts qualitative interviews with several stakeholders of the future product. Furthermore, patent research provides some information about the current state of research and can inspire new solution possibilities.

***Implementation Phase***. Depending on the project and the client's request, *Tribecraft* will participate in the implementation of the product. As a general rule, relatively small companies desire implementation, whereas larger firms tend to take the responsibility for implementation themselves.

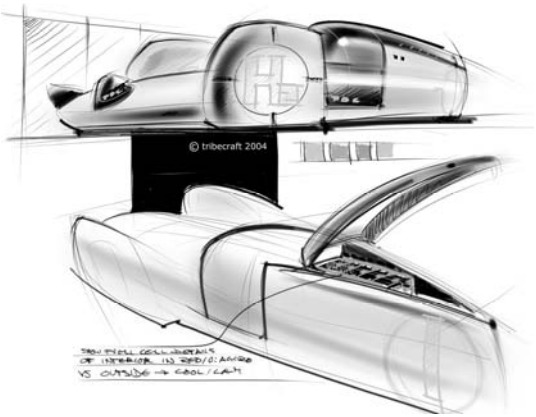
With the visualization of intermediary development results, *Tribecraft* presents drafts and pictures early to its customers (e.g., the product vision at the end of the idea phase) to show them the reality of the product environment. These visualizations neutralize the ground for the best product solution and turn clients away from any hasty suggestions or decisions.

> It can be annoying that certain clients sometimes have fix ideas about a product—which in reality turn out to be only pseudo-solutions. (Tribecraft founder and partner)

Therefore, the product vision gets developed by the *Tribecraft* team without involving the client, which leads the client beyond what it knows and provides a basis for more innovative products. Technically, only those elements for which there is enough infor-

mation for a visualization are depicted through these rough concepts; the other elements remain very vague (for an example, see figure 4-21). The intent behind this approach is to steer the client's attention toward what needs to be focused on and avoid concentrating on what remains vague.

Figure 4-21 Visualization example: emphasizing one specific product aspect at a time




Source: Tribecraft (2005).

To visualize the evolving body of knowledge about the future product, *Tribecraft* utilizes sketches, CAD, and physical modelling (mock-ups or simple functional prototypes). What makes *Tribecraft*'s process especially valuable is its dynamic combination of these media. *Tribecraft* workers always search for the best medium to express what they know, even in project presentations during client or user meetings. This visualization method demands that the item demonstrated has no more complexity than the client or user is able to understand (otherwise, again, the client focuses on the wrong aspects) and a maximum of completeness to depict the current state of information.

During the conceptual phase, more and more information about the future product is brought together. From this stage, in which functionalities and the use of materials become evident through prototypes, approximations can be made about the future product costs and the number of units that may be sold.

***Product innovation team***

Every project is led by one *Tribecraft* employee who is responsible for the project planning and steering and represents the interface with the client. In addition to the project

leader, any other *Tribecraft* employee can be 'booked' to the project as his or her resource expertise is needed. For a brainstorming session, the whole crew may work together. In later stages, a project generally is realized by two to three *Tribecraft* employees. Booking to a project may last as little as one month to guarantee the flexibility required to execute several projects at a time.

Because *Tribecraft*'s strength is the methodology, not the specialized know-how, required to develop products in the client's field, engineers from the client company often are part of the project team, whose participation varies among clients and projects. However, the project leader from *Tribecraft* takes the gatekeeping function, keeps the product vision in mind, and ensures that the focus on the basic product problem never gets lost.

### 4.5.3 Structural organization of customer integration

***Customer integration impact***

According to *Tribecraft*'s product innovation process, solutions and product ideas result naturally from profound analyses with clients and users. The neutrality with which the product developer approaches a job or challenge offers completely new and highly innovative answers to established product issues.

> We do not consider ourselves as producers, moreover as creators, precipitating a revolution in a product's conception. This revolution leads to cost reductions and completely new approach facing the basic problem. (Daniel Irányi, Tribecraft founder and partner, qtd. in Donath 2003: 16)

The analysis of the product environment enables a project start by making explicit the required product 'character.' This character becomes a product vision, which is further developed in tight cooperation with the product's environment.

Because *Tribecraft* strives for added value across different levels, it considers clients and end users of the final product as equally important. It attempts to understand both parties as well as possible and profits from every information channel that provides know-how about them. Existing knowledge about users, such as from the client's sales employees, is actively considered with the MLP as soon as it becomes disposable. However, *Tribecraft* recognizes the need to avoid a punctual user perception that is biased by the person from whom it is perceived. Such data may provide valuable know-how but also require analytical guidance and 'decoding' during the product innovation process.

***Intercompany prerequisites of customer integration***

Projects assign one person in charge from the client's side, who usually holds an operational management position. This person is contacted frequently and involved intensively in every development step. Problems can arise if significant changes that do not lie within the responsibility of this project representative emerge; in this case, upper management must be contacted to make strategic adjustments for the project and reset the project parameters.

If the projects are radically different in nature, meaning that *Tribecraft* has developed a product that is new to the client and its market, they generally remain the responsibility of the client's upper management. In this scenario, contact persons often are less involved in operational tasks but serve as the direct contact person for decisions or additional know-how.

The initial project planning, which involves establishing the project parameters, usually evolves during preliminary talks with the client and includes the methodologies to be applied as well. This planning covers the project scope, including the conceptual phase, and varies for each project.

***Intracompany prerequisites of customer integration***

Because projects start with an order from the client, *Tribecraft* intensively discusses the project aim with the responsible person from the client's side (usually a manager). The goal of this discussion is a precise linguistic specification of what is to be achieved, as well as the main benefits of the future new product. These meetings also lead to a long-term strategic outlook on the product and its future market position.

In the idea phase, research from market surveys is considered to determine whether it affects the crucial aspects of the new product. That is, such information is mainly relevant for sustaining the qualitative findings and communicating any crucial points. Furthermore, selected users participate in qualitative interviews that offer deep insights about the future product use situation. These interviews center around a checklist of relevant issues, which *Tribecraft* has learned from its discussions with clients and their experience. These interviews attempt to externalize tacit customer knowledge, which allows the capture of any intuitive decisions in product use that might constitute a unique selling proposition.

> We are very close to human beings and their way of thinking. We ask ourselves how people perceive a system and a product. Consequently, we proceed by deduction in order to improve this system or product, or both. (Tribecraft founder and partner)

At the end of the idea phase, the findings of the product environment analysis are presented to the client, along with a product vision. This product vision represents a visualization of the product's market potential and attempts to generate a consensus among all involved parties about the goals of the development project.

In the sequencing conceptual phase, the client is contacted regularly when there is a need for a decision about the project's further direction. In many meetings with clients, *Tribecraft* presents functional models and mock-ups, as well as functional prototypes. These meetings help indicate the issues that need to be focused on in the next development steps. If a client representative is part of the project team, he or she even accompanies and assists with the visualization and development steps.

During the conceptual phase, potential product users again provide insights about the product's environment. At this stage, *Tribecraft* puts a strong emphasis on conceptualizing prototypes such that users understand the problem *Tribecraft* wants to solve with them. Only this practice guarantees that the company can get the specific know-how it needs.

> If a user tries to sit on an item which is built to be looked at, the prototype misses his goal. (Tribecraft founder and partner)

The definite functional product specification (specification freeze) takes place at the end of the conceptual phase.

### 4.5.4 Incorporation of customer contributions

***Access to customer contributions***

When a *Tribecraft* team is developing a new product, the overall user situation of the new product and its strategic long-term focus are considered. To uncover the future use situation, *Tribecraft* creates 'storyboards' together with potential product users to reflect the typical course of a product's use. These storyboards contain all the insights that have been considered for the design and interface requirements.

Moreover, to investigate a product's use situation, *Tribecraft* films interview partners in their habitual environments and can enhance the situations by giving the subjects a mock-up or early prototype. The film documentation helps highlight specific aspects of

the product's use situation and handling, which really matter and indicate what solutions to unsolved problems remain. Consequently, both product relevance and the most important features are uncovered. The film medium further enables team members to review the documentation at later stages in the innovation process, when the same situation might need to be considered from the new perspective.

***Customer participation***

*Tribecraft* involves *professional users* as well as *'amateur' product users* and brings them together in meetings and workshops. Such workshops make the use situations explicit by demonstrating what the users do not recognize themselves. Further relevant user information comes from the client's employees, who interact closely with users, for example, at the point of sale. Sales employees are regarded as 'potentizers' (Potenzierer), because they know how to sell a project to users by mentioning certain product aspects and ignoring others. *Tribecraft*'s challenge is to analyze this information carefully to draw the right conclusions.

If clients participate in the team, they often like to work at *Tribecraft*'s site to learn more about *Tribecraft*'s way of working and 'taste the creative environment.' Clients also may provide space at their sites, which facilitates the integration of the project into the company and guarantees excellent know-how transfer between *Tribecraft* and its own employees. If there are no project team members from the client's side, regular meetings and discussions take place with the client contact partner. As a general rule, the *Tribecraft* team considers itself more productive when the client is integrated for important decisions but is not a project team member, because teams in new constellations first must get used to a new working environment and learn how to work together.

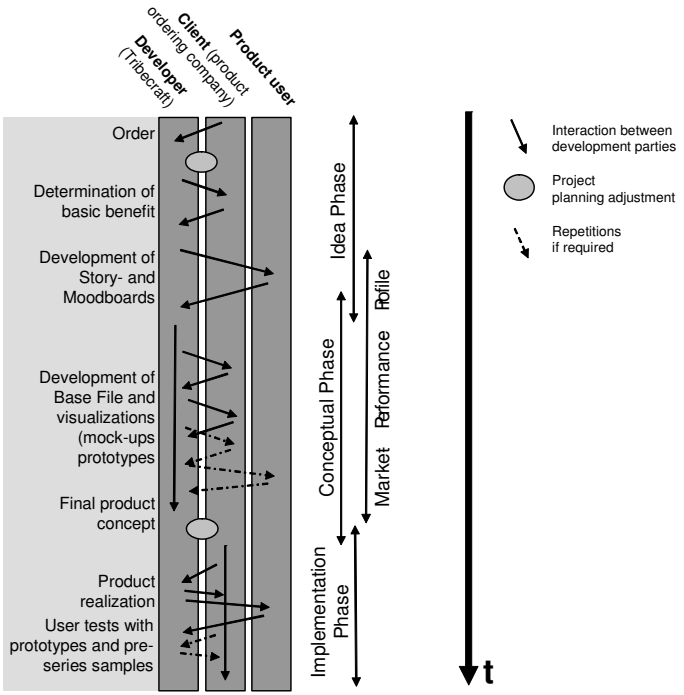
The client participates either as a decision maker or part of the project team. If the client representative participates in the project as a full member and provides expert know-how, he or she can be considered a development partner. Overall, the client is considered the 'deciding partner' who steers the project in the direction it needs. The user represents the deciding factor for the new product and might be considered a source from which developers can learn if they are able to draw the right conclusions. Together, developers and users find the best shapes and designs.

### 4.5.5 Summary

*Tribecraft*'s product innovation activities are summarized in figure 4-22, which shows the course of the customer integration activities during a product innovation project. The

product innovation process with three phases appears on the right side. The involved parties in the customer integration activities, illustrated by three pillars, are the developer (*Tribecraft*), the client or company that orders the development of the new product, and the product user. The arrows indicate the activities among the parties during the project. A description of the activities appears on the left side of the figure, and the circles indicate where project planning parameters are set, adjusted, and refined.

Figure 4-22 Summary of customer integration into product innovation at Tribecraft



# 5 Building theory on customer integration into product innovation

The single case studies in chapter 4 demonstrated how customer integration takes place in the practices of four industrial product developers: two development contractors and two in-house developing companies. During the iterative process of data collection and single case analysis, *tentative constructs and relationships* that determine customer integration into innovation projects began to emerge. The following cross-case analysis captures and refines these constructs and relationships to extend existing theory on customer integration into product innovation by building some new theory.

For a cross-case analysis in general, a new perspective must be taken toward the case study data by applying other case comparison criteria than those given by the initial framework (Eisenhardt 1989); a second application of the framework used for data collection would not reveal new insights but rather simply answer the questions asked by this framework. As Eisenhardt (1989: 541) notes:

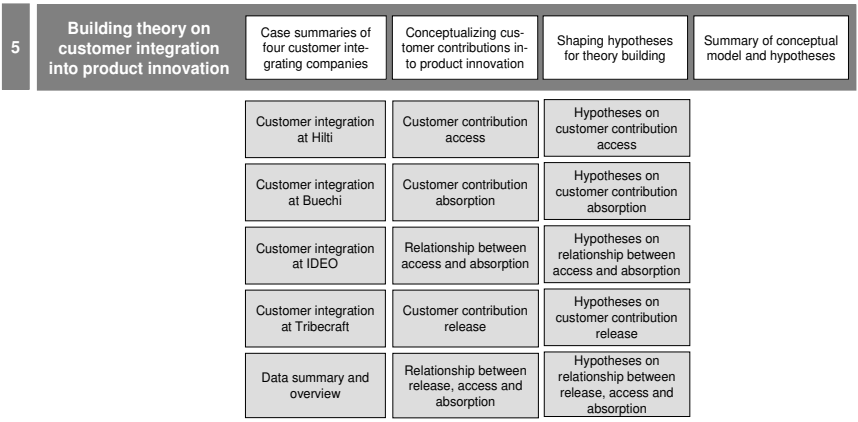
> Overall, the idea behind these cross-case searching tactics is to force investigators to go beyond initial impressions, especially through the use of structured and diverse lenses on the data. These tactics improve the likelihood of accurate and reliable theory, that is a theory with a close fit with the data.

Therefore, instead of the XP-based reference framework, tentative constructs and relationships serve as the analysis criteria during this cross-case comparison. Furthermore, to enhance internal validity, generalizability, and the theoretical level of theory building from the case study research, the cross-case analysis is conducted by continuously referring back to existing theory on customer integration into product innovation (Eisenhardt 1989). This procedure builds new research propositions that represent theory sentences, thus extending existing theory on customer integration into product innovation. The difference from quantitative research is that the evolving constructs, their definitions, and their measurement often emerge from the analysis process itself rather than being specified a priori (Eisenhardt 1989; Yin 1994).

In qualitative research, construct exploration and sharpening with data and existing theory is not a linear process but a highly iterative one. In line with the iterativeness of the analysis process, the presentation of results in this chapter does not correspond to the research process that led to the results but proceeds in a condensed manner to improve

its clarity. First, the following section reconsiders each case study from the perspective of the identified constructs and relationships to provide a focused data summary, as well as an overview of the cross-case similarities and differences (5.1). Second, the identified constructs and their relationships are elaborated from the perspective of existing theory on customer integration and product innovation, thereby leading to a conceptual model of customer contributions into product innovation (5.2). Third, linking the conceptual model from this theory with the case study data suggests research propositions that extend existing theory on customer integration into product innovation (5.3). Fourth, a summary of the model and propositions completes chapter 5 (5.4). Figure 5-1 offers an overview of the cross-case analysis and theory building as they are presented in this chapter.

Figure 5-1 Outline of chapter 5




## 5.1 Case summaries of four customer integrating companies

The cases presented in chapter 4 showed that customer integration into product innovation takes place in different forms. The practices of the four companies, which are further investigated herein, refer to the specific projects described by the case studies and are not representative of all projects by the companies. Anticipating the final research results of the cross-case comparison at this stage, and to improve comprehensibility, a data analysis reveals that theory on customer integration into product innovation can emerge by further specifying the *customer's contribution* to product innovations. Whereas literature has already addressed aspects of *customer contribution access* (see

chapter 2.3.1), this study identifies two new constructs, *customer contribution release* and *customer contribution absorption*. Definitions of these constructs, as they have been identified and shaped during the process of cross-case analysis, are as follows:

**Customer contribution access** refers to the availability of customer know-how, which depends on customers' characteristics and their disposition through embeddedness in their market environment.

**Customer contribution release** refers to the detachment of customer know-how to make it understandable and available for developers in product innovation projects and collectively create new innovation know-how.

**Customer contribution absorption** refers to the implementation of customer know-how through its translation and conditioning into the specifications of the product innovation.

Because new product success represents the overall goal of companies' efforts to integrate customers, this chapter also considers the *impact of customer contributions on new product success* in the case studies to sharpen the customer contribution constructs.

To provide a summary of the relevant case study data from the perspective of the identified constructs for further analysis, the case study summaries (*Hilti* section 5.1.1, *Buechi* section 5.1.2, *IDEO* section 5.1.3, and *Tribecraft* section 5.1.4) are presented according to the following questions:

- *Product innovation success:*
  What is the impact of customer integration on product success?
  Who is responsible for market introduction, and what are the consequences of this responsibility for product success?
- *Customer contribution access:*
  Which customers are considered in the product innovation process?
  What are their characteristics?
- *Customer contribution release:*
  How are customer contributions made understandable and available?
- *Customer contribution absorption:*
  How is product innovation organized to implement customers' contributions?
  In what activities are customer contributions implemented?

A *cross-case overview* of new product success and customer contribution access, release, and absorption is shown in four tables in section 5.1.5, following the summaries. This cross-case overview employs the definitions of the *customer*, *product user*, and

*product buyer* from chapter 1.4.2 to clarify the data analysis. The specific use of the term 'lead user' in practice for each of the four cases will be discussed in section 5.3.1.

### 5.1.1 Customer integration at Hilti: stage-gate process with structured customer integration

***Product innovation success***

*Hilti*'s most important success measure is the product's share in its specific market. As a consequence of the company's quality and price leadership policy (*Hilti* sells its products at a price up to 40 percent above its competitors), total customer satisfaction through product solutions that answer customer needs lies at the core of *Hilti*'s product innovation activity. Customer integration into product innovations is the fundament of the new products' success because it enables *Hilti* to discover and answer those product requirements that legitimize the price premium for *Hilti* products and that could not be identified solely through typical market research. The company has its own market organization, present in approximately 120 countries, that is responsible for market introduction and product distribution. This direct sales and services approach facilitates customer access through the closeness of its market organization to customers and helps identify real product needs.

***Customer contribution access***

*Hilti*'s market organization allows access to customers directly throughout the world. Customers selected for cooperation with innovation projects are mostly tied to *Hilti* through long-term partnerships. In its customer integration, *Hilti* remains one of the pioneering companies for the lead user approach. Lead users are those customers characterized by the elements defined by von Hippel (1976; 1986; 1988): first, they experience needs for a given innovation earlier than the majority of the target market, and second, they expect attractive innovation-related benefits from a solution to their needs and therefore are motivated to innovate. A third relevant *Hilti*-specific characteristic of lead users is that they exist in the range of the product's application field in the construction industry but have a reputation of being 'innovative pacesetters' that are interested in new solutions. In *Hilti*'s experience, lead users from other industries are rarely able to provide the insights required, because they are too far from the challenges of typical customers in the construction industry.

With regard to lead users, *Hilti* refers to the overall customer organization, not just single product users. Within the customer organization, *Hilti* differentiates between *product*

*buyers* and *product users*: the former are managerial representatives from construction or facility management companies or general entrepreneurs who make the investment decision to hire *Hilti* as a product supplier and set the project parameters, whereas the latter are the people who work on construction sites with *Hilti* products. In addition to product buyers and users, other industry stakeholders, such as architects and site planners, are considered. Because *Hilti* has an established, strong brand, customers are happy to collaborate, so it is not difficult for *Hilti* to get admission to their construction sites. Only customers with an overall positive attitude toward the new product are considered throughout the innovation project, which means that *Hilti* does not deepen its feedback from customers with negative attitudes. These types of customers are only contacted with the final product at the end of the project.

***Customer contribution release***

In the definition phase of a product innovation project, project leaders conduct interviews with product buyers and users, together with *Hilti* product managers from local markets. Discussions with product buyers capture their acceptance of a new application and indicate their willingness to pay for the new product or feature. Additional interviews with product buyers and product users aim at getting information about which customers are adopting which practices in what application field and identifying which trends are shaping the industry. To gain an overall picture of the construction business from different perspectives, architects and planners also are interviewed in separate sessions about their investment plans and the aesthetic aspects of a project. From these interviews, *Hilti* obtains relevant cost data, which it uses to set its development parameters.

During the concept phase, *Hilti* organizes user focus groups in which it releases contributions and allows users to test functional product prototypes. The insights gained from users through the field application of these prototypes come not only from what the users articulate but also from the evidence gleaned from watching them. To enable observations from different perspectives at the construction sites, *Hilti* engineers, along with the project manager, attend these meeting to gather purely technical aspects.

In the design phase, *Hilti* project members spend two to three days at the customer's site to develop a complete picture of the new product in the field. At this point, the customer receives two or three prototype variants, which are only marginally different. The product users provide feedback about marginal ergonomic aspects, which help finalize the product's 'look and feel.' The final check-up tests in the design phase attempt to prepare

the market organization and the customer for the new product, initiate sales activities, and obtain any further customer contributions.

***Customer contribution absorption***

In the definition phase, *Hilti* absorbs its customers' contributions about industry trends and willingness to pay; it also determines about 60 percent of the future product cost and nearly all of the product's specifications. In the sequencing concept phase, when product users test a first version of the functional prototype in focus groups, technical user feedback that focuses on the product's attributes gets absorbed into the final product design by project managers and *Hilti* engineers. With this procedure, the project manager need not translate his or her observations to the development team; instead, engineers report and implement them in their own technical 'language.' At the end of the concept phase, 80 percent of the future product costs have been determined. The customer feedback absorbed and integrated from tests during the design phase focuses on marginal ergonomic aspects and product handling.

For project planning, *Hilti* plans in detail the phase it will follow to the next decision gate and further generates an idea about the time of market introduction. This plan implements customers' contributions and is continuously adjusted.

### 5.1.2 Customer integration at Buechi: new product scope definition by distribution partners and users

***Product innovation success***

*Buechi*'s measure for new product success relies on the number of units sold in the first year through external distribution companies. For *Buechi*, the main sales drivers for its new products include the application flexibility of the new product, the avoidance of product overengineering, and a competitive price, which arises from the price sensitivity of *Buechi*'s market segment for laboratory equipment. Because of the relatively small company size, staff is always working at full capacity, so late project aborts or massive changes in a project direction significantly influence new products' success. Therefore, *Buechi* benefits from customer integration by identifying any relevant new product specifications right from the start of the project, which helps avoid any development activities that the market does not value. Because *Buechi* products are mainly sold through distribution partners, product success can be achieved only if distributors support the new product with their market development activities. Distributors' commitment therefore must be assured for product innovation projects as early as possible.

***Customer contribution access***

*Buechi* integrates contributions from its *distribution partners* and *product users* in its product innovation process. When requested, distribution partners that might distribute a new product provide market feedback based on their sales figures and direct user contact. These distribution partners also provide contacts to product users and arrange user visits for *Buechi* for specific product innovation projects. Because they are interested in the feedback and want to remain involved in the process, distribution partners usually accompany *Buechi* during user site visits. *Buechi*'s direct access to its products' end users is limited—and may be the reason *Buechi* missed several industry trends in recent years.

The most important users for *Buechi* are large pharmaceutical companies because of their requirements for automated, high-end solutions. Consequently, from *Buechi*'s perspective, they are the *lead users*. These companies are financially attractive players as a result of their size and buying volumes, but their needs differ from those of *Buechi*'s main user segment. *Typical users* request only partially automated solutions at minimal costs for a wide scope of laboratory applications. In turn, *Buechi* considers not only the pharmaceutical lead users during an innovation project but also the typical users, which ensures the relevance of any product development. *Buechi* selects typical users from its user database that stand out because of their openness to product innovations.

***Customer contribution release***

During the phase of market and technical analysis, product users and distribution partners evaluate a paper concept of *Buechi*'s product ideas. In the so-called 'pre-alpha test' during this prefunctional model development, product users are asked about product functionalities, ergonomics, and design to elucidate their know-how about the needed scope of a new product. After the functional model development phase, users and distributors are contacted during the prototype development phase to consider the advances in the emerging product prototype. The alpha test conducted during this phase attempts to confirm the core elements of the new product and provoke feedback about minor product modifications, such as changes in stability aspects, handles, or display illumination. Finally, with the beta tests in the pilot production and market introduction phase, only marginal contributions are requested, such as comments about the instruction book, packaging, or accessories. This beta test can be regarded as an overall test of the product solution and its quality, which also serves to test the means of production internally.

For the alpha and beta tests, the product manager and other members of the project team are present at the users' sites, which allows them to absorb the wide scope of market and technical feedback from the customer. Because its laboratory processes are very diverse, *Buechi*'s challenge is to identify and implement those requirements that are relevant for a broad user segment. The presentation of preconcepts to distribution partners and users supports this process at an early stage. *Buechi* only receives feedback from the distributor when it asks; without an active triggering, the distributor likely would not provide any market know-how. Furthermore, it takes significant effort to get distribution partners to share user know-how, because they tend to retain it instead. Therefore, it is difficult to capture the emerging trends in the users' environment. For this reason, *Buechi* undertakes significant efforts to enlarge the network of its own affiliates.

***Customer contribution absorption***

During the process phase of market and technical analysis, the project manager visits the user companies with a preconcept of a new product idea, which shifts the project toward the real product innovation potentials within which the users' laboratory processes lie. Additional pre-alpha tests focus on clarifying the product's technical feasibility and lead to a decision about the implementation of specific product functionalities. The first process step finishes when the technical feasibility and product functionalities have been cooperatively determined by the project manager and the user.

In the subsequent functional model development phase, there is no direct exchange with distribution partners or users. Only in the sequencing prototype phase, in which the engineering services department manufactures prototypes according to the concept developed by the business units, are the alpha tests conducted at users' sites and observed by the responsible distribution partner. These tests are arranged with typical users and try to absorb the relevance of and sales expectations for the new product from the distribution partners, as well as gather input about secondary functionality modifications from users. Alpha testing comprises several testing loops, between which prototypes are refined according to the feedback obtained. The alpha tests conclude when the partners and users agree to the product specifications. At the end of this phase, *Buechi*'s engineering services department has produced a functional prototype that matches the specifications of the project manager from the developing business unit. Finally, during pilot production and market introduction, the beta test provides some confidence about the components by verifying that the required quality can be manufactured and delivered. This last test leads to marginal new product adjustments that pertain to product handling and packaging.

For its project planning, *Buechi* emphasizes the creation of a reliable picture about sales expectations from the very start of the project. Therefore, sequencing development phases can be initiated only when the company has conclusive figures about market relevance at hand. Precise project parameters (cost, time, quality, and scope) must be known at the end of the concept phase, when the product concept is handed over to engineering services for prototype development.

### 5.1.3 Customer integration at IDEO: prototyping based innovation brokering

***Product innovation success***

Projects at *IDEO* usually start with a client from a product-ordering company. Clients generally have a clear focus on the market position they want or the market segment and target group they hope to address with a new, highly innovative product. In most cases, the client is responsible for the market introduction and distribution of the product developed by *IDEO*. As a result of its experience and prior highly innovative product solutions (*IDEO* has won multiple design awards), *IDEO's* brand currently evokes product success—yet the client pays for it (fees run from US$100,000 to more than $1 million, depending on the scope of the project). *IDEO*'s success measure reflects client satisfaction, from both a technical and an emotional perspective, that truly distinguishes it from competitors. *IDEO* gathers its clients' industry expertise for the specific new product under development to broaden its own developers' know-how and experience, which is the company's key asset.

***Customer contribution access***

*IDEO* deals intensively with its client's business and organization to gain the profound understanding required to develop a product that will yield the promised market success. The client itself is deeply involved in 'its' innovation project, especially if specialized technical or industry expertise is required, in which case engineers from the client's organization become part of the *IDEO* project team. If they are not directly involved in the team, the client meets with managers every week to ensure it remains in line with the client's expectations. Because the project's outcome in terms of time, cost, and product quality often cannot be predicted precisely at the project start, clients remain intensively involved during the whole product innovation process.

To deepen its know-how about the market environment in which new product will function, *IDEO* considers current and potential *product users,* which it also refers to as stakeholders, throughout the entire project. Appropriate users are identified according to

a networking approach (von Hippel 1988; Lüthje and Herstatt 2004): *extreme* users are selected by *IDEO*'s human factors experts and asked whether they know other users who might be even 'more extreme' in their use of a similar product. In addition to these extreme users, *IDEO* considers *average* users to capture the whole product application spectrum. The development team visits these users (usually in pairs), asks them questions, and observes their product handling or work flow. To capture local variations of existing products, *IDEO* assigns contact persons to different cultural areas, who collect the local products and send them to the responsible innovation team.

***Customer contribution release***

The most important element for obtaining relevant development know-how is prototyping: very rough prototypes—even the simplest model is considered a prototype—get demonstrated to clients and product users from the very beginning of an innovation project. Using these prototypes, developers continually check the relevance of their intermediary results or determine where potentials for improvements lie. With feedback from the client and product users, the developers can build the next prototype. This 'quick and dirty' prototyping approach allows for many design iterations and ensures that everyone is imagining the same design during discussions about a product.

This frequent, quick prototyping practice, which is applied throughout the development process, also serves as the most important means for the *IDEO* development team to communicate with clients and users. To avoid the situation in which users who test a sophisticated prototype focus too much on an aspect that does not matter at the time, *IDEO* teams build a new prototype for every feature under investigation.

***Customer contribution absorption***

The product innovation process consists of five iterative development steps that include the following activities: (1) observation and data collection, (2) know-how visualization in the form of prototypes, and (3) evaluation and refinement of the prototype. The iterations are enabled by the 'quick and dirty' prototyping practices, which in turn provide client feedback immediately and precisely to the developers before the next development step.

Both the client and product users are continually considered in every development step. Client exchanges take place whenever decisions have to be made or project parameters change. Users are contacted whenever new information about the product is required to complete the market picture or additional 'inspiration' is needed to advance the project.

Regular brainstorming sessions encourage the release and exchange of know-how by pulling together the different groups involved in the project to find solutions for an identified issue using different perspectives. The absorbed input and feedback from the client pertain to both project parameters (schedule, cost, and features) and technical expertise from the client's engineers involved in the project. Absorbed feedback from users reflects product application aspects.

In terms of project planning, feedback absorption from clients and users takes place for multiple prototypes, which leads to an evolutionary process of prototyping and refinement. The process ends when the client considers a product prototype to be 'good enough' to bring to the market. Other deciding factors for ending the process include timelines and budgets, both of which are continuously planned and negotiated together with the client.

Regarding its internal use of the contributions absorbed from its clients and users, *IDEO* counts on 'cross-fertilization' and 'know-how brokering' among its employees. All design teams are interdisciplinary and combine people trained in engineering, art and industrial design, psychology, and other fields. Within the organization, engineers do not specialize in any single industry but often move to new industries after completing a single project for a particular industry.

### 5.1.4 Customer integration at Tribecraft: product innovations driven by product character

***Product innovation success***

Companies that hire *Tribecraft* for a product innovation project expect to realize more innovative and thus more successful products than they could develop with their own R&D forces. *Tribecraft* develops new products by taking a strategic outlook of the product's future market position. It realizes this long-term perspective by basing a product innovation project on a product vision and anticipating the product's life cycle. *Tribecraft* considers a project successful when it precipitates a revolution in an existing product solution, meeting clients' and users' needs at their core. A further goal is to steer a product innovation project in a manner that allows the smooth integration of the product into the client's production line. Because *Tribecraft* is a young, small company—nevertheless it already has won prestigious design awards—it continues to build its reputation but already has attracted international clients. Similar to *IDEO*, *Tribecraft* benefits from integration with its client's industry expertise, which also is valuable for the personal development of *Tribecraft*'s staff.

***Customer contribution access***

*Tribecraft* s' development service is sought by *clients*, mostly product-developing companies, that hope to place their in-house technology in a new application field but lack market expertise. Other clients look for a provider of new and radical product ideas to realize a desired market position. Projects get processed in different manners, but *Tribecraft* always interacts closely with representatives from the client company. If specialized technical know-how is required for a product innovation project, engineers from the client's side can become part of the development team. At the project start, *Tribecraft* assesses the 'product character' with the client to determine the product's effects on the market and embed it within the client's brand. In addition to considering existing market data from the client, *Tribecraft* conducts qualitative interviews with several *product users* to gain deep insights about the future product use situations. Furthermore, it contacts *professional product users* as well as '*amateurs'* to address the whole user spectrum. Bringing various user types together in workshops reveals interesting insights about intuitive and unconsciously made use decisions in the context of a product application. Because *Tribecraft* strives for added product value from a long-term perspective, it considers clients and final product users equally important, such that clients and users are continuously contacted to provide a complete picture of the product's market environment. In addition to the client representative within the customer organization, *Tribecraft* also contacts sales representatives to attain their perceptions of users' behavior.

***Customer contribution release***

*Tribecraft* presents drafts and pictures at the start of the project to its clients and users to get them thinking about the long-term product goal and environment (i.e., the product vision at the end of the idea phase). This practice is supported by various techniques that stem from the designer's environment (e.g., the 'moodboard' used to indicate the product's effect on users). These visualizations neutralize the ground for the best product solution and turn clients away from their hasty suggestions and decisions. Therefore, rough concepts depict only those elements for which there is enough know-how to visualize; the other elements remain very vague. In this way, *Tribecraft* understands the product's technical and financial parameters and can successfully place the new product in the client's product portfolio. During interviews with product users, *Tribecraft* collects need and application input for the new product using a checklist of relevant issues.

If prototypes are presented to the client and users, *Tribecraft* employees attend these meetings and document what they see and learn. Such observations take place until the

implementation of the final product. With these multiple visualizations and rough prototypes, know-how about the emerging product gets released continually throughout the product innovation process and brought together in visualizations. From the stage in which the functionalities and materials become evident through the prototypes, approximations can be made about the future product costs and the number of units likely to be sold.

***Customer contribution absorption***

During the idea phase, *Tribecraft* integrates the collected data from users with the determined product character. In the conceptual phase, the client—a 'deciding partner'—is contacted on a regular basis, especially when a decision is needed to advance the project. During client meetings, paper concepts, models, mock-ups, and functional prototypes are presented to clarify the issues for the next development steps. Potential product users, during the concept phase, offer further insights about the product's environment through the 'storyboards' *Tribecraft* writes with them, which reflect a product's typical use and thereby reveal design aspects that need to be implemented. *Tribecraft* develops its projects within the framework of the client's requirements and long-term needs and profits from its expert know-how. *Tribecraft* employees' background in design and engineering disciplines enables them to incorporate technical aspects but still focus on product aesthetics. Overall, concept development remains on the abstract know-how collection level for a long time. Rough visualizations are completed continuously using absorbed client and user contributions; they also neutralize the ground to allow the best product solution to emerge. This practice moves clients away from hasty concept specifications that fail to consider all relevant aspects.

In its project planning, which is continually adjusted to the project's progress and any new identified potentials, *Tribecraft* records the growing body of know-how it obtains through information integration in a 'base file' that evolves from visual to functional specifications. The base file also includes adjusted parameters relevant for engineering and production. *Tribecraft's* goal is to be part of the evolving product on a continuous basis but with decreasing involvement and project control. This evolution enables easy project turnover from *Tribecraft* to the client.

### 5.1.5 Data summary and overview

The investigated product innovation processes of the four companies' projects and the customer integration activities that occur throughout these processes are presented in the

overview in figure 5-2. This overview summarizes the case study diagrams introduced in chapter 4. Referring back to chapter 3, figure 5-2 also includes the product innovation process and the customer integration activities of the XP method which was introduced to provide a new perspective on customer integration into product innovation projects.

The figure points out the companies' different emphasis on customer, distributor, client, and user contributions in the different phases of the product innovation projects. In XP and *IDEO's* practices, clients and users are continuously considered throughout the process, whereas *Tribecraft* strongly considers client and user contributions but in a more sequential manner (user after client contribution, fewer iterations). The in-house developer *Hilti* considers product buyers and users throughout the product innovation process, but these inputs do not shape the new product under development; instead, they test and confirm the development provided by *Hilti*, the developer. Within its own company, *Hilti* works like *IDEO* with multiple iterations among the development team members from the business unit and those from the market organization, but in its inter-organizational collaboration with product buyers and users, it does not function this way. At *Buechi*, the distribution partner and users do not appear during concept development but are strongly considered during the other product innovation phases.

Figure 5-2 Cross-case overview of product innovation processes and customer integration activities

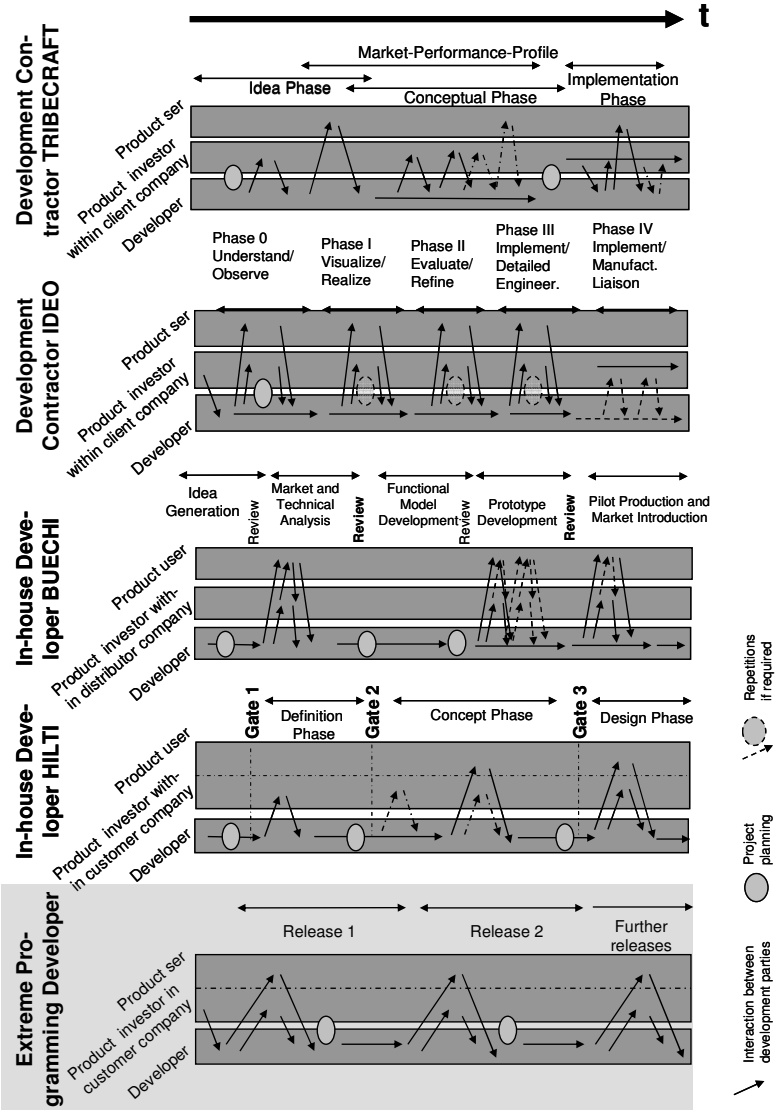


Figure 5-2 uses the term *product buyer* (see definition in chapter 1.4) in all five depicted cases in order to represent an individual level of analysis for the customer, instead of an organizational level to which the *client* or the *distributor* refer. For *Hilti*, the product buyer is the person within the customer company who makes the investment decision to adopt a product innovation. In the case of *Buechi*, the product buyer is the person within the distributor company who decides if *Buechi*'s product gets introduced to the market. In contrast, the person from the end-user organization (e.g., a pharmaceutical company) who decides whether to buy *Buechi* products from the distributor is referred to as the product user; in most cases, this person also works with the product. For both *IDEO* and *Tribecraft*, the product buyer is the person from the client company who decides to buy from the development contractors. The term 'customer' still refers to the overall organizations that acquire the product.

The following section presents a summarized data overview of *product innovation success,* as well as of the three constructs of *customer contribution access*, *release*, and *absorption*. This section does not address customer integration into product innovation with the *XP method* any more*,* because XP has already been used to build the conceptual framework for the case study data collection. Additional consideration of XP for data analysis would hinder the identification of new aspects by merely confirming those identified during the framework development (Eisenhardt 1989). Furthermore, the cross-case analysis attempts to build theory about customer integration into industrial product innovation on the basis of the data from the case studies, which reflect the industrial goods sector.

Referring first to *product innovation success*, table 5-1 shows an overview of the case data regarding the product innovation goal, innovation success measures, market introduction, and product distribution responsibility characteristics, as well as the financial project commitment time from product buyers, as they became evident in the four case studies.

Table 5-1 Data overview of product innovation success

| *Companies* / *Characteristics* | *Hilti* | *Buechi* | *IDEO* | *Tribecraft* |
|---|---|---|---|---|
| *Product innovation goal* | Answering and shaping market and user needs | Serving the market with suitable product solutions | Providing product differentiation through full user orientation | Providing product differentiation through strategic focus on product's long-term position |
| *Innovation success measure* | Market share | Market share | Client satisfaction, brand recognition | Client satisfaction, brand establishment |
| *Market introduction and product distribution responsibility* | Developer with own market organization | Distribution partner (in most cases) | Client | Client |
| *Financial project commitment from product buyer* | End of design phase | Production start (beta test) | From project start through product buyer initiating the project | From project start through product buyer initiating the project |

Focusing on the specific *contributions* customers make to product innovation, table 5-2 presents the case data regarding *customer contribution access*. In the case studies, customer contribution access becomes explicit through the product buyer–user constellation, the developers' motive for customer contribution collection, the locus of the customer integration initiative, and the points of product buyer and user consideration.

Table 5-2 Data overview of customer contribution access

| *Companies* / *Characteristics* | *Hilti* | *Buechi* | *IDEO* | *Tribecraft* |
|---|---|---|---|---|
| *Product buyer–user constellation* | Product buyer and user belong to same organization | Product buyer and user do not belong to same organization | Product buyer is part of client organization, sells the product to users | Product buyer is part of client organization, sells the product to users |
| *Developer's motive for customer contribution collection* | Assurance of product relevance and adjustments regarding product design and handling | Identification of adequate product scope and functionalities, market risk minimization | Identification of adequate product scope & functionalities, achievement of next level innovativeness | Identification of adequate product scope and functionalities, based on product character and strategy |

| | | | | |
|---|---|---|---|---|
| *Locus of customer integration initiative* | Developer | Developer | Product buyer | Product buyer |
| *Point of product buyer consideration* | Selectively across product innovation process | Selectively across product innovation process | Selectively across product innovation process | Continuously after definition of new product vision |
| *Point of user consideration* | During concept tests and final product tests | Predominantly at project start and final product tests | Throughout product innovation process | Predominantly at project start, periodically during product innovation process |

Table 5-3 summarizes the characteristics of the four case studies related to the release of customer contributions. These characteristics, which make the customer contribution release explicit from the case data, include activities aimed at contribution release performed by the developer, the prototyping principles, and the types of prototypes adopted throughout the innovation project.

Table 5-3 Data overview of customer contribution release

| *Companies* / *Characteristics* | *Hilti* | *Buechi* | *IDEO* | *Tribecraft* |
|---|---|---|---|---|
| *Activities aiming at contribution release* | Product buyer and user visits and observations, user workshops, and functional prototype tests | Product buyer and user visits, functional prototype test | Product buyer and user visits, observations, tests of mock-ups, design, and functional prototypes | Product buyer and user visits and observations, user workshops, tests of mock-ups, design, and functional prototypes |
| *Prototyping principle* | Providing functional proofs of technical product performance | Verifying new product scope though comprehendible prototype presentation to customers | Prototyping of every piece of information, one prototype per development issue | Focusing visualization of every piece of information, keeping abstract level as long as possible |
| *Type of prototypes* | Functional | Functional | Separate design and functional prototypes | Separate design and functional prototypes |

Finally, table 5-4 summarizes the characteristics of the four case studies pertaining to the *absorption of customer contributions*. The characteristics that make customer contribution absorption explicit from the case data include the people within the developer organization who decide about the implementation of customer contributions, the flexibility for implementing customer contributions over the product innovation process, and the project specification freeze.

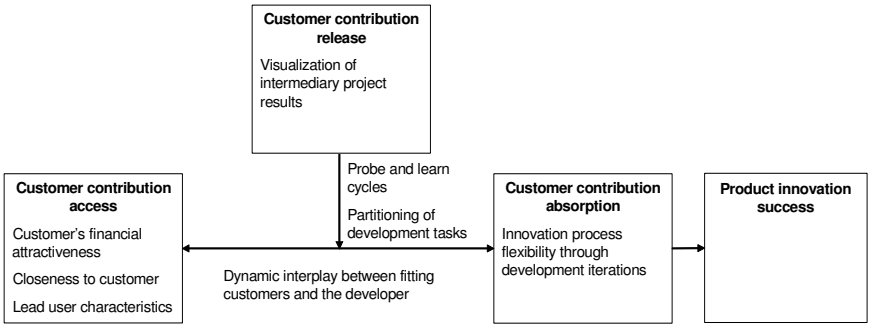
Table 5-4 Data overview of customer contribution absorption

| *Companies* / *Characteristics* | *Hilti* | *Buechi* | *IDEO* | *Tribecraft* |
|---|---|---|---|---|
| *People within developer organization deciding about implementation of customer contributions* | Project leader and product managers (from headquarters and market organization), engineers for specialized technical matters | Project and product manager, engineers for specialized technical matters | Whole project team, different competences | Whole project team, different competences |
| *Flexibility to implement customer contributions over the product innovation process* | Limited | High at the beginning, limited starting from functional model development | High throughout product innovation process | High throughout product innovation process |
| *Project specification freeze* | End of definition phase (before concept phase) | End of functional model development (before prototyping) | End of concept phase | End of concept phase |

## 5.2 Conceptualizing customer contributions into product innovation

To contribute to theory on customer integration into product innovation, the constructs identified from the case data must be embedded into existing theory. This process of tying emergent theory elements to existing literature enhances the internal validity, generalizability, and theoretical level of theory building from case study research (Eisenhardt 1989). Consequently, the identified constructs—customer contribution access, release, and absorption, their relationships, and their relationships with product innovation success—are investigated from the perspective of existing literature, as presented in chapter 2. Figure 5-3 provides an overview of the conceptual model of customer contributions to product innovations, which is developed in the subsequent sections.

Figure 5-3 Conceptual model for integrating customer contributions into product innovation




Regarding the overall relationship between customer contributions and *product innovation success*, the literature review in chapter 2.3.1 indicates the benefits of customer integration. Product innovation success can be improved if qualified customers bring their specialized know-how to the R&D process (Coch and French 1948; Boland 1987; von Hippel 1988; Zirger and Maidique 1990; Bacon et al. 1994; Helten 1994; Li and Calantone 1998; Veryzer and Borja de Mozota 2005). Further evidence for the positive impact of incorporating customer contributions emerges from *organizational learning theory* (see chapter 2.1), which states that better new products can be achieved through better knowledge, understanding, and implementation of relevant information (Fiol and Lyles 1985). By integrating customers, a company can incorporate/absorb relevant market information into its product innovation activities and thereby learn from its customers (Kok et al. 2003), which leads to a higher probability of new product success.

The inherent constructs of *customer contributions* to product innovation and their relationships are developed subsequently. Due to transparency of the conceptual model development from existing theory, the constructs and their relationships are presented in the following order: (1) customer contribution access, (2) customer contribution absorption, (3) relationship between customer contribution access and absorption, (4) customer contribution release, and (5) relationship among customer contribution release, access, and absorption.

Investigating the concept of customer contribution release in existing literature on customer integration into product innovation indicates that prior literature has not discussed a direct relationship between customer contribution access and release or between cus-

tomer contribution absorption and release. This state of affairs is plausible because the release of customer contributions serves as a moderating parameter to the relationship between contribution access and absorption: customer contribution release does not have an effect in single combination with either customer contribution access or customer contribution absorption. Therefore, customer contribution release is discussed in terms of its moderating impact on the relationship between access and absorption.

### 5.2.1 Customer contribution access

As defined in the introduction of chapter 5.1, customer contribution access refers to the availability of customer know-how and depends on customers' characteristics and disposition through embeddedness in the market environment. In line with these customer preconditions, the choice of the right partner from whom to acquire know-how represents a core aspect of interacting with customers (Gruner and Homburg 2000). Biemans (1992) states that, depending on the necessary contributions for new product development, the identity of these customers typically varies according to the extent and intensity to which the customer is involved, as well as the stage of the product innovation process. Relationship marketing research also shows the impact of partner characteristics on cooperative outcomes (Ganesan 1994; Doney and Cannon 1997).

In a product innovation context, Gruner and Homburg (2000) identify three different types of valuable cooperation partners for product innovation projects:

- Financially attractive customers.
- Close customers.
- Lead users.

First, customers' financial attractiveness relates to their ability to represent the target market and their reputation within that market (Ganesan 1994). Second, their closeness describes the relationship between the developing company and the customer, including the level of interaction outside the innovation project and the duration of the business relationship (Doney and Cannon 1997). Measures of user satisfaction also demonstrate the relevance of face-to-face contact in the context of customer access (Leonard-Barton 1993). Third, lead user characteristics suggested by von Hippel (1976; 1986; 1988) must be considered; their positive impact on product innovations has been demonstrated by several studies (Herstatt and von Hippel 1992; Lilien et al. 2002; Lüthje and Herstatt 2004). Lead users combine two characteristics: they expect attractive innovation-related benefits from a solution to their needs and are thus motivated enough to innovate, and

they experience needs for a given innovation before the majority of the target market does. Von Hippel (1986) and Urban and von Hippel (1988) propose that idea-generation studies can identify and garner learning from lead users, both within and beyond the intended target markets. Lead users outside of a target market often encounter even more extreme conditions with regard to a trend relevant to that target market (Lilien et al. 2002).

### 5.2.2 Customer contribution absorption

Customer contribution absorption refers to the implementation, through translation and conditioning, of customer know-how into specifications of the product innovation. Sequential and predefined approaches such as the stage-gate model of innovation (Cooper and Kleinschmidt 1986; Cooper 1994) are very useful but cannot capture completely the impact of dynamic, user-oriented development that absorbs customer contributions throughout the product innovation process (Veryzer and Borja de Mozota 2005). Griffin and Hauser (1993) find that the product innovation process must be designed to allow flexibility and absorb customers' contributions by 'building in the voice of the customer' without forcing the development in a wrong direction or restraining the customer to its initial inputs. Therefore, the process must be capable of responding to new information for a greater proportion of a development cycle (MacCormack et al. 2001), a characteristic rarely provided by a streamlined product innovation process. Rather, as Eisenhardt and Tabrizi (1995) state, the key to fast product development is building intuitive and flexible options to learn quickly about market and technology changes and shifts in uncertain environments. They further propose that the product innovation process should consist of navigating through the inputs from developers and customers rather than planning the development at the start of the project.

From the experiential perspective, a way to absorb customer contributions continuously during flexible product development uses multiple iterations. Multiple development iterations, complemented by extensive testing, and frequent milestones help overcome the randomness of missing or inappropriate technological and customer information (Eisenhardt and Tabrizi 1995; Terwiesch and Loch 2004). Eisenhardt and Tabrizi (1995) further suggest a more real-time, hands-on approach to fast product development, especially for uncertain products. Therefore, the basic aspect of *innovation process flexibility through development iterations* underlies customer contribution absorption.

### 5.2.3 Relationship between customer contribution access and absorption

In rapidly changing market environments, customer contributions must be accessed and integrated during the entire product innovation process to respond to their requirements 'on time.' To make this possible, design choices and decisions must be deferred until late in the development process, when better or more adequate know-how is available. Thomke and Reinertsen (1998) illustrate the required development practice with an example from a newspaper context: a daily newspaper makes content decisions at time horizons that range from weeks to hours. Whereas special sections are planned, and sometimes even printed, weeks in advance, advertisements are planned and prepared days in advance. The content of the front page and certain other pages is devised just hours before press time. In this case, rather than bearing the cost of expensive changes, the 'product requirements' are progressive. Furthermore, each section of the paper has its own timetable. Such a strategy means recognizing that product requirements do not represent a single monolithic entity that is either 'frozen' or 'liquid' but rather a more complex structure that can be both frozen and liquid simultaneously (Thomke and Reinertsen 1998).

Similarly, product development must occur as a dynamic interplay between developers and the right customers that fit the project. Although only the project framework is planned in advance, the specific product design adapts to the requirements of these selected customers. The customers change throughout the process, depending on the new know-how required to effect technological potentials. Therefore, the *dynamic interplay between fitting customers and the developer* provides the crucial element underlying the relationship between customer contribution access and release.

### 5.2.4 Customer contribution release

Customer contribution release refers to the detachment of know-how so that it becomes understandable and available for developers to collectively create new innovation know-how. Empirical research on decision making shows that customers frequently are unaware of their problems, underlying preferences, or choice criteria (Simonson 1993; van Kleef et al. 2005). Mullins and Sutherland (1998) point out that the inability of product buyers and users to articulate their required functionality and benefits for a proposed new product creates uncertainty for the marketer trying to bring a new product through the product innovation process. Von Hippel (1994; 1998) demonstrates in the context of technical problem solving that most of the information useful for product innovations is 'sticky'—meaning it is complex to acquire, transfer, and use in a new location. Informa-

tion stickiness pertains to attributes of not only the information itself but information seekers and information providers as well. Information stickiness can also be high because organizations typically must have or acquire related information and skills to release and understand new know-how that is beneficial and may be transferred to them (von Hippel 1994; Jensen and Szulanski 2004).

Von Hippel's work highlights the relevance of prototypes or, more generally, visualization media for transferring the project to the customer site and releasing customers' contributions. Visualization by paper concepts, mock-ups, and rapid prototyping are the most valued tools for achieving a holistic perspective on a product innovation project and can help in terms of know-how sharing and consensus over the course of a development project (Veryzer and Borja de Mozota 2005). It involves the design of rough product mock-ups that simulate a product's use in the customer context and transform the 'personas' (behavioral and motivational characteristics of target users) and use scenarios of target customers into a more tangible (product) form (Loch et al. 2001; Terwiesch and Loch 2004; Veryzer and Borja de Mozota 2005). In addition, the founder of *IDEO* sees visualization as the driving force behind advancing and improving a new product under development:

> Prototyping doesn't just solve straightforward problems. Call it serendipity or even luck, but once you start drawing or making things you open up new possibilities of discovery. (Kelley 2001: 38).

At different points in the product innovation process, physical representations of the product help create a common understanding of development issues that may arise from the different vocabularies and environments of the involved stakeholders. Furthermore, a product innovation is more easily integrated into people's minds and lives when it is constructed to evoke a shared experiential vocabulary and preexisting understandings (Schrage 2000). Therefore, visualization media and early prototypes throughout the development reflect a crucial aspect underlying customer contribution release. They are referred to as *visualization of intermediary project results*, because the term prototype is used broadly for the final, functionally developed new product.

### 5.2.5 Relationship among customer contribution release, access, and absorption

The realization of such a process requires development steps based on probing, testing, and learning, as has been demonstrated by Lynn and Morone (1996) in their work on probe-and-learn processes in which a new product under development grows through the continual interplay between developers and customers. Veryzer and Borja de Mo-

zota (2005) note the dynamic aspect of integrating customer contributions: the possibilities provided by new technologies are likely to emerge as a success only if they are designed to be consistent with users' evolving needs—a trait that requires anticipating the future or evolving together with customers' needs. Development teams must work with customers to 'coevolve' the design by probing with prototypes and working models and learning by gathering feedback on the performance of existing features, while remaining responsive to requests for additional functionality (MacCormack et al. 2001). Thomke and colleagues (Thomke et al. 1998) state that using prototypes and models helps reduce investments in those aspects that are irrelevant for the current stage of development and generate an awareness of what the customer really needs (Thomke and Reinertsen 1998):

> It is hard for inexperienced customers to accurately describe their needs. Needs become more refined (or change) as the customer comes in direct contact with the product and starts to use it. This happens quite often in systems that involve human–machine interactions, resulting in responses such as the familiar "I'm really not sure what I want, but I'll know when I see it." (Thomke and Reinertsen 1998: 3)

Organizational learning theory (see chapter 2.1) states that the behavioral elements of product development capability consist of quick and efficient information processing during each stage of the product development process (Kok et al. 2003) and across all parties involved (Kohli and Jaworski 1990; Adams et al. 1998). Whereas the central tendency of economic theorizing has been to view information as costlessly transferable, and much research on the special character of markets for information has been based precisely on this characteristic, scholars have long argued, and partially shown, that the costs of information transfer in technical projects can vary significantly (Nelson and Winter 1982; Rosenberg 1982; von Hippel 1994).

Referring further to von Hippel's work on sticky information (von Hippel 1994), he states that when information transfer costs are significant, there will be a tendency to carry out innovation-related problem-solving activities at the locus of the sticky information. In support, Rosenberg (1982) describes 'learning by using,' which involves problem solving carried out in use environments. According to von Hippel, two physically different information places typically are important for successful problem solving in a product innovation context: information on need, located initially with the user, and information on solution technologies, located initially with the manufacturer:

> A problem solver may first draw on user need information to generate some attributes for a desired new product or service. Then, manufacturer information may be

> drawn upon in order to develop a prototype that appears responsive to the specification. The prototype is next tested within its proposed use context to verify function and the accuracy of the initially stated need. (von Hippel 1994: 433)

The intermediate outputs of problem solving at each locus must be transferred to achieve the next probe-and-learn cycle. Therefore, this output must be less sticky than the information employed to produce the outputs. Such intermediate outputs may appear in the form of partitioned development tasks that are transferable at low cost as prototypes (von Hippel 1994).

Summarizing the aspects of the relationship among customer contribution release, access, and absorption, *probe-and-learn cycles* and *partitioning of development tasks* are the crucial elements that constitute this relationship. These elements have a moderating effect on the relationship between customer contribution access and absorption, in that they support the interplay between customers and the developer and therefore facilitate the integration of customer contributions into product innovations.

## 5.3 Shaping propositions for theory building

This third section merges the developed conceptual model for customer integration into product innovation with the case study data. Through consideration of the data, the model's constructs and their relationships are further sharpened, which leads to research propositions that constitute new theorizations about customer integration into product innovation. This procedure is conducted according to the recommendations of Eisenhardt (1989) and Yin (1994), who state that theory building requires the sharpening of the construct through refining the definition of the construct and building data evidence that measures the construct in specific cases. Again, the presented case data of the companies refer to the specific projects investigated in the case studies and are not representative of all projects by the companies.

### 5.3.1 Propositions on customer contribution access

***Financial attractiveness***

Evidence in support of the importance of financial attractiveness of integrated customers appears in all four cases. The measure of financial attractiveness uses the perceived industry impact and reputations of the selected customer organization involved in a specific product innovation project from the developer's perspective. For example, *Buechi* strongly focuses on large distribution partners, as well as on big players in the pharma-

ceutical industry. Because they lead the laboratory automation field, they provide the potential of customers that can cover the entire product innovation cost if they adopt the new product. *Hilti* also seeks collaboration with construction contractors that are involved in big, distinguished projects, preferably with the involvement of star architects. In the cases of the development contractors, the client's financial capability is a precondition, because collaboration is possible only at a very high price, especially for prestigious companies such as *IDEO*. The development contractors are further interested in developing new products for companies of good standing to establish their brand in the market.

The financial attractiveness of the *individual product users* involved in the process is not relevant in all four cases. For example, *Hilti* conducts focus groups with users of a new drilling machine on construction sites and is interested only in their honest feedback about the product use situation. In another example, *IDEO* explicitly considers users that are distant from the product buyer's organization for which *IDEO* develops the product. Whether they have the financial power to buy the new product does not matter.

The company's different consideration of customers' financial attractiveness highlights the need to use a differentiated customer consideration. Table 5-5 shows that the companies in all four cases employ a conscious differentiation between the product buyer and the product user when accessing customers' contributions.

Table 5-5 Cross-case evidence for access to different customers and contributions

| *Companies* / *Characteristics* | *Hilti* | *Buechi* | *IDEO* | *Tribecraft* |
|---|---|---|---|---|
| *Product buyer* | Representative of buying center from construction experts, general entrepreneurs, facility managers | Representative of buying center from the distribution partner | Product portfolio responsible or R&D manger within ordering customer organization | Product portfolio responsible or R&D manager within ordering customer organization |
| *Product buyer contribution* | Investment decision for expendable products | Providing user access, market development | Setting of project parameters (quality, time, cost) | Setting of project parameters (quality, time, cost) |
| *Product user* | Construction worker | Laboratory manager and assistants | Any person working with a similar product | Any person working with a similar product |
| *User contribution* | Testing of evolving product | Defining product scope, testing | Providing application know-how, source of inspiration | Providing application know-how, source of inspiration |

This differentiation between product buyers and users in the B2B context of R&D literature has not been considered explicitly by research so far. Whereas von Hippel (1988) focused predominantly on users (especially lead users), Brockhoff (2003) and Nambisan (2002) differentiate between divergent roles within the same customer organization, though they do not address the constellation of individual contributors from different backgrounds integrated for different reasons. As a result, the first proposition can be advanced to argue that in the B2B environment, product buyers and users need different consideration for the product innovation process according to their differential contribution.

> *Proposition 1a:*
> If in B2B constellations contributions from the product buyer and the product user are considered diversified, the access of customer contributions is positively influenced. Whereas the product user contributes by providing specific know-how about the product use situation, the product buyer acts as a parameter setter.

***Closeness to customers***

Closeness to customers represents a variable that facilitates interaction between developers and customers, and interview data support its importance. The closeness measures used were the geographical distance between the developer and considered customers and the number of personal contacts between representatives of the developer organization with product buyers and users throughout the product innovation project. The case study data support the value of close interactions with customers and note the relevance of face-to-face contact, which allows the developer to capture unarticulated customer contributions that can only be observed at the customer site. The following examples point to the relevance of closeness with product buyers and users by not only product managers, project leaders, and sales representatives but also product engineers and developers.

In the cases of the development contractors *IDEO* and *Tribecraft*, closeness to customers plays a fundamental role. Meetings with the product buyer's division can take place up to weekly to ensure a constant stream of feedback from the product buyer organization that improves the chance that the resulting new product will precisely match the market position the product buyer wants to achieve. The project parameters (schedule, cost, time, and features) are adjusted together with the product buyer if, in the course of the project, the parameters cannot be met. In addition, *IDEO* and *Tribecraft* observe and interview users at their homes and workplaces and provide them product mock-ups or

prototypes throughout the development process. With these activities, *IDEO* and *Tribecraft* ensure the fit with user needs and continuously gather new inspirations for product refinement.

That is, the case study data support the relevance of closeness for customer integration into product innovation. Closeness aspects found in theory thus are supported.

***Lead user characteristics***

The lead user concept (von Hippel 1976, 1986, 1988) postulates that lead users can contribute significantly to product innovations, especially those who (1) expect attractive innovation-related benefits from a solution to their needs and are motivated to innovate and (2) experience needs for a given innovation before the majority of the target market. Investigating these lead user characteristics from within the case studies leads to several new findings.

First, the case data support the first lead user criterion, namely, that users expect innovation-related benefits that a new product solution could yield. However, the second criterion does not apply in all cases. The development contractors in particular access highly innovative contributions from 'typical users,' not only from the 'leading edge,' because users from the mass market often face needs at the same time as inventive users. This finding has also been reported by Lettl and Herstatt (2004) in their study of lead user characteristics in the medical technology field, in which context the only difference between typical and lead users was lead users' ability to generate their own solutions according to their needs, whereas 'typical users' required the support of a professional developer to realize the same needs.

Second, the *Hilti* and *Buechi* cases demonstrate that product buyers and users who truly contribute to product innovation projects come from the same industry as the new product being developed. For the construction industry, customers from other industries cannot yield the necessary contributions, because they do not have the technical expertise required to provide qualified feedback for high-tech devices. This evidence does not support the findings of several studies on lead user integration that explicitly note the relevance of industry-external lead users (Lilien et al. 2002). In the slow-moving construction industry, radically new applications inspired by lead users from other industries would not be adopted by customers within the industry. *Hilti*'s most valuable contributors are those who are only one innovation cycle ahead of the rest of the market. For *Buechi*, the customers considered lead users represent the same industry as *Buechi* but also work within large pharmaceuticals and use highly automated laboratory equip-

ment. However, product innovations in the field of automation must be carefully adjusted to the relevant segment of typical users to define appropriate automation applications that have not been overengineered for laboratories with less automated processes. Consequently, the relevance of lead user input always gets verified by testing it with typical users that have less access to automation. This test of lead user input is also a standard practice at *Hilti*, such as the broad interview surveys at the end of the concept phase. Table 5-6 shows an overview of the case study data regarding the industry focus of users and other user characteristics.

Table 5-6 Cross-case evidence for user characteristics

| *Companies* / *Characteristics* | *Hilti* | *Buechi* | *IDEO* | *Tribecraft* |
|---|---|---|---|---|
| *Within-industry focus of considered users* | Yes | Yes | No | No |
| *Further user characteristics considered* | Users within organizations that are one development cycle ahead | Typical users with positive and negative attitudes toward new concepts | Extreme and average users | Professional and amateur users |

With regard to the aspect of integrating users with both positive and negative attitudes toward a new product under development, only *Buechi* considers users with a negative attitude throughout the product innovation process. The value of this measure is supported by Morrison, Roberts, and Midgley (2004), and *Buechi* attains broader and more critical evaluations of product concept's relevance.

For *IDEO* and *Tribecraft*, lead users are explicitly sought outside the industry for which the product is being developed. However, in the case of the development contractors, the consideration of typical users is necessary to guarantee the compatibility of the product innovation with the practices and values of a high-profit customer segment. Therefore, in addition to identifying leading-edge product applications, the company considers typical use situations throughout the product innovation process. However, *IDEO* integrates *extreme* and *average* users, whereas *Tribecraft* differentiates between *professional* and *amateur* users. *Tribecraft* even brings professional and amateur users together in workshops to make the differences in the use situations as explicit as possible. By considering lead and typical users, the degree of newness of lead users' contributions does not drop but simply is contrasted with the contributions of typical users. As

a result, differences become more explicit, which offers further insights into the development of the product innovation.

The lead user concept by von Hippel (1986; 1988) acknowledges the relevance of typical users who represent the broad market segment. However, typical users are considered only in the final stage of the lead user concept to test the solutions elaborated by the lead users. The concept testing phase verifies whether typical users find the lead users' solutions appealing. In contrast, the case study data reveal the high value of considering typical users not only after collecting input from lead users but also simultaneously, even during the same events. From these insights, a second proposition emerges regarding customer contributions from lead and typical users.

*Proposition 1b:*
If both lead user contributions and contributions from typical users are considered continuously throughout the product innovation process, the access of customer contributions is positively influenced. Whereas lead users provide inspiration for product innovations and come up with new product solutions, typical users require the support of a professional developer to implement their contributions. Typical users furthermore indicate the adoption and appeal of lead users' solutions for the high-profit market.

### 5.3.2 Propositions on customer contribution absorption

***Product innovation flexibility through development iterations***

The conceptual model developed from existing literature predicts that the absorption capacity of customer contributions depends on the product innovation process's flexibility. In the case studies, process flexibility can be observed in the amount of product innovation process formalization, the project planning practices, the time of the project specification freeze, and the deciding authority over customer contribution implementation (see table 5-7)

Table 5-7 Cross-case evidence for product innovation process flexibility

| *Companies* / *Characteristics* | *Hilti* | *Buechi* | *IDEO* | *Tribecraft* |
|---|---|---|---|---|
| *Product innovation process formalization* | High | Very high | Low | Very low |
| *Project planning* | Detailed upfront planning for next development stage, setting of market introduction point | Detailed upfront planning at project start, little adjustments if necessary | Planning cycles at the end of every project stage, continuous parameter adjustment | Informal planning at project start until end of concept phase |
| *Time of project specification freeze* | End of definition phase | End of functional model development | End of concept phase | End of concept phase |
| *Deciding authority over contribution implementation* | Developer | Developer | Developer with product buyer | Developer with product buyer |

The case data show that process flexibility for *Hilti* and *Buechi* is relatively high, because project planning is more rigorous compared with that of the development contractors. *IDEO* and *Tribecraft* have a less formalized product innovation process, with process steps serving more as guidelines than imposing rigor onto the project procedure, such that a new product evolves according to an interactive process among the manufacturer, product buyer, and users. As a result, the developers do not claim to predict and plan precisely how the final product will look, its price, to whom it will be relevant, or when and where it will be extended to a broader market. Project planning evolves from prototype to prototype by continually adjusting the project parameters each time. Consequently, *IDEO*'s and *Tribecraft*'s project planning is informal, focuses on the sequencing development cycle, and is continually adjusted. More specifically, the product buyer is involved in the decision about the implementation of the next product features, which were developed by the development contractors together with selected product users.

Because the potential of influencing product innovation goals (in terms of development cost, performance, and time) decreases during the product innovation process, the customer contribution absorption measures that take place at the beginning of the project have the most impact on the overall course of the project. The decreasing potential to influence project goals related to the depth of customer contribution absorption within the four case studies is illustrated in figure 5-4. The approximate intensity of customer contribution absorption is shown by a curve for each case study.

Figure 5-4 Potential to influence project goals related to customer contribution absorption

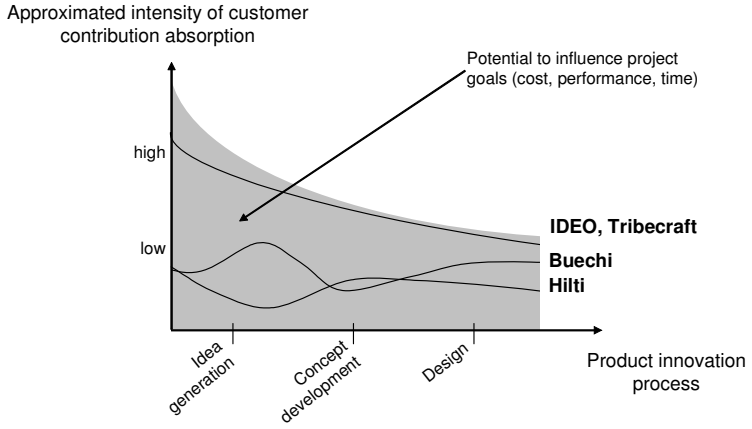



Figure 5-4 also tries to illustrate that the decisions about product features and functions at the beginning of the product innovation process have the most impact on the overall development project, which underlies *IDEO*'s and *Tribecraft*'s practices of absorbing product buyers' and users' contributions as early as possible in the product innovation process. Furthermore, both development contractors focus on implementing first those product functions and features that matter most to product buyers and users. At *IDEO*, for example, the team members create a list of possible product features based on insights from the human factors study with users. On the basis of this list, the developer identifies and prioritizes the 'make or break' features, which are fundamental for the realization of the product in terms of a risk assessment, together with the product buyer. After such a decision, *IDEO* can continue with its development according to the product buyer's priorities. As a result, the innovation project progresses through the implementation of product functions and features, and developers continually make decisions with

the product buyers about their sequence and adoption. This practice can be regarded as a collaborative dynamic prioritization of product features and functions by developers and product buyers, in which the input of users also is considered.

This practice of dynamic product feature and function prioritization also can be partially observed among the development practices of in-house developers. Whereas *IDEO* and *Tribecraft* involve the product buyer and users in prioritizing product features and functions at the idea stage, *Buechi* only applies feature and function prioritization in the early concept stage and *Hilti* only in the late concept stage and solely to adjust design and handling aspects. However, even though *Hilti* considers its product buyers for feature prioritization only during the late concept stage, it successfully practices dynamic product planning aspects through its formalized stage-gate process. This practice supports the relevance of continuous and iterative planning, as conducted by *IDEO* and *Tribecraft*. Although at *Hilti,* the rough project parameters are set at the project start, detailed planning is carried out at the gate only for the sequencing development stage, not for the whole project. Overall, the data suggest an iterative planning approach for the next development stage that focuses on product functions and features for which required development information is available. From these insights, a further proposition on product innovation planning and development iterations is derived.

*Proposition 2:*
If product innovation planning is iterative and is based on collaborative prioritization of product features by developers and product buyers, the absorption of customer contributions into product innovation is positively influenced. Although rough, general project parameters (time, cost, quality, scope) should be set at the start for the overall project, detailed project planning should be carried out only for the next development cycle.

### 5.3.3 Propositions on the relationship between customer contribution access and absorption

The conceptual model developed from literature has shown that product development must occur as a dynamic interplay between developers and customers. The case data support this statement in all four cases but indicate that this interplay takes place with different aims and scope. Whereas the in-house developer *Hilti* considers customers to ensure the relevance of the product idea for the market and to test its development activities at the customers' site, *Buechi* and the development contractors *IDEO* and *Tribecraft* seek customer contributions to determine the scope of the new product.

In terms of the specific customer contributions to product innovation, the case studies demonstrate that two major categories of contributions can be distinguished: major contributions in terms of determining new product scope and functionalities and minor contributions for verifying the product relevance and feedback about design and handling adjustments. An overview on these two contribution categories, as well as the customers' specific involvement within the cases studied, is shown in table 5-8.

Table 5-8 Cross-case evidence for different customer contributions

| *Companies* / *Characteristics* | *Hilti* | *Buechi* | *IDEO* | *Tribecraft* |
|---|---|---|---|---|
| *Determination of product scope and functionality* | Product buyer and users not involved; determined by Hilti | Users involved: selection of customers' subprocesses that are supported through automation | Product buyer and users involved: identification of distinguishing innovation potentials from the product's use situation | Product buyer and users involved: identification of distinguishing innovation potentials from the product's use situation |
| *Relevance verification and design adjustments* | Users involved: verification of the device's applicability in the new market, provision of abundant test information | Users involved: adjustment of the product–customer interface (product design and handling) | Product buyer and users involved: adjustment of the product–customer interface (product design and handling) | Product buyer and users involved: adjustment of the product–customer interface (product design and handling) |

A difference between the situation of *Hilti* on the one hand and those of *Buechi*, *IDEO*, and *Tribecraft* on the other hand lies in *Hilti's* strong leadership position and highly specialized expertise in the product area to which the case study refers. *Hilti* brings its mature technology to the market, a process assisted by the customer for 'fine tuning.' Overall, the customers accept what is technically feasible, which assures compatibility with its practices, needs, and values.

Regarding the in-house developer *Buechi* and the development contractors, they launched innovation projects in product areas in which they do not hold a leadership position. This situation arises for *Buechi* because it was attempting to enter a new product field and for *IDEO* and *Tribecraft* as a consequence of their business activity, which is not limited to a certain industry. Because the development contractors have only limited competences in-house for a specific innovation project, they connect with industry specialists and product buyers and users in their development activities. As a result, the

products *IDEO* and *Tribecraft* bring out are less dominated by the perspective of a single development company and more open to combining different technological possibilities and market needs. Summarizing this aspect of customer integration in the two different customer contribution categories—(1) determination of product scope and functionality and (2) relevance verification and design adjustments, as they have been used in the data analysis in the preceding table—figure 5-5 gives an approximate overview of the four cases' activities.

Figure 5-5 Different scope and degrees of collaboration into product innovation activities

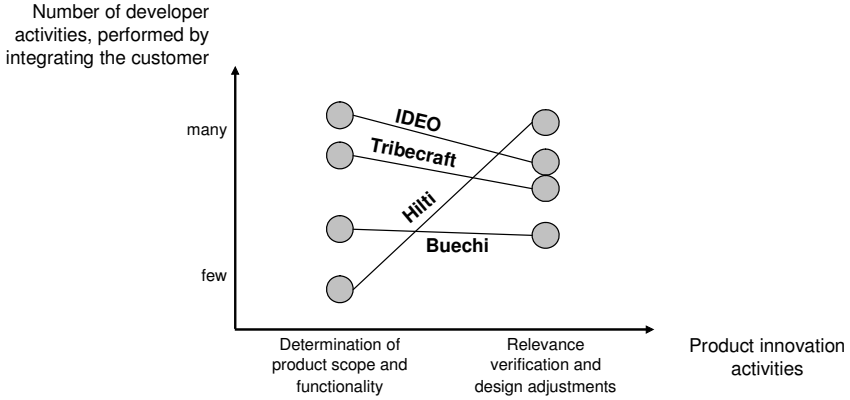



Figure 5-5 illustrates that in the *IDEO* and *Tribecraft* cases, the customer sets the frame for the product scope and functionality and therefore strongly influences the product specifications. *Buechi* needs its customers to identify the best application field. *IDEO* and *Tribecraft* shape the product together with their client from the very beginning and consider users for inspiration and validation. Therefore, the development contractors aim at achieving clear product differentiations together with the customers, detached from existing industry norms. From these insights, a third proposition can be derived, focusing on the company's initial position for an innovation project.

*Proposition 3a:*
If a product innovation project aims at strengthening a product leadership position, the consideration of customer contributions supports the product's relevance verification and design adjustment. If a product innovation project aims at entering a market in which the developing company does not have a product leadership position, the incorporation of customer contributions contributes to the determination of the new product's scope and functionality.

In analyzing the relationship between customer contribution access and absorption, the product buyer and user constellation in terms of responsibility for new product distribution and market introduction requires further consideration. This product buyer and user constellation is hereafter referred to as *market responsibility*. In the case of *Hilti*, the selected product buyers and users reside within the same customer organization, and therefore, the product buyer decides about the product application for its users. In the case of *Buechi*, the product buyer is the product distributor and market developer and therefore plays a crucial role in the distribution of the new product. Distribution partners are strongly sales driven and more past oriented than progressive about new market introduction. *Buechi* seeks support for product innovation projects from those distribution partners that are able to provide access to the market in which the target users are located.

In the *IDEO* and *Tribecraft* cases, the project-ordering product buyer has the full market responsibility and therefore bears the financial risk if a broad user segment cannot be reached. Furthermore, product buyers developing a new product together with a development contractor explicitly seek product differentiation from the industry standards. This scenario contrasts with the situation for, e.g., *Buechi*'s product innovation projects, for which distributors first must be convinced about the value of the product innovations. Table 5-9 shows an overview of the market responsibility and the aspect of the point in time at which the developing company receives a financial commitment for a specific product innovation project, which strongly influences developers' relationship with their product buyers.

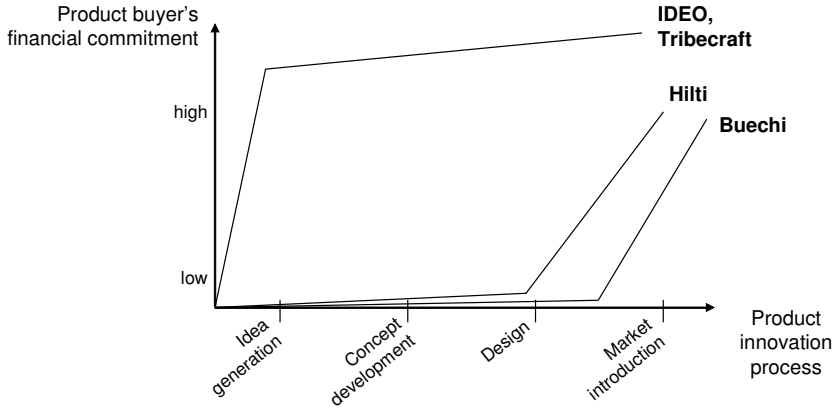
Table 5-9 Cross-case evidence for market responsibility and financial commitment

| *Companies* / *Characteristics* | *Hilti* | *Buechi* | *IDEO* | *Tribecraft* |
|---|---|---|---|---|
| *Product distribution responsibility* | Direct distribution by developer via own market organizations | Distribution via distribution partners and own affiliates | Distribution responsibility by project product buyer | Distribution responsibility by project product buyer |
| *Financial commitment from product buyer* | End of design phase | Production start (beta test) | From project start through product buyer initiating the project | From project start through product buyer initiating the project |

The product buyer's financial commitment is different from a product development mandate, when the new product is bought by the product buyer without its collaborative

involvement. Although for *IDEO* and *Tribecraft,* the product buyer's financial commitment is guaranteed from the project start, *Hilti* can gain its product buyer's financial commitment only after the product design phase, when users approve the final design. In the case of *Buechi*, the distributor commits itself to put the product in its catalogs only at the stage of market introduction. A rough overview of these differences in product buyers' financial commitment to the innovation project is approximately depicted in figure 5-6.

Figure 5-6 Differences in product buyers' financial commitment




For *IDEO* and *Tribecraft*, where the product buyer's financial commitment is provided from the project start, the product buyer is strongly devoted to the new product under development. According to its financial stake in the project and distribution and market introduction responsibility, the buyer significantly contributes its expert and market know-how to achieve product success in the market. *Hilti* and *Buechi* can achieve the product buyer's financial commitment only at a relatively late stage in the product innovation process, so the product buyers' engagement primary consists of setting restraints on the product costs and facilitating access to users. Because *Hilti* has a strong brand and its product buyers' price sensitivity is lower than that for *Buechi*, *Hilti* product buyers (construction experts, general entrepreneurs, facility managers) can more easily be convinced about innovative product solutions. In the case of *Buechi*, the product buyer (distribution partner) has distribution and market introduction responsibility but is not financially committed to a new product and therefore contributes solely from the perspective of how the biggest market shares can be achieved. Consequently, in the cases

of *Buechi* and *Hilti*, the product buyer is more a moderator than a contributor to the product innovation project. From these insights, the following propositions can be derived, pertaining to the impact of product buyers' distribution and market introduction responsibility and financial commitment.

> *Proposition 3b:*
> If the product buyer has market responsibility and is financially committed to a product innovation project at an early stage, his engagement in the project is positively influenced. The bigger the product buyer's market responsibility and the earlier it is financially committed to a product innovation project, the more it potentially contributes to the new product under development.

### 5.3.4 Propositions on customer contribution release

The conceptual model developed from existing literature has shown the relevance of visualizing intermediary product innovation results through working models, mock-ups, and early prototypes. To measure the degree of use of intermediary result visualizations by the case companies, the number of physical visualizations (which include very simple and approximate prototypes) has been analyzed. Furthermore, the start of physical visualizations in the product innovation process has been investigated. Table 5-10 lists these visualization practices in the four cases.

Table 5-10 Cross-case evidence for prototyping practices

| *Companies* / *Characteristics* | *Hilti* | *Buechi* | *IDEO* | *Tribecraft* |
|---|---|---|---|---|
| *Number of physical visualizations* | 3–6 | 2–4 | More than 15 | 10–15 |
| *Start of physical visualizations* | After functional model development | After functional model development | From project start | From start of concept phase |

Table 5-10 shows that *Buechi* and *Hilti* present functional prototypes to the customer at a relatively late stage. Therefore, few prototypes are built, but they comprise design and functionality aspects in one device. With these prototypes, the companies collect a broad spectrum of product buyer and user information. The application of these devices involves the challenges of focusing the customer on those issues for which its feedback really is required and its input can be implemented into the product.

In contrast with the prototyping practice of the in-house developers, *IDEO* and *Tribecraft* apply techniques to focus customers on single aspects of product modules, such that specific problems can be solved and product buyer decisions evoked. Every module of the new product under development is adjusted to product buyer and user needs. This process holds true for functional and design issues, which are elaborated separately. *IDEO* therefore builds several prototypes for every module to test each module specification. For example, whereas a first prototype aims at simulating the product's stability, a second simulates only the nature of the surface, and a third prototype is built only to simulate the future module's weight. From this evidence, a propositions for the release of customer contributions can be stated. It focuses on the partitioning of customer contributions.

> *Proposition 4:*
> If customer contributions are partitioned by concentrating customer know-how on one specific development issue, the release of customer contributions into product innovation is positively influenced. This contribution partitioning can be achieved through physical visualizations of single intermediary project results.

To realize those product functions and features that the product buyer prioritizes, the developers must pay attention to the new product architecture. This aspect is relevant for both the development contractors and the in-house developers. The compatibility and upgradeability of modules plays a crucial role, because they determine the performance of the resulting product system.

### 5.3.5 Propositions on the relationship among customer contribution release, access, and absorption

The conceptual model developed from literature has shown that through the integration of customers into product innovation in the form of a probe-and-learn process (Lynn et al. 1996), a new product can grow through the continual interplay between developers and customers. This new product 'growth' through the implementation of released customer contributions takes place in all four cases. To make this aspect explicit, table 5-11 lists the released and absorbed customer contributions at the product buyers' and users' sites, as well as the media employed to transfer the evolving product innovation project among the different sites and over time. To provide a concise overview, table 5-11 employs a simplified product innovation process model that is applicable to all four cases and makes the data comparable. Therefore, the product innovation process of the four companies is reduced to three stages: (1) idea generation, (2) concept development, and

(3) product design. Market introduction is not considered, because this step does not influence product development activity per se.

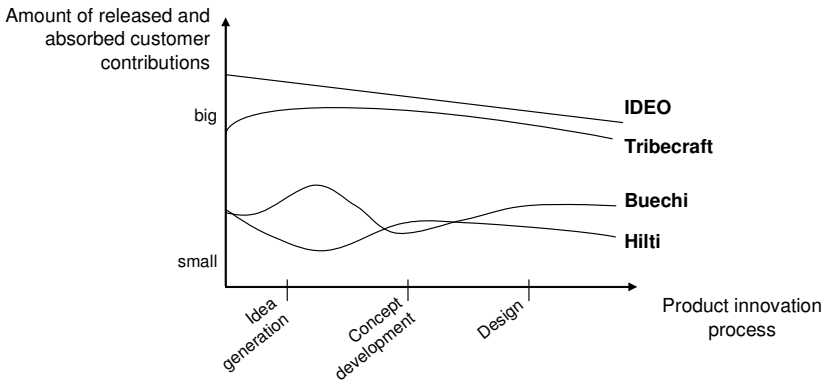
Table 5-11 Cross-case evidence for customer contributions to product innovations

| *Company* / *innovation phase* | *Hilti* | *Buechi* | *IDEO* | *Tribecraft* |
|---|---|---|---|---|
| *Idea generation* | *Contribution*: Trends, willingness to pay<br>*Actor:* Mainly product buyer<br>*Media*: Questionnaire | *Contribution*: Relevant product functionalities<br>*Actor:* Product buyer and user<br>*Media*: Paper concept, questionnaire | *Contribution*: Product use and technical parameters<br>*Actor:* Product buyer and user<br>*Media*: Questionnaire, video | *Contribution*: Long-term product strategy and character<br>*Actor:* First product buyer, second user<br>*Media*: Questionnaire, video, moodboard |
| *Concept development* | *Contribution*: Feedback from functional prototype test in focus groups<br>*Actor:* User<br>*Media*: Functional prototype | No product buyer and user involvement during concept phase<br>*Prototype phase:*<br>*Contribution*: Test feedback regarding relevant specifications<br>*Actor:* Product buyer and user<br>*Media*: Functional model (prototype) | *Contribution*: More use and technical information, feedback to mock-ups and rapid prototypes, insights into user 'personas'<br>*Actor:* Product buyer and user<br>*Media*: Mock-ups, rapid prototypes | *Contribution* More use and technical information, insights into use workflows<br>*Actor:* Product buyer and user<br>*Media*: Mock-ups, rapid prototypes |
| *Product design* | *Contribution*: Design adjustments<br>*Actor:* Product buyer and user<br>*Media*: Final prototype | *Contribution*: Marginal design adjustments<br>*Actor:* Product buyer and user<br>*Media*: Final prototype | *Contribution*: Feedback on final (integrated) design and functional prototype<br>*Actor:* Product buyer and user<br>*Media*: Final prototype | *Contribution*: Feedback on final (integrated) design and functional prototype<br>*Actor:* Product buyer and user<br>*Media*: Final prototype |

The case studies show that contributions from customers strongly vary with the project stage and visualization media employed. The companies employ different visualization

and transfer media, and the data reveal differences in the company practices. What becomes apparent is the connection between the use of early physical prototypes throughout the product innovation process and the extent to which product buyers and users shape the product under development. Figure 5-7 illustrates this connection in an approximate way: *IDEO* and *Tribecraft*, confronting product buyers and users continuously with physical prototypes over (almost) the whole development process, collect many customer contributions that they turn into the next prototypes. *Hilti* and *Buechi*, in contrast, drive the product innovation project more with their in-house know-how base and collect customer contributions only for adjustments in the product design and handling, in the case of *Hilti*, or for adjustments of the specifications' scope definition, in the case of *Buechi*.

Figure 5-7 Varying amount of released and absorbed customer contributions




The conceptual model further has shown that the intermediate outputs of problem solving at each locus must be able to be transferred between developers and customers to realize the next probe-and-learn cycle, as has been pointed out by von Hippel's research on sticky information and task partitioning (von Hippel 1994). Because *IDEO* and *Tribecraft* possess much less industry expertise than *Hilti* and *Buechi* in their markets, the development contractors need to transfer the product innovation project more often to release and absorb much more know-how from the beginning of the product innovation project. Due to their less specialized in-house industry know-how, the development contractors learn through their early physical representations of the product under development.

As a consequence, the products *IDEO* and *Tribecraft* bring out are less dominated by the perspective of one developing company and remain more open to different technological possibilities and market needs. The resulting products from the development contractors can be considered to have a higher *degree of innovativeness*. This concept refers to the noticeable superiority of the new product for product buyers, users, and the developer compared with the industry standard. The high degree of innovativeness is promised by the development contractors' business model and has been demonstrated, e.g., by the design awards won by the companies. If they were not able to develop products with noticeable improvements over the industry standards, in-house developers would not hire the contractors for their product developments. In contrast, *Hilti* and *Buechi* possess abundant expert know-how within their companies so do not experience the pressure of seeking externally for development expertise and involve product buyers and users less than do the development contractors. In turn, their development activities are always dominated by the in-house perspective on the new product under development.

Overall, *Buechi* and *Hilti* start from their technical core competences related to their industry, whereas the development contractors are independent of an existing product or competence portfolio. As a result, the development contractors act independently of their industry competence, whereas the activity of in-house developers can be considered company competence-dependent. Independence enables the development contractors to engage in flexible matchmaking among the technical skill base of their developers, the technical and market skill base of the product buyers, and the skill base for product application from considered users. In-house developers, in contrast, have a stronger and more specialized focus on their industry. It is more challenging for them to make connections between existing solutions and problems across industry boundaries. As a consequence, in-house developers release customer information in a form that appears more incorporated into the industry average. These insights lead to the next proposition, which focuses on the intensity of early customer contributions and the degree of innovativeness of the final product.

*Proposition 5:*
If in-depth industry competence in the market area of the new product under development is low, the product innovation's potential for a high degree of innovativeness is positively impacted.

## 5.4 Summary of conceptual model and propositions

Chapter 5 provides a cross-case analysis of the four case studies discussed in chapter 4. This cross-case analysis develops generalized proposition statements or theoretical claims that contribute to theory on customer integration into product innovation. The developed propositions are rooted in a model shaped from existing theory on customer integration into product innovation and are supported by the present data of the investigated companies. Figure 5-8 summarizes the model and propositions.

Figure 5-8 Model and propositions summary

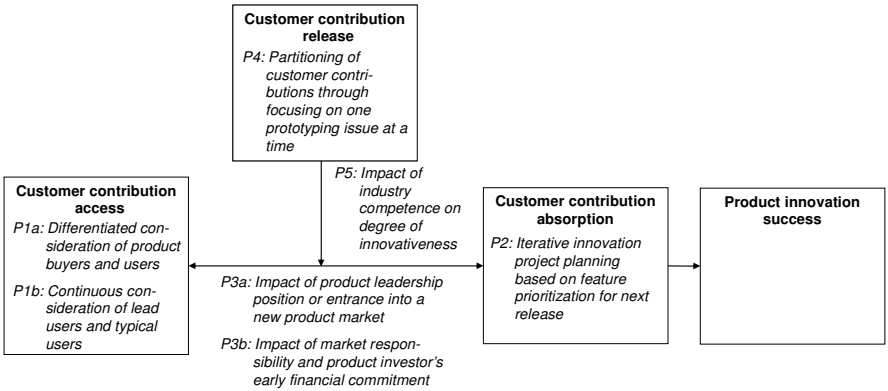



Table 5-12 shows an overview of the following constructs: customer contribution access, absorption, and release, and their relationships, as well as the developed propositions that extend theory on customer integration into product innovation. Whereas P1a, P1b, P2, P3a, P3b, and P5 are supported by the data of all companies investigated, support for P4 is provided by the customer integration practices of the development contractors (*IDEO* and *Tribecraft*).

Table 5-12 Constructs and propositions overview

| *Construct* | *No.* | *Proposition* |
|---|---|---|
| Customer contribution access | P1a | If in B2B constellations contributions from the product buyer and the product user are considered diversified, the access of customer contributions is positively influenced. Whereas the product user contributes by providing specific know-how about the product use situation, the product buyer acts as a parameter setter. |
| | P1b | If both lead user contributions and contributions from typical users are considered continuously throughout the product innovation process, the access of customer contributions is positively influenced. Whereas lead users provide inspiration for product innovations and come up with new product solutions, typical users require the support of a professional developer to implement their contributions. Typical users furthermore indicate the adoption and appeal of lead users' solutions for the high-profit market. |
| Customer contribution absorption | P2 | If product innovation planning is iterative and is based on collaborative prioritization of product features by developers and product buyers, the absorption of customer contributions into product innovation is positively influenced. Although rough, general project parameters (time, cost, quality, scope) should be set at the start for the overall project, detailed project planning should be carried out only for the next development cycle. |
| Relationships between customer contribution access and absorption | P3a | If a product innovation project aims at strengthening a product leadership position, the consideration of customer contributions supports the product's relevance verification and design adjustment. If a product innovation project aims at entering a market in which the developing company does not have a product leadership position, the incorporation of customer contributions contributes to the determination of the new product's scope and functionality. |
| | P3b | If the product buyer has market responsibility and is financially committed to a product innovation project at an early stage, his engagement in the project is positively influenced. The bigger the product buyer's market responsibility and the earlier it is financially committed to a product innovation project, the more it potentially contributes to the new product under development. |
| Customer contribution release | P4 | If customer contributions are partitioned by concentrating customer know-how on one specific development issue, the release of customer contributions into product innovation is positively influenced. This contribution partitioning can be achieved through physical visualizations of single intermediary project results. |
| Relationships between customer contribution release, access and absorption | P5 | If in-depth industry competence in the market area of the new product under development is low, the product innovation's potential for a high degree of innovativeness is positively impacted. |

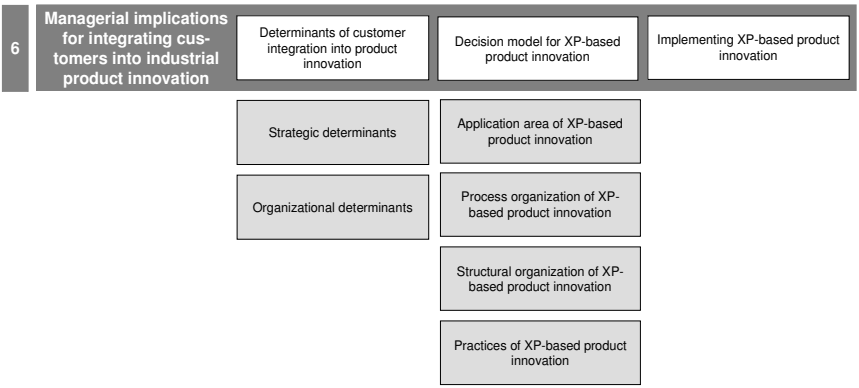
The model and its propositions build a conceptual frame, from which the following chapter derives a recommended solution for integrating customers into industrial product innovation.

# 6 Managerial implications for integrating customers into industrial product innovation

Based on the case study analysis and conceptual model in chapter 5, this chapter investigates the managerial implications for integrating customers into product innovation projects in practice. Therefore, determinants and a decision model are derived from the theoretical propositions. The *determinants* provide a guideline for choosing an appropriate customer integration strategy, and the *decision model* presents a recommended organizational solution for product innovation that integrates the customer and thereby enables a company to develop new products that respond to evolving customer needs and requirements. For the development of the decision model, this chapter refers back to the Extreme Programming (XP) method from software engineering, which was the starting point of this research. Because XP provides a new perspective on customer integration and the product innovation process of industrial product development, the decision model developed for industrial product development is XP based.

This chapter is structured as follows: first, the strategic and organizational determinants of customer integration into product innovation are derived from the propositions of the conceptual model in chapter 5 (6.1). Second, based on the determinants and using insights of the XP method from chapter 3, the XP-based decision model for customer integration into product innovation is developed (6.2). Third, implications for implementing effective measures for customer integration into product innovation are discussed (6.3). An outline of this chapter is presented in figure 6-1.

Figure 6-1 Outline of chapter 6




## 6.1 Determinants of customer integration into product innovation

The propositions developed in chapter 5 represent the starting point for the determinants of customer integration into product innovation projects, which are derived subsequently. They represent a strategic orientation guide for companies on how to integrate customers. First, propositions that lead to strategic determinants, in support of managerial decisions about the adequate strategic approach to customer integration, are presented (6.1.1). Second, the propositions leading to organizational determinants are discussed to support managerial choices of customer integration measures (6.1.2).

### 6.1.1 Strategic determinants: need anticipation versus technology and application brokering

The propositions that give insights into the customer integration aspects that influence a company's *strategic innovation decisions* relate the customer integration access, release, and absorption constructs to one another. These aspects are the company's product leadership position (P3a), the market responsibilities (P3b), and the consideration of external development resources due to industry competence (P5). In the following, these propositions are examined and extended to the strategic determinants. The subsequent consolidation of the determinants offers new insights into different strategic approaches for customer integration into product innovation that companies can follow.

***Determinant 1: industry empathy***

The derivation of the first strategic determinant relies on P3a (chapter 5.3.3) and P5 (chapter 5.3.5). Proposition 3a states that the leadership position of the company *in the area of the product under development* affects customer integration. As presented in the cross-case analysis, companies that do not occupy a technology or market leadership position in the product field integrate customers mainly to define the new product's scope and features (e.g., *Buechi*, *IDEO*, *Tribecraft*). In contrast, companies with a product leadership position integrate the customer into their product innovation projects for 'fine tuning' and adjustment (e.g., *Hilti*), because they already have a technological head start.

Propositions 5 shows that the consideration of external development resources has a determining effect on customer integration. The more input and know-how is integrated from customers and specialists external to the company, e.g., as a result of the company's insufficient competence, the higher is the potential for a high degree of innovativeness of the new product solutions. This degree of innovativeness refers to the noticeable superiority of the new product for users, distributions partners, clients, and the developer compared with the industry standard.

These two propositions together address the company's in-depth know-how regarding the product market and its related technology, which hereafter is referred to as *industry empathy*. Higher industry empathy implies that a company is in a market-leading position in the specific product field or that it has a technological head start and that it considers the uncertainty of the product innovation requirements low. Therefore, it generally considers customers and company-external specialists for marginal product decisions; it already possesses the leading development competences in-house. In contrast, lower industry empathy implies that a company has a weak position in the targeted product market, that technological constituents must be developed or acquired, and that the uncertainty of the product innovation requirements are considered high. Therefore, customer and company-external specialists are integrated for fundamental product decisions, not just product fine tuning.

Regarding industry empathy's effect on the new product's degree of innovativeness, high industry empathy can lead to a rather low degree of product innovativeness, because the market and technology are well known and perspectives external to the industry are rarely considered. This effect gets enhanced by the *maturity of an industry*: the more mature an industry, the stronger the tendency toward a low degree of product in-

novativeness, because possible product improvements become more and more marginal. Only the entrance of new competitors or the introduction of disruptive technologies (e.g., Christensen 1997; Paap and Katz 2004), which are hardly foreseeable, provoke big changes. Low industry empathy, in contrast, has a tendency to lead to a rather high degree of innovativeness, because there is a need for solutions and know-how from other industries, so new perspectives on a product development are included and enforced.

***Determinant 2: market responsibility***

The development of the second strategic determinant relies on H3b (chapter 5.3.3), which reveals that the customer's market responsibility, supported by its early financial commitment to a product innovation project, positively influences its engagement in the project. The cross-case analysis shows that the more the customer is responsible for the product distribution or the earlier it is financially committed to a product innovation project, the more it contributes to the new product under development.

As an illustration of this aspect of market responsibility, the in-house developer *Hilti* sells products to its customers using a direct approach with its own market organization, whereas the in-house developer *Buechi* sells most of its products through distribution partners. Therefore, both *Buechi* and its distribution partners have market responsibility: *Buechi* selects the distribution partners that are most appropriate to sell the new product, but the distribution partners access the product users and introduce the product to the market. In the case of the development contractors *IDEO* and *Tribecraft*, it is only the ordering client that has the market responsibility.

Restated, the market responsibility has a determining effect on customer integration and ranges from the developer's full product distribution responsibility to the client's full product distribution responsibility. When a developer is responsible, it determines the number of items sold by its own market organization efforts (*Hilti*). With combined developer and distributor responsibility (*Buechi*), the company must consider and relies on the skills of the distributor. Finally, development contractors are not directly affected by the number of items sold to the market by the client (*IDEO* and *Tribecraft*).

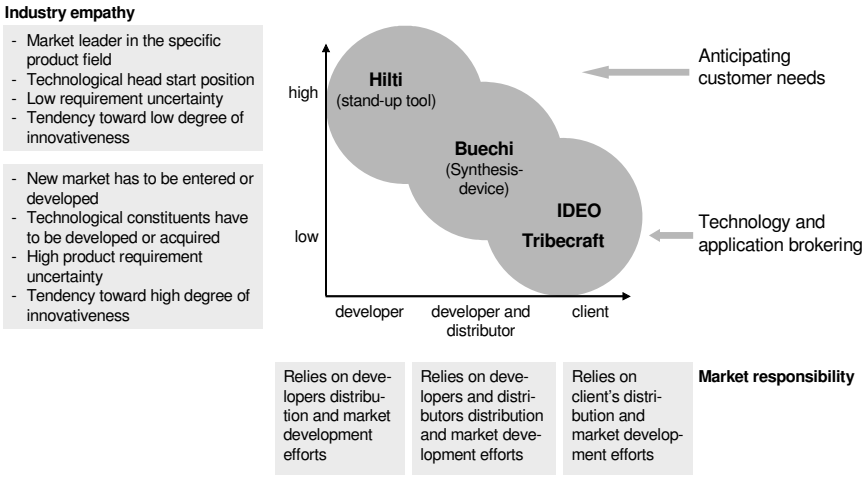
***Consolidation of strategic determinants: customer integration strategies***

Industry empathy and market responsibility offer two strategic determinants for customer integration into product innovation. This section discusses two customer integration strategies for product innovation projects that can be derived from these two determinants.

Figure 6-2 presents a two-dimensional matrix that relates the strategic determinants to each other. Compiling the data from the case studies of four companies that integrate their customers shows that their innovation projects can be assigned to a diagonal within the matrix. This positioning of the companies refers to the specific projects investigated in the case studies and is not representative of all their projects. The positions on the diagonal in the matrix reveal *consistent project strategies* for customer integration into product innovation—meaning they contain no complicating contradictions—as they are successfully followed by the case companies:

- *Hilti's* project position is characterized by high industry empathy and the developers' market responsibility. This combination leads to the possibility to anticipate customers' needs. However, this anticipation generally leads to product innovations with a relatively low degree of innovativeness, because the industry is mature and product improvements happen on a marginal level.
- *IDEO* and *Tribecraft* are characterized by low industry empathy in the affected product area and market responsibility solely with the client. This combination of low industry empathy with indirect market access by the developer leads to brokering between the technological and application know-how among the developer, its client, and users. This brokering approach generally leads to product innovations with a relatively high degree of innovativeness, as the project successes of *IDEO* and *Tribecraft* show.
- The position of *Buechi*'s project is in the middle of the two approaches, characterized by average industry empathy and market responsibility by both the developer and the client. From this position, *Buechi* considers the requirements of distributors as well as users and therefore combines aspects from *Hilti*'s as well as from the development contractor's positions.

Figure 6-2 Customer integration strategies for product innovation projects




The resulting two customer integration strategies for product innovation projects—anticipating customer needs and technology and application brokering—are discussed subsequently. Other customer integration strategies for product innovation projects, as they arise from the undiscussed areas in the matrix of figure 6-2, are possible too but must be reflected on carefully, as they are not consistent: *high industry empathy*, for example, combined with *indirect* market access through a client organization complicates the access to the end-users, which is fundamental for any anticipation of customer needs; a brokering strategy from the position of *low industry empathy* with an *own market organization* has the disadvantage that there are not as many perspectives among which know-how and technology can be brokered as would be the case if a distributor or client entity also contributed to innovation projects.

***Anticipating customer needs***. With this approach, the core assumption is that a company is able to foresee customer needs (Seely Brown and Hagel 2005). This strategy can be enabled by organizations' efforts to push product innovation resources and technological potential into areas with a high probability of achieving improvements. Considering the leadership status from which *Hilti* pursues this strategy, the company does not only anticipate but even 'shapes' industry standards in certain product areas. *Hilti* provides the customer with new technological possibilities, enabling it to achieve new performance levels through product application. However, this strategy faces severe

challenges in the case of unanticipated market shifts. According to Seely Brown and Hagel (2005), organizations that use so-called 'push' approaches are in danger of either piling up inventories or going through costly 'somersaults' to keep up with unanticipated market shifts. Therefore, product innovation teams must be prevented from 'reinventing the wheel' and coming up with an 'innovation' that has already been developed and implemented elsewhere (Gassmann and von Zedtwitz 2003). Furthermore, tight, long-lasting relationships with leading customers are crucial to guarantee that evolving customer trends do not get missed.

***Technology and application brokering***. The second strategic approach, technology and application brokering, promotes imitation across industries and linkages between technological and demand know-how from 'worlds' that previously were separate (Hargadon and Sutton 1997; Servatius 2004). The rationale underlying this approach attempts to bring together the relevant problem information with the actual problem-solving capability, even if abundant development competence does not reside within the developing company at the start of the project (von Hippel 1994). The success factors of this approach include experimentation, improvisation, and rapid learning. To realize it, developers must participate in distributed resource networks in which customers play major roles. Developers also have to operate across traditional corporate boundaries, collaborate on innovative solutions, and learn from one another to speed capability building (Seely Brown and Hagel 2005).

The two cases involving the development contractors *IDEO* and *Tribecraft* illustrate the application of this strategy. They apply an open innovation approach (Chesbrough 2003; Gassmann, Sandmeier, and Wecht 2004; Gassmann and Enkel 2006) by connecting with highly specialized engineers from the client company during a project. Due to the high skill level of the development contractors' staff, the learning effect resulting from the collaboration with these various industry experts is very high. In turn, the distributed and continuously reformed development contractor teams can generate ideas across different projects with higher degrees of innovativeness. Clients and customers are considered from the objective perspective of a third party, which brokers insights about different needs with the latest technological solutions. Therefore, the development contractors can be regarded as arbitrators between the potential of the technology and customer needs, acting as an interface and playing an important role in technology transfer and adoption (Veryzer and Borja de Mozota 2005).

### 6.1.2 Organizational determinants: impact of customer integration measures

The propositions that offer insights into customer integration measures on an *organizational level* are those that pertain to three constructs of customer integration access, release, and absorption. The measures involve the consideration of product buyers and product users (P1a), the consideration of lead and typical users (P1b), product innovation planning based on feature prioritization (P2), and the partitioning of customer contributions through prototyping practices (P4). These organizational measures, which lead to the organizational determinant of customer integration, are investigated next. The subsequent consolidation of the organizational determinants provides an overview of product innovation specifications that positively affect customer integration.

***Determinants of customer contribution access***

Chapter 5.1 defined customer contribution access as the availability of customer know-how, depending on customers' characteristics and their disposition through their embeddedness in the market environment. The following section presents the first two organizational determinants, based on H1a and H1b, developed through customer contribution access.

***Differentiated consideration of product buyers and users***. Proposition 1a indicates that in B2B constellations, access to customer contributions will induce a diversified consideration of the contributions from product buyers and product users. Whereas the product user contributes by providing specific know-how about the practical product use situation or technological expertise, the product buyer helps set product parameters. As a result, effective customer integration into product innovation requires, from the development team, an awareness of the specific role of the product buyer or user, which enables the team to approach that contributor in a way that will best access his or her contribution. The first organizational determinant within the construct of customer contribution access therefore refers to *product buyer and user consideration*. This determinant ranges from 'undifferentiated' to 'differentiated,' where a tendency toward 'differentiated' positively influences customer integration measures.

***Consideration of leading users and typical users***. The cross-case analysis highlights the relevance of integrating lead users as well as typical users throughout the product innovation process. Because the definition of lead users in the companies analyzed does not meet the classical lead user definition but considers other relevant criteria (e.g., lead users must come from the same industry, not be more than one innovation cycle ahead of

the industry average), these users are referred to as *leading users* to avoid an inappropriate comparison to the lead user concept (von Hippel 1986, 1988).

In the four cases analyzed, both leading and typical users are considered throughout the product innovation process. Whereas input and inspiration from leading users is sought mainly at the project start, typical users are considered on a regular basis to validate the relevance of the new product on a broad scale. The second organizational determinant within the construct of customer contribution access therefore is the *leading user and typical user consideration*. In this case, the determinant ranges from 'punctual' to 'continual,' where a tendency toward 'continual' positively influences customer integration measures.

***Determinant of customer contribution absorption***

Chapter 5.1 defined customer contribution absorption as the implementation of customer know-how through its translation and conditioning into the specifications of the product innovation. The following section presents this organizational determinant, using the propositions developed about customer contribution absorption.

Proposition 2 states that customer contribution absorption will induce iterative product innovation planning based on the collaborative and dynamic prioritization of product features and functions by developers and product buyers and considering the contribution of users. The cases surrounding the development contractors illustrate that planning flexibility enables the realization and implementation of customer contributions into the project. The development contractors' planning practices rely on an iterative approach: project parameters are set anew after each presentation of intermediary results to the customer in the form of early prototypes. The iterative planning practices contrast with a typical upfront planning model, as is adopted by many in-house developers, in which contributions from customers disturb the project plan and lead to delayed project deadlines. The organizational determinant within the construct of customer contribution absorption therefore is the *project planning practice* of the product innovation project. This determinant ranges from 'upfront' to 'iterative,' where a tendency toward 'iterative' positively influences customer integration measures.

***Determinants of customer contribution release***

Chapter 5.1 defined customer contribution release as the detachment of customer know-how to make it understandable and available for developers in product innovation projects and to create new innovation know-how collectively. The following section pre-

sents the organizational determinant based on the propositions developed with regard to customer contribution release.

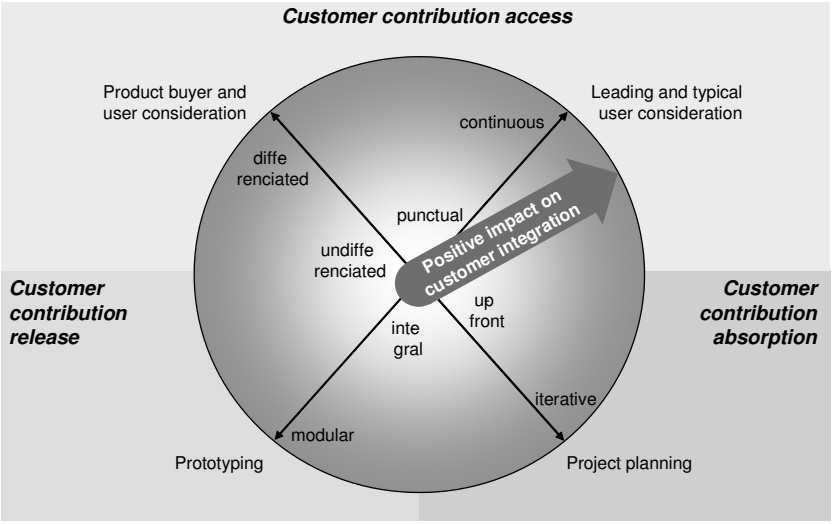
Proposition 4 states that the release of customer contributions into product innovations induces a partitioning of customer contributions, such that customer input and know-how is concentrated on a specific development issue that must be solved. The more easily a customer's needs can be partitioned, prioritized, and therefore continually integrated in the form of single functions and features, the better these customer contributions can be integrated into the product innovation project. The development contractors' cases in particular demonstrate how customer contributions can be focused on specific aspects that demand customer contributions for further progress. This partitioning of customer contributions occurs through physical visualizations of intermediary project results. Therefore, working models or prototypes address only the fundamental product aspects and eclipse the overall new product, which is still vague at early stages.

Visualization of intermediary project results and prototype adoption matter not only at a late stage of the product innovation process but also at the beginning, when the new product is being shaped. At the early stage of product innovation, the cross-case analysis shows that development issues, which are very technical and distant from the product application, are difficult to put into a form that allows partitioned customer contributions. However, the development contractors succeed in their practices and gain specific customer contributions to highly integral development problems. They have excellent skills in the application of simulations and the development of working models, which significantly facilitate the release of customer contributions. Instead of designing the highly integrated, total systems and product architectures, they master early and intermediary prototype adoption through modularization of the product aspect under investigation. In contrast, in-house developers provide integral prototypes that cover the full product functionality and design. Customers view these integral prototypes only at relatively later stages in the product innovation project. Therefore, the organizational determinant within the construct of customer contribution release is the *prototyping practice* during the product innovation project. The determinant ranges from 'integral' to 'modular,' where a tendency toward 'modular' positively influences customer integration measures.

***Consolidation of organizational determinants: impact on customer integration***

Figure 6-3 presents a summary of the organizational determinants of customer integration. It displays that tendencies toward the *specifications at the outer range* of the determinants positively influence the effect of customer integration measures, valid for both of the possible strategies for customer integration (i.e., anticipating customer needs and technology and application brokering). However, the determinants do not indicate that customer integration can be successful only if a developer adopts the specifications on the outer range in figure 6-3; the *specifications in the middle of the circle* also can lead to successful customer integration, but their adoption must be considered carefully.

Figure 6-3 Organizational determinants and impact on customer integration




These specifications of the organizational determinants that positively influence customer integration into product innovation are now referred back to XP from software engineering, the starting point of this research. This comparison to the XP method is ventured at this stage to investigate whether XP disposes of the specifications theorized to have a positive impact on customer integration. Table 6-1 compares the specifications of the organizational determinants among XP, the development contractors *IDEO* and *Tribecraft*, and the in-house developers *Hilti* and *Buechi*.

Table 6-1 Determinant specifications for XP, development contractors, and in-house developers

| *Developer type* / *Determinant* | *XP (software development)* | *Development Contractors (industrial products)* | *In-House Developers (industrial products)* |
|---|---|---|---|
| *Product buyer and user consideration* | Differentiated | Differentiated | Differentiated |
| *Leading and typical user consideration* | Continual | Continual | Punctual |
| *Project planning* | Iterative | Predominantly iterative | Upfront |
| *Prototyping* | Modular | Modular | Integral |

Table 6-1 shows that the specifications of the development contractors are similar to XP's specifications, even though the former focus on industrial products. These similarities in terms of product buyer and user consideration, leading and typical user consideration, project planning, and prototyping enforce the conclusion that in-house developers can improve their customer integration practices by adopting the specifications of the development contractors and XP. From this result, a decision model for XP-based product innovation is developed subsequently.

## 6.2 Decision model for XP-based product innovation

Integrating customers continually and from the early innovation stages is inexpensive compared with the costs of redesign work and the risk of product failure (Kessler and Chakrabarti 1999; van Kleef et al. 2005; Veryzer and Borja de Mozota 2005). To enable this continual customer integration into product innovation, a recommended solution in the form of a decision model for product innovation appears in the following sections. The decision model is referred to as XP based, because it builds on the preliminary results of this study, which were initiated by the investigation of the XP method from software engineering. Before presenting the decision model, the application area of XP-based product innovation is discussed (6.2.1). The model shown next comprises the process organization of XP-based product innovation (6.2.2), as well as the structural organization of XP-based product innovation (6.2.3). Finally, the practices of XP-based product innovation are presented (6.2.3).

### 6.2.1 Application area of XP-based product innovation

Chapter 6.1.1 discusses two consistent customer integration strategies for product innovation projects that offer insights into the design of a recommended solution for cus-

tomer integration and product innovation: anticipating customer needs and technology and application brokering. Depending on a company's starting position in the specific product area for the innovation project, the first or second project strategy may be more suitable.

In an environment with low product requirement uncertainty, a product innovation can be developed successfully with a traditional product innovation process. If a developing company has a leadership position with a technological head start, customer need anticipation can be realized through established product innovation management and does not demand a new approach. In contrast, in an environment with high product requirement uncertainty, new and more flexible practices for product innovation management are required. The technology and application brokering strategy integrates the customer not only for marginal product adjustments but also for contributions to a new product's scope definition and technical know-how provisions. The discussion of organizational determinants (chapter 6.1.2) clarifies which specifications positively influence the effect of customer integration; the innovation approach followed by the XP method and development contractors contains these characteristics.

> Therefore, the recommended solution for customer integration into project innovation offered by this study suggests that in those situations in which product requirement uncertainty is high, a technology and application brokering strategy is more suitable, and the degree of innovativeness of the product innovations tends to be high. Consequently, the decision model for XP-based product innovation, which will be developed in the following sections, does not generally claim that established innovation management principles must be abandoned but rather that they should be applied as is most appropriate.

### 6.2.2 Process organization: toward a discretization of the product innovation process

This section recommends a process organization for industrial product innovation in the context of *high product requirement uncertainty*, which suggests a technology and application brokering approach for customer integration. Therefore, this process model builds on the results from the strategic and organizational determinants of customer integration presented in chapter 6.1. The organizational determinants refer to the specifications that positively influence customer integration into industrial product innovation and are inherent to the XP method. The recommended process organization relates to the process structure of the XP method with the goal of generating a self-adaptive process

that contains the inherent ability to change over time (Beck 2000; Beck and Fowler 2001).

***Alternation between 'front-end' and 'back-end' product innovation activities***

To react to information from the market continually during the product innovation process, rather than in intervals or batches, a flexible process is needed. To attain this required flexibility, the product innovation process must be information and development activity oriented, rather than geared to a rigid project plan. Therefore, the process organization of product innovation calls for flexible project gates; these gates differ from project milestones planned at the start, in that they are continually determined by the implementation of *what customers value* and *what is technically feasible*.

For this innovation process, partitioning into a 'fuzzy front-end,' during which customer needs are discovered, and a 'narrow back-end,' which comprises actual NPD activities, is no longer required. Instead, the whole process becomes an *extended product definition phase,* from which, at the extreme, the start-of-production planning can follow. With this process, intermediary project results can be visualized with a working model or prototype, and their relevance can be tested continually through presentations of new ideas, depicted as a working model or prototype, to customers. Using their contributions, new 'front-end input' gets released, which subsequently can be implemented in the project. This procedure also might be considered a probe-and-learn process (Lynn et al. 1996), in which new insights gained from customers are continuously implemented through 'product probing.' The probing and learning continues until the best design has emerged from the customers' and developers' perspectives.

***Process 'discretization'***

Chapter 3 showed how this interplay between front-end and actual NPD activities, as well as between developers and the customer, works for XP. These insights demonstrate the value of *small development steps* that enable regular feedback from the customer. That is, XP's development steps lead to early releases or prototypes in the form of 'the simplest thing that works' (see chapter 3.1.2), which are presented to the customer for feedback. As a result, the probability that the client company will make the correct choices about the realized product functions and features that fit real customer needs increases. In XP, developers modify the products according to customers' contributions and as more know-how about required development activities becomes available. Furthermore, new relevant functions and features can be identified through the interplay

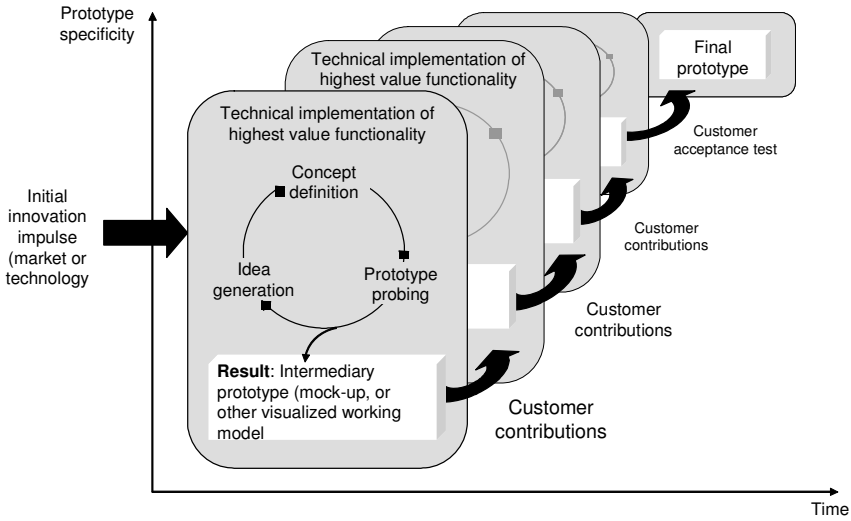
between customers and developers. Put into a process, the single development iterations lead to *discrete sequencing development steps* (Wecht 2006) that evolve through the continuous integration of customer contributions.

Discreteness refers to the characteristic that every development step leads to an intermediary project result (e.g., a prototype that can be presented to customers). The visualized intermediate results also can be transferred to customers' sites; such *transferability* is valuable because relevant information 'sticks' to the customer site and can be released only at that location (von Hippel 1994). The discrete steps of product development help determine the development priorities in the subsequent stages from both technical and customer perspectives. In turn, project decisions are based on the achieved intermediary results instead of the long-term project plan. This basis enables the innovation project team to *solve problems continually* as they come up and check new findings frequently with customers.

Figure 6-4 presents the product innovation process model based on discrete development steps. Within the process, project teams drive the development performance by *focusing on the highest-value activities* in every development, skipping unnecessary ones. Project managers shape the team and the workflow in response to new information from the customer, offered in response to new technological possibilities. The development activities within each discrete development step—idea generation, concept definition, prototype development, and product design—can take place 'on the fly,' because their limited scope makes them manageable. The resulting intermediary prototypes or working models enable quick evaluations of feature costs and alternatives. In addition, feature prioritization can be supported easily by the customer, which ensures a focus on the highest value functionality from the customers' perspective.

The product innovation project thus converges on the final prototype, a synthesis of the best solutions according to both technical and market perspectives. This innovation process based on discrete development steps hereafter is referred to as the *discrete product innovation process*. The discrete product innovation process ends when changes and moving targets from the market and technology perspectives become smaller and smaller. When the final prototype has been defined, it is transferred to the regular development process, which is required to, for example, develop the tools required for production.

Figure 6-4 Discrete product innovation process




### 6.2.3 Structural organization: toward customer-centered product innovation cells

The structural organization of the XP-based approach to product innovation shows the setup of the product innovation teams, which put the discrete product innovation process in place. To integrate the required contributions from customers and respond to their evolving needs, these teams and their procedures must have interaction capability at their center (Servatius 2004), and a tight coordination and centralization or R&D activities (Gassmann and von Zedtwitz 1999). Further requirements for a structural organization of product innovation teams that function in environments with high product requirement uncertainty are as follows (Holman et al. 2003):

- Ability to hit moving targets.
- Capacity to optimize development tasks to promote the end goal.
- Ability to improve quality, timing, and synthesis of product and process information constantly (i.e., right information to the right people at the right time).
- Flexibility to react to new information continually, not sequentially or in batches.
- Dynamic resource allocation.

A recommended solution for the XP-based structural organization of product innovation is presented subsequently.

***Customer-centered product innovation cell: operating mode***

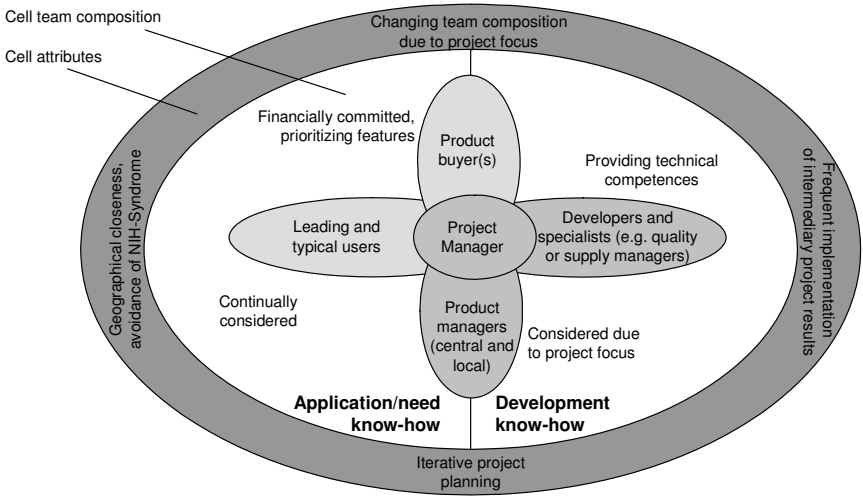
The setup of product innovation teams that meet the previously noted requirements is built on insights from the composition of XP teams and development contractor teams. These teams, which represent the structural organization of the XP-based approach for product innovation, hereafter are referred to as *customer-centered product innovation cells*. A cell refers to an organic team that grows and disbands in the company; is characterized by its flexible and changeable operations, with a structure and composition that quickly adapt to temporal and goal-focused jobs; gets integrated into the company across the existing orgnizational structures; and receives resources from different areas when their know-how is required, depending on the project focus. The basic thought behind a product innovation cell organizes product development around projects and product teams instead of functional areas. These cells thus represent the possibility of the creative leverage of a new understanding of product innovation potential outside the narrow product innovation process to achieve a new competitive advantage for the company.

The development focus within a product innovation cell rests on customer interaction, such that the result in the development of an innovative new product is an intense collaboration or coproduction with product buyers and users (Servatius 2004). Therefore, the cells are formed on the basis of understanding and actively designing interaction processes between the company and the customer to discover new innovation potential that could not be revealed by either the developer or the customer alone.

A product innovation cell begins with an impulse from the market or a technological potential. Immediately thereafter, the collaboration between the developer and the customer starts with defining the competitive position and the real areas of improvement that will be developed with the new product through the joint efforts of developers and customers. This collaboration happens through *brokering between application and need know-how from the customer side* and *technology know-how from the company side*. The outcome a cell develops cannot be determined precisely from the beginning, but the team can capture and answer real customer requirements for—and even their emotional need for and attachment to—products. Therefore, to solve a problem, the necessary information and problem-solving capabilities come together (von Hippel 1994). Figure 6-

5 shows the composition and fundamental practices of a product innovation cell that behaves like a development entity in an entrepreneurial manner.

Figure 6-5 Customer-centered product innovation cell




***Team composition of the product innovation cell***

The team composition of a customer-centered product innovation cell appears in the kernel in figure 6-5. It should consist of a *project manager* and a set of a few (ideally up to seven, as the development contractors' practices show) highly skilled *developers and specialists* that reflect the area of competence in which the new product is expected to reside. The developers and specialists provide the technical competence needed to develop the new product. Because the focus of the technical expertise required evolves around to the innovation potential identified during the course of the project, companies must train staff members and even specialists to 'wear more than one hat at a time,' such as developers who can play a variety of design roles, engineers who have training in several disciplines and can undertake both series and advanced engineering, and operations people who know how to both build prototypes and manage suppliers. People from the manufacturing department also participate to provide their know-how, so developers must confer with manufacturers during the design phase rather than simply hand over detailed specifications, as they might normally do.

Following a cross-functional approach, people from *product management* and marketing become part of the product innovation cell as well. They complement the team from the developing company's side by representing the interface of technological know-how and applications and customer need know-how. Product managers and marketers join the team from a central or local position in a specific market or customer segment, depending on the evolving focus of the new product under development.

Instead of having the marketing department undertake the research and 'throw the results over the wall' to R&D, the engineers in the product innovation cell should have direct and frequent contact with customers. Therefore, the cell team should be complemented by one or more *selected product buyers* who have a fixed role in the team. The product buyers thus get involved in dynamic product feature prioritization, which is key for customer contribution absorption (see chapter 5.3.2). The continuity of the product buyer's role is more likely if the developer succeeds in gaining the product buyer's early financial commitment. However, in industries in which it is not common for the product buyer to initialize or accompany the development of new products, single development initiatives can be lauched in which one product buyer is exclusively involved in a specific product innovation project, which guarantees its exclusivity for a certain time.

Furthermore, *leading and typical users* are continually considered by the project manager, developers, engineers, and product mangers to gather new inspiration about the product's use situation and validate intermediary development results. Databases of users and their status (leading or average) can be maintainted to support the accessibility of the proper users at the right time.

***Attributes of the product innovation cell***

The attributes of the customer-centered product innovation cell, shown in figure 6-5, further characterize the XP-based approach of product innovation and link this structural organization to its process organization, as presented in chapter 6.2.2. The first attribute focuses on a flexible team composition according to the resources required to realize the changing focus of the innovation project. Therefore, team leaders are responsible for a *changing composition of the team*, bringing together people with the right mix of skills to solve problems as soon as they arise and eliminate barriers to progress. However, this composition can be realized only if the required development resources are in place and accessible for the team:

> New product teams that have to beg resources from functional 'silos' inevitably lack the required flexibility and focus. (Holman et al. 2003: 6)

If the flexible resource allocation is supported by the organization, the team can grow within the cell, and new specialists can join according to the direction the project evolves.

The composition of the product innovation cells also enables a flexible integration of *development contractors* as outsourcing options for parts of the development efforts. After the completion of a project, the team members regroup into new compositions to realize the next project. The new know-how gained in an innovation project therefore spreads to the broader organization. This flexibility in the teams ensures the maximum learning effect for the organization through the constant dissemination of technical and market know-how.

The second attribute, *geographical closeness* of the team's participants, including product buyers and users, facilitates collaboration. Literature on geographical clusters indicates that firms located in close geographical proximity can benefit from agglomeration effects by drawing on a common infrastructure (Porter 1990). Furthermore, through this continuous collaboration between developers and customers, a *'not-invented-here' (NIH) syndrome* can successfully be avoided; the input of the customer is an institutionalized constituent of the cell. The expression 'NIH syndrome' (Katz and Allen 1982) refers to a negative attitude toward adopting knowledge that originates from a source outside one's own institution. The use of the term 'syndrome' already indicates this attitude's negative connotation and its potential negative consequences, which include the rejection of external ideas, the underutilization of external know-how, and the resultant negative effects on performance.

The third attribute, *iterative project planning*, occurs according to the product requirements that are continuously explored together with the customer during the course of the innovation project. Therefore, planning occurs in a flexible manner, with continuously adjusted gates driven by the focus of the specific project and not by upfront, defined milestones or gates, such as those set by a traditional NPD process.

The fourth attribute, finally, is the *frequent implementation of intermediary project results*. The practices of the XP teams and development contractors indicate that in highly uncertain product environments, companies need an early working version to gain new insights into the product requirements. Furthermore, the frequent implementation of in-

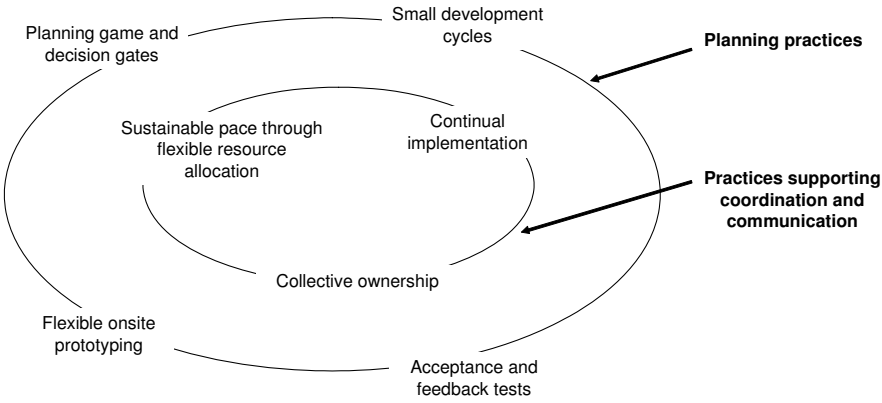
termediary project results supports the stability of the project team by providing a valuable communication platform within the team and to the company management.

### 6.2.4 Practices of XP-based product innovation

Studies in a software context suggest that the benefits obtained from an evolving product's early release to customers do not depend on the number of releases but on the intensity with which companies work with customers after the first release (MacCormack 2001). To investigate the specific work tasks carried out to achieve this collaboration intensity between developers and customers, the practices of the XP-based product innovation approach are discussed subsequently. Again, the practices from the XP method provide some new insights on how these practices might be applied to industrial product development.

Chapter 3.1.2 showed three categories of XP practices: planning practices, practices in support of coordination and communication, and technical practices for the team of the programmers. Subsequently, the practices of the first two categories are reconsidered and adapted for industrial product development. Because the third category clearly is software related, an adaptation to industrial products is not further sought. Figure 6-6 shows an overview of the adapted practices for XP-based product innovation in an industrial context.

Figure 6-6 Practices of XP-based product innovation




Source: adapted from Lindstrom and Jeffries (2004: 46)

***Planning practices***

***Small development cycles.*** The foundation of the discrete product innovation process builds from a sequence of small development cycles that provide control over an unpredictable process through iterations (Beck and Fowler 2001). A first key question of this process is how long an iteration should be. Considering the recommendations from XP method, the tendency is to make every iteration, determined by one or several visualizations of the development activities in the form of a mock-up or intermediary prototype, as short as possible. The length of the development cycles also can be determined according to the need for further customer contributions, without which the project cannot advance further. In this context, the development contractors show that visualization and immediate presentation to the customer are more valuable and efficient than making suggestions about what customers could value. Regarding visualization, developers should be encouraged to use existing components from other application areas to simulate certain functions instead of developing them by themselves.

A second key question pertains to the *right number of iterations* a project should run through. To provide an answer to this question, the cost aspect must be weighted against the risk evaluations. For the *risk aspects*, an evolutionary approach based on many iterations reduces risk by clarifying problems immediately, such as when problems in getting the core technical components to work together appear from the very start. With the evolutionary approach, the team can reschedule its later-stage work, perhaps by eliminating one or more features of the original design. If the development proceeds in a more traditional fashion, feedback about such problems would not be received until the various component modules had been integrated, much later in the process. For the *cost aspect*, building prototypes becomes more and more expensive the more specific the prototype becomes and as it approaches the final product. This trend is especially pertinent for developing products for industries such as heavyweight equipment or machinery for construction sites. Therefore, a careful evaluation of risk reduction and a corresponding prototype cost evaluation is crucial.

***Acceptance and feedback tests.*** Continual acceptance and feedback tests with customers should be conducted. In traditional product innovation approaches, teams try to create representative prototypes or models of the overall product they develop. To do so, however, the team needs detailed product specifications that become available only later in the development cycle, and it further needs a lot of time to construct the model. The discrete product innovation process, in contrast, plans customer tests according to the need to fill information gaps. Therefore, teams continually consider what information will be

most useful and when it will be accessible. Precise customer test information, focused on the development problem to be solved, thus can be released. Furthermore, the models trigger new contributions from customers. On the basis of this premise, early and simple models that yield the required information without extra work can be built.

***Flexible onsite prototyping.*** The onsite prototyping practice is adapted from XP's onsite customer practice. Onsite customer practices have been the subject of much controversy among XP method, in that the cases in which the client has enough disposable resources to allow its people to work at the developers' site are few. In the context of discrete product innovation for industrial products, a literal application of the 'onsite customer' practice is not targeted; the emphasis instead is on prototypes built for intermediary project results, which can be transferred and worked on at the different sites where the relevant information is located (von Hippel 1994), such as the developing company, the client, and the different groups or users.

The onsite prototyping practice implies that customers get accustomed to being contacted by the developer on a regular basis to release their feedback on the prototypes. In addition to the customer's early financial commitment, the presence of a prototype of an intermediary project result enhances customers' emotional commitment to a new product under development. These activities of providing simple models to customers are strongly facilitated by modular prototype architectures. Regarding this partitioning of product modules into single components that are tested at the customers' site in a separate manner, designers sometimes complain that the customers fail to grasp the *gestalt*, or entirety, of a design; when nondesigners pick it apart and make changes to the pieces, they compromise the overall effect. If these concerns are justified, test methods such as the 'moodboard', as practiced by *Tribecraft* (see chapter 4.4.2), can help display the overall product gestalt to customers. Furthermore, the consequent separation of design from functional prototypes continually provides a representation of the overall product and therefore maintains the proper focus until the end of the prolonged product definition phase.

Overall, an effective prototype might be anything from a clay model to a computer simulation, a process map, or even a spreadsheet (Hagel and Brown 2005). The emergence of CAD and engineering tools, combined with rapid prototyping technologies, has reduced the cost and time of product changes significantly (Thomke and Reinertsen 1998). The adoption of flexible prototyping techniques and technologies also lowers iteration costs. However, flexibility gains require greater investments in technology, skills, and know-how. The following aspects support effective prototype adoption:

- *Flexible prototype variation and combination.* Multiple types of working models and prototypes should be established, each of which conveys different information. When a group's work evolves, it should shift to different kinds of prototypes and employ various types of visualization possibilities.
- *Adoption of cross-discipline methodologies.* The application of innovative tools from other disciplines, such as the Finite Element Method (FEM) applied by *Tribecraft,* provides additional early modeling innovation potential and indicates the physical limits of certain product functions or materials.
- *Differentiation between design and functional prototypes.* Design and functional prototypes should be developed separately. Design prototypes do not require functionalities but aim only at generating an overall picture of the new product under development and releasing the 'character' the product will have in the end. Functional prototypes require only a minimum of design aspects but are built to test technical aspects.
- *Reduction of number of issues addressed.* Simple prototypes (or visualizations of intermediary results) should focus on very few development issues to get the precise information required from clients or other team members. Visualizations should be approximations that can be provided very quickly rather than sophisticated prototypes that require long development times before they can be demonstrated.
- *Focus on the benefits of every prototype.* Teams should ask who benefits from the solution as it comes out. Because a prototype implies trade-offs more explicit than obscure, it must be decided upfront who the models and simulations are for (Schrage 2000).
- *Reuse of existing components.* Teams should be encouraged to employ already existing components from other application fields to provide fast visualizations.
- *Collaboration with manufacturing.* When designing a prototype, designers should collaborate with manufacturers to explore ways to reduce the number of components and test the manufacturability. If after many iterations a final design concept is selected, everyone must support it. However, it is better to keep at least one back-up approach 'alive' in case the primary concept encounters unexpected problems (Thomke and Reinertsen 1998).

***Planning game and decision gates.*** As previously noted, the acceptance and feedback tests not only provide information about the intermediary development results but also build the foundation to release new input from customers. Analogous to the XP method,

this feedback can be captured in the form of 'user stories,' in which customers formulate single-use situations they want enabled. In the planning game practice, developers evaluate, together with the product buyers or users, which 'user stories' have the highest priority and what it takes to implement them.

Because the required competences emerge through personal discussions, the resulting planning is more reliable than if customer input arrives indirectly to the developers, such as through sales representatives or marketers. Misunderstandings or false expectations are avoided through the direct and collaborative elicitation of an appropriate plan. The planning game is 'played' for the sequencing development step, which attempts to implement the prioritized customer stories. In addition to these precise, short-term planning cycles, development contractors have demonstrated that rough overall project plans can be provided according to the rich experience of the developers involved and the team-based planning process.

All four XP parameters (time, cost, quality, scope) should be discussed with the product buyer during the planning game, but only three of them can be set (see chapter 3.1.2). Because the fourth is dependent on the others, it cannot be planned but will result from the other three. Furthermore, a project freeze must occur to establish a final step at the point when team members (including customers) have elicited and understood all product requirements. At this point, the development team commits to the final delivery date, and everyone involved knows that only dramatic changes in technology, markets, or corporate resources could reopen the decision. After this project freeze, the team does not ignore the market changing around it, but it is in a position to know which changes can wait to be accommodated later (e.g., with derivative products) (Tabrizi and Walleigh 1997).

Also in the new process, performance targets can be set and management reviews conducted. Unlike a conventional product innovation process, the team reaches decision gates when criteria are met, not when a given amount of time has passed. Project leaders can estimate in advance how long it might take to realize these goals, but because the team strives to do so as quickly as possible, waiting time and information gaps created by premature decisions are eliminated. The result is better decision making, more efficient development cycles (Holman et al. 2003), and less bureaucracy.

***Coordination and communication practices***

***Continual implementation.*** Designing the architecture so that a version of the product can be assembled at an early stage and distributed to customers requires explicit archi-

tectural choices. Building in the ability to accept additional functionality during later project stages adds further demands (MacCormack 2001). The key to an evolutionary process, in software as well as industrial products, is to develop an architecture that is both modular and scaleable. A modular system accommodates changes to the design of individual components without requiring corresponding changes to other modules in the system. A scaleable system allows initially unanticipated functions and features to be added at a later stage without disrupting the existing design and requires a solid underlying platform. The software context demonstrates that a high level of investment in architectural design correlates with higher-quality products (MacCormack 2001).

Thomke and Reinertsen (1998) claim that the careful selection of the boundaries between system components and design tasks (to minimize total system interdependencies) can have a significant impact on design flexibility and its associated development strategy. They further state that because task boundaries are usually selected in the earlier phases of a development project but play such an important role in the ability to react to rapid changes, mangers would be well-advised to plan the division of activities with great care—or at least build in sufficient flexibility to allow changes in partitioning as a project evolves.

In terms of the architectural issues of a flexible product innovation process, Thomke and Reinertsen (1998) propose leveraging the design architecture by isolating volatility in the design and reducing coupling between modules. Otherwise, a change in one component could cause a sequence of changes in other components, leading to an increase in design costs and time. The flexibility of a design can be increased by developing a design architecture that minimizes interdependence among individual components. Therefore, by partitioning the influence of a perturbing variable, it can be isolated to a small portion of the design. A special case of this general strategy moves the volatility outside the system boundary. This strategy is common among companies that perform ‘mass customization’ (Glazer 1999; Duray and Ward 2000; Piller, Moeslein, and Stotko 2004)

Reducing coupling between modules within the system also will lead to more product innovation process flexibility. A key technique for reducing coupling within the design is to increase the design margins at the interfaces within the architecture. This approach provides a buffer against changes that originate in one module. The essence of achieving this sort of architectural robustness lies in the design margins allocated to system interfaces. Thomke and Reinertsen (1998) place special emphasis on the fact that modularity itself does not produce robustness in design; rather, modules must be loosely coupled with one another.

***Collective ownership.*** Collective ownership refers to the team work within a customer centered product innovation cell. Since the focus of the developers is rather general than specialized, everybody is responsible for the overall product result. Developers do not only implement the project leader's plans but also participate in releasing contributions from customers by presenting intermediary prototypes, as well as in collecting new user stories and planning the next release.

Collective ownership can be seen as a 'disciplined action.' A developer never introduces major changes without consulting the team first and notifying it afterward. Furthermore, every developer must be ready to implement a necessary task, whether it is his or her special area or not. Without such readiness, the quick and 'on the fly' implementation of one development cycle does not work. In addition, anyone can make suggestions to improve or modify the overall design. Useful suggestions and design tasks that are not undertaken immediately are tracked for later consideration.

***Sustainable pace through flexible resource allocation.*** The possibility of developing a new product with a sustainable pace depends on the resources that can be allocated. The ability to allocate resources flexibly to each new product team (or cell) is vital: prototype testing might take place sooner than planned, or certain developers might be needed longer. To realize flexible resource allocation, projects should be ranked in order of priority, and those that can surrender some resources when necessary should be identified.

Moving from less flexible, process-oriented approaches to discrete, cyclical ones requires new organizational capabilities and skills. Without experienced project leaders, the ability to allocate resources as needed, and new ways of measuring the performance of project teams, companies will not be able to capture the potential efficiency improvements of these new approaches. They even may find that they lack discipline and forfeit the past year's gains (Holman et al. 2003).

***Practices summary***

Chapter 6.2.4 describes the practices underlying the developed approach of XP-based product innovation. A summary of these practices is presented in table 6-2.

Table 6-2 Summary of XP-based product innovation practices

| *Type* | *Practice* | *Description* |
|---|---|---|
| Planning practices | *Small development cycles* | Length of cycles: as short as one or several visualizations of the development activities in the form of a mock-up or intermediary prototype can be provided and determined by the need for further customer contributions and feedback to avoid speculations about the development's relevance |
| | | Reuse of already existing components for intermediary result visualization |
| | | Number of iterations: Cost versus risk evaluations. Concepts may take longer to develop with discrete iterating development steps, but the company saves time later by avoiding costly rework |
| | *Acceptance and feedback tests* | Goal of tests is to fill information gaps, enabled by early and simple prototypes built to yield the required information without extra work |
| | | Modular prototypes allow for parallel testing of intermediary results |
| | *Flexible onsite prototyping* | Presence of prototype at customers' sites to get customers accustomed to being contacted by the developer on a regular basis to release their feedback about the intermediary prototypes |
| | *Planning game and decision gates* | Formulation, prioritization, and timing of implementation of user stories of developers together with the customers |
| | | Discussion of project parameters (time, cost, quality, scope) with the client in the planning game, though only three can be set |
| | | Decision gates are reached when development criteria are met, not when a given amount of time has passed |
| Coordination and communication practices | *Continual implementation* | Requirement for a modular and scalable development architecture |
| | | Careful selection of boundaries between system components and development tasks |
| | | Planning of activity division with great care, isolating volatility in the design, and reducing coupling between modules by increasing the design margins at the interfaces within the architecture |
| | *Collective Ownership* | Project leader is coordinator but not on a different hierarchy level |
| | | Consulting the team first if major changes have to be introduced to enable quick and 'on the fly' implementation of new development tasks |
| | *Sustainable pace* | Permission for flexible resource allocation through organizational mechanisms and project leader's experience |

## 6.3 Implementing XP-based product innovation

The realization of a discrete product innovation process and customer-centered innovation cells is an ambitious undertaking that requires some changes in how companies innovate. The following section describes the implications for implementing an XP-based approach to product innovation in industrial practice and highlights the requirements for:

- Maintaining a balanced innovation project portfolio.
- Considering the imperatives of customer integration strategies.
- Establishing XP-based product innovation as a fixed or temporal approach.
- Selectively involving development contractors.
- Developing the skills of project leaders and team members.

***Maintaining a balanced innovation project portfolio***

The way companies currently invest in innovation is often unreliable: when innovation budgets are cut back, strong projects are abandoned along with the weak. The consequences can be that promising initiatives get cut off just when they are about to bear fruit (Wolpert 2002). Abandoned projects leave involved customers wondering how to reenergize the stalled initiative and wary of collaborating with the developer in the future. To avoid a random selection of abandoned projects, an overall *project innovation portfolio* is required to ensure that the product innovation efforts focus on those opportunities that have the greatest potential market impact and, once such projects are identified, that can be realized. If a project portfolio does not exist, promising projects may suddenly drop out of the priority queue in an organization.

Within its innovation project portfolio, every company should balance different types of innovation projects carefully, because innovation projects with a high degree of innovativeness are also associated with more project risk (Paap and Katz 2004). The specific project strategy should be selected according to the identified business scenario. On the one hand, companies should have projects for improving their current product segments with relatively low product requirement uncertainty, such as through anticipating customer needs. These projects ensure a competitive product introduced to the market in a foreseeable time; they also are best developed with a product innovation process that already has been successfully established in most companies.

On the other hand, companies should include innovation projects that do not follow this established process, that do not have the goal to enter the market at a precisely planned time, and that have the flexibility to respond to new opportunities discovered throughout the project itself through the intense interaction with the customer. The *XP-based model for product innovation* was developed for the latter, though companies should maintain the flexibility to change strategy throughout the course of the project if the former or latter strategy becomes more appropriate.

An innovation project portfolio also implies that the company sets and communicates ambitious targets, even when it has "no freakin' idea how to get to them" (Cagan, Vogel, and Boatwright 2005: 2). These targets are not just goals but shape corporate culture: they create overall demand for unconventional input. Only by setting ambitious goals can a company develop an instinct for finding the 'sweet spot' between the 'acceptable and the impossible' (Cagan et al. 2005).

***Considering imperatives of customer integration strategies***

Companies with a product leadership position are not necessarily as privileged as one might assume: they must remain vigilant to keep their head start. Their advantage over their competitors is that advanced customers and other specialized companies in the industry want the leading company to be part of their network. The question these developers face is whom to choose for their valuable innovation collaborations. Consequently, leading companies must learn to identify those companies that enhance and complement their capabilities. Only then can they remain partners of choice, which will keep them competitive in the long run.

Companies focusing their innovation projects on technology and application brokering should organize their brokering activity carefully to retain transparency about their activities among the departments involved. A possible solution is an 'in-house broker' who knows who has the resources required to realize a good idea and is in possession of the required contacts with valuable customers.

For both strategies, which can be followed by the same organization but for different projects or business areas, companies must consider secrecy aspects if they conduct problem solving and testing at customers' sites (von Hippel 1994). Revealing information about new products under development implies the confidential acquisition of this information by the customers involved. *Confidentiality* agreements and regulation of *intellectual property rights* is key. However, innovation development tasks undertaken outside the firm often are just a part of a whole, and revealing a part does not reveal the whole to imitators. Open behavior toward stakeholders generally is rewarded with gains in know-how and insights, which tend to outweigh the loss of secrecy.

***Establishing XP-based product innovation as a fixed or temporal approach***

The XP-based approach to product innovation requires a lot of organizational flexibility and major investments to implement in organizations. To ensure future product innovations, large multinational organizations have successfully established *innovation units* or

*departments*, which are responsible exclusively for highly innovative projects and establishing valuable relationships. Within these departments, the XP-based product innovation approach can be applied. The challenge they face lies in the acceptance of their work by the rest of the firm. Therefore, the employees in these departments and those who communicate with the larger organization must be selected carefully; they must be known and highly accepted by the department staff. Fixed innovation departments also involve a stable composition, which leads to the loss of innovativeness after a certain time, because they get 'too much used to each other' and lose their 'productive friction.' Consequently, innovation units and departments must be challenged continuously by new team members and specialists (Hagel and Brown 2005).

An XP-based product innovation approach also can be followed by *temporal innovation teams,* set up only for specific innovation projects and dissolved after the project is finished. This approach is easier to realize than are fixed innovation units, especially by small companies that cannot dedicate a whole group or unit exclusively to innovative tasks. To implement temporal innovation teams, organizations can create a virtual 'innovation budget' that is activated as soon as an idea from the technology or customer side is considered valuable enough to be pursued. On the basis of such ideas, innovation teams are built and receive a certain money and time budget, as well as an ambitious, objective target for developing the product innovation.

Another temporal possibility for putting XP-based product innovation in place is through a *venturing process.* This approach uses a certain 'innovation budget' that a company dedicates to high-risk projects that arise out of employees' ideas. In a venturing process, highly motivated employees take personal responsibility for a good product idea they have and develop it further. If the idea is considered valuable throughout a process of evaluation steps, more and more resources for its development can be allocated to create a product innovation cell. A set of unbureaucratic evaluation criteria pertaining to the selection of promising ideas are helpful in this sense. A founded product innovation cell should report directly to the CTO or R&D manager, in support of its high priority. Upper management should impose fewer constraints on these teams than on their conventional counterparts, so they can consider a broader set of solutions. If the potential is continually considered high, an official project manager gets assigned to the product innovation cell. This manager must have the ability to see the value of the different major players in the process, manage and motivate others, and unify them toward common goals. Regular checkpoints guarantee that the cell remains on track, that no resources are wasted, and that the team cannot delay the point when product designs

must be frozen. The product innovation cell must keep its options open longer and can respond to changes in the market at later stages in the development process.

Temporal initiatives face other challenges as well. After growing used to working flexibly with great responsibility, the high potential employees involved in such initiatives are difficult to place back in the organization at the end of the project. Furthermore, the selection process surrounding ideas that can be advanced by employees must be very transparent to avoid any sense of injustice in the choices.

Among the success factors of the temporal XP-based product innovation approaches, companies have to be in possession of *know-how and established procedures that can be 'pulled off the shelf'* as soon as an opportunity becomes apparent, as well as the ability to launch a *power effort* supported by the whole organization. These demands require the flexibility to remove employees from their daily business to achieve the realization of a project. A company must be comfortable with such initiatives, with *injecting agitation to the organization*.

***Selectively involving development contractors***

Alliances between organizations and development contractors enhance innovation and variation and enable organizational learning across company boundaries (Gassmann and Hipp 2001). The cases of the two development contractors, *IDEO* and *Tribecraft,* show that they can boost a project to new levels of innovativeness that the client organization would not have been able to achieve. According to Gassmann and Hipp (2001), in-house developers profit from development contractors in two ways. First, especially in an environment of dynamic technological change, the strong bond with external sources of know-how provides a valuable means to cope with complexity and uncertainty through the interspersion of resources, without any loss of flexibility. Second, external contacts facilitate thinking about current internal practices and routines. Therefore, in-house developers should selectively involve development contractors to profit from new innovation input to their organization.

In acquaintances with development contractors, one success factor pertains to the careful definition of their specific objectives and roles in the organizational innovation process. Agreement about and the use of the same tools and systems also is crucial; otherwise, communication differences can make the alliance unproductive. In addition, a measurement that tracks the proportion of externally sourced innovation or a systematic assessment of the performance by the company's innovation suppliers is required to maintain an overview of the innovation capability of the company. Also, an explicit guideline

should establish when to use external sources in general or each type of source in particular (Gassmann and Hipp 2001). Furthermore, companies must be careful with the signals they send to their own R&D department when they seek the support of a development contractor. The company's own developers and designers must be involved in the project to guarantee a smooth product handover for production and avoid a NIH syndrome (Katz and Allen 1982).

In the case of a complete outsourcing of tasks to development contractors, own company capabilities cannot be forgotten, and an organization must remain in place to understand and process the know-how generated externally. As a result, a minimum of internal competence is necessary to technically evaluate the development contractors, precisely specify the service desired, and evaluate the results delivered (Gassmann and Hipp 2001).

***Developing skills of project leaders and team members***

The application of the highly flexible XP-based model for product innovation imposes new challenges for project leaders. Therefore, the decision regarding whether a project leader is willing to work according to the new approach should be left to him or her. If he or she decides to adopt the new approach, the leader should be guided through a very careful coaching process that supports his or her application of the new method.

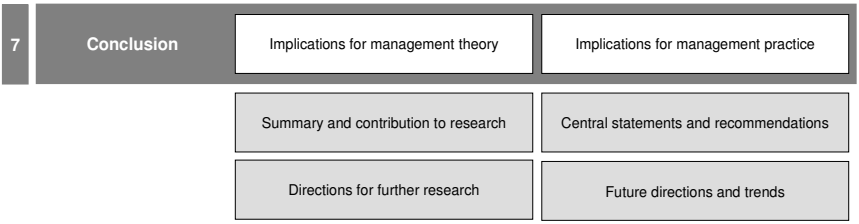
Furthermore, not every developer participating in the product innovation team is suited to or feels comfortable working according to the XP-based model, which requires a lot of entrepreneurial spirit and autonomy. People should be highly skilled and accustomed to flexibility and 'wearing several hats' at a time. Only those who are willing to participate in something new and challenging and bear the potential of discovering something exiting together with the customer should be selected for XP-based product innovation teams. Team-based incentives to bond the working groups and encouraging employees with multidisciplinary backgrounds support this type of culture (Linder, Jarvenpaa, and Davenport 2003).

As a result, XP-based product innovation must be embedded in a culture in which spontaneous efforts and external contributions are accepted and appreciated. As pointed out in section 6.3.1, an organization must be comfortable with flexible and unbureaucratic innovation initiatives that take place outside traditional product innovation processes and constantly inject a certain amount of agitation into the system to keep it agile and attentive to new innovation potentials. To maintain this agitation, XP-based temporal product innovation efforts can offer an effective solution.

# 7 Conclusion

Using the preceding findings as a basis, this final chapter derives some resulting implications for management theory and practice (see figure 7-1).

Figure 7-1 Outline of chapter 7




## 7.1 Implications for management theory

The implications for management theory first cover this thesis's contribution to management research. Subsequently, remaining questions for further research are discussed.

### 7.1.1 Summary and contribution to research

This thesis's contribution to research relates to product innovation management, particularly customer integration into industrial product innovation projects. The contribution covers the following aspects:

***Customer integration into product innovation: the state-of-the-art in research***

Integrating customers into product innovation enables quick reactions to market changes and the discovery of new product innovation potentials through customer collaborations. Although this topic has become an important issue for the development of new products, no research has provided a structure for how to integrate the customer methodically throughout the different phases of the product innovation process. The absence of such a structure is surprising because both product innovation management and customer integration have been widely discussed in management and marketing literature. Therefore, this thesis addresses the absence of research related to this issue by providing insights about continuously incorporating customer contributions into the product innovation process.

- Several scholars have identified the relevance of flexible approaches to product innovation processes that enable a company to respond rapidly to evolving technologies and markets. The importance of customer integration into product innovation also has been broadly investigated. The literature presents a multitude of aspects pertaining to how to organize customer integration structurally into the development of new products. Von Hippel (1976; 1977; 1988) has been the most prominent researcher to study a method for integrating customers into specific product innovation tasks with his lead user concept. However, he and his colleagues in this field do not tackle the integration of customer contributions throughout the different phases of the product innovation process.

  Therefore, a research deficit has been identified through a synthesis of the insights from customer integration and product innovation process literature; this deficit relates to the continuous embodiment of customer contributions through intensive interaction between R&D and the customer during the different phases of the product innovation process.

- The application of organizational learning theory has helped explain why customer contributions are valuable for product innovations and how they get incorporated into the product development process through a learning process that includes the acquisition, dissemination, and utilization of information from customers. Existing management research on customer contributions in product innovation generally focuses on the accessibility of contributions from customers and points to different contribution types that are valuable for product innovation. Furthermore, it emphasizes the different roles customers play in the product innovation process.

  This thesis contributes to customer integration literature by concisely summarizing the different customer roles and the corresponding contribution types of customers in the product innovation process.

***Reference framework development with Extreme Programming***

In response to the search for a model that describes the successful management of the incorporation of customer contributions into the product innovation process, the XP method from software engineering has been identified. Extreme Programming can be characterized as a product development method because of its iterative and highly flexible product innovation process and its collaborative approach between developers and customers. The approach offers new insights into how successful customer integration

into product innovation projects can be managed from a perspective external to the industrial product development context under investigation.

- An assessment of the XP method from the perspective of the presented literature on customer integration into industrial product innovation enabled the development of a reference framework, referred to as XP based. Investigating XP's product development process and customer integration practices highlighted the elements that constitute a flexible approach to product innovation: integrating the customer throughout the product innovation process and thus enabling responses to changing market information and the discovery of new innovation potentials.

  This research is one of the first studies to provide a reference framework for the investigation of flexible product innovation processes that integrate the continuous consideration of customer contributions.

***Building theory on customer integration into product innovation***

Whereas prior research has addressed the access of customers and their contributions in product innovation, no studies of product innovation or customer integration have considered the release and specific absorption of customer contributions into product development tasks. Differentiating these constructs is fundamental to recommending specific measures for the successful integration of customer contributions into the product innovation process. This thesis contributes to the lack of differentiation by introducing and discussing three different constructs—customer contribution access, release, and absorption—that affect the success of product innovations. The exploratory nature of this study, which uses XP for the reference framework to underlie the data collection for the case studies, facilitates the refinement and development of constructs that may be regarded as building blocks for an alternative approach to customer integration into product innovation. The constructs were developed through an iterative process of analyzing case data and management literature, with consideration of explanations from organizational learning theory. They have resulted in research propositions regarding the measures required to make each construct effective.

- The analysis of customer contribution access refers to the availability of customer know-how and depends on customers' characteristics and their disposition through their embeddedness in their market environment. The empirical investigation led to the following propositions:

If in B2B constellations contributions from the product buyer and the product user are considered diversified, the access of customer contributions is positively influenced. Whereas the product user contributes by providing specific know-how about the product use situation, the product buyer acts as a parameter setter.

If both lead user contributions and contributions from typical users are considered continuously throughout the product innovation process, the access of customer contributions is positively influenced. Whereas lead users provide inspiration for product innovations and come up with new product solutions, typical users require the support of a professional developer to implement their contributions. Typical users furthermore indicate the adoption and appeal of lead users' solutions for the high-profit market.

- The analysis of customer contribution release refers to the detachment of customer know-how to make it understandable and available to developers and to collectively create new innovation know-how. The empirical investigation leads to the following propositions:

If customer contributions are partitioned by concentrating customer know-how on one specific development issue, the release of customer contributions into product innovation is positively influenced. This contribution partitioning can be achieved through physical visualizations of single intermediary project results.

- The analysis of customer contribution absorption refers to the implementation of customer know-how through its translation and conditioning into specifications of the product innovation. The empirical investigation leads to the following proposition:

If product innovation planning is iterative and is based on collaborative prioritization of product features by developers and product buyers, the absorption of customer contributions into product innovation is positively influenced. Although rough, general project parameters (time, cost, quality, scope) should be set at the start for the overall project, detailed project planning should be carried out only for the next development cycle.

- The empirical investigation of the relationship between customer contribution access and absorption leads to the following propositions:

If a product innovation project aims at strengthening a product leadership position, the consideration of customer contributions supports the product's relevance verification and design adjustment. If a product innovation project aims at entering a market in which the developing company does not have a product leadership position, the incorporation of customer contributions contributes to the determination of the new product's scope and functionality.

If the product buyer has market responsibility and is financially committed to a product innovation project at an early stage, his engagement in the project is positively influenced. The bigger the product buyer's market responsibility and the earlier it is financially committed to a product innovation project, the more it potentially contributes to the new product under development.

- Finally, the analysis of the relationship among customer contribution access, release, and absorption revealed that contribution release has a moderating effect on the relationship between contribution access and absorption. It leads to the following proposition:

If in-depth industry competence in the market area of the new product under development is low, the product innovation's potential for a high degree of innovativeness is positively impacted.

### 7.1.2 Directions for further research

During the course of this thesis, the major research questions have been answered, but some new fields of interest also have emerged. Possible additional research questions, within the scope of this research, pertain to the following aspects:

- Although the relevance of the conceptual model for customer contributions to product innovation has been shown for the selected industry segments, the research propositions need to be examined with respect to the degree to which they hold in different development contexts and for various boundary conditions (e.g., market responsibility) in specific industries and product categories (e.g., degree of possible product modularity and transferability). Thus, a closer and differentiated analysis of specific industry structures and product categories could be the subject of additional investigations.

- The research scope of this study, limited to the four companies investigated, opens the field for additional research. An empirical investigation of the research propositions on a broad scale could assess the customer contribution constructs and their

relationships. For such an empirical test, appropriate measures for the customer constructs in the framework would need to be developed.

- In terms of its managerial implications and the XP-based decision model, this study of four companies and their business models and industry structures demonstrates that analogies to the XP method reveal potentials for significant process improvements. However, the overall application of the method in the context of industrial product innovation has not been investigated. Further analyses, such as in the form of action research projects, might implement the XP-based product innovation model to assess its overall applicability for different industrial contexts and refine its attributes.

## 7.2 Implications for management practice

This section summarizes the central statements and recommendations made throughout this research, focusing specifically on the practitioner's point of view. Subsequently, potential future directions and trends will be discussed.

### 7.2.1 Central statements and recommendations

The central recommendations refer to the practical problem of customer integration into product innovation, potential approaches to solve this problem, empirical insights, and proposed suggestions for R&D managers regarding the management of customer integration into product innovation projects.

***Key issues of customer integration: relevance of research subject***

- In response to the increasing demand for innovative new products and simultaneously shrinking R&D budgets, managers have long recognized the value of early and direct customer integration into product innovation projects. Traditional market research conducted by the marketing department and 'thrown over the wall' to R&D simply is not fast enough and often too unspecific to provide the insights developers need to target a product innovation precisely to a specific customer need. Even though methods for the early and direct integration of customers into the R&D department exist, practitioners struggle to adopt these sophisticated approaches, such as the lead user concept (von Hippel 1976, 1988). Furthermore, they claim that 'they do not know who their lead users are' and therefore find it difficult to locate appropriate customer innovators in a cost-effective manner.

The issues related to managing customer integration into product innovation have caused R&D managers to emphasize identifying adequate approaches and measures for the direct interaction between R&D and customers that explicitly focus on capturing customer contributions for product innovation projects. Customer integration activities have become one of the most important issues in product innovation management.

***Customer integration in industrial product innovation practice***

- As the value of integrating customers into product innovation has grown more evident in practice, most companies have started to develop special procedures and methodologies to do so. The case studies of companies with stellar customer integration practices demonstrate that throughout their innovation process, they adopt standard procedures for certain development tasks in which customers are involved. These tasks range from the generation of new product ideas to the refinement of new product concepts to prototype testing. Developers select customers for collaboration on the basis of their openness and progressiveness toward product innovations, the customers' reputation, or their financial commitment. Integrating customers means considering the person within the customer organization who is responsible for the investment decision (referred to as the product buyer), as well specific product users to get in-depth feedback about the specifications and requirements the new product must fulfill. To obtain access to the contributions these people can make to product innovation projects, developers conduct customer visits and present early product concepts and prototypes. To ensure that customers' contributions are fully and correctly understood, the developing companies send not only project managers but also developers to capture customers' feedback from different perspectives and avoid personal biases and translation errors. As a result, customers participate in different tasks and offer various contributions throughout the innovation process of industrial product developers.

Even though in-house developing companies are successful with their customer integration practices, they follow a rather rigid approach of customer integration. A more dynamic approach, which enables them to 'hit moving targets' throughout a product innovation project, promises to lead to improvements in product innovation success and therefore to the exploration of new innovation potentials, discovered together with customers.

- Especially in the practices of development contractors, the integration of customers into product innovation takes place in a very dynamic manner. As professional

technical service firms that develop product innovations with their client on a project basis, the selected development contractors create an innovation project by continuously confronting their client and product users with intermediary project results in the form of paper drafts, rough mock-ups, and prototypes. With their specialized prototyping techniques, development contractors not only get feedback about the relevance of the prototype's specifications but also trigger radically new ideas about how the product could be improved. The integration of these customer contributions, which are released throughout the development process, may be due to the development contractors' highly flexible product innovation processes and dynamic team structure. This team structure adjusts to the projects' focus, which evolves according to the discovered customer needs. The resulting products have a high degree of innovativeness and stand out through their design, which is perfectly adjusted to what customers—both clients and users—want.

| |
|---|
| Development contractors demonstrate a dynamic approach to industrial product development and provide new insights into an optimization of the innovation process of in-house developers. |

- The usefulness of investigating the practices of development contractors as well as in-house developers emerges through the consideration of XP, a product development method from software engineering. Both XP and the development contractors have a similar approach to generating new products: they are developed 'release by release,' starting with the simplest product solution that works and only adding complexity when the solution is approved by the customer and adjusted to fit its needs.

| |
|---|
| The practices from XP are specific for product development in a software context; however, they give valuable insights for the discovery of successful practices in industrial product innovation. |

***Managerial implications for integrating customers into industrial product innovation***

The managerial implications were developed from the results of a theoretical cross-case analysis of industrial in-house developers and development contractors. From the theoretical propositions, the determinants for integrating customers into industrial product development can be derived. The determinants lead to a decision model for managing customer integration; because XP was considered during the decision model develop-

ment, the model is referred to as XP-based. Finally, the implications for XP-based product innovation are discussed.

- ***Determinants.*** The derivation of strategic determinants attempted to support the managerial decisions for an appropriate customer integration strategy. The identified strategic determinants—industry empathy, or the company's recognition and in-depth know-how regarding the product market and its related technologies, and market responsibility—provide insights into two consistent customer integration strategies: anticipating customer needs and technology and application brokering. Whereas anticipating customer needs can be pursued by pushing resources into areas of anticipated innovation potentials and foreseeing and even shaping customer needs, technology and application brokering focuses on bringing together different perspectives and specialists and thus cross-fertilizing different industries.

  The customer integration strategy of anticipating product needs is consistent and therefore appropriate if a company has a market leading position in the specific product field, as well as a technological head start, and if the uncertainty of the product innovation requirements is low. The technology and application brokering strategy is consistent and appropriate if a company has a rather weak position in the targeted product market, technological constituents first have to be developed or acquired, and the uncertainty of the product innovation requirements is considered high. The brokering strategy generally leads to new products with the potential for a higher degree of innovativeness.

  The derivation of organizational determinants supports the managerial decision about the appropriate customer integration measures. The identified determinants are product buyer and user consideration, lead and typical user consideration, project planning, and prototyping.

  Customer integration is influenced positively when product buyers and users are considered in a differentiated rather than undifferentiated manner, when leading and typical users are continuously considered throughout the innovation project instead of punctually, when prototyping takes place in a modular way instead of an integral one, and when project planning occurs iteratively instead of upfront. These specifications of the organizational determinants that positively influence customer integration serve as the basis for the development of the XP-based product innovation approach.

- ***Decision model for XP-based product innovation.*** The XP-based decision model represents a recommended approach for product innovation projects in which the product requirement uncertainty is high and customer integration lies at the core of

the project. This product innovation approach does not aim to replace companies' existing product development processes entirely but is a recommended solution for innovation projects with a long-term perspective that want to achieve a high degree of innovativeness.

> The process structure of XP-based product innovation is composed of discrete sequencing development steps that evolve through the continuous integration of customer contributions. Discreteness refers to the characteristic that every development step leads to an intermediary project result, such as a prototype that can be presented to customers to collect new input. With this process, which is not planned upfront but only for the next development step, firms can keep their product options open longer, react to customer contributions later, and reduce the delays, bottlenecks, rework, and wasted effort inherent in modern product development processes.

> The organizational structure of XP-based product innovation is composed of a customer-centered product innovation cell, an organic team that grows and disbands within the company. It is integrated into the company across existing organizational structures and receives resources from different areas from which know-how is required according to the project focus. In addition to the project manager, product managers, developers, and specialists, customers are product innovation cell team members. The resulting team collaborates by loosely coupling and through discrete development steps instead of a rigid business process.

> The proposed practices for XP-based product innovation are derived from the practices of XP in software engineering: small development cycles, frequent acceptance and feedback tests, flexible prototyping at developers' and customers' sites, a planning game and decision gates that involve all project members, continual implementation of intermediary project results, collective ownership of the project responsibility, and a sustainable development pace.

- ***Implementing XP-based product innovation.*** The XP-based product innovation approach was developed for innovation projects for which the uncertainty of product requirements is high and the project has a rather long-term horizon. A balanced innovation project portfolio helps put an adequate emphasis on XP-based projects and ensure the product pipeline from both a short- and a long-term perspective. Innovation teams that work according to an XP-based approach can be established within a company in the form of organizationally established innovation departments (if the required resources are in place) or on a temporal basis, formed as soon as a product innovation opportunity is identified. Development contractors can significantly support XP-based product innovation teams by injecting new input and different perspectives into their projects. Finally, to ensure the successful implementation of XP-based product innovation, companies must develop the

skills of project leaders and team members carefully and consider their ability to cope with high flexibility and responsibility.

### 7.2.2 Future directions and trends

The future directions and trends presented in this section illustrate various opportunities for product innovation and the integration of customer contributions into an industrial product development context. These remarks go beyond the role that customer integration currently plays. This section suggests some potential approaches to manifest discrete product innovation as the future vehicle for new product development. Thus, the following comments on future directions and trends could be elaborated:

- ***Continuous adaptation of the product innovation process.*** Most established companies that develop industrial products have a well-elaborated process for their new product development. Although they may have been successful with their approach, managing product innovation projects in the future will need to be more creative, more flexible, more agile, and, most significant, more adaptable to change. Especially in environments in which industries merge, the continuous evolution of mechanisms used to bring out innovative products will be required not just to outperform competitors but to keep up with them (cf. Robson 2005). Hence, the product innovation process cannot be a stable procedure but must adapt as its environment changes; a project that begins using an adaptive process cannot maintain the same process a year later, because teams should constantly identify what works better and alter the process accordingly. Implementing a discrete product innovation process represents an adequate starting point to capture environmental changes and absorb them in the evolving process.

  Furthermore, to make an adaptive product innovation process work, the overall innovation system must be seamless throughout the organization, driven by a vision of where the company wants to go, nurtured by a strategy for getting there, and managed by people with a solid understanding of both the technology and the business. In turn, the R&D function will merge with marketing, and R&D leaders will become business managers as well (Larson 1998). These R&D managers have to be adept at procuring the resources needed to create teams with the proper skills and personalities and that arise and disband within a company, like business 'ecosystems' (Hagel and Brown 2005), to accomplish their mission. Communication among people with very different skills, experiences, and mindsets has to be supported by virtual laboratories and rapid prototyping techniques, combined with

new modeling capabilities, expert systems, and intercompany networks that provide an agile, holistic innovation process with a common language across business units and networked companies (Larson 1998). It thereby enables teams to install systems simultaneously rather than sequentially.

- ***Innovation functions absorbing R&D.*** A more progressive approach to product innovation management arises from a new structural approach for organizing the R&D department. No matter how loudly a CEO proclaims the need to embed innovation and creativity in the corporate culture, such initiatives tend to be the first cut when times get tough or priorities change (Wolpert 2002). The best way to protect projects from the swings in interest and funding that inevitably occur in individual organizations is to find ways for two or more partners to share ideas, technologies, and other capabilities actively, early, and often. These partners can be development contractors, suppliers, customers, or even competitors. A challenge to this approach is the risk of unauthorized appropriation of intellectual property, but independent intermediaries could facilitate the exchange of know-how about innovations among companies by bridging participants' knowledge gaps. These intermediaries—possibly in the form of development contractors, business lawyers, or venture capitalists—serve as trusted 'orchestrators': if a company needs outside capabilities to commercialize a technology, it could ask its intermediary to find partners with complementary skills and a client to find the precise and most valuable application. These intermediaries would be in a unique position to visualize new opportunities synthesized from the insights and technologies provided by several companies, opportunities that might never occur to companies working on innovation programs on their own. The intermediaries can be trusted to maintain confidentiality because if they ever violated the terms of an arrangement, no company would hire them again (Wolpert 2002).

  Pushing this approach to an extreme, customer-centered product innovation cells, as promoted within the XP-based product innovation model, could replace a company's R&D department. An intermediary would receive an assignment from the project principal, initiate product innovation cells, assemble the resources required from its network, and ensure that the new product was developed in complete detachment from the company ordering it. As a result, internal R&D could be abandoned and replaced by service intermediaries that would engage and integrate the innovation resources of externals to do the company's R&D.

- ***Automated creative thinking.*** The development contractors' practices demonstrate that the idea and opportunity discovery process must be primed, such that more recombinations and linkages among ideas and know-how are identified and considered in a timely manner. Systematic brokering reveals productive know-how links and partners that otherwise may have gone unnoticed, but creative thinking rarely uses the regularities of these productive links. Relational structures have been developed in a variety of disciplines, including linguistics (Eco, Santambrogio, and Violi 1988), anthropology (Levi-Strauss 1974), and artificial intelligence (Minsky 1988), and at least some of these structures are potential resources for creative thinking that could benefit product innovation (Goldenberg, Mazurski, and Solomon 1999).

  To provide an approach for generating ideas through systematic brokering, Goldenberg and colleagues (Goldenberg et al. 1999; Goldenberg, Mazursky, Horowitz, and Levav 2003) show that regularities can serve as skeletons or infrastructures for generating creative ideas. They suggest a template that follows a sequence of well-defined and first-principle operations (split, exclude, include, and link) for product components, according to which an algorithm can be defined to produce new ideas for products and features systematically. According to analyses of the quality of the resulting ideas, template-matched ideas generated in a human ideation process are best, template-matched ideas generated by the computer are rated lower, and non–template human ideas are rated lowest. This finding applies to both creativity and originality judgments.

  An approach of automated knowledge matching for idea generation has only become conceivable in recent times with the advent of sophisticated software agents and powerful, fast computer systems. A new generation of data analysis and supportive techniques, collectively labeled 'data mining methods,' can be used to handle the vast amounts of data in an electronic environment. The data mining process involves several steps: goal definition, data selection, data preparation and transformation, data exploration, pattern discovery, and pattern utilization. Specialized agents that support data mining also can be induced (Wilkinson 2003).

- ***Nothing-invented-here culture.*** The relevance of good collaboration with customers, suppliers, development contractors, and other company stakeholders has been noted by the open innovation impulse that occurred in innovation research (Chesbrough 2003; Gassmann et al. 2004; Gassmann and Enkel 2006). It is based on the recognition that no company is smart enough to know what to do with every

new opportunity it finds or is resourceful enough to pursue all the opportunities it might execute (Wolpert 2002). Therefore, all employees of the company have to become more open to input from outside the organization. In contrast with the not-invented-here (NIH) syndrome (Katz and Allen 1982), from which companies suffer if their employees refuse contributions from outside their department, an open company is characterized by a 'nothing-invented-here' culture (Servatius 2004). In this culture, whose practicability already has been demonstrated by the organizations of the development contractors, employees are extremely customer focused. They have multidisciplinary backgrounds and skills that they upgrade constantly through internal and external learning programs. They constantly search for new opportunities and applications for their work and develop broad networks of contacts. These employees spend a major portion of their time with customers in their markets, with support from automation for flexible, continuous testing and prototyping. Therefore, these employees' value is determined not only according to 'what they know' but also 'whom they know' and how they progressively realize their know-how in highly innovative new products.

In summary, this thesis addresses an area that, in both management practice and theory, is characterized by high relevance for the industry but a lack of previous research attention. This framework can serve as a guideline for integrating customers into industrial product innovation, though naturally some blank spaces remain that could provide a starting point for further research on this highly relevant topic.

*"The future is already here—it is just unevenly distributed."*
*—William Gibson, Novelist, November 30, 1999*

## References


Acebal, C. F. and J. M. Cueva Lovelle (2002). "A new method of software development: eXtreme programming." Informatik(2): 5-9.

Adams, M. E., G. S. Day, and D. Dougherty (1998). "Enhancing new product development performance: An organizational learning perspective." Journal of Product Innovation Management **15**(5): 403-422.

Akao, Y. (1988). Quality function deployment QFD: Integration of customer requirements into product design. Portland, OR: Productivity Press.

Akao, Y. (1990). Quality function deployment: Integrating customer requirements into product design. Portland, OR: Productivity Press.

Albers, S. and S. Eggers (1991). "Organisatorische Gestaltungen von Produktinnovations-Prozessen. Führt der Wechsel des Organisationsgrades zu Innovationserfolg?" Zeitschrift der Betriebswirtschaftlichen Forschung (zfbf) **43**(1): 44-64.

Alchian, A. A. (1950). "Uncertainty, evolution, and economic theory." The Journal of Political Economy **58**(3): 211-221.

Allen, T. J. (1966). "Studies of the problem-solving process in engineering design." IEEE Transactions on Engineering Management **13**(2): 72-83.

Allen, T. J. (1971). "Communications, technology transfer, and the role of technical gatekeeper." R&D Management **1**: 14-21.

Allen, T. J. (1977). Managing the flow of technology. Cambridge, MA: MIT Press.

Anand, B. N. and T. Khanna (2000). "Do firms learn to create value? The case of alliances." Strategic Management Journal **21**(3): 295-315.

Anderson, J. C. and J. A. Narus (1990). "A model of distributor firm and manufacturer firm working partnerships." Journal of Marketing **54**(1): 42-58.

Argyris, C. and D. A. Schön (1978). A review of the literature on organizational learning. Organizational learning: A theory of action perspective. C. Argyris and D. A. Schön: Reading, MS, Addison-Wesley, 316-336.

Athaide, G. A. and R. L. Stump (1999). "A taxonomy of relationship approaches during product development in technology-based, industrial markets." Journal of Product Innovation Management **16**(5): 469-482.

Atuahene-Gima, K. (1995). "An exploratory analysis of the impact of market orientation on new product performance: A contingency approach." Journal of Product Innovation Management **12**(4): 275-293.

Atuahene-Gima, K. (1996). "Market orientation and innovation." Journal of Product Innovation Management **13**(5): 456-457.

Bacon, G., S. Beckman, D. Mowery, and E. Wilson (1994). "Managing product definition in high-technology industries: A pilot study." California Management Review **36**(3): 32-56.

Beck, K. (2000). Extreme Programming explained—Embrace change. New York: Addison-Wesley.

Beck, K. (2003). Extreme Programming: Das Manifest. München: Addison-Wesley.

Beck, K. and M. Fowler (2001). Planning Extreme Programming. Boston: Addison-Wesley.

Berblinger, J. (1988). Das Prototyping-Projekt-Modell (PPM). Technische Hochschule Darmstadt: Dissertation.

Berry, L. L. and A. Parasuraman (1997). "Listening to the customer—the concept of a service-quality information system." MIT Sloan Management Review **38**(3): 65-76.

Bidault, F. and T. Cummings (1994). "Innovating through alliances: Expectations and limitations." R&D Management **24**(1): 33-45.

Biemans, W. G. (1991). "User and third-party involvement in developing medical equipment innovations." Technovation **11**(3): 163-182.

Biemans, W. G. (1992). Managing innovation within networks. London: Routeledge.

Billington, J. (1998). "Customer-driven Innovation." Harvard Management Update **3**(7): 1-3.

Boehm, B., T. Gray, and T. Seewaldt (1984). "Prototyping versus specifying: A multiproject experiment." IEEE Transactions on Software Engineering **10**(3): 290-303.

Boland, R. J. (1987). "The process and product of system design." Management Science **24**: 887-898.

Boutellier, R. and O. Gassmann (2001). Flexibles Management von Entwicklungsprojekten. High-Risk-Projekte - Quantensprünge in der Entwicklung erfolgreich managen. O. Gassmann, C. Kobe and E. Voith: Berlin, New York, Tokyo, Springer.

Brockhoff, K. (1998). Der Kunde im Innovationsprozess. Göttingen: Vandenhoeck und Ruprecht.

Brockhoff, K. (2003). "Customers' perspectives of involvement in new product development." International Journal of Technology Management **26**(5/6): 464-481.

Brown, S. L. and K. M. Eisenhardt (1995). "Product development: Past research, present findings, and future directions." Academy of Management Review **20**(2): 343-378.

Bruce, M., F. Leverick, D. Littler, and D. Wilson (1995). "Success factors for collaborative product development: A study of suppliers of information and communication technology." R&D Management **25**(1): 33-44.

Buechi (2004). Presentation by E. Freydl: Product innovation management at Buechi Labortechnik AG. Flawil, 02.12.2004.

Buergel, H. D. and A. Zeller (1997). "Controlling kritischer Erfolgsfaktoren in der Forschung und Entwicklung." Controlling **9**(4): 218-225.

Buttle, F. (1996). Relationship marketing: Theory and practice. London: Sage Publications.

Cagan, J., C. Vogel, and P. Boatwright (2005). The design of things to come: How ordinary people create extraordinary products. Philadelphia: Wharton School Publishing.

Cagan, J. and C. M. Vogel (2002). Creating breakthrough products: Innovation from product planning to program approval. Upper Saddle River, NJ: Prentice Hall PTR.

Campbell, A. J. and R. G. Cooper (1999). "Do customer partnerships improve new product success rates?" Industrial Marketing Management **28**(5): 507-519.

Cheng, Y.-T. and A. H. van de Ven (1996). "Learning the innovation journey: Order out of chaos?" Organization Science **7**(6): 593-614.

Chesbrough, H. W. (2003). "The era of open innovation." MIT Sloan Management Review **44**(3): 35-41.

Chesbrough, H. W. (2003). Open innovation: The new imperative for creating and profiting from technology. Boston: Harvard Business School Press.

Christensen, C. M. (1997). The innovator's dilemma. Boston: Harvard Business School Press.

Ciccantelli, S. and J. Magidson (1993). "From experience: Consumer idealized design: Involving consumers in the product development process." Journal of Product Innovation Management **10**(4): 341-347.

Clark, K. B. and T. Fujimoto (1990). "The power of product integrity." Harvard Business Review **68**(6): 107-118.

Clark, K. B. and T. Fujimoto (1991). Product development performance. Boston: Harvard Business School Press.

Clark, P. A. and N. Staunton (1989). Innovation in technology and organization. London: Routledge.

Coase, R. H. (1937). "The nature of the firm." Economica **4**(16): 386-405.

Coch, L. and J. R. French (1948). "Overcoming resistance to change." Human Relations **1**: 512-532.

Cohen, M. D., J. G. March, and J. P. Olsen (1972). "A garbage can model of organizational choice." Administrative Science Quarterly **17**(1): 1-25.

Cooper, R. G. (1979). "The dimensions of industrial new product success and failure." Journal of Marketing **43**(3): 93-103.

Cooper, R. G. (1990). "Stage-gate systems: A new tool for managing new products." Business Horizons **33**(3): 44-54.

Cooper, R. G. (1994). "Perspective third-generation new product processes." Journal of Product Innovation Management **11**(1): 3-14.

Cooper, R. G. (2001). Winning at new products: Accelerating the process from idea to launch. Reading, MA: Perseus Publishing.

Cooper, R. G. and E. J. Kleinschmidt (1986). "An investigation into the new product process: Steps, deficiencies, and impact." Journal of Product Innovation Management **3**(2): 71-85.

Cooper, R. G. and E. J. Kleinschmidt (1988). "Resource allocation in the new product process." Industrial Marketing Management **17**(3): 249-262.

Cooper, R. G. and E. J. Kleinschmidt (1991). "New product processes at leading industrial firms." Industrial Marketing Management **20**(2): 137-147.

Cooper, R. G. and E. J. Kleinschmidt (1995). "Benchmarking the firm's critical success factors in new product development." Journal of Product Innovation Management **12**(5): 374-391.

Crinnion, J. (1991). Evolutionary systems development. London: Pitman Publishing.

Crispin, L., T. House, and D. Wade (2002). "The need for speed: Automating acceptance testing in an XP environment." Informatik(2): 10-16.

Cyert, R. M. and J. G. March (1963). A behavioral theory of the firm. Englewood Cliffs, NJ: Prentice-Hall.

Dahan, E. and J. R. Hauser (2001). Product development—managing a dispersed process. Handbook of Marketing. B. A. Weitz and R. Wensley: London, Sage, 179-222.

Dahan, E. and J. R. Hauser (2002). "The virtual customer." Journal of Product Innovation Management **19**(5): 332-353.

Dahan, E. and H. Mendelson (2001). "An extreme-value model of concept testing." Management Science **47**(1): 102-116.

Dahlman, S. (1986). User requirements. A resource for the development of technical products. Dissertation. Department of Consumer Technology: Chalmers University of Technology, Gothenberg, Sweden.

Damodaran, L. (1996). "User involvement in the system design process—A practical guide for users." Behaviour & Information Technology **15**(6): 363-377.

Das, T. K. and B.-S. Teng (2000). "A resource-based theory of strategic alliances." Journal of Management **26**(1): 31-62.

Dearlove, D. (1998). "Innovation from the chaos." The Times (U.K.) **August 13**: 3.

Dicke, C. (2002). Prozess-Modell: "Extreme Programming". Münster, Universität Münster**:** 1-23.

D'Iribarne, P. (1997). "The usefulness of an ethnographic approach to the international comparison of organizations." International Studies of Management and Organization **26**(4): 30-47.

Dodgson, M. (1991). "Technology learning, technology strategy and competitive pressures." British Journal of Management **2**(3): 133-149.

Dodgson, M. (1993). "Organizational learning: A review of some literatures." Organization Studies **14**(3): 375-394.

Dolan, R. J. and J. M. Matthews (1993). "Maximizing the utility of customer product testing: Beta test design and management." Journal of Product Innovation Management **10**(4): 318-330.

Donath, M. (2003). "Tribecraft peut concrétiser les produits les plus forts." L'Agefi - finance - technologies - politique au quotidien **Septembre**(Vendredi 12): 16.

Doney, P. M. and J. P. Cannon (1997). "An examination of the nature of trust in buyer-seller relationships." Journal of Marketing **61**(2): 35-51.

Dornberger, R. and T. Habegger (2004). "Extreme Programming - Eine Übersicht und Bewertung." Reihe A: discussion Paper 2004-05: 1-51.

Drenth, R. (2002). Managing market learning at Hilti corporation—How to live customer value in a multinational company. Working Paper, Marketing Management for Service Companies, University of St. Gallen**:** 1-75.

Duray, R. and P. T. Ward (2000). "Approaches to mass customization: configurations and empirical validation." Journal of Operations Management **18**(6): 605-625.

Dyer, J. H. and K. Nobeoka (2000). "Creating and managing a high-performance knowledge-sharing network: The Toyota case." Strategic Management Journal **21**(3): 345-367.

Dyer, J. H. and H. Singh (1998). "The relational view: Cooperative strategy and sources of interorganizational competitive advantage." Academy of Management Review **23**(4): 660-679.

Eason, K. D. (1992). The development of a user-centered design process. A case study in multi disciplinary research. Inaugural lecture, HUSAT Research Institute, Loughborough University of Technology: Loughborough, 14 October.

Eco, U., M. Santambrogio, and P. Violi (1988). Meaning and mental representations. Advances in Semiotics. Bloomington: Indiana University Press.

Edwards, R. (1999). Lifelong (l)earning and a 'new age' at work. Lifelong and continuing education: What is a learning society? P. Oliver: Ashgate, Alershot.

Eisenhardt, K. M. (1989). "Building theories from case study research." Academy of Management Review **14**(4): 532-550.

Eisenhardt, K. M. (1989). "Making fast strategic decisions in high-velocity environments." Academy of Management Journal **32**(3): 543.

Eisenhardt, K. M. and B. N. Tabrizi (1995). "Accelerating adaptive processes: Product innovation in the global computer industry." Administrative Science Quarterly **40**(1): 84-110.

Eliashberg, J., G. L. Lilien, and V. Rao (1997). Minimizing technological oversights: A marketing research perspective. Technological innovation: Oversights and foresights. R. Garud, P. Nayyar, R. Praveen and Z. B. Shapira: New York, Cambridge University Press, 214-230.

Enkel, E., C. Kausch, and O. Gassmann (2005). "Managing the risk of customer integration." European Management Journal **23**(2): 203-213.

Enos, J. L. (1962). Petroleum progress and profits: A history of process innovation. Cambridge, MA: MIT Press.

Ernst, H. (2002). "Success factors of new product development: A review of the empirical literature." International Journal of Management Reviews **4**(1): 1-40.

Eureka, W. E. and N. E. Ryan (1994). The customer-driven company: Managerial perspectives on quality function deployment. Dearborn, MI: ASI Press.

Fiol, C. M. and M. A. Lyles (1985). "Organizational learning." Academy of Management Review **10**(4): 803-813.

Freeman, C. (1968). "Chemical process plant: Innovation and the world market." National Institute Economic Review **45**(August): 29-57.

Fritsch, M. and R. Lukas (2001). "Who cooperates on R&D?" Research Policy **30**(2): 297-312.

Ganesan, S. (1994). "Determinants of long-term orientation in buyer-seller relationships." Journal of Marketing **58**(2): 1-19.

Gassmann, O. and E. Enkel (2004). Towards a theory of open innovation: Three core process archetypes. Proceedings of the R&D Management Conference (RADMA), Lisbon, Portugal, R&D Management, Juli 6-9.

Gassmann, O. and E. Enkel (2006). "Open Innovation: Externe Hebeleffekte in der Innovation erzielen." Zeitrschrift Führung + Organisation(3).

Gassmann, O. and C. Hipp (2001). "Hebeleffekte in der Wissensgenerierung: Die Rolle von technischen Dienstleistern als externe Wissensquelle." Zeitschrift für Betriebswirtschaft(Ergänzungsheft 1/2001): 141-159.

Gassmann, O., P. Sandmeier, and C. H. Wecht (2004). "Innovationsprozesse: Öffnung statt Alleingang." io new management(1-2): 22-27.

Gassmann, O. and M. von Zedtwitz (1999). "New concepts and trends in international R&D organization." Research Policy **28**(2-3): 231-250.

Gassmann, O. and M. von Zedtwitz (2003). Innovation processes in transnational companies. The International Handbook of Innovation. L. V. Shavinina: Oxford, Pergamon, 702-714.

Gassmann, O. and M. von Zedtwitz (2003). "Trends and determinants of managing virtual R&D teams." R&D Management **33**(3): 243.

Gebhardt, A. (1996). Rapid Prototyping—Werkzeuge für die schnelle Produktentwicklung. München: Hanser.

Gemuenden, H. G. (1981). Innovationsmarketing: Interaktionsbeziehungen zwischen Hersteller und Verwender innovativer Investitionsgüter. Tübingen: Mohr.

Glaser, B. and A. Strauss (1967). The discovery of grounded theory—Strategies of qualitative research. London: Wiedenfeld and Nicholson.

Glazer, R. (1991). "Marketing in an information-intensive environment: Strategic implications of knowledge as an asset." Journal of Marketing **55**(4): 1-19.

Glazer, R. (1999). "Winning in smart markets." MIT Sloan Management Review **40**(4): 59-69.

Gold, B. (1987). "Approaches to accelerating product and process development." Journal of Product Innovation Management **4**(2): 81-88.

Goldenberg, J., D. Mazurski, and S. Solomon (1999). "Creative sparks." Science **285**(September): 1495-1496.

Goldenberg, J., D. Mazursky, R. Horowitz, and A. Levav (2003). "Finding your innovation sweet spot." Harvard Business Review **81**(3): 120-130.

Green, P. E., V. R. Rao, and W. S. Desarbo (1978). "Incorporating group-level similarity judgments in conjoint analysis." Journal of Consumer Research **5**(3): 187-193.

Griffin, A. (1997). Drivers of NPD success: The 1997 PDMA report. Chicago: Product Development & Management Association.

Griffin, A. and J. R. Hauser (1993). "The voice of the customer." Marketing Science **12**(1): 1-27.

Griffin, A. and J. R. Hauser (1996). "Integrating R&D and marketing: A review and analysis of the literature." Journal of Product Innovation Management **13**(3): 191-213.

Griffin, A. and A. L. Page (1996). "PDMA success measurement project: Recommended measures for product development success and failure." Journal of Product Innovation Management **13**(6): 478-496.

Gruner, K. E. (1997). Kundeneinbindung in den Produktinnovationsprozess: Bestandsaufnahme, Determinanten und Erfolgsauswirkungen. Wiesbaden: Gabler.

Gruner, K. E. and C. Homburg (2000). "Does customer interaction enhance new product success?" Journal of Business Research **49**(1): 1-14.

Gupta, A. K. and D. L. Wilemon (1990). "Accelerating the development of technology-based new products." California Management Review **32**(2): 24-53.

Gutman, J. (1982). "A means-end chain model based on consumer categorization processes." Journal of Marketing **46**(2): 60-72.

Hagel, J. and J. S. Brown (2005). "Productive friction: How difficult business partnerships can accelerate innovation." Harvard Business Review **83**(2): 82-91.

Håkansson, H. (1987). Industrial technological development: A network approach. London: Croom Helm.

Hallbauer, S. (1997). Prototypenmanagement im Entwicklungsverbund - Ein Gestaltungskonzept auf Basis des Modells lebensfähiger Systeme. Schesslitz: Rosch-Buch GmbH.

Haman, G. (1996). Techniques and tools to generate breakthrough products. PDMA Handbook of New Product Development. M. D. Rosenau Jr.: New York, John Wiley & Sons, 167-178.

Hansen, U., K. Jeschke, and P. Schöber (1995). "Beschwerdemanagement - Die Karriere einer kundenorientierten Unternehmensstrategie im Konsumgütersektor." Marketing ZFP **17**: 77-88.

Hansen, U. and T. Raabe (1991). "Konsumentenbeteiligung an der Produktentwicklung von Konsumgütern." Zeitschrift für Betriebswirtschaft **61**(171-194).

Hargadon, A. and R. I. Sutton (1997). "Technology brokering and innovation in a product development firm." Administrative Science Quarterly **42**(4): 716-749.

Hauschildt, J. and E. Kirchmann (2001). "Teamwork for innovation—The 'troika' of promotors." R&D Management **31**(1): 41-49.

Hauser, J. R. and D. Clausing (1988). "The house of quality." Harvard Business Review **66**(3): 63-73.

Hayes, R. H., S. C. Wheelwright, and K. B. Clark (1988). Dynamic manufacturing. New York: Free Press.

Helten, E. (1994). Ist Risiko ein Konstrukt? Zur Quantifizierung des Risikobegriffs. Risiko, Versicherung, Markt. Festschrift für Walter Karten zur Vollednung des 60. Lebensjahres. W. Schott: Karlsruhe, 19-25.

Herrmann, A. (1998). Produktmanagement. München: Franz Vahlen.

Herstatt, C. (1991). Anwender als Quellen für die Produktinnovation. Zürich: ADAG Administration & Druck AG.

Herstatt, C. and B. Verworn, Eds. (2002). Bedeutung und Charakteristika der frühen Phasen des Innovationsprozesses. Management der frühen Innovationsphasen - Grundlagen - Methoden - Neue Ansätze. Wiesbaden: Gabler.

Herstatt, C. and B. Verworn (2003). Management der frühen Innovationsphasen—Grundlagen—Methoden—Neue Ansätze. Wiesbaden: Gabler.

Herstatt, C. and E. von Hippel (1992). "From experience: Developing new product concepts via the lead user method: A case study in a 'low-tech' field." Journal of Product Innovation Management **9**(3): 213-221.

Hilti (1997). Hilti corporation (A&B). IMD Cases: Lausanne, IMD. **IMD-3-0663**, 1-12.

Hilti (2003). Hilti 2003: Maintaining a proactive sense of urgency. University of St. Gallen Case Study: St. Gallen, University of St. Gallen. **304-092-1**, 1-26.

Hilti (2005a). Presentation by R. García: Product innovation management and customer integration at Hilti. Schaan, 03.06.2005.

Hilti (2005b). Presentation by R. García: Product innovation management and customer integration at Hilti. Schaan, 11.08.2005.

Holman, R., H.-W. Kaas, and D. Keeling (2003). "The future of product development." The McKinsey Quarterly(3): 2-8.

Huber, G. P. (1991). "Organizational learning: The contributing processes and the literatures." Organization Science **2**(1): 88-115.

Hutt, M. D. and E. R. Stafford (2000). "Defining the social network of a strategic alliance." MIT Sloan Management Review **41**(2): 51-62.

Iansiti, M. (1998). Technology integration: Making critical choices in a dynamic world. Boston, MA: Harvard Business Press.

IDEO (2000). "IDEO product development". Harvard Business School Cases, Harvard Business School. **9-600-143**, 1-21.

IDEO (2003). "IDEO: An 'idea-intensive' organization at work". IMD Cases. IMD. Lausanne, IMD**:** 1-13.

IDEO (2005a). Presentation by R. Stancel: Product development and customer integration at IDEO. St. Gallen, 14.02.2005.

IDEO (2005b). Presentation by R. Stancel: Product development and customer integration at IDEO. St. Gallen, 02.06.2005.

Imai, K., N. Ikujiro, and H. Takeuchi (1985). Managing the new product development process: How Japanese companies learn and unlearn. The uneasy alliance: Managing the productivity-technology dilemma. R. H. Hayes, K. Clark and Lorenz: Boston, MA, Harvard Business School Press, 337-375.

Ives, B. and M. H. Olson (1984). "User involvement and MIS success: A review of research." Management Science **30**(5): 586-603.

Jassawalla, A. R. and H. C. Sashittal (1998). "An examination of collaboration in high-technology new product development processes." Journal of Product Innovation Management **15**(3): 237-254.

Jensen, H. R. (2001). "Antecedents and consequences of consumer value assessments: implications for marketing strategy and future research." Journal of Retailing and Consumer Services **8**: 299-310.

Jensen, R. and G. Szulanski (2004). "Stickiness and the adaptation of organizational practices in cross-border knowledge transfers " Journal of International Business Studies **35**(6): 508-523.

Jeppesen, L. B. and M. J. Molin (2003). "Consumers as co-developers: Learning and innovation outside the firm." Technology Analysis & Strategic Management **15**(3): 363-383.

Johne, A. (1994). "Listening to the voice of the market." International Marketing Review **11**(1): 47-59.

Johnsen, T. and D. Ford (2000). Managing collaborative innovation in complex networks: Findings from exploratory interviews. 16th IMP-Conference, Bath, U.K.

Kahn, K. B. (2001). "Market orientation, interdepartmental integration, and product development performance." Journal of Product Innovation Management **18**(5): 314-323.

Kale, P., J. H. Dyer, and H. Singh (2002). "Alliance capability, stock market response, and long-term alliance success: The role of the alliance function." Strategic Management Journal **23**(8): 747-767.

Kale, P., H. Singh, and H. Perlmutter (2000). "Learning and protection of proprietary assets in strategic alliances: Building relational capital." Strategic Management Journal **21**(3): 217-237.

Kanter, R. M. (1988). "When a thousand flowers bloom: Structural, collective, and social conditions for innovation in organization." Research in Organizational Behavior **10**: 169-211.

Karle-Komes, N. (1997). Anwenderintegration in die Produktentwicklung: Generierung von Innovationsideen durch die Interaktion von Hersteller und Anwender innovativer industrieller Produkte. Frankfurt/Main, Bern: Lang.

Katz, R. and T. J. Allen (1982). "Investigating the not invented here (NIH) syndrome: A look at the performance, tenure, and communication patterns of 50 R&D project groups." R&D Management **12**(1): 7-19.

Katz, R. and M. L. Tushman (1981). "An investigation into the managerial roles and career paths of gatekeepers and project supervisors in a major R&D facility." R&D Management **11**: 103-110.

Kaulio, M. A. (1998). "Customer, consumer and user involvement in product development: A framework and a review of selected methods." Total Quality Management **9**(1): 141-149.

Kelley, T. (2001). "Prototyping is the shorthand of innovation." Design Management Journal **12**(3): 35-42.

Kelley, T., J. Littman, and T. Peters (2001). The art of innovation: Lessons in creativity from IDEO, America's leading design firm. New York: Doubleday.

Kessler, E. H. and A. K. Chakrabarti (1999). "Speeding up the pace of new product development." Journal of Product Innovation Management **16**(3): 231-247.

Khurana, A. and S. R. Rosenthal (1997). "Integrating the fuzzy front end of new product development." MIT Sloan Management Review **38**(2): 103-120.

Khurana, A. and S. R. Rosenthal (1998). "Towards holistic 'front ends' In new product development." Journal of Product Innovation Management **15**(1): 57-74.

Kim, J. and D. Wilemon (2002). "Focusing the fuzzy front-end in new product development." R&D Management **32**(4): 269-279.

Kim, J. and D. Wilemon (2002). "Strategic issues in managing innovation's fuzzy front-end." European Journal of Innovation Management **5**(1): 27-39.

Kirchmann, E. M. W. (1994). Innovationskooperation zwischen Herstellern und Anwendern. Wiesbaden: DUV Deutscher Universitäts-Verlag.

Kline, S. J. and N. Rosenberg (1968). An overview of innovation. The Positive Sum Strategy—Harnessing Technology for Economic Growth. R. Landau and N. Rosenberg: Washington DC, National Academy Press, 275-306.

Koen, P., G. Ajamian, R. Burkart, A. Clamen, J. Davidson, R. D'Amore, C. Elkins, K. Herald, M. Incorvia, A. Johnson, R. Karol, R. Seibert, A. Slavejkov, and K. Wagner (2001). "Providing clarity and a common language to the 'fuzzy front end'." Research Technology Management **44**(2): 46-55.

Koen, P. A., G. M. Ajamian, S. Boyce, A. Clamen, E. Fisher, S. Fountoulakis, A. Johnson, P. Puri, and R. Seibert (2002). Fuzzy front end: Effective methods, tools, and techniques. PDMA Toolbook for New Product Development. P. Belliveau, A. Griffin and S. Somermeyer: New York, John Wiley & Sons, 5-35.

Kohli, A. K. and B. J. Jaworski (1990). "Market orientation: The construct, research propositions, and managerial implications." Journal of Marketing **54**(2): 1-17.

Kohn, S. and R. Niethammer (2002). Aufgabengerechte Kundeneinbindung im Innovationsprozess. Das innovative Unternehmen. Barske, Gerybadze, Hünninghausen and Sommerlatte: Düsseldorf, Symposion.

Kok, R. A. W., B. Hillebrand, and W. G. Biemans (2003). "What makes product development market oriented? Towards a conceptual framework." International Journal of Innovation Management **7**(2): 137-162.

Kotler, P. (1999). Kotler on marketing: How to create, win, and dominate markets. New York: The Free Press.

Kumar, V. and P. Whitney (2003). "Faster, cheaper, deeper user research." Design Management Journal **14**(2): 50-57.

Lappe, T. (2002). Extreme Programming—Darstellung und kritische Würdigung in der Literatur. Diplomarbeit: Universität Köln, Wirtschaftsinformatik.

Larson, C. F. (1998). "Industrial R&D in 2008." Research Technology Management **41**(6): 19-24.

Lei, D., J. W. Slocum, and R. A. Pitts (1997). "Building cooperative advantage: Managing strategic alliances to promote organizational learning." Journal of World Business **32**(3): 203-223.

Leibenstein, H. and S. Maital (1994). "The organizational foundations of X-inefficiency: A game-theoretic interpretation of Argyris' model of organizational learning." Journal of Economic Behavior & Organization **23**(3): 251-268.

Lempres, E. C. (2003). "A product is born." The McKinsey Quarterly(3): 1.

Lengnick-Hall, C. A. (1996). "Customer contributions to quality: A different view of the customer-oriented firm." Academy of Management Review **21**(3): 791-810.

Leonard, D. (1995). Wellsprings of knowledge—Building and sustaining the sources of innovation. Boston, MA: Harvard Business School Press.

Leonard, D. and J. F. Rayport (1997). "Spark innovation through empathic design." Harvard Business Review **75**(66): 102-113.

Leonard, D. and S. Sensiper (1998). "The role of tacit knowledge in group innovation." California Management Review **40**(3): 112-132.

Leonard-Barton, D. (1993). "Developer-user interaction and user satisfaction in internal technology transfer." Academy of Management Journal **36**(5): 1125-1139.

Leonard-Barton, D. E. (1995). Wellsprings of knowledge—Building and sustaining the sources of innovation. Boston, MA: Harvard Business School Press.

Leonard-Barton, D. E., E. Wilson, and J. Doyle (1993). Commercializing technology: Imaginative understanding of user needs. Sloan Foundation Conference on the Future of Research and Development, Harvard University, Boston, MA.

Lettl, C., Ed. (2004). Die Rolle von Anwendern bei hochgradigen Innovationen - Eine explorative Fallstudienanalyse in der Medizintechnik. Forschungs-/ Entwicklungs-/ Innovations-Management. Wiesbaden: Gabler Edition Wissenschaft.

Lettl, C. and C. Herstatt (2004). The role of users in the development of radical innovations. Proceedings of the R&D Management Conference (RADMA), Lisbon, Portugal, July 6-9, R&D Management.

Levi-Strauss, C. (1974). Tristes Tropiques. New York: Atheneum.

Li, T. and R. J. Calantone (1998). "The impact of market knowledge competence on new product advantage: Conceptualization and empirical examination." Journal of Marketing **62**(4): 13-29.

Lilien, G. L., P. D. Morrison, K. Searls, M. Sonnack, and E. von Hippel (2002). "Performance assessment of the lead user idea-generation process for new product development." Management Science **48**(8): 1042-1059.

Lilien, G. L. and A. Rangaswamy (1998). Marketing engineering: Computer-assisted marketing analysis and planning. Reading, MA: Addison-Wesley-Longman.

Linder, J. C., S. Jarvenpaa, and T. H. Davenport (2003). "Toward an innovation sourcing strategy." MIT Sloan Management Review **44**(4): 43-49.

Lindstrom, L. and R. Jeffries (2004). "Extreme Programming and agile software development methodologies." Information Systems Management(Summer): 41-52.

Littler, D., F. Leverick, and M. Bruce (1995). "Factors affecting the process of collaborative product development: A study of UK manufacturers of information and communications technology products." Journal of Product Innovation Management **12**(1): 16-32.

Loch, C. H., C. Terwiesch, and S. Thomke (2001). "Parallel and sequential testing of design alternatives." Management Science **47**(5): 663-678.

Lukas, B. A. and O. C. Ferrell (2000). "The effect of market orientation on product innovation." Journal of the Academy of Marketing Science **28**(2): 239-247.

Lüthje, C. and C. Herstatt (2004). "The lead user method: An outline of empirical findings and issues for future research." R&D Management **34**(5): 553-568.

Lüthje, C., C. Herstatt, and E. von Hippel (2005). "User-innovators and 'local' information: The case of mountain biking." Research Policy **34**(6): 951-965.

Lynch, P. and T. O' Toole (2003). After von Hippel: The state of user involvement research in new product development. 19th IMP-Conference, Lugano, Switzerland.

Lynn, G. S., J. G. Morone, and A. S. Paulson (1996). "Marketing and discontinuous innovation: The probe and learn process." California Management Review **38**(3): 8-37.

MacCormack, A. (2001). "Product-development practices that work: How internet companies build software." MIT Sloan Management Review **42**(2): 75-84.

MacCormack, A., R. Verganti, and M. Iansiti (2001). "Developing products on 'internet time': The anatomy of a flexible development process." Management Science **47**(1): 133-150.

Maidique, M. A. and B. J. Zirger (1985). "The new product learning cycle." Research Policy **14**(6): 299-313.

Maltz, E., W. E. Souder, and A. Kumar (2001). "Influencing R&D/marketing integration and the use of market information R&D managers: Intended and unintended effects of managerial actions." Journal of Business Research **52**(1): 69-82.

March, J. G. (1991). "Exploration and exploitation in organizational learning." Organization Science **2**(1): 71-87.

Markham, S. K. and A. Griffin (1998). "The breakfast of champions: Associations between champions and product development environments, practices and performance." Journal of Product Innovation Management **15**(5): 436-454.

Maron, R. M. and L. VanBremen (1999). "The influence of organizational culture on strategic alliances." Association Management **51**(4): 86-92.

Martin, A., R. Biddle, and J. Noble (2004). The XP customer role in practice: Three studies. Advanced Developers Conference (ADC), Salt Lake City.

Martin, A., J. Noble, and R. Biddle (2003). Being Jane Malkovich: A look into the world of an XP customer. Fourth International Conference on eXtreme Programming and Agile Processes in Software Engineering, Genova (Italy), Lecture Notes in Computer Science 2675, Springer.

Masten, D. L. and T. M. P. Plowman (2003). "Digital ethnography: The next wave in understanding the consumer experience." Design Management Journal **14**(2): 75-81.

McKee, D. (1992). "An organizational learning approach to product innovation." Journal of Product Innovation Management **9**(3): 232-245.

McLoughlin, D. and C. Horan (2000). "The production and distribution of knowledge in the markets-as-networks tradition." Journal of Strategic Marketing **8**(2): 89-103.

Menon, A. and P. R. Varadarajan (1992). "A model of marketing knowledge use within firms." Journal of Marketing **56**(4): 53-71.

Meyer, M. H. and A. DeTore (1999). "Product development in services." Academy of Management Executive **13**(3): 64-76.

Miles, M. B. and A. M. Huberman (1994). Qualitative data analysis. Newbury Park, CA, London: Sage Publications.

Miller, W. L. and M. Langdon (1999). 4th generation R&D: Managing knowledge, technology, and innovation. New Jersey: John Wiley & Sons.

Millson, M. R. and S. P. Raj (1996). "Strategic partnering for developing new products." Research Technology Management **39**(3): 41-49.

Minsky, M. L. (1988). Semantic information processing. Boston: MIT Press.

Mintzberg, H. (2005). Developing theory about the development of theory. Great minds in management. K. Smith and M. Hitt: Oxford, Oxford University Press, 355-372.

Mohr, J. J. and R. E. Spekman (1996). "Perfecting partnerships." Marketing Management **4**(4): 34-43.

Moore, C. (2002). "The new heart of your brand: Transforming your business through customer experience." Design Management Journal **13**(1): 39-45.

Moorman, C. and A. S. Miner (1997). "The impact of organizational memory on new product performance and creativity." Journal of Marketing Research **34**(1): 91-106.

Morgan, R. M. and S. D. Hunt (1994). "The commitment-trust theory of relationship marketing." Journal of Marketing **58**(3): 20-38.

Morrison, P. D., J. H. Roberts, and D. F. Midgley (2004). "The nature of lead users and measurement of leading edge status." Research Policy **33**(2): 351-362.

Morrison, P. D., J. H. Roberts, and E. von Hippel (2000). "Determinants of user innovation and innovation sharing in a local market." Management Science **46**(12): 1513-1527.

Mullins, J. W. and D. J. Sutherland (1998). "New product development in rapidly changing markets: An exploratory study." Journal of Product Innovation Management **15**(3): 224-236.

Murphy, S. A. and V. Kumar (1997). "The front end of new product development: A Canadian survey." R&D Management **27**(1): 5-15.

Myers, S. and D. G. Marquis (1969). Successful industrial innovations. Washington DC, National Science Foundation**:** 1-117.

Nambisan, S. (2002). "Designing virtual customer environments for new product development: Toward a theory." Academy of Management Review **27**(3): 392-413.

Nawrocki, J. R., M. Jasinski, B. Walter, and A. Wojciechowski (2002). Combining Extreme Programming with ISO 9000. EURASIA-ICT 2002, Shiraz, Iran.

Nelson, R. R. and S. G. Winter (1982). "The Schumpeterian tradeoff revisited." American Economic Review **72**(1): 114-132.

Nielsen, N. A., T. Bech-Larsen, and K. G. Grunert (1998). "Consumer purchase motives and product perceptions: A laddering study on vegetable oil in three countries." Food Quality and Preference **9**(6): 455-466.

Nottrodt, J. (1999). Qualitätssteigerung in der Produktentwicklung durch frühzeitige Nutzung von Informationen zu vorhandenen Produkten. Duesseldorf: VDI-Verlag.

OECD (2005). Science, technology and industry scoreboard. e-book edition: OECD Publishing.

Olson, E. L. and G. Bakke (2001). "Implementing the lead user method in a high technology firm: A longitudinal study of intentions versus actions." Journal of Product Innovation Management **18**(6): 388-395.

Paap, J. and R. Katz (2004). "Anticipating disruptive innovation." Research Technology Management **47**(5): 13-22.

Parry, M. E. and X. M. Song (1994). "Identifying new product successes in China." Journal of Product Innovation Management **11**(1): 15-30.

Paustian, C. (2001). "Better products through virtual customers." MIT Sloan Management Review **42**(3): 1-2.

Perrow, C. (1986). "Economic theories of organization." Theory and Society **15**(1/2): 11-45.

Perry, T. S. (1995). "How small firms innovate: Designing a culture for creativity." Research Technology Management **38**(2): 14-17.

Piller, F. T., K. Moeslein, and C. M. Stotko (2004). "Does mass customization pay? An economic approach to evaluate customer integration." Production Planning & Control **15**(4): 435-444.

Pitta, D. A., F. Franzak, and L. P. Katsanis (1996). "Redefining new product development teams: Learning to actualize consumer contributions." Journal of Product & Brand Management **5**(6): 48-60.

Polanyi, M. (1958). Personal knowledge. Towards a post-critical philosophy. Chicago, IL: University of Chicago Press.

Porac, J. F. and H. Thomas (1990). "Taxonomic mental models in competitor definition." Academy of Management Review **15**(2): 224-240.

Porter, M. E. (1990). The competitive advantage of nations. New York: Free Press.

Prasad, A. and P. Prasad (2002). "The coming of age of interpretive organizational research." Organizational Research Methods **5**(1): 4-11.

Punch, K. F. (1998). Introduction to social research: Quantitative and qualitative approaches. London: Sage Publications.

Quinn, J. B. (1985). "Managing innovation: Controlled chaos." Harvard Business Review **63**(3): 73-84.

Ragatz, G. L., R. B. Handfield, and T. V. Scannell (1997). "Success factors for integrating suppliers into new product development." Journal of Product Innovation Management **14**(3): 190-202.

Reichwald, R. and F. Piller (2005). Open Innovation: Kunden als Partner im Innovationsprozess. Working Paper TU Munich. Munich**:** 1-20.

Reynolds, T. J. and J. Gutman (1988). "Laddering theory, method, analysis, and interpretation." Journal of Advertising Research **28**(1): 11-31.

Rindfleisch, A. and C. Moorman (2001). "The acquisition and utilization of information in new product alliances: A strength-of-ties perspective." Journal of Marketing **65**(2): 1-18.

Robson, A. J. (2005). "Complex evolutionary systems and the red queen." The Economic Journal **115**(504): F211-F224.

Rosenberg, N. (1982). Inside the black box: Technology and economics. New York: Cambridge University Press.

Rosenblad-Wallin, E. (1985). "User-oriented product development applied to functional clothing." Applied Ergonomics **16**: 279-287.

Rosenblad-Wallin, E. (1988). "The design and evaluation of military footwear based upon the concept of healthy feet and user requirement studies." Ergonomics **31**: 1245-1263.

Rothwell, R. (1972). Factors for success in industrial innovations from project SAPPHO—A comparative study of success and failure in industrial innovation. Brighton, Sussex: S.P.R.U.

Rothwell, R. (1974). "The 'Hungarian Sappho': Some comments and comparisons." Research Policy **3**(1): 30-38.

Rubenstein, A. H., A. K. Chakrabarti, R. D. O'Keefe, W. E. Souder, and H. C. Young (1976). "Factors influencing success at the project level." Research Management **16**: 15-20.

Rumpe, B. and A. Schröder (2002). Quantitative survey on extreme programming projects. Third International Conference on Extreme Programming and Flexible Processes in Software Engineering, XP2002, Alghero, Italy.

Sandmeier, P., E. von Ziegler, and N. Jamali (2006). "Ideen sammeln brauch Strukturen." io new management - Zeitschrift für Unternehmenswissenschaften und Führungspraxis(1-2): 18-23.

Sawhney, M. and E. Prandelli (2000). "Communities of creation: Managing distributed innovation in turbulent markets." California Management Review **42**(4): 24-54.

Schmookler, J. (1966). Invention and economic growth. Cambridge: Harvard University Press.

Schrage, M. (2000). Serious play—how the world's best companies simulate to innovate. Boston: Harvard Business School Press.

Schroeder, D. M., C. Gopinath, and S. W. Congden (1989). "New technology and the small manufacturer: Panacea or plague?" Journal of Small Business Management **27**(3): 1-10.

Schumpeter, J. (1937). Preface to the Japanese edition of Theorie der Wirtschaftlichen Entwicklung, reprinted in Schumpeter, J. (1989). Essays on entrepreneurs, innovations, business cycles and the evolution of capitalism. R. V. Clemence: New Brunswick, NJ, Transaction Publishers, 165-168.

Schumpeter, J. A. (1939). Business cycle. New York: McGraw-Hill.

Scott, W., T. Rivera, and A. Tate (2003). "Turn your customers into interns." Quality Progress(November): 31-37.

Scott, W. R. (1987). Organizations: Rational, natural, and open systems. Englewood Cliffs, NJ: Prentice-Hall.

Seely Brown, J. and J. Hagel (2005). "From push to pull: The next frontier of innovation." The McKinsey Quarterly(3): 1-6.

Servatius, H.-G. (2004). "Next Practice des Innovationsmanagements." Information Management & Consulting **19**(Sonderausgabe): 1-8.

Seybold, P. B. (2001). "Get inside the lives of your customers." Harvard Business Review **79**(5): 80-89.

Shaw, B. (1985). "The role of the interaction between the user and the manufacturer in medical equipment innovation." R&D Management **15**(4): 283-292.

Shocker, A. D. and V. Srinivasan (1979). "Multiattribute approaches for product concept evaluation and generation: A critical review." Journal of Marketing Research **16**(2): 159-180.

Shrivastava, P. (1983). "A typology of organizational learning systems." Journal of Management Studies **20**(1): 7-28.

Sicotte, H., L. Préfontaine, L. Ricard, and M. Bourgault (2004). "New product development: Customers' and suppliers' assessment of the same project." International Journal of Technology Management **27**(2/3): 176-192.

Simon, H. A. (1969). The sciences of the artificial. Cambridge, MA: MIT Press.

Simonson, I. (1993). "Get closer to your customers by understanding how they make choices." California Management Review **35**(4): 68-84.

Song, X. M., M. M. Montoya-Weiss, and J. B. Schmidt (1997). "Antecedents and consequences of cross-functional cooperation: A comparison of R&D, manufacturing, and marketing perspectives." Journal of Product Innovation Management **14**(1): 35-47.

Song, X. M., R. J. Thieme, and X. Jinhong (1998). "The impact of cross-functional joint involvement across product development stages: An exploratory study." Journal of Product Innovation Management **15**(4): 289-303.

Souder, W. E. (1988). "Managing relations between R&D and marketing in new product development projects." Journal of Product Innovation Management **5**(1): 6-19.

Souder, W. E. and R. K. Moenaert (1992). "Integrating marketing and R&D project personnel within innovation projects: An information uncertainty model." Journal of Management Studies **29**(4): 485-512.

Stahl, M. J., W. K. Barnes, S. F. Gardial, and W. C. Parr (1999). "Customer-value analysis helps hone strategy." Quality Progress **32**(4): 53-58.

Stake, R. E. (1988). Case study methods in educational research: Seeking sweet water. Complementary Methods for Research in Education. R. Jaeger: Washington DC, American Educational Research Association, 253-300.

Tabrizi, B. and R. Walleigh (1997). "Defining next-generation products: An inside look." Harvard Business Review(November-December): 116-124.

Taylor, M. (1987). The possibility of cooperation. Cambridge: Cambridge University Press.

Terwiesch, C. and C. H. Loch (1999). "Measuring the effectiveness of overlapping development activities." Management Science **45**(4): 455-465.

Terwiesch, C. and C. H. Loch (2004). "Collaborative prototyping and the pricing of custom-designed products." Management Science **50**(2): 145-158.

Thamhain, H. J. (1990). "Managing technologically innovative team efforts toward new product success." Journal of Product Innovation Management **7**(1): 5-18.

Thom, N. (1992). Innovationsmanagement. Bern: Schweizerische Volksbank.

Thomke, S. (1995). The economics of experimentation in the design of new products and processes. Ph.D. dissertation: MIT Sloan School of Management.

Thomke, S. (2001). "Enlightened experimentation. The new imperative for innovation." Harvard Business Review **79**(2): 67-76.

Thomke, S. (2001). Experimentation matters—Unlocking the potential of new technologies for innovation. Boston, MA: Harvard Business School Press.

Thomke, S. and T. Fujimoto (2000). "The effect of 'front-loading' problem-solving on product development performance." Journal of Product Innovation Management **17**(2): 128-142.

Thomke, S. and D. Reinertsen (1998). "Agile product development: Managing development flexibility in uncertain environments." California Management Review **41**(1): 8-30.

Thomke, S. and E. von Hippel (2002). "Customers as Innovators - A New Way to Create Value." Harvard Business Review **80**(April): 74-81.

Thomke, S. and E. von Hippel (2002). "Customers as innovators: A new way to create value." Harvard Business Review **80**(4): 74-81.

Thomke, S., E. von Hippel, and R. Franke (1998). "Modes of experimentation: An innovation process—and competitive—variable." Research Policy **27**(3): 315-332.

Thomke, S. H. (1998). "Managing experimentation in the design of new products." Management Science **44**(6): 743-762.

Tidd, J., J. Bessant, and K. Pavitt (2001). Managing innovation: Integrating technological, market, and organizational change. New York: John Wiley & Sons.

The New York Times (1998). "IBM opens the doors of its research labs to surprising results." The New York Times: D1.

Tribecraft (2005). Presentation by D. Irányi: Product innovation management and customer integration at Tribecraft. Zürich, 03.08.2005.

Tushman, M. L. and P. Anderson (1986). "Technological discontinuities and organizational environments." Administrative Science Quarterly **31**(3): 439-465.

Ulwick, A. W. (2002). "Turn customer input into innovation." Harvard Business Review **80**(1): 91-97.

Ulwick, A. W. (2003). "The strategic role of customer requirements in innovation." Strategyn Inc **13**(12): Whitepaper.

Urban, G. L. and E. von Hippel (1988). "Lead user analyses for the development of new industrial products." Management Science **34**(5): 569-582.

Vahs, D. and R. Burmester (1999). Innovationsmanagement: Von der Produktidee zur erfolgreichen Vermarktung. Stuttgart: Schäffer-Poeschel.

van de Ven, A. and D. Ferry (1979). Measuring and assessing organisations. New York: John Wiley & Sons.

van Kleef, E., H. C. M. van Trijp, and P. Luning (2005). "Consumer research in the early stages of new product development: A critical review of methods and techniques." Food Quality and Preference **16**(3): 181-201.

van Maanen, J. (1983). Reclaiming qualitative methods for organizational research: A preface. Qualitative Methodology. J. Van Maanen: Beverly Hills, CA, Sage, 9-18.

Verganti, R. (1997). "Leveraging on systemic learning to manage the early phases of product innovation projects." R&D Management **27**(4): 377-392.

Verworn, B. (2005). Die frühen Phasen der Produktentwicklung—Eine empirische Analyse in der Mess-, Steuer- und Regelungstechnik. Wiesbaden: DUV.

Veryzer, R. W. and B. Borja de Mozota (2005). "The impact of user-oriented design on new product development: An examination of fundamental relationships." Journal of Product Innovation Management **22**(2): 128-143.

von Hippel, E. (1976). "The dominant role of users in the scientific instrument innovation process." Research Policy **5**(3): 212-239.

von Hippel, E. (1977). "Transferring process equipment innovations from user-innovators to equipment manufacturing firms." R&D Management **8**(1): 13-22.

von Hippel, E. (1978). "A customer-active paradigm for industrial product idea generation." Research Policy **7**(3): 240-266.

von Hippel, E. (1978). "Successful industrial products from customer ideas." Journal of Marketing **42**(1): 39-49.

von Hippel, E. (1986). "Lead users: A source of novel product concepts." Management Science **32**(7): 791-805.

von Hippel, E. (1988). The sources of innovation. New York: Oxford University Press.

von Hippel, E. (1994). "Sticky information and the locus of problem solving: Implications for innovation." Management Science **40**(4): 429-439.

von Hippel, E. (1998). "Economics of product development by users: The impact of 'sticky' local information." Management Science **44**(5): 629-644.

von Hippel, E. (2001). "Perspective: User toolkits for innovation." Journal of Product Innovation Management **18**(4): 247-257.

von Hippel, E. and R. Katz (2002). "Shifting innovation to users via toolkits." Management Science **48**(7): 821-833.

von Hippel, E., S. Thomke, and M. Sonnack (2000). "Creating breakthroughs at 3M." Health Forum Journal **43**(4): 20-27.

von Stamm, B. (2005). Innovation - Past and future. Presentation at the European Academy of Management Conference (EURAM), Munich, Germany, May 7-9, European Management Review.

Voss, C., N. Tsikriktsis, and M. Frohlich (2002). "Case research in operations management." International Journal of Operations & Production Management **22**(2): 195-219.

Vredenburg, K., S. Isensee, and C. Righi (2002). User-centered design: An integrated approach. Upper Saddle River, NJ: Prentice Hall PTR.

Wecht, C. H. (2006). Das Management aktiver Kundenintegration in der Frühphase des Innovationsprozesses. Wiesbaden: DUV Gabler Edition Wissenschaft.

Wharton (2005). "How companies turn customers' big ideas into innovations." strategy+business - Knowledge@Wharton, Wharton School, University of Pennsylvania(January): 4, Whitepaper.

Wheelwright, S. C. and K. B. Clark (1992). Revolutionizing product development—Quantum leaps in speed, efficiency and quality. New York: The Free Press.

Wilkinson, I. F. (2003). Entrepreneurship, innovation and the internet: New ways of priming the innovation process. Arsrapport 2002/2003, Tema: Nye Organisationsformer. V. Sogaard, S. G. Svendsen and M. J. V., Syddnask Universitet, Denmark, 61-66.

Williamson, O. (1981). "The economics of organization: The transaction cost approach." The American journal of sociology **87**(3): 548-577.

Wilson, J. Q. (1966). Innovations in organizations: Notes toward a theory. Approaches to organizational design. J. D. Thompson: Pittsburgh, University of Pittsburgh Press.

Wolpert, J. D. (2002). "Breaking out of the innovation box." Harvard Business Review **80**(8): 77-84.

Woodruff, R. B. and S. F. Gardial (1996). Know your customer: New approaches to understanding customer value and satisfaction. Cambridge, MA: Blackwell Business.

Wuersten, F. (2003). "Ein kleiner Diamant." Focus - Magazin der Absolventinnen und Absolventen der ETH Zürich(17): 20-21.

Wynstra, F. and E. Pierick (2000). "Managing supplier involvement in new product development: A portfolio approach." European Journal of Purchasing & Supply Management **6**(1): 49-57.

Yin, R. K. (1994). Case study research: Design and methods. Thousand Oaks, CA: Sage Publications.

Zalan, T. and G. Lewis (2004). Writing about methods in qualitative research: Towards a more transparent approach. Handbook of qualitative research—Methods for international business. R. Marschan-Piekkari and C. Welch: Cheltenham Glos, UK, Edward Elgar, 507-526.

Zirger, B. J. and M. A. Maidique (1990). "A model of new product development: An empirical test." Management Science **36**(7): 867-883.