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Kurt Gaubinger · Michael Rabl
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Innovation and Product Management

A Holistic and Practical Approach to Uncertainty Reduction

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Preface

The increasing complexity and dynamics of today's marketplace create an environment in which it is difficult for companies to produce innovations and market them successfully. Moreover, this environment dramatically increases the uncertainty of innovation activities. Against this backdrop, a company's systematic innovation and product management is increasingly important for success in these countervailing realities.

This is the point of departure for the book. Based on the fundamentals of innovation and product management, a holistic process model is offered in a compact manner with particular focus on innovation and uncertainty. This integrated consideration of innovation management *and* product management within an interdisciplinary approach represents a unique characteristic of this book. This position is important for practice-oriented research and education in the field of innovation and product management. It also provides an opportunity for practitioners to re-evaluate day-to-day issues within the context of conceptual considerations. Hence this book is addressed to thinking managers who want a practical but well-researched guide to innovation and product management. Furthermore, the book is approachable by graduate students from innovation management, engineering management, marketing, and product management disciplines to deepen their knowledge in their field. Additionally, many of the chapters are appropriate for advanced undergraduate students. Educational support materials are available including slides, recommended cases, and popular press articles that illuminate the ideas discussed in the book. In order to meet these requirements, the book was designed with a process-oriented structure (see Fig. 1). The book is divided into three major parts:

Part I covers the *Fundamentals of Innovation and Product Management. It* explains the connection between market-driven innovations and business success. Subsequently, the authors derive an integrated process model of innovation and product management on which the structure of the book is based. The "fuzzy" front end of innovation is explored and finally innovation strategy is discussed in the context of the planning of innovation and new product management.

Part II takes a closer look at the *Process of Innovation and Product Management*. Concepts related to idea management and open innovation are detailed along with

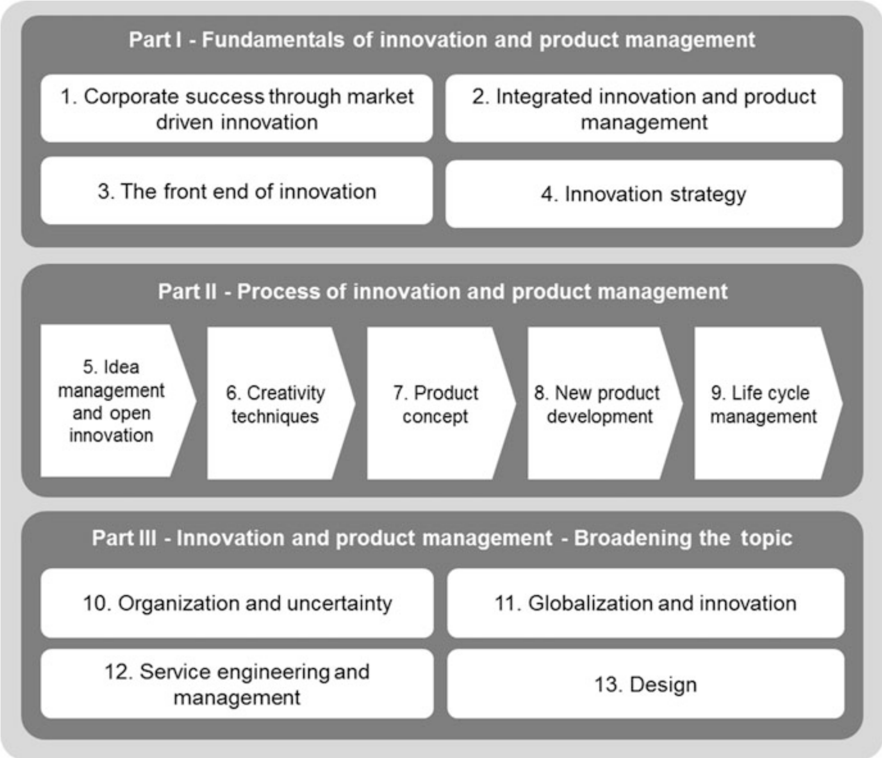

Fig. 1 Process-oriented structure of the book

creativity techniques. In the early chapters of this section, both the collection and generation of ideas are discussed alongside open innovation tools such as empathic design, idea contests, innovation communities, and the integration of lead users. Creativity techniques focus on the problem-solving process and offer a number of specific approaches. Next, ideas related to the product concept are described. The process of product design from a conceptual perspective and the fundamentals of product positioning and preference measurement are explained. Moreover the authors explain how methods like Quality Function Deployment and Target Costing contribute to an increase in customer orientation towards development activities. The next chapter describes the steps required for successful development projects along with the guidelines and the effects of Simultaneous Engineering, prototyping, model building, and model analysis. In the final chapter of this section, the fundamental tasks of marketing management throughout a product's life cycle are introduced.

Part III broadens the topics of *Innovation and Product Management*. In more depth, the authors tackle the organizational challenges of uncertainty. It explains the organizational forms of product management and deals with the organizational integration of innovation management in enterprises. Next, the authors describe the characteristics and peculiarities of innovation and product management in globalizing firms. Specifics of the service development process are developed in the context of engineering, management, and marketing. The book ends with an explanation of the ideas of industrial design, design orientation, and design thinking. It offers tools, current practitioner views, and an integration with the holistic framework of innovation and product development.

We owe a debt of gratitude to the many who supported us in writing this book. Our appreciation goes to Marion Huber for thoroughly formatting this book and to Lisa Schweitzer for refining the manifold figures. We would like to express our thanks to Beate Damm and Doris Coker who were responsible for the translation of a number of chapters of the book. We also acknowledge the support and enthusiasm of the team at our publisher, in particular, Barbara Bethke, Frank Tumele, and Prashanth Mahagaonkar. In addition, we are grateful to all of the specialists and practitioners in leading European and American companies who supported us in writing the variety of practical insights. These insights from different industry sectors offer valuable awareness into specific aspects of innovation and product management. Finally a very special word of thanks goes to Johann Füller who helped to establish the unique and valuable "Austrian-American relationship" of the authors.

According to the open innovation approach, we welcome feedback and contributions to improve further publications. We look forward to your response via the e-mail address: innovation_book@fh-wels.at.

Wels, Austria — Kurt Gaubinger
Wels, Austria — Michael Rabl
Williamsburg, VA — Scott Swan
Linz, Austria — Thomas Werani
Spring 2014

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Kurt Gaubinger is a Professor of Innovation Management & Industrial Marketing at University of Applied Sciences Upper Austria. He is Head of the Master's Degree Programme Mechatronics and Business Management and Vice Dean of the School of Engineering & Environmental Sciences. He received his Ph.D. in social and economic science from the Johannes Kepler University Linz, Austria. After teaching at the Universities of Applied Sciences Burgenland and Salzburg, Kurt Gaubinger became a full-time professor at the University of Applied Sciences Upper Austria in 2005 and was named Head of Department for Innovation, Design and Industrial Marketing in 2009. In 2013 he developed the Master's Degree Programme Mechatronics and Business Management. Prior to his career in academia he worked as a medical engineer for Siemens AG Austria and afterwards for an Austrian IT service provider as business unit manager. He presented his research at numerous conferences and has published several books and articles. His research interests include strategic innovation and product management, front end of innovation, commercialization of innovations, as well as IT-based innovation management.

Michael Rabl is Professor of Sensor Technology and Mechatronics at University of Applied Sciences Upper Austria. He is Head of the Bachelor's Degree Programme Innovation Engineering and Management and the international Master's Degree Programme Innovation and Product Management. He is acting as an independent expert for the European Commission for Research and Technological Development. As a senior researcher he was part of an international research group at the University of California Los Angeles working on the development of methods to cultivate algae as a feedstock for biofuels. In 2002 Michael Rabl became a full-time professor of Sensor Technology at the University of Applied Sciences in Wels, Upper Austria and was named Head of Study of Innovation and Product Management in 2003. In 2000, he received his Ph.D. in Electrical Engineering from the Friedrich Alexander University Erlangen, Germany. In 2013 he received his MBA in Innovation and Business Creation from Technische Universtät München, Germany. From 1999 to 2002 he worked for Siemens AG in Munich, first as an R&D engineer and later as a product manager. His current research interests are in the field of mechatronics, innovation management, and the development of international study programmes.

K. Scott Swan is a Professor of International Business, Design, and Marketing at The College of William & Mary (rated #1 undergraduate Marketing programme by BusinessWeek). He has lectured internationally at Tsinghua University in Beijing; Aoyama Gakuin University in Tokyo; WHU in Koblenz, Germany; Corvinus University, Hungary; the Vienna Business School; Management Center Innsbruck; and University of Applied Sciences Upper Austria. He has also conducted economic impact studies for the Virginia Port Authority and Norfolk Redevelopment and Housing Authority. His research interests include design, sourcing strategies, cooperative strategies, global product development, as well as the interaction between innovation and culture that have led to publications in journals such as *Strategic Management Journal*, *Journal of International Management*, *Journal of International Business Studies*, *Management International Review*, *Journal of Business Research*, and *The Journal of Product Innovation Management*. He is on the Editorial Review Board of *The Design Journal* and *The Journal of Product Innovation Management*. Professor Swan has worked in project management for Flour-Daniel, marketing management for Foremost Corporation of America, as well as founding several small businesses related to design.

Thomas Werani is Associate Professor at the Institute for Retailing, Sales and Marketing and Head of the Department for Business-to-Business-Marketing, Johannes Kepler University Linz. He studied business administration with a specialization in marketing, advertising, and marketing research at the University of Augsburg and the Vienna University of Economics and Business Administration (WU Wien). Dr. Werani started his academic career in 1993 at the Marketing Department of the University of Klagenfurt. In 1995 he joined Johannes Kepler University Linz, where he finished his doctoral thesis on the value of cooperative business relationships in 1998. After completing his habilitation Dr. Werani was appointed Associate Professor in 2004. He has received several prestigious research awards, including the 1996 Business Marketing Doctoral Support Award of the Institute for the Study of Business Markets (ISBM) at the Pennsylvania State University, and the Fourth Nestlé-Prize for Economics. Dr. Werani has presented his research at numerous international conferences and has published in several journals and books. He is on the Editorial Review Board of the *Journal of Business Market Management* and the *International Journal of Marketing*. His main research interests are in the field of business-to-business-marketing with special emphasis on pricing/value, innovation, branding, and relationship issues. In addition, Dr. Werani is a marketing consultant for a number of national and international companies.

Part I

Fundamentals of Innovation and Product Management

Corporate Success Through Market Driven Innovation

1

1.1 Introduction

Innovations continuously increase in significance in companies aiming at securing success in the long term [1]. The relevance of innovations in businesses and the national economy was already pointed out by Schumpeter [2]. However, increasing competitive pressure and an environment characterized by dynamism and complexity renders the task of successfully creating and marketing innovations more and more difficult for companies [3, 4]. For a company to survive under these difficult conditions, it needs to significantly increase the effectiveness as well as the efficiency of its internal innovation activities. This goal can be reached by means of *systematic innovation management* comprising a set of strategic and operational tasks for planning, organizing and controlling innovation processes.

This Chapter Will Discuss

- How can we differentiate between types of innovation?
- Which tasks are the core tasks of innovation management?
- Which key dimensions of uncertainty are crucial for innovation management?
- Which factors of innovation management positively impact the company's success?

Practical Insight

BMW Group: Focusing on Innovation

The BMW Group is one of the leading automobile and motorcycle manufacturers worldwide with a workforce of more than 100,000 associates in over 100 countries. Since the company was founded, innovations have ranked among the BMW Group's success factors. BMW is pursuing the goal of developing new, pioneering ideas for customers as efficiently as possible.

(continued)

K. Gaubinger et al., *Innovation and Product Management*,
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The company's constant effort is to create enthusiasm with technologically innovative products that are at the same time also emotionally appealing.

To pool all the relevant forces, BMW built the "FIZ" Research and Innovation Centre in 1986, which intentionally promotes interpersonal communication with its honeycomb-like floor plan, short routes, and open spaces. The Centre is the technical "brain" of the company and promotes the cooperation of more than 8,500 specialists in all areas and disciplines. Engineers, designers, model builders, computer specialists, scientists, production specialists as well as purchasing managers and employees from suppliers work together here to convert new concepts and ideas into genuine automotive innovations. One question is of fundamental significance at the FIZ Centre: What does the customer want and how quickly is a vehicle developed? To answer this question, the BMW Group has established the so called Product Evolution Process, abbreviated as PEP. This process is distinguished by the fact that as many individual tasks as possible are handled simultaneously and compiled in a multi-level, exactly defined plan providing the final result. Cooperation is therefore based not on isolated responsibilities, but rather on joint project management. In this context interdisciplinary, interdivisional decision-making groups ensure optimum support and follow-up on innovations from the initial idea all the way to its actual implementation in vehicle concepts of the future.

BMW Group FIZ, Munich *Photo: Copyright © by BMW*

Source: BMW [5]

1.2 Innovation and Innovation Management

In research as well as at the operational level, innovation is a term that is frequently used, but often not clearly defined. In order to prevent misunderstandings and to clearly identify tasks, we need to frame the term.

1.2.1 Framing of the Term “Innovation”

An analysis of current definitions [6, 7] shows the criterion of *novelty* to be a core feature. We need to identify the perspective from which the novelty of an achievement, a performance or a business model is assessed. There is a lot of support for labeling products and processes as innovative that are being introduced in a company for the first time.

A characteristic feature for differentiating an innovation from an invention is the aspect of its commercial exploitation and its utilization at the operational level. An innovation introduces an invention (a new product or process) to the market (innovation in a narrow sense) and making it competitive in the market (innovation in a broader sense) [8]. Furthermore, innovations differ from inventions in that they do not refer to a point in time, but are *process-relational*. A variety of concepts and models for structuring innovation processes can be found at the operational level and in literature [4, 9]. Such models help in visualizing and managing the process in its entirety. They aim at depicting tasks that are typical for a specific process-stage, allowing for a goal-directed use of methods. An example for a model of this kind is the process model developed by the authors of this book, integrating dimensions of innovation management as well as product management (Cf. Chap. 2/Fig. 2.4). However, we must be aware that innovation is doing something new in a complex and dynamic world and so the process involves dealing with *uncertainty*. Innovation management tries to convert this uncertainty to a calculated risk by means of target-oriented and early information provision. Tidd and Bessant [10] characterize innovation as process of reducing uncertainty but increasing resource commitment at the same time.

1.2.2 Innovation Management

Goal-oriented steering and shaping of innovation activities within a company require structured and coordinated activities aimed at an innovation’s successful introduction on the market or for the company’s internal use. Those activities are subsumed under the term *innovation management*. They comprise a set of strategic and operational tasks for the planning, organization and control of innovation processes and the creation of the required operational framework. Following Vahs and Brem [11], the following tasks are among the core tasks of innovation management:

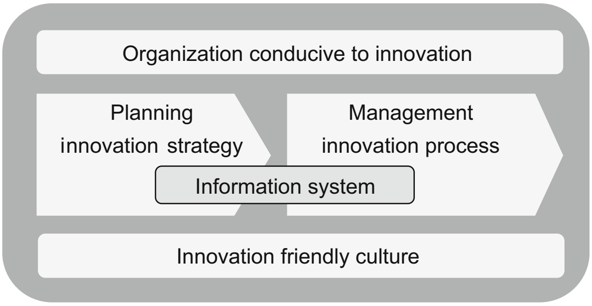


Fig. 1.1 Core tasks and elements of innovation management

- Defining innovation goals and strategies
- Planning, steering and controlling innovation processes
- Building and maintaining an information system serving as the basis for goal-oriented innovation control
- Building an organization structure conducive to innovation
- Building and maintaining an innovation-friendly company culture.

In addition to these tasks, (overview of task spectrum provided in Fig. 1.1), the overriding goal of innovation management consists in securing and expanding the *competitiveness* of the company in order to grant its economic success and continuance [12].

1.2.3 Classifying Types of Innovation

Based on their degree of novelty, innovations *by leaps and bounds* (radical innovations) from *step-by-step* (incremental) innovations can be distinguished [13]. The degree of innovation constitutes a multi-dimensional criterion. In general, it can be said that the degree of innovation correlates with the increasing proliferation of the following four dimensions [14]:

- The *technology dimension* diagnoses the technical uncertainty of innovation projects. A high degree of innovation is indicated if the technological know-how was not completely known or was not needed up to this point.
- If an innovation aims at customer needs that are new or have not been satisfied up to this point, it can be evaluated as radical in terms of its *market dimension*.
- Innovations can also necessitate change in the *organizational dimension*. The greater the extent of this change, the more radical the innovation.
- If innovations exert an influence on the *innovation environment* and if the changes brought about can be characterized as significant, e.g., the introduction of new modes of distribution, the radical quality of the innovation increases according to this dimension.

Innovations with a high degree of novelty have a strong profile in each of the four dimensions and generally entail a higher level of uncertainty. In contrast, product variants or incremental product improvements are bound to show a low

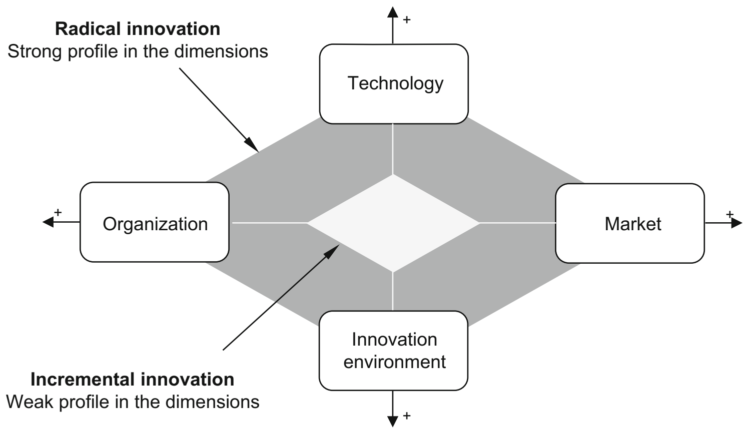


Fig. 1.2 Dimensions of the degree of novelty

to medium profile in the individual dimension. These interrelations are depicted schematically in Fig. 1.2.

Based on an innovation's degree of novelty, the following types of innovations can be distinguished [15]:

- *Fundamental innovations* constitute the highest level of innovation. Implementation of new technologies gives rise to new principles of operation, thus to completely new product generations or procedures. The steam engine, the jet engine or the microprocessor are often listed as examples of fundamental innovations entailing a plethora of successive innovations [16].
- *Disruptive innovations*, unlike so-called preserving innovations, are products or services that interrupt existing paths of performance improvement and usually cover completely new dimensions of performance. Those innovations are therefore of a radical nature. Though usually inferior in performance to existing innovations at the time they are launched, disruptive innovations usually appeal to a customer segment which only has some basic demands on the product, but is very price-conscious. As time goes on, disruptive innovations are being improved upon, thereby earning the respect of established customers and becoming a threat for established suppliers who have closed themselves off from this development [17].
- *Quality-improving innovations* feature a lower degree of innovation than fundamental innovations do. With basic functions remaining constant, this category of innovation only changes specific utility parameters, in the sense of an evolutionary improvement [16].
- *Adaptive innovations* adapt existing solutions to specific customer requests, thus they are usually characterized by an incremental degree of innovation [15].
- *Imitations* constitute reiterations of solutions already existing in other companies. Though imitations are "tarnished by the odor of lacking

Dimension	Criteria	Score	Weight	Weighted value
Technology	New material			
	New components			
	New technologies			
	New technique of production			
	…			
Market	New customer needs			
	New customer groups			
	New marketing mix			
	New distribution channels			
	…			
Innovation environment	New sources of supply			
	New forms of financing			
	New business models			
	New competitors			
	…			
Organization	New strategy			
	New organization			
	New responsibilities			
	New production facility			
	…			
			Innovation level:	

Fig. 1.3 Utility analysis for classifying innovation projects (Adapted from Hauschildt [18])

imagination", a comprehensive framework of innovation management should always consider the potential of imitations [18].

- *Fake innovations* are characterized by a degree of innovation that is low or zero. They refer to changes in products or processes which do not really provide new utility for customers [19].

On the operational level, the degree of novelty of innovations may be assessed by means of *check lists*, or more extensively within the framework of a *utility analysis*. If the project that is being assessed surpasses a previously determined value, the project is considered as "innovative". It should be dealt with in a specific routine set apart from regular operations. This routine is to be developed by taking into account the higher level of uncertainty and especially risks associated with innovations. Cooper [20] points out that the elaboration and complexity of this type of decision process should positively correlate with the degree of risk of an innovation project. Figure 1.3 shows an exemplary *utility analysis* which can be used to assess an innovation project's degree of novelty. This tool should be supplemented by data specific to the company.

1.3 Innovation and Uncertainty

By its nature innovation is about the unknown, about opportunities and possibilities associated with doing something new, which may or may not pay back in the future. As already mentioned above, managing innovation processes means dealing with uncertainty; or in other words "uncertainty will always plague the process of innovation" [21]. In this context many scholars build on the Galbraith's [22] definition of uncertainty: uncertainty means "the difference between the amount of information required to perform the task and the amount of information already possessed by the organization".

1.3.1 Dimensions of Uncertainty

Over 40 years of research has led to an extensive literature on types, sources and dimensions of uncertainty. These terms are often used interchangeably. Organization theorists have paid particular attention to one factor, which is referred to as environmental uncertainty and which plays a central role in the discussion about the interface between organization and environment, particularly in theories of organizational design [23–25]. Milliken [26] suggests three distinct types of external uncertainties, which are state, effect and response uncertainty. He distinguished the actual environment from its unpredictable characteristics, which may affect and change the organization and its actions that are not always under its control. Other scholars see innovation as a process of closing information gaps between user needs and technological opportunities [27–29]. Another school of thought highlights the contingent uncertainties between market, competition and technology [24]. Using a systematic approach to reviewing more than 100 scientific articles, Jalonen [30] identified 18 distinct factors, which create uncertainty in processes of innovation. Figure 1.4 shows these factors clustered into the three key factors of uncertainty which are technology, market and organizational resources.

These results are in line with other studies. Souder and Moenaert [31] state that the four main sources of uncertainty are *customer needs*, *competitive environments, technological environments* and *organizational resources*, whereas the first two sources are often stated as the cause for market uncertainty. The source *organization resource is* an internal dimension in which the gap of information (knowledge) can be reduced by adapting the organization of a company.

Technology Uncertainty An innovator faces technology uncertainty twofold, namely in terms of product specification as well as in terms of production processes [32]. It is the additional information about components and techniques a firm needs to create a new product or service according to a specification, which has to be also determined [33]. The uncertainty associated to product specification depends on the novelty of the technology, which itself causes uncertainty in respect to skills and knowledge required to successfully use a new technology [34]. In summary, this means that the technology uncertainty in innovation processes results from a lack of knowledge about the details of new technology or due to a deficit of knowledge required to use new technology or both [35].

Market Uncertainty Market uncertainties exist when a company is unsure about the nature of a particular market and its ability to create a product which will succeed in that market. They include issues related to customer needs and wants, which can be already existing or latent forms of interaction between the customer

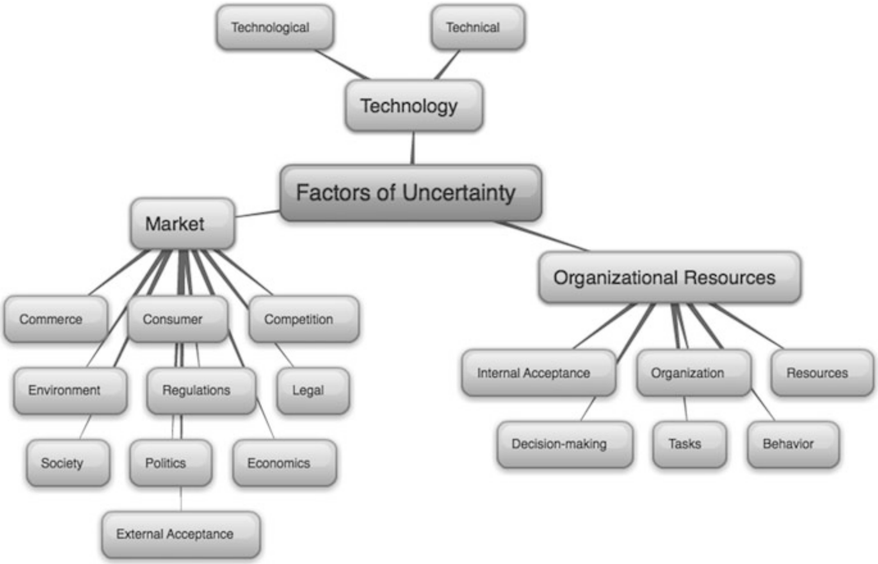


Fig. 1.4 Various factors of uncertainty in innovation (Based on Jalonen [30])

and planned products as well as methods of sales and distribution [36]. The uncertainty concerning unclear customer needs, the unknown behavior of customers, pricing and the demand for the innovation were recognized as the main sources of uncertainty caused by customers [37, 38].

But market uncertainty also manifests itself as a lack of knowledge about the activities of competitors. This kind of uncertainty faces a company typically in global and liberalized markets [39]. In summary, the market uncertainties in innovation processes exist, on the one hand, because of unexpected changes in the relations between company and customer and, on the other hand, due to unpredictable changes in relations between competitors, which might open new markets [40]. Many scholars include the dimension innovation environment (Cf. Sect. 1.2.3) in the dimension market [41, 42]. In this book this school of thought will be followed.

Organizational Uncertainty Organizational uncertainty contains factors of uncertainty such as resource uncertainty, decision-making uncertainty and acceptance uncertainty, where the last two factors can be subsumed as task uncertainty. Task uncertainty is caused by the non-routine nature of R&D-tasks and the high levels of technical and organizational interdependence required to execute them. A company has to reduce sources of uncertainty as a prerequisite to successfully innovate. But to do so, resources must be allocated, which introduces the *resource* uncertainty. The more uncertain the organization is about the market or the

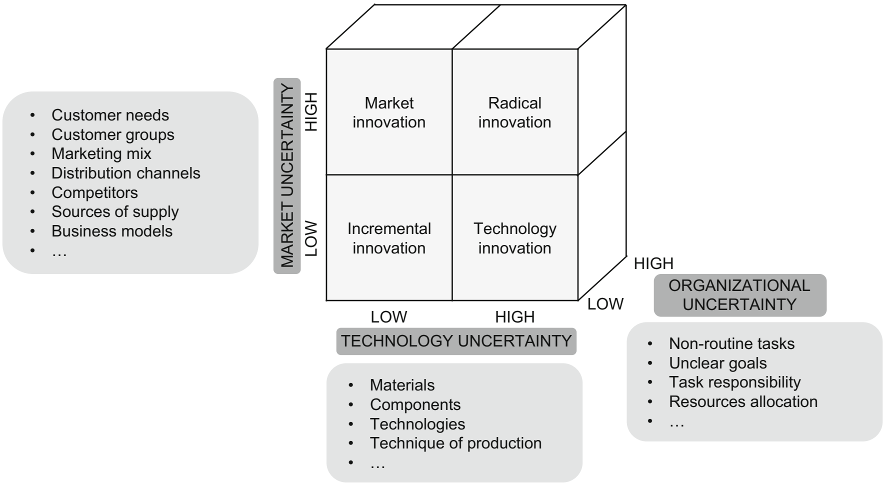


Fig. 1.5 Extended uncertainty matrix (Based on Lynn and Akgun [41])

technology, the more probable it is that the organization will be uncertain about the type and the amount of resources it needs [43].

Based on the model introduced by Lynn and Akgun [41] the authors developed an extended model including the third dimension organizational uncertainty which is shown in Fig. 1.5.

The matrix presents *four types of innovation* projects that differ in the level of technology uncertainty and market uncertainty. As already mentioned, technology uncertainty is characterized by factors like new materials, new components, new technologies, new technique of production, etc. In contrast, marketing uncertainty is related to factors like new customer needs, new customer groups, new marketing mix, new distribution channels, new competitors, new source of supply, new business models or similar factors.

Incremental innovations build on existing knowledge and thus are characterized by low technology and low market uncertainty. Examples of incremental innovations are product changes or improvements, extensions of product lines or "me too" products that are similar to the competition. *Market innovations* develop new markets with existing technologies and need a market-based strategy. The company has to obtain knowledge about the new market, its needs and requirements and the competitors. *Technology innovations* serve known markets with new technological solutions. The products are targeted to a well-defined market segment, but the intended technology is highly uncertain and new to the customer. The largest amount of uncertainty is associated with *radical innovation*. Both, the market and the technological requirements as well as the technical feasibility are not known at the beginning of the innovation project, since the market is not well understood and the product is evolving depending on the market.

The third dimension of the extended uncertainty matrix illustrates that the overall level of uncertainty for all types of innovation depends also on the structure of the organization and its resources.

Although uncertainty is inherent in every innovation process one can understand that depending on the amount of information already possessed different degrees of uncertainty can be distinguished. This will be explained in more detail in the following chapter.

1.3.2 Levels of Uncertainty

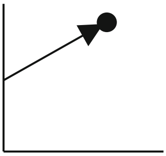
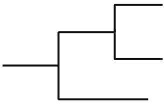
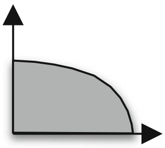
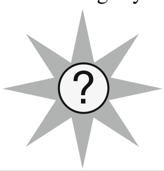
As already explained initially, innovation management tries to convert uncertainty to a calculated risk. Knowledge is of central importance to this process, since it is the key factor for this conversion [44]. Even in the most uncertain environments, it hardly ever occurs that an organization has absolutely no strategic important knowledge [45]. To differentiate between different levels of uncertainty it makes sense to think about uncertainty as “known unknowns” and “unknown unknowns”, [46] which leads to different degrees or levels of uncertainty.

Courtney, Kirkland, and Viguerie [45] define four different levels of uncertainty and conceptualized a framework for determining the level of uncertainty surrounding decisions in an organization. They state that it is often possible to identify clear trends and a host of factors, which are currently unknown but in fact could be known if the right analyses were done. The remaining uncertainty is then called residual uncertainty, which falls into one of four levels [45]. In Table 1.1 they will be explained in more detail.

After understanding the influence of uncertainty on innovation activities, it can be hypothesized that the development and adoption of systemic innovation in an organization may be hindered due to uncertainty. As already explained a central task of innovation management is to gather task oriented information during all steps of the innovation process to reduce uncertainty and therefore increase the probability of success.

In addition to the presented producer-related uncertainty dimensions, literature also covers *customer-related uncertainty*. In many markets there is an uncertainty related to intended purchase on customer side, which depends on two main factors. Firstly, uncertainty is driven by the amount at stake. Therefore, the higher the customer’s product specific investment the more uncertainty will play a role. The second factor refers to certain qualities of products. According to Darby and Karni [51] three qualities can be distinguished: search, experience, and credence qualities. Search qualities are known before the purchase, and products with such qualities do not lead to any customer related uncertainty. Experience qualities are known only after purchase, while credence qualities are unknown even after purchase. It is obvious that products with the latter two qualities involve a considerable amount of uncertainty at the time of purchase. Against this background the central task of a

Table 1.1 The four levels of uncertainty (Based on Courtney [47])

Level	Characteristics	Description
1	A clear-enough future 	One faces a Level 1 uncertainty; if the range of possible outcomes is narrow enough for this uncertainty to not be of importance for the decision at hand [48]. Of course this does not mean that the future is entirely predictable, but rather that a single forecast of the future can be developed for managing the innovation processes
2	Alternate futures 	Innovation managers face Level 2 uncertainty when the future can be described as one of a limited number of alternatives. In this case it is possible to define a limited set of possible future outcomes, one of which will occur [47]
3	A range of futures 	Level 3 uncertainty is similar to Level 2 uncertainty, in some respects. One can identify the range of potential futures, but the possible outcome may lie anywhere within the boundaries. No apparent point forecast appears although the range is defined by only a limited number of key factors [49]
4	True ambiguity 	For Level 4 uncertainties future outcomes are both unknown and unknowable. Not even the range of possible future outcomes can be identified [50]. Multiple dimensions of uncertainty interrelate and create an environment that is more or less impossible to foresee. Therefore, there is no basis to forecast the future

company is to reduce uncertainty and induce the customer to decide for the product. This uncertainty reduction has to consider two types of uncertainty [52]:

- *Behavior-related uncertainty*: this uncertainty is based on the fact that the customer rests his basic decision to purchase for a certain product or system unilaterally on the supplier's behavior. For the customer it is therefore crucial to well assess the supplier's behavior already during the initial acquisition. In particular, the customer has to be sure that the supplier does not exploit the product- or system-based relationship opportunistically by for example continuously increasing the prices for upgrading or neglecting the further development of the product.
- *Use-related uncertainty*: The second type of uncertainty can result from uncertainty regarding the evaluation of the offer's achievement potential, as parts of the service are sometimes purchased at a later stage. Use-related uncertainty can also result from the fact that customers are not able to evaluate type, frequency and time of future investments already before the purchase decision.

To avoid this uncertainty, appropriate actions like signaling, should be initiated by the supplier. Signaling activities serve as credible information about the capabilities of the company in terms of a problem solution for the customer and his empathy [53]. This is done mainly through communication measures about potentials of the company or other satisfied (reference) customers. Especially in high-tech markets potential customers faces technology uncertainty associated with every buying decision. The technology uncertainty perceived by these customers can be shaped by the actions of technology supplier in informing the potential adopters about likely future developments. Such signaling activities are aimed at announcements concerning investments in new products and services and plans to enhance the features of a technology [54]. In this context one of a widely used signaling tools is new product preannouncement, a useful communication measure that companies use to send messages to target groups before launching a new technology, product or service [55]. Thus the amount and clarity of signaling measures is an important mechanism to reduce especially the technology uncertainty perceived by the potential adopters and can have an impact on technology diffusion as a consequence. It also should be stated that signaling activities are becoming less and less necessary with increasing duration of the relationship, because the mutual information base is increasing.

1.4 Significance of Innovations for Business Management

The fundamental importance of innovations for a company's success is nothing new, since the ability to generate and implement innovations have always been key to the success of a company [56]. What is new is an increasingly dynamic and complex economic environment, forcing companies that want to stay competitive into developing new products within increasingly shorter intervals of time. *Globalization* is a significant factor in this context. On one hand, it opens up new procurement markets and consumer markets; on the other hand, it puts local markets under increasing pressure from foreign providers. Globalization is not only characterized by an increased mobility of goods and labor, but also by a high mobility of information and knowledge. This results in dramatic knowledge-based rates of increase accompanied by *technological progress*, which in turn entail many solutions inconceivable only 10 years ago [57]. At the same time, the interval in which *knowledge* can be applied is also getting shorter.

In addition to technological progress, the fact that *customer needs* are getting more and more met by specific solutions leads to a drastic reduction in *product life cycles* [58]. Studies show that product life cycles in the past 50 years have decreased on average by 75 % [57]. In light of the developments we have discussed, it is obvious that only companies who beat the competition at introducing innovative market offerings on the market, respectively at implementing innovative processes at the operational level, will attain long-term *economic success*.

A range of *empirical studies* attests the elemental connection between innovation activity at the operational level and the company's success. For instance, the results of the PIMS study confirm a positive correlation between product and process innovations at the operational level and the company's success [59]. A study by Salomo et al. [60] also clearly shows the connection between the company's degree of innovation and its success.

This success context generally results from the fact that with increasing product maturity, more and more competitors offer similar products, which makes price the decisive criterion and delivers diminishing returns. In contrast, the first provider of an innovative product on the market has the possibility of obtaining a temporary premium price by benefitting from the *pioneer or short-term monopolist profit* [61].

1.5 Success Factors of Innovation Management

As shown in the discussion up to this point, there is a significant correlation between innovative activities of a company and its efficiency and effectiveness. The central question to be raised is which factors positively affect innovation success and if there is such a thing as "the *recipe for success*" in innovation management. Even though "recipes" of successfully innovative companies cannot simply be transferred to another company or across countries, it is still possible to deduct the basic patterns of innovation success, consisting in individual factors of success or their combination. Hauschildt [62] identifies more than 60 empirical studies dealing with this subject matter. Surveys of relevant studies are also provided by Montoya-Weiss and Calantone [63] and Papies [64]. A leading role in innovation research can be accorded to Cooper and Kleinschmidt. A bibliometrical study conducted by Durisin, Calbretta, and Parmeggiani [65] attests to their importance. Within the framework of their "*NewProd*" research, Cooper and Kleinschmidt analyzed more than 2,000 new product projects over the past 30 years [66]. Based on their findings, Cooper and Kleinschmidt [67] identified a range of crucial factors which account for the difference between success and failure. Those factors are structured in Table 1.2 according to the areas of responsibility in innovation management and will be explained below.

1.5.1 Innovation Strategy

A clear and *transparent innovation strategy* forms the basis for effective innovation management. In accordance with the overall goals and strategies of the business entity, its innovation strategy ensures a goal-directed *allocation of resources* in the field of new product and innovation management. The *fields of innovation* the company intends to focus on (products, markets, technologies, etc.) need to be defined. In this context, articulating clearly *quantifiable goals*, such as the desired contribution of new products to the company's success, is of the essence. Those strategic innovation goals, which have to be *communicated clearly* within the company, will subsequently define the envisioned innovation portfolio. It is important for the *innovation portfolio* to contain projects that can be realized within a short time frame as well balanced with long-term and strategically significant projects.

Table 1.2 Success factors in innovation managements (Based on Cooper and Kleinschmidt [68, 69])

Innovation strategy	– Clear and transparent innovation strategy – Communication of innovation strategy within the company – Balanced portfolio of innovation projects – Unique and differentiated market offerings with high utility for customers – Use of synergies in all relevant areas and disciplines
Innovation process	– Implementation of a an innovation process clearly structured into different sections – Comprehensive market orientation throughout the entire development phase – Systematic procedure in the "front-end-of-innovation" – Comprehensive assessment of market and technology at the beginning of the innovation—processes – Clear and early project and product definition (product brief) – Early development of marketing concept and a well-conducted introduction on the market – Systematic assessment of innovation activities during the innovation process – Adaptability of innovation process
Resources and organization	– Interdisciplinary project teams – Effective and efficient project management – Goal-oriented budget planning – Support and commitment of top management
Innovation culture	– Space for employees to use time at their discretion – Integration of all employees into the innovation process (Idea management) – Open innovation culture – Financial resources for innovation projects ("seed capital") – "Autonomous" innovation teams for future-oriented projects ("skunk works")

Since successful innovations are characterized by a unique benefit for the customer and unique, *diversified products and services* are usually more successful than "me-too" approaches, benefit-oriented development of services and processes is of central importance. Within the framework of their innovation activities, companies often have to replace their inward-oriented way of thinking, which is focused on product or technical features, by an externally oriented perspective. From the deduction of the innovation strategy onwards and throughout the entire innovation process, the perspective has to be directed towards future customers' *needs* and the benefit expectations. This claim is derived from the fact that outstanding technical capacities do not always contribute to the customers' benefit, specifically when those capacities are "over-engineered" and consequently fail to contribute directly to meeting -customers' needs [70].

If we consider the ever more intensive and dynamic competitive environment, we need to identify explicit as well as latent customer needs in order to market offerings with a higher relative utility. However, depending on cost structure and customers' increasingly differentiated value system, it is likely that for companies in highly developed industrialized countries can only succeed if they generate this utility advantage not via the cost component, but via the value component within a strategy of differentiation. Both the consumer goods sector and the investment goods sector are characterized by an increasing degree of equivalence in technical performance profiles of competing products, resulting in a leveling of product utility. Hence the factor *design* becomes a more and more effective possibility of setting oneself apart from the competition [71–73]. Since there is no general consensus on the term *design* in research or in business, we will define it here in the sense it will be used in the following discussion:

> *Product design*: the set of properties of an artifact, consisting of the discrete properties of the form (i.e., the aesthetics of the tangible good and/or service) and the function (i.e., its capabilities) together with the holistic properties of the integrated form and function.
> *Product design process*: the set of strategic and tactical activities, from idea generation to commercialization, used to create a product design.

This definition was created by Luchs and Swan [74] based on an analysis of 168 technical articles, taking into account both the object aspect and the process aspect of design. By means of a focused esthetic, ergonomic and functional shaping of products, design can constitute an important starting point for differentiating service offers. It is within this context that the term "*User-Oriented-Design (UOD)*" established itself in recent years. The term emphasizes the fact that product development has to proceed from a thorough understanding of potential customers' needs in order to generate value for customers and thus success for the company [75]. In addition, design essentially contributes to the establishment of a brand, which holds a high potential for differentiation within itself.

In order for design to become an essential success factor in the company, all design-specific activities within the context of a company's strategy have to be planned, realized and controlled in a process-oriented way [76]. Finally, it remains to be said that companies—regardless of their specific focus of innovation—should take care to utilize existing knowledge, resources and skills in the fields R&D, production, design and marketing *in a synergetic way* [77].

1.5.2 Innovation Process

Companies whose development activities take place according to an *innovation process* broken down into easily identifiable sections are significantly more successful than those who do not proceed in this way. It is of crucial importance that the steps preceding actual development, such as finding ideas, evaluation and pre-development, are conducted systematically. A study by Salomo [78] also confirms the essential significance of conducting the early stages of the innovation process, the so-called "*Fuzzy Front End of Innovation*", in a systematic way.

In addition to a decisive orientation towards actual and potential customers' needs, a fundamental understanding of the competitive situation and the market condition constitutes another factor influencing the success of an innovation. In this context, it is important that *market orientation* determines the entire innovation project from the selection of ideas until the launching of the product [79].

Cooperative measures between providers and consumers, i.e., an early involvement of customers in the product development process, are especially important in investment good industries. Von Hippel [80] suggests focusing on pace-maker customers. His "*lead user concept*" shows that proceeding in this way not only entails an increase in quality, but also cuts down on development time. Another success factor connected with that aspect is an early *international orientation* of product development. In addition to the development of an international product, conceptualized in view of unchanged global demand, international orientation can also yield a local strategy concept [81]. Moreover, market attractiveness exerts an influence on innovation success and definitely has to be taken into account during project selection as well as during the project specification phase. In addition to a project-specific evaluation of the sales market and the competition, a detailed assessment of the technological environment (production, patent system, etc.) also plays a decisive role [82].

In order to build on these activities, a clear definition of the *product* and the resulting *project frame* prior to the start of development activities is of central importance. Since even the best product doesn't sell itself, the *marketing concept* and the market introduction also have to be planned early and systematically [83]. During the entire innovation process, activities have to be evaluated at clearly defined points ("*gates*") by a committee using transparent criteria and methods, deciding which activities are to be continued and which ones are to be terminated. Clearly defined activities during the individual segments of the innovation process ("*stages*") and at the gates contribute to an increased *implementation quality* of the tasks. Cooper and Kleinschmidt [84] also point out that top companies conduct their innovation processes *flexible* and *scalable*. This approach involves the definition of "lean" processes for innovation projects with a low degree of innovation respectively risk, characterized by fewer segments and control points.

Practical Insight

Pöttinger: Innovation Process as a Success Factor

The Competition *Best Innovator* by the international consulting agency A.T. Kearney gives an award to companies that implement innovation management effectively and in a sustainable way. About 1,000 companies participate in this annual event. In addition to aspects of communication policy, the

(continued)

main perk of taking part in this competition is a confidential evaluation with useful suggestions for individual improvement, received by each participant. The four categories of the competition mirror the central *factors of success* in innovation management. The category "*innovation strategy*" evaluates if and how the innovation strategy and its implementation is being developed and supported by top management. The second category, "*innovation organization and innovation culture*", evaluates to what extent innovation culture is anchored in the organization of the company. The third category evaluates whether the company utilizes "*supporting factors*" in its implementation of innovations. The category "*innovation processes*" evaluates if and how stringent innovation processes contribute to the company's success. In 2010, the Austrian producer of agricultural machinery Pöttinger was for the second time around the winner in this category. The innovation process of the company is structured clearly and comprises all activities carried out by the corporative actors, from strategic foresight to serial development. CEO Klaus Pöttinger considers the award to be an acknowledgement of the fact that Pöttinger's innovation management equips the company well for its ambitious goal of assuming a leadership position in technology.

Photo: Copyright © by Pöttinger

Sources: Pöttinger [97], ATKearney [98]

1.5.3 Resources and Innovation

The studies by Cooper and Kleinschmidt [87] point out the importance of cross functional *cooperation* between research and development as well as marketing, and their impact on success. This requirement can best be met by a project- oriented form of organization. A project-manager leads a cross-functional project team and is responsible for fostering and rewarding creativity and innovation. This aspect is also acknowledged by Ahmed and Shepherd [88], who emphasize the fact that cross-functional teams are the standard organization form for innovation projects.

In a standard scenario, the team comprises employees from the following departments: marketing, product management, development, design, production and quality management. For successful cooperation, professional and efficient *project management* as well as ongoing *communication* between team members is of the essence [77]. Team members also have to have sufficient *temporal resources* for their tasks within the innovation project, thus they need to be released from their regular work for the duration of the project. For successful innovation activity, financial resources are naturally as crucial. According to Cooper and Kleinschmidt, *top management* has the role "to set the stage in a way that allows for innovation." Consequently, innovations have to be perceived as an investment rather than a cost factor and *innovation budgets* have to be drawn up in a goal-oriented way [89].

1.5.4 Innovation Culture

An entrepreneurial climate characterized by short relationships for decision-making, informal channels of communication and tolerance of errors is conducive to the success of an innovation [90]. In addition, giving employees some space to use time at their discretion for creative tasks and for working on innovation projects also fosters the creation of an innovative environment. A frequently quoted best-practice example in this context is the company 3M, where employees can use a set share of their work time-depending on their position in the company-for own ideas and projects without having to report on them [91].

An established internal *idea management system*, combined with a system of perks and rewards, fosters a company culture conducive to innovation. Another contribution to a positive culture of innovation is awareness of the fact that ideas cannot only be generated from sources within the company, but also—successfully—from outside sources. An *open innovation culture* of this kind can help in overcoming the widespread NIH "Not-invented here" syndrome. The syndrome holds (erroneously) that an innovation process can only be successful when all of its phases have been conducted in-house [92]. Cooper and Kleinschmidt [93] point out the importance of providing budgetary resources ("seed money") in support of employees' work on "their" innovation projects. Innovative companies also support the formation of so-called "skunk work" groups, characterized by a high degree of autonomy and freedom from bureaucratic constraints, whose task consists in working on future-oriented projects [93].

Though some authors have detected major content-related and methodological flaws in research on success factors conducted up to this point [94], the authors of this book are convinced of the listed factors' usefulness as *reference points* for companies aiming at a performance increase in their own innovation activities.

1.6 Innovation Related Special Features of SMEs

The concluding remarks in this chapter will address the special innovation-related features of small and medium-sized enterprises (SMEs), in acknowledgement of the high relevance of SMEs for prosperity and growth in almost all countries of the world. If we are looking at the European Union, the statistics show that more than

99 percent of all companies fall into the category SMEs as defined by the European Commission. SMEs in the EU create about two thirds of the jobs in the private sector and are responsible for more than half of the value creation of all companies in the EU [95]. Small and medium-sized enterprises are equally important in the USA, where more than 99 percent of companies employ less than 500 employees.

In general, SMEs have the reputation of boasting a *high innovation potential* [96] based in part on the fact that owner and management are often identical, a setting that speeds up the innovation process. In addition, direct contact to customers, flat organization structures and flexible production facilitate the conversion of ideas into marketable products and services [97].

However, in today's highly dynamic and complex competitive environment, SMEs find it increasingly difficult to utilize their basically high innovation potential. It can be safely assumed that for SMEs as well, it holds true that this potential can only be exploited on the basis of systematic planning. It is this *planning aspect*, though, which constitutes one of the central weaknesses (with regards to innovations) of SMEs. Pfohl and Kellerwessel [98], among others, point out that the low importance attributed to planning is one of the major differences between SME and large companies. This general deficit in planning is continued in the operational part of innovation management. Herstatt et al. [99], having integrated a range of pertinent sources into their analysis, conclude that with regards to the management of innovation activities, it is especially the medium-and long term planning systems in SMEs that are underdeveloped. In this context, an unsystematic way of *information search* and connected with it, a lack of early awareness of new technologies, constitute the greatest weaknesses of SMEs. In addition, based on the results of a study by Gaubinger et al. [100], we find that innovations in SMEs are only rarely planned by cross-functional *teams*. The study also shows that in SMEs, a systematic evaluation of product ideas and product concepts is often missing. Finally, very few SMEs implement a structured *innovation process*. The *documentation* of development activities is also rarely structured and comprehensive.

Based on those findings, it can be concluded that SMEs could better utilize their innovation potential by implementing an *innovation process* fine-tuned to their needs. Employees from different *departments* should be integrated into this process, in accordance with the different tasks to be accomplished. This way, the planning and implementation of innovation projects can simultaneously take market aspects, technical aspects and financial aspects into account resulting in a reduced uncertainty of the innovation activities.

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2 Integrated Innovation and Product Management: A Process Oriented Framework

2.1 Introduction

For a company to succeed, competitive products are essential. A company therefore needs to have the capacity for developing *customer-oriented products,* successfully launching them on the market and optimizing the *product life cycle*. In order to do this effectively and efficiently, all related activities have to be planned, implemented, and controlled in a goal-oriented way within the framework of a systematic *management process*.

This Chapter Will Discuss

- What is the task spectrum of product management?
- What are the main stages of a process model presenting the typical tasks of product management, with special emphasis on the strategically significant innovation task of product management?
- Which steps should be conducted to implement an innovation management process?

Practical Insight

Palfinger AG: Innovation Process of a Leading Truck Equipment Manufacturer

Palfinger is one of the leading truck equipment manufacturers offering a comprehensive product portfolio of cranes, hooklifts, cable hoists, forklifts, lift-gates, service bodies and platforms. The core products of the company are Knuckle Boom Cranes. In this segment, the company is the global market leader, with almost 150 models and a market share of 30 percent. Driven by the motto “Be more innovative than the competition: breaking new grounds in construction and manufacturing”, the company has expanded steadily over

(continued)

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the past 30 years. In the business year 2011, it generated a turnover of almost $1.148 billion.

Palfinger strives to achieve sustainably profitable growth and the best shareholder value possible. To facilitate the implementation of its paramount objectives, Palfinger has defined three strategic pillars: *innovation, internationalization* and *flexibility*. Palfinger's concept of innovation does not only comprise the development of new parts and products, but also the refinement of processes and organization. Continuous research, also in collaboration with university based as well as private research centers, is conducted with the development and utilization of new material and techniques in mind.

A standardized innovation process divided into the three main phases of generating ideas, product development and marketing & sales constitutes the basis for all of the company's innovation projects.

The phase of *generating ideas* is supported by internal and external sources as well as by mixed development teams. Cross-departmental workshops and periodic innovation rounds, including strategic evaluation of individual project ideas, contribute to the development of a strategic innovation portfolio. Those internal mechanisms are supplemented by external collaboration with selected institutions of higher learning. Further important sources of information are provided by retailer meetings, interviews with end customers, and feedback provided by customer service and service partners. An array of systematic market studies supplements the activities during this phase.

At the next level of the process, *product development,* a product brief for promising products is developed. The product brief comprises all the specifications on the requirements to be met by the new product. Once it has been cleared for development, an interdisciplinary business plan is developed, leading into the first trial series. Following the mounting of the cranes, they are subjected to an intensive quality check based on the ISO 9001 standards. In addition, quality control conducts product audits on a regular basis, thus closely modeling actual customer service. After having been cleared by quality control, the product is tested on the market. If the final report is positive and the product has market potential, the test phase can segue into serial production.

In the phase *marketing and sales*, the new products make their first appearance, usually at big international trade fairs. In the run-up to those trade fairs, press releases are being sent to international industry specific and target group specific media. At the same time, the new products are featured in the news section of the company website.

(continued)

Palfinger Knuckle Boom Cranes *Photos: Copyright © by Palfinger*

Source: Kolar/Gaubinger [1]

2.2 The Role of Product Management

Based on the respective activity's impact on a company's potential for success, the task spectrum of product management can be divided into strategic and operative management tasks [2]. The related activities contribute to create the information base that is necessary for strategic and operational decisions and thereby reducing the existing uncertainty.

2.2.1 Strategic Tasks

Derived from the company's business strategy, the entire *product portfolio* has to be assessed in terms of its market and competitive criteria in a joint effort by management and product managers. This assessment constitutes the basis for formulating the company's *fundamental strategies* for all of its products and consequently for its *allocation of resources* [3].

Product management must analyze the business environment systematically and regularly in order to generate information benchmarks, essential for strategic product planning [4]. Due to the future-oriented necessity of strategic planning, analysis of the current situation does not suffice. Prospective developments of relevant environments have to be identified and considered at an early stage. In addition, in order to derive strategic action, a company's current *strengths and weaknesses* need to be analyzed and contrasted with identified developments in the business environment, e.g., SWOT (strength, weaknesses, opportunities and threats) analysis. Based on an evaluation of possible *strategic options* in light of their compatibility with overarching innovation and marketing goals, the next step consists in defining tangible *goals in product policy,* establishing the desired long- and medium-term market position of the products in question. The *product strategy* has to map out ways for reaching those goals, including the following aspects [5]:

- Market segmentation and selection of target groups
- (Target) positioning of new and existing products.

Since companies tend to be embedded in a dynamic business environment [6], strategic planning should be evaluated at least annually, may even involve a "rolling planning" framework, and adapted where necessary.

2.2.2 Operational Tasks

Derived from strategic product planning, initiation and market introduction of *product innovations*, alongside with maintenance and improvement of *existing products,* are the central tasks of product management [7]. The time period from initial product idea to market introduction is a central criterion for success, especially with regards to the increasingly dynamic, competitive and uncertain nature of markets. For this reason, incremental *innovation activities* have to be structured and coordinated by product management within the framework of a clearly defined innovation process while more radical innovation may not fit within a structured approach. Within their innovation activities, product management has to develop a bank of ideas for new products that fall within the parameters set by the product strategy. After the assessment, the selected ideas have to be turned into more clearly specified concepts that are the basis for the product development activities [8]. The next step for product management consists of creating a *market introduction concept*, concurrently with technical product development that is usually the responsibility of the research and development (R&D) department or the engineering design department. Product managers should monitor and control product development and market introduction processes by means of *project management* and project controlling tools. In addition, the product manager anticipates life cycle requirements and *adapts* existing products to changes in the marketing environment [9]. This task should be based on *life cycle analyses* conducted on a regular basis for the entire product program, to be followed by goal-directed measures of *product variation* and *differentiation* (line extension). In addition to these core tasks in product policy, there are an array of further operational tasks for product management, including drawing-up of short-term marketing plans (*product budgets*) and supporting distribution in the wake of product launches or product changes through sales aids and product-specific workshops [10]. Additional marketing-mix elements include concerns, for setting an appropriate *product price* based on identified utility for the customer and on the competitive environment, as well as for formulating *communication policy goals* and surrounding conditions. Figure 2.1 provides an overview of the essential strategic and operational tasks of product management.

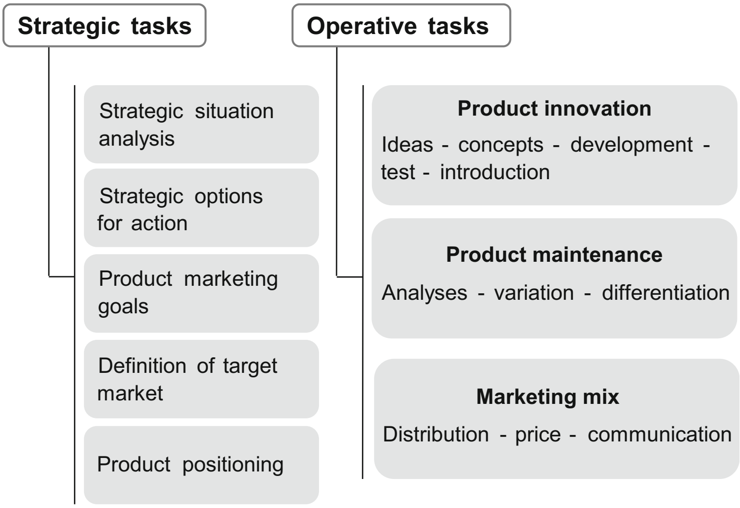


Fig. 2.1 Task spectrum of product management

2.3 Process-Oriented Innovation and Product Management

Process models present tasks in a structured way, ensuring a goal-directed application of *working techniques* and *methods*. Due to the central importance of product management's innovation task for the company's success, it is expedient to draw upon an established model of innovation management when developing a holistic process model.

2.3.1 Innovation Management as a Core Task

An array of concepts and models on how to structure *innovation processes* have been attempted over the years. Those models are designed to make the entire process visible and controllable [11]. At the operational level, the implementation of these models contributes to the standardization of real life processes in the field of innovation management [12].

2.3.1.1 Evolution of Innovation Process Models

For decades, innovation research has been characterized by *phase models*, dividing up the innovation process into individual phases and sub-phases, thereby structuring it on a temporal basis. However, the existing models differ significantly in terms of their focus and their degree of detail. Up until the 1960s, linear models were standard practice. Those models segmented management activities into sequential phases, each one followed by a management review [13]. In addition, those models had a strong *technology orientation* ("technology push"), not taking marketing aspects into account. Rothwell [14] therefore uses the label "*first generation* process models" in his five-stage classification system. In the mid-1960s, with market conditions being changed by more intensive competition and ongoing diversification, linear models characterized by a focused market-pull-orientation gained in significance. Those models were generally called *second generation* models. The corresponding approach pursued a consistent orientation of all development activities on customer needs, resulting in a general cessation of proactive R&D. Consequently, at many companies incremental innovation was the only type of innovation to be found [15]. It should be noted that Cooper [16] mergers the first two generations of Rothwell's taxonomy into one generation.

Due to the shortcomings mentioned above, the models of the second generation also were of limited usefulness in terms of expanding companies' innovative capabilities in the changing business environment of the 1970s often characterized by market saturation and high supply capacity. In order to identify the central factors for success in this changed environment, numerous studies focusing on success factors in new product development were conducted [17] (Cf. also the discussion in Chap. 1). Those studies found that the implementation of models integrating the previous two approaches, "technology-push" and "market pull", had a positive effect on a company's success. One of the seminal models in this context is the *combined model* ("push-pull-model") by Rothwell in which the impulse for innovation activities can be given by the supply side as well as the market side. In addition to this representative *third generation* model, Thom [18] created another seminal process model, which became the dominant standard model in German language publications. In this model, the innovation process is divided into the phases of *generation*, *acceptance* and *realization* of ideas, with each phase being structured into individual sub-phases.

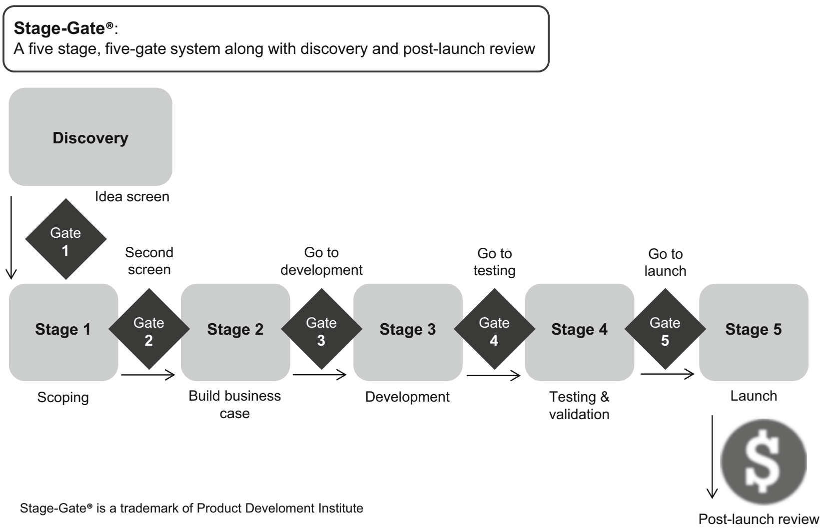
A central milestone in the development of innovation process models was the *Stage-Gate® model* by Cooper. Based on his extensive success factor studies, the author developed a holistic process model. In contrast to previous models, it has an interdisciplinary outlook and separates the innovation process into five stages. Each "stage" [19] is accessible via a "gate" serving as a checkpoint for quality control, the point of decision-making on terminating or continuing the project. The Stage-Gate® model separates the innovation process into the five stages of *finding & evaluating ideas, product concept, development, testing& validation,* and *market introduction.* It is important to note that no single department is solely responsible for any stage, but that the process is organized in a *cross-departmental* way. At each stage, members of different departments, such as R&D, marketing and production, cooperate to varying degrees. The decision on continuing or terminating the project is also taken in cross-functional cooperation at each gate, based on previously established criteria [20]. In the interest of increasing efficiency, activities within a stage are designated not to be carried out in sequence, but preferably in a *parallel* way and supported by *feedback loops.* For instance, Cooper suggests that at the third stage, *development*, a comprehensive marketing concept has to be devised alongside the physical development of the product. However, Stage-Gate® processes still have a fundamentally sequential character, i.e. a new stage should only be begun when all of the preceding stage's set tasks have been successfully completed and when a "go" decision has been made at the gate between the two stages. Cooper classifies the model described here as second generation model.

Theoretical Insight

Stage-Gate® Innovation Model

Robert Cooper's "Stage-Gate® process" is a conceptual and operational map for moving innovation projects from idea to launch and beyond. A standard Stage-Gate model is shown in the following and consists of five stages and five gates.

In each stage a set of recommended interdisciplinary and parallel activities need to be executed to progress the project to the next gate. The entrance to every stage is a specific gate which has a related set of mandatory deliverables which helps tough go/kill decisions to be made. Furthermore every gate consists of criteria against which the project is judged.



Overview of a typical Stage-Gate® Model

Source: Cooper [21]

From the late 1980s, due to intensifying global competition and increasingly faster product life cycles, short development periods ("time-to-market") became a more decisive competitive advantage. In the beginning, Japanese companies were at the forefront of this process, speeding up their innovation pace by conducting development activities in a parallel approach and involving suppliers early in the innovation process. Those two aspects (i.e., *parallelism* and *integration*) are a central characteristic of *fourth generation process models and* successful innovation management. Developments in *information and communication technology* increased performance and efficiency of parallel and integrated development processes even further. The use of linked CAD-systems, simulation and rapid prototyping technologies, and comprehensive information systems continues to reduce development time and development costs. “Electronification” of innovation processes thereby constitutes a decisive feature of *fifth generation* innovation management.

In the context of these more recent developments, Cooper expanded his second generation model into the third generation model including the “four fundamental Fs” [22]. Transitions between stages are fluid and activities can be conducted increasingly in parallel fashion (“*fluidity*”). Within the scope of a gate-decision, a project can be continued to some degree even if not all criteria for the respective stage have been met. Cooper talks about “*fuzzy gates*” here. Likewise, tasks of a subsequent stage can also be carried out prior to a gate-decision. An optimal allocation of resources between different innovation projects is an increasingly important factor in determining gate decisions (“*focused*”). Also, in third generation stage gate models, projects only have to pass through certain process stages, depending on the respective project’s degree of risk (“*flexibility*”). Processes are perceived as being scalable, hence those with a lower degree of risk can be processed in a “leaner” way, i.e., in fewer process segments and gates. One of the drawbacks of third generation process models, though, is that flexibility is often achieved at the expense of robustness, with projects that are continued on condition often not being aborted on time.

The last “evolutionary stage” of innovation process management systems is subsumed by Cooper’s term “NexGen™ Systems” [23]. In addition to an increased degree of scalability and flexibility, the most characteristic feature of these models is their openness in the sense of the *open innovation approach* (further discussion of the term *open innovation* in Sect. 5.2). Cooper emphasizes that companies should only implement innovation process models of a higher generation if they already gained extensive experience with second generation stage-gate models. For this reason, reference process models providing the basis for a first-time *implementation* of a systematic innovation process should include features of a second generation process model (according to Cooper’s classification system).

To conclude, Fig. 2.2 depicts the evolutionary stages of innovation management systems in terms of chronological sequence and respective focus.

2.3.1.2 Design as Sub Process of Innovation Management

As discussed in the first chapter of this book, homogenization of products on the technical-functional level is happening in many industries. Effective and efficient *differentiation* at this level can be accomplished mainly in the esthetic-emotional dimension. Using the definition from Chap. 1, the term “design” is understood to include functional and ergonomic aspects as well as features of brand strategy including the esthetic aspects of product development.

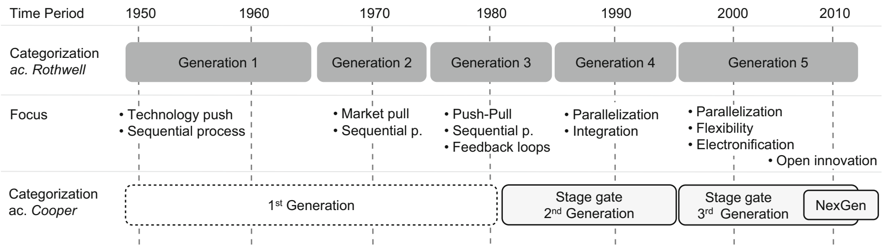


Fig. 2.2 Development of innovation management-systems (Based on Cooper [24, 25] and Rothwell [26])

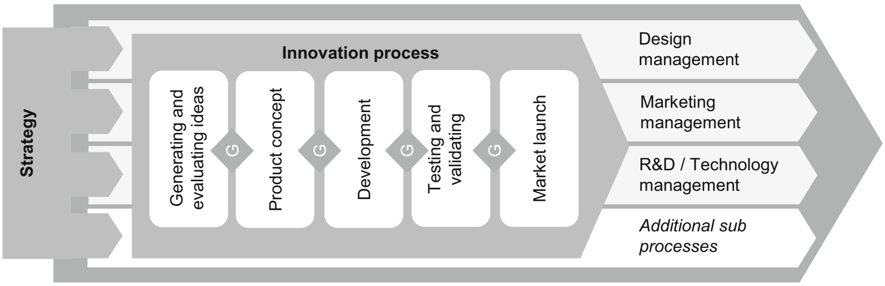


Fig. 2.3 Phase model of the innovation process

In order to make design its decisive *factor for success*, a company has to plan, implement and control all activities related to design in the context of its business strategy. During the entire innovation process, those activities have to be coordinated primarily with the two *core areas* of innovation management: R&D and marketing [27, 28]. The tasks are subsumed under the term "*design management*", comprising functional as well as organizational aspects. The importance of systematic coordination, especially of design management and marketing, is emphasized by a number of studies demonstrating that coordinated design and marketing activities significantly increase an innovation project's potential [29].

Expanding on those ideas and based on Cooper's second-generation model, Gaubinger and Werani [30] developed the phase model of the innovation process depicted in Fig. 2.3. Integrating design management as a third *core process* of innovation management, this model gives expression to the importance of design-specific activities in all phases of the innovation process and also visualizes its cross-functional and *interdisciplinary nature* at every stage.

2.3.2 Integrated Process Model of Innovation and Product Management

Based on the product management tasks that have been identified and on the reflections on structure and content of phase models of the innovation process, a

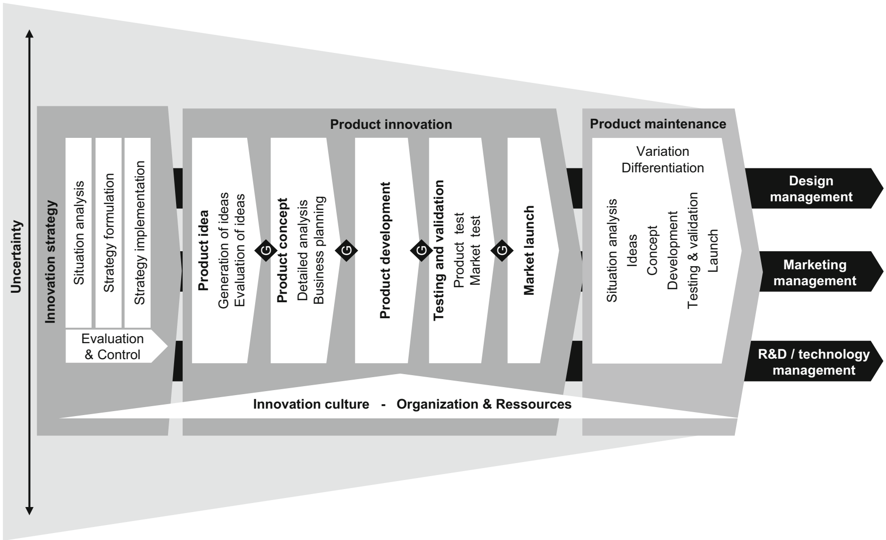


Fig. 2.4 Process model of integrated innovation and product management

fundamental process model of integrated innovation and product management is offered, whose structure and content is depicted in Fig. 2.4. The structure of this book is oriented towards the structure of the model. The activities encompassed by the model should preferably be carried out in a parallel way at all stages, both within disciplines (e.g., technology, marketing, design) as well as across disciplines.

In order to ensure long-term market success, innovation and product management has to continuously analyze developments both in the external and internal business environment within a *situation analysis*. In this context the challenge is to invest in acquiring early knowledge through a wide variety of methods (e.g., market research, scenario planning) to convert *uncertainty* to a calculated risk [31]. As soon as all necessary information is available, the *innovation strategy* can be formulated and thereby a long term plan can be drafted. The next phase encompasses the *implementation* of the strategy and aims at putting the strategy into action. The strategy process is being accompanied by an *evaluation* and *control* phase in order to measure the performance of the innovation strategy.

The defined strategy constitutes both the inspiration and the limiting framework for product managements' operational activities. Strategy-compatible fields need to be defined as starting points for *product innovation activities*. These fields for search facilitate an efficient *generation of ideas* within the framework of *innovation activities*. The next step consists in an evaluation of the ideas that have been generated. Based on a more in-depth analysis, the preferred ideas are submitted to further specification. In general, this winnowing and increasing focus culminates in the drawing up of a product brief, depicting the *product concept in detail*. If the success potential of the conceptualized product has been confirmed by feasibility studies, technical *product development* as well as the development of a detailed *marketing concept* can be started. Prior to *the market launch* of the developed products, several *tests* have to be conducted. These tests vary according to the complexity and strategic importance of the product, covering a spectrum from simple prototype tests to comprehensive market tests.

Products that have been introduced on the market have to be observed and analyzed throughout their *life cycle*. If there are discrepancies between the desired state and the actual state, product-specific measures have to be considered in the product maintenance phase. There is a range of options from changing or improving existing products (*variation*) to introducing an additional product variant (*differentiation*) to *elimination* of an existing product and possibly the concomitant development of a replacement product (*innovation*). Planned product variation and differentiation also have to proceed through all the stages corresponding to the innovation process from idea generation to market launch. However, depending on the planned activity's degree of innovation, extent and intensity of activities at each stage of the process may vary.

In summary, it can be seen that every activity in the process contributes to gaining further knowledge which reduces external and internal uncertainty and increases the chances of a successful outcome. Concurrent with this process of reducing uncertainty, which we call "innovation funnel", resource commitment is increasing steadily.

As can be seen in Fig. 2.4, all activities of the innovation and product management process model require a close interdisciplinary interaction and communication mainly with R&D, marketing and design management. This aspect is highlighted again in the following illustration (Fig. 2.5).

In the scope of this book, activities where this cross-functional approach is of central importance are labeled with the corresponding symbols: marketing [MKT], research & development [R&D], design [DES].

Especially in a SME, it is not common to have three separate departments, but someone has to handle these three sub processes. In this case one or more persons are responsible for the process tasks independent of their department.

2.4 Implementing the Process Model

Due to the cross-functional relevance of the process model (described in Sect. 2.3.2) as well as the strategic importance of its encompassed activities, implementation is a challenging task. Therefore, following the discussion in Cooper [32], process implantation should proceed in four steps with regards to the Stage-Gate® process.

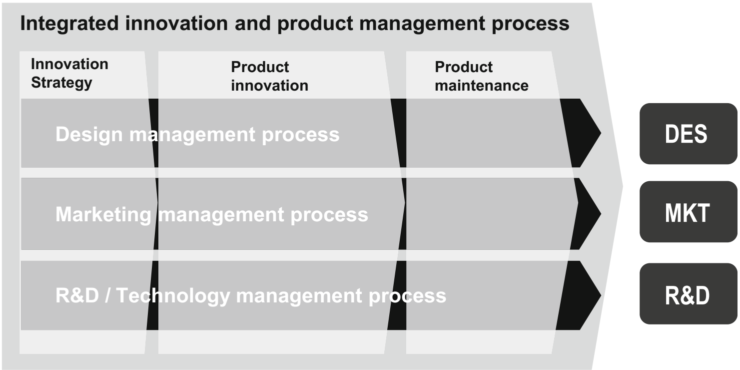


Fig. 2.5 Interdisciplinary interaction and communication between the different processes and departments

2.4.1 Team-Building

Introducing a new process model to a company is full of hurdles. The first and often most taxing challenge consists of achieving management consensus that the new process will increase the *competitiveness* of the company through increased efficiency and effectiveness of product-specific activities. For this reason, the official kick-off of a new process initiative should be accomplished by *top management*, independent of the original initiator. Top management should also designate a person in charge of the process.

Since the introduction of a comprehensive process model requires the involvement of a large number of people, the designated project coordinator, in cooperation with management, has the responsibility of building a *project team*. This team should be representative of functions and product areas centrally affected by the introduction of the process. Thus, it is crucial for success that the team includes leading members of R&D, procurement, manufacturing, design, sales and marketing, in addition to product management. Before the project team takes on its actual tasks, a company-internal *workshop* can create awareness for the urgency for improvements and give interested company members the chance to participate.

2.4.2 Analysis

An essential task of the project team consists in *analyzing* current practices in the areas of product strategy, product development, product program policy and product maintenance. The problems and weak points identified in this analysis provide motivation for improving the processes related to innovation management and product management [33]. Current practices in innovation and product management can be assessed by an internal study or an *analytical workshop*. The analytical workshop provides transparency and shared understanding for strengths and weaknesses of the ongoing formal and informal processes. However, there is the risk of participants influencing each other and of the status quo being only assessed vaguely due to time constraints. An *internal study*, the second option of assessment, is especially suited for the purpose of soliciting input from different levels of hierarchy and experts with diverging viewpoints. When using this predominantly qualitative mode of analysis, great care has to be given to prevent a manipulation of the respondents by the interviewers. This requires a systematic approach and careful training of the interviewers. Also, the first round of surveys is usually followed by a new cycle of interview fine-tuning in order to establish validity. At the operational level, the combined use of both methods is in order. For instance, weaknesses and potential for optimization can be ascertained by means of an internal study, to be refined and verified later by respondents in a workshop.

The quality of analysis is influenced by many factors. In an internal study, the *interview guideline* is of central importance. It has to cover the scope of desired information, in order to ensure consistency and comparability of results [34]. Regarding the issue of who should be involved in the analysis, one can state that analysis can only be as good as the interview partners or the participants of the workshop. For this reason, all *employees* affected by product-related planning and implementation should be included in the analysis. Proceeding in this way will capture a broad spectrum of perspectives on the processes and the challenges, as well as increasing the assessment's degree of detail.

Another key factor for success in an *analysis workshop* is the skill set of the moderator. For this reason, only a seasoned moderator acting neutrally and creating an open and cooperative atmosphere should lead the workshop. It is the moderator's responsibility to see to it that no important aspects are lost. At the same time, the discussion should not meander into unimportant issues. Continuous visualization of the (intermediary) results of the workshop supports the efficiency of the analysis. In general, the number of workshop participants should not exceed twelve people. A minimum of 1–2 days should be set aside for the workshop. To conclude, it remains to be said that the processes and activities to be assessed should be depicted graphically in process diagrams and extensively described verbally at the end of the analysis.

2.4.3 Process Specification

Building on the analysis of the company's current position, the next step is the development of the company-specific process. First, the project team should convene to *develop an abstract model* of the new process, using the model presented in Sect. 2.3.2 as a blueprint. For each stage, the *purpose* and the *main activities* to support each stage's purpose must be defined. The draft is usually revised in the wake of the project team's meeting. Further precision and *adaptation* of the draft definitely requires the participation of affected company members and management. For this end, each member of the project team should hold *information meetings* in order to gather feedback from other relevant company employees.

Depending on the size of the company and the degree of employee participation, further rounds of feedback gathering can be planned. The concept generated in this way must be approved by management prior to the project team's further specifications [35]. Once *approval* has been granted, it is the project team's responsibility to further *specify* the stages of the company-specific process model in terms of the organization and the tools and methods to be used.

Since most tasks in innovation and product management are interdisciplinary, there are many cross-sections between departments throughout the process phases where all departments are linked at one point in time by the need for benchmarks and information exchange. These cross-sections have to be clearly defined and subsequently be complied with. In this context, so-called *cross-section agreements* are an optimal instrument. Those agreements should clearly define relevant processes and related activities. They should also define which type of information should be exchanged among the departments, at what point this should be done and which tasks a given department should accomplish for another one. It is important that these agreements are explicit and have the support of high level management that can create and enforce them [36].

Defining the process organization is closely connected to identifying an appropriate *organizational structure* for the company. There is an array of possible organizational forms, to be discussed in Sect. 10.3.

2.4.4 Process Implementation

Prior to the introduction of a company-specific process in integrated innovation and product management, all employees affected by the process, including those who have not been involved in its conceptualization up to this point, should be informed about its advantages. By means of *internal marketing strategies* (e.g., information sessions, intranet, brochures, etc.), the desired outcomes of the new process are communicated to employees.

Once employees have been sensitized to the importance of the new process, training in the required *technical knowledge* as well as *personal knowledge is commenced*. To this end, *guidelines* concisely depicting and describing relevant processes, activities and people in charge are of the essence. In addition to implementing these measures, the project team also has the responsibility of assessing and specifying to what extent the company's *IT systems* (data bases, communication systems) have to be adapted and extended [37].

To conclude, it has to be stated that once a process has been introduced, it requires constant optimization and *adaptation* to change. Reasons often include the company's use of new technologies (e.g., the introduction of an engineering data management system) or the growth and development of the company itself.

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3 The Front End of Innovation

3.1 Introduction

According to Murphy and Kumar [1], the *Front End of Innovation* (FEI) is the time between identifying an opportunity in a market place and the start of the NPD execution. Koen et al. [2] describe the early stages of the innovation process as the activities that take place prior to the formal, well-structured NPD process. Supplementing this, Herstatt and Verworn [3] emphasizes the go/no-go decision for implementing a concept as the end point of the early phase. The early stages of the innovation process between first consideration of an opportunity and the point when it is judged ready to enter the structured development process are defined as the *Fuzzy Front End* [2]. Here the company develops the first concept of the product to be developed and decides whether or not to invest resources in the further advancement of an idea. The Fuzzy Front End disappears when a company approves and starts formal development of the product concept [4].

This Chapter Will Discuss

- What are the characteristics of the Front End of Innovation?
- Which factors influence the success at the FEI?
- Which models can be applied to structure the FEI?

Practical Insight

Coloplast: Organizing the Front End of Innovation

Coloplast was founded in 1954 when nurse Elise Sorensen developed the first self-adhering ostomy bag as a way of helping her sister, a stomach cancer patient. She took her idea to a various plastics manufacturers, but none showed interest at first. Eventually one, Aage Louis-Hansen discussed the concept with his wife, a nurse, who saw the potential of such a device and

(continued)

K. Gaubinger et al., *Innovation and Product Management*,
Springer Texts in Business and Economics, DOI 10.1007/978-3-642-54376-0_3,

persuaded her husband to give the ostomy bag a chance. Hansen's company, Dansk Plastic Emballage, produced the world's first disposable ostomy bag in 1955. Two years later Dansk Coloplast was founded and the success story began. Today, Coloplast develops products and services that make life easier for people with very personal and private medical conditions. Their business includes Continence Care, Ostomy Care, Wound and Skin Care, and Surgical Urology and the company has subsidiaries in 20 and factories in 5 countries around the world

Working closely with the people who use Coloplast's products is one of their secrets of success. Through panels of users, specialist nurses and other health professionals they manage to gain deep insights into how their products are used and which features users would find valuable. By this Coloplast can quickly bring pioneering products to their consumers based on the responses and needs from them. This is done by combining their portfolio of competences, materials and design along with input from many parts of the organization.

The involvement of professionals and end-users in various boards and panels is an integrated part of Coloplast's innovation process which consists of the three main stages front-end innovation, new product development and global roll-out. Activities at the front-end are opportunity identification, opportunity analysis, idea generation & enrichment, idea selection and concept definition.

Photo: Copyright © by Coloplast

Source: Coloplast [6], Foss et al. [7], Bessant et al. [8]

3.2 Characteristics of the Front End of Innovation

As discussed before, in this phase of the innovation process market and technological uncertainty is high while the degree of available information is rather low, as depicted in Fig. 3.1 [2, 8].

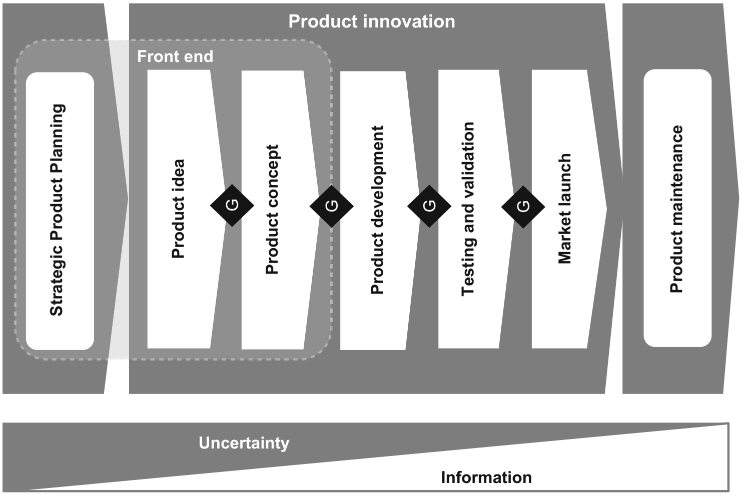


Fig. 3.1 Uncertainty reduction and growth of information during the innovation process

Although a certain degree of uncertainty and equivocality are inevitable, over the course of time, as information gets more reliable, uncertainty decreases [9].

Cooper and Keinschmidt [10] empirically shows that the greatest differences between winners and losers are found in the execution quality of predevelopment activities. The quality of executing pre-development activities as well as defining a project prior to the development phase are central factors for product success [10]. Activities in the early innovation phase tend to be carried out in an unstructured way and with limited resources, because these activities' importance is underestimated.

Several authors [2, 11, 12] have attempted to identify the central characteristics of the early phase. While early innovation phases do not always follow the same pattern, it is possible to define central common factors, summarized in Fig. 3.2. Documentation, formalization and clear responsibilities stand out as the factors that are less prominent in the early phase. In contrast, uncertainty (especially with regards to technology, required resources, strategic fit), ambiguity and creativity are among the features that are generally present and important in the early phase. However, all characteristics of the early phase are dependent on the specific company and its context, varying according to the degree of novelty, size of the company, the company's experience with innovation activities along with company culture [13].

It follows that activities and decisions in the early phase profoundly influence the success of the innovation project, effecting not only development time and costs, but also all downstream decisions in the innovation process [13–15].

Fig. 3.2 Characteristics of the front end of innovation (Based on Verworn [11], Montoya-Weiss and O'Driscoll [12] and Koen et al. [2])

3.3 Success Factors at the FEI

A number of studies investigate success factors [e.g., 14–18]. There is a significant correlation between the efficiency (doing things right) in the FEI of a company's innovation process and its effectiveness (doing the right things). By taking a look at the literature, the success factors regarding the FEI can be differentiated into about six categories: process, culture, strategy, market, performance, organization/structure. Focusing on the first category, the process of the early stages is controversial in the literature and can be considered from two sides: While some authors refer to flexibility in the early phase as critical to success [15], for others perceive a systematic process with defined review points represents as a success factor [19].

Figure 3.3 provides an overview of process-related success factors of the FEI identified by renowned experts in innovation management.

Structuring and managing the innovation process represents one of many critical process-related factors traditionally associated with innovation success. One of the principal objectives of process models is to structure typical tasks to ensure the targeted application of work techniques, methods and tools. A well-defined process is transparent to all departments so a common understanding can be developed, which facilitates communication within the company [20].

3.4 Models of Front End of Innovation

Managing the so-called Fuzzy Front End of Innovation is a continuous conflict between creativity and systematization [21, 22]. As already mentioned, the early stages imply high risk and uncertainty, ill-defined results and an unclear way of setting and achieving goals. Therefore, it is essential for organizing the FEI in order to find the right balance between flexibility and creativity (weakly-defined processes and targets) on one hand and structure and bureaucracy (well-defined processes and targets) on the other hand. Too much structure kills creativity,

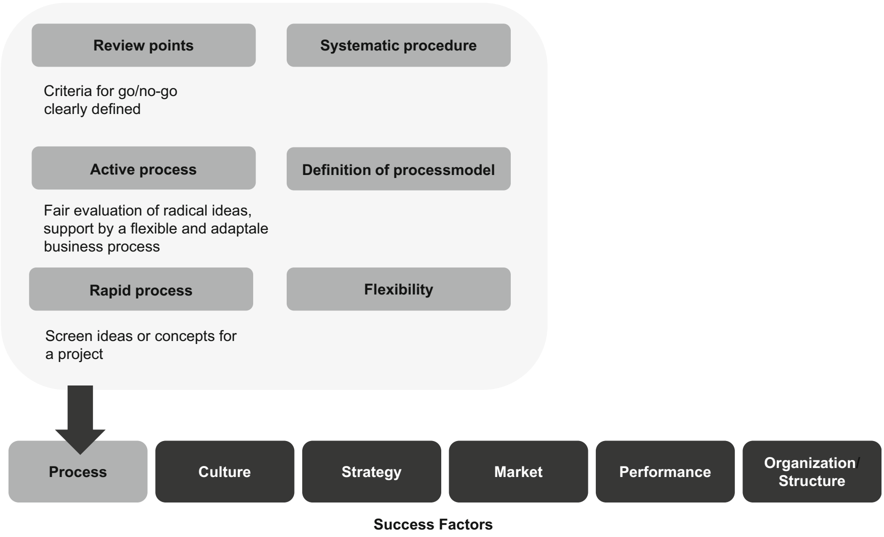


Fig. 3.3 Success factors of the front end of innovation

while too little structure negatively affects FEI-performance [22]. This relationship between degree of formality and performance shows an inverted u-shape curve implying that too much as well as too little formality is negative. Herstatt and Verworn [3] also stresses the importance of a situation-appropriate balance between structured process and sufficient room for creativity.

There are a vast number of innovation process models that divide the FEI into phases, stages, steps or elements, varying with regard to priorities, number of phases, perspective, definition of starting point and the ending point of the process and degree of detail [21, 23, 24]. Sequential models follow a linear course, conduct one task after another and thus allow for easy access to recommended actions, facilitating transparency and predictability [25–27]. However, they also run the risk of not corresponding to reality and of not adequately considering creative exchange and feedback loops among employees.

Therefore, a lot of literature advocates flexible processes in innovation management. Models with flexible and dynamic processes, feedback loops and parallel actions are mainly referred to as iterative process models [26]. Koen et al. [2], for example, support a circular shape of the front-end elements, which means that ideas are expected to flow and iterate between the sub-phases, because these sub-phases of the fuzzy front end are unpredictable, chaotic, informal and poorly-structured by nature. According to Ayers et al. [28], flexibility, ambiguity and keeping a broad set of possible options open are especially vital to innovation success. Cooper and Kleinschmidt [29] also point out that top companies conduct their innovation processes to be flexible and scalable.

Though iterative models get very close to reality, their practical implementation turns out to be difficult, based on the abstract nature of these models that don't lend themselves easily to planned recommendations for employees to follow. Therefore, companies tend to focus on sequential process models for managing the FEI, even if these sequential methods cannot be transferred one-on-one to the Fuzzy Front End, which is characterized by iterative learning cycles [26].

Generally, parallelism and integration seems to be a central success factor not only in NPD execution but also in the FEI. The use of linked IT-systems, simulation and rapid prototyping technologies, along with comprehensive information systems continue to reduce development time and costs. "Electronification" of innovation processes thereby constitutes a decisive feature of the *latest generation* of innovation management processes.

3.4.1 Variable Degree of Structuring the Front End of Innovation

The term Fuzzy Front End incorrectly suggests that the early stages of the innovation process have to be unstructured, fuzzy and chaotic by nature and cannot be managed because all of its unknowable und uncontrollable factors [2, 30]. However, creative problem-solving does not necessarily occur chaotically, but may very well be subject to structure and regularities. This rather speaks to the position of Steiner [31], who holds that a deterministic chaos, where creativity is guided through certain formal processes, is advantageous as it enables employees to fully unfold their creative potential without distraction but with clear goals and time frames. Quinn [32] also perceives "controlling the chaos" as a potential way out of this dilemma. This approach does not imply suppressing the chaos, but just controlling it. Similarly, Brown and Eisenhardt [33] point out the importance of a "dissipative equilibrium" between chaos and bureaucracy. For Van Aken and Weggeman [34], an ideal management regime contains approaches that both operate formally (tightly managed) and free (undirected exploration). Cooper [35] offers his stage-gate-process with flexible gates and fluid stages (3rd generation), an approach which successfully manages to straddle chaos and bureaucracy. Hence, due to the pros and cons of both sequential and iterative models, many look for a complementary combination of these two approaches in order to define a better process structure [36].

3.4.2 Theoretical Process Models for the Front End of Innovation

Effectively managing the front end of innovation represents one of the most important and simultaneously challenging activities for innovation managers [37]. In the later phases of the innovation process, a structured stage gate process is widely accepted in theory and practice, whereas at the FEI a broad variety of concepts and process models for systematizing the innovation process currently can be found [38–40]. Difficulties in the early innovation phase arise mainly from its dynamic, fuzzy, unstructured and informal nature [1]. Process models have been developed to structure the FEI to reduce its fuzziness [41] and to visualize and manage the process in its entirety [42, 43]. Consequently, the following chapter is concerned with the evolution of innovation process models as well as theoretical process models.

Process models for the FEI are useful in order to give the uncertain contents of early innovation more stability and predictability. These models typically divide the early stages of the innovation process into distinct phases with assigned tasks and responsibilities [27]. However, existing literature tends to show a lack of structured front-end processes to support an effective early-stage management. Selected from the multitude of available models, the ones presented in the following section are one not only frequently used, but also offer added value in terms of structure and flexibility.

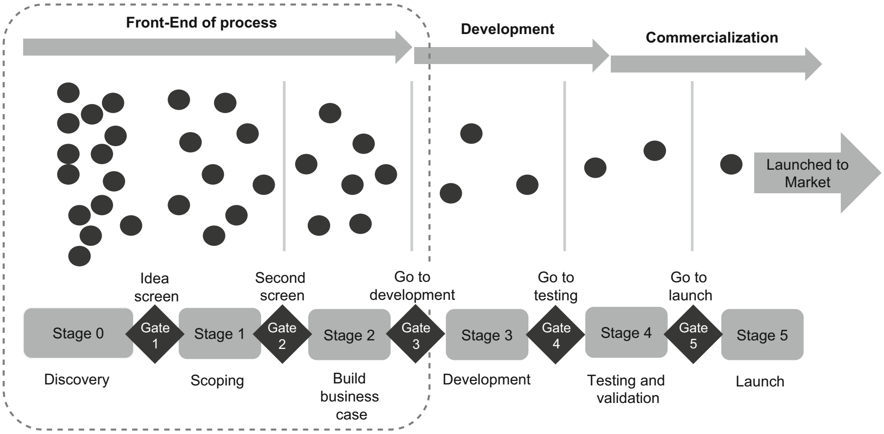
3.4.2.1 Stage-Gate® Process

The Stage-Gate® process from Cooper [44] divides the innovation process into stages separated by "gates" where go/no-go decisions are made based on information generated during the activities in the previous stages (Fig. 3.4). New ideas collected during the Discovery Phase (Stage 0) through internal as well as external sources are evaluated and filtered during Stage 1 according to criteria like strategic fit, market attractiveness and technical feasibility. During the Scoping Phase (Stage 1), a first rough elaboration of market-related and technical advantages is carried out, to be followed by further evaluation at Gate 2. At the subsequent Stage 2, detailed tests with regards to technology, market and competition are carried out, culminating in the draft of a business case depicting the route from ideas to product concept. At Gate 3, which separates the front end of innovation from the development phase and also referred to as "Money Gate", an even more detailed assessment forms the basis for making a decision on the launch of a development project.

Cooper's model has evolved over time through several generations. He expanded this 2nd generation model into the Stage-Gate® Model (third generation), characterized by "four fundamental Fs" [35]. Transitions between stages are fluid and activities can be conducted increasingly in parallel fashion ("fluidity"). Within the scope of a gate-decision, a project can be continued to some degree even if not all criteria for the respective stage has been met. Cooper talks about "fuzzy gates" here. Likewise, tasks of a subsequent stage can also be carried out prior to a gate-decision. An optimal allocation of resources between different innovation projects is an increasingly important factor in determining gate decisions ("focused"). Also, in third generation stage-gate models, projects only have to pass through certain process stages, depending on the respective project's degree of risk ("flexibility"). Processes are perceived as being scalable, hence those with a lower degree of risk can be processed in a "leaner" way, i.e., in fewer process segments and gates. One of the drawbacks of third generation process models is that flexibility is often achieved at the expense of robustness. With projects that are conditionally continued, they are often not being aborted on time. The last "evolutionary stage" of innovation process management systems is subsumed by Cooper's terms "NexGen™ Systems" [45]. In addition to an increased degree of scalability and

Cooper's Stage-Gate® Process (2nd Generation)

Model:



Pros:

- Very famous and frequently cited model
- Flexible to both radical and incremental innovations
- Integrates both the market and technological perspective
- Activities are performed in parallel fashion.

Cons:

- Product concepts can be stopped too early
- Gate-keepers low level of knowledge can lead to wrong decisions
- Lack of flexibility due to sequential approach.

Fig. 3.4 Stage-Gate process (2nd generation)

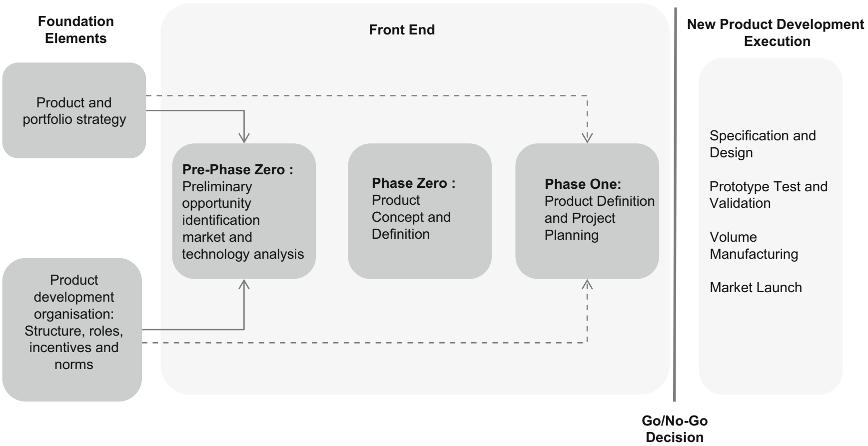
flexibility, the most characteristic feature of these models is their open innovation approach.

3.4.2.2 Three Phase Front End Model

Khurana and Rosenthal [46] separate the Front End of Innovation in their sequential process model into the three sections: Pre-Phase Zero, Phase Zero and Phase One. Project-specific elements (such as project definition, planning, and product concept) continuously support the project. Project-independent activities, so-called "foundation elements", also influence Pre-Phase Zero and are important push factors and influence the quality of implementation as well as the efficiency. They primarily consist of a clearly defined product portfolio strategy as well as roles, norms and structures for the organization of product development. Over the course of Pre-phase Zero, innovation opportunities are being searched for and ideas are being generated via market and technology analysis. The new innovation project is launched, with an elaboration of the concept to follow in the ensuing Phase Zero. In Phase Zero, not only customer needs, but also market segments, competitive situations and business prospects (e.g., profits) are identified. Finally, in Phase One, the technological and economic feasibility of the product concept is assessed and

Three Phase Front End Model by Khurana/Rosenthal

Model:



Pros:

- Additional consideration of elements of the organizational environment (foundation elements)
- Useful tool for visualizing and structuring front end activities, reducing the fuzziness and easing communication.

Cons:

- No feedback loops
- No description of the preliminary opportunity identification and idea generation in detail
- Tool lacks flexibility
- Decision-making could be enhanced by a more structured process (especially in Pre-phase Zero and Phase one).

Fig. 3.5 Three phase front end model

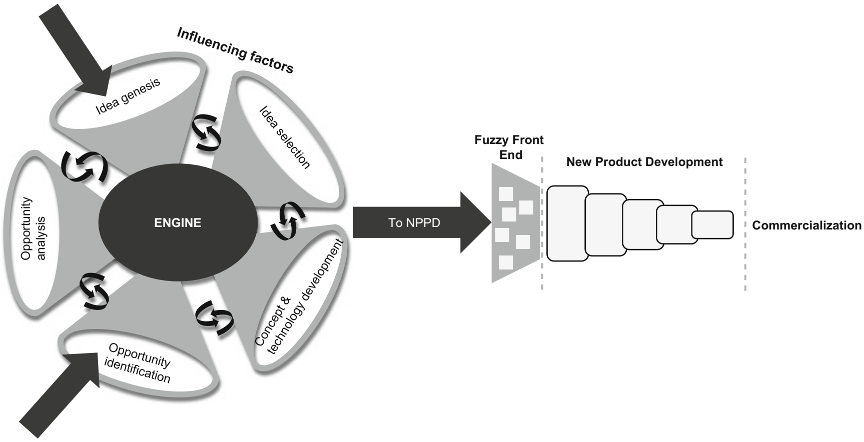
the product development concept is planned. Management eventually concludes the early phases of innovation with a decision on the continuation or conclusion of the presented business case, presented as Go/No-Go decision [25, 41, 46–48] (Fig. 3.5).

3.4.2.3 New Concept Development Model

The New Concept Development (NCD) Model from Koen et al. [2] is intended to help agents of innovation to better manage the early stages of the innovation process and to provide a common language on the FEI activities. It consists of three parts: engine, front-end elements and influencing factors. A characteristic feature of the NCD Model is the circular, iterative arrangement of the five front-end elements. They are not subjected to any particular order, but can be carried out at random, as often as desired, in parallel fashion or consecutively. In the course of opportunity identification, the goals of the company are considered along with tools (e.g., brainstorming) and problem-solving techniques (e.g., causal analysis), to enlarge the number of possibilities are increased. Finally, at the stage of opportunity analysis, technological and market-related criteria are used to assess the whether the opportunity makes sense. In the phase of idea genesis, detailed ideas are

New Concept Development Model by Koen et al.

Model:



Pros:

- Includes all company related factors
- Stimulates innovation due to its non-sequential order of phases
- Flexible with regards to both radical and incremental innovations.

Cons:

- Abstract model that is hardly transferable to a business situation
- Practitioners criticize the lack of application of these methodologies
- Model mainly focuses on product development
- Influencing factors are not controllable.

Fig. 3.6 New concept development model

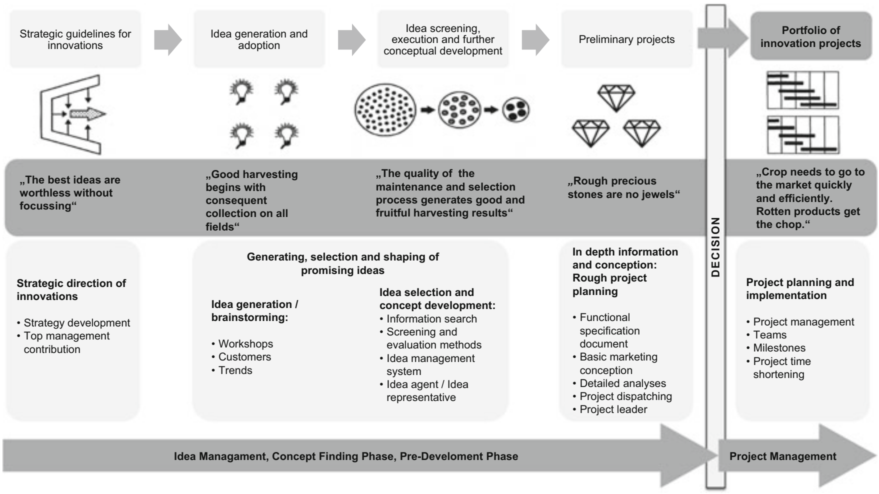
developed in an evolutionary, iterative process. The most promising ideas are selected in the following process of idea selection. The engine of the Front End Elements is composed of all factors that can be managed by the company (e.g., leadership, culture, business strategy) and can create an environment for successful innovation. In addition, internal (e.g., organizational skills, technologies, strategy) as well as external factors beyond the company's control (e.g., channels of distribution, customers, competitors) also influence the Front End of Innovation.

In their NCD model, Koen et al. put the focus on the product development aspect and, at most, only partially integrate the technology process development. The larger the investment in the technology development process, the more the resources needed, the more the structure is required for decisions and the less likely the integration of technology development into the framework of the NCD process [2, 41, 47, 49, 50] (Fig. 3.6).

3.4.2.4 Concept Exploration Phase of the Innovation Process

In his holistic innovation process model, Geschka [51] distinguishes the four consecutive phases of concept generation, development of innovation elements, Concept Exploration Phase of the Innovation Process by Geschka

Model:



Pros:
- Builds on management commitment
- Bulk approach for idea screening
- Easy to implement
- Simple process.

Cons:
- Little flexibility
- Sequential model
- No gates implemented.

Fig. 3.7 Concept exploration phase of the innovation process

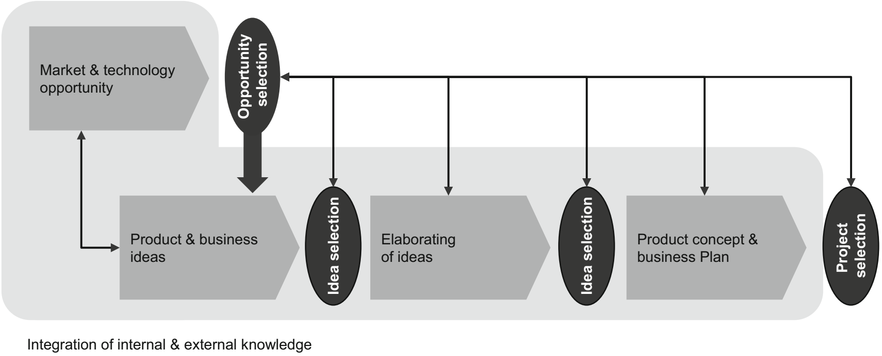
creation of market readiness and market introduction. He calls the first phase, i.e., the concept generation phase, the front end of innovation, presenting it in detail in a separate model. According to Geschka, the early phase begins with strategic orientation, i.e., top management's intention of implementing innovations. In the subsequent phases 2 and 3, ideas are being generated, collected, evaluated and selected. As selected ideas are being developed further, a concept turns into a pre-project already connected with costs and increased input. Pre-projects are subjected to detailed analysis. Finally, at the decision gate, one pre-project is chosen to segue into the product development process [51, 52] (Fig. 3.7).

3.4.2.5 Integrated Front-End Process Model

The Integrated Front-End Process Model by Sandmeier et al. [36] can be described as a guide or as a checklist, ensuring the completeness of activities in the early phase while at the same time according the necessary space to creativity. This model consists of three main phases, whose activities are connected with each other through filters and which are not passed through strictly in sequence. Over the course of the first phase, identification of market and technology opportunities, the innovation strategy is defined and closely linked to the company's overall strategy.

Integrated Front-End Process Model by Sandmeier et al.

Model:



Pros:

- Integration of customer knowledge at all phases of FEI
- Considers creativity and structure
- Possibility of shaping in a company-specific way
- Continuous refinement of the process through feedback loops
- Integrated front-end model (structured model with iterative characteristics).

Cons:

- Rather complex model
- Hard to implement
- Requires definitive communication structures.

Fig. 3.8 Integrated front-end process model

Likewise, an innovation target system is defined. Based on the company's vision, it is composed of the company's short-and long-term goals. In addition, new market and technology ideas are being generated in this first phase as new products of the company are being identified, requiring constant tuning with the company's strategy.

Finally, one or two opportunities and search areas reach Phase 2 (idea management), which concentrates on generating, collecting and evaluating ideas and subsequently on creating a balanced business and product approach with selected ideas. For those ideas that have not been filtered out, a rough product concept and a business plan are drawn up in Phase 3. The central success factor of this approach consists of the integration of customer knowledge throughout all phases and steps of the FEI. Feedback loops between the individual phases facilitate a continuous development and refinement of the entire process. The Integrated Front-End Process Model is, in essence, a structured process model with defined courses and activities, but also with feedback loops providing it with iterative characteristics [26, 36] (Fig. 3.8).

Practical Insight

Shell GameChanger: To create space that frees minds for innovation

GameChanger is an open innovation process at Shell for ideas that have the potential to transform today's energy industry. Its original role was to streamline the often "fuzzy" front end of R&D. Since 1996 GameChanger has been running by an autonomous team at Shell that helps inventors to develop their novel, early stage ideas from mind to proof of concept. Shell invests a separate pool of funds, amounting to roughly 5 to 10 percent of the total R&D budget, to realize this simple, fit-for-purpose, real-time process. Successful projects graduate for further development under a core R&D program, a license to another firm, or a new venture company. Because GameChanger focuses on high-uncertainty projects, the process was designed to be dynamic and flexible so that it could amplify successes as well as truncate failures at an early stage. In seven distinct steps, every idea is analyzed, screen by different groups and compared against benchmarks. In case of revolutionary ideas, more effort is spent on creating a learning opportunity.

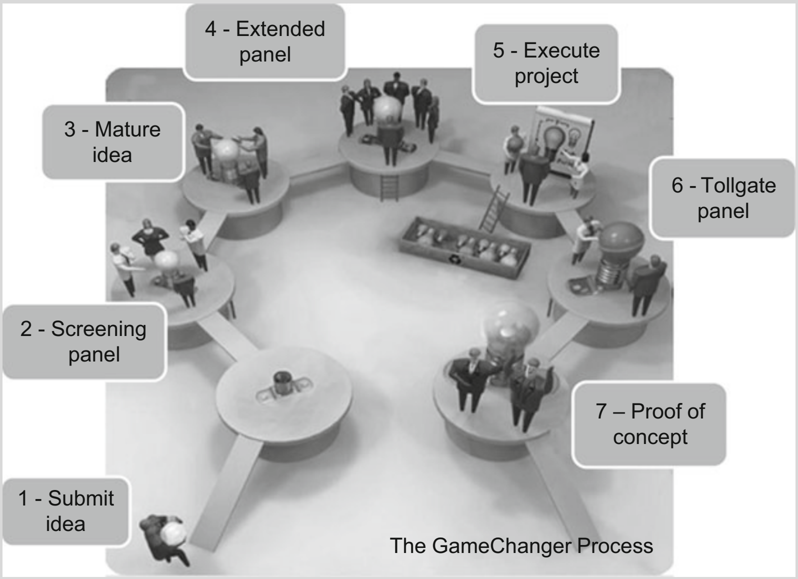


Photo: Copyright © by Shell

Since the beginning of GameChanger, the program has invested over $250 million in more than 2,000 ideas, turning 200 into commercial projects and helping Shell to deliver more energy to customers today. So the intent of creating some "safe" space, where more breakthrough ideas could incubate, creates a continuous stream of new options for management investment.

(continued)

Creating GameChanger was a management innovation that allowed Shell to convert an "either/or" dilemma into a "both/and" solution, by segmenting some limited space that would work by different rules, but within boundaries.

Source: Shell [86], Conser [87]

3.4.2.6 Holistic Front End of Innovation Model

To balance the conflict between structure and creativity with respect to flexibility, a new scalable process-oriented framework for structuring the front end of innovation was developed by Gaubinger and Rabl [55]. Figure 3.9 shows this framework and its four modules. The module *Innovation Strategy* encompasses three stages and is dedicated to strategic-oriented opportunity identification (Cf. Chap. 4). *Technology Development* (TD) is integrated as a main module of this framework due to the fact that although TD projects represent a small proportion of a typical company's development activities, they are often vital to the company's growth and survival.

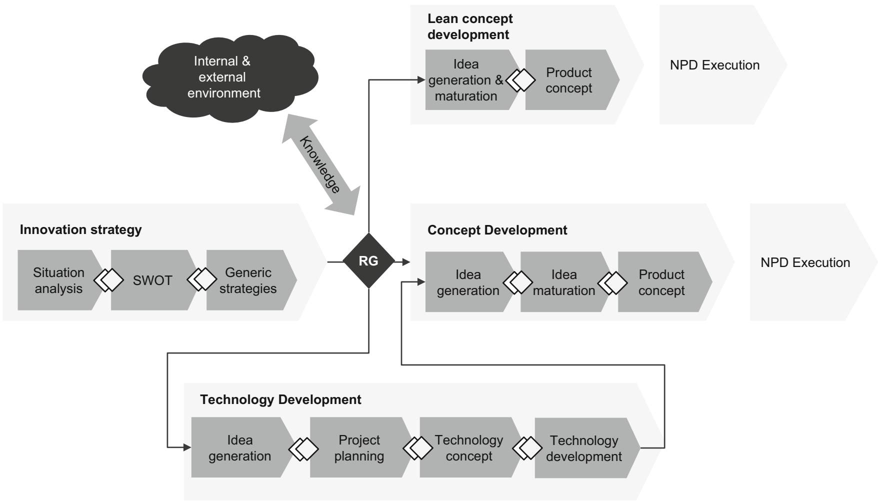
While theory and practice show that one innovation process model does not fit all projects, this framework is a scalable model and includes two different front-end processes for concept development. In accordance with Cooper [45], major new product or platform developments have to go through a finely structured multi-stage front end process whereas moderate risk development projects such as modifications, relaunches and extensions follow a leaner process with fewer stages and gates (*lean concept development*). Hence, it is essential that the decision at Routing Gate (RG) depends on the degree of novelty and level of uncertainty of the potential project. Pöttinger, a leading Austrian manufacturer of farm machinery, for example, has implemented two different process models for predevelopment activities and series development depending on the novelty of the idea.

At the Routing Gate, 'strategic courses of action related to innovation', which is the outcome of the strategic phase, must be assessed in a two-step procedure. First, it is evaluated if the potential project is targeting natural sciences and technical advancement, the enhancement of an existing product or the development of a new product. In the first case, the process *technology development* must be chosen.

Following Cooper [56], the technology development process "feeds the NPD process" and consists of the following sub phases: idea generation, project planning, technology concept and technology development. Especially in the field of technology development, idea generation is often accomplished by the R&D department, but it should be also the result of other activities.

[**R&D**] In the project planning phase, it is necessary that the whole development team creates a general state of knowledge [57]. Essential activities in this phase are technical literature search, patent and IP search and a preliminary technical assessment [56]. Based on these activities, an initial project plan is prepared. Since TD projects are usually based on vaguely defined market information at project start, Holistic Front-End Process Model

Model:



Pros:

- Integration of strategy
- Scalable model (three paths depending on project type)
- Openness to external environment
- Feedback loops and fuzzy gates.

Cons:

- Complex assessment at RG
- High complexity overall

  Projects might be stopped too early.

Fig. 3.9 Holistic framework for the front end of innovation

project planning must be specified with increasingly certain information in the ongoing phases.

[**MKT, R&D**] In a next step, the technology concept must be defined. Based on detailed conceptual technological analysis, the application potential of the new technology concept has to be evaluated. Industries with potential application fields are evaluated concerning their strategic fit and their attractiveness using checklists. With even more detailed analysis, relevant target industries and target market segments can be determined. These activities are the foundation for the identification of a pilot customer, who ensures the application-oriented development of the new technology happening in the next phase.

[**R&D**] In the technology development phase, the full experimental plan has to be implemented and the technological feasibility must be proved. Effectiveness of development activities can be improved if a potential user of the technology or a potential customer can be already integrated in this phase to evaluate and determine specific technological requirements and basic conditions. The inter-organizational planning and the execution of the project have to be carried out using sound project management tools.

If the identified strategic course of action is related to the improvement of an existing product or the development of a new product, the second evaluation stage has to be executed (*concept development*) (Cf. Chap. 7). Moreover, two characteristic features of this model are its open innovation approach and its fuzzy gates, where projects can be continued to some degree even if not all criteria for the respective stage have been met.

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Innovation Strategy

4

4.1 Introduction

A company's long-term success is dependent on channeling its activities toward suitable strategies. Strategies occur at the corporate level but also relate to specific areas, such as the development and realization of innovations. Success, however, will ultimately only be achieved, if each strategic level of the business are logically and consistently linked to each other in a structured way.

This Chapter Will Discuss

- What is a strategy and how are innovation strategy and strategic business management connected?
- Which areas does the innovation strategy encompass, how can this strategy be characterised and what approaches to overcoming uncertainty are offered within this context?
- How can we breath new life into innovation strategy in a systematic way?

Practical Insight

BASF AG: Strategic Foresight in an International Chemical Concern

The BASF company, with its headquaters in Ludwigshafen (Germany), is one of the leading chemical firms in the world that employs more than 110,000 staff, serves customers in almost all countries of the world through a network of approximately 380 production sites and in 2012 had a turnover of $98 billion. Orientation toward the future, as well as long-term thinking are two characteristic elements of the BASF culture which, to a large extent, have their roots in the intensity of assets and capital within the chemical industry, associated with large investment risks, as well as in the long term planning processes, which are necessary for research.

(continued)

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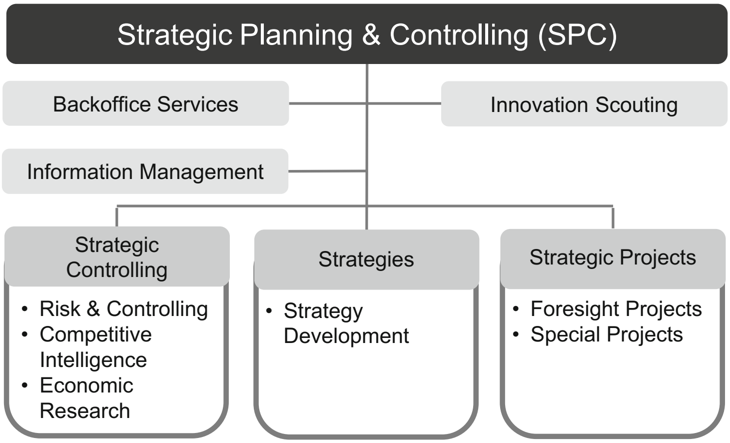
Strategic management has a long tradition with BASF. Founded on decades of experience in strategic trend research and futurology, the strategic foresight process is led by "Strategic Planning & Control" (SPC). This area reports directly to the chief executive. Its primary tasks are to identify long-term profitable business areas, promote synergies throughout the corporation, as well as coordinate and monitor strategy development and implementation. As illustrated below, the SPC area is organized into three staff units (i.e., back office services, information management, and innovation scouting) and three sub-areas (strategies, strategic control, and strategic projects), with approximately 40 staff altogether.



Structure and task fields of the BASF central area "Strategic Planning & Control "

As part of strategic foresight activities—denoted as "futuring" within BASF—diverse methodological approaches (e.g., middle- and long-term trend monitoring, "wargaming", scenario analysis, technological forecasting, delphi studies) are used to construct a systematic information base for strategic planning and, by association, the innovation strategy. The generation of information happens at the level of general influencing factors (e.g., demography, globalisation), as well as at the industry level. On the basis of this outside-in orientation ensues a discursively developed strategic planning which integrates the various company levels: business unit strategies are developed on the lowest, regional strategies on the middle and the corporate strategy, as integrating factor, on the upper level.

Source: BASF [1], Müller [2]

4.2 Innovation Strategy as Part of the Corporate Strategy

Life cycles are becoming increasingly shorter making successful innovations indispensable for the long-term success of a business. This implies that a business needs a consistent innovation strategy, yet this strategy cannot be developed in isolation from the corporate strategy. The innovation strategy is therefore a central component of the strategic planning for the business as a whole [3].

4.2.1 What Does Strategy Mean?

The term strategy originated with the Greek word "stratégos", which is a composition of the words "stratós" (= army) and "ágein" (= to lead). The term strategy therefore stands for the "art of commanding an army". So it is not surprising that strategy in businesses shows parallels to that of the military sector. For centuries numerous principles for business strategies were derived from military practice [4]. Despite these similarities, it is necessary to make a clear distinction between business strategies and military strategies, as the former aim primarily at the satisfaction of customer requirements (not primarily a reaction to the actions of the competition). The aim of a business is not to employ the necessary resources in order to destroy the enemy—i.e., the competition—as in a war. The aim is rather to use appropriate strategies (including a suitable innovation strategy), based on the potentials and competencies available within the business, in order to remain competitive [5].

According to the classical understanding of strategy in the management literature, a strategy is a planned package of measures which a company uses in order to achieve long-term goals [6]. The main characteristics of a strategy would therefore be [7]:

- High complexity,
- Long-term nature and continuity,
- Deliberate planning and shaping of objectives,
- Responsibility of the top-management,
- Strict orientation on objectives, and
- Adaptibility with regard to possible changes within the business and its environment.

However, Mintzberg [8] points out that the classical understanding of strategy, as outlined above, only reflects one part of reality, since the question of strategy implementation has been ignored. Therefore, he refers to that part of an ex-ante planned strategy (*intended strategy*) which is actually imlemented as a *deliberate strategy*, whereas he refers to the part that is not implemeted—e.g., due to wrong assumptions or problems of implementation—as *unrealized strategy*. The strategy that can ultimately be observed in reality (*realized strategy*) can either be composed of the already mentioned deliberate strategy or alternatively, of an *emergent strategy*. The latter results, for example, from a situational adaptation of an intended strategy, or from a completely new strategic orientation. These considerations, visualised in Fig. 4.1, reveal that the classical understanding of strategy corresponds

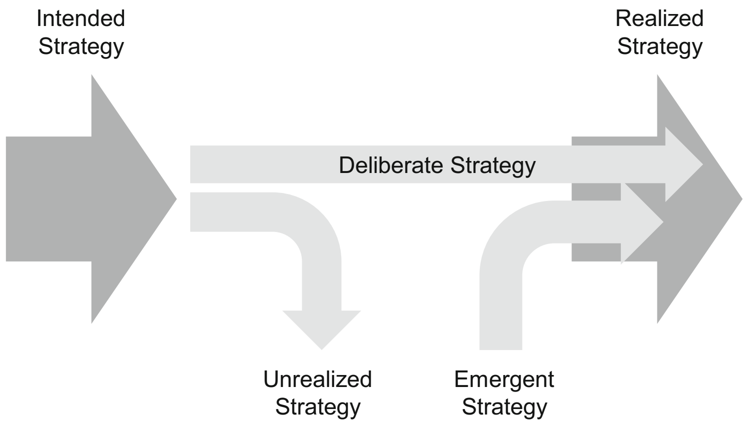


Fig. 4.1 Types of strategies (Based on Mintzberg [8])

to that of a deliberate strategy. However, the realized strategy does not necessarily have to be the result of ex-ante planned activities. Therefore Mintzberg [9] defines a strategy more generally as a *pattern of consistent actions*, independently of whether they are intendend or not.

4.2.2 Innovation Strategy and Strategic Business Management

As illustrated in Fig. 4.2, the innovation strategy needs to be understood as an integral component of long-term strategic business management. Ideally, the latter is oriented on the *corporate vision*, which reflects the long-term objective, as well as the fundamental values of a business. The corporate vision forms the basis for the determination of concrete *corporate objectives*, which again form the basis for the formulation of the *corporate strategy*. Based on the corporate strategy the *innovation strategy* is formulated. The latter aims at realising the long-term innovation objectives of a business and serves the optimum allocation of resources [10].

With regard to the understanding of the innovation strategy in the context of strategic business management, the two approaches shown in Fig. 4.3 can be identified [11, 12]. The innovation strategy can be understood as a *functional strategy* that stands alongside other functional strategies, such as marketing, production, finance or human ressources, yet with distinct tasks and aims. In this case the innovation strategy comes close to an R&D strategy. However, there is a risk of functional isolation, which is counter-productive for the realization of innovation-promoting synergy potentials between business functions. In this respect, it seems expedient to understand the innovation strategy as a *meta strategy*, which serves to integrate all other functional areas of a business. This is accomplished by making relevant knowledge within all functional areas available for innovations and by

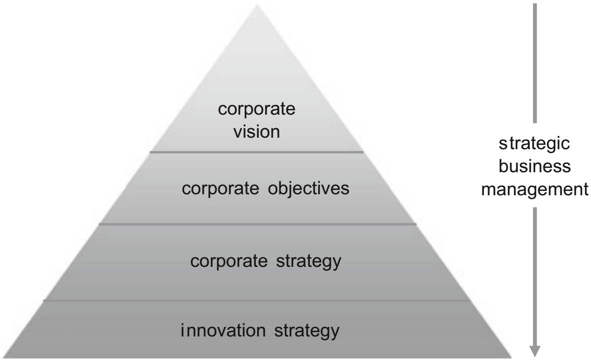


Fig. 4.2 From corporate vision to innovation strategy

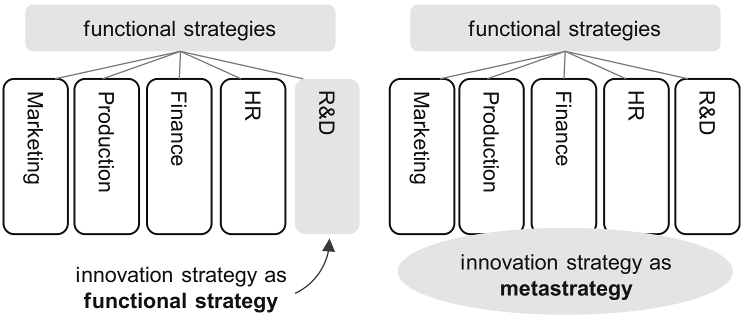


Fig. 4.3 Alternative views of innovation strategy (Based on Vahs and Brem [13])

prioritising the resources specific to each area according to the set innovation objectives. The consequent cross-sectional character of the innovaton strategy demands a comparatively high effort invested in communication and coordination to integrate the individual areas of a business. Nevertheless, this is offset by the potential to increase the business' innovation capacity.

4.3 A Closer Look at Innovation Strategy

First, a close examination of the innovation strategy is offered including how it manifests itself in business practice. Last, the contribution of the innovation strategy and its potential to reduce uncertainty will be demonstrated.

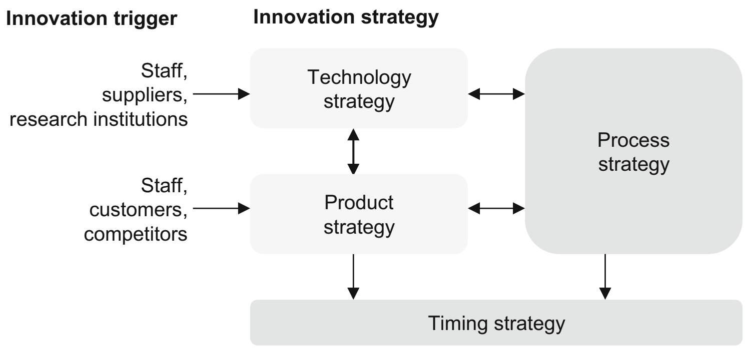


Fig. 4.4 Components of the innovation strategy (Based on Vahs and Brem [15])

4.3.1 Components of the Innovation Strategy

Here, the term innovation strategy will follow the thoughts of Vahs and Brem [14], which charaterize an innovation strategy by means of four content components, namely those of technology, product, process and timing strategy.

As illustrated in Fig. 4.4, there are interdependencies between the various components of innovation strategy. Thus, new technologies and processes which have been inspired by staff, suppliers or research institutions make the development of new products possible. Alternatively, new products that have been initiated by staff, customers or competitors, can be the trigger for the development of new technologies and processes. The four components of the innovation strategy can be characterised in detail as follows:

- [***R&D***] *Technology strategy*: This strategy is used to determine which technologies should be devoloped and which should be abandoned. The technology strategy is of particular significance, as many groundbreaking innovations are induced by technology rather than the market.
- [***MKT***] *Product strategy*: With product strategy, the decision is which products are going to be developed, kept or eliminated. Thus, it becomes clear that there is a great interdependence between the product strategy and the product policy within marketing. The product strategy must not operate on the level of individual products, but rather needs to take account the overriding aspects of the *product-mix* [16]. Thereby the product mix is initially characterised by the two dimensions of *breadth* and *depth*. The former refers to the amount of product lines in the product mix, whereby a product line encompasses products that are closely related to each other on the basis of of an appropriate criterium (e.g, customer requirements). The depth, however, describes the amount of products or product variants within a product line. Besides the breadth and depth, the *consistency of the product mix* also needs to be considered. This refers to the extent to which the individual product lines are connected, whereby this connectedness can be viewed from the perspective of the supplier (e.g., similarities in manufacturing the products) as well as the buyer (e.g., similarities in the usage

of the products). These factors illustrate that a company can only develop a balanced product strategy, if the three dimensions of breadth, depth, and consistency of the product mix are simultaniously taken into consideration.

- [***R&D***] *Process strategy*: The process strategy frequently results from the chosen technology and product strategy. Initiation of process innovations from new technologies is expected to lead to a cost reduction and quality improvements. New products can lead to process innovations, especially when they are necessary for the manufacturing process.
- [***MKT***] *Timing strategy*: After the determination of technology, product and process strategy, decisions need to be made with regard to the timing of the new invention, i.e., the time when the development of product and processes needs to be completed (*timing of inventions*), and the time when the product should be launched in the market (*timing of innovation*). If existing products are to be replaced by new ones, it is necessary that the timing strategy is harmonized with the life cycle of the existing products.

4.3.2 Characteristics of the Innovation Strategy

While an innovation strategy should address all components identified in the previous chapter, it also must account for diverse business or situation-specific characteristics. These characteristics refer to the activity type of the innovation strategy, the trigger for the formulation of the innovation strategy, and the timing of the innovation.

- [***MKT***] *Activity type of the innovation strategy*: Urban and Hauser [17] distinguish between *reactive* and *proactive characteristics* of the innovation strategy. Reactive means to deal with the pressures as they occur, whereas a proactive strategy explicitly aims at allocating resources to preempt undesirable future events and achieve goals. Thus, for example, a reactive behaviour pattern would correspond to waiting until a competitor launches a new product and if it is successful, copying it. A proactive approach would attempt to beat competitors with a new product difficult to copy or improve upon.
- [***MKT, R&D***] *Trigger for the formulation of the innovation strategy*: An innovation strategy can originate either with newly developed technologies or processes (*technology push*) or with the requirements of customers (*market-pull*) [18]. In the first case, the innovation activities are primarily driven by competencies in terms of an inside-out orientation, whereas the second case presents an outside-in approach, where innovations are developed with the aim to satisfy specific, even if sometimes only latently existing, customer requirements. When innovation projects are analyzed, it becomes evident that both of these ideal types (i.e., tech. pull or market push) rarely appear in their pure form. Independent of what is driving the innovation strategy, the requirements and needs of the customers must be met through appropriate product offerings.

- [***MKT***] *Innovation timing*: As explained in Sect. 4.3.1, innovation timing refers to the moment when the product enters the market and is an integral component of the innovation strategy. On the basis of the market entry of the product, the following characteristics of the innovation strategy can be distinguished.

  When following a *pioneering strategy* (first-to-market), a company aims to occupy the role of innovation leader and hence to be the first to introduce new developments into the market. The core idea is to generate a first mover advantage, i.e., at least a temporary competitive advantage. Furthermore, the reputation as pioneer can result in an image advantage. These advantages, however, are countered by the fact that the pioneer first needs to develop the market for an innovation often requiring significant expenditures [19, 20].

  A second option, regarding the timing of market entry, lies in implementing an *imitation strategy*, whereby the innovation activities of competitors are observed and promising innovations imitated. Here, a business can either occupy the role of the *early* or the *late follower*. The former enters the market shortly after the pioneer with a comparable achievement, while the latter waits until market developments and the buyer behaviour are stabilised before entering the market. The essential opportunities, which result from pursuing an imitation strategy, rather than a pioneering strategy, lie in minimizing expenditures and risk of market entry, while exploiting the experiences of the pioneer for the optimization of their own product. However, the problem with this strategy is that no pioneer advantages can be gained; it is merely possible to obtain the status of a productivity or efficiency leader. If the requirements of the potential customers are already satisfactorily met by the pioneer, substantial barriers need to be overcome in order to be competitive within the market [20].

  It needs to be mentioned that in multi-product companies the aforementioned options for innovation timing are usually softened in favor of a strategy-mix, which is dependent on the individual market situation and the availability of resources. It is hardly possible to be innovation leader in all areas. For that reason, imitation products are often used to round off a portfolio [21].

4.3.3 Innovation Strategy and Uncertainty

As explained in Chap. 1, uncertainty can be viewed from the perspectives of both the supplier as well as the buyer, whereby the former perspective is relevant in the context of strategic planning. If the deliberations of Wiltbank et al. [22] are followed, the classical strategic management literature knows two fundamental options for how firms can decide what to do next: They should either try harder to predict better or move faster to adapt better. Which option is to be preferred depends on how a company estimates its ability to predict changes in its environment. Irrespective of whether a company decides to follow the *planning approach* (“deliberate strategy”) or the *adaptive approach* (“emergent strategy”), the essence of both approaches is the *positioning of the organization* within an *exogenously given environment*.

If the rational planning approach is followed, it implies that with the increase of uncertainty, organizations, which are better able to analyze and predict changing situations, are more successful than organisations which do not have this ability. Alternatively, the adaptive approach suggests that organizations have to be flexible and react quickly to changing situations in order to be successful. In contrast to the planning approach, uncertainty is not met with a predictive ability, but rather the company is positioned in such a way, that it is possible to react fast and flexibly to uncertain and unpredictable events. Thus, it becomes clear that the fundamental difference between the planning approach and the adaptive approach lies in its *dealing with uncertainty*.

Planning and adaptation are to be regarded as ideal-typical approaches in reference to the positioning of the organization within an exogenously given environment. In business practice, however, these approaches can easily combine. Thus, Grant [23] talks of "*planned emergence*" when he observes businesses that meet uncertainty by reducing their planning activities in favor of adaptive and flexible solutions and are thus looking for a balance between strategic guidelines and a pure emergent strategy.

Wiltbank et al. [24] demonstrate that the positioning approach outlined, with its ideal-typical options, planning and adaptation, can be challenged by *construction strategies* with *visionary* and *transformative approaches* as ideal types. "While positioning deals with the relative emphasis on prediction and navigating an exogeneous environment, construction deals with deliberate efforts to make the environment endogenous" [25]. This implies that, compared with positioning strategies, construction strategies choose a different approach to overcoming uncertainty, in that they attempt to *control the uncertainty inducing environment* to the largest possible extent by active measures. Depending on how this control is exercised, the approach is either visionary or transformative. "Visionary approaches have strong connections with predictive approaches to strategy, and embody heroic notions of insightful and persistent entrepreneurs that seem to impose their will upon the world. Transformative approaches focus on co-creating goals with others in a mutually persuasive process where action often precedes clear goals and predicted outcomes. Actors using this type of strategy transform extant means into new futures" [26]. Figure 4.5 summarises these reflections graphically.

Wiltbank et al. deal with positioning and construction strategies and the associated possibilities to overcome uncertainty within the context of the corporate strategy. As the innovation strategy is directly derived from the corporate strategy (Cf. Sect. 4.2.2) it can be assumed that the same approaches to overcoming uncertainty are found on the level of the innovation strategy. This becomes clear when contrasting where innovation is a result of the systematic analysis of buyer preferences (positioning strategy) versus companies that reduce uncertainty by revealing previously unknown preferences through innovative products and are able to control the thereby newly emerging markets (construction strategy). Apple, with products such as the iPod, iPhone or iPad is an example for the latter approach.

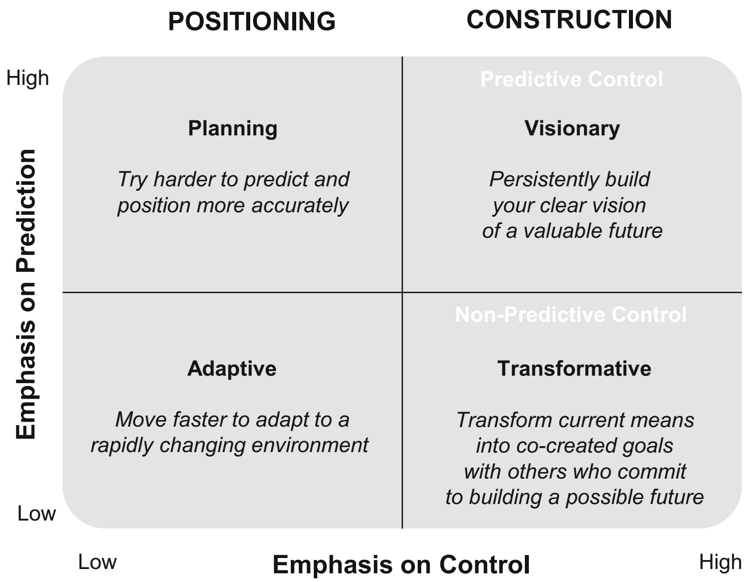


Fig. 4.5 Framework of prediction and control (Based on Wiltbank et al. [27])

4.4 Bringing Innovation Strategy to Life: A Process Oriented Approach

As was shown in the previous chapter, companies can use different approaches for dealing with uncertainty on the strategic level. When a *process-oriented approach* to the innovation strategy is subsequently outlined, there is a strong *emphasis on prediction*. This does not mean, however, that innovation strategies are always the result of a systematic and plan-based procedure. Nevertheless, strategies with low emphasis on prediction, due to their nature, cannot be described systematically, which means that only a predictive approach to strategy can ultimately be the object of the following considerations.

The process-oriented approach to the innovation strategy, as illustrated in Fig. 4.6, is based on four phases. The strategy process begins with a situation analysis, which serves as a collection of necessary information from within and outside the company. As soon as this information is available, the innovation strategy can be formulated in the second phase and thereby a long-term plan can be drafted. The third process phase encompasses the implementation of the strategy and aims at putting the strategy into action. The process is completed with an evaluation and control phase in order to measure the performance of the innovation strategy. If it does not meet expectations, there can be repercussions on individual or several preceding process steps and corresponding learnings may be triggered.

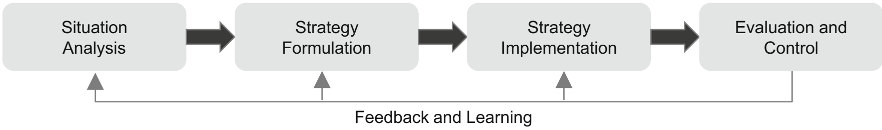


Fig. 4.6 Process-oriented approach to the innovation strategy (Adapted from Wheelen and Hunger [28])

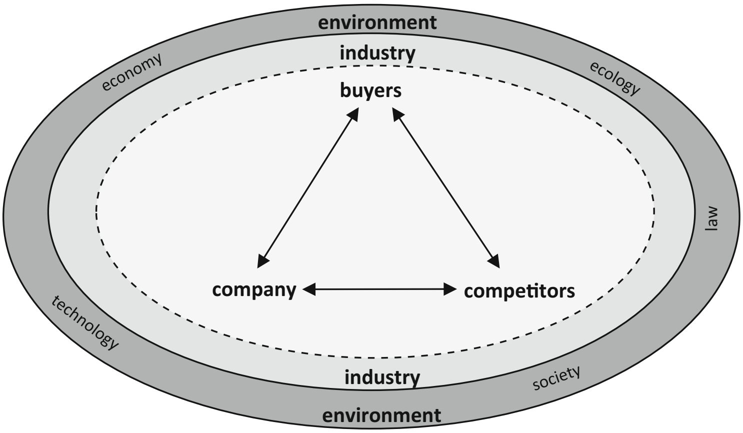


Fig. 4.7 Fields of information of the situation analysis

4.4.1 Situation Analysis

Before a company can start with the formulation of its innovation strategy, it needs to create an appropriate information base. On one hand (as illustrated in Fig. 4.7), the task of the situation analysis consists of the collection, analysis, preparation and communication of information about the status quo of the company itself and the relevant company environment (industry environment, industry, buyers, competitors). On the other hand, the situation analysis also needs to deal with future developments [29].

The situation analysis is characterised by a high degree of complexity. As can be seen in Fig. 4.7, a multitude of factors need to be considered which have an impact on the formulation of the strategy. Moreover, these factors influence each other, and the uncertainty about future developments further reinforces the complexity. In order to control this complexity, it is necessary to base the situation analysis on an appropriate structure. One such structure is illustrated in Fig. 4.8 and forms the frame of reference for the following explanations.

4.4.1.1 Company Analysis

[***MKT, DES, R&D***] The *value chain analysis*, which originates from Porter [30] forms the starting point for the company analysis. The value chain of a company consists of various value activities, on the basis of which valuable products and

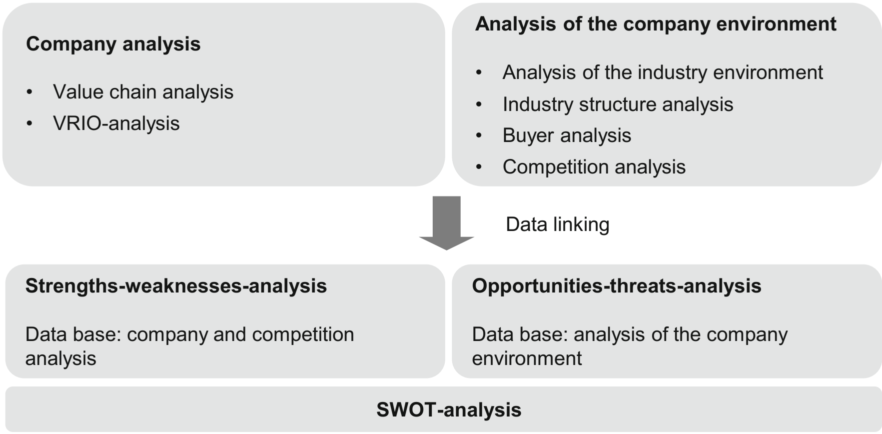


Fig. 4.8 Structure of the situation analysis

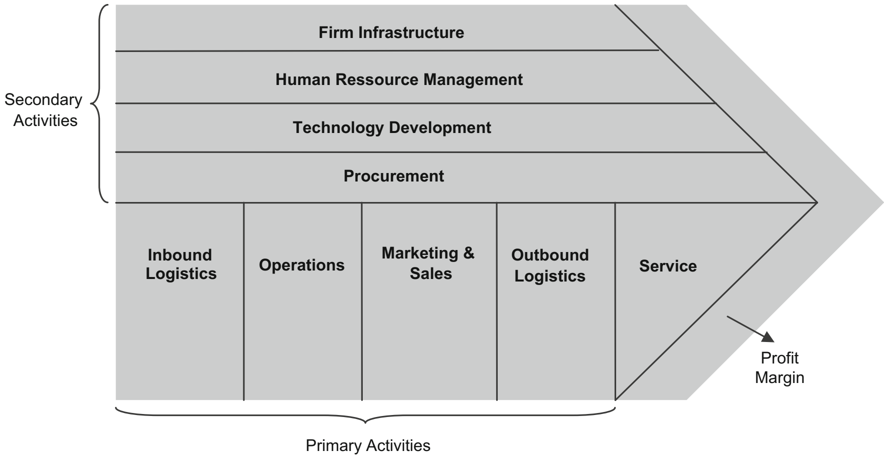


Fig. 4.9 The value chain according to Porter [31]

services for customers can be delivered, which in return promote a corresponding profit margin for the company.

As illustrated in Fig. 4.9, the value activities of a company can be divided into primary and secondary activities. Primary activities refer to the physical production and marketing of products or the generation of services. These activities are subject to a logical sequence which starts with the activities at the beginning of the generation of products or services, and ends with the activities that relate to contact with the customer. Secondary activities, on the other hand, facilitate und support the generation of products or services and therefore the primary activities.

All value activities and the associated resources and abilities represent building blocks for the achievement of competitive advantage. Even though the value chain analysis creates a systematic approach to sources of competitive advantage, it does not yet state wherein starting points for competitive advantage actually consist.

Table 4.1 The VRIO-scheme (Adapted from Barney [33])

Valuable?	Rare?	Difficult to imitate?	Exploited by organization?	Competitve implications
No	–	–	–	Competitive disadvantage
Yes	No	–	–	Competitive parity
Yes	Yes	No	–	Temporary competitive advantage
Yes	Yes	Yes	No	Sustained competitive advantage
Yes	Yes	Yes	Yes	Core competency

In order to answer this question, the value chain analysis should be supplemented by a *VRIO-analysis*.

[***MKT, DES, R&D***] The VRIO-approach, developed by Barney [32], serves the identification of core competencies, which can be understood as the highest possible manifestation of competitive advantage. The term 'VRIO' stands for the initials of the following four key questions which are used for the identification of core competencies:

- *The value question*: Do the respective resources and abilities of a company permit an adequate reaction to opportunities and threats from the company environment? Answering yes to this question means, that the respective resources and abilities are valuable for the company.
- *The rarity question*: Are only a few (or no) competitors in possession of the respective resources or abilities? If yes, these are classified as rare.
- *The imitability question*: Is it impossible, or hardly possible (i.e., only at a high costs) for competitors to imitate resources and abilities of a company?
- *The organization question*: Is a company organised in such a way that its valuable, rare and unimitable (or hardly imitable) resources and abilities can be optimally exploited? If this question can be answered with yes, the highest possible manifestation of a competitive advantage for the respective resource or ability—and therefore a core competency—has been achieved.

Table 4.1 demonstrates the logic of the VRIO-approach as a whole. If a resource or ability is not valuable, questions about rarity, imitability and optimal usage by the company are irrelevant—there exists a competitive disadvantage. If a resource or ability is valuable, but not rare, a competitive parity is given. If a resource or ability is rare, but easy to imitate, then there is a temporary competitive advantage. A sustained competitive advantage exists, if the question whether the respective resource or ability is optimally exploited is the only one to be answered with no. If this question can also be answered in the affirmative, a core competency is existent, based on the logic of the VRIO-scheme.

4.4.1.2 Analysis of the Company Environment

[***MKT***] The first section of the analysis of the company environment is the analysis of the *industry environment*. This analysis covers factors external to the company, which can be of a quantitative as well as a qualitative nature and exert an influence over the relevant industry. These factors cannot—or only to a limited extent—be controlled by the company itself. Quantitative factors, for example, cover general price trends, while qualitative factors, for example, relate to the technological dynamics, change of values or altered legal situations. The effects that environmental changes have on industries must by no means be underestimated. For example, a change in social values (e.g., ecology trends) can lead to completely new markets within the automobile industry (e.g., electromobility), which supercede successively traditional markets (e.g., cars with conventional motor). In order to anticipate such developments and to put timely, precautionary measures in place, the relevant industry environment needs to be analyzed regularly.

[***MKT***] A second sector of the analysis of the company environment is the *industry structure analysis*. According to Porter [34], the industry structure, through competitive intensity which accompanies it, constitutes an essential parameter for the profit potential of a company within a particular industry. Within this context, he identifies the following five driving forces of industry competition:

- Threat of potential new entrants to an industry,
- Pressure from substitute products,
- Bargaining power of buyers,
- Bargaining power of suppliers, and
- Rivalry among current competitors.

In order to be able to estimate the power of each driving force, Porter [35] suggests a series of criteria for each force. Ultimately, the collective power of the five driving forces of the industry competition determines the profit potential within an industry.

[***MKT***] While the buyers are already regarded from the perspective of their bargaining power within the industry structure analysis, in the course of the *buyer analysis* it is especially important to ask the following questions [36]:

- Which customer segments can be distinguished in the market?
- Which fundamental requirements do the (potential) customers have?
- In which direction will the fundamental customer requirements change?
- What changes in customer behaviour are to be expected?

A detailed analysis of buyers with regard to customer benefits is conducted at a later time (Cf. Sect. 7.3).

As well as buyers, relevant competitors are also already part of the industry structure analysis (from the perspective of the degree of rivalry among current competitors and the entry of potential new market players). [***MKT***] Contrary to this structural view, *competition analysis*, which constitutes the concluding part of the analysis of the company environment, deals with individual competitors. Therefore, some additional questions need to be answered [36]:

- How strong is the market position of the respective competitors and how does this position change?
- What are the strengths and weaknesses of the competitors?
- Which strategies are used by the competitors?

4.4.1.3 Data Linking

As illustrated in Fig. 4.8, the situation analysis is concluded by linking the data, which have been obtained in the course of the internal (company analysis) and external analyses (analysis of the company environment). Thus, with a view to the following formulation of the innovation strategy, a significant information base is available.

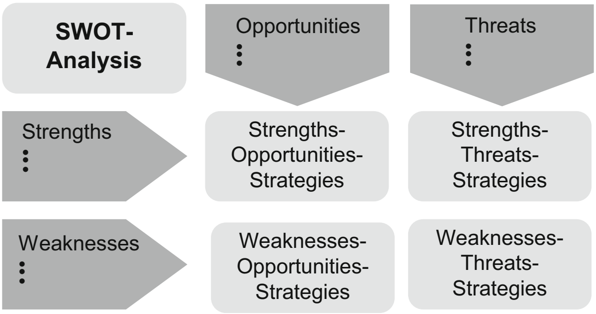
[***MKT***] The first step of data linking is to create a *strengths-weaknesses-analysis* of the company itself. A direct connection exists thereby between the above analysis and the VRIO-analyis [37]: A weakness is always present, when the respective resources or abilities of a company do not allow an adequate reaction to opportunities and threats from the company environment and are therefore not valuable for the company. Strengths, however, are present, when, based on the VRIO-scheme, at least the value question can be answered positively. The result of the strength-weaknesses-analysis is therefore a strengths-weaknesses profile of the company itself, which is differentiated according to the individual resources and abilities and based on the availability and extent of competitive advantages. Since, in the course of the VRIO-analysis, the relevant competition also needs to be taken into consideration (Cf. the rarity and imitability questions), it becomes clear, that the company analysis as well as the competition analysis form the data basis for the strength-weaknesses-analysis.

[***MKT***] The second step of data linking is an *opportunities-threats-analysis*. Opportunities and threats are consequences of the specific constellation of factors external to the company, the characteristics of which are determined as part of the analysis of the company environment. The identified opportunities and threats should be classified according to their success or threat potential, as well as with respect to the probablility of their occurrence, in order to subsequently make adequate prioritising of measures possible [38].

[***MKT***] The last step of data linking, and at the same time the basis for the derivation of strategic actions, is a *SWOT analysis*. The abbreviation “SWOT” stands for the terms “strengths”, “weaknesses”, “opportunities” and “threats”. Thus, it becomes clear, that a SWOT analysis aims at the integration of the results of the strength-weaknesses and the opportunities-threats analysis, by contrasting both results (Fig. 4.10).

If a company strength meets an environmental opportunity, the company should build up or reinforce its competencies in this area further (*strength-opportunities-strategies*). If certain weaknesses impede the utilization of environmental opportunities, the company needs to reduce the distance to the competition through increased efforts (*weaknesses-opportunities-strategies*). Company strengths that meet with environmental threats imply that the strengths should be utilized in such a way, that the given market risks are as greatly reduced (*strengths-threats-strategies*). Last but not least, company weaknesses that occur simultaneously with environmental threats lead to considerable market risks. If environmental threats cannot be avoided, every effort must be expended to remove the identified weaknesses in order to lower market risks (*weaknesses-threats-strategies*) [39].

Fig. 4.10 SWOT-Analysis (Based on Gaubinger [39])



4.4.2 Strategy Formulation

As illustrated in Fig. 4.2, the innovation strategy is derived from the corporate strategy. The situation analysis constitutes the starting point for the formulations of the corporate, as well as the innovation strategy. Therefore, as a first step resulting from the situation analysis, corporate objectives (and under certain circumstances also the corporate vision) need to be reviewed in order to be able to subsequently evaluate—and possibly adapt—the current corporate strategy. Only on this basis is it possible to formulate suitable innovation objectives (or to revise existing objectives), which in turn form the point of reference for the formulation of the innovation strategy.

The mere fact that the innovation strategy consists of four interdependent sub-sections (Cf. Sect. 4.3.1) suggests that there are generally several strategic options to achieve the defined innovation objectives. Therefore, as part of strategy evaluation and selection [40], it is necessary to evaluate possible variants of the innovation strategy on the basis of suitable criteria and methods and finally to formulate and implement the strategy variant which shows the greatest potential for achieving the objectives.

4.4.3 Strategy Implementation

Strategy implementation should be taken to mean the step by which—on the basis of an appropriate *budget* and a *systematic innovation and product management process* (Cf. Sect. 2.3.2)—the formulated innovation strategy is implemented. In the course of strategy implementation the following two principles should be considered:

- *Structure follows strategy*: Initially, this principle implies that each innovation strategy needs *organizational structures* that are appropriate to its implementation, that is, adapted to the respective strategy (Cf. Sect. 10.3). Furthermore, depending on the chosen innovation strategy, the question arises whether all innovation activities should be conducted by the company itself (*closed innovation*) or whether innovations could also extend beyond the realm of the company for the purpose of an *open innovation approach* (adoption of external innovations and cooperation with other companies) (Cf. Sect. 5.2). Since the innovation strategy—

dependent on the dynamics of the company environment—can vary with regard to overcoming uncertainty (Cf. Sect. 4.3.3), this can ultimately lead to the necessity *of making the innovation process more flexible* [41, 42].

- *Culture follows strategy*: When the question after the essential requirements for successful innovations is raised, a *company culture that fosters innovation* is regularly mentioned. The task of such a culture is to provide a framework for orientation and action that facilitates the smooth development and realization of new ideas [43]. From this perspective, each innovation strategy, no matter how well it is formulated, remains ineffective, if it does not go hand in hand with a company culture that supports its implementation.

4.4.4 Evaluation and Control

Within the systematic strategic planning of innovation, it is vital to conduct an evaluation and develop controls for strategy performance, which concludes the strategy process outlined in Fig. 4.6. In practice this means that in the case of an unsatisfactory strategy performance, that is, when the set innovation targets have been missed, *corrective measures* have to be initiated within the relevant phases of the strategy process and appropriate *lessons* should be deduced.

[***MKT, DES, R&D***] A known and proven instrument for capturing strategy performance is the *balanced scorecard* (BSC), which was introduced by Kaplan and Norton [44]. However, this does not only cover the aspect of *strategic success control*, but at the same time serves as *strategy implementation*. The BSC is based on a closed management cycle which consists of the following four steps [45]:

- Formulation of vision and strategy,
- Communication of the strategy in order to achieve commitment,
- Planning and establishment of objectives, key figures and strategic measures,
- Improvement of strategic feedback and learning.

An integral part of the BSC is the translation of the set objectives into concrete *key figures* which will be used for strategic success control for appropriate target-performance comparisons. As well as quantitative key figures, other key figures can be selected that pertain to the intangible assets of a company and are of a qualitative nature [46]. Kaplan and Norton [47] suggest four *standard perspectives* for the BSC which are in a causal relationship with each other. Figure 4.11 shows the corresponding structure of a BSC.

For the performance measurement of the innovation strategy, the BSC can be deployed in such a way that the former is integrated directly into the BSC. However, it is also possible to work with *innovation scorecards*, the logic of which is based on the balanced score card [49]. At any rate, it is decisive that the innovation strategy within the respective scorecard is operationalized by means of all parameters relevant for the strategy realization. Finally, exemplary *scorecard key figures* shall be mentioned as a means of measuring the performance of an innovation strategy—on the basis of target-performance comparisons in various target dimensions [50]:

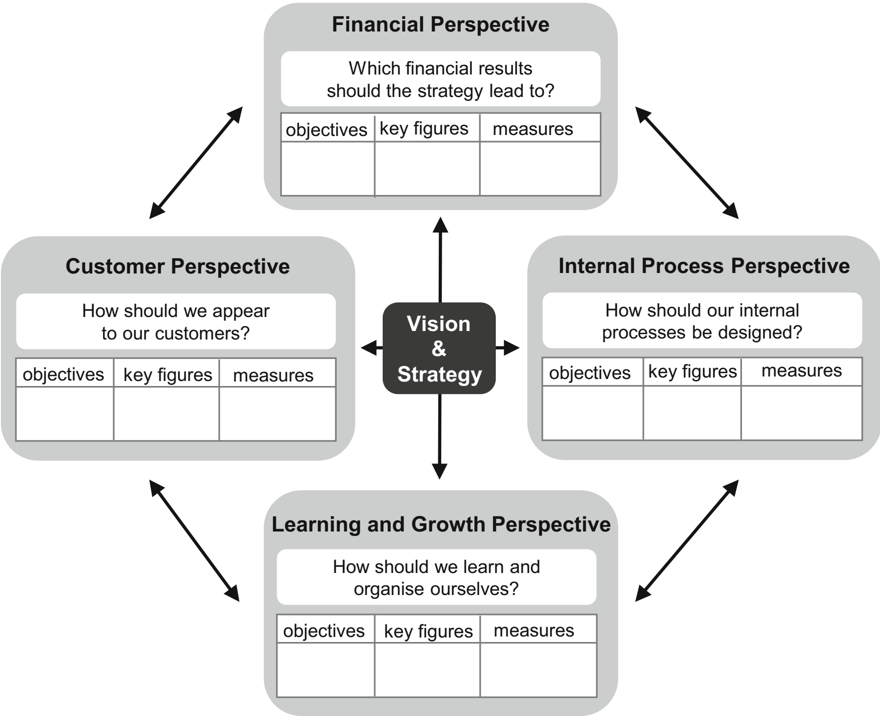


Fig. 4.11 Structure of the balanced scorecard (Adapted from Gaubinger [48])

- *Time-to-market-targets*: project duration, time-to-profit, time advantage over competitors;
- *Financial targets*: turnover of the innovation, target contribution of turnover to the total turnover volume of new products, EBITDA of innovation, targeted share of profit from new products;
- *Market targets*: degree of market penetration, targeted market share, increase of customer satisfaction;
- *Quality targets*: downtimes, complaint rates.

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Part II

Process of Innovation and Product Management

5 Idea Management and Open Innovation

5.1 Introduction

An essential *success factor* in innovation management requires first-rate implementation in the early phases of the innovation process (from innovation impulse through generating and evaluating ideas to concept elaboration). In practice, however, many companies execute the early phases in an unstructured way with few resources. Also, with both the high uncertainty of idea practicality and the low degree of documentation typical for early phases, it is often referred to as the F*uzzy Front End* of the innovation process [1]. However, since implementation quality has a high impact on innovation success, companies can manage this effect by conducting idea generation and idea evaluation in a strategic way [2].

This Chapter Will Discuss

- What are the core processes in open innovation?
- Which sources of information can be used for idea generation within the scope of innovation management?
- Which tools can be used to implement an open innovation approach?
- What are the framework conditions for successful management of ideas?

Practical Insight

Wintersteiger: Open Innovation to Support Global Market Leadership

Wintersteiger, an Upper Austrian mechanical engineering company, is involved in completely different target markets with its four business units: Sports, Seemech, Woodtech and Leveling Technology. With an overall turnover at $170 million in 2012 and an export rate at 90 %, "We are a global market leader and leading innovator in all corporate divisions, but still must not overestimate ourselves", emphasizes CFO Roland Greul. He expresses

(continued)

K. Gaubinger et al., *Innovation and Product Management*,
Springer Texts in Business and Economics, DOI 10.1007/978-3-642-54376-0_5,

that at Wintersteiger, attention will always be given to driving innovations forward, as well as operating in a customer-oriented, flexible manner and with maximum efficiency. It is for this reason that technology leadership and the innovation rate is high at Wintersteiger.

In order to strengthen its innovation performance, Wintersteiger has full-fledged innovation management that reports directly to corporate management. Dedicated employees work according to a systematic and clearly defined innovation process. The Wintersteiger idea management system is a part of this comprehensive process that incorporates lateral thinking. It was created to effectively assess the most diverse ideas. The company has adopted an open innovation approach and innovative ideas from outside the company are taken up regularly. A comprehensive methodological toolbox supports this process. The company frequently conducts expert workshops, creative meetings with customers, lead-user projects and technology discussions. The innovation network is also very important in scenarios where the company collaborates with universities, colleges, technical schools and other institutions through research projects, diploma theses and faculty work. In addition to this "outside-in approach", Wintersteiger is also open to technology transfers to other industries in the context of an "inside-out approach". This method contributes to commercializing the output of the innovation activities outside their own industry to market to a broader base.

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Source: Wintersteiger [3]

5.2 Open Innovation: A Central Approach

The open innovation approach has become increasingly important for both theory and practice over the last decade. Stronger global competition on one hand, has led to stronger cooperation between the firm's stakeholders. Also, new information and communication technologies, on the other hand, foster the efficient integration of partners into the innovation process [4]. The central idea behind this approach is that external ideas have the same importance as internal ideas and that external paths to market (e.g., through licensing, joint ventures or spin-offs) are as important as internal paths to market. According to this approach, the innovation process has

Table 5.1 Principles of closed and open innovation (Based on Chesbrough [7])

Closed innovation principles	Open innovation principles
The smart people in our field work for us	Not all the smart people work for us. We need to work with smart people inside and outside the company
To profit from R&D, we must discover it, develop it, and ship it ourselves	External R&D can create significant value; internal R&D is needed to claim some portion of that value
If we discover it ourselves, we will get it to market first	We don't have to originate the research to profit from it
The company that gets an innovation to market first will win	Building a better business model is better than getting to market first
If we create the most and the best ideas in the industry, we will win	If we make the best use of internal and external ideas, we will win
We should control our IP, so that our competitors don't profit from our ideas	We should profit from others' use of our IP, and we should buy others' IP whenever it advances our own business model

shifted from a closed system to the new mode of an open system involving a wide range of internal and, importantly, external players. This intensified integration and participation in the innovation process leads to a broader information base—both need and solution information—and therefore reduces risk and uncertainty. The following quote summarizes the basic idea of open innovation: "Not all the smart people work for us, so we must find and tap into the knowledge and expertise of bright individuals outside our company" [5]. Thus, competitive advantage often is originated from leveraging the ideas of others [6]. Table 5.1 shows the characteristics of an open innovation approach in comparison to a closed innovation approach.

Within the open innovation approach, three archetypical processes can be distinguished. By means of the *outside-in process,* the company's own knowledge base is enriched through the integration of external knowledge sources as for example customers, suppliers and other external experts. According to Enkel et al. [8], this process reflects the attitude that the *place of knowledge* creation is not necessarily equal to the *place of innovation*. Their study revealed that idea and knowledge sources are mostly clients (78 %), suppliers (61 %), and competitors (49 %), as well as research institutions (21 %). Further, partners in other industries are frequently integrated into innovation processes [8]. This supports our early integration of customers into the innovation process (see Chap. 2).

As already mentioned, commercializing ideas outside a company's own industry or traditional market is called an *inside-out process* and aims at generating profits by licensing intellectual property (IP) and/or leveraging technologies. Besides the commercialization of their own technologies in new markets, also called cross-industry innovation, the generation of new business models, such as spin-offs and new ventures, are also common activities within this approach [9].

The combination of the outside-in process with the inside-out process is called the *coupled process*. Within this stage-gate process, companies are often cooperating with other companies or their stakeholders in strategic networks and jointly developing and commercializing innovations. Enkel and Gassmann [10] find

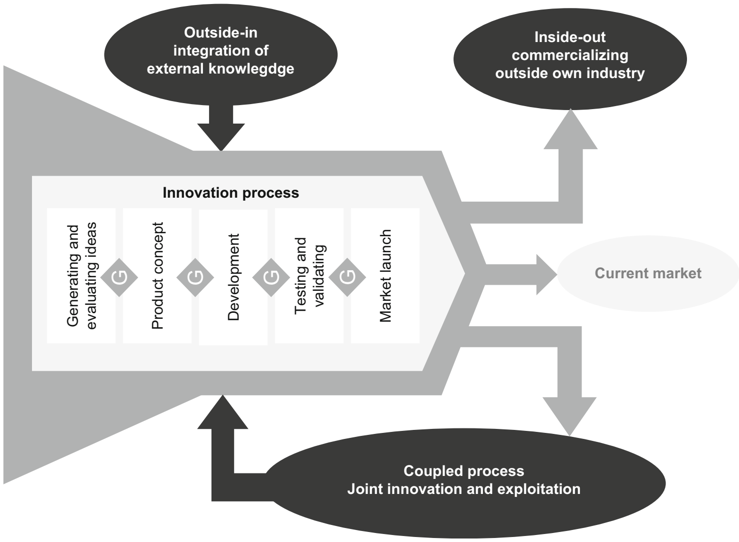

Fig. 5.1 Three core processes for open innovation (Adapted from Chesbrough [12] and Enkel et al. [8])

that in high-tech industries, the number of joint R&D projects comprises almost 50 % of a company's R&D projects. As with most cooperative projects, a balanced give-and-take is crucial to success [11]. Figure 5.1 summarizes the basic ideas of these three approaches.

The above discussion shows that due to the outside-in process of the open innovation approach, valuable sources of knowledge can be located within as well as outside the company. This topic is discussed further in the following sections.

5.3 Gathering Ideas

In general, the starting point of the idea finding process is, firstly, the set of discrepancies between the actual state and the target state. Secondly, it consists of business opportunities identified through the analysis of the business environment. Based on those findings, techniques are implemented for gathering problem-solving strategies, referred to as *ideas*.

5.3.1 Collection Versus Generation of Ideas

[***MKT***, ***DES***, ***R&D***] Depending on the problem-solving strategies' degree of novelty, ideas can be gained in two ways [13]:

- *Collection of ideas:* Existing ideas are gathered from a variety of sources, e.g., customers, suppliers, employees, competitors, etc. In this process, no attempt is being made to generate new ideas. It is assumed that for most problems, solutions have already been found and that they only have to be systematically collected. In this way, scarce resources are being conserved.
- *Generation of ideas:* The development of new problem-solving strategies is actively supported in many cases by the application of creativity techniques [14]. In this process, ideas previously not available to the company, are being developed. This process can consist of inventing novel ideas as well as further developing and customizing existing products and problem-solving strategies [15].

In business practice, the two processes are usually implemented in parallel or in a supplemental fashion to *maximize the variety of ideas*. The likelihood of finding a more radical solution increases exponentially with the number of solution variants. Idea generation offers a high potential for future-oriented solutions. There is also a strong correlation between the number of ideas and the likelihood of useful ideas [16].

Very often, idea generation is considered to constitute the beginning of the innovation process but this is myopic. This perspective disregards the necessity of a concrete goal; it is possible to generate many ideas without any of them providing a solution to an important problem. Therefore, the actual idea finding process has to be proceeded by the definition of *search fields*. Based primarily on strategic goals of the company, these fields provide a concrete direction for search and development.

5.3.2 Definition of Search Fields

[***MKT***] Within the framework of innovation management, search fields constitute the link between strategic innovation planning and *gathering ideas*. Search fields are usually defined on the basis of strategic goals of the company by using tools such as SWOT analysis, analysis of competitors, portfolio analysis, futuring and scenario analysis [17]. In defining a search field, the most important thematic fields for generating ideas are established in order to drive the company's vision in a goal-oriented way.

A widespread possibility for substantiating as well as visualizing search fields is the *cause-effect diagram*, also called a *fishbone diagram* or *Ishikawa-diagram*. Developed in the early 1950s by the chemist *Kaoru Ishikawa,* it facilitates identification of a problem's causes and depicts dependencies in the form of a diagram. It is therefore suitable for creatively finding ideas, on one hand, but also for identification of a problem, on the other hand [18]. Search fields help managers focus on problem-relevant action alternatives and assist not only the process of gathering ideas but also the utilization of the ideas.

5.3.3 Sources of Information and Ideas

We must deal with an overabundance of information sources because most of them do not yield great ideas. Experience shows that it requires a variety of sources in order to find a promising idea. As already mentioned, the inventor of brainstorming, *Alex F. Osborn,* stated this succinctly: "*Quantity breeds quality*" [19]. Usually less than 10 % of innovation ideas can be pursued further. In order to achieve this outcome, all available sources of information and ideas have to be used consistently, with the proviso that pre-selection of search fields needs to be accomplished. If the expected output of a source is, in economic terms, disproportionate with regards to the costs of its development, that development should be avoided [20]. If this economic viability check is conducted prior to the allocation of resources, the allocation can be optimized. The only caveat is that lateral thinking or using peripheral vision demands looking at relevant information outside the normal information sources, often outside the industry.

Figure 5.2 shows the most common external and internal sources of information as well as their relevance for gathering ideas. Figure 5.2 clearly shows that the focus of collecting ideas is on a goal-oriented utilization of sources of information, while their contribution in generating ideas is rather peripheral. However, by way of using creativity techniques, the contribution of individual external sources of information (e.g., customers, suppliers) as well as internal resources (e.g., employees) can be significantly increased.

Therefore, in order to increase performance in the early phase of innovation, collecting ideas entails systematic procurement and evaluation of information on ideas from all sources. Furthermore, selected sources of information have to be embedded in creative processes in a goal-directed way.

5.3.4 External Sources of Information and Ideas

The possibilities for exploring external sources of information and ideas are manifold. Opportunities for exploring new information arise in conversations with customers and suppliers, with participating in conferences, seminars, or other events, through contacts with universities or advisors, or in studying publications or patents. In accordance with the open innovation framework, companies should be aware that *where new knowledge is created* does not necessarily coincide with *where innovation is utilized*. Through exploiting external sources of information and ideas, the amount of information required to perform the task is increased, which reduces the level of uncertainty connected with each innovation activity.

5.3.4.1 Customers

[***MKT***] As affirmed by the literature and business practice, the customer is an indispensable source of ideas and information [22].Success resides only in those product innovations with which the customer associates an essential *utility*

++ : high relevance
+ : medium relevance
- : no relevance
/ : use not possible

Sources of information and ideas			Gathering ideas: Collection of ideas	Gathering ideas: Generation of ideas – Without application of creativity techniques	Gathering ideas: Generation of ideas – With application of creativity techniques
	Open innovation	Publications	+ +	-	/
		Patents	+	+	/
		Competitors	+	+	+
		Suppliers	+ +	+	+ +
		Customers	+	+	+ +
		Employees from peripheral company segments	+ +	+ +	+ +
	Closed innovation	Employees	+ +	+ +	+ +
		Documents	+ +	-	/

Fig. 5.2 Overview on sources of information and their relevance in gathering ideas (Based on Vahs and Brem [21])

advantage compared to competitors' products. Von Hippel [23] emphasized that customers "are the first to develop many and perhaps most, new industrial and consumer products". However, since customers are trapped in their own world experience and, daily challenges, explicit methods and procedures for customer integration must be employed. Particularly in the early phases of the innovation process, the big challenge consists of assessing *undefined customer* needs. It should be pointed out, that besides customer's role as valuable supplier of ideas, they could also be empowered to select ideas for further development [24].

Still, the advantages of customer integration into the idea gathering phase are counterbalanced by a series of *risks* that need to be considered. Early and intensive integration, in particular, can result in a loss of know-how to the customer and in arguments about intellectual property right. In order to minimize that risk, clear agreement has to be reached in advance. Furthermore, it is advisable to test cooperation with the customer with small projects at the preliminary stage of the innovation project [25].

Nevertheless, there are strong arguments for customer integration into the innovation processes; it enables companies to develop better products and, at the same time, to reduce costs and risks. Therefore, the important prerequisite is the willingness and ability of the customers to deliver valuable input [24].

5.3.4.2 Suppliers

Suppliers are an increasingly important source of information for innovations [26]. A trend towards a "system supplier" can be observed. The system supplier is responsible for closed product functionalities, thereby becoming a *know-how* carrier and supplier of ideas [27]. *Cooper* was able to demonstrate that ideas suggested by suppliers have a high success rate [28].

Especially in businesses characterized by a high degree of mutual dependency ("*supplier business*"), an early integration of the supplier into the product development process and a work-load sharing approach based on the concept of "simultaneous engineering" provides a great advantage and, subsequently, performance. This approach helps to avoid bottlenecks in knowledge and other resources that could negatively impact competitive advantages. For the supplier to become a valuable source of ideas and a partner in development for the producer, the latter has to build up innovation-friendly structures and processes at the preliminary stage, while connecting all participants through information technology [29]. Finally, it has to be mentioned that not all suppliers are willing to collaborate with all buyers. This situation occurs frequently when the producer has no strategic relevance to the supplier. In this case, it is important for the producer to achieve a preferred customer status with key suppliers. Possibilities to achieve this status are, primarily, *technical importance* of the customer because of a similarity of technological resources, or *commercial importance* because of purchasing volume or the existence of shared cultural values [30].

5.3.4.3 Other Competitors

[***MKT***] Within the scope of a competitive analysis, an attempt is made to obtain information about strategies, products and innovation-related strengths and weaknesses of competitors. The scope tends to be restricted to the actual state, since it is almost impossible to obtain future-oriented competitor data. [***R&D***] A widely used method in this context is *reverse engineering*. In this process, competitors' products are dissassembled in order to identify their underlying functional, construction and manufacturing principles. Though useful ideas can surely be generated this way, reverse engineering remains by and large a reactive instrument, its scope being limited to closing the current gap with the competition [31].

5.3.4.4 Publications and Patents

Publications comprise a broad range of information types that need to be further specified. Typical examples are publications and statistics by public institutions, chambers of commerce and associations as well as institutes, universities, disciplinary journals and books or publications by companies. Because all external environmental factors, including political, economic, social, technological, ecological and legal variables, can provide sources of novel ideas, publications should be scanned according to these categories [32]. This approach is recommended especially if ideas are required for the identification of product improvements, new product applications and new markets. If the search is for problem-solving strategies, this type of information is easily accessible by everyone and its use is generally limited to a description and is unlikely to contribute directly to a competitive advantage.

In contrast, a thorough analysis of published *patents* provides a variety of insights into new products, in particular new technologies, which can stimulate a company's own developments. A further advantage of patent and property right research consists of avoiding unnecessary duplications at the preliminary stage [33]. However, in order to scan and identify potentially useful patents, a company needs to have knowledge in this area, otherwise it is inefficient and not likely beneficial [31].

Practical Insight

Commend Intl.: Comprehensive Idea Sources for Intercom Innovations

Commend is a worldwide provider and innovator of intercom systems based on a comprehensive range of audio and video call terminals, servers and control desks, as well as related software and accessories. With local representation in over 50 countries, an annual turnover of $75 million and an export rate of 95 %, Commend serves markets from car parks to hospitals, universities, leisure facilities and industrial operations. The latest innovations, along with the growing convergence of intercom hardware and software, have inspired the launch of Commend's value enhancing product philosophy: "Intercom 2.0".

This translates into a strong commitment to product quality and longevity, along with an emphasis on innovation. This philosophy is reflected by Product Management working in close collaboration with other departments especially R&D and Manufacturing, in a clearly defined stage-gate process. Since its implementation, the duration of the FEI (Front End of Innovation) stages was reduced to only 3 months—a very short time by common industry standards.

Two additions to Commend's set of product managerial tools and methods have proven particularly effective to broaden the information base and therefore support Commend's product lifecycle management approach. First, "Customers' Voice" is a comprehensive customer survey package based on a balanced mix of written (on-line) and face-to-face interviews of end customers and distribution partners. The high quality of feedback data has increased understanding and the ability to meet customers' current and anticipated needs and wants. Second, Commend's internal Intranet/Extranet platform "my.commend" is designed to support internal product management workflows. It provides a company-wide, easy-to-use communication channel enabling everyone involved in the product management process to collaborate on any aspect, from finding and refining ideas to coordinating workflows and posting relevant records, test results or documentation. The key benefit lies in employees' ability to view a single platform across all partner organizations and departments. This significantly reduces redundancies and

(continued)

related costs while supporting everyone with an overview of the product lifecycle at any level of detail.

Photo: Copyright © by Commend

Source: Commend [38]

5.3.5 Internal Sources of Information and Ideas

5.3.5.1 Employees

[***MKT***, ***DES***, ***R&D***] A considerable creative potential lies with a company's *employees*. On one side are systematic and structured processes and on the other a spirit of innovation offering considerable possibilities for gathering information and ideas. An important role is accorded the employees of the R&D department, since they are already engaging with new technologies within their job responsibilities. In applying and combining these technologies as well as in further advancing the product program, an R&D employees' idea identifying process is usually undertaken from a technological perspective. Thus, in order to avoid "over-engineering", effective focus of R&D activities requires a decisive market orientation when defining search fields.

A department whose activities involve regular contact with customers is *sales*. This department always has up-to-date information on customers' needs and wishes. This information has to be systematically collected and evaluated by the sales staff. In addition to sales, the *service department* constitutes another important source of ideas and information. As persons actively engage with customers, employees in the sales department should serve as a conduit for customers' suggestions and demands to be integrated into the innovation process.

In addition to these often neglected "core inside innovators", as sources of ideas are "peripheral inside innovators". This group consists of employees across all functions, units and levels of a firm for whom "gathering ideas" is not part of their job description. With this group, ideas are offered from self-motivation, engagement, intrinsic interest and confidence [35]. To get access to this valuable source of information, a corporate proposal system or idea management system is of vital importance.

An internal idea capture system, also called an *employee suggestion system,* is an institutionalized program of generating ideas from employees. It motivates employees to participate through reflection as well as shaping their area of responsibilities [36]. Ideas and suggestions generated this way are centrally collected and evaluated by the company. A widespread form of corporate proposal systems is the continuous improvement process (CIP), also known under the Japanese term *KAIZEN* (KAI = improvement, ZEN = to the better), it denotes a long-term strategy for identifying and eliminating friction in work processes and the work environment. The CIP integrates knowledge and experience in a way that gives rise to small improvements. An attractive and transparent stimulus system [37] is a prerequisite for a workable corporate proposal system. It is only through continuous and noticeable stimuli that employees are motivated for a long-term commitment to participate. Motivation research generally differentiates between extrinsic motivation, guided by material stimuli (e.g., money, promotions), and intrinsic motivation, for which self-realization and acknowledgement are of greater importance [38]. With regards to creative processes, an adequate utilization of both stimulus approaches should be carried out. In many companies the corporate proposal system was the basis for the development of an *idea management system,* where the explicit search for ideas for innovation is the center of interest. That issue will be treated in detail in Sect. 5.5.

5.3.5.2 Internal Documents

If all the knowledge available at the company is systematically processed, stored and made usable, *document research* becomes a reliable instrument for gathering ideas.

[***MKT***, ***DES***, ***R&D***] Information relevant for innovation can be found, for instance, in planning processes in business, marketing, innovation, distribution, R&D reports, product requirement documents, analyses of the competition, market research reports, quality reports, after-sales reports with customer complaints, etc. The variety of sources demonstrates the importance of orienting the data structure on innovation activity, the goal being an efficient utilization of internal documents as a source of ideas. This can allow company documents to be tapped with reasonable ease. At the same time, they guarantee consistency with regards to previous innovation planning [39].

5.4 Open Innovation Tools

As already mentioned, many scholars and practitioners have encouraged the idea of democratizing innovation by empowering customers and other external experts to take a much more active role in product development [40]. The ever increasing functionality of the internet allows companies to build strong on-line communities through which they can integrate literally thousands of external persons and groups into their innovation processes. Success stories of open-source software projects have encouraged companies across many industries to create on-line platforms that integrate their customers into their innovation processes more directly, more actively, and more systematically [41]. This section will sketch five methods suitable for ideas at the Front End of Innovation.

5.4.1 Empathic Design

The award-winning global design firm IDEO, which takes a human-centered and design-based approach to help organizations innovate, believes that "seeing and hearing things with your own eyes and ears is a critical first step in creating a breakthrough product" [42]. This approach is also the basic principle of empathic design. This method is based on *observing users* carrying out everyday activities in relation to the object to be analyzed, in that object's operating environment. Since customers have often grown accustomed to the use of current products and may no longer notice problems in use, observation can help in identifying errors in usage as well as "home-made" problem-solving strategies. In this way unarticulated and latent customer needs can be identified which often leads to breakthrough innovations. A five step *process* is recommended for this method [43]:

- *Research design*: In a first step, it has to be clarified who should be observed and how to develop an empathetic understanding. In most cases, the target group are individuals or groups of users who perform a task. Next, the behavior is defined that should be observed along with the setting of the observation (artificial or real-life). It is also important to define the observer, because personal differences (e.g., training and education) influence the extraction of information from the observation. [***MKT***, ***DES***, ***R&D***] Therefore, the best way to capture different aspects is to send out a multidisciplinary team consisting of marketers, engineers, product designers, usability professionals, etc. [44].
- *Capturing data*: As a rule most data are gathered from visual and auditory indications. Thus, videography is a frequently used tool. Additionally, researchers may ask a few open-ended questions to get less filtered and focused information to help interpret the observed actions.
- *Analysis and reflection*: After gathering the data, team members have to reflect on what they have observed, and review each others' data that has been gathered. In this phase the team members try to identify all of the target group's possible problems, needs, and motivations.
- *Brainstorming for solutions*. Creativity phases are the most valuable parts in any innovation process. In the empathic design process, brainstorming is specifically used to transform observations into many visual representations of possible solutions.
- *Developing prototypes of possible solutions:* Prototypes specifically clarify the appearance and features of products or services as well as how they are used. [***R&D***] This helps the discussion with potential consumers of the innovation

because of their concreteness. The physicality allows easier, more realistic trial and makes it easier for potential customers to offer better feedback on elements they like and suggestions for improvements.

To manage this process, researchers must have specific skills, such as proficiency at collaborative and interdisciplinary work. Simultaneously, they need to have expertise to understand data, in particular visual and spoken data. Most important of all, the researcher should have the ability to create and present innovative prototypes, secure feedback, then quickly iterate so that each prototype's feedback can be turned into improved prototypes and ultimately result in superior products.

5.4.2 Idea Contest

Idea contests can be used very well in the early phases of an innovation process, since competition stimulates participants' creativity and improves the quality of the contributions. In an idea contest, the company asks the general public or a specific target group to submit thematically-oriented contributions. Those contributions are subsequently analyzed by a group of experts that then gives achievement-based rewards [45].

A wide range along with a rich diversity of innovation contests can be observed in practice. Bullinger and Möslein [46] give a synopsis of ten key design elements of innovation contests and their attributes (Fig. 5.3).

In order to appeal to a relatively large number of potential idea suppliers, idea contests should preferably use *on-line-based* systems. For every crowdsourcing campaign, an on-line based idea contest should be divided into three phases: a preparation phase, a campaign phase and an evaluation phase [47]. In the *preparation phase,* the on-line platform is adapted to meet the project requirements. The design of the interfaces is adapted to reflect the project hosts' corporate identity. Then a precise description of the campaign's goal and the legal terms and conditions must be added to the platform. Together the topic visualization and the description of the campaign's goal form an "idea call". The final part of the preparation phase is the training of a moderator, also called community manager. The software tool itself can support the idea collection process only to a limited extent. The main value of such a platform is created through a continuously active network of interested people. It is the community manager's role to guide and support this network. This will help keep the level of participation and involvement high.

The *campaign phase* starts with the invitation of potential community members. The invitation communication contains information on the goals of the initiative and the benefits to participants [48]. In addition, participants receive continuous reporting on the latest ideas. The collaborative mechanisms of the platform encourage participants to not only submit their own ideas but also to discuss other members' submissions [49]. All submitted ideas are normally displayed in a central trend pool. In this phase, it is also important that the community manager

<table>
<tr><th>Design element (synonyms): definition</th><th colspan="12">Attributes</th></tr>
<tr><td>1. Media (-): environment of innovation contest(IC)</td><td colspan="4">Online</td><td colspan="4">Mixed</td><td colspan="4">Offline</td></tr>
<tr><td>2. Organizer (-): entity initiating IC</td><td colspan="3">Company</td><td colspan="3">Public organization</td><td colspan="3">Non-profit</td><td colspan="3">Individual</td></tr>
<tr><td>3. Task/topic specificity (problem specification): solution space of IC</td><td colspan="4">Low (Open task)</td><td colspan="4">Defined</td><td colspan="4">High (Specific task)</td></tr>
<tr><td>4. Degree of elaboration (elaborateness, eligibility, degree of idea elaboration): required level of detail for submission to IC</td><td colspan="2">Idea</td><td colspan="2">Sketch</td><td colspan="2">Concept</td><td colspan="2">Prototype</td><td colspan="2">Solution</td><td colspan="2">Evolving</td></tr>
<tr><td>5. Target group (target audience, target participants, composition of group): description of participants of IC</td><td colspan="6">Specified</td><td colspan="6">Unspecified</td></tr>
<tr><td>6. Participation as (eligibility): number of persons forming one entity of participant</td><td colspan="4">Individual</td><td colspan="4">Team</td><td colspan="4">Both</td></tr>
<tr><td>7. Contest period (timeline): runtime of IC</td><td colspan="3">Very short term</td><td colspan="3">Short term</td><td colspan="3">Long term</td><td colspan="3">Very long term</td></tr>
<tr><td>8. Reward/motivation (-): incentives used to encourage participation</td><td colspan="4">Monetary</td><td colspan="4">Non-monetary</td><td colspan="4">Mixed</td></tr>
<tr><td>9. Community functionality (community application, communication possibility tools): functionalities for interaction within participants</td><td colspan="6">Given</td><td colspan="6">Not given</td></tr>
<tr><td>10. Evaluation (ranking): method to determine ranking of submissions to IC</td><td colspan="3">Jury evaluation</td><td colspan="3">Peer review</td><td colspan="3">Self assessment</td><td colspan="3">Mixed</td></tr>
</table>

Fig. 5.3 Ten key design elements for innovation contests (Based on Bullinger and Möslein [46])

appreciates the activities of the members regularly and gives them feedback. The community manager supervises all discussions like a moderator to avoid unfairness and inappropriate content [50]. Furthermore the quality and quantity of the ideas depend on the degree to which the contest manages to attract creative participants with relevant knowledge [51]. Therefore, it is essential to understand how the crowd can be motivated to participate.

[***MKT***, ***DES***, ***R&D***] In the *evaluation phase*, assessment of the submitted ideas can be accomplished in several ways. First, it needs to be determined, whether to apply a jury evaluation, a peer review or a self-assessment (Cf. also the discussion under Sect. 5.5). Figure 5.4 shows an exemplar with the homepage of an on-line

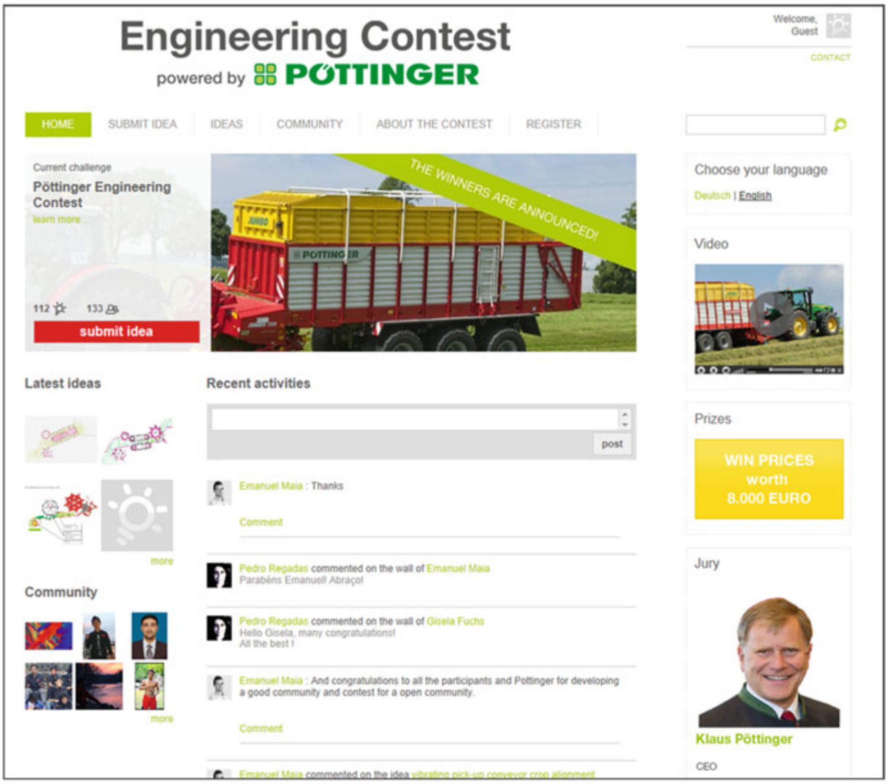

Fig. 5.4 Idea contest (*Copyright © by Poettinger*)

based idea contest accomplished by an Austrian producer of agricultural machinery.

5.4.3 Integration of Lead Users

Particularly in the early phases of innovation, the focus should be on "lead users" [52]. These are the users of products and systems whose needs correspond to the technological edge but their needs are still unknown to most others (but later will be shared by the general market). Lead users are also creatively looking for solutions to their problems and consequently, they are used as "need predictors". In their role as trend-setters with a need for progressive solutions, lead users provide concrete stimuli for the shaping of products or services [53]. In addition to the integration of progressive customers in the process of gathering ideas, the integration of experts from analogous markets can also be expedient. [***MKT***] These external industry experts have proven to be especially valuable when reducing discontinuous innovation's market risk [54] along with introducing "lateral" ideas.

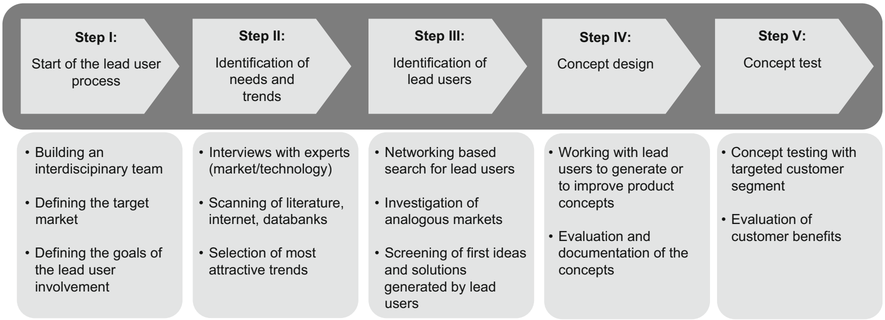

Fig. 5.5 Lead user process

Based on von Hippel [55, 56] and adapted from Lüthje and Herstatt [57], the following process for implementation of the lead-user-concept is offered (Fig. 5.5):

- *Start of the lead user process*: **[*MKT*, *DES*, *R&D*]** At the beginning of a lead user-based project, a dedicated, interdisciplinary team is selected, consisting of people from R&D, marketing, sales, industrial design and production. In a next step, the project team defines the search field (e.g., a product, service or market-oriented area), for which an innovative concept should be developed [58]. The goals of the process must be demarcated (e.g., desired degree of innovation, contribution of the project concerning company or marketing goals).
- *Identification of needs and trends* : Lead users are individuals who are ahead of their time in an important dimension. ***[MKT]*** Thus, the next step consists of the identification of that dimension. In order to keep down expenditures on the survey, a trend definition should be conducted on the basis of sector reports, technology reports and publications of external research institutions [59]. In addition, managers and engineers of a sector can be asked to identify the major expert in their area or the person they turn to when problems in this area arise. Experts identified in this way can then be asked to identify the main trend in their area.
- *Identification of lead users*: Lead users are rare and so it is difficult to detect them. ***[MKT]*** For this reason, the most challenging task of this step in the process consists in identifying users whose current *range of application* corresponds to the identified trend and who would benefit greatly from an improvement of the currently available product. In addition, lead users are *not satisfied with* the current *product as supplied*, thus willing to contribute to its *further development* [60]. Those specific characteristics of lead users have to be converted into a set of questions adapted to the innovation process, identifying innovative users via screening or pyramiding. In the pyramiding method, innovative users are identified via "snowball sampling" starting out from a small number of people and gradually creating a network of appropriate experts via recommendations. This method is especially appropriate when the group of innovative customers is difficult to define and when there is a strong social network within the target group. This search technique is thus particularly effective for complex, technical problems.

If the group can be defined, the search method of choice is *screening*. In this method, classical market research methods are used to question a representative sample with regards to its lead user qualities. Based on their responses, appropriate respondents can be selected. Weaknesses of screening are low sample efficiency, high search costs and the reliance on the self-assessment of respondents. Thus, the elaboration of efficient lead user identification methods is still a major challenge to researchers. In particular due to the growth of the internet and the related rise of on-line communities, the task of identifying lead users is now often accomplished by e-mails, on-line forum posts, and broadcasts to community websites [61]. In this context a new method, known as "netnography", is being considered as an effective way to find lead users. Netnography combines the internet and ethnography by using publicly available information to identify on-line communities of interest and study them (e.g., behavior) without active participation [62]. For lead user identification, the posts of the most active community members are compared to the set of lead-user characteristics. In addition, innovation competitions and toolkits (Cf. Sect. 5.4.4) can also help in identifying innovative customers, users and experts for open innovation. For radical innovations, in particular, lead users and lead experts should be found in analogous markets [63]. Analogous markets resemble each other in terms of their needs and/or the technology, but belong to different sectors.

- *Concept design*: [***DES***, ***R&D***] With regards to concept development, the options are to either choose a small group of lead users or simply one pacemaker customer, then to develop an innovative product concept in a collaborative workshop. The goal of this workshop does not have to be the complete development of a product concept. Lead users' inputs constitute valuable information but there are often limits on how much they can delineate the development process [64]. In this context, von Hippel [65] stresses the need for integrating R&D employees, lead users and the marketing department ("joint problem-solving"). In this type of pull-approach, innovations are directly induced by the market. The involvement of the R&D department increases the effectiveness of the innovation process by reducing departmental self-reference. Furthermore, it can countervene the frequently encountered "not invented here" (NIH) syndrome. Finally, it needs to be stressed that based on the collaborative process of idea generation and product conception, clear policies on the remuneration for ideas and their commercialization must exist from the beginning.
- *Concept test:* [***MKT***, ***R&D***] Preceding product development and the development of a marketing strategy, the concept must be tested first by average users [66]. In these tests, the newly-developed concept is evaluated in relation to existing concepts. Target customers are presented with a description of the different concepts and subsequently evaluate them. Based on the results, companies can draw conclusions on customers' preferences and purchasing decisions. To obtain the potential utilities of each product feature and its tradeoffs, a conjoint analysis can be conducted. Von Urban and Hippel empirically show that "average users" prefer the product conceptualized in conjunction with lead users. Furthermore,

they demonstrate that lead users' preference structures are not significantly different from average users' preference structures. This validates the utility and expressive power of the lead-user approach [67].

5.4.4 IT-Based Innovation Toolkits

The development and diffusion of IT-based innovation toolkits are essentially driven by the evolution of hardware, software and the improved usability of web 2.0 applications. Von Hippel and Katz [68] define toolkits for user innovations as "coordinated sets of 'user-friendly' design tools that enable users to develop new product innovations for themselves." Using graphic or visual representation, open innovation toolkits facilitate the articulation of customer needs for "normal" users as well as lead users [69]. For a successful implementation, open innovation toolkits have to fulfill five basic requirements (see von Hippel and Katz [70], Reichwald and Piller [71]):

- *Learning by doing via trial-and-error:* Toolkit users tend to be more satisfied with a solution generated by themselves if they have run it through the entire problem-solving cycle. Therefore, they need feedback on the solution simulated with the toolkit. This allows for an evaluation followed by an iterative improvement of the solution. In general, this "learning by doing" dramatically improves the quality of the solution.
- *Appropriate solution space*: The solution space of a toolkit defines all variations and combinations of feasible solutions. As a rule, the solution space should only allow for variants and combinations that are technically feasible from the point-of-view of the producer.
- *User friendliness*: This requirement describes how users perceive the quality of interaction with the toolkit. User friendliness is influenced to a large extent by the fun factor in development, the satisfaction with the solution and the investment of time and intellectual resources. Heterogeneity of these factors necessitates different toolkit versions.
- *Modules and components*: Modules and components are the building blocks of a toolkit (e.g., programming languages, visualization, libraries), which make up its operational functions and are available to support problem-solving.
- *Transfer user design*: This requirement is met after internal toolkit users have developed their solution for manufacturing or the concept has been transferred to the company from outside. A transfer of this kind entails a flawless translation of the customer solution into the language of the seeker or manufacturer.

[***MKT***, ***DES***] Toolkits vary in terms of their goals, their designated target groups and their design principles [72]. Three basis types can be distinguished. They are depicted in Table 5.2.

Based on motivation research, Füller [74] identifies ten motive categories that help explain why customers engage in virtual co-creation projects (see Table 5.3).

Understandably, not all motive categories are relevant for all consumers participating in virtual co-creation projects. In this context four differently

Table 5.2 Categories of toolkits (Based on Reichwald and Piller [71], Möslein [73])

	Goal	Principles	Users
Toolkit for user innovation	Creation of new ideas and new concepts Creation of new features	Broad solution space Compares to a "chemistry kit" High cost of usage Trial-and-error	Innovators with lead-user characteristics
Toolkit for user co-design	Customization through product configuration (sales tool)	Restricted solution space Compares to a "Lego kit" Low cost of usage (standard modules) Partial trial-and-error	All kind of innovators
Toolkit for idea transfer	Transfer of existing innovation ideas from users to manufacturers and/or form solvers to seekers	Unlimited solution space Compares to a "blackboard" Low cost of usage No trial-and-error (only feedback)	Innovators with lead-user characteristics

motivated consumer types engaging in virtual co-creation can be identified. *Reward-oriented consumers* are motivated to engage in virtual co-creation mostly because of their desire for monetary rewards. In many cases they are late adopters and show moderate interest in virtual new product development as well as moderate web usage. The *need-driven consumers* however participate in co-creation mainly because they are dissatisfied with available solutions on the market. These types of consumers can be characterized as highly skilled early adopters with highly exploratory behavior and a high interest in virtual new product development. Curiosity, as reason for participation in co-creation, is extraordinarily important for the third group. These *curiosity-driven consumers* are ranked among the early majority in product adaption but show a moderate to low exploratory and novelty seeking behavior. The *intrinsically-interested consumers* yield high on every motivational aspect connected with the innovation activity but don't respond to monetary rewards. Normally this consumer type is highly skilled, likes to fiddle around, solve problems and also has a high interest in virtual product development [76].

Ideally a company should target all envisaged types of consumers with its virtual co-creation platform and meet their expectations. Therefore, the consumer characteristics have to be considered at the design of the co-creation platform.

Table 5.3 Motive categories for engaging in virtual co-creation projects (Based on Füller [75])

	Motive category	Description
Intrinsic	Intrinsic playful task	Individuals contribute to new product development because they may consider it as a playful and enjoyable activity, valued for its own sake and therefore perceived as intrinsically rewarding rather than an effort
	Curiosity	Consumers may engage in virtual co-creation projects during NPD just because they are curious. They have a desire of knowledge because of intrinsic reasons
Internalized extrinsic	Altruism community support	Altruism may motivate consumers to engage in virtual co-creation activities and to support producers in innovating new products
	Make friends	Getting in touch with like-minded people—employees and consumers—may be a reason for consumers to participate in virtual NPD. Beyond the interest in the topic, the possibility to get in contact with like-minded people is a reason why consumers engage in virtual communities
	Self-efficacy	Consumers virtually working on new product development tasks, similar to "Hackers" may derive a sense of accomplishment due to their contributions. They may perceive the co-creation activity as a challenge to be mastered
	Information seeking	Consumers may engage in virtual co-creation projects because they are seeking innovation or product-related information pertinent to their hobby, upcoming product purchase, or just through novelty-seeking behavior. Prior studies show that people participate in on-line communities because they are looking for information relevant to them
	Skill development	Engaging in virtual new product development enables consumers to improve their skill and gain additional knowledge. They may be interested to learn more about new technologies and products and find solutions to hitherto unanswered questions
	Recognition-visibility	Consumers may participate in virtual new product development to become visible and get recognition from other participants as well as from the producer. On-line community members are motivated to share their know-how and participate in activities for ego gratification or the desire for peer recognition
Extrinsic	Personal need—dissatisfaction	Personal need may motivate consumers to engage in virtual NPD. Sports enthusiasts start to modify or develop their own products because they are dissatisfied with existing products and because they derive benefit from using their innovation
	Compensation—monetary reward	Immediate as well as delayed payoffs. . .may be the reason why consumers engage in virtual co-creation during NPD

5.4.5 Idea Market Places

Virtual places, where innovation supply and demand convenes, are called idea market places or innovation markets. They are known as web 2.0 on-line platforms, where innovation seekers announce problems (so called "innovation challenges"), for which they seek solutions. Innovation providers, often called "solvers", propose concrete solutions or concepts for the posted problems [77]. InnoCentive, founded in 2001, is one of the most frequented innovation markets and acts as intermediary, connecting innovation provider and innovation seeker. The company declares itself as "the global leader in open innovation, crowdsourcing and prize competitions" (Fig. 5.6). In June 2013, InnoCentive reported over 300,000 registered solvers from nearly 200 countries, more than 1,600 challenges posted, more than 494,000 project rooms opened for collaborative work, more than 39,000 solutions submitted and a total of more than 40 million award dollars posted [78].

Furthermore, there are numerous innovation markets available both for seekers and solvers. Examples include Atizo, IdeaConnection, Innovation Exchange, NineSigma, Presans, TekScout, etc. [80].

5.4.6 Innovation Communities

Due to the ever-increasing performance of on-line-based IT and social software applications, virtual innovation communities are increasingly gaining in importance. In general, innovation communities are characterized by voluntary cooperation between developers and innovators on a specific topic area with the absence of direct authorities [81]. Virtual innovation communities have received special attention for the development of open source software, well known examples include the operating system Linux, the browser Mozilla and the server Apache. In addition to these user-initiated projects, producer-initiated innovation communities also are gaining in importance. In the latter scenario, a specific innovation task is given to the community, whose members collectively work on the solution. For example, the Apple Developer Connection (developer.apple.com), is where innovators are invited to offer solutions around Apple products [82].

5.4.7 Classical Market Research

[***MKT***] In addition to the methods listed above, which are suitable for the identification of latent customer needs, a full spectrum of *classical market research* methods are available. By means of well-documented methods like qualitative and quantitative surveys, group discussions, observations, product tests, customer needs and indicators of customers' requirements for new products can be identified [83]. In this context, customer preference, satisfaction and loyalty analysis is highlighted.

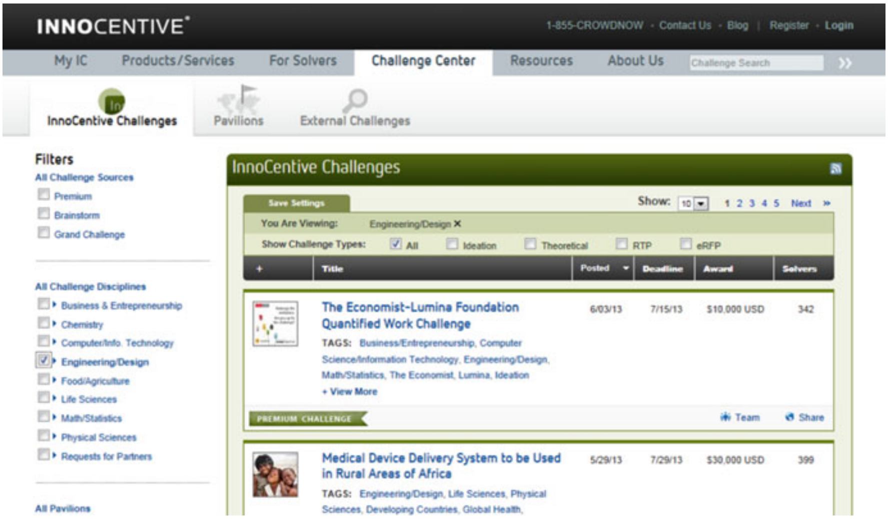

Fig. 5.6 Homepage of the innovation market "InnoCentive" (*Source*: InnoCentive [79])

The fact that classical market research has mainly been limited to generating starting points for incremental innovation is often due to (average) customers' inability to know or articulate their needs. As proof, customer surveys show time and again that novel or unknown features are often rejected in tests by customers [84].

5.4.8 Challenges with Open Innovation

Moving towards an open innovation model is not easy. Great care should be taken while breaking down any "Not Invented Here" culture internally along with strategic partners. Additionally, effective intellectual property sharing has to be ensured. Customers and partners have to be moved away from a reactive towards a proactive approach [85]. If this is done properly, the company helps guarantee that the generated inputs and ideas will be processed expeditiously and that the "information supplier" will be given appropriate feedback [86].

5.5 Idea Management

In addition to a variety of novel problem-solving strategies created in the course of the idea generating process, nearly every company has a plethora of "old ideas" from previous activities. Oftentimes, this wealth of problem-solving strategies is not systematically used, resulting in a "reinvention of the wheel." This potential can only be tapped by defining a site and a department responsible for collecting, storing, coordinating and processing ideas and problem-solving strategies, along with making them available [87]. This process is referred to as “Idea Management”.

5.5.1 Collecting and Storing Ideas

Following the generation of ideas, the process of *collecting ideas* plays an important role in idea management. First, ideas gathered from a variety of different sources have to be documented systematically and comprehensively. The representation of all ideas in a uniform way is of the essence [88]. When collecting ideas, a high degree of standardization is advantageous, since it facilitates later research on ideas and allows for searches to be comprehensive. Due to the data demands, a computer-assisted storage system in the form of a databank is possible for this large job of *storing data* [89]. This pool of ideas is a collection platform for all ideas, suggestions and problem-solving approaches. The early pool of newly submitted ideas is followed by the *screening phase* in order to grant an optimal allocation of the available personal, financial and material resources in this process. Ideas that are not valuable or lack a concrete link to practical application are filtered out but still archived in the third pool of ideas (“waste basket” or “circular file” for those who prefer euphemisms). All remaining ideas considered mature and that can be rated are transmitted into the pool of ideas II [90]. This process is shown in Fig. 5.7.

Ideas from different sources have to be demonstrated systematically and comprehensively. The higher the degree of standardization, the easier the ability to process and recall. A prerequisite for effective idea processing is a standardized idea-form (“idea one pager”) that contains the following categories:

- Title/topic
- Person submitting, date
- Standardized description of idea (functional principle, use, areas of application, etc.)
- Categorization (technical functions, relevant product categories, relevant market segments, etc.).

Generally, each “idea supplier” (e.g., employee, customer) should be enabled to submit his or her idea in a simple way. Additionally, transparent documentation of an idea’s processing criterion is essential for the long-term acceptance of an idea management system.

Finally, there is a whole range of options for collecting and motivating employees’ participation in the innovation process. *Innovation Boards* (“pin boards”) communicate effectively, for instance, the innovation motto of the month. Furthermore *Motto Weeks,* in accordance with defined search fields, revive idea generation from all employees on selected topics. In addition, *Round Tables* for innovation promote internal exchange of information (e.g., customers’ problems) among employees. All the innovation related activities should be summarized in an *Innovation Calendar*, which gives an overview of the innovation activities like date and motto of the Round Table meetings, training opportunities, innovation workshops, external events in the field of innovation, etc.).

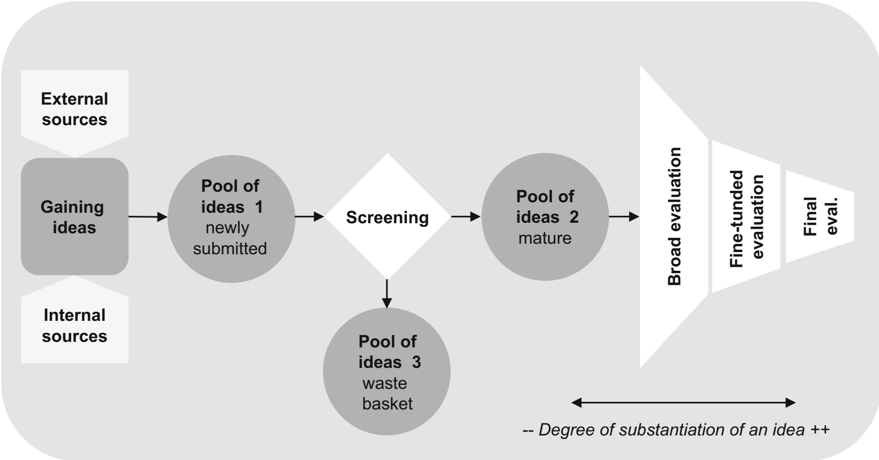

Fig. 5.7 Phase model for gathering and evaluating ideas

5.5.2 Idea Evaluation

The process of idea evaluation usually is comprised of several *filter phases* during which ideas are evaluated according to their degree of maturity and put into clear, comprehensible order. In general, this evaluation assesses a product idea in terms of its technical feasibility, it prospective market success, its contribution to the set goals and its strategic fit with the innovation strategy [91]. For assessment, individual filter phases consist of appropriate evaluation criteria chosen with a need for increasing degree of detail. Ineffective solutions or unrealizable ideas should be discarded early in order to avoid the higher expenses in fine-tuned evaluation.

In a first filtering step, ideas selected from Idea Pool II must comply with important minimum requirements. From this *broad selection*, 50 % of ideas are being winnowed on average [92]. Since ideas generated during the idea gathering process often exist only in relatively weakly delineated form, they have to be substantiated during the evaluation phase [91]. Information should thus be procured in parallel fashion to the evaluation process for further conceptual development of the idea. Specifically, this allows them to be turned into problem-solving approaches and finally into implementation concepts [93]. Ideas thus substantiated can now be evaluated within a *fine-tuned evaluation,* whittling down ideas to approximately 30 % of the original number. Further substantiation yields concrete product concepts, which are closely examined and evaluated in a third and final step: the *final selection.*

In every phase, ideas are evaluated on the basis of *evaluation criteria* that can be divided into mandatory and desirable criteria [94]. The *mandatory criteria*, derived from fixed conditions in the environment and from goals, are indispensable for carrying out a task. If not complied with, they constitute a “knockout criterion” for a desired development. In addition, criteria can be divided into quantitatively and qualitatively measurable ones. Quantitative criteria primarily comprise monetary, capacity and time period ones, while qualitative factors are concerned with

Table 5.4 Characteristics as a basis for deriving evaluation criteria (Based on Vahs and Brem [96])

Economic characteristics	Cash flow, return on investment (ROI), turnover, profit, costs, capital expenditure
Characteristics of product and production process	Product quality, capacity, flexibility, reliability, non-financial assets, familiarity
Technological characteristics	Ease of integration into existing innovation and product program, technological synergy effects
Marketing characteristics	Market volume, market share, market growth, competitive situation, suitability of distribution system, fit for existing product program
Structural characteristics	Degree of processing, organizational type of production, temporal, personnel and spatial capacities, work load distribution, etc.
Labor management characteristics	Demands on/challenges for employees, workplace security, motivation, qualification, existing development know-how, etc.
Temporal characteristics	Duration of innovation process, timing of market introduction, recoupment period, duration of product life cycle, etc.
Other characteristics	Ecological impact of innovation, consideration of legal framework, etc.

political, social, technological, etc. complexities [95]. Table 5.4 shows a selection of possible evaluation criteria.

The evaluation criteria feed into different *evaluation processes*. While *qualitative* criteria are more likely to be used for product ideas with a low degree of maturity or substantiation, *quantitative methods,* such as different types of investment appraisal, come to the forefront when an idea has reached a high degree of maturity [97]. Due to the focus of this contribution on evaluating ideas in the early phases of the innovation process, the following section will discuss qualitative evaluation methods in greater detail. Quantitative methods will be discussed in another section (Cf. Sect. 7.5.3).The simplest form of a qualitative measure is *verbal assessment*. In this process, the expression of characteristics is put into words. The use of *checklists* provides the basis for a systematic evaluation of characteristics. It is especially suitable for broad selection. In the checklist method, a catalog of evaluation criteria important for the assessment of an idea is drawn up. An initial idea assessment is greatly facilitated by the use of mandatory criteria providing unambiguous statements and thus helping to make clear decisions. If the criteria are formulated in the sense of an unambiguous yes/no decision, the method is referred to as *dual assessment*.

Another method consists in *paired comparisons*. This method systematically compares product ideas by pairing and ranking them. It is a summative examination of alternative ideas' characteristics [98]. In a *utility value analysis*, a fairly large number of decision options is evaluated and ranked on the basis of several interrelated characteristics. In this process, the total utility value of an idea is assessed on the basis of weighted scalable criteria [99]. Using qualitative as well as quantitative target criteria of different weights, this method takes into account a multi-dimensional target set. Therefore, it is extremely suitable for the fine-tuned evaluation of ideas [100].

In many companies the innovation manager is responsible for preparing the collected ideas for their evaluation in an interdisciplinary idea board. In addition to the innovation manager this board usually consists of all relevant functional unit managers (e.g., R&D, marketing, product management, design and production). For projects with a high degree of innovation and especially at the so called "money gate" at the end of the conception phase always members of the top management are part of this idea board. This applies particularly in innovation projects with a high degree of uncertainty.

5.5.3 Incentive System

An evaluation system that is transparent to everybody constitutes one success factor in idea management. In addition, a clearly defined system of premiums contributes to the success of idea management, motivating idea suppliers through material and immaterial incentives. Ideas with calculable utility have to be distinguished from others. First, ideas without calculable *utility* are generally not rewarded with *financial premiums*, although systems are possible that reward each idea with a submission premium or *material premium*. For instance, employees of the internationally successful agricultural technology specialist Pöttinger receive a premium for each idea submitted (Cf. Practical Insight: Pöttinger). An alternative to money consists of *vouchers* or *premium points,* which then can be exchanged for material premiums through catalogs, premium shops or partner companies.

Money premiums for ideas with calculable utility can be computed in different ways. One possibility consists of linear calculations using the premium in relation to its *calculated utility value*. Other possibilities consist of interval-based calculations or combinations of a basic amount with a percentage share of the calculated utility. In general, those agreements are part of overall company internal policies. For ideas with non-calculable use, companies resort to *qualitative criteria* for evaluating ideas. Those criteria include, for instance, quality and scope of the idea. Using a cost-utility analysis, the criteria are assigned a corresponding point value that constitutes the basis for assigning a material premium or voucher [101].

Practical Insight

Pöttinger: Conditions for Successful Idea Management

Founded in 1871 by Franz Pöttinger, the company started its skyrocket like rise in 1963 with the invention of the self-loading wagon. This leads to its position as the current world market leader (http://www.poettinger.at). The slogan "innovative, engaged and with handshake-sealed quality" has characterized the Pöttinger brand since its inception and is anchored in the

(continued)

company's philosophy. Pöttinger has established a comprehensive idea management system. A. T. Kearney has awarded them the "Best Innovator Award" two times already.

The Pöttinger idea management system "PIM" is set-up to reward each idea submitted (submission premium). If a patent based on a submitted idea is registered, the submitter receives additional remuneration based on the "service inventor policy". If an award is bestowed on a idea at one of the major agricultural technology fairs (e.g., machine of the year), the submission team or development team is entitled to an additional premium.

The company is aware that an incentive system or reward system for product ideas is important for employees' engagement, but only constitutes one component of motivation. For goal-directed motivation of employees, innovation management continually provides additional impulses for fostering and demanding creativity. For instance, all employees are entitled to devoting 2 % of their working time to pursuing their own ideas, independent of assigned tasks. For this end, a special room with creativity-inducing infrastructure (e.g., color, arrangement, music, tables, desks, working tools, materials related to creativity techniques, etc.) is provided. In addition, Pöttinger offers a broad program in continuing education focusing on creativity techniques and innovation management.

Source: Baldinger et al. [102]

In addition to premiums and other material incentives, immaterial incentives can also contribute to employees' motivation. An official recognition of idea providers by management, for instance in a ceremony or in a company magazine, can be a greater reward than a monetary premium especially for some types of contributors. Further, immaterial incentives can serve as public signs of appreciation, e.g., certificates, reserved parking lots, visits to trade fairs, exhibitions, or continuing education seminars.

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6 Creativity Techniques

6.1 Introduction

In organizational theory, an organization is seen as a system that faces uncertainties and where information processes take place [1]. The innovation process can therefore be seen as information processing activities that lead to a reduction of uncertainty [2]. Every company faces the challenge to reach a balance between the necessity for efficiency and for creativity. On one hand, companies demand stability and defined processes to accomplish daily tasks both quickly and efficiently. On the other hand, companies also need to be creative and to develop new products to compete in the future. The consequence is that firms need to make room for creativity to enable its employees to find new ideas and with it new innovations. The more ideas the lower the uncertainty that the perfect idea was missed for or as A. F. Osborn, inventor of Brainstorming, said: "quantity breeds quality."

Gaining ideas—*collecting ideas* as well as *generating ideas*—is an essential component of the innovation process. A collection of ideas provides a sizeable bank of approaches, though the majority of ideas often fail to be a "strategic fit". There is a high degree of uncertainty as to whether the "perfect idea" is even contained in any pool of ideas. Generating ideas is a much more promising and focused way of providing ideas in line with the goals, strategies and possibilities of a company. In this process, creativity techniques are an indispensable tool for success.

This Chapter Will Discuss

- How do we use creative techniques?
- What are the main stages of the creative process?
- How can creativity enhance the problem-solving process?

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Practical Insight

Ideo: Creative Tools for Design Thinking

IDEO has developed some of the world's most successful products like the Apple mouse or the Palm V handheld organizer. It is a global design firm that takes a human-centered, design-based approach to helping organizations, in both the public and private sectors, innovate, grow, and bring to market new ideas. They do this through identifying new ways to serve and support people by uncovering latent needs, behaviors, and desires. IDEO helps organizations build a creative culture along with the internal systems required to sustain innovation and launch new ventures. IDEO is ranked as one of the most innovative companies in the world and is winner of 38 Red Dot awards, 28 iF Hannover awards, and more IDEA awards than any other design firm.

In the late 1970s, David Kelly earned his master's degree in product design from Stanford. First, he thought he would go on for a doctoral program but many companies were approaching the Stanford Design School looking for someone to solve their product design problems. Together with graduates from Stanford he founded IDEO.

Although one might get the impression that IDEO is chaotic because of the eclectic appearance of their office space and atypical approaches, they have a well-developed and continuously refined methodology. This methodology has five basic steps:

1. Understand the market, the client, the technology, and the perceived constraints on the problem.
2. Observe real people in real-life situations to find out what makes them tick.
3. Visualize new-to-the-world concepts and how the customer will use them.
4. Evaluate and refine the prototypes in a series of quick iterations.
5. Implement the new concept for commercialization.

But this is not the only secret of success of IDEO, they believe everyone can be creative. Its goal is to tap into that wellspring of creativity within all in order to continuously innovate. IDEO fosters an atmosphere conducive to freely expressing ideas, breaking the rules, and freeing people to design their own work environments. By focusing on teamwork, they generate countless breakthroughs, fueled by the constant give-and-take among people ready to share ideas and reap the benefits of the group process. IDEO has created an intense, quick-turnaround, brainstorm-and-build process they call "the Deep Dive". Their seven secrets for better brainstorming along with six ways how to kill a brainstormer are put on the wall to help to keep sessions on track.

Photos: Copyright © by IDEO

Source: IDEO [3], Kelley [4]

6.2 Creativity

While there is a plethora of definitions of the term "creativity," the term was coined in a 1950 lecture by the American psychologist Guilford [5]. A commonly accepted definition is [6]: "Creativity is the capacity of persons to produce compositions, products, or ideas of any sort which are essentially new or novel, and previously unknown to the producer. It may involve the forming of new patterns and combinations of information derived from past experience, and the transplanting of old relationships to new situations and may involve the generation of new correlates."

Brainstorming, developed in the late 1930s by *Alex F. Osborn*, is considered the oldest creativity technique. But it wasn't until the so-called "Sputnik Shock" in the late 1950s that creativity researchers in the USA embarked on intensive research, especially for finding solutions of technological and military challenges [7]. Thus emerged the branch of applied creativity research, whose results are summarized by Rhodes [8] as the so-called 4 Ps of creativity:

- Person: a human being
- Process: mental processes that are operative in creating ideas
- Pressure: influence of the environmental pressure on the person and the mental process
- Products: ideas that are usually expressed in the form of either language or craft.

These four basic elements help in subdividing and substantiating the diffuse term "creativity" (Fig. 6.1 depicts their interaction). Section 6.3 of this book will discuss the phases of the creative process in greater detail.

In creativity research, a frequently asked question is whether creativity is innate or learned. This question requires further elaboration.

Since the 1960s, the hemisphere model is used for explaining creativity. According to this model, the two hemispheres of the brain accomplish essentially unrelated tasks, each hemisphere acting independently of the other [10]. The *left hemisphere* is responsible for "digital thinking," that is logical thinking, organization and analysis. This part supports routine workplace tasks. In contrast, the *right hemisphere* is the site of "analog thinking", responsible for fast spatial processing, general overview, synthesis of all previous impressions and processing of visual impressions. Only the linking of both hemispheres, i.e., the analytical skills of the left hemisphere and the synthesizing skills of the right hemisphere, can give rise to creativity and thus significantly foster the generation of ideas.

It is here that creativity techniques take their starting point. There is such a variety that it is difficult to choose the most suitable method for a given task. Today, more than 100 creativity techniques can be identified globally [11]. On one hand, they strengthen intuition. On the other hand, they support creativity by proceeding in a systematic, analytical way (an oxymoron that is not lost on good practitioners).

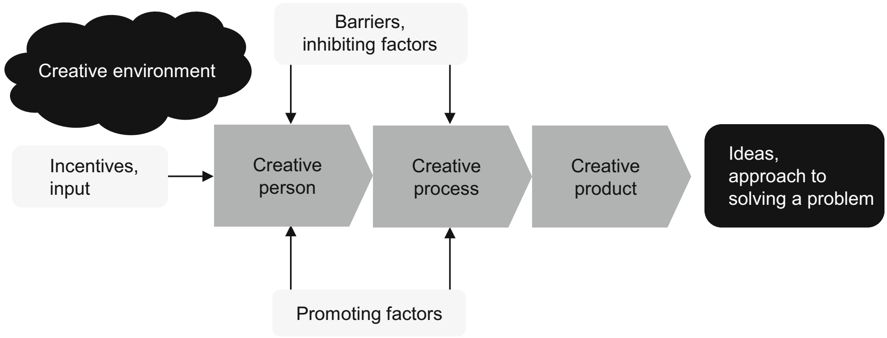

Fig. 6.1 Factors influencing creativity (Based on Kneiß [9])

6.3 The Creative Process

Based on *Freud*'s model of the psychic apparatus, which perceives creativity as the interplay of logic and imagination, *Guilford* [12] distinguishes between mental products, mental content and mental operations. It is the mental operations that are especially important for the creative process. The mental operation *convergent thinking* denotes the analytic and systematic elaboration of a given idea, while *divergent thinking* signifies the production of new ideas and the exploration of new paths. If these two mental operations are employed consciously and separated in time, a more efficient problem-solving approach is possible. Figure 6.2 assigns divergent and convergent thinking to the temporal axis of the problem-solving process.

Graham Wallas' model, published in his 1926 book "The Art of Thought", constitutes the basis for many creative processes in the literature. Wallas [14] distinguishes between the following four phases:

1. *Preparation*: openness, perception of a problem or the possibility for a creative solution
2. *Incubation*: "sleeping on it", mulling it over, can take between minutes and years
3. *Illumination*: eureka experience, inspiration, sudden insight
4. *Verification*: includes elaboration, evaluation and implementation, "making sure that the solution works"

In Fig. 6.3, these four phases have been incorporated and elaborated into an overall model of *The Creative Process*.

The three segments on the right of Fig. 6.3 are detailed as follows:

- *Logical segment*: The growing awareness of a problem and its subsequent intensive examination, primarily in a rational way, take place at the beginning of the creative process [16]. Connections are made transparent, possible approaches to problem-solving are viewed from all angles. People involved in the creative process immerse themselves more deeply in the structure of the problem, trying to rid themselves of rote behavioral patterns and thought patterns in order to make room for unconventional and novel thoughts. In this phase, it is primarily the left hemisphere of the brain that is at work.

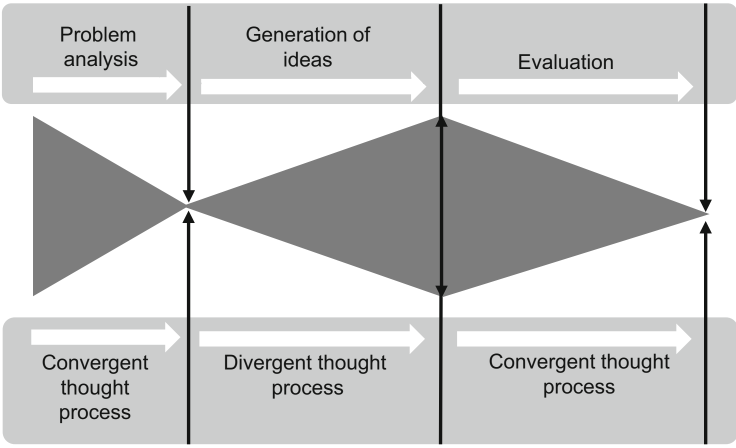

Fig. 6.2 Convergent and divergent thinking in the problem-solving process (Based on Linneweh [13])

In this segment, an array of techniques can be used to clarify the problem [17]:

– Mind-mapping, Ishikawa diagram as well as structural diagrams and flow charts visualizing and clarifying the problem;
– W-questions and check lists supporting content-related infusing of the problem;
– Progressive abstraction (mainly of the frequently asked question ("What is this all about?") clarifying the core or the cause of the problem).

- *Intuitive segment*: In this creative phase in a narrower sense, the problem is passed onto the subconscious. A transition takes place from the factual and rational to the intuitive and creative level. The thought processes taking place now link all of the information and insights on the problem with previous experiences. During this process, the right hemisphere is in charge, parsing the entire memory for matching. Letting go of set ways of thinking and perceiving is crucial in this phase; quantity and originality of ideas are called for here. Ideas generated in this way are often referred to as "flashes of genius"—often fuzzy, intangible and difficult to describe in detail. This segment ends in the development of one or several problem-solving strategies that subsequently have to be verified and prioritized.
- *Critical segment*: It is here that ideas are evaluated and verified. Each variant is assessed and ranked according to criteria that are standard practice of idea assessment (e.g., strategic, economic, technical, social, ecological), but also with regards to applicability and novelty value. In this segment, it is once again the primarily analytical left hemisphere that is being used.

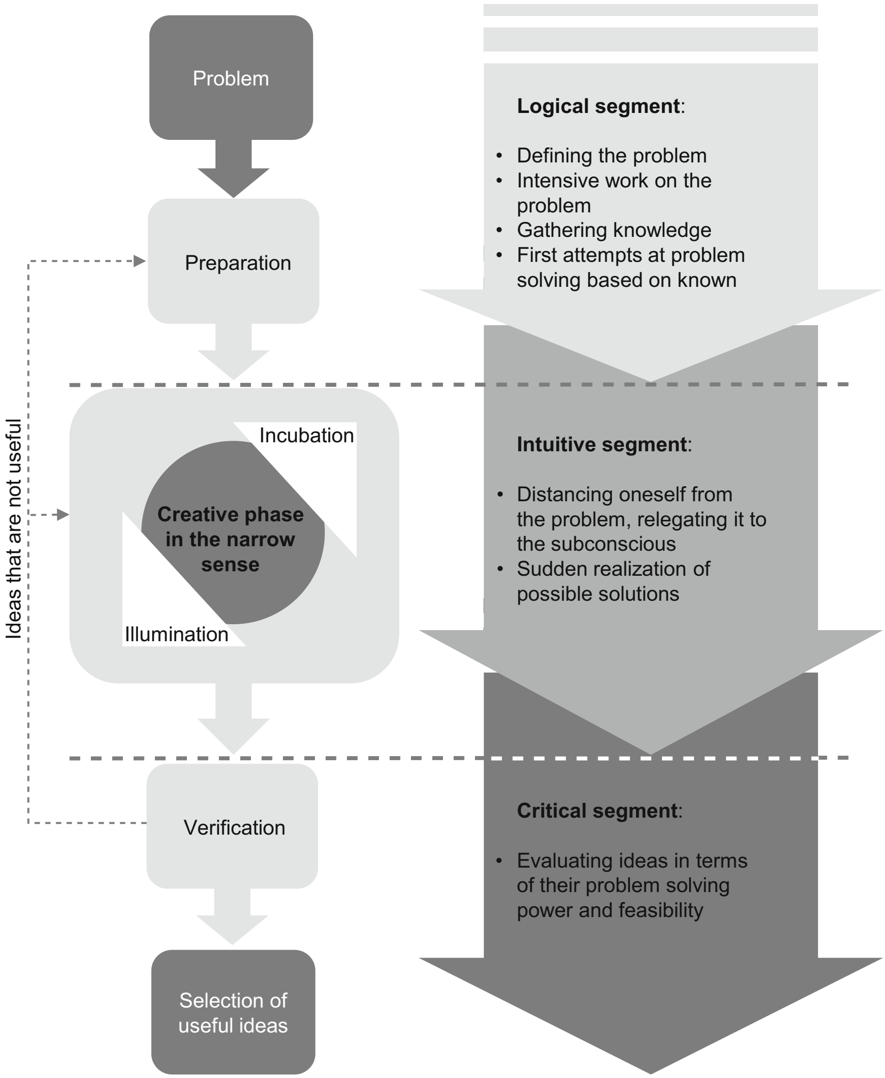

Fig. 6.3 The creative process (Based on Schlick [15])

6.4 Use of Creativity Techniques

Creativity techniques act as a kind of catalyst, releasing a person's or a group's creative potential. In general, they are based on the application of heuristic principles such as association, abstraction, analogy, combination, variation, etc. They are commonly perceived as search techniques used for problem-solving or for finding new ideas [18].

6.4.1 Classification of Creativity Techniques

Categorizing the individual techniques is challenging, since methods exist in many variations and usually contain elements of multiple categories. However, two major clusters of methods can be distinguished based on their basic principle for fostering creativity, i.e., *systematic-analytical models* and *methods stimulating and enhancing intuition*. This classification can be supplemented by an additional classification based on the principle triggering the idea, juxtaposing *association/variation with confrontation* [19]. In operational practice, though, it is advisable to match certain creativity techniques with frequently occurring types of problems in order to facilitate selection. *Geschka* assigns suitable techniques for different problem types [20]. However, he concedes that his recommendations are "not imperative and somewhat fuzzy", being dependent on a number of factors such as the type of problem, the situation, the set goal, and users' habits and preferences. With these caveats, Fig. 6.4 lists the major problem types with recommended techniques.

6.4.2 Creativity Techniques in the Problem Solving Process

A survey conducted in 2010 by an academy for executive personnel on the subject "Creativity and Leadership: Vision, Reality or Contradiction?" collected responses from more than 600 German managers from diverse backgrounds in terms of industries and company size. The responses showed brainstorming to be the most common and most frequently used creativity method by far [21]. Further popular creativity techniques included brain-writing, mind-mapping, the Walt Disney method, morphological box, storytelling, Six Hats and the 6-3-5 Method. This result provided the basis for the selection of techniques to be discussed here and was supplemented by additional methods that can be easily applied, independently of departmental background, in all situations where a company is looking for new ideas. Also see "Thinkertoys" by Michael Michalko [22] for a range of creative-thinking techniques.

6.4.2.1 Brainstorming

Brainstorming is not only the oldest creativity technique, but also the best known one. It was developed in the 1930s by *Alex F. Osborn*, co-owner of a large American advertising company, and is used for collecting a large number of ideas over a very short period of time. Spontaneous responses to a specific question are gathered without comment [23]. Brainstorming can be used at any point in the problem-solving process, from the initial question via clarification and rephrasing of the problem up to the collection of spontaneous solutions. Brainstorming takes place in heterogeneous groups of 4–12 participants and should not take longer than 20–45 min. The generation of ideas takes place in waves and should not be cut short after the first activity peak.

In this process, it is crucial to observe the four basic rules of brainstorming [24]:

- No criticism of presented ideas is allowed.

	Problemv	Description	Example	Recommended techniques
1	Identification and analysis of a problem	Presenting and clarifying a problem.	Poor sales results, problems with quality	- Mindmapping - Morphological box - Progressive abstraction - Fishbone diagram
2	Collecting ideas	Looking for alternatives for a Specific purpose	Product variations, Ideas for new products	– None (individual) – Brainstorming
3	Problem of procedure	Searching for a way to Reach a given result	Identifying relevant customer problems	– Brainwriting – Brainstorming
4	Improvement challenges	Seeking to improve an existing concept, product or process	Re-launch of a products, value analysis	– Attribute listing – Osborn checklist – Brainstorming or brainwriting on weak points – SIL Method
5	Searching for an application	Possible applications for a new technology have to be found	Where can a new substance be used? What can new software be used for?	– Brainstorming – Brainwriting
6	Effecting a change in behavior	People are to be influenced to act a certain way.	How can employees' awareness of corporateidentity be increased?	– Circulating index cards – Mindmapping – Analysis of stimulus words
7	Technical invention problem	A (technical) problem is to be solved in a novel way.	A new operating element or functional principle	– Analysis of stimulus words – Visual confrontation – TRIZ problem solving principles – Osborn Checklist – Morphological box – SIL Method
8	Finding a marketing solution	Finding a name, finding a slogan, getting noticed	Names for a new product, slogan for a new prospect, new advertising campaign	– Brainstorming – Brainwriting – Morphological box – Analysis of stimulus words – Visual confrontation
9	Development of a system concept	Solving a complex problem consisting of several interacting components	Development of a security system Software development	– Morphological box – TRIZ problem solving principles – Brainwriting
10	Explanatory problem	Finding an explanation for a phenomenon, a result or an effect	Finding reasons for a declining market share, quality flaws, functional errors.	Cannot be solved in one move. Requires pre-analyses. (Brainstorming or progressive abstraction). Analysis yields a type 1-9 problem.

Fig. 6.4 Juxtaposition of frequently occurring problem types and suitable creativity techniques (Based on Geschka [20])

- Quantity before quality: a lot of ideas should be produced within a short time period.
- Participants are allowed and even encouraged to pick up and further develop the ideas of others. There is no copyright on them.
- Crazy ideas can be expressed as well; they are stimulating and refreshing.

Figure 6.5 depicts the standard course of brainstorming. A seasoned moderator is required for assuring that participants adhere to the rules. It is the moderator's job to ask stimulating questions when the flow of ideas subside, to activate quiet participants and to subdue dominant ones. All ideas are written down in the

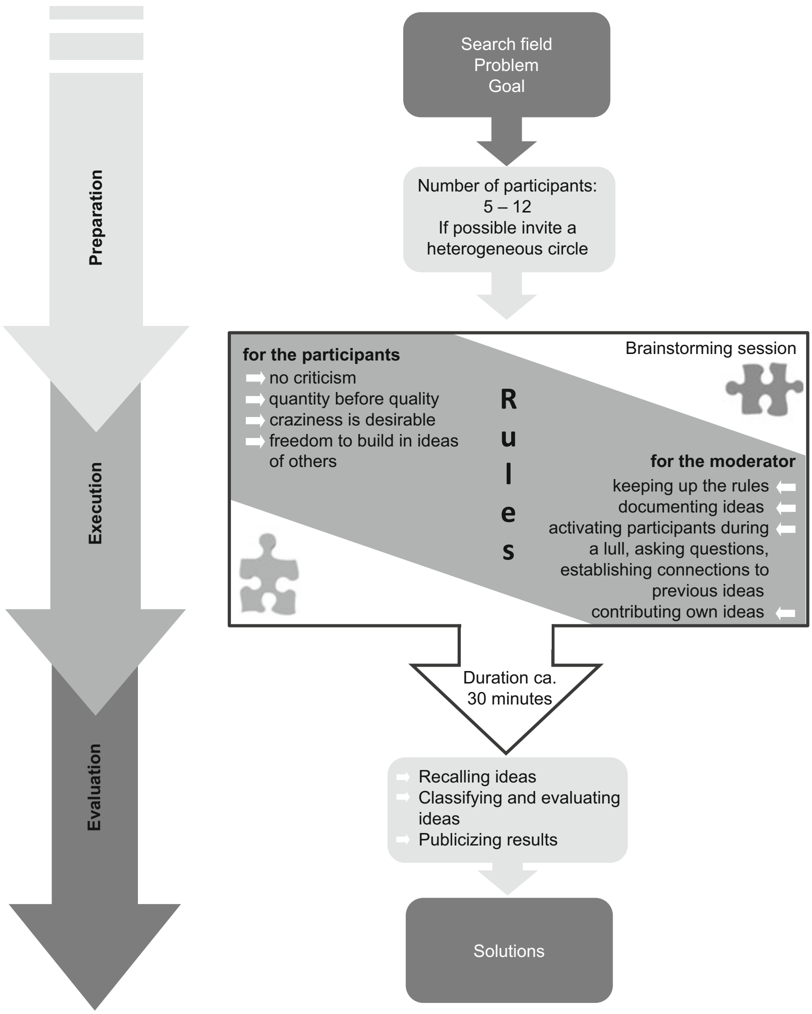

Fig. 6.5 The brainstorming process (Based on Schlick [25])

minutes, making sure that no suggestions get lost. Frequently occurring errors are faulty or lacking documentation of search fields (Cf. Sect. 5.3.2), or flawed minutes.

6.4.2.2 SCAMPER (Osborn-Checklist)

The Osborn Checklist was developed by *Alex F. Osborn* as a second part to brainstorming, in order to expand the view on a problem's environment and to develop solutions [26]. In 1996, Bob Eberle organized the original questions into the handy, easy to remember mnemonic SCAMPER. The letters represent the key words and phrases of the checklist as a guideline in the form of a catalog of questions, aimed at facilitating new perspectives or solutions. In addition to brainstorming, other areas suitable for application of the Osborn checklist are product and procedure development

Substitute	What can be substituted? What might be used or be done instead?	**Put to another use**	What else can this be used for? How might something be used or applied in a new or different way?
Combine	What things/ideas can be combined? Can purposes be combined?	**Eliminate**	What could be deleted? What should be ommited?
Adapt	What might be changed or used in a different way? What else is like this?	**Reverse or rearrange**	What are the opposites? What other arrangements might be better?
Modify, Magnify or „Mini-fy“	How can this be altered for the better? What might be made larger or smaler? What can be added?		

Fig 6.6 SCAMPER (Based on Michalko [27], Treffinger et al. [28])

of an already existing product or process. Figure 6.6 lists the seven questions that guide creative thinking into different areas even new territories. In this way, potential options for changes in a product or a procedure are systematically illuminated.

In this process, the individual questions are not answered in a superficial way but are examined for variants of solutions through a short brainstorming process. The Osborn checklist can be used throughout the problem-solving process.

6.4.2.3 Mind-Mapping

This creativity technique was developed in 1974 by *Tony Buzan* [29]. Its primary purpose is to help structure and visualize problems, taking into account the interplay of both hemispheres of the brain by combining visual with logical thought. In this way, the problem can be presented in the form of an overview with an open structure, making it possible to illuminate minor aspects, show new connections or add new points. Mind-mapping materializes as a tree-like map of ideas, with the problem featured as the stem, the different solutions as major branches and all further ideas and aspects as minor branches (Fig. 6.7). Using terms, pictures, numbers and colors, ideas are visualized in the shape of a unique field of solutions, with the option of adding on new ideas at any time. Mind-mapping lends itself very well to search and analysis in the process of defining problems.

6.4.2.4 Morphological Box

The Morphological Box was developed in the 1950s by Swiss astrophysicist *Fritz Zwicky*. It offers a systematic, analytical approach to the generation of ideas [31] by structuring a set search field comprehensively without overlaps according to all conceivable criteria. By dividing the problem into individual elements and finding solutions for those problem elements, a comprehensive solution can be built from a combination of individual solutions. A matrix consisting of parameter and manifestations of the parameter is being drawn up. Different solution paths are then input (Fig. 6.8). In creating the matrix, it is important that the parameters be

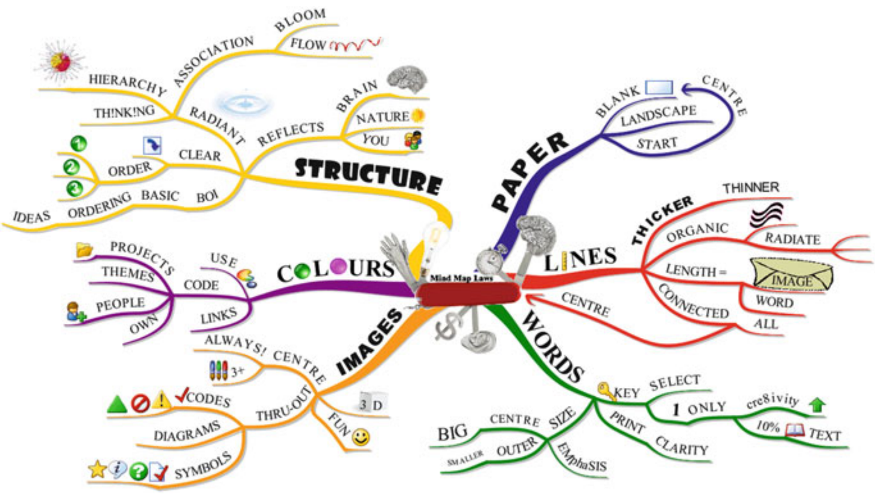

Fig. 6.7 Laws of the mind-mapping and how to use them (Reprinted from Buzan and Buzan [30] by permission of Pearson Education Ltd.). The Mind Map Book – Unlock your creativity, boost your memory, change your life. Tony Buzan. Pearson Education Ltd. 2010, BBC Active

Parameter	Options			
The person murdered	wealthy widow	valuable racehorse	head of a seminar	prostitute
The cause of death	shock	shooting	unascert-ainable	(English) ale
The scene of action	London in the smog	nightclub in Paris	golf course	Frankfurt Stock Exchange
The murderer	heir	priest	Aunty Mary	participant in a seminar
The motive	greed for money	blood-lust	habit	to eliminate the person in on the secret
The case is cleared up by	coincidence	self-denunciation	traces in the snow	idea generation
The hero	James Bond	foreign worker	journalist	Jimmy Carter

Fig. 6.8 Morphological box for new ideas for criminal stories (Based on Geschka [33])

relevant to the solution, applicable to all manifestations and independent of each other [32].

6.4.2.5 Brain-Writing Method

Brain-writing is an enhancement of brainstorming and was developed in Europe [34]. Its focus is on spontaneously writing down as many ideas as possible, using the same rules as in brainstorming. Since the written word replaces oral

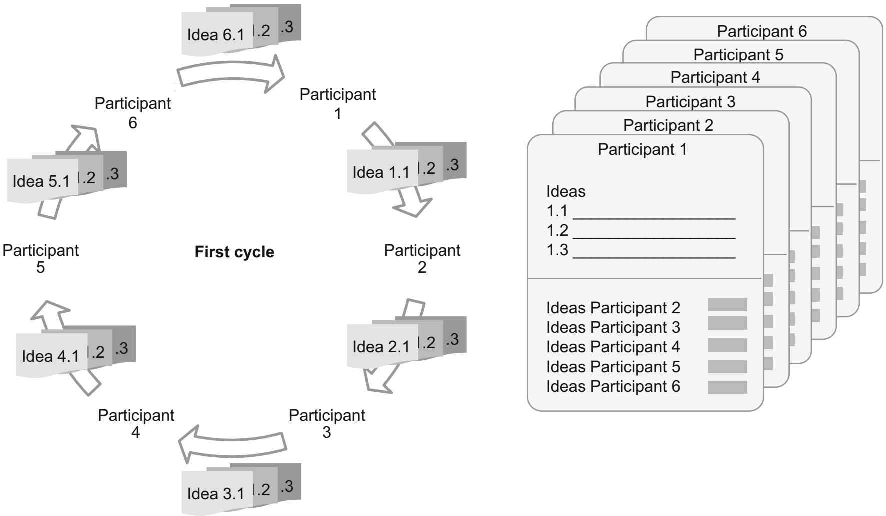

Fig. 6.9 Course and form of method 635 (Based on Hauschildt and Sören [35])

communication here, this is the method of choice when conflicts or tensions between participants are expected to occur, or when there are dominant persons among the participants. Brain-writing methods are also very suitable for search problems requiring more reflection time.

The best known form of brain-writing is *Method 635*, which has *6 people* write *3 ideas* each down within *5 min*. Everybody then passes their ideas onto their neighbor (Fig. 6.9). Over the course of five rounds, the participants comment on, develop or supplement each other's ideas. A 30 min session thus yields 108 ideas including redundancies and unclear statements which have to be weeded out. Since participants‘ ideas are written, a protocol is automatically generated.

6.4.2.6 SIL-Method

The SIL-method originally was developed in the late 1970s by Helmut Schlicksupp at the Batteile Institute in Frankfurt, Germany [36]. SIL is the German acronym of the translated title: Systematic Integration of Problem Elements. A slight variation of this method is also known under the name of Blender. Here the goal is the gradual integration of as many ideas as possible into a single integrated, final solution which is acceptable to all participants [37].

SIL aims to leverage synergies from interdisciplinary teams on problems that require eclectic solutions or offer only limited number of possible solutions, such as those found in industrial or product design tasks [38]. The key to this method is to merge the benefits of individual solutions to an integrated solution in collaborative work. It combines elements of Brain-writing and Brainstorming, thus taking advantage of the strengths of each.

The SIL-Method is a combination of individual work and teamwork. The team should consist of six to eight people, each person bringing their specific areas of

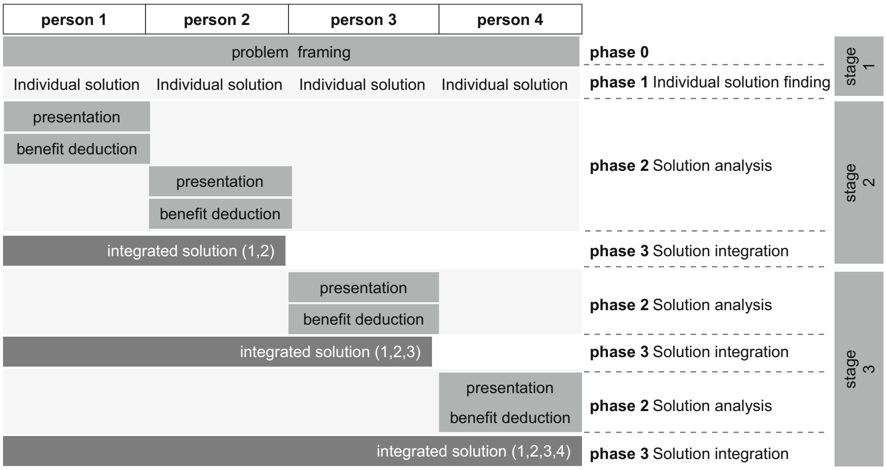

Fig. 6.10 Schematic representation of the SIL process

expertise and experience to the table [39]. By means of consistent creative synergy, the capacities existing in the team can be connected to each other. This method is especially suitable for more complex problems calling for comprehensive and mature solutions. In the wake of an extensive analysis and a precise representation of the problem, each participant designs a solution that is as detailed as possible. Subsequently, the first participant presents his or her solution, which is then discussed by the team in order to identify this solution's particular strengths or advantages. A presentation and discussion of the second solution ensues. Finally, a combined solution is built from the strengths of both solutions. The third solution and all the ones that follow are successively presented and discussed, then integrated into one or more comprehensive solutions. Figure 6.10 shows the multi-stage process of the SIL technique when used with a group of four participants.

Compared to Brainstorming, the procedure of the SIL-Method is much more challenging for the participants and even more so for the moderator. This is also true of the time invested in the method, which can often be two to three hours. As a trade-off, by way of its detailed and positive discussion, the SIL-Method provides each participant with feelings of success. In general, it results in comprehensive and mature solutions, whose acceptance is furthered by involving each participant in the search for solutions.

Practical Insight

sprint>: Competence Center for the Front-End of Innovation

The early stages of innovation, from strategy and ideas up to the concept phase, have a leveraging effect on the success of a project. To maximize the performance of the Front End of Innovation, a goal-oriented and systematic approach is needed. This is where the research and transfer center at the University of Applied Sciences Upper Austria in Wels is positioned. This

(continued)

Systematic Product Innovation Transfer Center, known as sprint>, combines the research activities of a innovation and product management program with reliance on a systematic utilization of advanced methods and tools to enhance the effectiveness and efficiency of the early phases of innovation.

Thus, sprint > allows participants to map areas of expertise along the entire front-end process, reflected by the following four areas:

- sprint > research—modern methods of market research and innovation research
- sprint > lab—ideation and creativity workshops
- sprint > design—design concepts and workshops
- sprint > tec—engineering methods for the early phases.

The sprint > lab is a room that is specifically designed to support creative activities. A large-scale interactive whiteboard (5.2 m × 1.17 m) in combination with 3D projection and 3D screens provide a flexible, multi-media and creativity-enabling platform, so that a complete immersion in a topic can take place.

One of the creativity techniques is the SIL-Method. As described above SIL involves a lot of different components such as individual and moderator guided collaborative work. SIL provides the users with the freedom to use sketches or handwriting for ideas and does not limit the input to a specific type. Using the equipment of the sprint > lab, digital paper and multiple Anoto pens (able to track individual's written contributions) can be used to facilitate private content creation (Stage 1) and a large-scale interactive whiteboard offers public space for moderated discussion or collaborative work (Stage 2 and 3). The digital paper captures handwriting and drawings on paper and enables displaying the content to the public via the interactive whiteboard system. Afterwards, content thus created can be edited, copied and moved.

sprint>lab, University of Applied Sciences Upper Austria, Wels Campus

Source: FH OÖ [41]

6.4.2.7 Theory of Inventive Problem Solving (TRIZ)

TRIZ is the Russian acronym for the Theory of Inventive Problem-solving, a method using an algorithmic approach for solving technical and technological problems. It was developed by Genrich Altshuller and his colleagues at the Moscow patent office in the 1940s. He assumes that an invention follows certain laws and rules. To this point, the method has analyzed over 2.8 million international patents.

Altshuller identified and extracted a number of innovation patterns and laws of ideation. The distinct features of TRIZ can be summarized as follows [41]:

- A precise description of the problem itself often leads to creative problem-solving.
- Problems with different names have been solved in different industries, but the solutions may be comparable to a specific problem across industries.
- Further development of technical systems is based on certain basic rules.
- Contradiction is a central element that continuously generates innovations in thousands of patent specifications.

The TRIZ methodology can be used to highlight technical conflicts that often occur within the product innovation phase and channel them into a solution. Especially during the phases of idea generation or detailing, TRIZ can help to identify and use analogies. During these phases, ideas are generated that often lead to a technical contradiction that can be solved.

The central point of this method is the handling of contradiction. A big part of a developer's work is to dissolve seeming and actual contradictions. The accentuation of these contradictions is supposed to help overcome conceptual barriers and to find new approaches.

The general approach of the TRIZ methodology follows a basic pattern of four steps and is based on the identification and use of analogies (Fig. 6.11). First, the specific problem is analyzed and abstracted so that problem description can be put into an analogy. Then earlier problem statements can be used to transfer the solution principles of these problems back to the specific problem [42].

The TRIZ method contains the approaches and tools developed by Altshuller et al. They can be divided into four groups:

1. *System*: These tools are used to analyze the problem systematically and to define exactly the contradiction that requires a solution.
2. *Knowledge*: The aim of this tool is to use already available knowledge in an optimal way. One can use so-called effect-databases that describe technical and physical effects with regard to problems to provide an ideal utilization of available resources.
3. *Analogies*: Once a technical contradiction has been defined it can be described as an abstract problem—independent of a specific product or circumstance. For many "standard problems" there are "standard solutions". These "standard solutions" are based on analyses of patents and invention disclosures and provide information on which solution was most likely to have led to success in the past. Therefore, analogies to past problems can help to solve a current problem. These analogies have been put into a systematic approach, the so-called contradiction matrix. It uses 39 technical parameters to describe the contradiction and contrasts them according 40 innovation principles.
4. *Visions*: The fourth group of tools is used to define further development of products. Technical principles are deduced from past products in order to

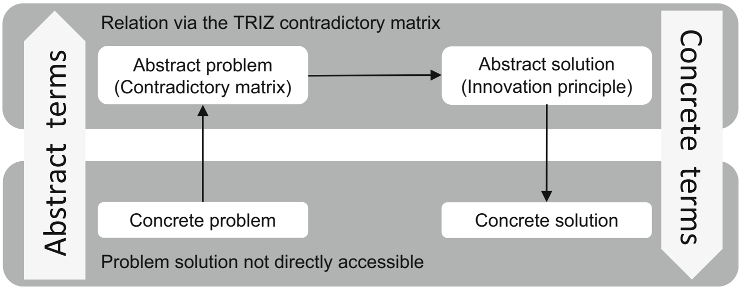

Fig. 6.11 Problem solving process using the TRIZ methodology (Based on Eversheim et al. [43])

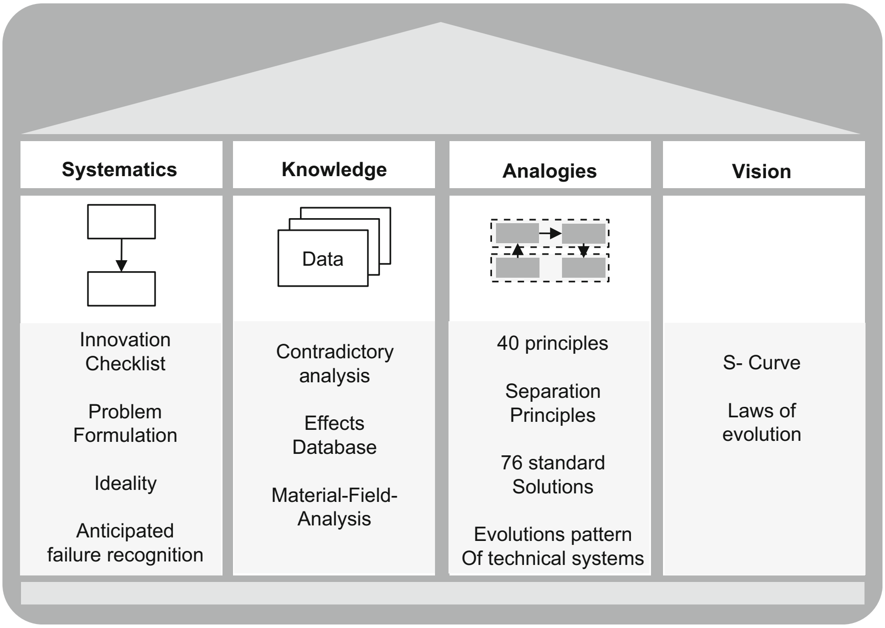

Fig. 6.12 Tools for the TRIZ methodology (Based on Eversheim et al. [46])

imagine what one's own product could look like or how the problem can be solved in the future.

Figure 6.12 shows these four pillars together with a number of similar methods. Since the TRIZ methodology does not require a certain sequence in the application of the tools or a specific procedure that must be followed, the tools listed below are a few of many other options [44, 45].

An increasing number of software programs has been developed that can support idea generation based on TRIZ. These software programs offer many methods of TRIZ, and use databases containing a multiplicity of effects. In addition, most programs contain a documentation function that facilitates the storage of solutions

Creativity technique	Mechanism for generating ideas	Degree of maturity of generated ideas	Degree complexity of ideas/ solutions	Duration of application
Brainstorming	Free association, no critical feedback allowed	First impulses, search fields, ideas with a high degree of abstraction	Low	Short (20' - 45')
SCAMPER	Analytics	Concrete product improvements and further development of products	Requires existing solution or concept as starting point	Short to medium (15' - 2 h)
Mind-mapping	Analytics and association	Complex information can be structured in a playful way, generating new ideas in the process	Also suitable for more complex problems	Medium (1 - 2 h)
Morphological Box	Analytics, total combination of all characteristics	Relatively complete mental model	Also suitable for problems that are very complicated at the technical level	Short to medium (ca. 2 h)
Method 635	Free association or chain of association	First impulses, more concrete chains of ideas	Relatively low	Short (30')
SIL Method	Free association or chain of association/combination of team work and individual work	Comprehensive and mature solutions of a high quality	Also suitable for more complex Problems	Long (2 – 3 h)
TRIZ	Analytics	Relatively complete solution	Also suitable for more complex problems	Long (2 – 3 h)

Fig. 6.13 Comparison of creativity techniques

found during idea generation. Providers of those programs are listed at http://www.triz-online.de, http://www.aitriz.org and http://www.trizasia.com.

6.4.3 Comparison of Creativity Techniques

To conclude, Fig. 6.13 compares and contrasts the essential features of creativity techniques discussed in this chapter.

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Product Concept

7

7.1 Introduction

For many companies arriving at a product concept is one of the most important stages of the product innovation process, since cost and quality of new products as well as the complexity of research and development are largely determined by the decisions taken. It is therefore recommended to keep the product concept actions as a separate step in the process and not to integrate it into the product development phase. Separating these two steps ensures that the basic decision to proceed with product development is carefully prepared with subsequent course corrections so the termination of development projects due to insufficient planning can be largely prevented. However, it can be observed in many companies that the product concept phase is neglected and development activities are undertaken based on a promising but ill-conceived product idea. Not infrequently, the hasty and insufficiently planned development of a product is the cause for a subsequent flop.

This Chapter Will Discuss

- What are the central steps of the product conception phase?
- Which information needs are crucial in the conception phase?
- Which tools are relevant in the conception phase?
- Which methods can be applied for preference measurement?
- What are the objectives and process steps of the target costing approach?
- What are the dimensions and procedures of concept testing?
- What are the instruments of QFD?
- How can a House of Quality be build?

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Practical Insight

Rosenbauer: Systematic Product Development in Firefighting Technology

Rosenbauer has been active in fire-related services since 1866. The first fire trucks were built in the 1920s, which also saw the beginning of exports to China. As a result of its constant inventiveness, Rosenbauer has had a major influence on fire-related services in Austria, Germany and the rest of the world. It has established a reputation as the branch's innovation and technology leader. The product range of the company includes the entire needs of fire departments and is segmented by vehicles, hydraulic platforms, extinguishing systems, vehicle and operations management as well as equipment and stationary extinguishing systems.

At Rosenbauer the specific requirements of fire fighters are understood and responded to through the institutionalized innovation management. Thereby, development projects are generally carried out through a four-phase model: (I) initialization, (II) concept, (III) realization and (IV) market launch. This phase model already contains clear work packages for the front end of innovation to begin with the generation of ideas to clear product specification and the definition of a detailed development-project plan in the concept phase. These steps are outlined briefly in the following example.

To maintain and expand the leadership of fire extinguishing systems, the portable fire pump FOX, one of the top products on the market, was successfully introduced. To meet the requirements of the market, the key customer buying criteria were determined in the first phase. High performance, low weight, a high carrying comfort, simple usability and high reliability were identified as the key features of the product. At the beginning of the development project Rosenbauer defined the clear goal of surpassing competing products in terms of all key buying criteria to be the premium product. Furthermore, an emotional differentiation from the competition was targeted with regards to the design. All the criteria were classified into "must have" and "nice to have" criteria and summarized together with the cost and schedule goals in the specification sheet. After that a feasibility check, a detailed investment appraisal and a risk analysis were conducted. Building on these analyses a detailed requirement specification was created that built the foundation for further development steps.

Photos: Coypyright © by Rosenbauer

Source: Rosenbauer [1], Hofbauer et al. [2]

7.2 Systematic Product Concept Development

Product ideas resulting from the idea evaluation process, which are usually still at an abstract level, form the starting point for the product concept. Within the framework of the product concept phase, these product ideas need to be translated into concrete product concepts that then form the basis for product development. Essential tasks of the product concept stage are detailed analyses both of the market and the competitive environment. The final concept is determined by what is of value and what is of benefit to the customer [3]. It is quite common that several product concepts are developed from one single idea.

The product concept stage ends with the decision for or against the development of the planned product. Because this decision entails far-reaching financial and organizational consequences for a company, it should be prepared carefully and be validated through qualitative and quantitative concept evaluations. Once studies confirm the feasibility and the potential for success of one or several product concepts, technical product development as well as the drafting of the marketing mix can commence. The different steps of the concept phase as well as their integration into the product innovation process are shown in Fig. 7.1.

7.3 Analyzing Markets and Competitors

[**MKT**] In order to design new products in a customer-oriented manner, more detailed analyses of the relevant market and the competitive environment is required in addition to the analyses related to the collection and evaluation of ideas. The objective of these detailed analyses is to obtain sufficient information necessary for further specification of the selected product ideas [4] and therefore to reduce market uncertainty in its sub dimensions customers and competition.

In the context of these analyses, the general *market condition*, the concrete desires and requirements of the target customers as well as the *competitive situation* need to be thoroughly investigated. Since the same idea can often be applied to different markets, it is recommended that the detailed analyses are performed for all potential markets and target groups so that product concepts are developed in parallel.

7.3.1 Information Needs

[**MKT**] Both the present and future market situation plays an essential role in deciding whether to serve a particular target market. Therefore, information is needed about the *market potential*, i.e., the quantitative demand that the market may reach for a particular product in a given period of time, as well as information concerning the estimated *sales potential*, that is, the amount, which a provider believes is able to be achieved in relation to the market potential. Additionally,

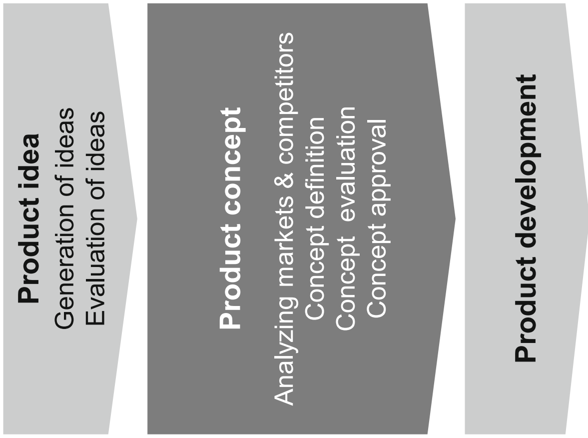


Fig. 7.1 Steps of product concept stage and integration into the product innovation process

market entry opportunities and threats should also be anticipated to reduce uncertainty. It is especially promising to cultivate those markets that not only offer positive sales potentials, but also have low entry barriers [5].

The analysis of needs and requirements of the target group should be the primary focus. Unfortunately, this part of the analysis is often omitted because companies believe they already have an accurate understanding of the customers' needs. Even when assessments are produced they rarely correspond to the actual needs of customers. Therefore, customer requirements should not be neglected and must be thoroughly investigated with appropriate tools. It is imperative to find answers to the following questions [4]:

- What is of value, i.e., benefit to the customer?
- Which unsolved problems do customers face with the current solution?
- Are there possibilities to offer alternative solutions to the customer?
- What benefit could an alternative solution provide for the customer?
- Which characteristics should a new solution provide that offers more value than competing offerings?

These questions show that target segment analysis should focus on the verification of solutions that endow the customer with a unique benefit. Customer benefits can be provided in various dimensions such as functional, experiential, symbolic.

Since customers buy a product if its value outperforms the value of alternative offers, the *competitive situation* also needs to be considered as a part of the detailed analyses. Identifying competitive products with their specific strengths and weaknesses is necessary to understand which market positions are open and the potential for differentiation. This need to compare offerings against competitors, requires a *positioning analysis*. This suggests significant dimensions on which customers perception of competing products differ or are similar [4].

7.3.2 Positioning Analysis

[**MKT**] Products are likely to be more successful if they deliver a higher value than competitive products. In this context, a company has to anchor products on the perception of customers. The features that are used for positioning the product have to be highly relevant to the customer and must be based on their preference profile ("ideal product") [6]. The positioning of products can be summarized as the product related differentiation from the competition which is based on the subjective perception of customers, rather than objectively verifiable product features [7].

7.3.2.1 Positioning as Strategic Approach

Positioning, as a strategic approach, guides the formation of the marketing mix. Therefore, the positioning of products is not subordinate to the individual market tactics, on the contrary, the positioning strategy determines the possibilities for the elements of the marketing mix, as can be seen in Fig. 7.2 [8].

The positioning of products can never be seen in isolation from market segmentation. Market segmentation refers to the split of a market into market groups, each of which responds to a specific marketing-mix. Each segment is internally homogeneous with regard to their market reaction (e.g., customers share as similar set of wants), yet heterogenous across segments.

According to the STP approach, segmentation, targeting and positioning go hand-in-hand, since products are positioned in correspondence to their target-segment. Thus, the respective potentials of the individual segments are exploited through unique marketing mixes [9]. From this perspective, product positioning constitutes an integral part of differentiated market cultivation.

The following two *strategies for product positioning* can be distinguished [10]:

- *Adapting offerings to customer preferences:* In general, this strategy aims at aligning product design with customers' perceptions of the ideal product. However, the perceived product position in a market segment can also be shifted *without changing the product* by using *strategic communication* to change customers' perceptions of actual product features.
- *Adapting customer preferences to product offerings:* In general, this strategy aims at changing customers' perceptions of the ideal product by way of strategic use of *communication tools.*

Ultimately, both strategies use communication to reduce the distance between the ideal product and the real product. Additionally, they can be employed jointly.

7.3.2.2 Reactive vs. Active Positioning

In many markets, pursuing a *reactive positioning* approach and aligning marketing with articulated customer desires will not suffice. In order to obtain a competitive advantage, *latent customer needs or desires* have to be detected and satisfied by appropriate marketing activities. At the core of this *active positioning* is the use of unique needs or desires previously unknown to the customer, but important to the decision. Two approaches can be drawn upon in the development of active positioning [11]:

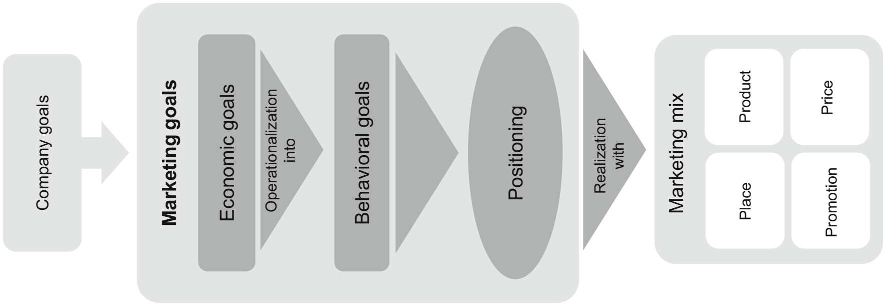


Fig. 7.2 Positioning as guiding principle for the marketing mix (Based on Esch [8])

- *Outside-in-orientation*: In a first step, latent customer needs or desires within a customer segment are identified. This is followed by an active search for innovative solutions. Since latent customer needs and desires cannot easily ascertained through classical market research tools, *explorative methods* such as the lead user concept [12], creativity techniques or expert talks need to be employed.
- *Inside-out-orientation:* In this approach, innovative solutions are being developed based on a company resource potential or core competence to be applied to the latent needs and desires of customers being pursued.

An outside-in-orientation is only successful when there are market entry barriers for the competition based on their lack of specific resources. The inside-out-approach entails the risk of developing products not matched to customer needs. Therefore, only a synthesis of outside-in- and inside-out-orientations will lead to longterm competitive advantages [13].

7.3.2.3 Positioning Models

As mentioned, positioning of products implies to embed them in the customers' perceptions. In order to visualize the product position in perceptive space, *two-or three-dimension positioning models* are created. It is important that these "*perceptual maps*" are generated from *customer research information* rather than "constructed" from a company perspective [14].

From Fig. 7.3 it can be seen that positioning models are based on four core elements [15]:

- *Attribute dimensions:* Those are represented by the three axes of the positioning model and span the relevant perceptual map of the respective customer segment.
- *Positions of* products: Own products as well as competing products will be positioned according to their *characteristics as perceived* by the customers.
- *Position of the ideal product:* The ideal product reflects the product requirements of the respective customer segment based on relevant feature dimensions.
- *Distances between positions of products and ideal product:* With regards to the distances in positions between product and ideal product, positioning models are based on the following hypotheses.

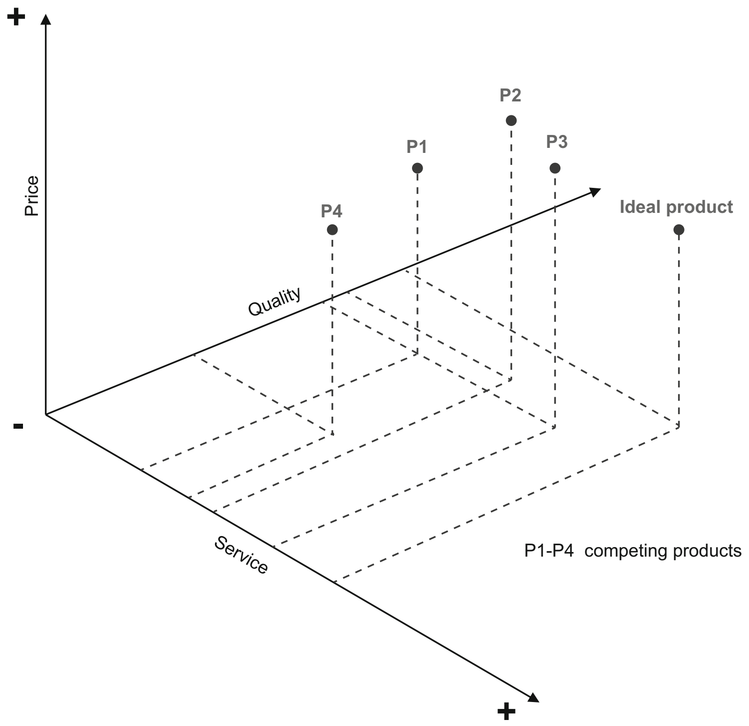


Fig. 7.3 Example for a three-dimensional positioning model

– The shorter the distance between real product and ideal product, the greater the customer's preference for the respective product.
– The product with the shortest real-ideal distance is the one that will be purchased.

It should be noted that positioning models can be used in reactive positioning, but also in active positioning. In the final analysis, the models differ only with respect to whether or not their respective feature dimensions are of a latent character.

From a methodological point of view, several approaches for generating positioning models are available. The ones that are most frequently mentioned are *factor analysis* and *multi-dimensional scaling* [16]. While factor analysis pursues the path of deriving product positioning in the perceptual space of customers based on their *evaluation of product features*, multidimensional scaling opens up the perceptual space based on an *evaluation of similarities* between the respective products. Compared with a factor analysis, *multi-dimensional scaling* allows relevant product features to not be known in advance. Thus, the outcome of the procedure is not influenced by pre-set product features [17].

7.4 Concept Definition

[**MKT, DES, R&D**] Based on detailed analyses, the actual product concept can be drafted. Here, all available information regarding target markets, target groups, competitive situation and differentiation potential must be condensed in order to draft one or several product concepts which describe the new product from the perspective of the customers. It is recommended to describe the product requirements as broadly as possible, in as much detail as necessary, so there remains an ability to alter the concept without significant repercussions to subsequent stages.

In the context of concept definition, the following management tools and methods are particularly important:

- *Preference measurement via conjoint analysis:* Numerous methods can be employed to support the difficult task of identifying customer requirements and translating them into concrete product features. Especially useful is the preference measurement method in the form of conjoint analysis.
- *Target costing*: In determining the performance data of the product, it is important to consider all relevant restrictions. On one hand, a plethora of laws, regulations, guidelines and standards need to be taken into account. On the other hand, the realization of the product needs to be guided by the price that is obtainable in the market. It is particularly useful in this context to deal with the question of reasonable target costs early, since the future success of a product depends decisively on its cost-performance-relationship.
- *Requirements specification sheet*: Based on various data sources, the product concept should be defined by an interdisciplinary team and recorded in writing in a performance specification.
- *Quality function deployment:* This method supports the difficult task of identifying customer requirements and translating them into design targets and major quality assurance points. This comprehensive approach will be described at the end of this chapter because it guarantees quality not only in the concept stage but also at every phase of the product development process.

7.4.1 Preference Measuring via Conjoint Analysis

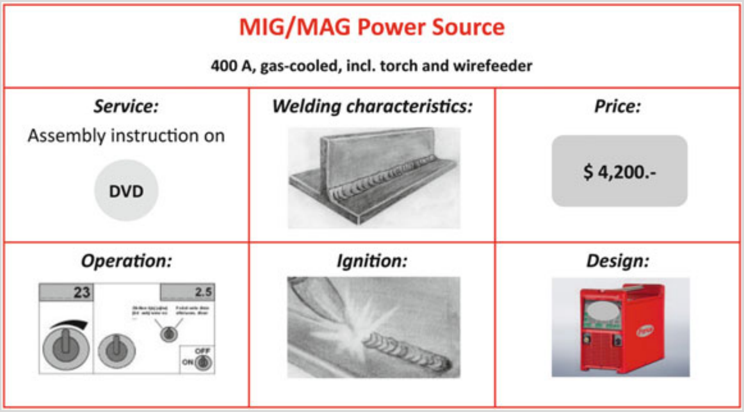
Even if on the basis of a positioning model ideal perceptions are known for a customer segment, this doesn't solve the problem of how to conceptualize the product closest to those ideal perceptions. In this context, the methodology of *conjoint analysis,* tying up product features and preferences, promises to be very helpful [18].

Practical Insight

Fronius International: Product Optimization with Conjoint Analysis

Fronius is Europe's market and technology leader in the welding industry. The company's products meet the very highest standards in technology, workmanship and handling. For testing likely customer acceptance in the concept phase, Fronius applies conjoint analysis to measure user preferences for alternative product concepts. The application of this method is a valuable contribution to reduce the market uncertainty of new product development projects.

With this analytical technique, the relevant product attributes and several of their corresponding levels are defined. Hypothetical products (known as stimuli) are formed so that respondents can rank them according to their preferences within a market research survey. An example of a stimuli based on six relevant attributes is represented in the following Figure.



After performing the data collection in conformity with a full profile method, Fronius uses the statistical program SPSS to derive the utility (part worth) for each of the attribute levels and their relative importance. These utility functions indicate the perceived value of the different attribute levels and how sensitive customers' perceptions and preferences are to changes in product features. It can answer important questions such as whether the customer would accept a price increase if specific upgrades to the product were incorporated. This information forms a valuable basis for the optimization of product concepts in an early stage of the innovation process.

Photos: Copyright © by Fronius

Source: Pichler et al. [22]

[**MKT**] Conjoint analysis is a mathematical-statistical procedure for decomposing global preference judgments, i.e., it aims at determining the partial contributions of individual features in creating a complete preference for the overall product, service, or concept. The technique has been used not only to optimize products but also to construct such varied projects as hotel concepts (e.g., Holiday Inn Express) and the content of an advertisement insert for Lowes (realistic vs. cartoon pictures, number of products displayed, color vs. B&W, etc.). In conjoint analysis, the respective contribution of several features to a general preference for an overall concept (e.g., product) is assessed via experimental design, by estimating so-called "partial utilities". The following six steps are typical in a conjoint analysis [20]:

- *Identification of product attributes and attribute levels*: This step is of crucial importance, since the setting of product attributes and corresponding levels decisively influences validity and reliability of the results of the study.
- *Choice of the preference model*: With the decision for a specific preference model, a functional connection between attribute level and preference is established, allowing for an estimation of partial utilities [21]. Four preference models can be applied, which are the ideal vector model, the ideal point model, the anti-ideal point model and the partial utility model. The latter has a special position here, since this approach allows for a flexible function describing the relationship between attribute levels and preference.
- *Setting of the survey design*: The initial decision is whether to use the profile method or the multiple two-factor method. The major difference between these methods is that in the profile method, the respondents have to evaluate complete products described by all relevant attributes, whereas the two-factor method (trade-off analysis) only asks for preferences on possible combinations of the levels of two attributes at a time. With an increasing number of attributes and attribute levels, the use of profile method entails an overwhelming effort in analyzing all possible combinations. Therefore, a selection of subset of product alternatives are evaluated, i.e., a reduced design, should be selected. Such a reduced design is meant to represent the complete design as accurately as possible, to keep the effort of questioning within reasonable limits and at the same time to allow the calculation of all partial utilities. [**DES**] With regards to the presentation of objects to be evaluated, the techniques that are applicable in the profile method are, in essence, verbal, visual and physical shaping of objects. These techniques can also be used in combination.
- *Evaluation of objects*: Within the profile method, when using a simultaneous evaluation of objects, especially rankings or ratings are used to ascertain preference judgments, which in turn serve as input to conjoint analysis. While in ranking, the respondents are asked to put the objects to be judged in an unambiguous and complete order, rating uses multiple scales.
- *Estimation of utilities:* The preference judgments in the previous step constitute the basis for the estimation of partial utilities for all attribute levels. A whole array of procedures is suggested in the literature. (e.g., Green and Srinvasan [22], Gustafson et al. [23]). Based on the estimated partial utilities, total utilities for all product alternatives as well as relative importances for individual attributes can be calculated.

- *Aggregation of utilities*: The conjoint method is geared towards evaluating the preferences of individuals. Thus, if person-related results are at the forefront, the evaluation and subsequent interpretation of individual utilities constitutes the conclusion of conjoint analysis. However, in conjoint analysis, it is less the individual preference forming processes than the ones at the group level that are of interest. It is for this reason that the desired results are aggregated partial utilties. Two basic methods can be used. One option consists in conducting individual analyses for each respondent, norming the estimated partial utilities and subsequently aggregating them per attribute level by way of calculating an average value based on all respondents. On the other hand, a common conjoint analysis can be conducted, in which the respondents are perceived as replications of the research design. In this case, the partial utilities are not calculated individually any more, but simultaneously for all respondents.

Traditional conjoint analysis, as sketched above, has to be modified if drawn upon to *ascertain the customers' willingness to pay* for a product or service altogether. Here, it is preferable to use the method of *limit conjoint analysis* [24, 25]. This approach is an extension of the classic conjoint analysis insofar as the latter is supplemented by a *choice decision*. In case the objects are evaluated according to the ranking method, each respondent is not only asked to rank the relevant objects according to preference, but also to indicate up to which rank they would actually be willing to buy them. For this purpose the so-called *limit-card* is to be put behind the last object worth buying: Thus all objects placed in front of the limit-card are deemed worth buying by the respondents, whereas all objects placed behind the limit-card are deemed not worth buying. Consequently the position of the limit-card is interpreted as the benefit-limit and thus *benefit zero*. All objects placed in front of the limit-card, that is, the objects worth buying, exhibit positive total utilities, whereas all objects placed behind the limit-card for which there is no willingness to buy, exhibit negative total utilities.

The fact that objects worth buying and not worth buying are differentiated in the limit conjoint analysis by using the limit-card or benefit zero can now be used to determine individual willingness to pay. Based on the common assumption that higher prices have a negative influence on the total utility, the question needs to be asked which price leads to a total utility of zero for a particular object and therefore exactly represents the purchase limit [26]. This price forms the absolute upper price limit and therefore reflects the willingness to pay of the respective person. As a general rule, however, it cannot be assumed that the price levels represented in the conjoint-analytic design show exactly the price that causes a total utility of zero. Rather, this price has to be determined on the basis of the results of a regression analysis which establishes the functional link between the price levels and the corresponding partial utilities from the conjoint analysis.

It should be noted that the benefit zero can only be used as a purchase limit under the premise of a unique position of the respective product or service within the market. If a product or service is in competition with other products or services, it will only be purchased, if it is at least equal to the strongest offer from the competition. Therefore in case of the absence of a unique position, the total utility of the strongest competing offer needs to form the reference point for the calculation of the willingness to pay [27].

7.4.2 Target Costing

In addition to the description of the target market and the customer requirements, the product concept should contain preliminary *cost estimates*. Target costing is rapidly rising in importance, caught between the growing individualization of customer requirements and the cost pressure from tougher global competition. In view of this situation, companies increasingly realize it is often no longer possible to fix the price based on standard cost accounting techniques [28].

7.4.2.1 Basic Idea and Objectives of Target Costing

Target costing is not an alternative cost accounting system, but should be seen as a strategic cost planning, steering and controlling instrument. Its chief aim is to secure cost coordination of all business areas with respect to the life cycle of a product. Compared to standard cost accounting techniques, the principle of target costing is a top-down process, which starts with the question of how much a product is allowed to cost from the perspective of the customer.

Thus, target costing turns the frequently existing thinking on its head, as the target profit is placed at the beginning of the calculation from which target costs are derived. This principle is explained in Fig. 7.4.

The basis for the determination of target costs is the target selling price, which has been determined by market research and from what the targeted profit margin is subtracted. With this approach, cost specific upper limits are already determined at the beginning of the development process. Thereby, an escalation of the costs of development and manufacturing processes is prevented. Since up to 80 % of the production costs of a product are incurred during the early phase of the development and construction process, an early orientation on the target costs leads to the preservation or expansion of a competitive advantage. [**MKT, DES, R&D**] Moreover, the interdisciplinary cooperation between marketing, R&D, construction, design and production necessary for target cost management has a positive influence on the innovation capacity of a business [29].

7.4.2.2 Basic Model and Process Steps of Target Costing

The target costing process proceeds in several steps illustrated in Fig. 7.5 [30, 31]:

(a) Identification and Evaluation of Customer Requirements

[**MKT**] After the basic positioning of the product, customer requirements must be determined through market research. In this context, conjoint-analysis is particularly useful, as the utilities of product attributes can be quantified [29]. The calculated partial utilities for the individual product attributes form the basis for determining the respective proportions of the benefits derived from the functions of the outlined product concept.

Standard cost accounting (bottom up)	
R&D costs	1,800
+ material costs	1,200
+ manufacturing costs	3,300
+ administrative costs	300
+ distribution costs	680
= primary costs	**7,280**
+ profit	750
= sales price	**8,030**
What if the customer are willing to pay just 6,000?	

Target costing (top down)	
target selling price	6,000
- target profit margin	750
= allowable cost	5,250
Target cost splitting	
R&D costs	*1,250
+ material costs	*1,000
+ manufacturing costs	*2250
+ administrative costs	*250
+ distribution costs	*500
= calculated target costs	5,250
** Systematic identification of cost-reduction potentials until target costs <= allowable costs!*	

Fig. 7.4 Calculation processes in comparison

Fig. 7.5 Process steps of target costing

(b) Rough Draft of the New Product

[**MKT, DES, R&D**] On the basis of the desired product features a rough draft of the product is subsequently drawn. This draft defines the product components through which the product functions are realized [32].

(c) Determination of the Target Selling Price and Derivation of the Target Costs

[**MKT**] The target costing process requires that the company determines a specific target selling price acceptable to the market. An appropriate tool for this task represents the limit conjoint analysis as indicated above. This *market-into-company approach* can be used to derive the target costs from the target selling price, according to the previous explanations. The desired profit margin (target profit margin) is subtracted from the determined target selling price in order to determine the allowable costs. This is shown in Fig. 7.6.

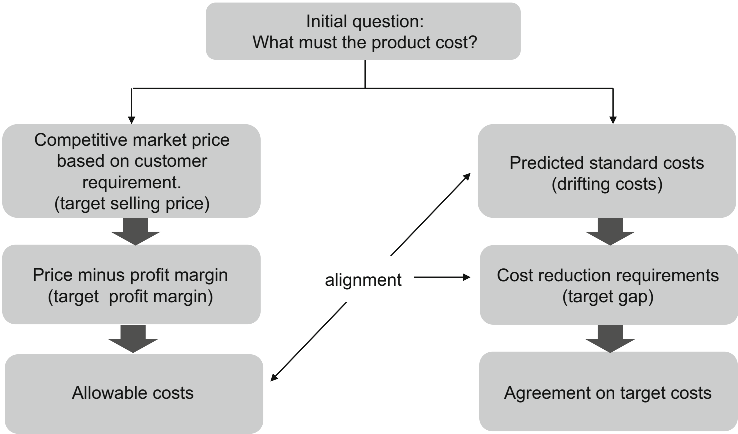


Fig. 7.6 Procedure for derivation of target costs

The *allowable costs* are defined as the maximally permitted costs and depend on the customer requirements and the competitive situation [33]. Subsequently, the allowable costs are contrasted with the *drifting costs*, which are estimated on the basis of the available know-how and the experience level within the company. The difference between allowable costs and drifting costs is referred to as the *target gap*. The target gap demonstrates the cost reduction requirements and specifies the potential for the determination of target costs. The final target costs are dependent on the factors of influence within and outside of the company and serves as the absolute upper cost limit that requires adherence.

(d) Weighting of Product Components and Allocation of Target Costs

In target cost splitting, the overall costs are divided between product functions or product components [34]. Essentially, the component method or the function method can be used. In the *function method,* the product is viewed as a composition of many different functions which serves to satisfy customer requirements and customer needs.

In contrast, the simpler *component method* allows target costs to be split directly between the respective product components [35]. This method represents the classic approach in target costing and is therefore more closely examined hereafter. In this method, target costs are split in two stages and a *components/functions matrix* is created. For each product component, interdisciplinary teams estimate the degree to which the component contributes to the delivery of a function, whereby all components of a function deliver 100 %. The component's contribution to the delivery of the function is multiplied by the proportion of the function's benefits to the total benefits. These values are added across all functions, from which ensues the *benefit proportion* for the component which subsequently enters the target cost index (Fig. 7.7).

Function / Component	F1 (10%)		F2 (20 %)		F3 (31%)		F4 (5%)		F5 (24%)		F6 (10%)		Benefit proportion (component)	Proportion allowable costs	Proportion drifting costs
	%	%	%	%	%	%	%	%	%	%	%	%	%		%
K1	60	6	65	13	68	21			17	4			44	220	31
K2			30	6	23	7			32	8	50	5	26	130	27
K3									17	4	10	1	5	25	3
K4					3	1			17	4	40	4	9	45	12
K5			5	1	6	2			17	4			7	35	4
K6	40	4											4	20	7
K7							100	5					5	25	16
Benefit proportion (function)		10		20		31		5		24		10	100	500	100

Explanation:

30 Proportion of component 2 to fulfill function 2.
6 By means of the benefit proportion of function 2 (20%) weighted share of component 2 to fulfill function 2.

Fig. 7.7 Components/functions matrix (Based on Link et al. [36])

With the aid of the component's benefit proportion, market- and customer-oriented allowable costs can be allocated to each component, which constitute the target costs for the individual components.

(e) Calculation of the Target Cost Index

The allowable costs are subsequently compared to the drifting costs on the product and component level. If drifting costs are higher than allowable costs, then costs need to be reduced. In order to identify the focus areas for cost reduction the target cost index is calculated.

The *target cost index* (TCI) expresses the relevance of a component in relation to its proportion of costs (drifting costs) and represents a measure for the discrepancy between customer relevance and cost causation. The calculated values at component level are illustrated in Table 7.1. Table 7.2 illustrates the significance of the index value according to its characteristic.

Since it is surely too narrow and impractical to set the standard for target costing at a target cost index of exactly 1, an optimal target cost zone needs to be defined, within which the target cost indices of the individual components should be located. This zone of tolerance (also called optimal value zone [39]) is specified in the diagram for the control of target costs and is depicted in Fig. 7.8. This zone decreases with increasing relevance (benefit proportion) and proportion of costs. There is a call for action with regard to components located outside of this tolerance zone. Possibilities for cost reduction and/or an increase in delivery of functions need to be determined [38]. The optimization of the target cost index is a valuable instrument for the management of costs and functions with regard to market conditions and customer requirements.

Table 7.1 Component specific target cost index and calculation formula (Based on Link et al. [37])

Component	Benefit proportion (component)	Proportion drifting costs	Target cost index
K1	44	31	1.42
K2	26	27	0.96
K3	5	3	1.67
K4	9	12	0.75
K5	7	4	1.75
K6	4	7	0.57
K7	5	16	0.31

Table 7.2 Significance of the target cost index (TCI)

TCI = 1	The ideal value of the target cost index is one. This means an optimal delivery of customer functions, as the proportion of the costs of a component exactly matches the value with which the component contributes to the delivery of product functions. Thus cost causation and relevance of the component are identical
TCI > 1	If the target cost index is greater than one, the corresponding product component is of great value to the customer, yet does not receive sufficient resources for its realization. There is a need for an increase in appreciation
TCI < 1	If the target cost index is less than one, the costs incurred by the component are too high compared to the generated customer benefit. There is a need for cost reduction

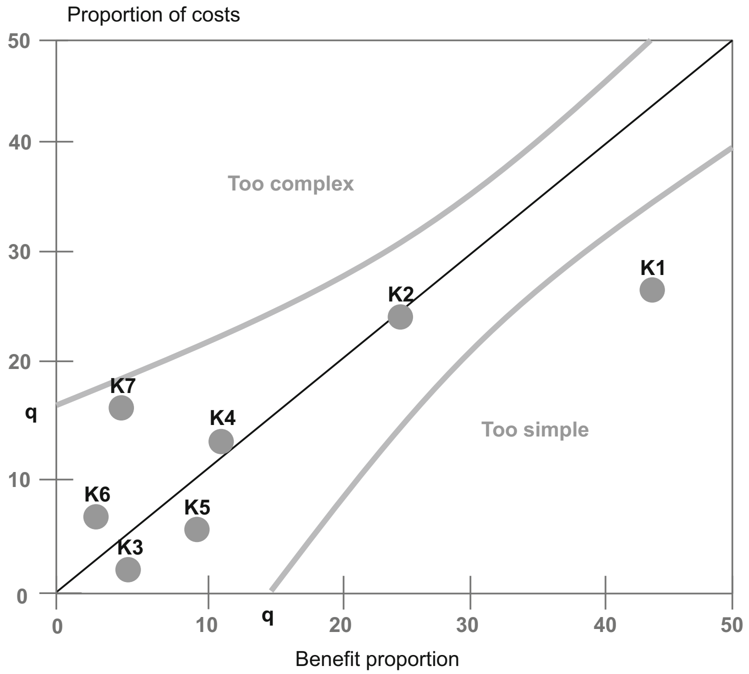


Fig. 7.8 Diagram for the control of target costs (Based on Link et al. [38])

(f) Measures for the Achievement of Target Costs

[**MKT, DES, R&D**] Target costing in product development is closely connected to other technical and economic methods. The cost reduction potential and/or the value enhancement potential (i.e., the bridging of the gap between allowable costs and drifting costs by reviewing the functions, changes in construction, etc.) can be supported by the following important methods [40]: quality function deployment (QFD), value analysis and value engineering, simultaneous engineering as well as process cost calculation.

7.4.2.3 Use and Limits of Target Costing

As has already been mentioned, target costing can be of use in the development of new products, as well as the re-engineering of existing products. The high efficiency of the method can be achieved because the method is used early, specifically in the conception and development phase of performance features, and is connected with integrated business planning. Thus, market orientation can be increased as well as needless costs decreased. This leads to higher profitability and an increase in competitive advantage.

A major problem with target costing is that the product structure needs to be already known in the early concept phase in order to split the target costs between the product components. This is rarely the case, especially with highly innovative products. Furthermore, the method can be deemed somewhat subjective, especially in the determination of which components deliver what level of function. Moreover, the elaborate efforts needed to obtain the necessary information also need to be taken into consideration [41].

7.4.3 Requirements Specification Sheet

[**MKT, DES, R&D**] Ideally, the product concept is drawn up by an interdisciplinary team of employees from various departments and recorded in a performance specification. This is essentially a detailed description of the requirement profile of the product without defining steps for the realization of the product. Altogether, the following items should be described in the product concept or *requirements specification sheet* [42, 43]:

- Definition and description of the target market,
- Customer requirements
- Essential performance data of the products
- External and internal restrictions that need to be considered
- Estimated production and project costs and
- Time-frame for objectives and project milestones.

The clear definition of the requirements specification sheet is a key factor to reduce market, technology and organizational uncertainty.

7.5 Concept Evaluation

The drafted product concepts should be evaluated in terms of their acceptability, their potential to satisfy needs and their profitability through appropriate methods before the start of the product. This step is essential to reduce market uncertainty. Next to the identification of weaknesses and the generation of suggestions for improvement, the selection of the concepts that should be pursued further is central to this process. The following explication of evaluation methods is restricted to those processes that are most frequently discussed in the literature including concept tests and scoring models, in particular, as well as different methods of economic analysis.

7.5.1 Dimensions and Procedure of Concept Testing

[**MKT, DES, R&D**] Alternative concepts for new products or product variants are tested in a *concept test*. Concepts are clear and concise statements or representations of the essential characteristics of a product and its benefits for the (potential) buyer/user [44, 45]. The concept test can be used for verification of product ideas at an early stage of the innovation process or to reduce a large number of existing rough concepts to meaningful alternatives by a customer's point of view [46].

The concept test investigates impression and utilization attributes of a possible product and can either be restricted to the evaluation of a single concept statement (*evaluation test*) or to testing different positioning strategies for a concept (*positioning test*) [47]. The concept test allows an early estimation of the customer's reaction to a potential product, without the need for the product to be developed, i.e., before higher development investments are made. In addition, it provides a first determination of attractive market segments and gives suggestions for improvements of the product concept [48].

Typical questions which should be answered in the context of a concept test are provided in Table 7.3. As explained earlier, the assessment is carried out by the experimental subjects not on the basis of actual product experience, but due to a *verbal, visual* or *multimedia* presentation of a product idea [49]. The easiest, most economic, fastest, and mostly used form is where a *verbal brief description* using simple statements is formulated for the core idea and the respondent is asked to evaluate them in regards to favor and purchase intent as well as uniqueness and credibility [50]. Test procedures, which virtually represent the product concepts, become increasingly important due to the increasing efficiency of the IT infrastructure.

[**R&D**] Studies show that *virtual models* (e.g., CAD, virtual prototyping, etc.) have similar assessment abilities as tests of actual products and allow considerably more valid statements of customer acceptance versus pictured rough concepts. Virtually represented product concepts or virtual prototypes have another advantage over real prototypes in that they can be remodeled and therefore be reused for tests with little effort [51].

For the *research design,* a two-stage procedure is recommended. In the first step, a product concept is analyzed through qualitative techniques, such as focus group

Table 7.3 Dimensions of concept testing (Based on Kotler and Keller [52])

Question	Dimensions of concept testing
Do you see a clear and credible benefit in it?	Employability and credibility of the concept. When a negative response the concept must be modified
Would this product solve a problem or meet a need? How big is this problem/need?	Intensity of need. The stronger the need is, the bigger is the prospective customer interest in the product
Currently how many other products meet this need? How much are you satisfied with these products?	Need gap and satisfaction gap. The bigger the gap, the bigger is the prospective customer
Is the price in a reasonable proportion to the benefit? What price would be most appropriate?	Perceived benefit. The bigger the perceived benefit the bigger is the prospective customer interest
Would you buy the product? (for sure, probably, probably not, certainly not)	Buying intention. This should be highly developed by all (potential) customers, whose previous answers were positive
Who would use the product, when and for what purpose?	Potential users, situation of use and reason of purchase will be determined

discussions and individual exploration, with regards to general appearance, understanding and uniqueness. In the second step, the revised concepts are evaluated through a quantitative survey. The focus lies on a target group and position-specific design of the tests [53]. It makes sense to perform more than one concept test. Rough concepts should be refined and evaluated in an *iterative process* so that through repeated testing, feedback and selecting the determination of a final concept may be facilitated and therefore the development of the new product is supplemented [54].

Concept tests are readily used for incremental innovations because they normally lead to meaningful and valid results. Radical innovations are less meaningfully evaluated because of the lack of imagination and foreknowledge. While consumers cannot properly estimate future needs, concept tests for radical innovations are often not recommended. But empirical studies conclude that even for radical innovations, concept tests may give important clues as to the acceptance of the products and therefore should not be relinquished [55]. It should be noted that these tests for tadical innovations primarily include lead-user and that the respondents have an appropriate product and background knowledge [56]. Moreover, for testing of radical innovations, virtual tests procedures are suitable through interactive computer simulations and multimedia linking (e.g., with audio data). Relatively realistic product presentations are possible—not only with the product but also the future environment can be presented [57].

7.5.2 Scoring Models

One widespread method for the evaluation of product concepts is the *scoring model*. Scoring models can be used for ascertaining the extent to which alternative product concepts correspond to pre-defined requirement criteria. These can, for example, refer to the agreement of the concepts with the corporate strategy and marketing goals, the basic feasibility of the concepts, the legal admissibility and the availability of resources for the realization of the concept. Thus, scoring models serve to evaluate concepts in-house, based on pre-defined criteria where a weighting of the criteria also takes place. The implementation of the scoring approach occurs in four steps [58]:

- *Step 1*: Clear and distinct definition of evaluation criteria relevant to success.
- *Step 2*: Weighting of individual evaluation criteria, according to their importance for product success.
- *Step 3*: Evaluation of product concepts, with regard to the level of compliance with the individual criteria.
- *Step 4*: Calculation of total values for the final evaluation of each individual product concept.

The advantage of scoring models lies, without a doubt, in their flexibility and simplicity, which is why they are also frequently used in practice. However, a critical view must be taken in selecting and weighting the evaluation criteria, as well as on the evaluation of the product concepts because of its intrinsic subjectivity. Therefore, it is recommended to use scoring models in combination with other methods of concept evaluation.

7.5.3 Profitability Analysis

Those product concepts that have proven themselves in the concept tests and scoring models should then be subjected to an economic examination. Economic analyses are conducted relatively late in the innovation process, because they require detailed cost information and realization of the product idea, which can only be obtained with great effort [59].

Economic analyses can be conducted using a variety of different procedures, including *break-even analysis* and *capital budgeting* introduced here. Break-even analysis is a procedure which portrays profit as a function of the quantity of sales. While the future quantity of sales can only be estimated, the break-even point is determined at the intersection of expected costs and revenues (Fig. 7.9). This point indicates the quantity of sales at which production costs are recovered [60]. The question remains, whether this quantity of sales can be achieved or exceeded in practice.

Furthermore, static and dynamic methods of capital budgeting can be used for concept evaluation. For these methods, it is assumed that the financial inflows and outflows, can be estimated in advance. Two of the most prominent procedures of capital budgeting are the calculations of profitability and amortization.

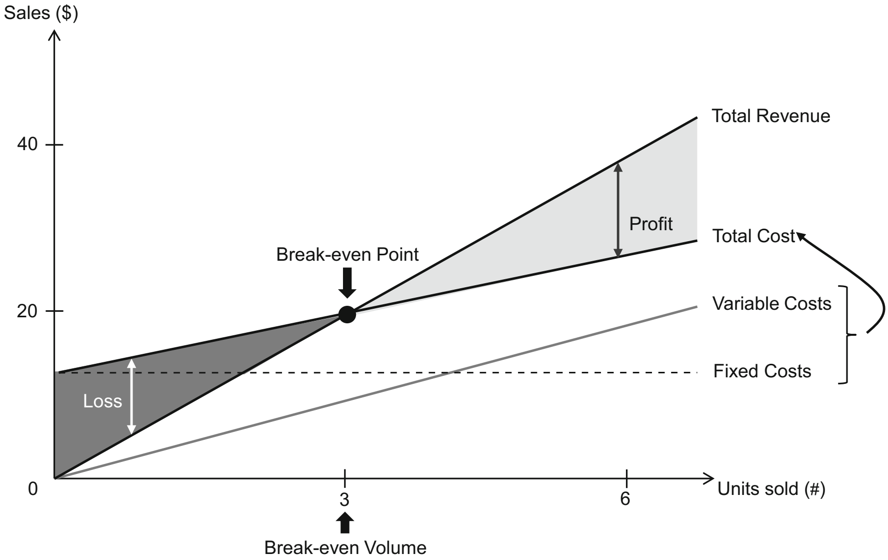


Fig. 7.9 Break-even point

In the context of *profitability calculations*, for each potential product the average return of the capital employed can be calculated according to the following formula:

$$\text{Profitability} = \text{annual profit/capital investment} * 100\ (\%)$$

The *amortization calculation* answers the question of how many years it takes until the investment in the new product has been amortized:

$$\text{Amortization time in years} = \text{capital investment/annual profit}$$

The major advantages of the so called static methods of capital budgeting lie in their simplicity of use and the relatively small amount of information required. These methods are therefore especially useful for the evaluation of short-term projects and in the case of unreliable forecasts. The weakness of the methods, however, is that they do not account for changes over time. Average values over a single period of time—which do not take into account any temporary differences in deposits and payments—are considered [61]. This disadvantage can be avoided by the application of dynamic procedures which distinguish between the different times at which monetary transactions are made.

Using the net present value (NPV) method, future inflows and outflows that result from a product launch, are discounted by means of an appropriate interest rate on capital, using the following formula:

$$NPV = -C_0 + \sum_{i=1}^{T} \left(\frac{C_i}{(1+r)^i} \right)$$

where

NPV = Net present value

C_0 = investment

C_i = cash flow at the end of period i

r = interest rate on capital

T = temporal horizon (i = 0, 1, 2, . . .n).

The NPV formula is also drawn on when using the IRR (internal rate of return) method, with the difference that the capital value is set at zero and the associated discount interest rate has to be found. This internal interest rate can be determined by using the following formula:

$$0 = -C_0 + \sum_{i=1}^{T} \left(\frac{C_i}{(1+R)^i} \right)$$

where R denotes the internal rate of ruturn.

When evaluating alternative product concepts, preference should be given to the one with the highest internal interest rate.

In summary, compared to statistical methods, dynamic methods of capital budgeting are better suited to creating an economic decision-making basis for the realization of alternative product concepts. Further, they portray the financial consequences of product realization more realistically. However, even when using these methods, there remains the fundamental problem of the predictability of monetary values. Alternatively, as with all quantitative evaluation methods, the qualitative aspect of concept evaluation is left out of consideration. Such methods should be used in conjunction with other evaluation methods to arrive at product concepts.

7.6 Concept Approval

Following the examination of the product concepts, a decision needs to be made as to which concept should be realized. When deciding whether to pursue a product concept, all the conducted qualitative and quantitative analyses that make economic sense should be considered, as such a decision can have far-reaching consequences for the business.

[**MKT, DES, R&D**] The approval of product concepts concludes the product concept phase. Those who took part in the decision have agreed and a thorough project justification, as well as a detailed project plan, have been worked out. Only then can a technical realization of the product concept commence. From here forward, the company commits to heavy spending in the development of approved concepts. Some firms call this important step the “money gate” [62].

It is therefore of great importance to consider the customer’s needs and benefits not only during the entire concept phase but also through the technical requirements specification by the R&D department. One method for deploying the “Voice of the Customer” into the design of new products is Quality Function Deployment, which will be explained in the following.

7.7 Quality Function Deployment

Quality Function Deployment (QFD) is a method for translating the “Voice of the Customer” into “Action of the Developers” [63]. It is an appropriate approach to identify customer needs and therefore to reduce uncertainty.

7.7.1 Introduction

The factors of *quality, cost* and *time* increasingly move to the foreground. As a result, there is a call for ever shortening development times, but with improved quality and a reduction of costs. QFD meets this requirement as well, increasing every employee’s awareness of quality and guaranteeing high-quality development while simultaneously reducing expenses [64].

7.7.2 What Does Quality Function Deployment Mean?

QFD is a procedure for developing a quality project draft that meets customer requirements. It provides unique methods for guaranteeing quality at every phase of the product development process. [65]. Introduced in 1966 by *Joji Akao,* it was implemented in Japan in 1972 at Mitsubishi Heavy Industries. In the 1980s, QFD reached the US industry and was used, for instance, by the Ford Motor Company. In addition to its role in product development, QFD also influences processes required for production. In this context, it is of the essence that all customer requirements be communicated to all areas of the company clearly. In other words, the “Voice of the Customer” must be anchored in more than marketing; it must be in all departments, i.e., development, construction, procurement, logistics and distribution. In particular, QFD constitutes an essential element for systematically transitioning from product brief to system specification [66]. Thus, QFD is primarily an essential communication process and only secondarily a documentation process.

In recent publications, different forms of QFD have been developed but all share the following characteristics [67]:

- Consistent focus on customer requirements;
- Measurable technical quality features interwoven with customer requirements;
- Use of multi-functional, consensus-committed teams; and
- Multi-level planning process using planning and communication matrices called *House of Quality*.

7.7.3 Systematic Quality Management Through QFD

Systematic quality management plays an important role in product development. It is responsible for technical product quality and customer utility. It also allows for the early detection and minimization of sources of errors and risks. Like Failure Mode and Effects Analysis (FMEA), Quality Function Deployment is an instrument for consistently implementing customer expectations in products and services.

As a rule, QFD consists of two instruments: a *quality planning team* and the House of Quality [68]. [**MKT, DES, R&D**] The *quality planning team* consists of representatives from the departments of marketing, development, construction, procurement, production, logistics, distribution and service. QFD steers the entire product development process, assuring that departments work cooperatively and synchronously rather than isolated and sequentially (Fig. 7.10).

The House of Quality (HoQ) serves to document the thinking and planning processes of all participants in the QFD process as a system of matrices. The forms of the matrices correspond to the shape of a house (Fig. 7.11).

Through cooperation, QFD helps to overcome department-focused thinking, replacing it with process-based thinking. In the spirit of *Total Quality Management* (TQM), QFD becomes the instrument of communication throughout the company, fundamentally improving the flow of information and consequently cooperation. The essential elements, the so-called seven segments in the TQM circle, are depicted in Fig. 7.12. There are customers at the center with integration of employees, planning, continuous improvement, process management, economic success, and environment and society. Thus TQM's philosophy, method and strategies constitute the basis for QFD.

The *areas of application* of QFD are manifold, reaching from new product development via improvement of products and services of all kinds to optimization of business processes and administration [71]. The literature tends to stress generation-specific improvements, since customer specifications are assessed in a general way, lacking the necessary degree of detail [72, 73]. However, QFD provides significant support in the areas of quality, time and cost—getting new products to market faster, at lower costs and at higher quality. The literature mentions a reduction in development time between 33 % and 55 %, a cost reduction of up to 60 % and a reduction of required product changes by 50 %, with constant or improved product quality [74–76].

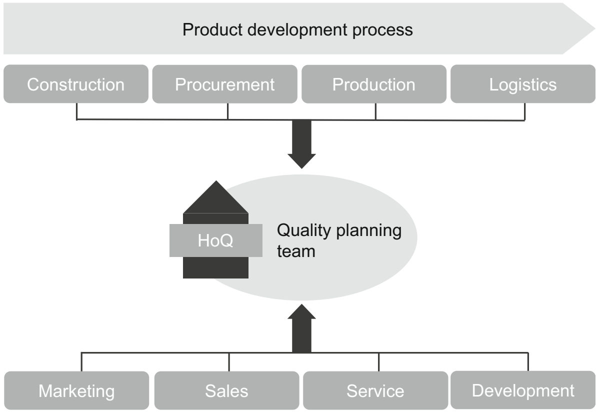


Fig. 7.10 Depiction of the two instruments of QFD (Based on Zoschke [68])

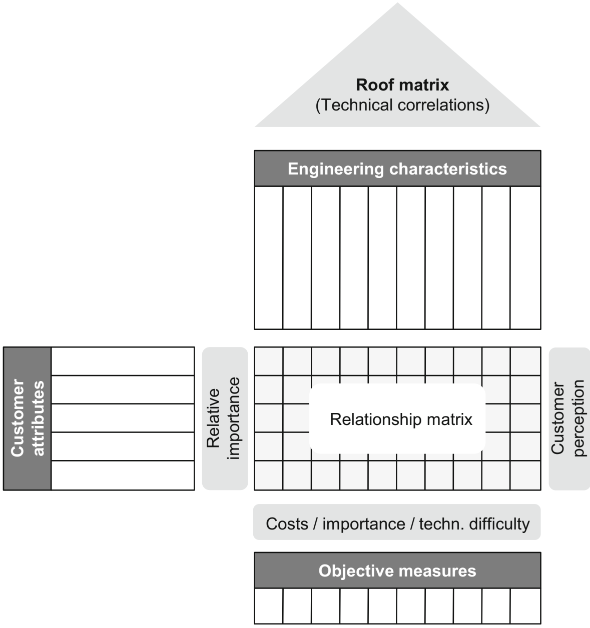
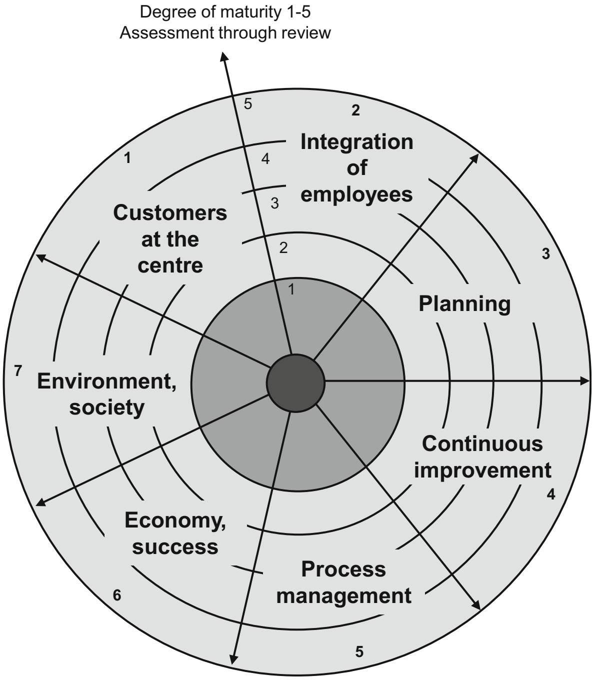


Fig. 7.11 Basic structure of the House of Quality (Based on Hauser and Clausing [69])

7.7.4 The QFD Process

Since its inception more than 40 years ago, Quality Function Deployment has been consistently innovated. The House of Quality approach, in widespread use today, was developed by the American Supplier Institute ASI [74] and is explained in detail below.

Fig. 7.12 The seven segments of the TQM circle and a company's degree of maturity (Based on Saatweber [70])



7.7.4.1 House of Quality Approach

The House of Quality approach is at the core of the QFD process. It serves the purpose of documenting the thought and planning steps in the product creation process [77]. By virtue of its structure, HoQ provides a systematic and transparent form of documenting results. It underpins the work of the quality planning team by fostering a systematic approach to proceed through clearly defined "rooms". Its foundation provides support by consistently asking the questions: "*WHAT* do customers expect" and "*HOW* do we as a company meet those requirements?" Figure 7.13 provides a simplified overview of the first HoQ's areas of documentation, with the horizontal, market-directed axis representing the customer and the vertical axis representing the degree to which the company meets the customer orientation. Figure 7.14 shows the complete first house [78, 79]. Subsequent HoQ phases follow.

7.7.4.2 General Structure of the House of Quality

Customer requirements constitute the entry into the HoQ. They can be assessed by a market survey that answers the following questions [82]:

- *Who is the customer?*
  Here, representative customers of a homogeneous target segment are defined by their needs and other demographic, geographic and psychographic variables.
- *What is the customer's significance for the company?*
  One important determination is whether the customer is a market leader. Also, what is the volume of their orders?

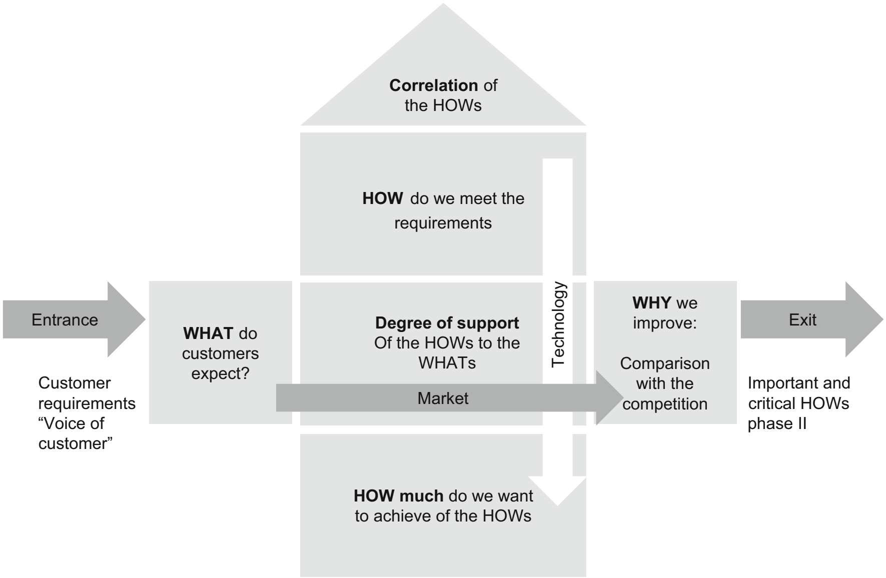


Fig. 7.13 Simplified depiction of the first House of Quality (Based on Saatweber [80])

- *What are the full range of customer's needs, wishes and expectations (WHAT)?* Conducting an analysis of complaints, returns and trends. The results complement customer expectations.
- *What do those wishes mean to the customer?* Wishes are evaluated on the basis of market analyses or direct customer surveys.

Identifying articulated and unarticulated customer needs is clearly of central importance in the QFD process. One method for identifying those needs is the *Kano Model* [83]. Named after Japanese professor *Noriaki Kano,* the model identifies three factors of satisfaction and juxtapositions them with the degree of fulfillment (Fig. 7.15).

The *basic factors* are fundamental requirements presupposed, but not explicitly recognized, by the customer. However, their absence creates dissatisfaction and helps determine the product's long-term success or failure. Therefore, these factors are of the highest priority in HoQ. The *performance factors* are requirements articulated by the customer. They are therefore easier to assess but are immediately integrated into the customer's level of satisfaction. Their importance in the HoQ is expected and determined by the customers. In contrast, *exciting factors* are unexpected and provide a pleasant surprise or inspiration to customers. These novel product qualities significantly contribute to customer satisfaction. Often their importance for the HoQ can only be estimated. In addition, the Kano Model takes into account the development of factors over time: exciting factors evolve into performance factors, performance factors into basic factors. Thus the time axis incites continuous action and ongoing innovation. Many methods for identifying

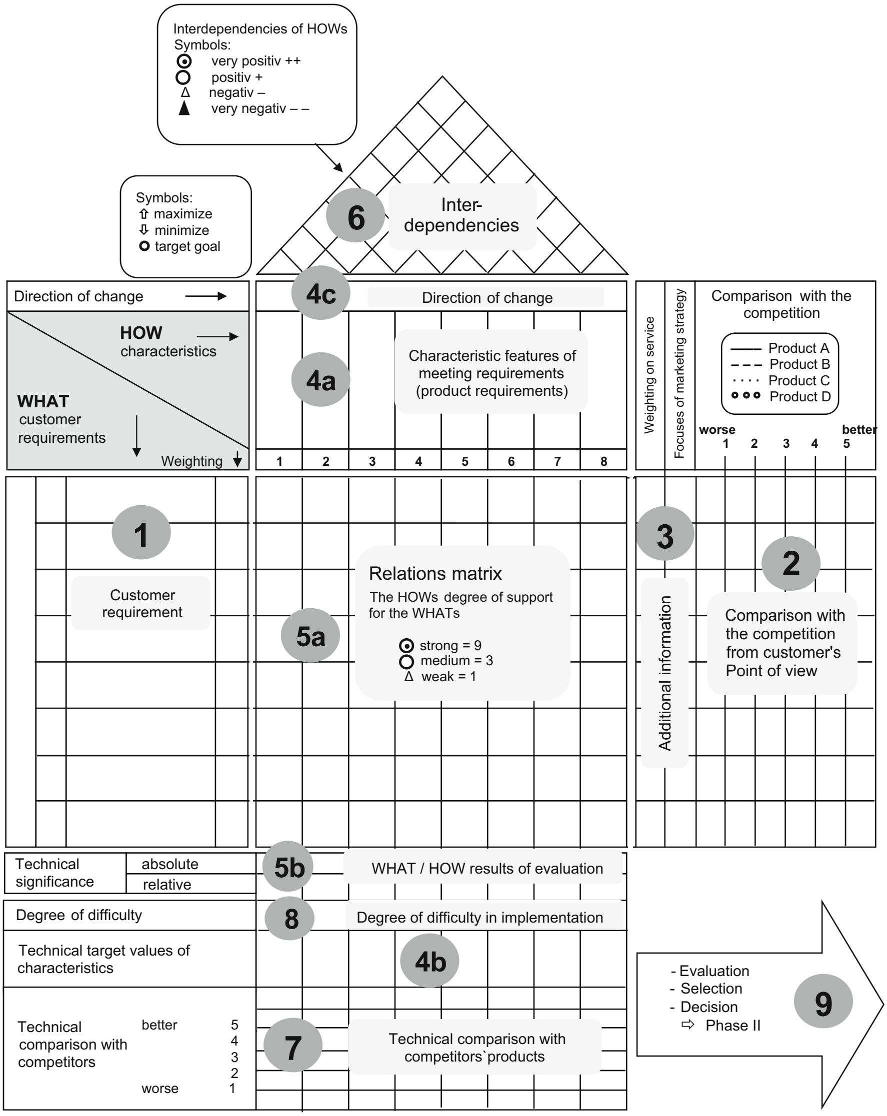


Fig. 7.14 The House of Quality (Based on Saatweber [81])

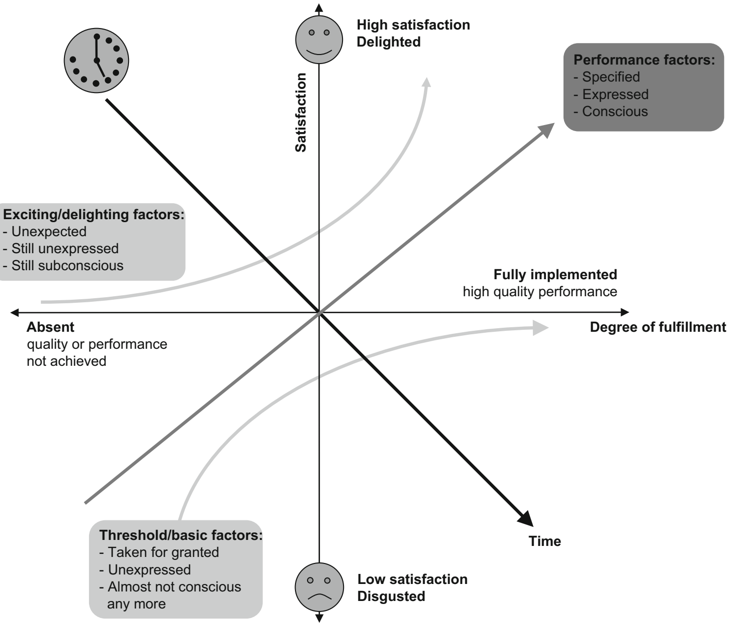


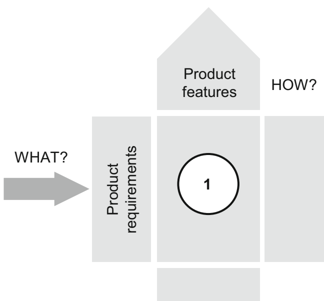
Fig. 7.15 The Kano model (Based on Kano et al. [84])

inspiring factors can be found in the literature. [**MKT, DES, R&D**] There is an array of options for utilizing internal and external sources of information including the evaluation of complaint forms, error statistics or repair reports along with direct customer involvement (e.g., lead user cooperation) or customer observation.

Once all relevant information is on hand, a step-by-step creation of the House of Quality can begin [85, 86]. In the following section, the steps in working with the first HoQ will be explained in detail with the sequence of steps corresponding to the numbering system (Based on Saatweber [85]).

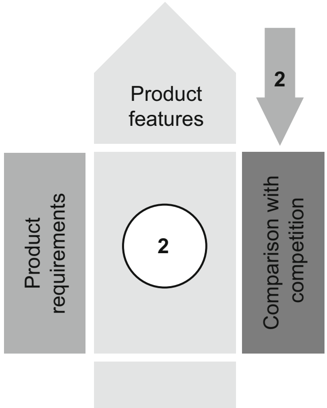
Step 1: Customer Requirements (WHAT)

[**MKT**] The input to the first house is provided by the "Voice of the Customer". Customer requirements on the product are structured (for instance, primary, secondary and tertiary ones) and their importance weighting is entered. Care should be taken to generate product attributes and their significance to the customer by way of user segment market research [87].



Step 2: Comparison of the Competition

[**MKT**] In the right "wing" of the HoQ, the company's own (existing or planned) product is evaluated with regards to similar competing products. Strengths and weaknesses *as seen from the customer's perspective*, gathered through observation of customers' actions, benchmarking or customer surveys, are entered [88]. These measures are subjective—"perception is reality" from the customer's perspective—and not the company's perceived knowledge of absolute facts.

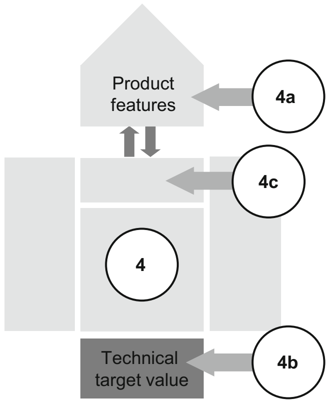


Step 3: Additional Information

If further information is available, it can be entered at this stage. In addition, the company's strategic preferences can be integrated in the sense of a *planned product positioning*, possibly necessitating a new evaluation of the weighting from Step 1.

Step 4: Product Features (HOW), Technical Target Values and Direction of Optimization

[**MKT, DES, R&D**] The technical performance values meeting customer requirements need to be defined. A solution neutral definition should be used in order not to anticipate any one specific technical solution. The characteristic features have to be objectively measurable and also changeable.

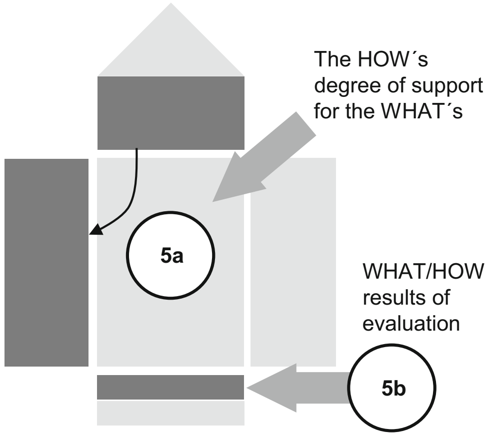


4a Translation of customer requirements into product features. The Voice of the Customer is translated into the language of the developers.

4b Fixing of desired target values of features (4a), the question is asked, "What is the desired measurable target value of the product feature?"

4c Fixing of the direction of changes in the sense of an optimization (increase, decrease, remain constant?). This facilitates recognizing and evaluating of interdependencies.

Step 5: Relationship Matrix, Technical Significance

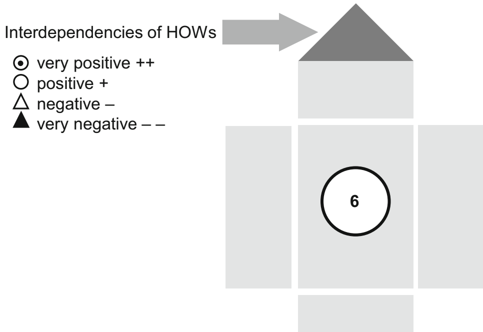


[**R&D**] At the center of HoQ, the so-called *relationship matrix*, the comparison between individual customer requirements and technical performance features takes place.

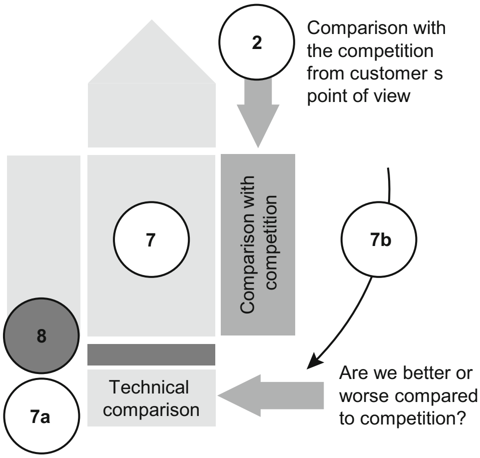
5a How strongly does each individual feature (4a) support a customer requirement (1)? This evaluation is carried out with symbols (e.g., o = medium) or numbers (e.g., 9 = strong).

5b In addition to chart values, calculations for absolute and relative importance are offered. The importance weightings emphasize those technical characteristics that play a decisive role in product development.

Step 6: Interaction of Product Features



[**R&D**] At the roof of the HoQ is the correlation matrix describing the interaction between features. In this process, the degree of positive or negative correlation of individual product features is noted. Technical performance features and their possible configurations cannot always be shaped at liberty, since technically-conditioned interdependencies might exist. A possible conflict of goals is in evidence here.



Step 7: Technical Comparison with the Competition

[**MKT, R&D**] In the "basement" of HoQ, a technical comparison of the competition with the evaluation from the customer's perspective is conducted. This draws upon experts using methods such as reverse engineering or value analyses of competitors' products.

7a Technical comparison against competitors.

7b Comparison of subjective customer perspective (2) and objective technical perspective (7).

Step 8: Degree of Difficulty in Implementation

[**R&D**] The degree of difficulty in implementation is entered here. For each quality feature, the quality regulation team estimates the difficulty of changing characteristics in a predetermined direction of optimization (4c).

Step 9: Evaluation and Transition to Phase II

[**MKT, DES, R&D**] Review and selection of important and critical product features for further development in the second House of Quality. All rooms and cells are completely filled and all steps in the thought and work processes are documented in a transparent way.

By way of example, Fig. 7.16 shows the first completed HoQ in the example of a light-emitting diode (LED) [89].

7.7.4.3 Multi-step Sequential Character of QFD and Its Phases

The QFD approach not only serves systematic development of product concepts but also links them with subsequent phases of product or component planning, process planning and production planning. The interlocking nature proceeds by successively working with a unique House of Quality in each phase, with the results of the preceding HoQ becoming the introductory values for the following phase. Thus a cascade model proceeding in several phases is created [90]. Figure 7.17 depicts the QFD process and its phases according to the American Supplier Institute (ASI). This 4-Phase Model constitutes a multi-layered instruction which can serve as a basic structure for development activity. Starting with market research assessing customers' requirements and wishes, it eventually reaches the implementation of production processes [91]. The bases of individual steps of development are defined HoQs, in which goals (WHAT) and implementation (HOW) are set in relationship

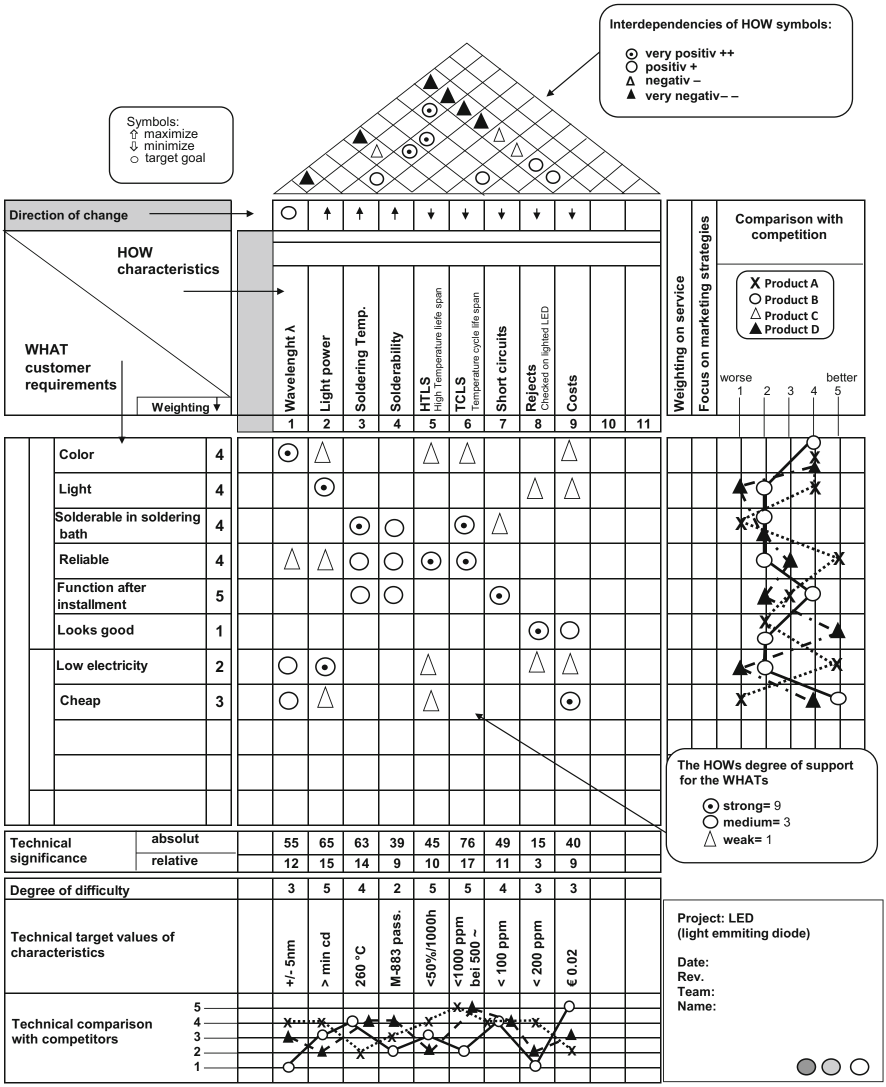


Fig. 7.16 First HoQ for the example of a light-emitting diode (Based on Saatweber [89])

with each other. The "HOW" of the preceding phase becomes the "What" of the subsequent one.

The four phases I, II, III. IV are preceded by the so-called Phase 0, the information gathering phase [92]. [**MKT, DES, R&D**] The participating departments vary in each phase. They are listed in Fig. 7.17. These five phases implicitly convey the voice of the customer through to manufacturing and are subsequently explained further:

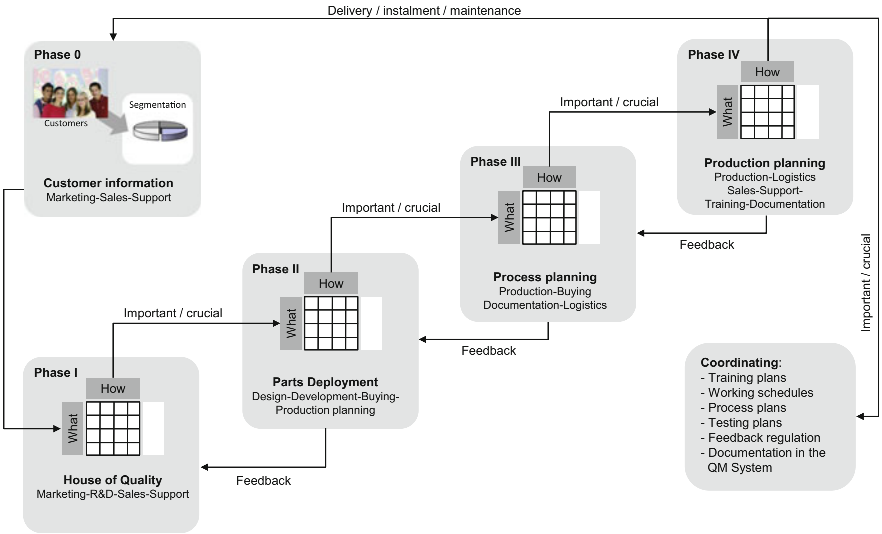


Fig. 7.17 The QFD process and its phases (Based on Saatweber [93])

- *Phase 0: Information gathering* (Cf. Sect. 7.4.1)
  In this phase, the "Voice of the Customer" is recorded. Customer requirements are gathered and segmentation is accomplished. Descriptions are developed. Marketing is called upon here to translate customer wishes into suitable specifications. Methods used in this phase are market research, strategic planning, portfolio techniques, trend analyses and market segmentation.
- *Phase I: Concept planning phase—HoQ* (Cf. Sect. 7.7)
  This stage is where product planning occurs with its input being customer requirements. The raw input is translated into the language of developers within the company. Methods used here are the affinity diagram, target costing or creativity techniques. Phase I ends in the selection of the essential critical "HOW" criteria, constituting the "WHAT" as input to Phase II. Depending on the complexity and degree of detail of the product, several HoQs might have to be drafted in this phase.
- *Phase II: Part and component planning phase*
  In Phase II, construction and technological planning occurs, with product part characteristics being in the foreground. Parts that are critical or difficult are examined in detail, using different methods, i.e., value analysis, Failure mode and effects analysis (FMEA), fishbone diagram or target cost techniques, constituting the basis for, among other things, make-or-buy decisions. Critical product features (WHAT) are being translated into quality features of parts (HOW). Phase II ends in the selection of the essential critical "HOW" criteria, constituting the "WHAT" as input to Phase III.
- *Phase III: Process planning phase*
  In this phase, the process features operating on and interacting with the part features at the entrance of the House of Quality are developed. Here, the

descriptions of the process requirements are developed in order for the parts, the components, and finally the product to reach the required quality. Methods used in this phase include Process-FMEA, Design for Assembly, Design for Manufacturing, testing planning and statistical process control, respectively. Again, the selection of the essential critical "HOW" criteria, constitutes the "WHAT" as input to Phase IV.

- *Phase IV: Production and manufacturing planning phase*
  In this phase, a detailed description of various procedures comprised of duties and testing instructions as well as training materials are developed. Also, documentation is compiled.

7.7.5 Strengths and Weaknesses of QFD

One of the *strengths* of using QFD is the fundamental improvement of internal cross-functional communication, since team-oriented application requires an intensive cooperation across all departments. Through consistent and transparent documentation requiring consensus throughout the planning process, an direct information flow to all participating departments is accomplished. Since this situation offers a better understanding of customer requirements, QFD supports customer-centered product development, provided that customer requirements have been identified reliably. In addition, the predetermined structure of product development provides critical orientation during the early phases.

These strengths of QFD are counterbalanced by *weaknesses*. In real life application, the complexity of the QFD approach can quickly become confusing, necessitating concentration of features distinguishing quality and competition to simplify. Setting priorities is thus one of the most essential tasks in using QFD [94]. In addition, the transformation of insufficiently valid and reliable customer requirements into technical performance features can create problems. Furthermore, due to its "soft" method of assessment, QFD is often perceived as "too subjective" or even "dubious". Its introduction often meets with resistance, since implementation usually necessitates a change in organizational structure and in power relations. Furthermore, QFD requires a high commitment to continuous training.

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The New Product Development 8

8.1 Introduction

The basic condition for long-term, profitable growth of a company is the development and introduction of new products. However, opportunities accrued from new product development (NPD) are offset by considerable technical, temporal, personal and financial risks. Several studies attest to the fact that systematic implementation of the new product development process has a considerable influence on the success of new products [1] (Cf. Sect. 1.5.2). This chapter will present product development itself as a generally applicable procedure, elaborating on simultaneous engineering as a roadmap for the shaping of product development processes.

This Chapter Will Discuss

- How can the structuring of an innovation process reduce uncertainty?
- What is the Front End of Innovation and which models describe it?
- How can NPD projects be managed?
- What is simultaneous engineering?
- Which tools of virtual and rapid prototyping can be used to produce materialized/non-materialized prototypes?

Practical Insight

FACC: Customers Provide the What, FACC Delivers the How

FACC is the leading force in the development and production of components and systems made of composite materials. Their high-quality lightweight solutions help to ensure safety, save weight, provide for more comfort, and enhanced noise reduction aboard passenger, cargo, and business aircraft along with helicopters.

(continued)

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Research and development have been priorities of the company since its inception, with the reduction of uncertainty in research and development (R&D) projects playing a central role at FACC.

In addition, FACC has an entirely digitized product development work flow. Starting with design engineering, then concept optimization, detailed development and on up to the simulation of parts and production processes, all the steps are described comprehensively in a numerical way. Furthermore, in prototype development, various design concepts for parts are worked out, evaluated and tested intensively under real-life conditions.

The customer's product requirements. Based on those requirements, FACC's engineering team, in close cooperation with the customer, develops product ideas, design drafts and compatible manufacturing concepts that excel in terms of their function, structural weight, along with costs and scheduling.

Design & analysis: Together with customers on their sites, FACC's specialists prepare technical concepts in the so-called joint definition phase. In several design quality gates, the design is specified to the smallest detail. Based on comprehensive strength analyses, FACC's stress engineers assure the static strength and fatigue requirements of the relevant aircraft components. The Design Office translates these development activities into engineering documents (e.g., drawings and parts lists) for their use in production.

Material & process engineering: Material and process engineers optimize materials and processes with a view to achieving the highest process reliability and quality.

Manufacturing engineering: During the manufacturing stage, the Manufacturing Engineering unit is in charge of the practical implementation of the product concept and subsequent design documentation. In the case of new developments, experts help turn the drafts into commercially manufacturable products.

Tool design: The Tool Design unit develops special-purpose fixtures, production tools, and machining programs required for the manufacturing process. The result is CAD drawings and CAM programs used to numerically control the manufacturing machinery.

Testing: Structural tests are indispensable for the development and certification of components. They verify the stress engineering methods used for the strength analysis in order to ensure efficient and safe use in subsequent in-flight operations.

The test engineers analyze and test complete fiber composite aircraft structures, subsystems, and individual components for fatigue and static strength. In this context, impacts (e.g., bird strikes), temperature, and humidity are taken in consideration, as are manufacturing defects or delaminations. Based on the test concepts, suitable test equipment and systems are developed.

(continued)

Photos: Copyright © by FACC AG
Source: FACC [2]

8.2 New Product Development

Before a company can make structural decisions with respect to the new product development process, it must decide how open to make their development process. The classic view of *closed innovation* is based on the premise that as much as possible high-quality knowledge is put together, bundled and processed internally. New products are generally developed in-house. Cooperation with other companies, universities, research institutions or with suppliers and customers are not excluded in principle, but usually take place to a lesser extent and often only at the beginning of the innovation process. Development activities are easily overseen and controlled, but with intense international competition, the risk that development projects take too long or run completely in the wrong direction is high. The lack of networking in the innovation process often leads to ideas that do not fit with the existing business or complement core competencies.

Open innovation, however, systematically involves all relevant stakeholders in the innovation process. In addition to external experts and research institutions, target suppliers, partners and customers are involved throughout the process. The benefits of this cooperation can be faster market entry, a more economical development or the realization of a new business model. Through the open innovation approach, it is also possible to more fully identify opportunities and uncertainties related to new product development because of the open access to all stakeholder perspectives.

8.2.1 Uncertainty in New Product Development

New product development (NPD) is associated with considerable uncertainties. Beside market- and technology-related sources of uncertainty, the degree of novelty of the underlying concept is a significant source of uncertainty. Unclear goals, vague product specifications, etc. may lead to substantial delays in the project. While companies have to manage the innovation process as efficiently as possible in order to be competitive, new ideas need slack for creativity. The resulting conflict causes difficulty for companies trying to achieve both efficiency as well as flexibility. Due to their often opposing implications for managing NPD projects, this is not an easy task.

The presence of uncertainty presents a challenge for precise planning of product development activities. Thus, a central issue is how best to manage the NPD process under uncertainty. The NPD process is generally described as several distinct phases with activities using various types of information to transform product ideas into marketable goods [3]. The phases and activities can be performed serially (often referred to as sequential engineering), which leads to reduction of uncertainty before the next phase begins, since the information received downstream is complete. This, however, usually results in a long process development time.

To reduce development time, the phases can be arranged to overlap. Doing so increases uncertainty since downstream activities use incomplete information produced from upstream phases. To overcome this problem, sharing information among NPD participants (functional interaction) is often combined with overlapping activities (also known as concurrent or simultaneous engineering). This approach ensures that project team members can consider all the implications of making decisions based on incomplete information [4].

8.2.2 Classification of New Products

The literature does not provide a classification of new products into specific categories. Very often the distinction between the categories is subject to judgment. Nevertheless, it is noteworthy that the vast majority of new products are variations on existing formats. Only 10 per cent of all new products are truly innovative, meaning new to both the market and the company, thus involving the greatest risk. Conversely, most new product activity is dealing with the improvement of existing products. The following general classification from Booz et al. [5] defines the commonly accepted categories of new product developments:

- *New-to-the-world products* are the first of their kind and create a new market involving usually a significant development in technology. They represent the smallest proportion of all new products introduced.
- Although not new to the market, *new product lines* are new to the particular company and provide an opportunity for the firm to enter an established market not addressed by them. A subcategory is *additions to existing lines*. Here the company already has a line of products in this market, but the new product is significantly different from the present product offering but not so different to qualify as a new line.
- When new products are replacements of existing products, they are referred to as *improvements and revisions to existing products*. Over time most products receive numerous modifications in order to improve performance, reliability and to reduce manufacturing cost, providing increased added value. This classification represents a significant proportion of all new product introductions.

- Although the category *cost reductions* of products offers no new benefits to the customer other than possibly a lower price, from the company's perspective it may be very significant. Offering similar performance while reducing production costs provides immense added-value potential and thus produces great financial rewards. The key contributing factors here are improved manufacturing processes and the use of different materials. In contrast to the improvement category a cost reduction may not necessarily result in a product improvement.
- The discovery of new applications for existing products is called *repositioning* and has as much to do with technical development as with consumer perception and branding.

8.2.3 Agile Product Development

Agile product development can be seen as the ability to change the product under development or the process of how it is developed, even relatively late in the development process, without being too disruptive. Therefore, the later one can make changes, the more flexible the process is; and the less disruptive the change is, the greater the agility. Two primary forces are driving the demand for this flexibility. First, *product complexity* has increased. As products acquire more and more functionality, it is harder to forecast requirements. Second, in most markets the *rate of change* is increasing, thus reducing the effectiveness in forecasting the future using traditional management approaches [6].

Sources of change are

- What customers want,
- How they might use the product,
- How competitors might respond, and
- New technologies being applied in the product or in its manufacturing process.

The more radical a product innovation is, the more likely are changes during development [7].

Not only physical products are developed professionally. Specifically, software development is more and more important. Software development projects are characterized by increased communication and organizational needs. Therefore, in recent years several models have emerged for the software development process. Many industrial NPD software projects apply *agile methodologies*, such as Scrum, eXtreme Programming (XP) and Feature-Driven Development (FDD). In addition, the V-model has establised itself as a suitable tool. However, due to the increasing integration of electronics and software in all product groups, the V-Model can be used as a general model of development and will be described in detail below.

8.3 The V-Model for a Systematic Product Development Process

Many companies consider product development as a detached stand-alone activity that can be covered, more or less, by a standardized product development processes. In practice, a variety of diverse process types have been established. These can be divided into innovation and product development processes, with the scope of the process serving as distinguishing criterion. Process structures already containing the phases of generating and selecting ideas and ending in the successful market introduction of the product are referred to as *innovation processes*. In contrast, *new product development processes* only serve the purpose of structuring product development activities. The degree of formalization can vary to a great extent, ranging from barely documented process descriptions via written guidelines to computer-assisted project management systems [8]. In Fig. 8.1, the process model of integrated innovation and product management described in detail in Chap. 2 is supplemented by the V-Model, a standard model for the product development process. Attention should be paid to the correlation between the stages in the product innovation phase and the phases of the V-Model, which will be explained in the following.

Once the preliminary phases have been completed, the result of the conceptual phase consists in two or more product concepts that have to be implemented in the product development phase in several cycles of design, prototype building and checking. Important parameters in this process are technical development, product design and development of the marketing concept [9]. The discussion in this section will be limited to technical development, focusing on a mechatronic product, which comprises the disciplines of mechanics, electronics, software technology and automatic control engineering. A mechatronic product thus constitutes the most general form of a product and can therefore serve as a basis for product design in any one of those disciplines.

In technical product development, it is not only the product itself that is being made tangible and detailed. The framework for iterative processes also includes development and testing of the processes of its production and manufacturing as well as the appropriate tools. Market analyses not only constitute the starting point for product conception and development, but also are to be conducted in parallel fashion to technical realization. Ongoing communication between customer and developer are of the essence, since this is the only way of ensuring a direct translation of customer wishes and requirements into product features. One of the working methods that can be employed here is Quality Function Deployment (QFD) (Cf. Sect. 7.7). In order to conduct development activities in an efficient way, product management is also of great importance. In recent decades, the area of product development has undergone great changes due to the use of *computer-based methods*. These methods entail performance increases in the areas of construction, modeling, calculation, simulation and data management, allowing for shorter development periods (Cf. Sect. 8.5.2).

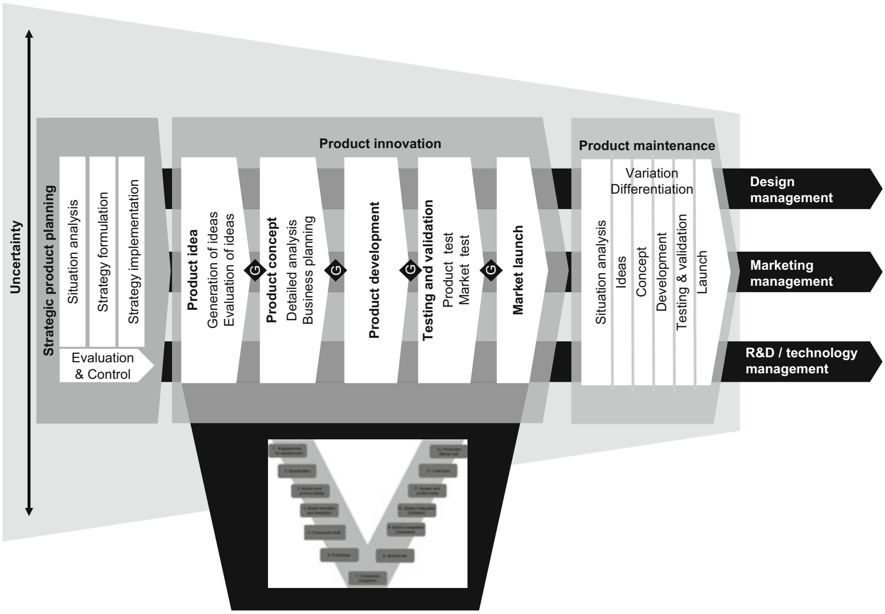


Fig. 8.1 Depiction of the process model of integrated innovation and product management supplemented by the V-model

The *V-Model* is an internationally acknowledged standard process originally designed for the development of new IT systems. Based on the VDI Guideline 2206 and the V-Model from the area of software development, *Isermann* developed an extended V-Model depicting the most essential steps in the development of mechatronic products. This model provides a basis for structuring development processes that is suitable for all company types [10]. It is a very flexible model for planning and conducting system development processes in which each development step is verified in order to ensure that given requirements are met. The V-Model supports projects by setting up results and goals in order to avoid unnecessary tasks and idle time. In addition, communication between commissioner and consignees is also regulated in order to avoid misunderstandings between participants. All these measures are meant to ensure that projects are not aborted prior to their completion and that they stay within budget and time limits. Furthermore, the V-Model supports product and process quality for the entire set of functions and minimizes project risks. Summarizing, it can be said that the V-Model regulates the “who”, “what” and “when” components of carrying out project tasks.

In precise terms, the V-Model is comprised of

- The procedure model
- The assignment method
- The functional tool requirements.

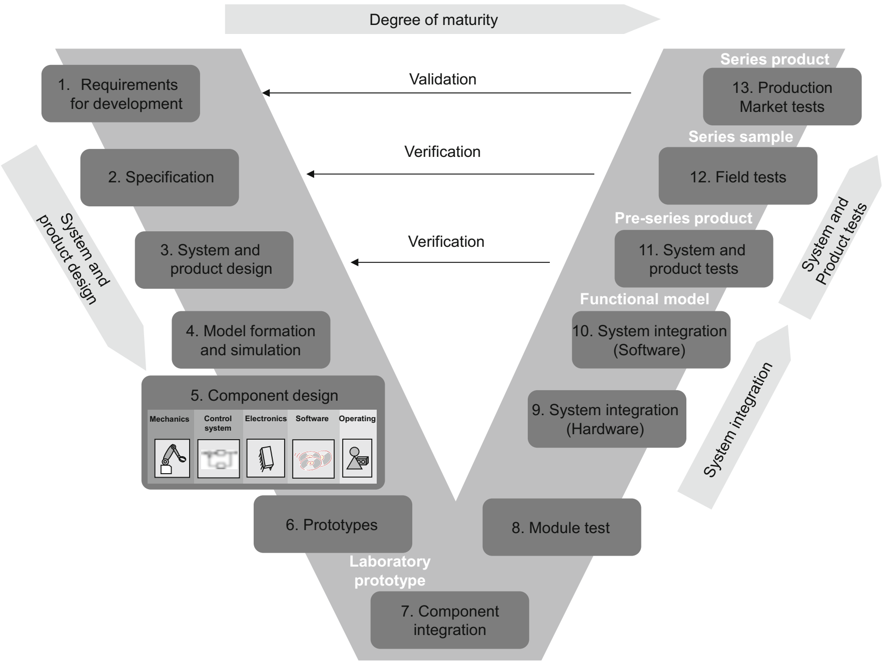


Fig. 8.2 Steps in the design of mechatronic systems according to the extended V-model (Based on Isermann [10])

Thus, the extended V-Model depicts the steps to be taken over the course of system development, the results that need to be produced in the process and the required content of these results. In addition, it also delineates the methods to be applied in the development process and the functional characteristics of the tools to be used.

The array of products in the industrial goods sector ranges from simple product parts systems and supplier components to highly complex production plants. The multifaceted nature of the products is reflected in the corresponding development tasks and the process of organizing them. Modern methods can be used for shortening and improving the development process. Those methods provide goal-directed possibilities for defining, substantiating and optimizing product qualities, allowing for an optimization of time, quality and costs in complex products such as mechatronic systems. Figure 8.2 briefly presents the extended V-Model and its phases alongside corresponding tools.

8.3.1 Requirements for Development

[**MKT, DES, R&D**] In this step, the basic function and data of the product are being evaluated with regards to requirements for scheduling, reliability, safety, development and production costs. At the end of the process, the results are gathered in a document of requirements; the so-called *requirements specification sheet* also named *product requirements document (PRD)*.

8.3.2 Specifications

[**MKT, DES, R&D**] Based on the requirements specification, this step accomplishes an initial division into manageable modules as well as their specification. Measures for meeting necessary functions, technical data, performance, reliability and security requirements are defined. Initial reflection on sources of supply as well as on limits for development and production of the final product are being conducted, resulting in the *technical specification sheet* also called *functional specification documentation (FSD)*.

8.3.3 System and Product Design

[**DES, R&D**] In this phase, system modules are classified in a detailed way and specified with regards to mechanics, hydraulics, electronics, microcomputers, sensors, actuators, control system, software and user input module. Conventional solutions are simplified at the mechanical or electric draft level, respectively optimized by adding sensors, actuators and control system, and thereby creating synergies. The result at the end of this phase is contained in *system development documents*.

8.3.4 Model Formation and Simulation

[**R&D**] This step requires a model-based development for the simulation of components with regards to overall behavior. To this end, mathematical models are generated either theoretically or experimentally–based. An array of *modeling and simulation tools* for the purpose of structural optimization such as Finite Element Method (FEM), multi-body simulation (MBS) and computational fluid dynamics (CFD) are applied during this and the subsequent phase for the purpose of structural optimization or prediction of structural durability. Thus components and system behavior are simulated with regards to different parameters, generating results in the form of draft data, mathematical models and detailed information on individual models. Figure 8.3 depictures various analysis methods simulating aircraft components.

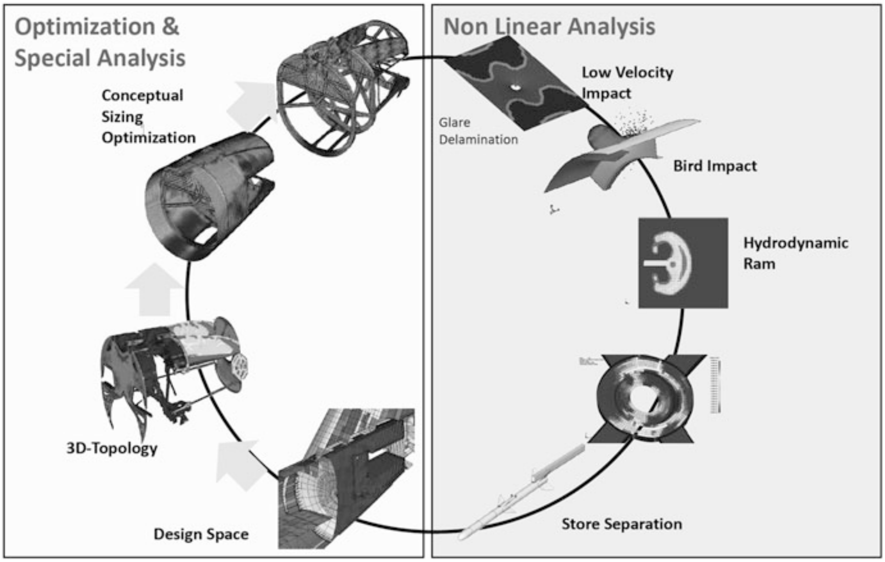


Fig. 8.3 Simulation of aircraft components (Reprinted by permission of Cassidian/Manching)

8.3.5 Domain-Specific Component Draft

[**R&D**] This phase is comprised of the drafting of components from the different domains such as mechanics, automatic control engineering, software, etc. and their subsequent integration, using computer-based drafting tools of the type mentioned under step 4. Reliability and safety aspects are of particular concern in this phase. Another important component at this point is the design of the human-machine interface, taking different parameters into account. The result consists of components that can be integrated but stand-alone.

8.3.6 Prototypes

[**MKT, DES, R&D**] Many innovation projects fail because technical feasibility has not been incorporated early enough in the process. Often, essential questions such as "Can the new product be realized in the existing plants at reasonable costs?" or "What is the required investment for new tools or plants?" are being ignored. The earlier these kinds of questions are answered objectively, the higher the degree of influence on the course of the project (and subsequent quality and cost). The first step in this project is typically the construction of lab samples based on standard components or modification of previous products. The result is referred to as a *prototype*. A *prototype* is defined as a new product produced for the first time, serving practical testing and further development purposes. The construction of a prototype is an iterative process. In addition to technical motivated questions about durability, fit, finish, manufacturing costs, and industrial design, prototypes can answer questions about customer reactions, that is if the customer can evaluate the component in this early stage. This can contribute in reducing the market uncertainty [11].

Assesses single components is carried out using *visual* or *multimedia* presentation of a component prototype [12]. Test procedures, which virtually represent the component concepts, become increasingly important due to the increasing efficiency of the IT infrastructure.

Studies show that *virtual models* (e.g., CAD, virtual prototyping) have similar assessment values as customer tests of actual components and allow considerably more valid statements of customer acceptance than pictured rough concepts.

Virtually represented components concepts or virtual prototypes also have the advantage over real prototypes that they can be remodeled and therefore be reused with little effort for other tests [13, 14]. Increasingly *rapid prototyping* is used in this phase to make a physical prototype, which allows for production of functional models with complex forms in a relatively short time. The results are validated prototype components that in general can be integrated into the final product. The different models will be presented later.

8.3.7 Component Integration

[**DES, R&D**] The components mechanics, electronics, operation and control device including implemented software are being developed for integration into the complete product. Often MBS is being used in combination with MATLAB/Simulink software in order to simulate the interaction of mechanics, electronics and automatic control engineering in a precise way. The results then serve as the input for the next step.

8.3.8 Module Test

In this phase, stress tests and load tests of the hardware components of *each module* are conducted. Though often observed otherwise in practice, testing is desirable not only at the end of each design iteration but also at various phases of the innovation process. The earlier the testing done in this process, the more uncertainty can be reduced by discovering errors before the design has progressed too far. The sooner errors can be identified and corrected the more likely the final design will be error free. Generally, it can be said "the more testing, the better." The time and resources invested in each phase of the innovation process can be viewed as a call option that gives the firm the right to invest in the next stage of the project with a small investment. After each test, the firm can exercise its right to invest in the next stage or to let the option expire [15].

The results of the component tests constitute the basis for further development of technical, functional and aesthetic characteristics of the product and contribute an improved prototype [16]. This provides the company with the possibility of additional information and possible product improvement. Since this trial-and-error

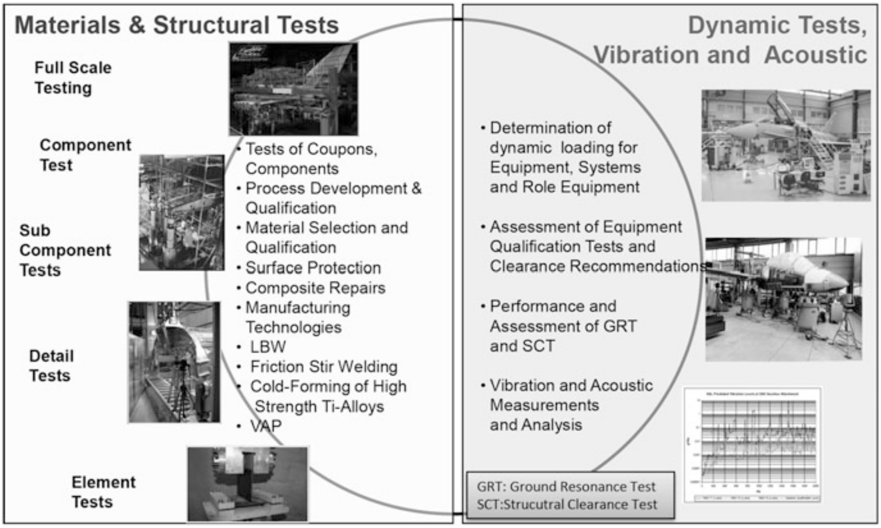


Fig. 8.4 Testing of aircraft components (Reprinted by permission of Cassidian/Manching)

approach is relatively time and cost intensive in as much as possible, instead of building components and analyzing them on test rigs, parts are being simulated within a computer environment. This is referred to as "hardware in the loop" (HIL). Often *reverse engineering* is used for comparing virtual models with physical prototypes to detect deviations.

A side benefit of prototype testing is risk management. Based on challenges in prototype construction, potential problems at the serial production stage, often resulting from complexity of the product or the steps in its processing, can be anticipated. Continuous development of the prototype helps with reducing these risks and uncertainty in general. Figure 8.4 depictures various testing methods applied on aircraft components.

8.3.9 System Integration (Hardware)

[**MKT, DES, R&D**] This step implements the spatial integration of mechanic and electronic components as well as sensors and actuators into the final product. It puts special emphasis on creating synergetic effects, and checks creative parameters such as integration in the installation space, haptics, ergonomics, installability, etc. In subsequent steps, it is primarily the physical product that is checked and tested. If the function does not meet customer requirements, the components have to be modified or redesigned. A complete product consisting of mechatronic components marks the end of this phase.

8.3.10 System Integration (Software)

[**MKT, DES, R&D**] In this step, software components are integrated into an array of different modules. The result of this process consists of a functional model of a mechatronic product integrating its hardware and software.

8.3.11 System and Product Tests

[**MKT, DES, R&D**] All functions are tested in simulators or the final operational environment, verifying product specifications and ending in reliability tests and safety tests. In case of deviations, components have to be modified or redesigned. The desired result of this phase in the innovation process is a fully functional prototype, ideally to be built with material that can be used in serial production. This step reduces technical insecurity by the largest possible extent. However, plants and tools to be used in serial production are not a necessary component of this phase. In general, they are examined at a later stage.

8.3.12 Field Tests

[**MKT, DES, R&D**] The last stage of product development consists of various tests of the final product, i.e., checking whether the functions meet all customer requirements. This step requires the compilation of statistics on performance data, errors and failures. Validation ascertains that the final product meets the requirements from Step 1. In case of deviations, a new draft for a modification will ensue.

Therefore, comprehensive customer-oriented testing has to be conducted at this point in order to reduce market insecurity.

In product tests, products are experimentally used or consumed by subjects to evaluate within experimental investigations. The subjects are asked about their subjective perceptions and/or judgments [17]. In contrast to technical acceptance tests and product tests for consumer protection, it is not objective standards that are the focus, but *subjectively perceived product features*.

In the context of innovation management, product tests are mainly used to determine the customer value of different *product alternatives*, to find an *optimal design* of the individual components of the product from a customer's perspective, or to test the *usability* under real-life conditions [18].

Through systematic, isolated and controlled inspection of products or product components, product tests provide indications as to the customer value of a product and why a specific product or product component is accepted or rejected.

The tests range from those that are limited to a search for errors and weaknesses, to comprehensive acceptance tests that determine consumer acceptance and allow initial sales forecasts. The following section describes the main considerations for the design of product tests.

8.3.12.1 Full Test vs. Partial Test

In the context of product tests, if complex products can be *considered as a whole*, then one speaks of full tests. With partial tests only certain product characteristics or the impact of alternative forms of these characteristics are of interest. Such partial aspects are for example brand or the operating of a product [19].

8.3.12.2 Studio Test vs. Home-Use Test

A product test can either be carried out at the manufacturer's premises or in a market-research studio (studio test) or can be given to the subject for use in their own facilities or business (home-use test). In favor of a studio test high internal validity can be achieved because all parameters, which the subjects are exposed to, can be controlled. Additionally, spontaneous reactions to a product can be easily collected [20]. The artificial context makes the transferability of the results to a real-life usage situation very difficult and thus reduces external validity [21].

The *home-use test* is close to reality; however not all important variables are controllable. So, for example, the influence of individuals other than the user can bias the results. Additionally, it cannot be determined, if the test is performed according to the instructions [22]. In the industrial goods sectors, a home-use test in the form of pilot facilities or functional prototypes are the main techniques for qualitative benefit estimations, particularly helpful for highly innovative products [23, 24]. In this context, special procedures such as beta testing [25] as well as test and learn [26] are becoming more and more important. In addition, it should be noted that the product tests should be performed with lead users [27].

8.3.12.3 Blind Test vs. Identified Test

In a blind test, visual influences, e.g., brand name but also shape and color, should be avoided, so that the evaluation of the product is only carried out on *non-visual characteristics*. Thus this test should facilitate the view of one or some few product's features. When respondents are asked after the blind test, which brand this product could be, most will reply with the name of the leading product. From a research prospective, this can be a validity problem if the brand leader is performing a blind test, because then it is a de facto test (comparing against itself) not a blind test. To reduce this problem it is proposed to imagine a non-existing new brand in order to avoid a positive bias of products due to their (suspected) affiliation with strong brands [28, 29].

With an *identified test* all elements of the *marketing mix are visible*, so the product is presented in its planned form and color, including manufacturer's data and brand name. These tests reflect the actual buying behavior better than blind tests, because the aesthetics of the product has a significant influence on the perception of the product [29, 30]. The brand name and brand-typical shapes and colors play an important role not only in the consumer goods, but also in the industrial goods sector. Hybrid forms are so called partly neutralized product tests, in which a single component, usually the brand name, is omitted.

Which of these tests is selected depends on the research purpose. It can also be useful to carry out a blind test and an identified test for the same product, to test the effect of visual attraction of product perception. So, for example, a comparison between blind and identified test offers information on the brand image. Through a semantic differential it can be examined which characteristics play a role on a positive versus a negative influence on the brand [28, 31].

8.3.12.4 Monadic Test vs. Comparison Test

The *monadic test* evaluates a single product. In *comparison tests* at least two products are evaluated. In the *successive comparison test* this comparison takes place consecutively, with the *parallel comparison test* simultaneously [32]. The experimental set-up in comparison tests is either accomplished with a test group of two test products or with multiple test groups of various products compared against a standard product. For example, the standard product can be a newly developed product, while competing products act as alternative products. With comparisons, subjects naturally look for differences even if they are little noticed or these differences are not relevant for the purchase decision. On one hand, this can lead to an exaggeration or distortion of the results. On the other hand, the results are more selective and clearer versus monadic tests [33–35].

An alternative to the monadic tests, which tries to combine the strengths of both test forms, uses several test groups, each testing only one product variant. Afterwards the polarity profiles of the groups are compared. Through this approach, distortions, e.g., the over-reporting-effect or the selection of extremes, which arise equally strong in all groups, can be leveled [36].

8.3.13 Production and Market Tests

[**MKT**] Production planning should occur simultaneously with product development, encompassing available technologies for production, assembly and quality control. Compared to concept tests or product tests, market tests are "the most realistic form for testing market chances" [37].

In very uncertain environments where information regarding customers and features cannot be obtained, information can be gathered by launching a product variant. This product can then be seen as part of the concept design phase but the level of uncertainty is reduced substantially by analyzing the real-live experience [38]. As Lynn et al. argue, "probing with immature versions of the product makes sense if it serves as a vehicle for learning" [26]. This approach of course is only useful if management is confident enough that one of the product variants will be successful.

In market tests, the final product is offered for trial purchase shortly before its market introduction. The goal is to test the entire marketing mix of a new product, the interaction of individual elements, and in estimating the potential market success of the new product. In contrast to conceptual tests, which focus on a qualitative evaluation of market success market tests are about quantitative prognosis of market shares, sales volumes and turn-over [39]. Initial purchasing rate, repurchasing rate and the relative purchasing intensity of customers constitute the basis for forecasting. While market tests play an important role in consumer goods, they are less frequent in many industrial goods due to the sectors' customer-specific services and long repurchasing cycles [40]. Market tests can be categorized into uncontrolled market tests, controlled market tests and test market simulations.

8.3.13.1 Uncontrolled Market Test

An uncontrolled market test is the simplest form of assessment. It is confined to product sales during a predetermined time period in a *geographically delineated submarket*. Nothing but the turnover of the product is measured with the intention of estimating future sales. In addition, the product's sales can be compared with that of similar products in order to draw conclusions on the quality of the marketing mix. Further, alternative marketing concepts can be used in two or more other regions in order to observe their respective effects.

The strength of this method resides in its relatively *simple feasibility*. The method basically consists of a limited market introduction that reduces risk versus an immediate introduction into the entire market without tests. The main challenge of this method consists of finding a representative area. The "problem of transferability of data to the entire market essentially remains unsolved" [41]. A further problem is in the assessment of repurchasing rates for products with a long life-span, since a test in this case would take several years [42]. Additionally, these actions do not go unnoticed by competitors, who can significantly interfere with the test and its results by means of promotional activities or buying up of the new product [43]. In general, uncontrolled tests have limited expressive value, since not all influential factors can be monitored and managed. Consequently, it can only be assumed which factors were decisive in the products' success or lack thereof [44].

8.3.13.2 Controlled Test Market

A controlled test market (*store test*) is defined as "trial sale of products under controlled conditions in selected stores" [45]. This test is meant to assess sales opportunities and the effects of price differences as well as placement and promotional activities on the sale of the product as compared to the company's other products and competitors' products. For example, during a store test, perhaps 30 stores are supplied with the new product and a market research firm guarantees the implementation and capture of relevant marketing mix measures on site for several months [46]. Since store tests presuppose the sale of products in retail stores, the method is irrelevant for many companies in the industrial sector (e.g., plant construction and suppliers).

8.3.13.3 Test Market Simulation

At their core, test market simulations are "product tests extended or supplemented by a simulation of purchase" [40]. By using this method, major drawbacks of traditional market test procedures, especially the difficulty in the selection of representative submarkets, *cost and time expenditures* as well as *disclosure* to competitors, can be reduced [47]. New product developers can integrate potential reactions of competitors into market simulations in order to test different competitive strategies within a computer environment. Increasingly, multimedia technologies can be used for testing virtual products in test market simulations, sometimes replacing the testing studio [48, 49]. A weakness of test market simulations consists in the artificiality of the trial situation, which may be reduced due to more realistic simulations in the future.

In general, the procedure is an iterative one comprised of various cycles. Due to the different interfaces, the various sub disciplines of mechatronics and their integration, development is more complex here than it is for purely mechanic or electric systems.

The goal of reducing the time to market entry, and thereby gaining a competitive advantage, creates additional time pressure for development projects. The only remedy consists of an orchestrated parallel procedure throughout the product development process and all related processes [50], this procedure is referred to as *Simultaneous Engineering (SE)*.

8.4 Simultaneous Engineering (Concurrent Engineering)

In traditional product development, the steps are usually carried out *sequentially*. Based on the definition of customer requirements and selection of ideas, a constructive concept is developed (system design) and implemented by way of prototypes. The planning of the production phase does not start until after the test phase, in which the product has to pass several tests. This chronology results from the necessity of information required for the product launch cannot be passed to the respective departments until very late in the process. Finally, large-scale production can begin (Fig. 8.5) but it is not until that stage that information on actual costs becomes available, limiting control until late [51]. This sequential processing of individual steps results in limited flexibility. Due to a lack of fine-tuning of the different process steps, inefficient allocation of resources is another consequence of this traditional approach.

Simultaneous engineering (also referred to as concurrent engineering) was developed in order to specifically remedy the process-induced shortcomings discussed above. Especially when high market and technological uncertainty is present the early stages in the NPD will be influenced heavily. In this case the necessary information about potential design choices is not known or cannot be discovered. Simultaneous engineering offers the possibility to keep the product concept open to change due to the overlap of the stages with those that follow [52]. The sequential process is thus replaced by a simultaneous and integrative process. There is a parallel alignment of all information and processes required for new development and are geared towards reduction of development time [51].

Consistent project management throughout the entire product life cycle provides the basis for this goal-directed, interdisciplinary cooperation between development of product, production and distribution development [53]. The fundamental goal of simultaneous engineering consists of optimizing the product generation process with regards to the so-called "magic triangle" [54]. This magic triangle consists of

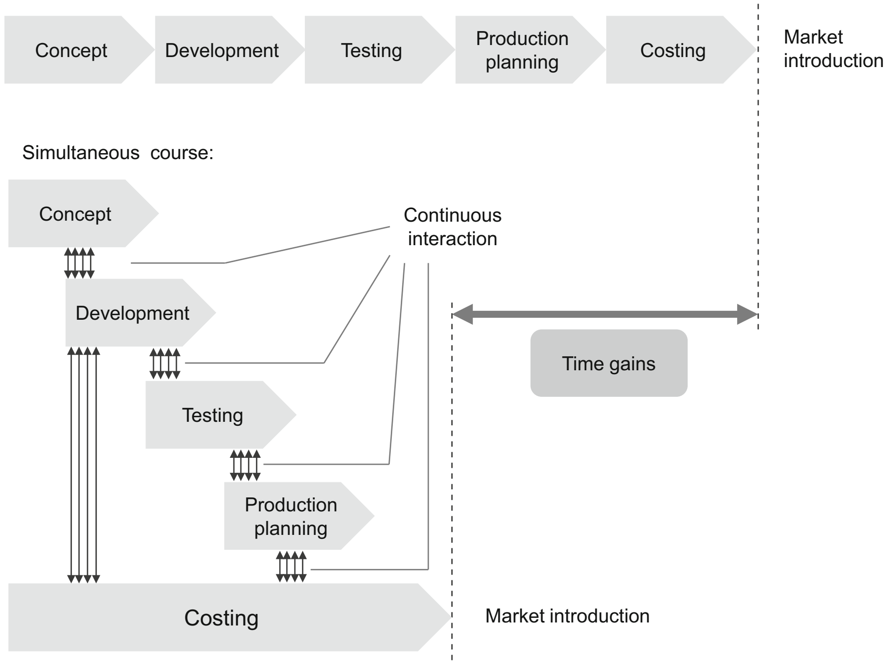


Fig. 8.5 Comparison of sequential and simultaneous approach (Based on Vahs and Brem [55])

shortening product development time, reducing development costs and improving product quality in accordance with customer requirements.

8.4.1 Guiding Principles of Simultaneous Engineering

The three guiding principles of simultaneous engineering [56, 57] serve the purpose of achieving the goals discussed above and provide direction for shaping product development processes: parallelization, standardization and integration.

8.4.1.1 Parallelization

In accordance with this guiding principle, a temporal parallelization of activities by way of appropriate methods, e.g., multi-project-management is attempted. Development phases, previously attempted sequentially, are broken down and processed simultaneously. *Independent activities* need to be distinguished from mutually dependent activities. *Interdependent* processes have to be managed in a way that uncouples their content while still maintaining a connection. This modularization of individual steps simplifies exchange of information between modules. Parallelization is a safeguard against pushing back downstream tasks due to an upstream delay, eliminating the need for a buffer. The crossing of temporal barriers considerably improves coordination. There are various possibilities for parallelization.

On one hand, different products or generations of products can be developed simultaneously. On the other hand, individual phases of the development process or simply design activities can be in parallel at various levels [58].

8.4.1.2 Standardization

A permanent profile and regulation of the process of product generation, independent of individual persons and events, is referred to as *standardization*. It pertains to technical and structural aspects such as components or modules, process-related factors (such as phases) or aspects of structure and organization (such as interfaces between projects or departments). Often, existing solutions from previous developments are disregarded. A standardization of working steps avoids duplication of effort, relieving decision-makers of recurrent decisions, thus freeing up time for innovative and creative tasks. What should be avoided is over-regimentation, since idea-dependent activities are best managed on a flexible basis. In conclusion, the main effect of standardization is increased efficiency due to cost reduction.

8.4.1.3 Integration

[**MKT, DES, R&D**] In accordance with fundamental nature, simultaneous engineering (SE) places a high value on the integration of activities. Its goal consists of closely linked individual activities in view of the desired outcome of the process. Integration within the framework of development can refer to individual product components as well as on functional areas within the company. Process integration of the departments via SE teams minimizes losses at the interfaces, resulting in product development in accordance with all departments' requirements. By integrating product management, marketing and distribution, the customer is integrated as well, increasing the likelihood of success for the subsequent market introduction. Figure 8.6 summarizes the three guiding principles of SE.

8.4.2 Effects of Simultaneous Engineering

The *positive effects* of applying these three guiding principles are extraordinary. Production time from development contract to serial production can decrease by up to 50 %, production costs decrease by 25 % on average with development costs remaining constant, and overall costs fall by 20 % [60]. Figure 8.7 depicts savings in time and cost when using SE in the product generation process.

On the other hand, *drawbacks and risks* of SE consist of a relatively high coordination effort, a high pressure on employees to work with "uncertainty" and the resulting errors of judgment with the possible effects of failed planning on the entire innovation process [61].

Goal-directed use of various methods within the product development process can support the goals and guiding principles of simultaneous engineering [62]. The role of these methods is akin to that of a catalyst, structuring cross disciplinary cooperation and communication via formal guidelines. Thanks to systematization, the specific competences of individual business units can be combined and

Guiding principle	1	2	3
Goals	Shortening development times	Reducing development costs	Meeting quality standards
Method for reaching goal	Making more parallel areas of activities	Standardizing working processes, technical/ structural and organizational aspects	Integration of functional areas and product components
Advantages	- Reduction of buffer times - Good coordination options - Usually no increase in total development time even with minor delays	- No re-iteration of decisions - Utilization of experience gained in previous development processes	- Minimization of losses at company internal interfaces - Customer requirements are already taken into account at the level of development

Fig. 8.6 Increasing efficiency through simultaneous engineering (Based on Weiber et al. [59])

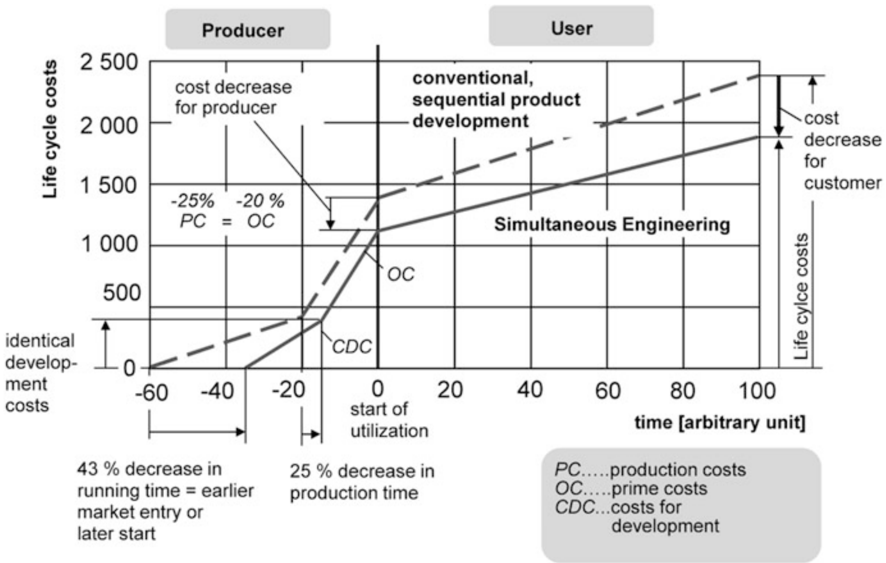


Fig. 8.7 Time and cost savings when using SE in product development (Based on Ehrlenspiel [60])

documented. Some methods identified in the literature should be mentioned here. First, *Quality Function Deployment (QFD* (Cf. Sect. 7.7) translates customer requirements into product requirements. Second, *Failure Mode and Effects Analysis (FMEA)* serves to evaluate products and processes early in order to avoid potential errors in subsequent product generation phases. Third, t*echnology planning* facilitates the choice of appropriate production technologies. Finally, *Design for Assembly (DFA)* provides a method for assembly-appropriate construction.

As a product development project progresses, prospective solutions are specified in more detail and realized via different intermediate stages. In technical systems, this usually implies a transition from an immaterial state (e.g., ideas, sketches and drafts) to different intermediate stages (e.g., models, prototypes) and finally to the finished product. In essence, it is objects in the form of data and information that are being passed between the phases of the process. The following section will discuss essential tools.

8.5 Tools of Virtual and Rapid Prototyping

Virtual prototyping denotes the process of building computer simulation models that closely mirror reality, the knowledge gained from these analyses feed into the development process. Similar to the scenario of using real prototypes, function and performance are evaluated. Virtual prototyping has the additional benefit of saving time and money, since it reduces or eliminates the need for building and testing physical prototypes. The next sections offer first a practical insight and then an overview of methods used in virtual prototyping.

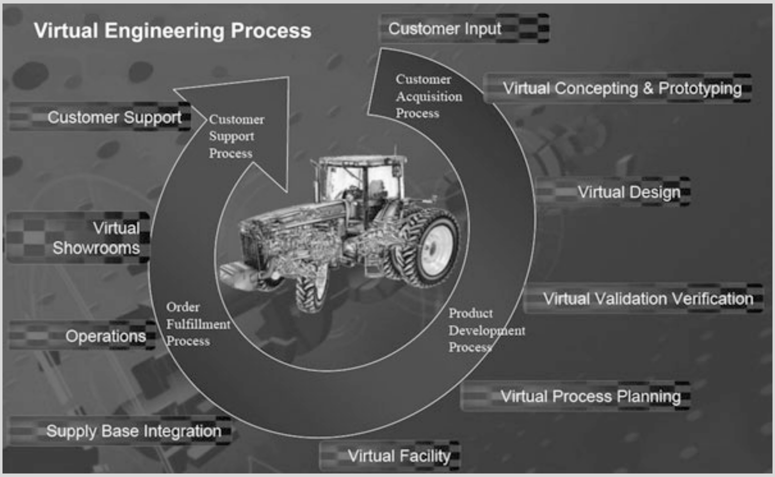
Practical Insight

John Deere: Use of Virtual Reality for Equipment Design

John Deere is based in Moline, Illinois, and one of the largest manufacturers of agricultural, construction and forestry machinery in the world. In 1837 John Deere had a vision to help farmers in the Midwest. He fashioned a polished-steel plow in his Grand Detour, Illinois, blacksmith shop that lets pioneer farmers cut clean furrows through sticky Midwest prairie soil. Today, John Deere is listed as 85th in the Fortune 500 America's ranking and 89th in the Forbes World's Most Powerful Brands ranking.

John Deere has a long-standing experience in virtual engineering. Already in the 1980s they started employing physical simulation using a motion base and a visual scene for vehicle operator interface design. Pilot studies of Virtual Reality (VR) began in 1994 at the construction machinery division in cooperation with the Iowa State University. The aim was to influence design decisions before building physical prototypes. By using VR models instead of physical prototypes, normally done with a sequence of fiberboard mockups, they saved $80,000 in mockup cost. The project was a huge success. Over time virtual engineering at John Deere spread out to all departments spanning from product development, facilities and operations planning along with training/education to data analysis and marketing.

(continued)



Today John Deere has an evolving virtual engineering process in place offering simulations, global integration and immersive collaboration encompassing most activities from customer input to customer support, including virtual conceptualization & prototyping, virtual design, virtual validation/verification, virtual process planning, virtual facility and virtual showrooms.

Photos: Copyright © by John Deere
Source: John Deere [70], Duncan [71]

8.5.1 Definition Prototyping

The development of a new product is a complex interdisciplinary process fueled mainly by human creativity. Every idea is evaluated on whether it has a positive influence on preferred product characteristics. For this reason, many ideas are discarded. The degree of detail in models and prototypes used for verification greatly increases with the product's degree of maturity. Prototypes do not have to display all characteristics of the final product, but only those that are relevant for the evaluation. Product characteristics can be checked in real-life simulators or by using numeric calculations. The first procedure is known as "trial", while the latter one is referred to as "simulation". In spite of their various differences, both procedures have one thing in common: a re-enactment of reality.

Simulation as a tool for virtual prototyping can be used at the early stages of development in order to evaluate complex relations and product characteristics. Time is of the essence here. However, simulation will obviate the need for simulation in very few cases. Especially for complex products, regular verification of results via real tests is required. At the same time, the number and complexity of trials can be reduced to a large extent by virtual prototyping.

8.5.2 Options for Product Representation

With increased calculation and graphic capabilities of the modern computer, the possibilities for product representation also increase. In the past, the most important carrier of information was the technical drawing. Still used in manufacturing, it has to meet the criteria of completeness, unambiguousness and non-contradiction. However, the untrained eye has to have a lot of imagination in order to perceive the product in its entirety with a drawing. The introduction of 2D CAD software did not change the nature of drawings. It took the introduction of 3D CAD systems to inaugurate a new way of thinking and to provide the basis for virtual prototyping. An early depiction of a product, closely mirroring reality, serves as the driving force for new creative ideas. This serves as breeding ground for more product innovations, and fosters communication in the development team.

8.5.2.1 CAD Models

In 3D-CAD, the form of the product is represented by an internal computer model, a so-called volume model. This is a constructed from a mathematical description, is unambiguous and is free of contradictions. Technical drawings are derived automatically by means of cuts. By defining and changing parameters and conditions (constraints), changes in shape can be implemented in a very short time (this process is called variant technique). In addition to geometrical data, material and kinematics can also be depicted. This allows for the calculation of total weight, the moments of inertia and the center of gravity. A 3D CAD model can also serve as a basis for photorealistic views and animations in order to highlight important characteristics of the model. In today's product development environment, the 3D CAD model has a deserved place as the central carrier of information, providing the basis for almost all methods of virtual prototyping.

8.5.2.2 Digital Mock-Up

The individual parts of complex products are constructed in 3D CAD. The successive assembly of individual parts into modules and functional groups up until the final product is called *digital mock-up (DMU)*. In addition to information on the product shape, the complete 3D model contains information on the structure and location of components. DMU is often used for “packaging” (putting parts and components together) in order to demonstrate the feasibility of a construction plan. The following questions have to be answered in that process: Can all parts be arranged without a collision? Can all parts be mounted and demounted? DMU also provides efficient options for the analysis of variants. In the past, these analyses were conducted with expensive and time-consuming 1:1 models made from model material. In DMU analyses, interactive visualization is of great importance. Therefore, in most cases it is conducted in teams to assure quality decision making. For visualizing the 3D structure, the use of virtual reality techniques is on the rise.

8.5.2.3 Virtual Reality

Virtual reality (VR) denotes a computer-generated environment that serves as a user interface and is characterized by *immersion* (inclusion of the user in the virtual environment), *interaction* (the possibility of interaction with the *virtual environment in real time) and imagination (illusion of manipulable objects)*. The degree of VR implementation depends on many factors ranging from simple 3D visualization to a complete immersive environment called CAVE. In the latter method, stereoscopic pictures are projected on up to six sides of a cube-shaped space. Interaction proceeds via electronic tracking systems and navigation tools (magic stick). In projection, active or passive stereo can be used. In active stereo, the two images (left and right picture) are depicted in turns through one projector or in parallel fashion (passive stereo) with two projectors. Using appropriate lenses (e.g., shutter, polarization filter, interference filter), the two views can be decoded by the viewer’s brain. Nowadays so-called auto stereoscopic devices, allowing the viewer to see a three dimensional virtual image without auxiliary tools, are also available. In addition to visual feedback tools, there are also force feedback approaches (Fig. 8.8).

8.5.2.4 Augmented Reality

Augmented reality is a logical extension of virtual reality. This technique enriches a real scene, which remains visible through a semi-transparent virtual-reality helmet, with computer-generated information. Another possibility for implementation consists in the conflation of both “worlds”. A camera picture can be superimposed by a view of the virtual components. Augmented reality techniques are mainly used at an advanced state in development.

8.5.3 Model Building and Model Analysis

Model building means creating a representative physical substitute model in order to evaluate the function and behavior of a product. It is essential that the physical substitute model depicts the relevant characteristics of the real system. The analysis is basically an experiment with a mathematical model. The computer-based procedure is also referred to as simulation. Insights gained in this procedure can initiate an improvement of product characteristics. This procedure in assessment and

Fig. 8.8 VR testing lab with haptic feedback (Reprinted from Kuhlen and Jerabkova [65])

improvement can be conducted in a short time especially at the early stages of development. It allows for an early detection and "mitigation" of problem spots. Conscientious model-building adapted to the correct context is the precondition for immediate utilization of simulation results [66]. The experience of the design engineer is of major importance here. Since a detailed description of all methods is beyond the scope of this chapter, only a short overview can be provided.

8.5.3.1 Finite Elements Method

For the analysis of structural mechanical problems, the method of choice is the finite elements method (FEM). Physical bases are provided by the theory of elasticity. Time-and space-dependent partial differential equations are solved on an approximate basis. This is done via discretizing (linking) of the part in a 3D CAD geometry with a finite number of small elements. For those homogenous forms, there are analytical solutions. By listing the framework conditions (stress and restraints), the unknown quantities at the vertex of the finite elements are being calculated. The results can be depicted graphically (Fig. 8.9a). FEM provides a variety of possibilities for analyses, ranging from simple statistical studies to modal analysis (eigen frequencies and eigen mode) and response analyses. In most cases, a linear material behavior is assumed. However, many practical calculation problems are not linear (e.g., contacts, dents and bents). In those cases, FEM calculation is significantly more complex.

8.5.3.2 Multi-body Simulation

Multi-body simulation (MBS) is used for the analysis of complex technical systems consisting of a variety of coupled moveable parts. Individual parts can also be depicted as flexible bodies with static and dynamic characteristics. Applications of MBS are extensive and diverse. They include, for instance, analyses of driving dynamics of a vehicle or the dynamics of a combustion engine [67]. The main area of application is the calculation of component cut loads that in turn are needed for FEM and operational durability analyses. The following methods of analyses can be

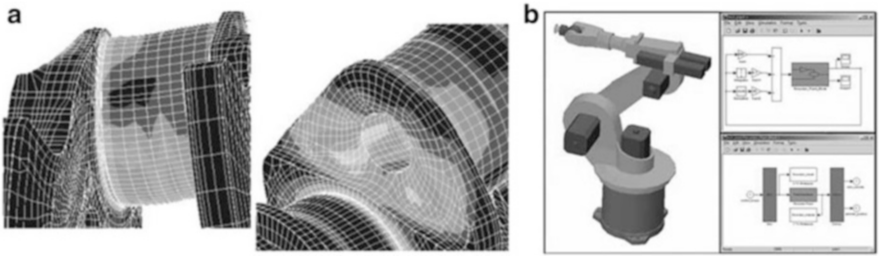


Fig. 8.9 (**a**) Stress distribution of a FEM analysis (*left*), (**b**) Simulation model of a mechatronic system (*right*) (Reprinted from MSC Software [68])

used finding a statistical equilibrium, modal analyses (eigen frequencies and normal mode of oscillation), analyses of operational vibrations, response computations, calculation of transfer functions and frequency-response analyses. With regards to mechatronic systems, multi-body simulation provides an optimal basis. Via interfaces with MATLAB/Simulink or direct integration of simple controller, the interaction between mechanics, electronics and standard behavior can be accurately predicted (Fig. 8.9b) [68].

8.5.3.3 Operational Durability Prediction

When combining the results from FEM and MBS analyses with the knowledge of material characteristics, the durability respectively life span of a part can be predicted [69]. Stress distribution is read off of FEM, while load/time data is read off of MBS. Material data are either stored already in a data collection or are calculated on the basis of trials. By way of suitable equivalent stress approaches, local damage or the safety margin against permanent fatigue fracture can be investigated and depicted in color through the FEM model. The quality of the result is to a large extent dependent upon the quality of initial data. Insufficient net resolution, unsuitable selection of an equivalent stress method, false assumed stress values and poor quality of material data have a cumulative effect. With experience, it is possible to use this method for a goal-oriented proportioning of parts (light-weight construction).

8.5.3.4 Flow Simulation

Flow simulation, known as *Computational Fluid Dynamics (CFD)*, deals with the flow of liquids and gasses, an integral part of many machines. The behavior of both media is described in site-dependent and time-dependent partial differential equations, the Navier Stokes equations. Similar to the FEM method, the CFD method approximates the equations mentioned above by segmenting the volume influenced by the current into a finite number of finite volume cells, thereby solving a system of linear equations. By fixing initial conditions and framework conditions in the depicted area, the control space, insights can be gained on the actual values of the flow under investigation. Those values are mainly distributions of pressure, temperature and speed, values notoriously difficult to ascertain by means of measurement. Thus CFD provides a solid basis for understanding and optimizing complex current flows.

8.5.3.5 Structure Optimization

The simulation procedures described so far are usually employed for evaluating the performance of a given component or part under predetermined conditions. Using the principle of trial and error, product improvements are carried out.

In order to shape this process in a more efficient and goal-oriented way, structure optimization is used. In this process, the optimal shape of the part is being calculated on the basis of constraints, installation space and required performance. Structure optimization can also take into account restrictions on manufacturing (e.g., the possibility of demolding). In essence, two areas of application are distinguished: *topology optimization* and *form optimization*. In topology optimization, the optimal material distribution for the entire part is being sought. The result corresponds to biological structures and is based on the same mechanism. This method tends to be used primarily in early stages of development. In form optimization, it is only the local geometry within a limited defined segment that is being optimized (e.g., a notch). This method can be used to eliminate a part's weak spots.

8.5.3.6 Further Aspects

In recent years, multi-physics simulations have gained importance. This approach combines physics models from structural mechanics, fluid mechanics and electrodynamics, as well as other disciplines within physics, in one analysis. The coupling of the various disciplines can be carried out through co-simulation or a direct unification of underlying equations in one individual server. The latter method provides significant advantages in terms of speed and stability.

8.5.4 Product Data Management

Without structured administration, it is impossible to keep track of the enormous amount of data accrued over the course of product development. In recent years, it has become customary to extend the data management process over the entire product life cycle. This approach has become known under the umbrella term *Product Lifecycle Management (PLM)*. PLM Software packages serve as a platform for integrating product data from different application systems, comprising 3D CAD models, simulation models, text documents and others. Via the PLM system, the various data inventories are converged and administered in a common digital product model. Via interfaces, they can even be linked to enterprise resource planning (ERP) systems.

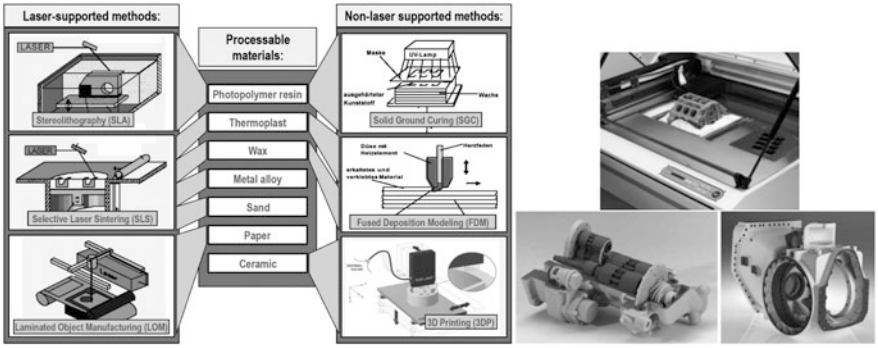


Fig. 8.10 Overview of current rapid prototyping methods (*left*), concept models produced by 3D-printing methods (*right*) (Based on Steinbatz and Rabl [71])

8.5.5 Rapid Prototyping

Rapid prototyping (RPT) does not introduce a new concept [70]. Rather, it is mainly about a fast and cost-efficient generation of prototypes at various stages of the development process, especially during the initial stages. The starting point is once again a 3D CAD model, which is to be materialized in RPT plants via various layers of coating (2.5 D method). A variety of materials are available for coating, ranging from plaster, wax, paper and plastics to metal. The initial form of construction material is most often pulverized or liquid. The fixation of the model is conducted by means of external stimulation via laser, UV light, temperature or binding agents. Construction times vary, depending on the method and material chosen. In concept models made from plaster, it is a matter of a few hours (depending on the height of the part). With modern plants, metallic powders can be connected locally with a laser beam. This method, called laser sintering, directly generates metal prototypes with about 90-95 % of the basic material's characteristics. RPT models enable persons without specific technical knowledge to visually understand complex mechanisms and potential problems. Especially in the area of usability, these kinds of models have become indispensable. Figure 8.10 gives an overview of standard rapid prototyping methods divided into laser-supported and non-laser supported procedures and some examples for models produced by 3D-printing methods.

8.5.6 Reverse Engineering

Reverse engineering (RE) moves in the opposite direction of rapid prototyping. Starting from a real component part, a digital image in 3D CAD is generated by means of digitizing the surface or the entire volume. Component parts are sensed by 3D scanners In general, these scanners capture the component part's surface by means of optical measurement methods, using the principle of triangulation.

Measurement data of a computer tomography (imaging by sections) can also be used, especially when the interior of the component part is important. The result of this digitization process is a 3D point scatter diagram. It is reconverted into surfaces by consolidating neighboring 3D points into simple surface elements. This step is also referred to as "polygonization" and provides the basis for the ensuing definition of individual free-formed surfaces (so-called NURBS). Via standardized interfaces, NURBS can be imported into 3D CAD programs. Several CAD programs have their own module for conducting a reconversion into surfaces. Summing up, reverse engineering allows for changes accomplished with real prototype to be quickly transmitted into the digital world.

Examples for RPT Companies Online

- http://www.shapeways.com/
- http://www.emachineshop.com/
- http://www.thingiverse.com/
- http://www.materialise.com/
- http://www.makerbot.com/
- http://www.fabathome.org/
- http://www.phidgets.com/
- http://www.protoshare.com/
- https://www.ponoko.com/
- http://www.quirky.com/

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9 Life Cycle Management

9.1 Introduction

Rapid technological progress, changing customer needs and increasingly intensive competition are in many cases characteristic features of the business environment. This situation entails an ongoing adaptation of product policy strategies throughout the life cycle of a product in order to ensure a company's survival. New products have to be introduced to the market while existing products have to be continuously improved. In this context, we should mention *product innovation* (radical changes) and *product upgrades* (incremental changes) as core tasks of product management [1]. Once a company has tapped new performance potential with successful new products, product upgrades help realize the long-term potential by prolonging the products' *life cycle*.

This Chapter Will Discuss

- What is the explanatory power of the product life cycle concept?
- What is the introductory phase's impact on innovation success?
- Which management tasks have to be conducted throughout the product life cycle?

Practical Insight

Fronius International: Lifecycle Management of a Technology Leader

"Welding is a passion! Those who lack enthusiasm for this matter will never muster interest for exploring the world of welding and unlocking more and more of its secrets," says Klaus Fronius, member of the executive board and son of the founder of Fronius International GmbH in Wels (Upper Austria). Today, Fronius is Europe's market and technology leader in the welding industry.

(continued)

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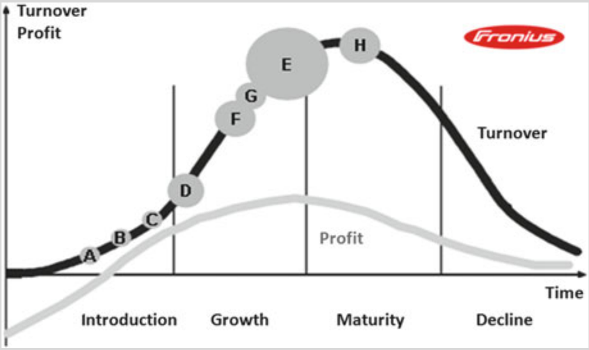
Several times, Fronius International GmbH was the recipient of the Austrian innovation award.

Fronius is the premium supplier in welding technology. Fronius' products meet the very highest standards in technology, workmanship and handling. The company has a solution for every application area. From compact welding machines, MIG/MAG and TIG applications to complex automated welding systems. In addition to products, Fronius' customers are being offered services by way of engineering, consulting and training programs. In accordance with the premium strategy, emphasis is placed on the field of research and development. About 10 % of turnover is annually invested in the research and development department in order to secure the lead in know-how. It is Fronius' goal to not only maintain its market position among the world's five largest manufacturers of welding systems, but to ascend.

Within strategic product planning, in addition to solid customer and market data, it is portfolio analysis that constitutes an important source of data informing product life cycle management. Using a multiple factor approach, all product groups of the welding technology section are being evaluated for their respective competitive advantage and market attractiveness. In addition to the portfolio analysis, Fronius' strategic planning also employs a life cycle analysis to understand sales problems, resulting in improved marketing decisions at the introduction but also throughout the product life cycle. Life cycle analysis is conducted separately for the markets Europe, America and Asia. The figure below depicts the results for the European market and shows that nearly all product groups can be assigned to the first two phases in the life cycle, indicating the attractiveness of the company's product range.



In order to enhance their leading market position, Fronius is constantly optimizing and modifying its products. In addition, their strategy is to frequently develop new product variants and flanking services for specific

(continued)

customer segments. Though Fronius puts effort into product maintenance, an even higher amount is invested into the development of new technologies and products. This position is notable. Many companies in a comparable situation invest the majority of their time and money into the improvement and growth of existing attractive products. In contrast, Fronius uncompromisingly pursues the strategy of technology leadership, clearly focusing on the development of innovations. Even though those developments are usually technology-driven ("technology push"), close collaboration with product management ensures that basic customer needs are the dominant focus, thus ensuring long-term market success. In the context of market expansion, product innovation along with process and marketing innovations gain in significance. Examples include the team-selling concept, ensuring optimal local customer care.

Photos: Copyright © by Fronius
Source: Pichler et al. [2]

9.2 The Product Life Cycle Concept

The product life cycle model is an important concept in product management. It provides insight into strategic alternatives in product policy, especially within the framework of planning [3]. The basic idea of the concept is that products are subject to the law of growth and decay, in a similar way as natural organisms. If it is possible to determine the current life cycle phase of a product, *instruments of marketing policy* can be used more effectively.

The product life cycle is often represented as an *s-shaped sales curve*. The s-shape is based on the theory of *adoption* and *diffusion* of innovations. This theory holds that a new product is only purchased by a small number (about 2 %) of *innovator* customers immediately after its market introduction who are willing to take risks and who are willing to buy without knowing anyone who has purchased the product. The number of buyers increases successively with a range of *imitators* that rely on word-of-mouth and increasing avoidance of risk. *Rogers* defines this *process of diffusion* as "the diffusion of a new idea from the origin of its invention to its adoption by consumers and users". Adoption in this context denotes the original purchasing decision by customers, respectively the decision to always use the invention for this specific purpose in the future. However, this decision usually proceeds in multiple steps [4]:

- Knowledge: the customer becomes aware of the new product
- Interest: the customer gathers information on the new product
- Decision: the customer evaluates the usefulness of trying the new product
- Implementation: the customer tries the product for the first time and gains experience
- Confirmation: the customer tries to justify his purchase. If the experience during the phase of using the product was positive, he will use the product for this purpose on a regular basis.

According to this model, suppliers of new products should make the course through these five steps easy for potential customers. However, it is important to keep in mind here that potential customers greatly differ in their willingness to try new products. Rogers distinguishes between *five groups of adopters*, all of them displaying different behaviors specific to the respective group:

"*Innovators*" are willing to take risks. They are the first ones to adopt new products and thus constitute the "gateway to the market". Since the size of this group tends to be limited, the adoption rate after market introduction only increases slowly. Still, innovators have to be identified, targeted and convinced of the new product, since it is part of their role as opinion leaders to exert a significant influence on the adoption processes of the other groups. *Early adopters* are a little more cautious. Since this group tends to be well integrated into its environment, its behavior is decisive for the majority of the remaining target group. This majority of potential customers, in contrast to the first two groups, are risk-averse. One part, the "*early majority*", acts with a lot of deliberation, adopting innovation a little bit earlier than the average. The second part of the majority, characterized by wait-and-see and skepticism, reacts more slowly. This "*late majority*" only adopts an innovation at a point when the largest segment of the market has already tested it. The remaining group of buyers, the "*laggards*", is averse to change. It only accepts a former innovation once it has become a tradition.

This idealized perspective on the temporal progression of product purchases constitutes the basis for a diffusion curve, which follows a normal Gauss distribution (Fig. 9.1).

The sociological theory of adoption and diffusion shows that only a few potential customers will buy the product immediately. Only innovators and then early adopters will buy the product at its market introduction. Market entry of competitors tends to increase the product category's legitimacy and recognition value while speeding up the adoption process. Once these potential of initial buyers has been exhausted, the rates of increase will diminish. The development of sales along a time axis, yields the so-called product life cycle curve, usually divided into five phases [6]. Transitions between the individual phases of the life cycle model tend to be less predictable but marked by changes in sales volume. Still, a company-specific definition is subjective. Figure 9.2 shows an idealized model of the life cycle divided into the phases of introduction, growth, maturity, and decline. The development phase has been integrated into the model here in order to depict the typical

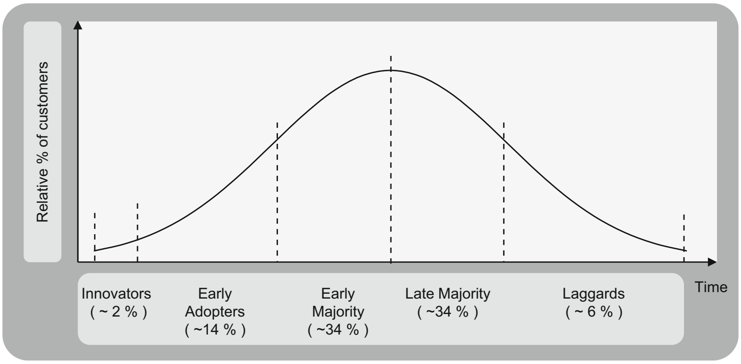


Fig. 9.1 Adoption groups in the diffusion process (Based on Rogers [5])

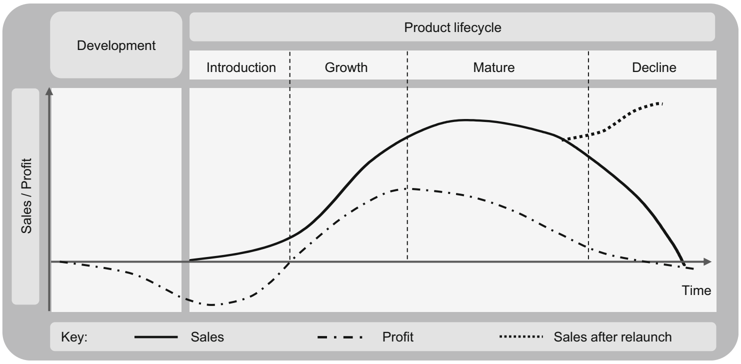


Fig. 9.2 Life cycle model (Based on Polli and Cook [7])

development of profits in its entirety. Each element of the marketing mix (i.e., product, price, communication, and distribution) along with competitive situation would change at each phase.

In discussions of the life cycle's value, irritation is often expressed that transitions between phases are not clearly delineated. For instance, a product category (e.g., wheel loader) might have already been assigned to the mature phase for a long time, whereas the producer's product line is still in the growth phase and an individual product is just being introduced on the market. In addition, the product life cycle of *international* companies can be at a different stage in the respective countries. A product might be in the decline stage in one country and simultaneously in the introductory phase or growth phase in another country [8].

In spite of its popularity in theory and practice, the product life cycle concept is beset with an array of *problems* which must be considered in its application. For instance, it is important for product management to know that a product's sales development does not follow a natural and regular cycle. The product life cycle is not the cause, but rather the consequence, of measures chosen by product management. Thus, the life cycle model is just an *explanatory model*, not a prescriptive model. For example, a decrease in sales does not necessarily mean that the product is in the phase of decline. In this situation, all measures that could affect an increase in sales should be checked. Sales could be stimulated by a change in functional or esthetic product features, thus prolonging the life cycle phase. The different aspects of this "core task" of product management will be discussed in the course of this chapter.

9.3 Market Introduction of New Products

9.3.1 The Introduction Phase's Significance for the Market Success of Innovations

The introduction phase of a new product extends from its first-time availability on the market to the point of reaching the *profit threshold* (often used to define the end of the introduction phase). [***MKT***] This phase is usually characterized by a large *scope of action* for product management in terms of decisions regarding distribution policy, communication policy, and pricing. Therefore, even prior to the introductory phase, decision makers have to dedicate an intensive thought process to the ways of introducing the product.

As discussed in the first chapter, two central *success factors of innovation management* consist of developing a marketing concept early and conducting the market introduction well. [***MKT***] The marketing concept should define whether the company would enter the market first with a new product (pioneer strategy), shortly after the pioneer's market entry (early follower strategy) or as a niche supplier [9]. In addition, particular attention should be paid to utilizing marketing specific synergies (e.g., product-spanning use of communication tools).

9.3.2 Management Tasks During the Introductory Phase

Essential tasks of communication policy during the introductory phase is, on one hand, the process of creating recognition of the product novelty in the target group and, on the other hand, the reduction of potential customers' *uncertainties* with regards to utility, price-performance ratio and reliability of the new product. [***MKT***] In this context, it is important to quickly acquire first *reference customers*, the already mentioned innovators. In addition, it is crucial to diagnose and eliminate potential "teething problems" of the product early on. For this reason, it is often advisable to start out with only one *basic product* or only a few product variants. Distribution in this phase is usually selective, since *distribution channels* still need to be built up. As the sales volume in the introductory phase is usually low, while market introduction costs (e.g., advertising, publicity or event expenses) tend to be high, *no profits* are usually generated during this phase.

Characteristics of the introductory phase			
Customer	Sales volume	Competitors	Profits
Innovators	Low	None / few (relative monopoly position)	Negative
Implications for marketing			
Product	Price	Distribution	Communication
Offering basic product Diagnosing and eradicating „teething problems“	High (skimming) Low (penetration)	Selective building of distribution network	Creating product awareness for the target group, reducing uncertainties

Fig. 9.3 Characteristics and marketing implications of the introductory phase

In this phase, a high price level is often chosen, since a certain part of the target group (the innovators described above) consider it a part of their self-image to possess the latest product generation and are thus willing to pay a higher price for it. Once this target group is has been skimmed, the price is successively lowered in accordance with the remaining target group segments' respective willingness to pay. This strategy is subsumed under the term *skimming strategy*. In contrast, a *penetration strategy* pursues the goal of quickly gaining market share through a low price in order to benefit from economies of scale [10].

[***MKT***] In addition to implementing these marketing measures, product management needs to use internal marketing measures in order to create a large-scale *acceptance* of the new product within the company. This entails a performance motivation for all employees involved in the marketing process, specifically with regards to sales and distribution. Figure 9.3 summarizes essential characteristics and marketing implications of the introductory phase.

9.4 Product Maintenance as a Core Task of Product Management

The term "product maintenance" subsumes all measures contributing towards *prolonging* the *life cycle* of products already introduced to the market. The continuous improvement of products is gaining in significance, especially with regards to increasingly short product life cycles resulting from technological progress and intensive global competition [11].

9.4.1 Information Base for Product Maintenance

The life cycle model described above explains the development of product sales primarily ex ante (after the fact), but stimulates thinking on problems and tasks in product policy. It is difficult to do an ex ante prognosis on the development of a product. [***MKT***] For this reason, product management is called upon to conduct an ongoing analysis of the *company* as well as its *business environment*.

Business analysis is not only comprised of a systematic analysis of the company's internal *resources* and *potential*, but also an ongoing assessment of all of the company's products' place in the life cycle, their *sales contribution* and their *profit margin*. [***MKT***] In addition, it is an essential task of product management to continuously monitor developments in all relevant *environments* in order to detect actionable needs as early as possible. In a similar way as the process of generating product innovations, product maintenance also calls for regular *monitoring* of the relevant business environment. In particular, it is changes in *customer needs* and *competitors' activities* that are identified and evaluated in terms of strategic responses and required measures in product policy [12].

9.4.2 Strategy Continuum in Product Maintenance

In product maintenance, a fundamental difference exists between product variation and product line extension. *Product variation* is a change in products already introduced to the market, ranging from small changes (product adaptation) to decisive changes leading to a product relaunch. In contrast, a *product line extension* changes significant elements of a product already introduced on the market and broadens the product family. Though the degree of novelty in these product policy options varies greatly, it can be stated that all measures of product maintenance is characterized by a degree of novelty that is lower than the degree of novelty in product innovation. This relationship is depicted in Fig. 9.4.

Product adaptation usually consists in minor adaptation of products already introduced to the market. [***MKT, DES, R&D***] Some examples are changes in product color or packaging or labels due to laws and regulations. If an existing product is replaced by a follow-up product (*product relaunch*) or if an additional product variant is being developed for a specific customer segment (*product line extension*), this process is referred to as incremental or evolutionary innovation. Therefore, prerequisites for a successful relaunch or a successful product line extension consist of companies' reservoirs of abilities and competence throughout the *innovation process*, i.e., from idea management via product development until market introduction [13].

9.4.3 Management Tasks During the Growth Phase

The onset of the growth phase is characterized by a rapid increase in sales volume, since the early adopters are quick to appreciate the new product's advantages. Since production overhead and marketing expense are now spread over a larger production volume, profits rise to their highest levels during that phase. This development increasingly attracts competitors and product variants flourish.

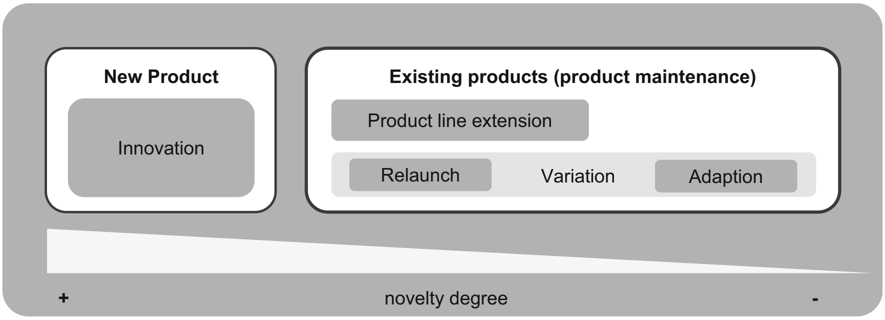


Fig. 9.4 Strategic directions in product policy

$$PM = x_s * (pm_n - pm_s) + (x_a * pm_n)$$

with PM: additional profit margin
x_s: number of substituted products
x_a: number of additional new products
pm_n: profit margin of new model
pm_s: profit margin of substituted model

Fig. 9.5 Calculation of the cannibalization effect (Based on Diez [15])

During this phase, the company attempts to keep up growth for as long as possible. [***MKT, DES, R&D***] With this aim, the *product* needs to be continuously *modified*. This modification can consist in improved product quality, new features, additional services or improved design. In addition, *product variants* are introduced in order to better meet varied customer needs [14]. This process is referred to as product line "*stretching*" or "*filling*". Since an increase in the number of products correlates with an increase in complexity and costs, manufacturers should already define modular product structures ("*platform concepts*") within the framework of their strategic product and development planning. However, the growing number of product variants not only entails an increase in *costs*, but also the danger of *cannibalization*, i.e., customers buying a new product within the company's product line instead of the previously purchased product. When this type of substitution effect occurs, a supplementation of the product line only makes sense when the cannibalization assessment results in an additional profit margin Fig. 9.5. A appropriate calculation method is depicted in Fig. 9.5. Hence, the product manager has to balance the possible gain that can be achieved by sales of the new products against the loss of sales of the existing product line and additional costs incurred by the new product. [***MKT***] The bases for those calculations are provided by market research and detailed cost analyses.

[***MKT***] In addition to measures in product policy, communication policy is aimed specifically at maintaining growth in sales. This process entails building product *awareness* in the target group by clearly emphasizing the *products' advantages*. Another goal in this phase of the product life cycle often consists of intensifying distribution via the number and variety of distribution channels [16].

Characteristics of the growth phase			
Customer	Sales volume	Competitors	Profits
Early adopters	Rapidly increasing	Number of competitors increases	Increasing (highest)
Implications for marketing			
Product	Price	Distribution	Communication
Product variation, services	Depending on penetration vs. skimming strategy	Intensification of distribution	Build brand recognition across target group

Fig. 9.6 Characteristics and marketing implications of the growth phase

If a company is pursuing a penetration strategy, it tries to attain a leading position during this phase, using communication and distribution policy. Because of increasing competition and higher volumes, *product prices* may start to lower and companies are likely to achieve their highest profit levels. In contrast, if it is a skimming strategy that is being pursued, the price is already low to attract early adopters', build quick volume, achieve economies of scale, and drive down costs so as to make profits and solidify a leadership position. Figure 9.6 summarizes the main characteristics and marketing focus of the growth phase.

9.4.4 Management Tasks During the Maturity Phase

In many companies, a majority of products is in the maturity phase, characterized by *slower growth in sales* or even stagnation. This phase usually takes up more time than preceding cycles. The flattening of the sales curve can be traced back to a saturation effect in the market which often leads to a shakeout of competitors. At the transition to the maturity phase, profits reached their maximum level, but then recede due to high elasticity in demand and intensity of price competition, exacerbated in many sectors by imports from low-wage countries.

In order to lessen price pressure, a fundamental product change, like a *relaunch*, adapting the product to changed conditions, is of the essence. [***MKT, DES, R&D***] The spectrum of adaptations ranges from minor improvement through changes of one or more product features to fundamental change. Features related to the *functionality of the* product constitute a central starting point for a relaunch but changes to address *symbolic* or *experiential* needs also can be important. Changes to products aim to improve flexibility of use, user friendliness, efficiency or safety, in many cases entailing a redesigning process. In order to facilitate a relaunch, potential options for variation should already be incorporated in the conception and development of the basic product. [***R&D***] Another starting point for product modification can be found in the *physical* features of products. Product quality in terms of reliability or durability is often enhanced by a change in material or by new production methods [17]. [***DES***] *Aesthetic* product features provide another opportunity for increasing the attractiveness of products during their life cycle. Especially in markets where technical-functional product features increasingly resemble each other, product design oriented and adapted towards the target group is crucially important in creating preference [18]. For this reason, products need to be increasingly shaped with emotional design features and adapted to changing customer preferences throughout the product life cycle. This is not only true for consumer good markets, but increasingly also for industrial goods [19]. Changed or novel *services*, so-called value-added services, are further starting points for a product re-launch. Value-added services are secondary services offered only in combination with a core product. This service package is intended to differentiate the offer from a competitor's core product, providing a higher utility to the customer. It should be mentioned here that often the starting points discussed above are not only better at meeting changed needs of an existing customer segment, but can also attract new target groups [20].

[***MKT***] All the relaunch measures in product policy usually have to be supplemented by measures in *communication* and *distribution*. It should be emphasized again that a product relaunch is subject to a systematic planning process, which is structured in a similar way as the product innovation process, though usually more simple due to a lower degree of complexity in the decision-making process.

In addition to focusing on the target group served so far, the company should also be ready to expand the market for its products during the maturity phase (*market modification*). This robustness goal can be achieved by opening up new demographic market segments. As an alternative, new geographic market segments can be appealed to within the framework of an *internationalization strategy* [21]. In this context, the company should meet the specific needs of the new target groups by specific product variants (*product line extensions*). If expansive product/market strategies of this kind are being pursued, the *distribution approach* and all other marketing mix elements need to be adapted accordingly (Cf. Sect. 11.3).

In the maturity phase, product management can also modify elements of the marketing mix independently of product policy in order to revive sales. If relative competitive advantages cannot be maintained by means of product modification, a defensive *pricing policy* calls for orienting prices towards the competition [22]. This policy can entail a lowering of prices, special offers or a change in conditions of payment. In the wake of an increased pressure on prices, *process innovations* gain significance in terms of improving the company's efficiency and consequently its cost structure. During the maturity phase, *communication efforts* should also be increased, with the goals of inducing repeat purchases and informing new target groups acquired through market modification. In addition, focused *customer relationship management* should aim at maintaining or increasing customers' loyalty.

In conclusion, it should be stated that during the maturity phase, product management has to be especially aware that the sales of a new product does not follow a natural cycle. Rather, it is a central task of product management to counter stagnation by systematic use of marketing tactics. Relevant marketing approaches and characteristics of the maturity phase are summarized in Fig. 9.7.

Characteristics of the maturity phase			
Customer	Sales volume	Competitors	Profits
Large majority Market modification	Peak in sales	Decreasing	High but decreasing
Implications for marketing			
Product	Price	Distribution	Communication
Standard emerges, variants decline, Relaunch	Increasing orientation on competitors	Further intensification of distribution	Battle of brands, increasing expenses

Fig. 9.7 Characteristics and marketing implications during the maturity phase

9.4.5 Management Tasks During the Phase of Decline

The decline phase is characterized by a marked decrease in sales and profits. A large product line is no longer competitively required and only a small number of customers (laggards) are still purchasing the product. Competitors, too, are often eliminating directly competing products during this phase. Many companies underestimate costs associated with maintaining "old" products (e.g., storage costs, maintenance of price lists and brochures). [***MKT***] For this reason, a company has to introduce an assessment methodology for identifying weakly performing products.

Based on the product assessment, the company has to decide whether to keep the product in its product line. If a decision is made in favor of keeping the product, measures for *product variation* (re-launch) and/or *market modification* should be considered. If the company decides in favor of elimination, it has two options. If the strategy of *harvesting* is pursued, the level of sales is kept as high as possible while costs for the product (e.g., advertising, customer service, distribution expenses) are successively lowered, resulting in an increase in cash flow [23]. If market conditions prevent pursuing this strategy, a product with a low sales volume should be quickly *eliminated* in order to free up financial resources for the remaining product range.

At any rate, a company must assess whether the product slated for elimination is in a complementary relationship with other products, which would forestall its being taken out of the product range. Also, decisions in favor of elimination always have to be taken in connection with market introduction of the follow-up product. In this context, drawing up a *phasing-out plan* is an important task of product management. All measures in marketing policy have to be planned in detail and tuned to the product-specific conditions in order to ensure an effective and efficient transition from the old product to the new one. Figure 9.8 summarizes the essential characteristics and marketing focuses of the phase of decline.

Characteristics of the phase of decline			
Customer	Sales volume	Competitors	Profits
Laggards	Decreasing	Numbers decrease, vs. innovative competitive products	Decreasing
Implications for marketing			
Product	Price	Distribution	Communication
Eliminate products/variants with low sales volume Possible relaunch	Possibly lowering prices	Selective weeding out	Reminder communication, lower expenses, maintain loyal customers

Fig. 9.8 Characteristics and marketing implications during phase of decline

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Part III

Innovation and Product Management: Broadening the Topic

10 Organization and Uncertainty

10.1 Introduction

Due to increasingly complex frameworks for innovation, the implementation of *organizational structures conducive to innovation* is gaining importance for success (Cf. Sect. 1.4). In addition to shaping the process organization, it is essential to integrate the innovation function as well as product management into the company structure. There is a reciprocal dependency among the innovation and product management process, division of work, cooperation and specialization in a successful company's long-term organizational structure.

This Chapter Will Discuss

- How can the organizational structure reduce uncertainty?
- Which types of organizational structures can be differentiated?
- In what way is integrated innovation and product management to be implemented in an organization?
- What is an ambidextrous organization?

Practical Insight

Ciba Vision: Ambidextrous Organization for Radical Innovations

Ciba Vision was established in the early 1980s as a unit of the Swiss pharmaceutical giant Ciba-Geigy and sells contact lenses and related eye-care. Although the company produced innovative products in the beginning, by the mid-1980s it remained a distant second to market leader Johnson & Johnson. Without radically new products, Ciba Vision knew it would loose more and more ground. If they wanted to survive and grow, their organization would have to continue making money in the mature conventional contact lens business while simultaneously producing breakthrough innovations.

(continued)

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In the early 1990s, they launched several development projects, each focusing on revolutionary change. The entire corporate R&D budget would now be dedicated to producing radical innovations, while the traditional units would continue to pursue incremental innovations. But this meant creating autonomous units for the new projects, each with its own R&D, finance and marketing functions. Small groups within a company were formed and given the freedom to shape their own organizations to obtain both types of innovations—ambidextrous organizations. Ciba Vision successfully launched a series of contact lens products, pioneered a new lens manufacturing process that dramatically reduced production costs and became market leader in some segments. In 2012, Ciba Vision, a subsidiary of Alcon, was acquired by Novartis.

Source: Ciba Vision [1], O'Reilly and Tushmann [2]

From theory, an organization is a system where information processes take place and faces uncertainties [3]. The integrated innovation and product management processes introduced in this book can therefore be seen as information processing activities that lead to a reduction of uncertainty [4]. Regardless of whether a person has been designated as in charge of uncertainty reduction in the organizational chart, this responsibility has to be accomplished for long-term success. Often, it is taken on implicitly or as an add-on where it is not part of the job description.

Based on a thorough literature review, Tidd [5] developed a framework to identify the most significant contingencies along with the best configuration of organizational structures and management processes. His approach focuses on environmental contingencies related to complexity and uncertainty. Figure 10.1 depicts a summary of the relationships between environmental contingencies, type and degree of innovation, organizational configurations and performance. In addition, it shows how innovation and product management tasks overlap and go hand in hand, respectively, depending on the contingencies.

In contrast to Tidd's approach, Christensen [6] distinguishes between two major types of innovation, namely *sustaining innovation*, which continues to improve existing product functionality for existing customers and markets, versus *disruptive innovation*, which provides a different set of functions which are likely to attract a very different segment of the market. In this respect, every organization faces the challenge to reach a balance between the necessity for efficiency and the necessity for creativity. On one hand, companies demand stability and defined processes to accomplish daily tasks fast and efficiently. On the other hand, companies also need to be creative and to develop new products in order to compete in the future [7]. In Fig. 10.2 this contradiction is depicted.

Firms, by necessity, need to innovate but how can that goal be obtained without reducing efficiency? How can innovation AND product management be integrated within an organizational structure? It is a question of balance. This trade-off between efficiency and flexibility is one of the keys to an enterprise's long-term survival.

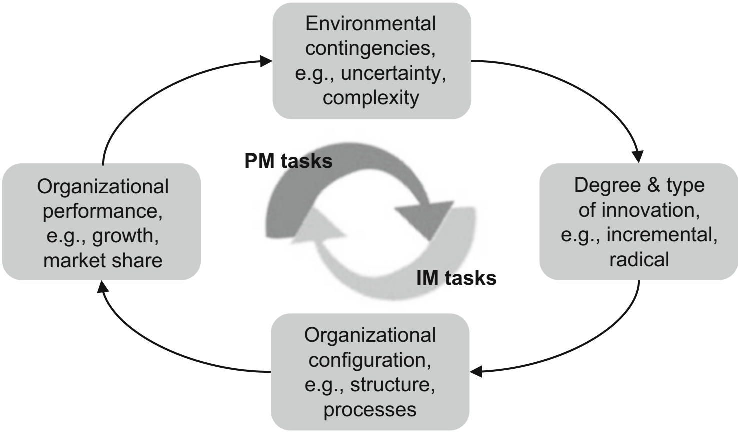


Fig. 10.1 Innovation and product management tasks vs. organization (Based on Tidd [5])

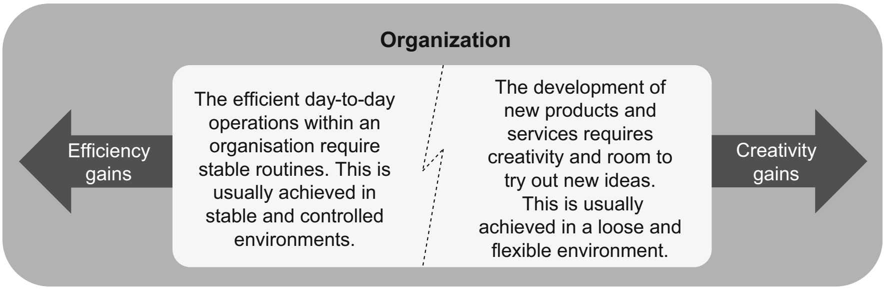


Fig. 10.2 Managing the contradiction between efficiency and creativity (Based on Trott [7])

Thompson [8] describes it as the central "paradox of administration". Managers must choose between organizational structures suitable for routine, repetitive tasks and those suitable for non-routine, innovative tasks. The company needs to make sure that there is a constant effort to reduce costs and improve efficiency, and therefore, quality in its operations. But simultaneously, it needs to make room for innovations in terms of new product development and necessary improvements and adaptations.

It is obvious that organizations need to *explore new knowledge* and to *exploit existing knowledge* in order to create both types of innovations, radical and incremental [9]. The ability of a organizations to do both, simultaneously explore and exploit, is called ambidexterity and was used first by Duncan [10]. He argues that for long-term success companies should build on dual structures, namely different structures to initiate versus execute innovation. Tushman and O'Reilly [11] propose building ambidextrous organizations to balance incremental and radical innovation projects within a company. They conceptualize that the different types of innovation projects are managed in contradicting organizational structures, processes and organizational culture. O'Reilly and Tushman [12] point out that efficiency and innovation need not be strategic trade-offs and underline the central role of senior teams in building dynamic capabilities. Regarding ambidexterity, a dynamic capability can be understood as a set of activities (or routines) taken by senior managers that allows the company to identify threats and opportunities and to reallocate assets (organizational structure, people, and resources) to adapt to the new conditions.

After understanding the relationship between innovation and organization and the influence of uncertainty on every innovation process, it can be hypothesized that the development and adoption of systemic innovation in an organization may be hindered due to uncertainty.

As already explained, the integrated innovation and product management process can be seen as an information-processing activity, which very much depends on the structure of an organization. It is therefore necessary to understand the basic organizational structures, which can be found in every company. The following section will first explain the fundamental structures. Then it will describe how an organization and its patterns of interaction and behavior can enhance the innovation and product management processes.

Mintzberg [13] defines the structure of an organization as the ways in which it divides its labor into a number of distinct tasks and then coordinates them. Both structure and processes depend very much on the degree and the type of innovation adopted by an organization. Firms have to develop the ability to configure and reconfigure organizational resources to capture existing as well as new opportunities to innovate and hence to survive over time [14].

In their study of electronics firms, Burns and Stalker [15] looked at the impact of technical change on organizational structures. They suggest that "*organic*", flexible structures, characterized by the absence of formality and hierarchy, support innovation more effectively than "*mechanistic*" structures, which are characterized by lower complexity, higher formalization and centralization, strict task differentiation, extensive procedures and a high vertical differentiation. In today's hypercompetitive environments, organic rather than mechanistic organizational structures are necessary for successful industrial innovations. In general, an organic organization is more adaptable, more openly communicating, more consensual and more loosely controlled [16]. Table 10.1 summarizes the major differences between organic and mechanistic organizations [17]. A closer look reveals that the mechanistic organization doesn't support the management of creativity and the innovation process in the same way as the organic organization does.

Obviously some organizational structures are more suitable for supporting innovations than others. Research on the subject offers a vast number of prescriptions for innovative organizations. Many of them highlight the need to eliminate bureaucracy, unhelpful structures or obstacles blocking communication [18]. But not all types of innovation projects will be successful in organic, loose, informal environments or "skunk works". One has to determine an appropriate organizational structure in respect to the operating contingencies, but too little order and structure may be just as bad as too much.

Table 10.1 Organic vs. mechanistic organizational structures (Based on Trott [17])

Organic	Mechanistic
Channels of communication Open with free information flow throughout the organization	Channels of communication Highly structured, restricted information flow
Operating styles Allowed to vary freely	Operating styles Must be uniform and restricted
Authority for decisions Based on the expertise of the individual	Authority for decisions Based on formal line management position
Free adaptation By the organization to changing circumstances	Reluctant adaptation With insistence on holding fast to tried and true management principles despite changes in business conditions
Emphasis on getting things done Unconstrained by formally laid out procedures	Emphasis on formally laid down procedures Reliance on tried and true management principles
Loose, informal control With emphasis on norm of cooperation	Tight control Through sophisticated control systems
Flexible on-job behavior Permitted to be shaped by the requirements of the situation and personality of the individual doing the job	Constrained on-job behavior Required to conform to job descriptions
Decision making Participation and group consensus used frequently	Decision making Superiors make decisions with minimum consultation and involvement of subordinates

One has to expect that the choice of the organizational structure will be influenced significantly by the nature of the industry in general and the product being developed in particular [19]. The way the activities of the organization are managed will also be considerably affected by its structure. It is not possible to modify one without influencing the other.

The following chapter will present aspects of company structure as a basis for selecting a suitable innovation and product management organization.

10.2 Fundamental Dimensions of Organizations

Organization of a company consists of both organizational structure and operational structure, which are inextricably linked. *Organizational structure* divides a company into structures such as units, departments, areas, etc., assigning certain tasks and responsibilities. The *operation* of the business is reflected in organizational and operational structure, primarily in organizing the content-related, temporal and spatial sequence of the work processes.

Within a company, different concepts for organizational structure are conceivable. In general, they can be divided into the three organizational dimensions *specialization, configuration* and *coordination* [20], depicted in Fig. 10.3. In the

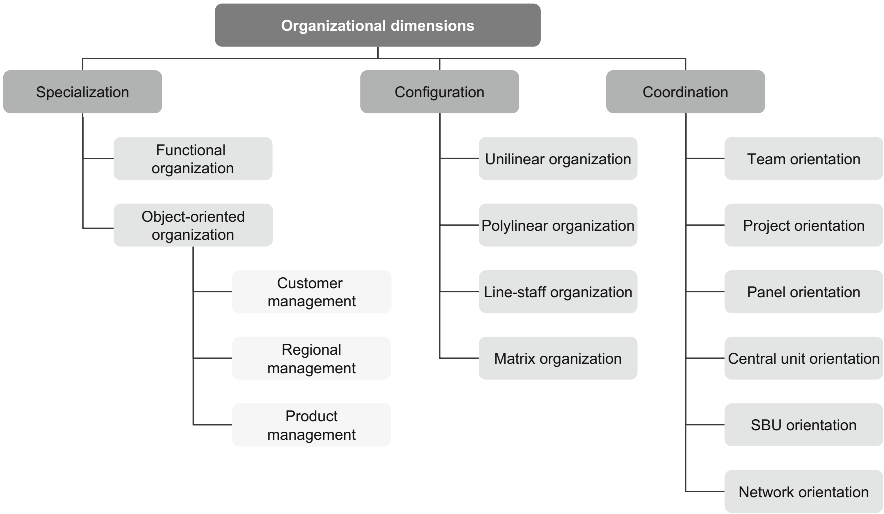


Fig. 10.3 Organizational dimensions (Based on Mintzberg [20], Pepels [21])

following sections, organizational structure will be examined along these dimensions [20, 21].

10.2.1 Specialization

Specialization within the organization denotes an assignment of distributable tasks. Basic types of company structure are function orientation and segment orientation, with segment (or object) orientation being a widespread form of organization.

10.2.1.1 Functional Organization

In a traditional functional organization, people are grouped primarily by discipline, each working under the direction of a specialized sub function manager and a senior functional manager [22]. The advantage of grouping people with similar proficiencies and knowledge is that they can learn from each other and further increase the knowledge of the firm in the particular function [23]. Studies show that the functional organization of technical personnel leads to more effective technical performance [24] and to better integration of incremental innovations [25]. For more radical innovations, a cross-disciplinary process is necessary; separation by functions will only hinder innovations [26]. Therefore, the functional structure is favorable for the development of products or services which require very little or no interaction between the different functions. Otherwise, the project structure should be used. This organizational structure gives rise to several advantages and disadvantages, listed in Fig. 10.4 accompanied by a short description and instructions for use.

Functional organization		
 GM….General Management P…….Procurement AC…..Accounting & Finance MA….Manufacturing HR….Human Resources RD….Research & Development MS....Marketing & Sales	**Short profile:** Orientation on an operational principle **Application:** - In small and medium enterprises - In a relatively stable business environment - In enterprises with a relatively limited homogeneous product program - Improvements of existing products - New products of low innovation - Sequential processing possible - Fosters deep specialization and expertise	**Advantages:** - Clearly delineated task areas that are easy to control - Limited need for specialized experts - Exploitation of effects of specialization **Disadvantages:** - Concentration of leadership tasks within company management - Disproportionate share of specialists - Lack of understanding for other departments, and lack of complete view - Often strong pressure on the departments to give top priority to short-term projects - Conflicting demands on staff (prioritization of projects) - Balance between short-term projects (order and discipline) and innovative projects (freedom and flexibility)

Fig. 10.4 Evaluation of functional organization (Based on Mintzberg [27], von Stamm [28])

10.2.1.2 Object-Oriented Organization

Object-oriented organization aligns its structure with objects or categories such as customers, areas, or products/product groups.

- Customer-oriented organization
  Customer management focuses on the buyer, offering the individual customer the company's relevant product portfolio in its entirety. A customer-oriented company can be divided, for instance, into the departments of trade, private clients and converters, etc. This organizational structure gives rise to several advantages and disadvantages, listed in Fig. 10.5 accompanied by a short description and instructions for use.
- Regionally-oriented organization
  Regional management is organized along the principle of space. A region-oriented company organization is comprised of, for example, the areas of the Northern region, Southern region, Eastern region, Western region. Fig. 10.6 lists the benefits and drawbacks of this form of organization.
- Product-oriented organization
  In this type of organization, *product management* orients itself on individual products/product groups as revenue and cost factors. Operating cross-functionally, it takes over product-related coordination of all activities within the company, aiming at improving the individual product/product groups' contributions to success. In this type of organization, various advantages and disadvantages arise. They are listed in Fig. 10.7 alongside a short profile and usage instructions.

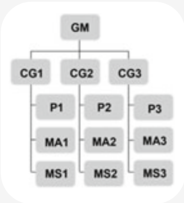
Customer-oriented organization		
 GM….General Management CG…..Customer Group P……..Procurement MA….Manufacturing MS….Marketing & Sales	**Short profile:** Various functions are summarized, taking objects as starting points **Application:** - With a limited number of customers - Requires differentiated marketing - Highly qualified managers are available for customer service	**Advantages:** - Company can specialize in customer service - Close customer relations can be built (informal customer retention) - Competitive advantage due to optimal meeting of customer requirements **Disadvantages:** - Potential competence problems of employees when assigning customers - High costs for intensive customer service - Customer service requires highly qualified managers - Focus on individual customer require-ments entails the danger of poor delinea-tion of purchasing groups

Fig. 10.5 Evaluation of customer-oriented organization (Based on Pepels [29])

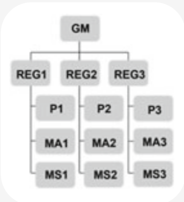
Regional organization		
 GM…..General Management REG....Region of distribution P………Procurement MA…..Manufacturing MS…..Marketing & Sales	**Short profile:** Regional management is organized along the principle of region **Application:** - No convergence of areas of distribution - High number of standard products available - Very well linked organization	**Advantages:** - Orientation on regional specifics is close to actual markets - Areas of responsibility are clearly delineated **Disadvantages:** - Difficult coordination with headquarters (market-specific adaptation vs. centralized standard production) - Danger of losing a unified market policy - Operational problems push strategic activities into the background

Fig. 10.6 Evaluation of regional organization (Based on Pepels [30], Mintzberg [31])

10.2.2 Configuration

Configuration, as an organizational dimension, is about the choice among an unilinear organization, polylinear organization, line-staff organization or matrix organization. The leadership system being configured in this way is also referred to as *leadership organization*, with instructions for these types. The following section provides an overview of these types of organizational structure (Table 10.2).

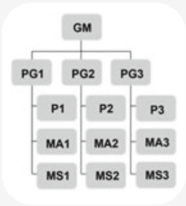
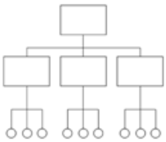
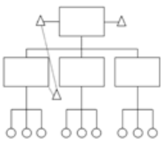
Product-oriented organization		
 GM….Management PG….Product group P.……Procurement MA…Manufacturing MS....Marketing & Sales	**Short profile:** Is oriented on individual product/product groups as revenue and cost factors **Application:** - With a variable product program - With high degree of market complexity and market dynamics	**Advantages:** - Facilitates responsibility for success objects and coordination - High degree of marketing orientation - Fast and flexible market adaptation in a scenario of rapidly changing market - Differentiated marketing is possible **Disadvantages:** - Danger of competence conflicts and priority arguments among product managers - Little utilization of synergy effects - Enlargement of the distribution department, often in conjunction with a streamlining of other departments - Need for employers with special qualifications, previously non-existent in that form

Fig. 10.7 Evaluation of product-oriented organization (Based on Pepels [32])

- Unilinear organization
  In operational practice, an *unilinear organization* is the most widespread type of organization. It is characterized by the fact that each subordinated position only receives instructions from a single supervisor. Individual positions are only connected via a single line, the administrative way, with the different line segments serving at the same time as lines of communication.
- Polylinear organization
  In a *polylinear organization,* a subordinate position receives instructions from multiple management positions. In this type of organization, reporting relationships are interwoven in multiple ways, i.e., each employee has several supervisors. Thus a system of multiple reporting relationships is created, with employees turning directly to the respective supervisors with their problems. This arrangement is also called “the principle of the shortest way.”
- Staff-line organization
  Staff-line organization is characterized by having positions without authority. These executive support units supplement the management units, supporting them in matters of coordination. Due to their knowledge, they have a decisive influence on decisions.
- Matrix organization
  In the *matrix structure,* people are grouped in a similar way as in the project structure. However, unlike the projects structure, the matrix structure has dual lines of communication and authority [35]. Team members report to the head of their functional area and to the project team leader. He is appointed as project manager and given full responsibility for accomplishing the objectives of the project, including performance, cost and time. The project manager may report

Table 10.2 Types of organizational structures (Based on Vahs and Brem [33], von Stamm [28], Holt [34])

	Product-oriented organization		
Unilinear organization		**Short profile**: Classical organizational pyramid based on the principle of unified instructions. As a rule, communication only proceeds vertically	**Advantages**: – Simple/transparent – Competences, communication relations and reporting relations are clearly defined **Disadvantages**: – Long lines for administrative processing – Overburdening of management – Possible filtering of information – Overemphasis on the power of a position
Staff-line organization		**Short profile**: A linear organization is supplemented by executive support units without authority, supporting the respective linear position	**Advantages**: – Management units are supported by executive support units – Competences, communication relations and reporting relations are clearly defined **Disadvantages**: – Frustration of units – Loss of transparency during the decision-making process – Informal dependence of the decision-making unit on the echelon
Polylinear organization		**Short profile**: Instruction based on the functional master principle, i.e., only supervisors are specialized and multiple reporting relationships are standard	**Advantages**: – Shortening/flexibility of lines of instruction – Support of management – Specialization of decision-making units **Disadvantages**: – Complex structure – Possible overlap of competences – Coordination problems in big companies – Possible competition between departments

(continued)

Table 10.2 (continued)

	Product-oriented organization		
Matrix organization		**Short profile**: Organization is structured on the basis of various criteria (e.g., tasks, objects, projects, etc.), generating a multi-dimensional structure **Application**: – Complex projects which require simultaneous efforts of experts from several disciplines – Large projects, here the project manager is often supported by team leaders within the individual functions	**Advantages**: – Direct lines – Reduction of staff-line conflicts – Avoidance of unilateral decisions **Disadvantages**: – Overlap of competences – Staff members have to cope with more project managers – Project manager competes with other project managers for scarce resources – Projects are cutting across the authority lines of the functional departments – High need for coordination – Time consuming decision-making process

to the chief executive or to a functional manager [36]. Here the decision-making responsibility rests with the project team. The project manager negotiates with heads of functional departments for necessary resources of staff and equipment. The staff is assigned either on a part-time or a full-time basis. The tasks are often broken down into independent activities that therefore allow simultaneous processing. But this also implies high demands on social and political skills of the project manager. Clear goals and well-understood technology will result in an effective balance of power [28].

Since the project team members are from different functional areas, the matrix structure is seen as cross-functional. Many scholars see this interdisciplinary approach as a success factor for fostering creativity and initiatives [37]. It also encourages the company to focus on both customer needs and technical feasibility during the entire innovation process [38]. Additionally, studies show that innovation projects embedded in a matrix structure achieve relatively high success rates [39].

10.2.3 Coordination

The coordination dimension of the organization is about the orientation of teams, projects, central management units, panels, SBUs (strategic business units) and the network of the organization. This dimension is referred to as secondary

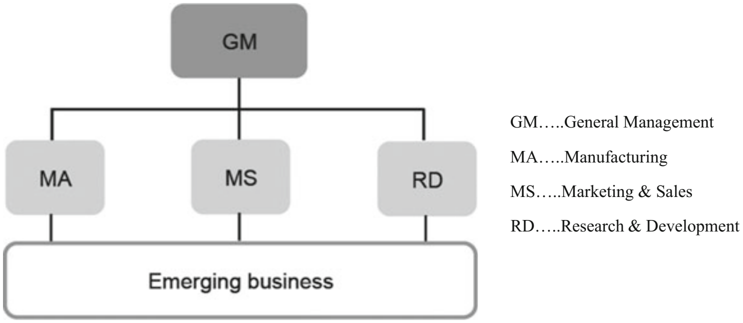


Fig. 10.8 Cross-functional teams (Based on O'Reilly and Tushman [45])

organizational structure, supplementing the primary organizational structure of specialization and configuration by additional factors that are central to the company's competitiveness [40]. They will be explained in detail in the following.

- Team orientation

  A team organization is most often used for as an organizational form with flattened hierarchies. Team members represent different hierarchical levels as well as different areas of knowledge and belong to different departments (cross-functional). They work together long-term (unlike in a project) and are responsible for implementing results (unlike a panel).

  The academic literature reveals that one key factor for successful innovation is the existence of cross-functional teams [41–44]. The employment of cross-functional teams has a positive relationship with creativity in innovation projects, producing shorter development time along with higher product innovativeness. Cross-functional teams operate within the established organization but outside the existing management hierarchy [45], as can be seen in Fig. 10.8. A number of organizational practices support organizational creativity in cross-functional teams, such as frequent and open communication, building organizational slack, attitude to risk, and involvement of top management [46]. The implementation of cross-functional teams in an organization can be done in different ways, as already shown.

- Project orientation

  A project structure, with its virtue of imposing integration of various functional inputs, is preferable for tasks that require continuity and a high degree of interaction between functions. The project team consists of employees with different functional competences essential for the success of the project. These employees are usually assigned for the duration of the project and report to the project manager but may have multiple projects. Especially in small to medium-sized organizations the team members operate on a "part-time" basis. In larger organizations, where several projects are concurrently in progress, there may be sufficient resources to enable staffs to be wholly concerned with a single project [26]. This approach may be of particular interest if a company wants to explore a new area; in this case, a special project organization may be created for this purpose. The scope of a project might vary considerably and spans from idea generation over idea conception to practical applications [47]. The project manager has full responsibility for the project and is given the necessary resources for planning and implementation. The team should be co-located [28]. One major disadvantage of the project structure is that it tends to remove team members from their functional groups in which they interact with coworkers of their own discipline. This problem has led to the creation of an organizational structure that is a "compromise", the so-called matrix structure [48] as already explained previously.

- Panel orientation

  A panel orientation consists of a combination of function orientation and object orientation, with panels being groups of people designated to find solutions for given tasks. In most cases, the tasks are long-term, with a permanent panel convening at regular intervals over an open-ended period (unlike a project). The panelists are exempted from their other responsibilities while working for the panel (unlike a team). The panel only serves the purposes of information, consultation and decision, not implementation (unlike the central department). At the forefront of the panel's work are the coordination of plans, improved distribution of information and utilization of synergy effects.
- Central unit orientation

  An organizational form emerging from polylinear organization, a central unit orientation is set-up on a long-term basis (unlike a project). It also consists of the executive function (unlike a panel) and is concerned with only one function (unlike a team). Central units are especially suitable for large companies in which it is possible to centralize certain areas. In most cases, administrative tasks such as finance, personnel, taxes, controlling, etc. are sectioned off. In operational practice, while marketing is often organized project-, customer- or regionally-oriented, activities removed from the market are oriented on function.
- SBU Orientation

  A strategic business unit (SBU) is a combination of product and market orientation. Depending on its form, it can be a profit center or service center. The preconditions for a viable SBU are an independent strategic market task, independence in decisions and clearly delineated costs and products.
- Network orientation

  In recent years, there has been an increasing trend towards global cross-business organization forms, facilitated mainly by new information and communication technologies bridging time and space. In contrast to traditional organization forms, those structures exist not only internal to the company, but also between businesses or business branches.

These organization types are displayed in Fig. 10.9, listing advantages and disadvantages alongside with an evaluation.

Building on the basic organizational forms that have been presented, the following chapter will discuss organizational forms of innovation management.

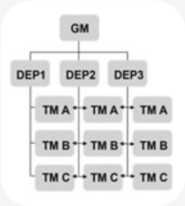
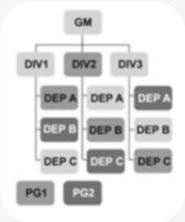
Team orientation	 GM.....General Management DEP…Department TM…..Team member	**Short profile:** Temporary limited organization form with flattened hierarchy **Application:** In interdisciplinary tasks where short routes of communication are required	**Advantages:** - Concentration of knowledge by many people in one group of experts - Hierarchy of little importance - Employees can be assigned to a team **Disadvantages:** - Higher coordination required - Individual performance or responsibility is less obvious - Danger of load peaks and idle time
Project orientation	 GM.....General Management DIV….Division DEP…Department PG…..Project group	**Short profile:** One-time task taken care of by interdisciplinary team members **Application:** - For complex tasks in interdisciplinary projects - Large projects which justify employing experts from different functions - For new solutions or new products - Firms in dynamic markets	**Advantages:** - Coordinated sequencing of complex tasks - Profit and loss account for the entire project (profit center) - Facilitates coordination despite the in-terdisciplinary nature of the project **Disadvantages:** - Competence problems of employees due to dual reporting relations to de-partment coordinator and project leader - Issue of reintegration of staff - Isolation from the rest of the organization - Dispensing people to the project full-time might cause problems in the basic organization - Difficult to maintain specialization and carry forward learning from previous projects
Panel orientation	 GM…..General Management PL…...Panel P….......Procurement MA…..Manufacturing MS…..Marketing & Sales PD…...Product REG....Region C….…Customer	**Short profile:** Constitutes a combination of function- and object orientation **Application:** In larger and more complex companies	**Advantages:** - Panel works on tasks long-term - Improved distribution of information - Use of synergy effects **Disadvantages:** - Only part time work only meets at in-tervals - Only serves the purposes of infor-mation, advice and decision-making, not of implementation

Fig. 10.9 (continued)

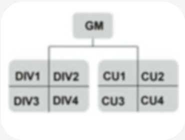
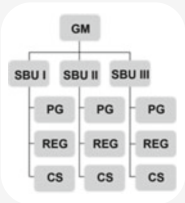
Central unit orientation	 GM…General Management DIV…Division CU….Central unit	**Short profile:** Decision competence and authority to issue are centralized **Application:** - For market-remote tasks as interface management	**Advantages:** - Relief and support for management units at all levels - Good utilization and use to capacity of cost-intensive experts and resources - Functional, non-hierarchical authority **Disadvantages:** - High level of need for specialists - Danger of competence conflicts - Danger of excessive focus on depart-ment
SBU orientation	 GM….General Management SBU....Strategic business unit PG…...Product group REG…Region CS……Customer segment	**Short profile:** Is a product-market combination and follows the center-concept **Application:** - For independent strategic market tasks - Access to external market with clear, directly attributable costs and products	**Advantages:** - Highly transparent structure allowing for clear assignment - Contributions in performance are clearly attributable within the organization **Disadvantages:** - Internal competition for the allocation of resources to individual SBUs - Organization structure can often not be represented in its entirety - Allocation of objects of decision to individual SBEs is often difficult
Network orientation		**Short profile:** Structures between companies or independent units of a widely diversified company **Application:** - Small and medium companies - Companies with a high degree of specialization	**Advantages:** - High degree of flexibility - Utilization of widely diversified core competences - Set-up and interpretation of network organization can be steered individually depending on task **Disadvantages:** - Intensive coordination between organizational units required - Higher coordination effort - Synergistic effects can only be exploited to a limited degree

Fig. 10.9 Overview on the organizational dimension coordination (Based on Pepels [40], von Stamm [28])

10.3 Organizational Structures for Innovation Management

A company has two fundamental alternatives for organizing its innovation activities. It can decide to *self-implement* all activities connected with planning, carrying out and controlling innovations. For this end, organizational units are set up either with central control and/or decentralized, and carry out the required tasks either permanently or for a limited time (Cf. Sect. 10.2.2). Alternatively, innovation activity can be carried out *across companies (outsourcing)*, with a majority of innovation activities being carried out by other companies and/or research institutions. In practice there is often a combination of these organizational forms. Figure 10.10 provides an overview on basic variants of innovation management within the framework of the alternatives. Its structure also frames subsequent discussion.

10.3.1 Company-Internal Innovation Activity

Within the framework of an innovation-friendly culture, all areas of the company should feel responsible for carrying out the innovation function. (Cf. Sect. 5.3.5). However, responsibility for implementation of the innovation function should be assigned to a specific position.

If the company views innovation as a *temporary task*, it should choose the organizational form of individual project management, forming a project group specifically for the duration of the project [49]. In contrast, if innovation activity is to be carried out on a more permanent basis, innovation management should be the task of a specialized organizational unit. In general, executive support units, staff-lines or panels can serve that purpose (Cf. Sect. 10.2.2).

However, these organizational alternatives, differentiated according to time frames, are not mutually exclusive. In order to optimize innovation performance, many companies have an institutionalized innovation management as well as a corresponding project management in place, the latter mainly being in charge of implementing specific innovation projects [50].

10.3.1.1 Centralization of Innovation Management

With regards to centralizing innovation management within the company structure, there are four main alternatives.

10.3.1.2 Innovation Management as Central Executive Support Unit

In this organizational form, innovation management *supports* central management in planning, implementing and controlling innovation-specific tasks and decisions. (Fig. 10.11a). However, due to formally non-existant authority and decision-making competence, it is questionable whether this organization form can carry out the complex and interdependent tasks of innovation management. (Cf. Sect. 10.2.2). For these reasons, implementation of this organizational form is more suitable for small and medium enterprises (*SMEs*), since these are structured on a functional basis and allow for central management's immediate access to all relevant persons and information [51].

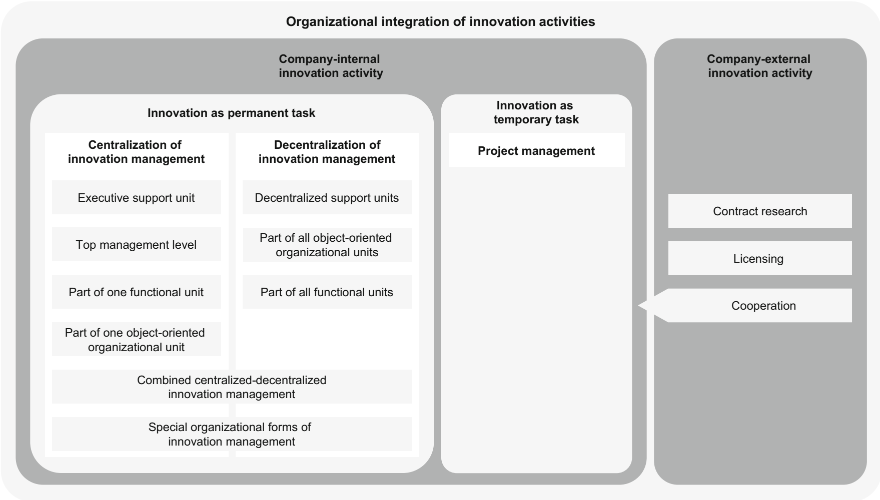


Fig. 10.10 Organizational variants of innovation management

10.3.1.3 Innovation Management as an Upper Management Area

In contrast to the set-up of executive support units, innovation management is endowed with *leadership competence* here, having the same rights and responsibilities as all other organization units at this level (Fig. 10.11b). For this reason, in *functionally* organized companies *innovation goals* are on a par with other functional goals. The challenge in this organizational form consists of existing *departmental egos* often preventing extensive cross-functional cooperation [52] (Cf. Sect. 10.2.2). This is, of course, an impediment to interdisciplinary and cross-departmental innovation processes. In *divisional organizations***,** this organizational alternative is even more of a drawback, especially in heterogeneous product programs, where it usually gets in the way of satisfactory fulfillment of segment-specific goals [53].

10.3.1.4 Innovation Management a Part of a Functional Area

Integration of innovation management into a functional area only makes sense if it has a significant influence on the perception of the innovation function. In companies where the generation of new knowledge is pursued in a long-term, systematic and cost-intensive way, the functional area is often the research and development department [54]. For an overview of organizational structures in research and developmemt, cf. for instance Hauschildt [55], Pleschak and Sabisch [56] or Nebe [57]. If innovation management is anchored in this department, innerdepartmental *coordination* of innovation activities can be improved, but cross-functional innovation activity cannot be guaranteed. The same holds true for

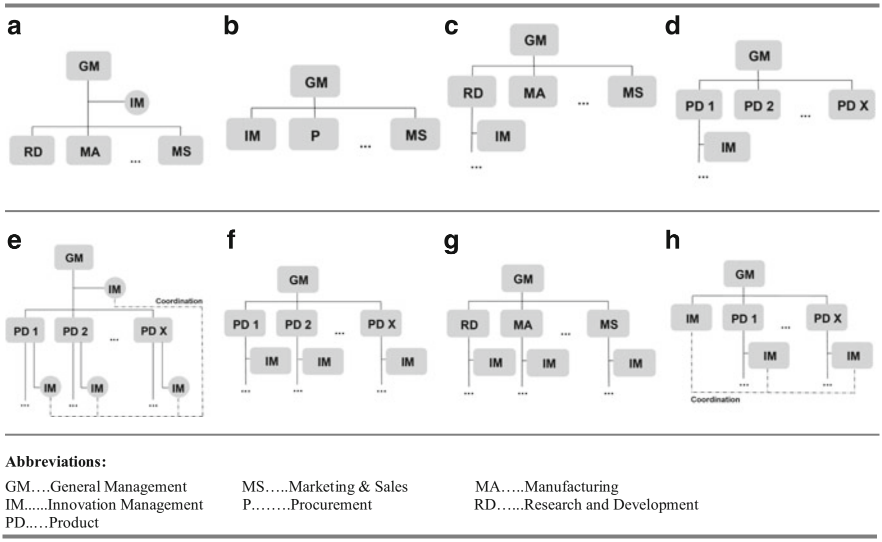


Fig. 10.11 Organizational forms of innovation management (Based on Vahs and Brem [64]). (**a**) Central support unit, (**b**) area of top management, (**c**) part of a functional area, (**d**) part of an object-oriented organization unit, (**e**) decentralized support units, (**f**) Part of all object-oriented units, (**g**) Part of all functional units, and (**h**) Combined centralized/decentralized. *GM* General Management, *MS* Marketing & Sales, *MA* Manufacturing, *IM* Innovation Management, *P* Procurement, *RD* Research and Development, *PD* Product

anchoring innovation management in the functional areas of marketing or *product management* (Fig. 10.11c).

10.3.1.5 Innovation Management as a Part of an Object-Oriented Organizational Unit

In object-oriented organizations, innovation management can be integrated into a *dominant* unit (Fig. 10.11d). Just like in the organizational form discussed above, here, too, some very important object-overlapping aspects cannot be taken into account. For this reason, this structure variant is hardly of practical significance [58].

*W*ith regards to centralization of innovation management, it can be said that this form of organization is only suitable for functionally-structured companies with a relatively homogeneous product program. In order to take the *interdisciplinary aspects* of innovation tasks into account, innovation management should, by all means, maintain closeness to the upper level of management. In all cases, the imminent danger in centralizing the innovation function consists in keeping other employees and managers from thinking about innovation by inadvertently fostering the perception that innovation agendas are the exclusive task of the central innovation management body [59]. Further consequences of centralized innovation management often include a low degree of market orientation, an unsatisfactory degree of *flexibility* regarding adaptation to the business environment and tendencies of organizational spin-offs [60].

10.3.1.6 Decentralization of Innovation Management

A decentralization of innovation management is given when innovation specific tasks have been distributed among various organizational units and individual innovation management areas are each put under independent leadership. In this context, the following structural alternatives can be distinguished:

Innovation Management as Decentralized Executive Support Unit

Integrating innovation management by way of decentralized executive support units secures *market relevance*, and *the opportunity of reacting* even to small changes in the innovation environment (Fig. 10.11e). However, these advantages are counterbalanced by major disadvantages. One major danger consists in a duplication of work by different support units, resulting in an ineffective and inefficient use *of company resources*. For this reason, support units' activities should be coordinated in a goal-oriented way, e.g., by a central unit. The *disadvantages* specific to this organizational form have to be considered [61].

Innovation Management as Part of Object-Oriented Organizational Units

Integrating innovation management as a component of all object-oriented organizational units (e.g., product-specific or regional-specific *divisions*) is another possibility for decentralizing the innovation function. In operational practice, it is found mainly in divisionally-organized companies with a *high degree of* product *differentiation* and/or of regional focus (Fig. 10.11f.). With the exception of disadvantages specific to supporting units, this organizational form has the advantages and disadvantages as listed above.

Innovation Management as Part of All Functional Areas

In theory, there is the possibility of anchoring innovation management via *line units* extant in all functional areas (Fig. 10.11g). The advantage of this organizational form consists in the immediate relation to the functional areas. Since this decentralized organizational form is also connected with a need for additional resources counterbalanced by a relatively low increase in utility, this organizational alternative is hardly of practical relevance [62].

Summarizing, it can be said that decentralized innovation management, especially due to its high degree of *market proximity* and *quickness of response*, is generally suitable for divisionally- or regionally-organized companies. Major drawbacks of this type of organization are the insufficient exploitation of specialization opportunities and the high expense for coordination of the units.

10.3.1.7 Combined Central-Decentralized Innovation Management

In order to combine the two basic organizational alternatives described above, and reducing concomitant disadvantages, innovation management can be anchored in the company through a combination of central and decentralized elements. As a rule, *central organizational units* are responsible for basic and cross-functional tasks and their coordination, while product- or market-related tasks are managed by decentralized organizational units. In order for central innovation management to successfully carry out its tasks, it first has to be accorded the right to set guidelines and inform innovation management units' personnel (Fig. 10.11h). This principle is referred to as the *Dotted Line Principle* and is used for building a second organizational connection [63]. Since the material and personal expense of centralized/decentralized innovation management is very high, this organizational form can, as a rule, only be implemented by large companies. For anchoring fast, cross-functional and efficient innovation with high market proximity, special forms of innovation management should be used. This will be discussed in the following sections. Figure 10.11 schematically depicts all organizational alternatives discussed so far.

10.3.1.8 Special Organizational Forms of Innovation Management

In addition to the organizational forms presented so far, there is an array of special organizational forms combining the respective advantages of centralized and decentralized organization forms. They are especially suitable for small and medium enterprises (SMEs).

Decentralized Innovation Management and Steering Committee

In SMEs, innovation tasks that are close to the market are assumed directly by object-oriented organizational units. Depending on the size of the organizational unit, either its own innovation managers can be employed or else the coordinator of this organizational unit carries out this function as a part-time innovation manager in addition to his main responsibility. For instance, if the company's organizational structure is product-oriented, *product management* carries out this decentralized innovation task. (Cf. Sect. 12.4).

In order to secure cross-functional coordination, a coordinating body in the form of a *steering committee* can implement. This steering committee assumes central responsibility for the innovation activity and should have an *interdisciplinary* composition. Above all, this committee, which can also be referred to as a steering team, should be composed of members of general management as well as representatives from the departments of marketing, product management, along with research and development. In addition to the alignment of departments on innovation-related matters, the typical *tasks* of a steering committee include the development of the innovation strategy, the evaluation and selection of innovation ideas, the setting of goals and the control of individual innovation projects, and the preparation of budget allocations [65].

Innovation-Friendly Supplemental Structures via Team Organization

As already mentioned, the interdisciplinary nature of innovation activities is an essential factor for success in innovation management. In particular with flat organizational structures, which are typical of many medium-scale companies, implementation of innovation management as a *team* constitutes an additional option. The teams should be formed as interdisciplinary for a number of reasons. Firstly, the complexity of today's development problems is difficult to be thoroughly understood by individuals or functional units. Secondly, an interdisciplinary approach facilitates acceptance of innovations by all relevant departments [66]. Furthermore, interdisciplinary teams have the capacity to view a process in its *entirety* and to conduct activities simultaneously. Finally, the conflation of multiple perspectives also increases *the creative potential of* the group, facilitating *reciprocal learning* among team members [67]. All these factors contribute towards developing and marketing innovations more effectively and efficiently [68].

One possibility for innovation management via interdisciplinary innovation teams consists of the establishment of an innovation core team, ideally with a company management member and the leadership of R&D and marketing. The tasks of this core team correspond, by and large, to those of the steering committee mentioned above. Depending on concrete development tasks, this core team can be expanded by employees from production, quality control, procurement, finances and controlling, legal department and external experts [69].

In addition, different teams can be used in the idea finding process, increasing the quantity and quality of generated ideas. For instance, so-called *champion teams*, usually recruited from top employees of product management and product development, can be employed. Those teams work on demanding individual tasks, with the goal of generating ideas for more radical innovations and new product generations. In addition, employees specifically selected from all functional areas can act as *innovation scouts*, detecting radical product innovations and inventions within previously defined search fields. For this activity, the employees, just like those of the champion team, are generally entitled to setting aside a certain percentage of their working time. Furthermore, specific *innovation teams* can be created for individual product innovation and product development tasks, welcoming members from all departments and hierarchical levels. Those innovation teams are being steered and coordinated by a project *steering team*, whose coordination duties have been outlined above [70]. If a product idea is judged by the steering committee to be potentially successful, a *development team* is subsequently created for each new development project and charged with the task of further developing the idea to market in as little time as possible [71].

Since the types of teams presented here can also be built up in a parallel way within the existing organizational structure, they are often referred to as *supplemental structures*. In addition to the teams listed above, the following team structures can supplement existing innovation management [72]. In *quality circles*, members of a department meet on a regular basis to formulate solutions for bigger, self-articulated challenges existing in their work environment. *Product committees* are also designated for long-term time frames. Formed by employees from various departments, they usually take over product management tasks and are mainly in charge of innovation coordination between research & development, production and marketing. For the development of completely new products and technologies, a so-called *New Business Development (NBD)* department can be installed, with its responsibility being the discovery, selection and implementation of highly innovative development projects.

10.3.2 External Innovation Activities

Since the implementation of innovation projects tends to be capital-intensive, a company has to decide which innovation activities are to be conducted internally, whether some innovation services should be commissioned from external institutions and if so, to what extent. Using an optimal *make-or-buy policy*, capital commitment is to be reduced, the cost structure as well as capacity utilization is to be improved and a stronger know-how specialization is to be facilitated [73]. The following section presents some basic options for a company to improve its innovation performance without pursuing internal innovation activity or by supplementing its in-house innovation activity, respectively.

10.3.2.1 Contract Research

Contract research denotes the process of commissioning other companies, research institutions or specialists, to develop a product or process in the company's name and at the company's expense [74]. In addition to the research object, the duration and financial framework as well as the further utilization of the innovation have to be fixed in the contract. Reasons for commissioning a research project from an external institution often consist in a shortage of own *capacity*, lack of technological *lead, underdeveloped know-how* and lower *R&D costs* of the partner, as well as concomitant potential for speeding up the *innovation process* [75].

10.3.2.2 Licensing

Licensing is a frequently used method for introducing new development results in companies concentrating their development capacities on other fields of innovation or not doing extensive research [74]. In licensing, a company purchases the right to the use of a process or a product, the patent or registered design of which belongs to a third party. Though an active licensing policy helps with reducing deficits in know-how, time or capacities, it should only be used as a supplemental measure for proactive innovation management focusing primarily on further development of its own core competence.

10.3.2.3 Cooperation

In addition to purchasing external innovative know-how, a company can also be innovative in conjunction with other companies within the framework of cooperation. An essential goal when entering into cooperation is an increase of the company's own competitiveness, building additional strengths with the partner or mutually canceling out weaknesses [76]. According to *Porter,* cooperation is designated to be a strategy for extending competitive competence, not for creating this competence [77].

Innovation Cooperation

Within the framework of innovation cooperation, a company with at least one partner conceptualizes an innovation specific task program with deliberate separation of contributions [78]. In many cases, the cooperation takes place within the realm of R&D (*horizontal cooperation*), However, *vertical cooperation* is also conceivable, e.g., with one cooperative partner being concerned with development tasks, while the other is in charge of marketing the product [79].

Joint Research

Joint research generally takes place in special *institutions* established and financed on a long-term basis by the participating companies [80]. Results are at the disposal of all commissioners. Typical joint research institutions can be found, for instance, at universities, facilitating large-scale innovations also for companies lacking the necessary R&D capacities and competences [76].

Joint Ventures

With the foundation of a joint venture, the highest possible commitment intensity of the cooperative partners is reached. A separate company, newly founded or purchased by the partners, primarily takes over *innovative, risk-intensive tasks*, thereby assuming the character of a "venture unit". At the preliminary stage, this type of cooperation has to consider not only the advantages of cooperation discussed above, but also the danger of know-how drain and the emergence of unwanted dependencies between partners.

In summary, no organizational structure can offer a perfect environment for innovative products and their management. The challenge of being efficient and innovative at the same time is especially difficult struggle for organizations. A solution one can find in the literature is an ambidextrous organization. In the following chapter, this term will be explained and demonstrated how this concept can be implemented.

10.3.3 Ambidextrous Organization

Many studies of organizational literature show that successful firms are ambidextrous [81–83]. As mentioned before, the term ambidexterity denotes an organization's ability to be aligned and efficient in its management of everyday business demands (exploitation) while simultaneously being adaptive to changes in the environment (exploration). March [84] proposes that *exploitation* is associated with activities such as "refinement, efficiency, selection, and implementation" while *exploration* refers to notions such as "search, variation, experimentation, and discovery". Therefore, ambidexterity can be defined as a company's ability to run complex and contradictory organizational structures in a way that renders it capable of short-term efficiency and long-term innovation [85]. Managing this paradox of efficiency and flexibility is a demanding task. On one hand, efficiency requires a bureaucratic form of organization with high levels of formalization, specialization, standardization and hierarchy. On the other hand, bureaucracy itself hinders the process of continuous change and adaption required for flexibility. Therefore, organizations are confronted with a tradeoff between efficiency and flexibility [86].

O'Reilly and Tushman [87] investigate the process of how organizations innovate. They find that some companies have been fairly successful in exploiting the present and exploring the future at the same time. To do so they separate their new, exploratory units from their traditional, exploitative ones, thereby allowing different processes, structures, and cultures in one company. At the same time they manage this organizational separation through close links across units at the management level. O'Reilly and Tushman [88] believe that an ambidextrous organization is "a practical and proven model for forward-looking executives seeking to pioneer radical or disruptive innovations while pursuing incremental gains". A schematic representation of the basic structure of an ambidextrous organization is depicted in Fig. 10.12.

This structure can be supported by many initiatives. Job enrichment enables workers to become more flexible and innovative while still doing their routine tasks. Switching is supported as the structure segregates roles for dealing with the two kinds of tasks, hence giving workers time to focus on each. The resulting specialization, because of the structurally independent units, permits these units to refine their capabilities in each activity and to carry out routine and non-routine activities in parallel fashion [90].

The ambidextrous organization concept offers a solution for dealing with the contradiction between incremental and radical innovations, which can be found in every company. Based on this thought, the next chapter will summarize the literature and introduce a new framework for reducing uncertainty in innovation by adapting organizational structures.

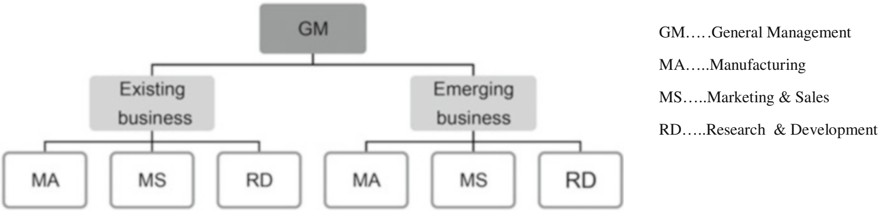


Fig. 10.12 Schematic of an ambidextrous organization (Based on O'Reilly and Tushman [89])

Practical Insight

Procter & Gamble: The Inventor of Product Management

The Procter & Gamble Company, also known as P&G, is a multinational consumer goods company headquartered in Cincinnati, Ohio. Its products include pet foods, cleaning agents, and personal care products. Procter & Gamble is the world's biggest consumer products company with more than $80bn in sales. Fortune magazine awarded P&G a top spot on its list of "Global Top Companies for Leaders", and ranked the company at fifteenth place on the "World's Most Admired Companies" list.

The origins of product management go back to the 1930s at P&G when a manager named Neil McElroy was responsible for Camay soap, a lesser brand to the company's leading Ivory soap brand. Camay was not selling well and he decided that a dedicated "brand man" (and supporting team) was needed to ensure that sales of the brand were being maximized. In essence, the "brand man" is responsible for the business success of the brand (product or product family). The role of "brand man" or "brand team" was a very successful management innovation at P&G which today has more than 50 leadership brands, 25 of these brands generating more than $1 billion in annual sales.

Over the years product management has been implemented beyond Consumer Packaged Goods (CPG) companies. While the position's significance varies among industries, today it is far more common in technology than in consumer goods where it's all about the brand. Technology companies such as Apple and Microsoft have more complicated, expensive products and therefore a stronger need for implementing product management in their organization. Since a couple of years there is a strong movement towards the integration of product management organization also in industrial goods companies.

Photos: Copyright © by P&G

Source: P&G [106], Khan [107]

10.4 Organizational Structure for Product Management

In general, the responsibility for a given product or product group is at the center of the assignment of positions within organizational structures. The hierarchical position of product managers mainly depends on the question of whether or not their area of responsibility comprises operational and/or strategic tasks. This aspect should be considered when anchoring product management within the company [93]. In case of *strategic responsibility*, the product manager should directly report to general management or departmental management, thus being assigned the same hierarchical level as functional management. A coordinator of product management becomes necessary when the number of product managers unduly increases the *leadership span*. Product managers with *operational* responsibility are being integrated hierarchically into functional areas, with their area of expertise determining the departmental assignment. In general, the departments in question are likely to be marketing or R&D.

10.4.1 Requirements for a PM Organization

The capacity of product management (PM) essentially depends on its organizational anchoring within the company. The challenges are partially due to the fact that a PM organization serves a variety of different purposes:

- Safety and expediency in fulfilling functions
- Fostering creative, innovative processes
- Product-related, cross-functional coordination.

Criteria that can be used for *efficiency assessment* of PM organizations are coordination ability, market adaptability, motivational capacity and options for control. Prior to choosing a PM organization form, it should be evaluated with regards to respective advantages and disadvantages.

As a rule, the process of anchoring product management has to support and promote the inherent tasks, i.e., planning, control, coordination and information. *Planning tasks* not only are composed of a product-related marketing strategy and the steps of its implementation, but also budgeting and planning for success. *Controlling tasks* are composed of operational controls as well as result controls as a follow-up on planning for success, *Coordination tasks* are particularly important, since expectations with regards to product policies can only be realized in cooperation with other internal and external partners [94, 95]. *Information activities* are composed of market observation, analysis and prognosis of product success, as well as the exploration of new sources of product-related information. Figure 10.13 summarizes the criteria derived from the requirements of the organization of product management.

The organizational forms presented in the previous section show actual structures encountered in operational practice. Within product management, only a few of them have proven themselves to be useful [97]. For instance, within the

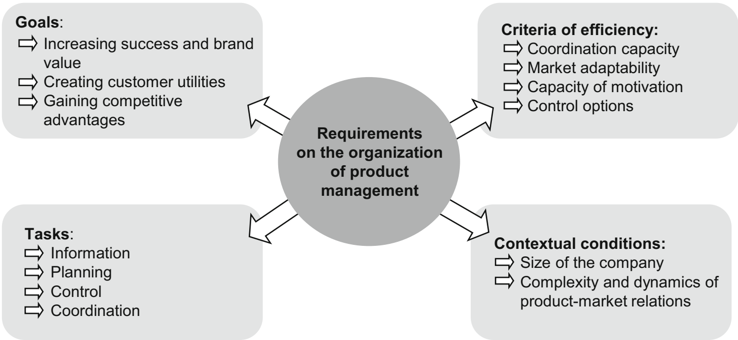


Fig. 10.13 Overview of requirements of PM-organization (Based on Köhler [96])

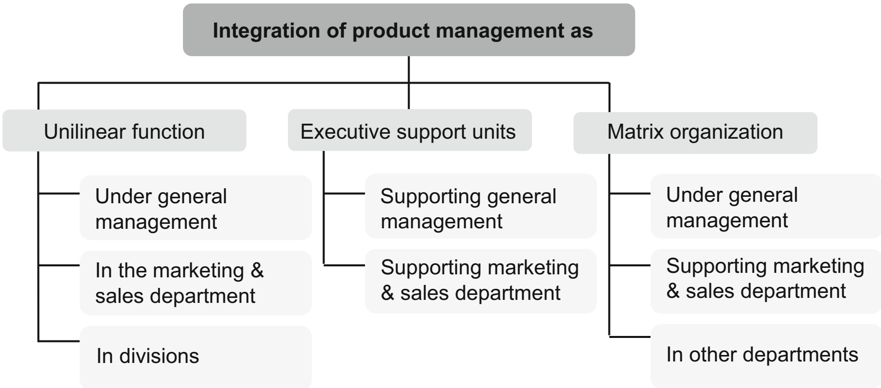


Fig. 10.14 Options for organizational anchoring of PM

framework of *unilinear function*, individual function-oriented departments such as market research, advertising or sales, are assigned to product managers. A product-related parallel structure can be justified by the size or significance of product programs (brands). In an *executive support unit*, product managers are lifted out of the structure to directly report to general management or marketing management. Being in charge of the products, they are co-responsible with executive officers for optimal solutions. Conflict potential exists due to the fact that an executive support unit only has a supporting function for another decision-making body. An employee within an executive support unit can basically act only via a supervisor. This principle hinders product managers' implementations. In a *matrix organization,* there are multiple reporting functions, deliberately breaking the unilinear principle. Putting products as carriers of success at the center of corporate behavior, a product-oriented organization form is combined with a function-oriented organization form. As a function generalist, the product manager is co-responsible with the function-specialist for optimal results. Figure 10.14 gives an overview of the possibilities for anchoring product management in the organization.

10.4.2 PM as Unilinear Function

If product management is integrated as a unilinear function, this procedure is usually carried out at a very high level of hierarchy, under general management or marketing management. Figure 10.15 juxtaposes these options.

10.4.3 PM as Executive Support Unit Function

Other organizational possibilities ensue from anchoring product management as an executive support unit, usually assigned to general management or marketing/distribution management. Figure 10.16 presents the typical features.

10.4.4 PM in a Matrix Organization

In a matrix organization, it is the product manager, as a generalist, who decides on the "what" and "when" of his product program. The "how" is decided on by the function specialists. Figure 10.17 represents the typical features.

The integration of product management into marketing as a matrix used to be widespread in the consumer goods industry and was later taken over by companies with technical products and services. Product management can be a part of distribution, especially in companies with traditionally strong distribution. An integration of PM into the R&D department is mainly chosen by companies engaged in research-intensive high-tech sectors.

In conclusion, it can be said that due to cross-functional tasks of product management, it is especially matrix organization that provides great advantages, since the cross-sectional function can be implemented very well in this form of organization. For this reason, in operational practice it is the most frequently used organization form in product management.

Following the preceding section's discussion of various organization forms in general and the organizational anchoring of innovation and product management in a company, the remaining sections presents a framework for integrated implementation in relation to the degree of innovation.

10.5 Organizational Structure Framework

Based on the basic organizational structures explained in the last chapters, a basic scheme for an organizational structure, capable of handling the challenge of both simultaneously exploring new knowledge and exploiting existing knowledge, is presented here (Fig. 10.18). This schematic builds on a general organizational structure as a template, which includes common functional units such as finance, R&D, marketing, manufacturing and so on. This structure is similar to the matrix organization as explained in Sect. 12.4.4. On a second level, subunits like

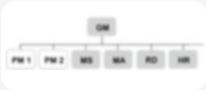
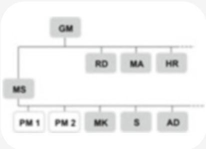
Directly under management	 GM…General Management PM….Product Management MS….Marketing & Sales RD….Research & Development MA…Manufacturing HR….Human Resources	**Short profile:** Product manager is on a par with coordinators of main functional areas. Only suitable for small companies with few major functions and little PM.	**Advantages:** - High assertiveness - Highest level of hierarchy - Direct access to GM **Disadvantages:** - Burdening of GM - Additional operational tasks for GM
As division in marketing and sales	 GM….General Management RD…..Research & Development. MA.....Manufacturing HR…..Human Resources MS…..Marketing & Sales PM......Product Management MK.....Marketing S…….Sales AD….Advertising	**Short profile:** Combines all market-directed functions in marketing.	**Advantages:** - Concentration of market-oriented functions **Disadvantages:** - PM is dependent on administrative route - Cross-coordinating function of PM - Marketing director can entail bottlenecks
As division in marketing	 Abbreviation cf. upper schema	**Short profile:** Marketing is structured on the basis of products. Product manager has coordinating duties, suitable for larger companies.	**Advantages:** - Coordinating function - PM has access to all marketing functions - High degree of assertiveness **Disadvantages:** - Coordinating duties take time away from the product - No expert coordination of individual functions - No balancing of capacities between disciplines

Fig. 10.15 Product management as unilinear function

engineering, innovation management research, etc. (on the R&D side) and market research, sales development, etc. (on the marketing side) are depicted. On the other dimension, different divisions along with their subunits such as product management, sales, etc. are drawn. For better readability, the lines of communication and interaction are not shown.

This organizational chart has been extended with the two major dimensions of uncertainty as used throughout this book. Each box in the chart represents a functional unit. Additionally, the four quadrants of the uncertainty matrix have been integrated into the box along with a color-coding. Dark gray shows that the

GM…General Management
RD….Research & Development
MA…Manufacturing
HR….Human Resources
MS….Marketing & Sales
PM….Product Management
S…....Sales
MK....Marketing
AD….Advertising

Short profile:

Executive support unit advises and supports marketing department, does not have decision-making authority or reporting authority. Not recommended for PM

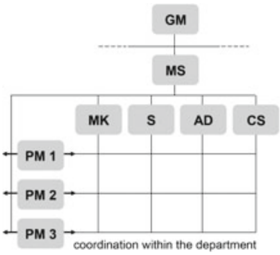
Advantages:

- Concentration of product-relate conceptual tasks and planning

Disadvantages:

- No reporting authority or decision-making authority
- Very limited in its impact

Fig. 10.16 Product function as staff function



GM….General Management
MS…..Marketing & Sales
PM…..Product Management
MK….Marketing
S……..Sales
CS…...Customer Service
AD…..Advertising

Short profile:

Organization has many interfaces with other departments. Results in conflict potential and great need for coordination. Department coordinator rarely gets involved. Especially effective when other functional units are also divided into product groups in accordance with PM.

Advantages:

- Constructive and cooperative finding of solutions
- Short ways
- High degree of participants' own responsibilities

Disadvantages:

- Time-intensive need for coordination and communication
- No direct authority to issue
- Conflicts in times of capacity crunches

Fig. 10.17 Product management in matrix organization

functional unit is leading the innovation project, while light gray means the unit is involved in the project.

To show which functional units are contributing to the different innovation projects running in a company, different backgrounds were added, its pattern varying depending if the project deals with incremental, market/technology or radical innovation.

The business development unit is usually directly reporting to the general management. Not all companies have implemented this unit especially small companies. In this case the innovation manager takes over the responsibilities for developing new businesses.

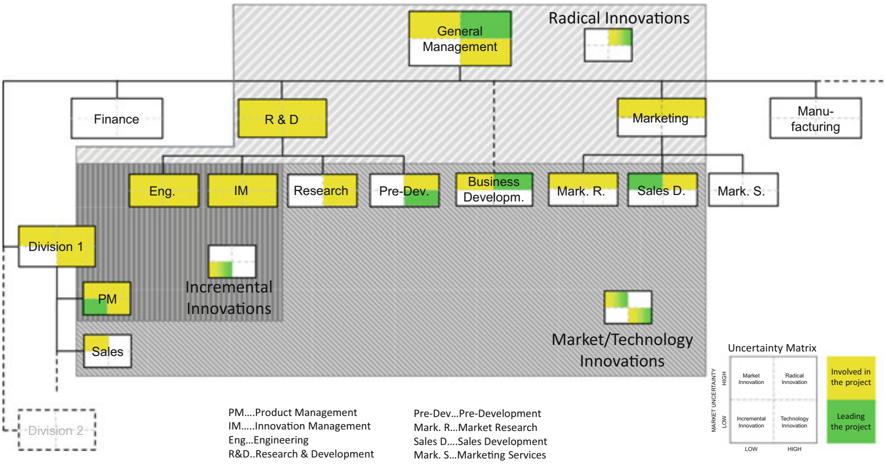


Fig. 10.18 Basic structure of an organization coping with uncertainty

This framework can be used as a blue print for any company that wants to implement a differentiated innovation management system in its organization, in order to cope with various sources of uncertainty and its different levels. Not all units might be implemented into a company, since the implementation very much depends on the size of the company, the number of innovation projects and existing organizational structure.

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Globalization and Innovation

11

11.1 Introduction

As one would expect in the global context, fast moving companies respond to an ever-changing market in diverse countries or hide in ever smaller niches away from global competition. These globally competitive companies are challenged to launch multiple products while leveraging global technology platforms. Companies all over the world are contributing to global innovation. Countries with sophisticated buyers and aggressive competitors are likely to be the home to global innovations [1]. Alternatively, many do not recognize the innovation potential in developing economies, but as C. K. Prahalad, in *The Fortune at the Bottom of the Pyramid* [2], posits—innovating for the lowest income segments can offer great opportunities. Innovation in China (see motorcycle example), like earlier US' "Yankee ingenuity", is evolving rapidly. Peripheries, margins, geographic edges, and boundaries are becoming more central as sources of innovation. Russian innovation, often within severe limitations, created very functionally robust products like MiG jets, spacecraft, and weapons, e.g., AK-47. While globalization and innovation have often been treated as distinct topics, we focus on exploring the connection between the two that can create significant economic value.

This Chapter Will Discuss

- What are the major forces that drive globalization?
- What are the effects of uncertainty in globalization?
- How to conduct a global environment assessment?
- What are the strategic aspects of global product development?
- How to manage global offers?

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Practical Insight

China: Localized Modularization

"Localized modularization"—is a loosely controlled, supplier-driven approach that speeds up time to market, cuts costs, and enhances quality. The heart of this new system is a series of "process networks" mobilizing specialized companies across many levels of an extended business process. Entrepreneurial, privately owned motorcycle assemblers such as Dachangjiang, Longxin, and Zongshen orchestrate the networks. The Chinese system makes it possible for the assemblers to modularize production in parallel by outsourcing components and subassemblies to independent suppliers. In contrast to more traditional, top-down approaches, the assemblers succeed not by preparing detailed design drawings of components and subsystems for their suppliers but by defining only a product's key modules and specifying broad performance parameters, like weight and size, in rough design blueprints. The suppliers take collective responsibility for the detailed design of components and subsystems. Since they are free to improvise within broad limits, they have cut their costs and improved the quality of their products quite rapidly. In this production-driven form of modularization, suppliers of components and subassemblies—the frame, the engine, the suspension—take much of the responsibility for coordinating their work. Solving problems by combining people from diverse fields makes the solution more creative.

Thanks to these innovations, the Chinese have made rapid gains in motorcycle export markets, especially in Africa and Southeast Asia. China now accounts for 50 % of global production of motorcycles. Their average export price has dropped from $700 in the late 1990s (already several hundred dollars less than the cost of equivalent Japanese models) to under $200 in 2002. The impact on rivals has been brutal: Honda's share of Vietnam's motorcycle market, for instance, dropped from nearly 90 % in 1997 to 30 % in 2002. Japanese companies complain about the "stealing" of their designs, but the Chinese have redefined product architectures in ways that go well beyond copying, by encouraging significant local innovation at the component and subsystem level.

More recently, the quality and price has risen. BMW, Honda, Peugeot, Harley Davidson, MV Agusta, Piaggio, Yamaha and Suzuki have all committed to long-term partnerships with leading Chinese companies. Due to this influx of foreign motorcycle culture and expertise, the Chinese industry has rethought its strategy and thus breaking in to the mainstream market. According to China Customs statistics for the first half of 2013, China exported motorcycles totaling 5.717 million units, worth USD 2.9 billion, at the average export price of $507.

(continued)

Photos: Copyright © by chinaSMACK

Source: Chinasmack [10], China Motorcycle News [11], Hagel/Brown [12]

11.2 Globalization and Innovation Interactions

The globalization of innovation is the result of the increasing international scope of the generation and diffusion of technologies. The transmission of innovations that address needs across cultures has met less resistance than religious, social or political ideas. Now, technology creates an instantaneous bridge across cultures even though learning processes can be long and cumbersome. Thus, while technology markets tend to be relatively culture-insensitive, few non-US high-tech startups have evolved into global companies. Tariff and non-tariff barriers play a role.

Product-based technology must globalize fast or risk fading away, usually with its fiercest rivals for demanding customers in primary markets. Globally strategic countries are major sources of innovation, offer highly skilled and/or low-cost R&D workers, and exhibit highly demanding customers. Firms outside the primary markets must plan to be global early in the PLC—small countries require quick global acceptance because you can't hide in your home country—competitors will come at you quickly.

New technologies play a fundamental part in making globalization possible, and globalization makes innovation possible. This iterative, mutually enforcing, virtuous cycle drives the quick pace and creates a desperate need to deal with the uncertainty. It is necessary to understand the environmental conditions or drivers that companies compete within.

A fit among the environmental *drivers* of globalization, the marketing *levers* (Table 11.1) and the *organizational factors* is necessary to obtain the benefits of globalization (Fig. 11.1). Since the customer is the focus of the firm, the marketing levers to be used are important benchmarks for support activities. The organizational factors include the physical resources, knowledge and abilities that often reside in the people, processes, structure and culture of the firm.

Figure 11.1 presents the framework for diagnosing and developing globalization strategy. Industry globalization drivers are externally determined by industry conditions or by the economics of the business, while global strategy levers are choices available to the worldwide business. Industry globalization drivers (underlying market, cost, and other industry conditions) create the potential for a

Table 11.1 Strategic options from the use of five levers (Adapted from Yip and Hult [1])

Marketing levers	Pure multidomestic strategy	Pure global strategy
Market participation	No pattern	Signif. share in major mkts.
Products/services	Custom to Co.	Stand. Worldwide
Location of value-added activities	All in all Co's	Concentrated—each in diff. Co
Marketing	Local	Uniform worldwide
Competitive moves	Stand-alone	Integrated across Co's

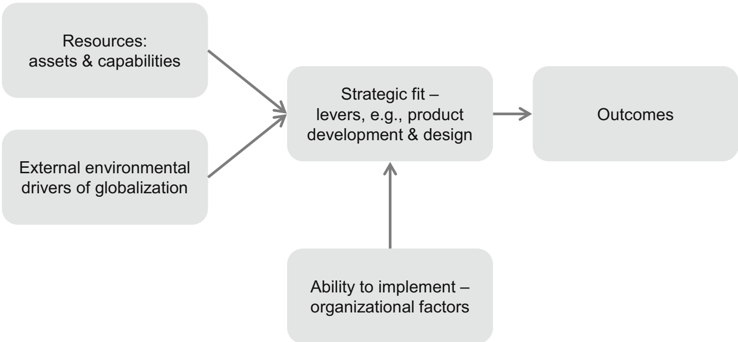


Fig. 11.1 Model of globalization

worldwide business to achieve the benefits of global strategy. To achieve these benefits, a worldwide business needs to set its global strategy levers (e.g., use of globally standardized products) appropriately relative to the industry drivers, and relative to the position and resources of the business and its parent company. The organization's ability to implement the formulated global strategy affects how well the benefits can be achieved.

Another way of viewing the relationship among these different forces and factors is in terms of a globalization triangle. Industry globalization drivers, global strategy levers, and global organization factors need to work together to achieve potential globalization benefits.

11.2.1 Globalization Drivers

Drivers can broadly be classified as customer, cost, government and competitor [1]. Drivers are environmental variables that are not controllable and require companies' strategies to adjust, react, and anticipate. For product development, the most relevant drivers are:

- *Common customer needs* (customer): convergence of lifestyles, tastes, and functional requirements that allow a more standardized product to be accepted into the marketplace, e.g., Starbucks in China.

- *Global customers* (customer): organizations desiring standardized products and components everywhere in the world, e.g., Honda and BMW buying exactly the same parts in Marysville, OH and Spartanburg, SC as they do in Japan and Germany.
- *Global scale economies* (cost): the scale required to drive costs low enough to be profitable is not gained in a single country even the size of the U.S. nor even on a regional basis like the EU but require global participation and market share e.g., blockbuster Hollywood movies costs generally require success on multiple continents to recover their investment.
- *High product development cost* (cost): increasing cost of research, development, and introduction costs of products, e.g., Gillette's investment of hundreds of millions of dollars in R&D along with introduction costs of each new generation of razor.
- *Fast changing technology* (cost): accelerating technological innovation that lowers the relative market life and decreases the payback period of investments.
- *Favorable trade policies* (government): reduction of tariff and non tariff barriers through free trade agreements (e.g., NAFTA), trading blocs (e.g., EU), World Trade Organization initiatives, bi-lateral agreements, and increasing participation of China, India and others in the global economy.
- *Compatible technical standards* (government): reduction in the number of requirements and differences among countries so the cost of adaptation is reduced and ability to easily participate in more countries (e.g., reducing the number of national regulations, possible permutations and related adaptation costs of in vitro diagnostic medical devices as EU harmonized codes).
- *Globalized competitors* (competitor): rise of competitors who are using global scale to drive down costs, help lead customer convergence of tastes, and pave the way for more interdependence of countries.

11.2.2 Global Marketing Levers

Globalization strategy is multidimensional. Setting strategy for a worldwide business requires choices along five broad strategic dimensions that are prescribed by the environmental drivers. These dimensions identify whether the strategy lies toward the multilocal end of the continuum or the global end. Each of the five dimensions may be in a different place on the continuum:

- *Market participation* involves the choice of country-markets in which to conduct business, balance across countries and the level of activity, particularly in terms of market share.
- *Products/services* involve the extent to which a worldwide business offers the same or different products across countries.
- *Location of value-adding activities* involves the choice of where to locate each of the activities that constitute the entire value-added chain-from research to production to after-sales service.

- *Marketing* involves the extent to which a worldwide business uses the same brand names, advertising, and other marketing elements across countries.
- *Competitive moves* involve the type and extent to which a worldwide business takes competitive action across countries.

For each global strategy dimension or lever, a multilocal strategy seeks to maximize worldwide performance by maximizing local competitive advantage, revenues, or profits; while a globalized strategy seeks to maximize worldwide performance through sharing and integration. Intermediate positions are, of course, feasible and often the implemented solution. A business that has a fully globalized strategy would make maximum use of each of the five global strategy levers and would therefore have fully global market participation, global products and services, global location of activities, global marketing, and global competitive moves. But, it is not a matter of either/or—most companies are not, pure examples of either strategy extremes—companies must use the strategies that match the environmental drivers. Table 11.1 summarizes the five discussed levers and their implementation in the two pure strategic approaches.

11.2.3 Innovations for Global Markets

Globalization of innovation can be categorized into three areas: (1) the international exploitation of technology produced on a national basis; (2) the global generation of innovations; and (3) global technological collaborations [6]. First, national technology taken internationally includes the export of innovative goods, licenses and patents along with international production of goods designed domestically. Second, global generation of innovations include R&D along with other innovative activities that takes place anywhere or the acquisition of new capacity through existing or newly-developed R&D labs. Finally, global technology collaborations include university and research centers along with scientific projects, exchanges and even the flow of scholars and students across countries. Further, these global collaborations can produce innovative technology at the firm level through joint ventures and other cooperative strategies related to projects and the exchange of information and equipment.

11.2.4 The Effects of Uncertainty in Globalization

The McKinsey Quarterly [7] in *Leading through Uncertainty* offers advice to global companies that are trying to deal with dynamic environments. Companies that nurture flexibility, awareness, and resiliency are more likely to have long-term survival and health. Many formal processes such as Six Sigma, TQM, etc. were developed to deliver more predictable innovations and performance to organizations. As the environment becomes more complex and uncertain, it drives faster change, and these predictable, structured processes can be impediments to agility and responsiveness to dynamic customer needs and technological shifts.

To have greater flexibility means developing many options that are exercised based on trigger events. Companies need to develop internally consistent scenarios along with coherent, multi-pronged strategic plans to address each scenario (see below scenario quadrant for example). They must be ready to pursue any of them quickly. To be more aware requires critical knowledge in a crisis, but is worthless without decision-making skills and an ability act before the world understands. Superior business intelligence requires difficult network building but can make the difference in capturing opportunities. Companies must create "eyes and ears" across businesses and geographies to both gather and exchange information vertically and horizontally within the organization to make sense of diverse, overwhelming, and conflictual information.

To exhibit more resilience allows a company to withstand a crisis and break ingrained structures and behaviors that undercut productivity and effectiveness. Such abilities are difficult and take time to implement but are valuable in any scenario. Dramatic change makes employees uncomfortable, especially in difficult to understand environments, but the long-term effectiveness of the firm is understandable. As globalization proceeds, it is likely that the vertical organizational structures move toward ad hoc and matrix approaches. These structures require employees to answer to several competing bosses, complicate decision-making and often produce turf wars between product managers, functional managers and country managers. Communication can become little skirmishes. On the flipside, streamlining can better define roles and produce better collaboration that can improve effectiveness and decision-making. This is accomplished through reducing unproductive complexity. Companies who nurture flexibility, awareness, and resiliency are in a better position to remain calm, assess options and proactively proceed through the global environmental barriers.

11.2.5 Opportunities at the Bottom of the Pyramid

Jugaad is a Hindi word meaning an improvised solution born from ingenuity. It seeks opportunity in adversity—to do more with less, to think and act flexibly, to keep it simple, to include the margin and to follow your heart [8]. There are many examples of this approach in our own culture (e.g., Franklin stove). The Soviet Union was extremely good at low resource, robust creativity (e.g., AK47, MiG jets). Also this idea of innovation under severe resource constraint is at the heart of design in social entrepreneurship. For example: Mitticool is an off-the-grid, refrigerator using the natural cooling effects of clay (readily-available, cheap material) and the cooling effect of evaporation. It was created for villages in the deserts of India where there was little access and an inability to afford electricity.

Immelt et al. [9] go further by offering examples of portable ultrasound machines and small turboprop jet engines. General Electric is using developing markets as sources of innovation that then contribute to success in world markets. Products, services, processes and management approaches are innovated in developing countries. This then allows trust building, flexibility and learning which helps to counterbalance the uncertainty and competitive intensity of the global environment. Finally, this engagement with alternative ways of thinking and new environments helps equip companies to question basic assumptions and avoid being blind-sided by disruptive products and services from developing and emerging economies. These developing and emerging economies will become catalysts for significant product and business innovation.

11.2.6 Diffusion in Global Markets

An important part of identifying new product ideas for global markets is to ascertain their ability to be adopted into global markets. Designing products that are acceptable to foreign customers require consideration of the adoption-diffusion process. Four factors are likely to influence the ability of products to be accepted: individual differences, personal influences, product characteristics and country differences. As was discussed in the Product Life Cycle chapter, consumers have differences related to their preference toward risk and what influences their purchase decisions. Innovators accept risk and are comfortable with adopting products that may not be used by anyone they know. Followers tend to be risk averse and prefer to know someone who discuss (word-of-mouth) their experience with the product. Personal influences include peer pressure and other social factors and familial sources.

The likelihood of successful adoption also is influenced by the following five product characteristics:

- *Observability*: can potential adopters easily see the benefits or can they be easily communicated (e.g., the depth and glossiness of the exterior paint of the BMW Z4)?
- *Triability*: can potential adopters easily try out the product (e.g., the quality of the alloy to keep a Benchmade knife sharp)?
- *Complexity*: can potential adopters easily understand and use the product (e.g., Apple iPhone intuitive design versus alternatives)?
- *Compatibility*: can potential adopters easily fit the product to their existing values and attitudes along with offering low switching costs (e.g., similarly priced but more accessible music through iTunes based in the cloud)?
- *Relative advantage*: can potential adopters easily perceive greater value in the product than offered by alternatives (e.g., Amazon Prime free two day shipping)?

Differences among countries can also influence the speed and adoption rate of innovations. Homogeneous populations tend to speed adoption. Countries where the product was introduced after lead countries tend to have higher adoption speed (although quality is likely to increase over time while costs decrease). Demographic, psychographic and life style differences can also effect diffusion of innovations across countries (e.g., average age, mobility, urban percentage, labor force percentage of women, and national cultural variables—level of individualism and uncertainty avoidance).

11.3 Global Environment Assessment

11.3.1 Global NPD and Culture

Cultural convergence continues to increase due to globalizing products, movies, experiences, travel, economic development, urbanization and mass media coverage. English is the international language of business and communication. While globalization leads to increasing homogenization, not all people will move towards a single culture. Civilizations tend not to change much because they are based on history, language and most importantly religious beliefs. Awareness of cultural differences can allow companies to identify niche opportunities.

Cultural differences influence new product development and innovation. Culture and management practices are intertwined. NPD processes have been developed in western cultural environments and may have application difficulties in other cultural settings. Links between formalization, centralization, role flexibility and interfunctional climate mechanisms with the Hofstede dimensions of Power Distance, Masculinity and Uncertainty Avoidance of national culture suggest that national cultural values and settings of the respondents are important when determining best integration approaches of marketing and R&D in NPD [10].

For example, German innovation was associated with activities that were more clearly divided, sequential and scheduled while Chinese innovation is better described as overlapping [11]. European and US firms tend to be more formal while Japanese is better described as holistic [12]. As Kotabe and Helsen [13] summarize the research with emphasis on Nakata and Sivakumar [14], "Decentralization, often found in egalitarian (low power distance) cultures, encourages idea generation and feedback. On the other hand, a centralized structure (high power distance) is probably a strength for the implementation steps of the NPD when rigor and control become more critical. Cultures with low uncertainty avoidance—characterized with risk taking and little need for planning and structure—are probably beneficial for the initial steps of the NPD process. At later stages, risk avoidance and planning become more desirable. These traits are typically found in cultures with high uncertainty avoidance."

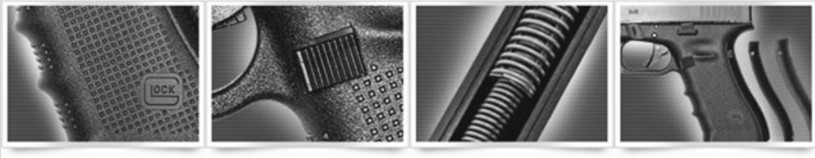
Practical Insight

Glock: Overtaking Established Global Brands

The Glock pistol is an "ugly plastic gun" that has taken 65 % the U.S. market from Colt, Remington, and Winchester—established, historical brands that had forgotten how to innovate and produce quality products. Glock, with no experience in the small arms market, reverse-engineered, industrial designed, innovated, and memorably marketed to the influencers in the U.S. market (e.g., federal and NYC law enforcement, shooting instructors, special forces, Hollywood, and rap/hip hop stars). A combination of *functional*

(continued)

(e.g., durability, safety, ease of maintenance and assembly with 36 parts, interchangeable parts, robust to being dropped, submerged and subjected to temperature extremes—and still accurately fire), *experiential* (e.g., lightweight, low recoil, natural aiming, low profile to reduce "kick" rotation, consistent trigger pull resistance, ease of holster extraction, and the security of a large capacity magazine) and *symbolic* benefits (e.g., aggressive, military styling with "bad boy" attitude and a pop culture profile known to all through U.S. Airport security signs, TV, books, and movies) drove its success. Glock introduced processes and new materials (e.g., molded polymer) from experience in other industries (curtain-rods, knives, and shovels) along with a deep understanding of what customers wanted.



Photos: Copyright © by http://us.glock.com 2013

Source: Barrett [24]

Similarly, cultural dimensions influence research and development activities at the subsidiary level. In particular, the higher the uncertainty avoidance and individualism and the lower the power distance and masculinity indexes the higher the level of research and development activities performed. Secondly, the type of management model influences the organization of research and development activities of the subsidiaries [16].

11.3.2 Economic Environment

Economic data, including income, consumption patterns, population, urbanization, infrastructure, geography, and attitudes, offer insights to assess the market potential. International data are increasingly available but may need to be supplemented by, more interpretive data. Economic environmental data even if recent, are backward looking and cannot be fully depended on to get a understanding of future growth, development and opportunities. Understanding the interrelationships among economic indicators is critical to predicty social development and market potential. Ongoing economic integration in the world creates opportunities and challenges—both requiring an ability to react with flexibility or be proactive with robust approaches. NAFTA, North American Free Trade Agreement, created the largest trading bloc in the world. The EU has gone further through cooperation that goes beyond trade. Companies must be able to anticipate this long-term economic trend's impact on their strategies.

11.3.3 Financial Environment

Financing and a company's credit terms are important marketing and risk management tools. In an international context, an understanding of the foreign exchange market along with available governmental assistance programs allow the international product manager to make more informed decisions. All countries around the world have programs that support exporting through education, risk reduction programs and financial incentives. Financial turmoil is common and the product manager will need to adjust strategies to maintain viability in the market (e.g., terms that appeal to the customer), manage country risks as well as manage the company's financial liquidity and flexibility.

11.3.4 Political and Legal Environment

An understanding of the political and legal environment of individual countries along with the laws and agreements governing relationships among nations is critical for product managers. While compliance is required, a detailed knowledge of the laws that control exports and imports along with regulating the behavior of firms (e.g., antitrust, corruption, boycotts, and ethics) can allow firms to avoid expensive problems, cut costs and take advantage of regulatory opportunities. Changes in the political and legal environment can cause serious problems if they are not anticipated, e.g., product regulations that require substantial alterations or withdrawal from the market. Most difficult is the situation where the international product manager is caught between home and host country laws. Finally, international legal action may be slow, difficult to receive favorable judgment and may not be adhered to by the government. An international company must foresee political and legal changes attempt to legally shape the political environment and influence laws or strive to adapt as best as possible.

11.3.5 Scenario Analysis

Scenario analysis is a powerful approach to conducting situation analysis, making assumptions explicit, surfacing important drivers that vary, dealing with uncertainty, clarifying possible future events, promoting creative long-range thinking, determining the firm's possible responses and producing robust, action-oriented contingency plans [17].

1. *Define the scope* of the analysis: to encourage deep analysis, creative thinking and relevance the markets/industries, the *environmental/internal factors* and *timeframes* should be defined;

2. Identify the *drivers*' of future strategic contexts: to determine the 3–5 important forces that *are likely to* drive the firm's future;
3. *Select specific levels, changes, or events* within each driver: to frame the future across varying possibilities;
4. *Combine those drivers* and levels/changes/events to *develop comprehensive scenarios*: to create internally consistent scenarios where all the variables combine into a believable possible context.
5. *Select three or four scenarios* for analysis: to bound rationality not to choose the most likely;
6. *Analyze and plan* for each selected scenario: to have a response if the firm finds itself in that context; and,
7. *Integrate* results to identify directions, actions and investments: to appraise strategic alternatives.

11.4 Strategic Aspects of Global Product Management

11.4.1 Global Expansion Strategies

Three global expansion strategies are possible for foreign product entry: *extension, adaptation* and *invention* [18]. Companies can extend their domestic products to foreign markets unchanged (e.g., Coke). This is the least expensive and fastest approach. The downside is that it could be an ethnocentric extension that does not find a receptive audience—not everyone wants the same thing. Products can also be adapted so that they better fit with foreign customers (e.g., Black & Decker tools with smaller handles). This requires a little more investment of time and money. It usually translates to a possibility of more sales but the expense of adaptation may not allow payback—a polycentric view that everyone is different may lead the company to adapt when not necessary. Finally, products can be designed from scratch for foreign customers (e.g., BMW creating the new Mini). A geocentric view suggests that there are similarities and differences. Companies that can identify products that meet similar functional needs across countries can develop standardized products that can be differentiated if necessary by other means, e.g., distribution, pricing, advertising execution, positioning, service, etc.

11.4.2 Standardization vs. Adaptation?

As identified above, drivers can favor a product strategy with a more standardized product that may include a few modifications to accommodate local regulations or market conditions. This is more a product-driven orientation whose goal is to minimize costs and attract customers with quality products and lower prices. The drivers can also favor a more dramatically adapted product strategy that appeals through a more market-driven orientation to appeal to differences across countries.

Adaptation seeks to increase customer satisfaction with products that are customized to local market conditions.

Importantly, the point is not standardization versus adaptation but to what degree each is emphasized. The question is what parts, elements, components can be left unchanged and what will have to be adapted to receive the best benefits? This is best described as a core vs. peripheral question. How can the company maximize the core so as to reduce costs while using the peripheral to differentiate and increase customer acceptance and satisfaction. Product design policies that use this idea include a core-product approach, a modular approach and a platform approach. The goal of the core-product approach is to maximize the core while matching the adaptations to local market needs. The goal of the modular approach is to develop a range of product parts that can be combined in different ways to create alternative products that are better adapted to local market conditions. Finally, the goal of a global platform approach is to achieve product diversity with scale—delivering variety with efficiency—is the key to success. This strategy can be a powerful growth driver, but typically comes with increased product complexity. To manage this complexity, companies need a product-platform approach that delivers the following benefits:

- Control product costs (i.e., design, development and manufacturing costs) by standardizing required components;
- Capitalize on new market opportunities with price premiums for customized products;
- Synchronize product configurations used by sales with engineering-defined options so the right product is configured for the right market.

Practical Insight

Prinoth: Global Design and Global Platform

You are driving your metallic silver Pininfarina styled (think Ferrari designers) vehicle. It is dark, well below zero, snowing, and you are on a steep, icy slope (sometimes steeper than 45 degrees). Worries?—None. No chance of dinging a fender; the Prinoth Beast is the most powerful piste groomer in the world! No idea what a "piste" is? Most skiers appreciate the groomed slopes they leave in their wake. Prinoth's Beast is powered by a 12.5 liter Caterpillar C13 Acert turbo diesel engine, which delivers 527 hp and an ability to move tons of snow with its advance. With superior power and 45 % greater track area than rivals, it is able to do more, faster. On top of its performance, it is comfortable and looks good with a cockpit that is simple, intuitive, and safe. The design inside and out was accomplished by the world-famous Italian Pininfarina studio.

Auto racer Ernst Prinoth opened his automotive garage in Gröden in 1951 and offered his first slope vehicle in 1962. Prinoth is now part of the Leitner Group, with more than 70 subsidiaries, based in Sterzing, Italy, is the world

(continued)

leader in ski lifts, ropeways, and installations as well as snow groomers, tracked utility vehicles, urban cableways, and wind turbines. A snowmaking division added at the end of 2010, provides a complete offering for all winter-based technologies.

The acquisition of groomer products from the Canadian manufacturer Camoplast (previously Bombardier) in 2005, the acquisition of Camoplast's tracked utility vehicle products in 2009, and a strategic alliance with a German forestry machinery manufacturer, AHWI, a specialist in vegetation management: processing forestry and agricultural land along with seeking solutions in the global development of biomass, gave Prinoth three distinct market solutions that meets each need with a common core tracked global platform.

Photos: Copyright © by Prinoth

Source: Prinoth [28]

While competing in global markets, companies have a bias toward standardization and there are many reasons why these products fail. First, most companies perform an insufficient level of market research—they don't know where they can profitably adapt. Table 11.2 summarizes a set of questions that should be answered for products under consideration. The use of the list will guide the international product manager through the analysis.

A poor understanding of how and when to adapt products leads to lost profit opportunities, disenchanted local subsidiaries and poor acceptance in local markets. Costs and subsequently prices may have been lowered but consumers demanded and were willing to pay for a more adapted product. Second, companies may make the mistake of rigid implementation. The product could be standardized but other elements needed to account for local tastes and better ideas from subsidiaries. Third, companies may have a narrow vision of local markets and do not believe they can learn from subsidiaries. Knowledge sharing and transfer is limited with these companies and can lead to lost opportunities and profits. Fourth, poor resource allocation, implementation and follow-up lead to under investment in the support of global products.

Table 11.2 Factors affecting product adaption (Based on Czinkota and Ronkainen [20])

Cultural and psychological factors affecting product adaptation
I. Consumption patterns
A. Pattern of purchase
1. Is the product or service purchased by relatively the same consumer income group from one country to another?
2. Do the same family members motivate the purchase in all target countries?
3. Do the same family members dictate brand choice in all target countries?
4. Do most consumers expect a product to have the same appearance?
5. Is the purchase rate the same regardless of the country?
6. Are most of the purchases made at the same kind of retail outlet?
7. Do most consumers spend the same amount of time making the purchase?
B. Pattern of usage
1. Do most consumers use the product or service for the same purpose or purposes?
2. Is the product or service used in different amounts from one target area or country to another?
3. Is the method of preparation the same in all target countries?
4. Is the product or service used along with other products or services?
II. Psychosocial characteristics
A. Attitudes toward the product or service
1. Are the basic psychological, social, and economic factors motivating the purchase and use of the product the same for all target countries?
2. Are the advantages and disadvantages of the product or service in the minds of consumers basically the same from one country to another?
3. Does the symbolic content of the product or service differ from one country to another?
4. Is the psychic cost of purchasing or using the product or service the same, whatever the country?
5. Does the appeal of the product or service for a cosmopolitan market differ from one market to another?
B. Attitudes toward the brand
1. Is the brand name equally known and accepted in all target countries?
2. Are customer attitudes toward the package basically the same?
3. Are customer attitudes toward pricing basically the same?
4. Is brand loyalty the same throughout target countries for the product or service under consideration?
III. Cultural criteria
1. Does society restrict the purchase and/or use of the product or service to a particular group?
2. Is there a stigma attached to the product or service?
3. Does the usage of the product or service interfere with tradition in one or more of the targeted markets?

11.4.3 Complexity of Global Sourcing

The logistical management of the interfaces of R&D, manufacturing and marketing activities on a global basis is called global sourcing strategy [13]. This includes the decision of producing products, components, and parts in-house versus procuring from without. Differing objectives among R&D, manufacturing and marketing make these decisions extremely complex. R&D may not have the resources to proceed with discontinuous innovations so they focus on many incremental, quick innovations. Manufacturing may focus on reducing costs through a smaller number of variations along with ease of assembly and manufacturing. Marketing may focus on the ever-changing nature of demanding consumers and difficult competitors with a technology lead along with the need to significantly modify, extend, and proliferate the number of product options. Global sourcing strategy tries to simultaneously reduce costs, increase quality, enhance customer preference and increase competitive leverage [1].

There is generally an over capacity in many industries. The competitive advantage has thus shifted from the efficient delivery of volume to reliably delivering quality products unavailable in the home country. There is a growth in global manufacturing made possible by widespread availability of technology, labor, communication tools, and logistical support to tie the worldwide manufacturing facilities into the operations of the firm. Thus, the competitive advantage of the firm is connected to the comparative advantages of the countries—ownership advantages, internalization advantages and locational advantages.

Kotabe and Helsen [13] state that there are three important interrelated activities in the value chain. They list R&D (i.e., technology development, product design, and engineering), manufacturing and marketing activities. The interfaces among these areas lay out the challenges and scope of a global sourcing strategy (Fig. 11.2) Product development must go hand-in-hand with supply chain design and management.

The complex sourcing strategies are also a result of the increasing role of cross-organizational interfaces. The increasing complexity of the technological content of products, processes and services is a driver of the need for cooperative strategies as is the dispersed nature of cutting edge knowledge necessary for innovation [21]. Lam [22] states, “knowledge is generated through the repeated combination and re-configuration of diverse disciplines and expertise in flexible forms of organization”. Industrial knowledge is of a synthetic nature spun from knowledge bases spanning industries, generic technologies and highly specialized knowledge gained through experience with demanding customers, the best suppliers and the leading research environments. The higher the complexity, the more dynamic the industry, the more likely the firm is going to be dependent on others.

Uncertainty also emerges from interdependencies as the firm sources knowledge from others. Partner companies and their resources don’t stand still. Chaotic, unpredictable markets demand corporate reaction. New platform technologies emerge, e.g., nanotechnology, and frontiers move in unpredictable directions. Competitors offer discontinuous products and transform their value chains. These discontinuous innovations in turn establish of new trajectories that may require knowledge or ideas from, as yet, unidentified sources. Customer preferences are unpredictable and not controllable.

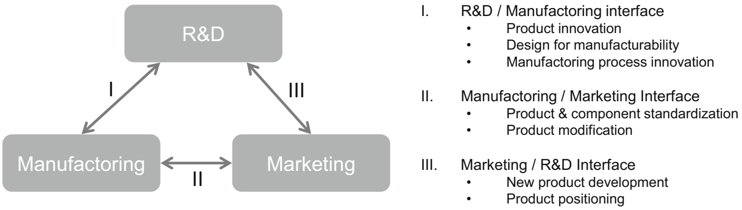


Fig. 11.2 Interfaces among R&D, manufacturing and marketing

11.4.4 Entry Strategies

New technologies are fundamental to globalization. Communication and transportation are critical elements in the growth of exporting and exporting/entry strategy connection. The strategic rule for making an entry decision is first to look at all viable options (Fig. 11.4). There are many comparisons and trade-offs required but goals are often trying to maximize profits subject to company resources, risk, and non-profit objectives (e.g., sustainability). Strategic approaches vary (Cummins prefers joint ventures while Caterpillar prefers wholly-owned subsidiaries and foreign direct investment). Overall design may require combinations of the various choices and strategies of a company may change over time (Fig. 11.3).

International trade offers one possibility for an innovator company to benefit from its technology. There are obstacles to international trade: high transportation costs, governmental barriers to imports, and ability to control others appropriating the technology in the importing country. Another possibility, without exporting physical products, is to license technology to foreign firms. In order license technology it should be of able to be codified. There are concerns with keeping others from appropriating the firm's technology (Fig. 11.4).

International access and R&D investment wherever it offers the most advantage offers many benefits. First, learning from proximity to local markets that can allow both inspiration into the process and adaptation of the product for the market. Second, flexibility with respect to working across time zones and lowering risks with multiple locations. Third, access to expertise and creative differences across cultures. Fourth, leveraging nontraditional sources of innovation. Alternatively, there are difficulties with coordinating and managing global projects especially when there are "not invented here" or short-term biases.

11.5 Managing Global Offers

11.5.1 Global Product Policy

Product policy decisions that support the NPD process in a global context are important for success. Global companies have three options: *extension* of the domestic strategy, *adaptation* of local strategies or *invention* by designing products

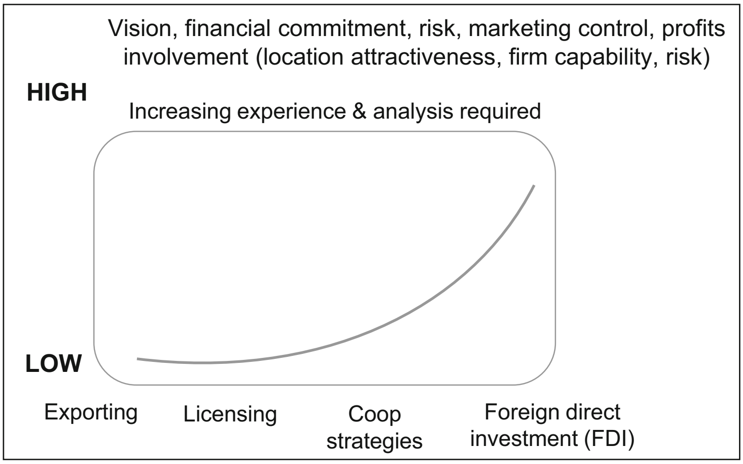


Fig. 11.3 General path of internalization

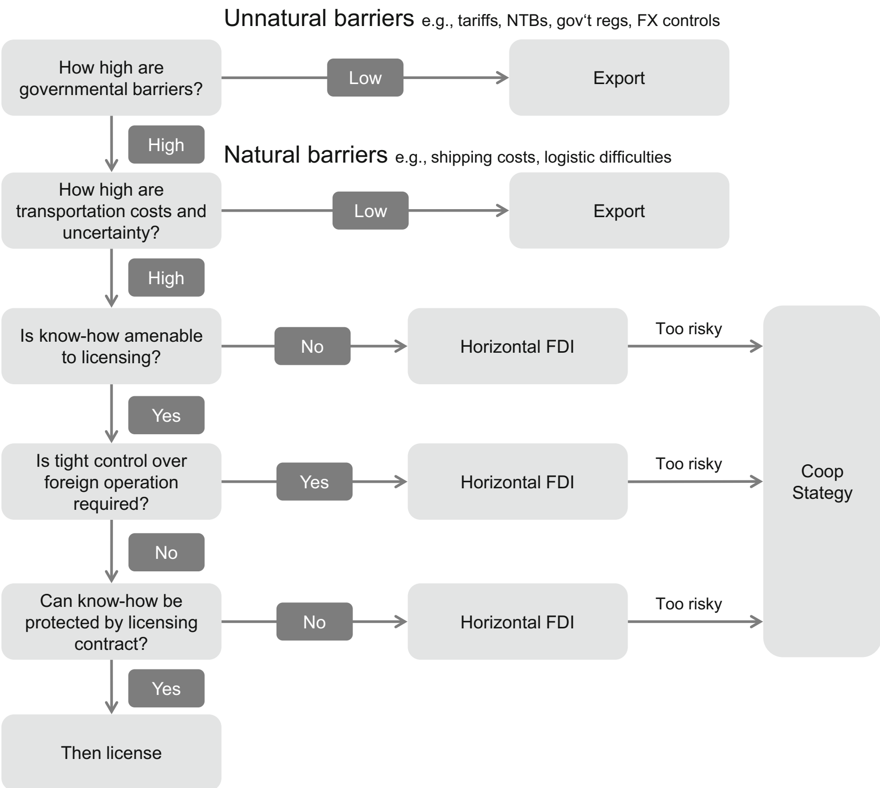


Fig. 11.4 An entry strategy decision framework

that meet common needs of global customers. These three options require the company to make tradeoff decisions related to standardization versus customization. In actuality, this issue is a matter of degree: the extent to which the company should adapt or standardize its product strategy? Companies must strike a balance to capture the benefits. Approaches that use modular or core-product approaches can minimize the risk of overstandardization of their product offerings while still capturing the scale economies of a more a uniform product policy.

There are two dominant ways of developing global products. First, companies can develop products for global market initially. This approach considers the needs of strategic markets in the beginning. Managers identify commonalities and design the largest possible standardized core, while allowing for necessary customization around the periphery. Second, a less desirable option but more common, companies adapt existing products from national sources. Many businesses focus on differences and create product lines that are less standardized by not having a global perspective.

There are several tools to help make global product design decisions but conjoint analysis allows companies to make tradeoffs across different country markets. The new product development process itself in a global context doesn't differ substantially but must handle the complexity of multiple, interacting markets. Companies must address a number of other complicating factors: How to coordinate global NPD efforts across different cultures? What approaches and communication channels would be best to inspire the exchange of ideas? What alternatives are available in each country the steps of the NPD process (e.g., test marketing)?

11.5.1.1 International Product Portfolio Management

International product management must develop and maintain a competitive product portfolio. Yip and Hult [1] suggest that successful product portfolio requires answering the following questions:

- Which current products of the company may be marketed internationally?
- Which products should not be offered internationally?
- How can the products to be marketed internationally be bundled into an attractive offer for the different local or regional markets served?
- What additional products are needed to increase the local or regional attractiveness of the current product portfolio? Should they be developed in-house or procured from suppliers?
- When should which product be introduced in which country market?
- When should products offered in international markets be eliminated?
- How much of the limited resources of time, capital, and capabilities are to be invested in which parts of the product portfolio?
- Where in the lifecycle is each of the products in each of the countries that constitute the portfolio?
- What is the duration of the lifecycles across products and across time?

11.5.1.2 Services

As also highlighted in Chap. 12, services are becoming a greater part of the extended product offering (see Marlin Steel Insight below). As companies seek to improve their competitive advantage, they turn to services to supplement their product offering. Several global challenges put hurdles in the way of offering services internationally. Face-to-face contacts are expensive but may be more critical with services. Trade barriers (tariff and non tariff) tend to be more difficult to surmount. Finally, measuring satisfaction is difficult because accounting for equivalence issues make market research expensive and time-consuming.

Practical Insight

Marlin Steel: Fighting Global Competition

In 1998, Drew Greenblatt bought Marlin Steel that specialized in a single product: they were the king of the wire bagel baskets. It was really just a metalworking shop: 18 employees, most at minimum wage, using hand tools to bend and weld metal, with $800,000 a year in sales. Marlin didn't own a fax machine, and most of the equipment was from the 1950s. His intellectual property written was on yellow pads of paper. Purchase orders arrived by mail. The pace was methodical and unhurried -each employee made 15 or 20 baskets a day. Within 5 years Chinese factories started making bagel baskets and selling them for $6 each. Marlin sold its baskets for $12 apiece.

Today, a decade later, Marlin Steel continues bending heavy-gauge wire to make baskets, but instead of going to Bruegger's to hold bagels, the baskets go to the factories of Toyota and Caterpillar, Merck and GE to hold everything from microchips to turbine blades. The start: "The Boeing guy needed a plus-or-minus tolerance on the wires. We weren't used to that at all. We just used a tape measure." If the bagels didn't fall out then it was considered a quality product. Boeing was prickly, demanding, unforgiving. An aerospace assembly line was waiting for the baskets. That's why they had to be perfect and why Boeing needed them fast—and why the price didn't matter. The cost of the baskets ($24 per) was trivial compared to the cost of not making airplanes.

The lesson for Greenblatt was that the wire basket was only part of his product. To Boeing, he was selling engineering, precision, and speed, too. Marlin now has $3.5 million worth of computerized industrial robots—a couple that can pull and bend hundreds of feet of wire a minute; an automated router; an automated welder; a steel-punch press; a cutting laser—the input hasn't changed but the company's sales exceeded $5 million in 2012.

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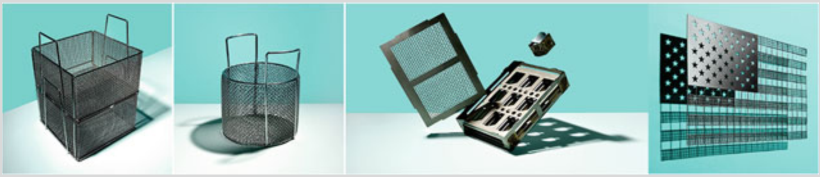

Photos: Copyright © by Fast Company 2013 June

Source: Fast Company [36]

The uncertainty of services requires companies to obtain and understand market research to reduce the risk. The complexity of a service offering may challenge the company's ability to perform test marketing. International services marketing is further complicated by language barriers, governmental interference, cultural differences, scarcity and willingness of internal technical resources, difficulty in customizing the service to meet a new country's requirements and difficulty with overseas support infrastructures.

Managers, who have spent their working lives in one country, context, and likely relatively stable environment, are unlikely to grasp the full range of opportunities. As uncertainty grows, managers tend toward cognitive biases that magnify risk, minimize reward, and thus shorten their time horizons. They do not have a growth mindset and avoid uncertainty and risk. They focus on threats rather than opportunities, uniformity rather than broad thinking, and timidity rather than experimentation. Globalization requires a growth mindset.

Without a profound shift in mindset, executives are increasingly vulnerable to innovation blowback—the prospect of institutional innovations in developing economies provides a platform for disruptive products and services in the developed economy. Institutional innovations are becoming the basis for a new form of strategic advantage—getting better faster by more effectively working together in larger and larger ecosystems of participants [24].

11.5.2 Pricing, Communication, Global Logistics and Distribution

NPD and innovation interfaces with marketing require additional thought. One of the biggest pricing concerns in global markets is price escalation. Exporting requires a larger number of steps, higher risks, and incremental, compounding costs as more intermediaries are paid larger percentages. Product development must account for these additional costs (e.g., eliminate costly features, downsize the product, assemble/manufacture overseas, adapt the product to reduce tariffs, design to be reduce shipping costs, etc.) to target the landed price that is consistent with the positioning of the product.

Global logistics and distribution is closely associated with pricing issues. NPD and innovation initiatives, related to sourcing inbound materials and designing and managing the production and assembly of outbound products, can significantly affect costs. Designing products to minimize costs related to shipping and tariffs (e.g., IKEA).

The message strategy in communicating to global customer has implications for NPD and innovation. One of the more difficult issues is the standardization/adaptation choice. Having a standardized product is an efficient approach but given cultural differences, can the firm sell the same product and position differently across countries without undercutting the benefits of a consistent image. Also, there can be great inspiration from listening to global consumers—product innovations can come from anywhere in the world.

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Service Engineering and Management 12

12.1 Introduction

In many sectors, independent or product-related services are of great importance in the process of gaining competitive advantage. This is especially true for *technology-intensive products*, where the complete offer frequently represents a complex bundle of physical products and complementary services. The reason for this lies in the fact that such product service systems can solve customers' problems in a more comprehensive and customized way than the physical core product alone. Some companies, for instance Caterpillar, generate a significant percentage of their profits through product-related services [1]. With the possibilities of technological differentiation increasingly diminished by the process of standardization in many areas of technology, an increase of so-called "*value-added-services*" for the purpose of setting oneself apart from the competition is to be expected.

This development means that many product manufacturers are transforming more and more into service providers. This change constitutes a major managerial challenge because services require adapted structures, processes, skills and even new business models [2].

This Chapter Will Discuss

- What is the importance of services in maintaining a company's competitiveness?
- What are the specific features of services?
- What are the characteristics of the service engineering process?
- What are the characteristics of service marketing?

K. Gaubinger et al., *Innovation and Product Management*,
Springer Texts in Business and Economics, DOI 10.1007/978-3-642-54376-0_12,

Practical Insight

Siemens Medical: Remote Services for Medical Imaging Systems

Photos: Copyright © by Siemens

Today, Siemens is active in around 190 regions, occupying leading market and technology positions worldwide with its business activities in the Energy, Healthcare, Industry, and Infrastructure & Cities Sectors. The healthcare sector stands for innovative products and complete solutions as well as service and consulting in the healthcare industry. Within this industry one major business field is medical imaging, where X-ray systems, Ultrasound systems, CT and MRI scanners are core product fields. The importance of the medical image in healthcare is constantly growing, making healthcare more effective and patient friendly. With innovative imaging technologies diseases can be detected earlier and more precise, they can be treated more specific and less invasive and the therapeutic result can be closely monitored.

To maximize the availability of the systems, Siemens offers a broad service range. With a Siemens service contract, customers are connected to the Siemens Service Center via Siemens Remote Service (SRS), an efficient and comprehensive infrastructure for the complete spectrum of remote support. Many services, updates and even immediate repairs that previously required on-site visits are performed remotely. Up to 50 % of all deviations can be detected via remote connection before they interfere with the workflow. Due to this service the customers can take the following advantages:

- Earlier failure detection
- Faster repair times
- Planned spare parts replacement
- Prevention of unscheduled downtimes
- Improved patient planning and throughput
- Minimization of on-site visits.

The following standard services are powered by Siemens Remote Service:

Diagnosis and Repair: In case of an unexpected system malfunction, the service engineer dials into the system. With the remote repair function, the engineer can often correct software errors immediately online. If an engineer is required on site, the service center is able to support that person efficiently

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and with remote diagnosis. The Siemens Service Center can identify defective parts and accelerate their delivery, keeping repair times to a minimum.

Event Monitoring: Early detection of potential system malfunctions is a prerequisite for appropriate actions. Event Monitoring periodically screens the performance of the system. If a deviation from a predefined value is detected, a status message is automatically sent to the Siemens Service Center.

Software Updates: Software Updates installs the latest recommended updates on your system on a continuous basis.

LifeNet: Competitive advantage in the modern healthcare environment is determined by access to information. Siemens LifeNet offers their customers up-to-the-minute system- and application-related information, directly at the user console of your imaging system.

Source: Siemens [3]

12.2 The Importance of Services

The service sector has become increasingly important compared to the agriculture and physical goods production sectors. A glance at the statistics shows that services are dominant in many countries and accounted in the Euro area for 72.9 % of the gross national product (GDP) compared to 78.8 % in the USA in 2011. Table 12.1 indicates the contribution of services to the economy in selected regions and countries.

It must be noted that the service sector includes a wide range of offerings. The public sector covers, for example hospitals, schools, police and fire departments and post offices. The private non-profit sector also includes museums, churches and private colleges. A considerable part of the business sector such as banks, insurance companies, repair companies, consulting firms and airlines is in the service business [5]. But also manufacturing firms are offering product-related services such as hotline, repair and maintenance services. To structure this wide range of services the World Trade Organization (WTO) classifies services into 12 major categories and a plurality of sub categories (Table 12.2).

The portion of the service component on the company's offering is another possibility to classify services. According to Kotler [7] five categories can be distinguished, with the boundaries between the categories being fluid in the sense of a continuum (Fig. 12.1).

The increasing importance of services and particularly hybrid goods is due to the fact that pure tangible products are often no longer sufficient to successfully differentiate oneself from competitors. Companies have to offer holistic solutions to customers' problems which consist of bundles of tangible products and services.

Table 12.1 Key economy characteristics of major economic areas in 2011 (Based on European Central Bank [4])

	Unit	Euro area	United States	Japan	China
Population	Millions	332.4	312.0	127.9	1,348.1
GDP (share of world GDP)	%	14.2	19.1	5.6	–
Value added by economic activity:					
Agriculture, fishing, forestry	% of GDP	1.7	1.2*	1.2*	10.1*
Industry (including constructions)	% of GDP	25.4	20.0*	28.1*	46.8*
Services (including non-market services)	% of GDP	72.9	78.8*	70.7*	43.1*

* 2010 figures

Table 12.2 Classification of services (Based on World Trade Organization [6])

Services sectoral classification list	
1. Business services	7. Financial services
2. Communication services	8. Health-related and social services
3. Construction and related engineering services	9. Tourism and travel-related services
4. Distribution services	10. Recreational, cultural and sporting services
5. Educational services	11. Transport services
6. Environmental services	12. Other services

Category	Pure tangible product	Hybrid goods			Pure service
		Tangible good with accompanying services	Balanced hybrid good	Major service with accompanying minor goods	
Characteristics:	No service accompany the product	Offering consists tangible good complemented by one or more services	Offering consists of equal parts of physical products and services	Offering consists of a major service complemented by supporting goods	Offering consists primarily of a service
Examples:	Detergents, lubricants, screws, etc.	Trainings, maintenance, warranties, etc.	Build-Operate-Transfer (BOT), development of prototypes, etc.	Food and drinks offered during a flight.	Massage, consulting, translation service, etc.

Fig. 12.1 Categories of offerings (Adapted from Kotler [7])

The service component of the hybrid product often has a major impact on customer satisfaction and can also make a significant contribution to revenue [8]. These hybrid products are also called product service systems (PSS) and are characterized normally by a high number of components that are developed by different disciplines [9]. More factors for a higher level of increase in demands for services are listed in Table 12.3.

Despite this wide range of services, some generic characteristics can be identified which are suitable for a majority of services. These characteristics will

Table 12.3 Reasons for increased significance of services (Modified from Kotler [10])

Private sector	Companies
• More leisure time entails an increase of demand for services in the areas sports, culture, wellness, etc.	• More complex technologies and markets entail expert support by market research institutes, technology advisers, etc.
• Advanced household technology ("intelligent home") causes demand for installation and maintenance services	• Cost pressure leads to outsourcing of specialized and temporary tasks
• Affluence brings about outsourcing of certain tasks such as laundry, yard work, preparing meals, etc.	• Focusing on core competence leads to outsourcing of support functions such as storage and transportation
• Modern information and communication technologies enable new services like online based purchasing platforms, product configurators, etc.	

be discussed in the following chapter and considered during the development as well as at the marketing of services.

12.3 Characteristics of Services

A number of researchers have identified generic characteristics of services. For service management to be goal-oriented, those characteristics have to be understood and acknowledged. Since a service "is considered to be a human or automated performance potential that is yet to be realized" [11], its *immaterial nature* (intangibility) can be viewed as the first central feature of services. As long as a service has not been rendered, it is always incorporeal and cannot be experienced through sensory perception. It follows from this fact that services cannot be stored or transported. *Lack of a shelf life* means that the customer can only utilize a service during the time it is produced. For instance, the service potential of a service technician or a consulting service expire when they haven't been used, since unutilized hours cannot be stored away for use during times of peak load. The second characteristic feature derived from immaterial nature is the fact that services usually cannot be consumed at a location other than their place of origin, hence they are *not transportable*. However, the general validity of this service-specific characteristic has to be qualified, since various technological innovations have made it possible to separate production and consumption of services in time and space [12]. Examples are commissioning instructions via DVDs, or service hotlines.

The *service competence* of the service provider is another feature of services. Any service requires the provider's particular skills as well as the willingness to provide the service [13]. *Service quality* can vary to a great degree, in particular when the service is provided by a human being. Therefore, service providers have to be especially mindful of quality control.

The third specific feature of services is the fact that service customers invest themselves or an object within their control into the service process. By means of that *integrative quality*, they can influence the process result [14]. Since there is also

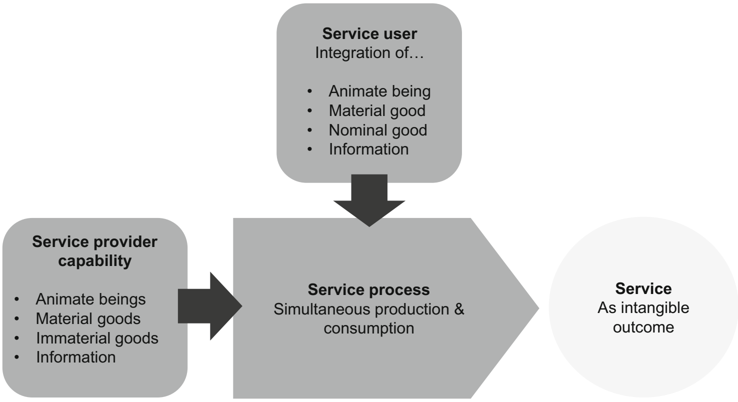

Fig. 12.2 Generic characteristics of service and the service process

an influence that service providers exert on service customers or service objects, we can talk about a two-fold or reciprocal influence of service provider and service customer [13].

The generic characteristics of services discussed in the preceding paragraph are of central importance in the process of service production. Those connections are depicted in Fig. 12.2. An understanding of these connections is in turn the basis for effectively conducting the development and marketing process of services, which will be discussed in the following two chapters.

12.4 Specifics of the Service Development Process

Service development processes (SDP) are often less organized than product development processes. Research has identified that successful companies perform their service development processes in a more formal manner but there is still potential for improvement (Fig. 12.3). Seventy-three percent of the analyzed firms declared that there is a huge demand on the provision of structured service development processes [15].

The development of service innovations follows the same logic as the development of physical goods and therefore the basics of the development frameworks does not have be changed [16]. Based on a systematic analysis of customer needs and other trends in the firm's environment, ideas for services are generated, a service concept is defined and the service is developed, validated and commercialized. Because of the generic characteristics of services however, some stages of the operational service innovation process have to be modified. Figure 12.4 shows the main stages of this process within the holistic innovation management framework. It can be seen that based on the results of the *strategy process* "offerings" have to be generated. If an offering includes only service components it is a pure service, specific *ideas* for the composition of this particular service

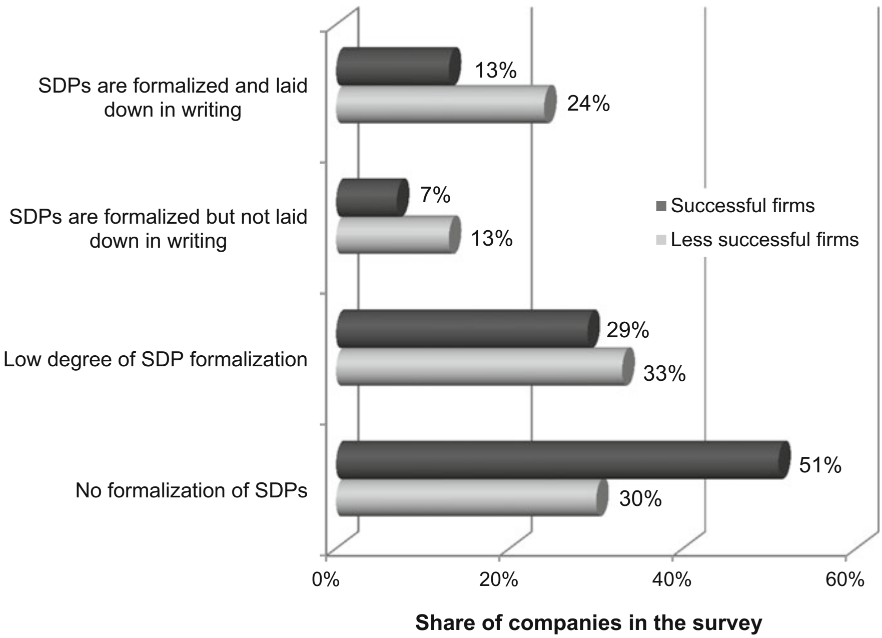

Fig. 12.3 Formalization of service development processes

should be generated. At this point it has to be mentioned again that manufacturers need to become more efficient at matching services to their products to remain competitive [17]. But the development of such hybrid product needs holistic handling and therefore services are best designed in parallel to new product development.

In hybrid products, services are taken into account at the stage of conceptualizing the material product. For instance, medical technology companies conceptualize their MRI scanners with a built in automatic trouble-shooting connection, via a telecommunication network or web-based, connection to a service point in the headquarters. This way, many problems can be analyzed and fixed online, without necessitating a service technician's customer visit on site (Cf. Practical Insight Siemens).

Following the generation of service ideas, *evaluation* of the ideas are made. Based on a more in-depth analysis, the preferred ideas are submitted to further specification. In general, this winnowing and increasing focus culminates in the drawing up of a service brief, which define the *core requirements* of the service. This forms the basis for development of the service concept. The connection between generic characteristics of service and the service process, as depicted in Fig. 12.2, requires four sub concepts within the SDP process [18, 19]:

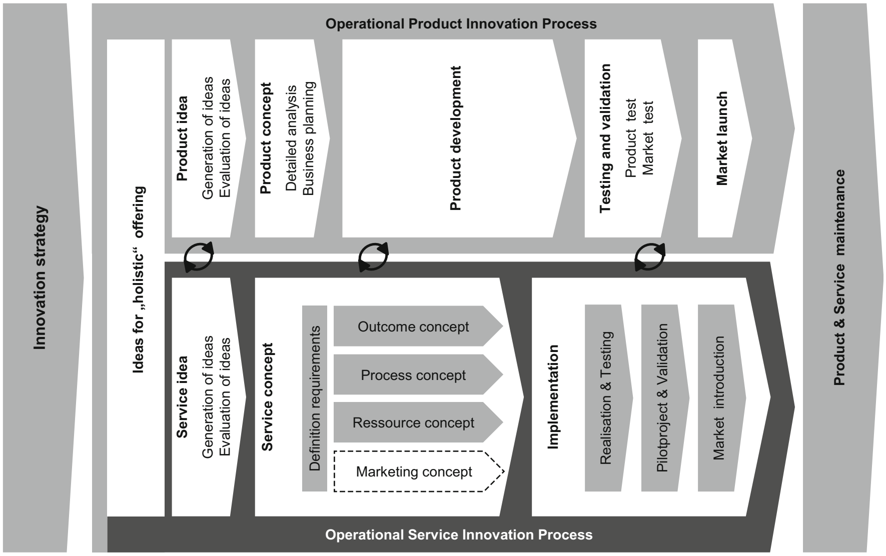

Fig. 12.4 Service innovation process within the innovation management framework

12.4.1 Sub Concepts Within the SDP Process

The Outcome Concept *The outcome concept* describes the detailed outcome of the service process from the customer's point of view. Service content with regards to problem-solving required by the customer is described in detail. In a way that is analogous to what a parts list does for tangible assets, the outcome concept describes the individual services and service components as well as the documents and information that are part of the service process. Thereby the defined outcome contains certain material and immaterial consequences for the external factor. This sub concept thus deals with the "what" and should contain the following information [20]:

- Description of utility for customers
- Description of core services
- Description of possible supplementary services
- Description of service modules
- Description of important variants (module combinations), e.g., for customer groups
- Distinguishing standardized service components from individual (customized) service components
- Delineation of service levels and quality standards
- Listing of all important documentation and important documentation.

The Process Concept *The process concept* describes all partial steps and interfaces that are necessary for providing a service. In addition, it also shows at which points in the process the external factor is integrated. The process concept

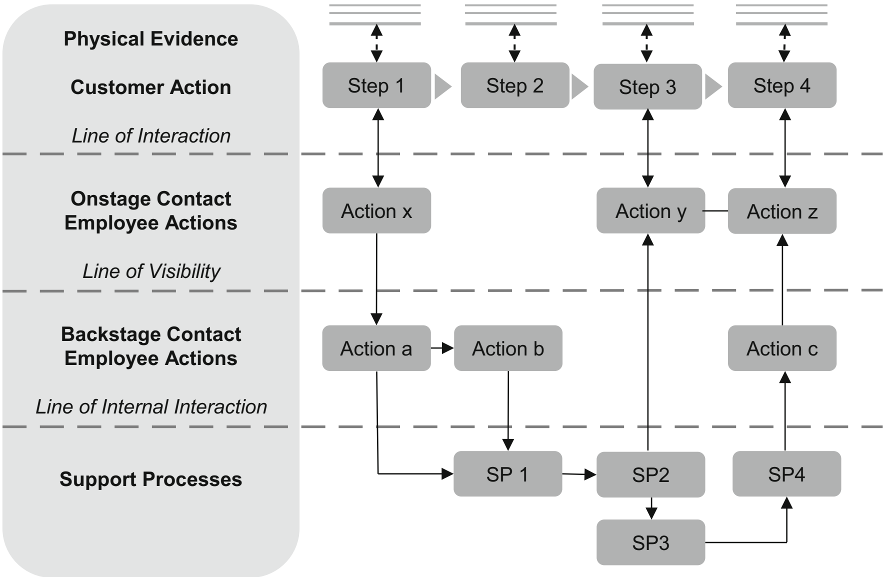

Fig. 12.5 Service blueprint example

component describes the "how" of providing a service and contains all critical interactions between the external factor and the service provider. The service blueprint is an essential tool in making these connections. The service blueprint technique was first described by Shostack [21] and divide processes into different components (Fig. 12.5).

- *Customer actions*: Chronological description of all of the steps that customers take as part of the service delivery process. This element is always at the core of the service blueprint and is depicted at the top of the blueprint.
- *Front office/visible provider actions*: This component shows the face-to-face interactions between the service provider and his customers. It is separated from the component "customer actions" by a "line of interaction".
- *Back office/invisible employee actions*: These actions are invisible for the customers and are separated from the visible provider action through the "line of visibility". They are activities the employees of the service provider undertake in order to prepare for serving customers or that are part of their role responsibilities.
- *Support processes*: These processes are required for the service to be delivered. The "internal line of interaction" separates those processes of the back office from the front office actions.
- *Physical evidence*: For each customer action, and every moment of truth, the physical evidence that customers come in contact with is described at the very top of the service blueprint. These are all the tangibles that customers are exposed to and that can influence their quality perceptions.

The Resource Concept *The resource concept* comprises the description of the personal and material capacities of the service provider. It defines the types of tools, software, infrastructure and know-how that are needed to provide the service. The focus here is on identifying those resources that are necessary to subsequently perform the services Thus, the resource concept is the "by what means" part of service provision.

The Marketing Concept The *marketing concept* has to be developed in parallel fashion to the development of services, just like marketing concepts for material products have to be developed in parallel fashion to the development of these products. This aspect will be discussed separately in the following sub-chapter.

12.4.2 Implementation of Services

Following conceptualization, step-by-step implementation is carried out in three steps.

Realization and Testing In this step, the concepts that have been devised have to be implemented on the levels of technology, organization and personnel in order to create the capacities for providing a service. This includes the following essential activities:

- *Providing documentation on a service*: Writing a service manual informing employees of customer expectations, service-processes and resources to be employed.
- *Determining the organization of providing services*: Responsibilities and interfaces are clearly defined.
- *Integration*: Integration of services into the company's IT structure (accounting, marketing information structures, etc.).
- *Human resources*: Employee training and new hires.
- *Internal tests*: Conducting acceptance tests with employees, operating funds and other resources relevant for providing services.

Pilot Project and Validation In this phase, an external test is conducted with several customers in order to test their acceptance of the services on an objective level and in terms of its price. During this phase, close communication with the customer is of the essence. Customer feedback should directly affect the conception phase, adapting processes, organization and skills as necessary.

Market Introduction Within the framework of large-scale introduction, the service is offered to the target segment. Monitoring the launch entails target-performance comparison of expenses and turnover as well as analysis of actions and reactions of competitors. "Final" adaptations might be necessary.

Table 12.4 Specifics of service marketing (Based on Meffert and Bruhn [22], Kotler et al. [23])

Features of services	Implications for service marketing
Intangibility – Non-storability – Non-transportability	Materializing the service Measures for adapting demand – Differentiation of price-performance ratio – Communication actions Measures for adapting supply – Flexible employees (part-time, cooperation, etc.) – Re-allocation of work load at peak times – Increasing integration of service customers Distribution – Tight service net – Bringing the customer (human or object) to the supplier
Competence of service provider	Materialization of competence – Appearance of personnel – Office equipment and its appearance – Quality of tools and equipment, etc. Documentation of service competence – Rewards, references, etc. Quality control – Hiring and further training of qualified service employees Standardization of processes ("Service Blueprint")
Integration of external factors	Needs-based orientation through the service project Standardization of process

12.5 Marketing for Services

The characteristics of services listed in Sect. 12.3 imply a range of specific components for the marketing of services. They also have to be considered during the conceptualizing and commercialization of services. Table 12.4 gives an overview of these specific components.

It is a consequence of the *immaterial nature* of services that certain services have to be materialized (e.g., high-quality reports on feasibility studies, demonstrating a consulting firm's quality and competence). The *non-storability* of services entails the need for coordinating production capacity and demand [24]. Coordination of demand can consist in differentiated prices, transposing part of the demand from peak times to times of lesser demand (For instance, costs for the start-up of a machine vary depending on lead time before the order). In addition, being flexible in the adaptation of production capacity (e.g., by redistributing the workload at peak-times) can also counterbalance the problem of non-storability of products. The lack of *transportability* necessitates a higher density of distribution for services in high demand (e.g., service points for construction machinery). If this is not a given, either the customer or the object have to be brought to the service provider or vice versa.

In order to visualize the *competence* of a service provider, it is important to materialize his potential with the envisioned positioning in mind. This process can take place via appearance of personnel and office equipment as well as by the way tools and machines that are necessary for providing the service are being used [25]. In addition, lists of references and awards also help in attesting the service provider's competence. Since the service provider has a considerable influence on the result of the process, training and continuing education of employees as well as standardization of the product play an important role in terms of service quality (e.g., through intensive training programs and clearly defined maintenance guidelines in medical technology companies).

Due to the fact that in general, the *service customers* or their object have to be integrated into the service process, the needs of the service customer have to be taken into account throughout the entire service providing process. *Integration* of the customer is also one of the causes contributing to the individualistic nature of services, making it difficult to standardize them. For this reason, an attempt needs to be made to at least standardize the working processes and the potential of the service provider [26].

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Design 13

13.1 Introduction

> "Good strategy is design, and design is about fitting various pieces together so they work as a coherent whole." [1]

Today's managers must successfully navigate "wicked problems". The global environment for new products is highly competitive, dynamic, uncertain, unpredictable, and constantly disrupted. Technical competence must be bulwarked by an ability to find novel perspectives rather than depend on past experience. Companies must adapt, respond creatively on-the-fly, and envision new opportunities as well as the consequences of wide-ranging choices. They need to embrace experimentation, make many small bets with the knowledge that most will fail, but a design approach offers a way forward to innovation even in uncertainty—an action approach with an invaluable opportunity to learn.

This Chapter Will Discuss

- What are the definitions and history of industrial design, design thinking and design orientation?
- What is the culture of design orientation and how is it supported (i.e., structure, processes, and people)?
- What are the design thinking principles and tools used to unleashing creativity and innovation?
- What are the thinking processes designers use in a broad range of problem-solving situations?
- How does design interact with other functions in product development and innovation?

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Practical Insight

Gillette: Designing Razors for India

Procter & Gamble executives say it was striking the first time they witnessed a man shave while sitting barefoot on the floor in a tiny hut in India. He had no electricity, no running water and no mirror. The 20 U.S.-based executives observed the man in 2008 during one of 300 visits they made to homes in rural India. The goal? To gain insights they could use to develop a new razor for India. "That, for me, was a big 'a-ha'," said Alberto Carvalho, vice president, global Gillette, a unit of P&G. "I had never seen people shaving like that."

The visits kicked off the 18 months it took to develop Gillette Guard, a low-cost razor designed for India and other emerging markets. Introduced 3 years ago, Guard quickly gained market share and today represents two out of every three razors sold in India. The story of how Guard came to be illustrates the balance companies must strike when creating products for emerging markets: It's not as simple as slapping a foreign label on an American product.

To successfully sell products overseas, particularly in developing markets, companies must tweak them so they're relevant to the people who live there. And often, that means rethinking everything from the product's design to its cost. More companies will have to consider this balancing act as they increasingly move into emerging markets such as India, China and Brazil to offset slower growth in developed regions such as the U.S.

Gillette has sold razors in India for over a decade. The company had 37.3 % market share in 2007, selling its high end Mach 3 razor, which costs about $2.75, and a stripped down Vector two-bladed razor on the lower end, which goes for about 72 cents. But Gillette wanted more of the market. To do that, P&G executives would have to attract the nearly 500 million Indians who use double-edged razors, an old fashioned T-shaped razor that has no protective piece of plastic that goes between the blade and the skin when shaving. This razor, which makes skin cuts more likely, costs just a few pennies per blade.

Carvalho, who spearheaded Gillette's effort to grow market share in India, didn't want to rush into designing a product, though. Gillette had stumbled once before with its early version of the Vector in 2002. The version of that razor had a plastic push bar that slid down to unclog the razor. The bar was added because Indian men have thicker hair and a higher hair density than their American counterparts. Adding to that, they often shave less frequently than American men, so they wind up shaving longer beards.

Gillette, which is based in Boston, wanted to test the product among Indian consumers before launching it, but instead of making the costly trip abroad, they had Indian students at nearby Massachusetts Institute of Technology test the razor. "They all came back and said, 'Wow that's a big improvement'," Carvalho recalls.

(continued)

But when Gillette launched the razor in India, the reaction was different. Executives were baffled about why the razor flopped until they traveled to India and observed men using a cup of water to shave. All the MIT students had running water. Without that, the razor stayed clogged.

"That's another 'a-ha' moment," Carvalho said. "That taught us the importance that you really need to go where your consumers are, not just to talk to them, but observe and spend time with them to gather the key insight."

P&G acquired Gillette in 2005 and the next several years were spent integrating the companies. But in 2008, the focus on India returned when Carvalho decided to bring 20 people, ranging from engineers to developers, from Gillette's U.S. headquarters to India for 3 weeks.

They spent 3,000 h with more than 1,000 consumers at their homes, in stores and in small group discussions. They observed people's routines throughout the day, sometimes staying late into the evening. They also hosted small group discussions. "We asked them what their aspirations were and why they wanted to shave, and how often," Carvahlo said.

They learned that families often live in huts without electricity and share a bathroom with other huts. So men shave sitting on their floors with a bowl of water, often without a mirror, in the dark morning hours. As a result, shaving could take up to half an hour, compared with 5–7 min it takes to shave in American households. And Indian men strain to not cut themselves.

The takeaway: In the U.S., razor makers spent decades on marketing centered on a close shave, adding blade after blade to achieve a smoother cheek. But men in India are more concerned about not cutting themselves.

"I worked in this category for 23 years and I never realized with those insights that's how they think about the product," said Eric Liu, Gillette's director of research and development, global shave care. With that knowledge, the Gillette team started making a new razor for the Indian market. In 9 months, P&G developed five prototypes.

The company declined to give specifics on each prototype for competitive reasons. But they tested things like handle designs, how well the blade cuts hair and how easy the razor is to rinse. The resulting Guard razor has one blade, to put the emphasis on safety rather than closeness, compared with two to five blades found on U.S. razors.

One insight from filming shavers was that Indians grip the razors in many different ways, so the handle is textured to allow for easy gripping. There's also a hole at the handle's base, to make it easier to hang up, and a small comb by the blade since Indians hair growth tends to be thicker.

Next, the company had to figure out how to produce the razor at the right price. "We had to say 'How do we do this at ruthless cost?'" Carvalho said. P&G scrutinized the smallest details. It cut the number of components in the razor down to 4 compared with 25 needed for Mach3, Gillette's three-blade

(continued)

razor. They even made the razor's handle hollow so it would be lighter and cheaper to make.

"I can remember talking about changes to this product that were worth a thousandth, or two thousandths of a cent," said Jim Keighley, the company's associate director for product engineering. The result? The Guard costs about one third of what it costs to make the Vector. Gillette sells the Guard for 15 rupees, or 34 cents, and each razor blade is 5 rupees, or 12 cents.

The company's strategy seems to have worked. P&G says with 9 % market share, Guard has grown share faster than any other P&G brand in India. And Gillette's market share for razors and blades in India has grown to 49.1 %, according to Euromonitor. That's up from 37.3 in 2007.

Photos: Copyright © by P&G, Associated Press

Source: Daily Mail [2]

13.2 Design as a Comprehensive Approach

13.2.1 History of Industrial Design

While art has been practiced through the history of man, industrial design, as a business function within the firm, began in the late 1920s [3]. The industrial revolution contained the seeds for industrial design but The Great Depression required firms to look for ways to differentiate their products moving away from a production orientation. Traditionally, Industrial designers sought to improve the form (i.e., aesthetics), function (e.g., ergonomics, usability), and interaction of these two aspects. This has expanded to include strategic impact, production/ assembly, marketability, the servicescape, and even broader into problem solving and a way of thinking.

There are many events, approaches and movements that have had an impact on industrial design. Modernism, streamlining, the introduction of electronic products, the role of emotion and experience along with our emergence in the knowledge economy and its impact on services and servicescapes—all offer important insights into the implementation of design in business context. While experiential and symbolic needs are important pursuits, the one that has had particular influence on business design has focused on functionality.

13.2.2 Understanding Design Orientation

Remarkably, it has been estimated that only about 1 % of companies really dig-in on design. Why do so many companies want to be stronger in design yet fall flat? A possible answer is that the path to a design-oriented company is not well understood and is more complex to engender than is commonly presented. This explanation is supported by empirical and case-based evidence—it shows that a design orientation requires a change of culture and the development of previously ill-defined capabilities. The success of design-oriented firms is driven by a relatively unique and deep-rooted, design-based culture rather than more transient and varying strategies.

Design Orientation (def.): an organizational culture consisting of values, norms, and behaviors which emphasize the importance of design issues, including elements in which design is treated as a strategic asset, a focus is placed on aesthetics, user-centeredness is an organizational emphasis, lateral thinking is pervasive, and futurism drives much thinking and behavior [4].

13.2.2.1 Strategic View of Design

The first dimension of a company's design capabilities is taking a *strategic view of design*. An important ability is to recognize the power of design for the pursuit of competitive advantage and elevate that understanding to the highest executive levels. Design becomes a "strategic asset", an integrating and overriding focus, difficult for competitors to replicate, and results in competitive advantage and superior performance.

13.2.2.2 Focus on Aesthetics

The second dimension of design capabilities is an ability to *focus on aesthetics*. Resources are channeled toward enhancing the look, feel, smell, taste, and touch of products. Aesthetics is more than styling—it is the importance of all the little details and each feature that comes together to represent the company's or brand's "look". Aesthetics include the tuning of the Miata muffler to reflect the sound of a classic British racing car, the scent of a Candle Factory votive, and the subtle texture and use of stainless steel in Gillette's razor blade handle.

13.2.2.3 Emphasis on User-Centered Design

The third dimension of design capabilities is an *emphasis on user-centered design* (UCD). This is an organization-wide emphasis on developing products and service environments with superior kinesthetic or experiential characteristics [5]. This aspect emphasizes "ease of use", "intuitive operation" and suggests a strong customer-centric focus during the product development process. User-centered design reflects a holistic approach, where all elements come together in a total package.

13.2.2.4 Lateral Thinking

The fourth dimension of design capabilities is *lateral thinking* is an organization-wide ability to scan for new inputs, materials, influences, and product technologies currently being applied in other fields that offer new product ideas. This concept is related to environmental scanning (e.g., Daft et al. [6]). Lateral thinking can be seen as being sensitive to more social influences, casting a wider net, considering more things in different ways, and absorbing a range of inputs from areas as diverse as fashion, auto racing, cartoons, world music, food, movies, etc. Lateral thinking is about diverse perspectives and ideas from outside the current context. Firms practicing this approach are sensitive to the possibility that new technologies and radical innovations often arrive from outside their industries [7].

13.2.2.5 Futurism

The fifth dimension of design capabilities is *futurism*. This is an organizational commitment to prospecting for next-generation trends and technologies. This concept is a broad version of "future-market focus", the extent to which a firm emphasizes future customer needs and markets and projected competitor actions [8]. A culture that emphasizes futurism strengthens the company's ability to create a record of innovation [9]. Companies that embrace futurism expect to find ideas that haven't been invented yet. They are receptive to acting even while experiencing discomfort, learning through the process of seeking new ideas and challenging the definition of what is possible. These companies are constantly thinking about how things on the horizon could be better.

13.3 How to Engender a Design Orientation

These five cultural dimensions of a design orientation require other elements to support them: processes, structure and people.

13.3.1 Processes

What kind of product management processes support design thinking? The previous thought leaders in design thinking have moved quickly to solving problems related to product form and function in order to lower risks. The rise of uncertainty is a major driver of companies' search for techniques and processes that will allow them to function where traditional business approaches fail. With the loss of stable state, companies must act before they know, in order to learn [10]. Where do companies get guidance to act before they know? One answer is to think like a designer. As Stanford, IDEO, and frogdesign show a design thinking approach offers tools to act within uncertainty and learn by doing. Liedtke [11] suggests that managers would benefit from thinking like designers. As we have seen from the emerging literature, there are many processes that companies can implement to think and act like designers:

1. There is a great benefit to empathize with customers and deeply understand their needs, especially those not articulated. Ethnography and observation techniques are recommended. The focus should be on identifying important customer problems that are solvable.
2. Designing for business is the intersection of technology (feasibility), business (viability) and human values (usability, desirability).
3. There is benefit to generating as many solutions as possible, even a few crazy ones—(using divergent thinking Steve Jobs asked for solutions that "look good enough to lick" and error messages that appear as haikus [12]. Scenario planning is a tool for imagining possible futures and identifying important solutions to consider [13].
4. Learn the benefits of sketching, prototyping, and making it real. An idea made physical, even in low resolution, allows for visualization, playing, testing, refining, pivoting and importantly facilitates communication, feedback and collaboration.
5. Simple stories are a powerful approach to persuasion, inspiration and influence. Storytelling is an effective way to activate emotions, build trust, and establish confidence [14].
6. Learning to experiment is critical. Life is a journey of learning that requires comfort with ambiguity, new experiences, and a broad group of skills. New opportunities are detected and risks are reduced by taking action and making "Little Bets" [15]. A quick, imperfect prototype is seen as a hypothesis to be tested and subsequent, quick iterations allow companies to succeed more often. "I am always doing that which I cannot do, in order that I may learn how to do it." This is the philosophy of Picasso and Antoni Gaudi (architect/designer of several World Heritage sites).
7. To innovate one must learn how to talk differently, see differently [16], think differently, work backwards, make analogous connections, reformulate, have comfort with ambiguity, challenge assumptions, and engender "Lateral Thinking" [17].
8. Build your team so as to produce inclusive strategic conversations. Start conversations with possibilities—use strategic stretch to increase possibilities.
9. Uncertainty requires strategy to be made as experienced, using design tools and thinking, de-risks by creating value for customers and the company [18].
10. Why do I have to have ten reasons? Ask questions that may undercut that which all others accept as true.

13.3.2 Structure

What kind of organizational structure supports design thinking? Autonomous design units operate with wide latitude and creativity, and have minimal reporting ties to other functional areas. Autonomy is related to an ability to scan the environment, to evaluate markets and competitors, and to quickly accomplish reconfiguration and transformation ahead of competition [19]. Greater autonomy allows the design area to explore, learn and develop into a more effective resource and more adaptive to changing environmental conditions. A combination of autonomy and high external knowledge produces superior-performing team units [20]. Thus, design unit autonomy should positively influence design capabilities. Autonomy is seen as a sign of status in many organizations [21]. This independence is perceived as increasing the strategic significance of the unit and as an important organizational resource. As this resource grows in importance, it should exert more influence on the development of a design-driven organizational capability.

Another aspect is the design unit's power. Design power is defined as the design unit's ability to steer organizational strategy, direct other functional units, and accumulate the resources it desires, thus aligning primarily with positional power. Theory suggests that design power will be negatively associated with the establishment of design capabilities. Dominant individuals or groups within organizations, especially without a traditional power base, can inspire retribution and undermining behavior due to jealousy, competitiveness or other self-serving motivations. For example, Iannello [22] suggests that the possession of unique knowledge by a powerful individual or group and its deprivation from others results in a form of authoritative domination. A design department wielding a more subtle influence, exercises thought leadership, and is admired by other functional areas. The more dominant the formal design unit, the less likely that deep-rooted design capabilities will be developed within the organization. This suggests a delicate balance is required between the design function and an organizational appreciation and emphasis on design.

13.3.3 People

What kind of people support design thinking? Learning is complex especially in dynamic environments. Ambiguous feedback, missing information, and random noise usually make people uncomfortable. First, managers must be comfortable with risk and uncertainty. Second, a dependency on traditional rationality, analytical tools, and legacy approaches undercuts a person's ability to function well in unpredictable environments. Design thinking allows one to learn in complex environments and offer solutions to "wicked problems". Third, it is important to have someone who can envision, create and implement game changing initiatives—someone who can communicate, motivate and influence others.

13.4 Transition from "Designer" to "Way of Thinking"

> "In the varied topography of professional practice, there is a high, hard ground overlooking a swamp. On the high ground, manageable problems lend themselves to solution through

Table 13.1 Comparison of different design approaches

	Traditional business approach	Design approach
Underlying assumptions	Rationality, objectivity, reality as fixed and quantifiable	Subjective experience, reality as socially constructed
Method	Analysis aimed at proving one "best" answer	Experimentation aimed at iterating towards a "better" answer
Decision Drivers	Logic, numeric models	Emotion, experiential models
Values	Pursuit of control and stability, discomfort with uncertainty	Pursuit of novelty, dislike of status quo
Level of focus	Abstract or particular	Movement between abstract and particular

> the application of research-based theory and technique. In the swampy lowland, messy, confusing problems defy technical solution. The irony of this situation is that the problems of the high ground tend to be relatively unimportant to individuals or society at large... while in the swamp lie the problems of greatest concern."
> Donald A. Schön [23]

The approach that designers have used to solve problems has been seen to have broader application. The notion of design as a "way of thinking" can be traced in the sciences to Herbert A. Simon's 1969 book *The Sciences of the Artificial* [24]. Richard Buchanan's article in 1992 *Wicked Problems in Design Thinking* [25] expressed a broader view of design thinking that has been highly influential in addressing intractable problems through design. Design thinking is a practical, iterative, creative approach for solution-focused thinking. Design thinking has been successfully applied by companies to drive innovation [9].

13.5 Traditional Business Approach vs. Design Approach

A design approach can be viewed as a complement to traditional business analysis and planning, but with a different perspective [26] as shown in Table 13.1.

The traditional business approach is suited for well-defined and well-understood problems. When confronted with ill-defined, wicked problems then a design approach is more appropriate. Design thinking is generally considered the ability to combine *empathy* for the customer and context to derive inspiration, *creativity* in the generation of insights and solutions, and *implementation* to offer solutions that are *desirable* to the customer, *feasible* to bring to market and financially *viable*.

13.6 Current Views of Design Thinking

13.6.1 Stanford's Hasso Plattner Institute of Design

At Stanford's d-school—the design thinking process is taught as a methodology for creative and human-centered problem solving that empowers collaboration across disciplines and tackle the world's biggest challenges. They offer a great exercise (wallet) that introduces the design thinking approach in about an hour [27]. They work closely with IDEO. The five interactive steps they define are:

- *Empathize*: understanding the needs of those you are designing for
- *Define*: framing problems as opportunities for creative solutions
- *Ideate*: generating a range of possible solutions
- *Prototype*: communicating the core elements of solutions to others
- *Test*: learning what works and doesn't work to improve solutions.

13.6.2 IDEO

Tim Brown, CEO at IDEO, offers a five-point model for strategizing by design [28]:

1. *Hit the Streets*: Any real-world strategy starts with having fresh, original insights about your market and your customers—insights from observation of and experience in the market to create a much more robust customer experience.
2. *Develop as a T-Shaped Person*: Both deep and wide, quantitative and qualitative, collective idea-making, and explore insights from many different perspectives and recognize patterns that point to a universal human need—patterns that yield ideas.
3. *Build to Think*: Design thinking is inherently a prototyping process with the goal of helping us work through the problem and eliciting feedback—we build to think and actually begin to build the strategy itself and make it more powerful.
4. *The Prototype Tells a Story*: Prototyping simultaneously generates feedback and enables corrections—It allows testing, refining and pivoting, if necessary, for your strategy as it continually evolves. With uncertainty, it gives you an opportunity to uncover problems and fix them in real time.
5. *Design Is Never Done*: The market is always changing; your strategy needs to change with it. Since design thinking is inherently rooted in the world, it is ideally suited to helping your strategy evolve.

IDEO offers a "Hear Create Deliver" format summarized in the Fig. 13.1 below. It can be used to impart an empathetic approach to product development. The abstraction process, prototyping and implementation steps help deliver a product that has resonance with the customer.

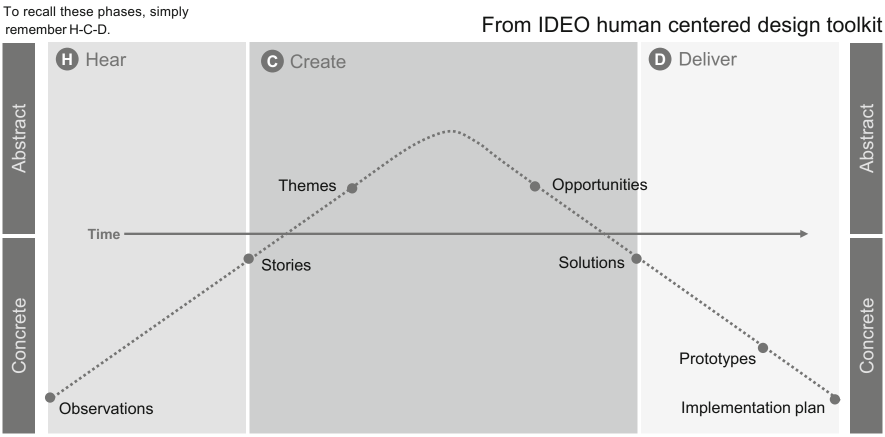


Fig. 13.1 IDEO's "Hear Create Deliver" format (*Source*: IDEO [29])

13.6.3 Frogdesign

The frogdesign toolkit identifies six interactive and iterative activities (Fig. 13.2) that are moved through to achieve a goal [30]:

- *Clarify your goal*: Goals are in the middle and are inspired by the other five peripheral activities. The major parts of "clarifying your goal" is defining what problem to solve and goals to accomplish. Each time you take action through one of these activities, you learn. Goals change over time based on learning. It is important to continually monitor whether goals have changed.
- *Build your group*: This activity includes identifying and respecting unique strengths, providing constructive feedback and group improvement, connecting with the community for help, building on each other's ideas and capturing conversations to fuel inspiration.
- *Seek new understanding:* Explore people's perspective on issues that matter to them and uncover their unmet needs. Look for difficulties or obstacles to solve. Watch what people do in real life—it adds a great deal to what they say. Capture words, sketches, photos and video to inspire. Finally, look for patterns that can illuminate important issues and possible solutions.
- *Imagine more ideas: E*xhaustively envision as many ideas as possible. More ideas and unusual ideas, equals more opportunities for a great solution to emerge. Practice listening and sharing. Build off of each other's ideas—don't criticize. Combine pieces from many ideas to get the best idea possible—everyone owns great ideas.
- *Make something real*: Prototype, tell a story, dramatize, storyboard, sing or make a collage. Start with low fidelity and continuously refine to a finished product with constructive feedback.

Fig. 13.2 Frogdesign interactive activities for design (*Source*: Frogdesign [31])

- *Plan for action*: Post everyone's action items, motivate and encourage accountability. Celebrate small wins and connect with others who can help. Be willing to adapt.

13.7 Design Thinking Outcomes

While design capabilities are concerned with developing new insights that ultimately result in innovative products, it is not generally based on the kind of breakthroughs in basic science and engineering that drive radical innovations. A design-focused company is most often focused on innovation through improved aesthetic approaches, enhanced user experiences, advanced flexible product platforms, incorporated technology from other sources and added desirable features [32]. Design capabilities are positively associated with innovation speed, acceptability in the market place and financial performance.

Many of the benefits of design capabilities may be tempered in times of market turbulence—large swings in customers' preferences. Design capabilities are based largely on customer empathy as compared to expanding and developing new markets through technology-based, breakthrough products. Design capabilities emphasize competitive advantage through aesthetics and user-centered thinking. Design capabilities may offer a broader, more forward-thinking attitude towards new product and service development than is typically suggested in the market orientation literature.

While important sources of growth and competitive advantage, these design driven innovations may be more "incremental". There is a concern that the exploitation of current capabilities may hinder the development of more dramatic or radical innovation due to sunk costs, risks, uncertainty, or the belief that past successes will always continue [33]. There generally are some important organizational benefits related to a design orientation: employees are more enthusiastic and committed. Finally, design capabilities are a significant driver of firm- and product-level performance. These performance outcomes are expected to weaken in more turbulent environments yet be stronger in more competitively intense situations.

13.8 Tools & Integration with NPD

Business training generally focuses on the transfer and application of established theory and technical skills: “learning in order to do.” This is a reasonable way to convey knowledge, but not to create it. Gaudi approached his work by “doing in order to learn,” relentlessly experimenting and prototyping to see what might be. By emphasizing insight, playful experimentation and real-time learning, they unleashed creativity, achieved a broader vision of the possible, and ultimately, world-changing work. These design tools below tend to be used in the Fuzzy Front End of Innovation where companies are developing the concept of the product and before they decide whether or not to invest resources in the advancement of an idea.

Thought leaders in business are embracing “doing in order to learn,” and are turning to the methods of industrial design and of the arts for tools to stimulate innovative thinking and solutions. Jeanne Liedtka posted [34] ten tools to help managers think creatively. She states, “At its heart, design thinking is simply using a different set of tools. Ask a designer, and of course he or she will tell you that they have hundreds, if not thousands, of different tools. But, as we observed designers at work in our research, we were able to identify a small subset of these as not only foundational but—the best part—also teachable to managers. Using these ten tools, managers with support and training can identify and execute opportunities for new growth and innovation that their old tool kits missed. So here is my top ten list:

- *Visualization* is about using images. It’s not about drawing; it’s about visual thinking. It pushes us beyond using words or language alone. It unlocks a different part of our brains allowing us to think nonverbally. Storytelling is one form of visualization, and is a good place to start for those of us who think in terms of Power Point.
- *Journey mapping* (or experience mapping) is an ethnographic research method that focuses on tracing the customer’s “journey” as he or she interacts in the process of receiving a service from an organization, with special attention to emotional highs and lows. Experience mapping helps identify needs that customers are often unable to articulate. Because managers are familiar with flow charts, it doesn’t feel as different as other design thinking tools may.
- *Value chain analysis* examines how an organization interacts with value-chain partners to produce, market, and distribute new offerings. Analysis of value-chain offers ways to create better value for customers along the chain and uncovers important clues about partners’ capabilities and intentions.
- *Mind mapping* is used to represent how individual bits of information are linked to a central idea or insight and to each other. Mind maps generate, visualize,

structure, and classify ideas to look for patterns and insights that provide key design criteria.

- *Brainstorming* is a tool that has received a bad name among managers, but doesn't deserve one. The kind of structured brainstorming approaches that designers use are far more productive than the free-form shout-out that we've all endured in the past.
- *Rapid concept development* takes the many ideas you create during brainstorming and puts them together in creative and interesting ways.
- *Assumption testing* focuses on identifying assumptions underlying the attractiveness of the new ideas you've created during concept development. It then uses available data to assess the likelihood that these assumptions will turn out to be true. These assumptions are then tested through thought experiments, followed by field experiments, which subject new concepts to four tests: value creation, execution, scalability, and defensibility.
- *Prototyping* allow us to make abstract new ideas more tangible to potential partners and customers. These include storyboarding, user scenarios, experience journeys, and business concept illustrations—all of which encourage deep involvement by important stakeholders and allow them to provide us with better feedback.
- *Customer co-creation* allows managers to engage a customer in the process of generating and developing new business ideas of mutual interest. If most new ideas fail because customers turn out not to want them, co-creation can be the most value-enhancing, risk-reducing approach to growth and innovation.
- *Learning launches* test the key underlying value-generating assumptions of a potential new idea in the real world. But, in contrast to a pilot or a full new-product rollout, a learning launch is a learning experiment conducted quickly and inexpensively to gather market-driven data."

See Ogilvy and Liedtke [35] for more details on these tools.

13.9 Design as an Operational Process

13.9.1 Robust Product Design

Rothwell and Gardiner [36] first suggested the use of the term robust design to denote a product design that has sufficient inherent versatility to enable it to evolve into a "design family" of significant variants. Robust strategic response capabilities (i.e., the potential for success under varying circumstances or scenarios), such as robust design capabilities, are an organizational response to rapid technological change and the inability to forecast [37]. An enduring advantage is created through an ability to anticipate evolving customer needs and dynamic competitive situations across a broad range of contexts.

With the increasing desire for products suitable for widely varying markets worldwide, this study offers insight into capabilities associated with successful robust design in global product markets. These robust design capabilities (i.e., the possibility for success under varying circumstances or scenarios) are a potential organizational response to rapid change and uncertainty, which also improve the likelihood of product acceptance on a global basis. From literature, executive interviews, and anecdotal evidence, four capabilities associated with robust product design are derived: (1) functional; (2) aesthetic; (3) technological; and (4) quality based. A model is proposed and an empirical test conducted that considers the moderating influence of environmental uncertainty on the relationship between these robust capabilities and firm performance. The findings suggest that the use of robust design capabilities are affected by uncertainty and have an important influence on firm performance and speed to market. Specifically, the product development process tends to be characterized by aesthetic and technological robust design capabilities in more certain environments and functional robust design capabilities in more uncertain environments when seeking to improve firm performance. Alternatively, technological design capabilities in more certain environments and functional design capabilities in more uncertain environments are associated with improved speed to market.

Practical Insight

Bell: Robust Design in the Bell-47 Helicopter

Alongside paintings and sculptures by Picasso, Monet, and Rodin in New York's Museum of Modern Art (MOMA), a plaque near the Bell-47 Helicopter reads:

"Between 1946 and 1973 more than 3000 Bell-47 helicopters were made and sold in 40 countries. It looks as straightforward today as it did 40 years ago. Like the Jeep, it was designed without the imposition of self-conscious styling. Yet Arthur Young, its designer, knew particularly well that on juxtaposing a transparent plastic bubble with the open structure of the tail boom, he had created an object whose delicate beauty is inseparable from its efficiency. The utilitarian character of the design makes one overlook the aesthetic reason for its most decisive detail: The plastic bubble is made in one piece rather than in sections held together with metal seams as in other helicopters. Even though this means a more expensive replacement if the bubble is damaged, the appearance is so pleasing that most connoisseurs of heli-design have preferred it. On seeing the Bell-47D1 people think of a hovering insect. The visual metaphor is so strong that the machine is often referred to as the "bug-eyed" helicopter. There is a certain poetic logic to the resemblance, since one of the principal uses of the Bell-47D1 is pest control by crop dusting and spraying. It can hover like a dragonfly at an altitude of 10,000 feet."

"The Bell-47 functioned well for almost 30 years across different uses, countries, and contexts. Aesthetically, its expensive bubble enhanced the product's desirability through superior vision (functionality); better

(continued)

adaptability of form to function; and the aesthetic appeal of form, color, and texture. The Bell-47 helicopter frame also was able to incorporate new technology (e.g., instruments, engines). Advances in technology also could be incorporated or rejected, depending on the motivation (i.e., government requirements or costly increases in functionality). These quality-based considerations allowed for manufacturing and assembly at an attractive cost while reliably performing in the field and improving functional considerations. Strategically, costs were not necessarily minimized, but investment in each of these capabilities produced a product that was recognized as globally superior. Finally, these robust design capabilities offered unique attributes to the product while interacting with the other attributes".

Photo: Copyright © JPIM
Source: Swan et al. [39]

13.9.2 Dieter Rams Ten Principles of "Good Design"

Bauhaus and functionalism has been a powerful inspiration to designers. Dieter Rams, as the successor to this design movement, is considered to be one of the most influential designers of the last century. Within 40 years of working at Braun, Dieter Rams produced and oversaw over 500 innovative products as chief of design. Many of his designs are featured in museums throughout the world. Jonathan Ives, lead designer for Apple, among many others are inspired by Ram's principles [39]:

- *Good Design Is Innovative*: The possibilities for innovation are not, by any means, exhausted. Technological development is always offering new opportunities for innovative design. But innovative design always develops in tandem with innovative technology, and can never be an end in itself.
- *Good Design Makes a Product Useful*: A product is bought to be used. It has to satisfy certain criteria, not only functional but also psychological and aesthetic.

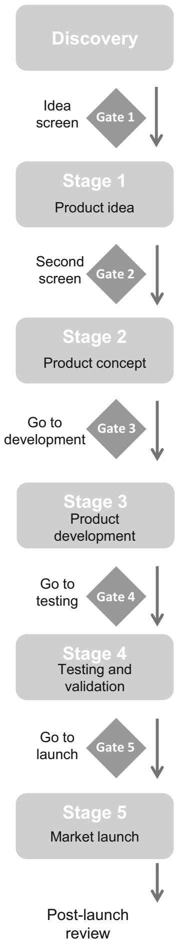
Good design emphasizes the usefulness of a product while disregarding anything that could possibly detract from it.

- *Good Design Is Aesthetic*: The aesthetic quality of a product is integral to its usefulness because products are used every day and have an effect on people and their well-being. Only well-executed objects can be beautiful.
- *Good Design Makes A Product Understandable*: It clarifies the product's structure. Better still, it can make the product clearly express its function by making use of the user's intuition. At best, it is self-explanatory.
- *Good Design Is Unobtrusive*: Products fulfilling a purpose are like tools. They are neither decorative objects nor works of art. Their design should therefore be both neutral and restrained, to leave room for the user's self-expression.
- *Good Design Is Honest*: It does not make a product more innovative, powerful or valuable than it really is. It does not attempt to manipulate the consumer with promises that cannot be kept.
- *Good Design Is Long-lasting*: It avoids being fashionable and therefore never appears antiquated. Unlike fashionable design, it lasts many years—even in today's throwaway society.
- *Good Design Is Thorough Down to the Last Detail*: Nothing must be arbitrary or left to chance. Care and accuracy in the design process show respect towards the consumer.
- *Good Design Is Environmentally Friendly*: Design makes an important contribution to the preservation of the environment. It conserves resources and minimizes physical and visual pollution throughout the life cycle of the product.
- *Good Design Is as Little Design as Possible*: Less, but better—because it concentrates on the essential aspects, and the products are not burdened with non-essentials. Back to purity, back to simplicity.

These aspects of design have had a larger impact on the broader view of design. These principles work for products but they are also strategic in nature. They go to the mission, the philosophy and the strategies of the company. They help usher in the movement from the industrial designer using a design way of thinking to a broader set of practitioners throughout the company.

13.9.3 Process-Oriented Industrial Design

Goffin and Micheli [40] introduce the idea of industrial design as a structured (Stage Gate) NPD process. It describes key design issues, potential conflicts and key quotes related to six parts of the process from "Discovery" to "Post-launch Review." This figure explores issues around the integration of industrial design into a structured NPD process (Fig. 13.3).



Key design issues	Potential conflicts	Key quotes
- Explore concepts, opportunities - Participate in ideation and imagination - Identify users' high-level wants and needs - Offer inspiration from other products	- CEO and management might not know what „design“ is - The design is dictated without allowing exploration - Narrow brief - No clear direction	„Thinking a discovery is amazing but being told that in fact is not“ (Focus group; Designer 7)
- Narrow down ideas whilst keeping creative flair alive - Rating and selecting concepts - Draw up specification and definition of needs - Talk with other functions, establish barriers	- CEO and management can be too evaluative and restrictive, not understanding design goals - Fighting over responsibilities and roles - Hard to understand users' real needs	„Marketing also landed to overrule „design“ input – frustrating!“ (Focus group; Designer 3)
- Discuss plausibility of design - Justify product idea and costing - Provide design specification - Discuss ideas and research made	- Miscommunication of intention and idea of design - Disagreement with decision makers - Project killed off despite it being cost justified - Conflicts with ideas or no conflict because there isn't an interaction	„Not been involved here – probably should have been to present design ideas being shot down because they are too expensive“ (Focus group; Designer 3)
- Develop concepts and work on aesthetics - Create prototype of final concept – Model, CAD - Work with shop floor to resolve issues - Take into account all discussions made from previous meetings	- Moving off topic to what your manager/client wants - Market changes - Ingnorance of how difficult it is to make changes - Adding own personal style to improve design	„Try to keep „on track“ when manufacturing wants to make key changes due to „tooling“ etc.“ (Focus group; Designer 3)
- Create test plans - Resolve issues - Revise and refine design - Help with prototyping - Present to an audience to see if it meets the needs	- No involvement of designers to see process and methods - Wrong specs - Manufacturing changes - Product doesn't work - Design not meeting brief - Clients want more	„Not really been involved but should be, so as to be able to enter into compromises with engineers regarding changes and product failures, and provide learning for the future.“ (Focus group; Designer 3)
- Get brand right - Help with presentation and exhibition - Provide final check of layout, materials and lighting - Communicate design effectively through illustration	- Time - Completion to a good standard - Change in market - Introduction of new regulation - Misunderstanding so underselling the product	„Link with marketing to explore and push all the key features and benefits of the product designed as well as the more „business“ benefits that „marketing“ and „senior management“ would focus on.“ (Focus group; Designer 4

Fig. 13.3 Issues around integrating industrial design into a structured NPD process

13.9.4 Integration of Design into a Holistic Framework

The integration of ideas into a holistic design framework is used to visualize the concepts and their relationships. In this context different design process models exist in literature. Thereby Bruce and Cooper [41] identified four basic stages in these processes: formulation, evolution, transfer and reaction. A detailed four-stage process was offered by Heufler [42] that identifies design specific activities between the idea stage and volume production.

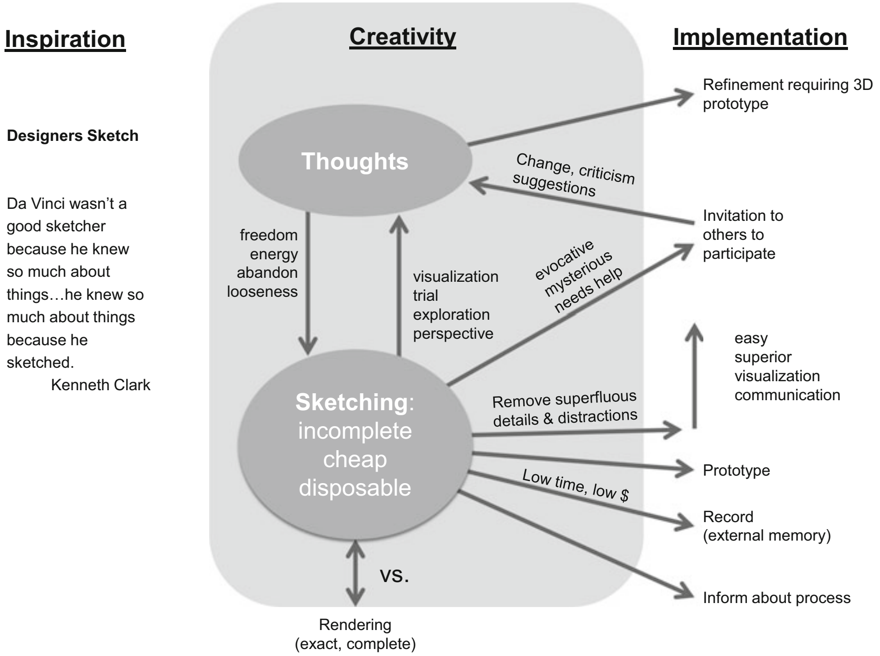


Fig. 13.4 The use of sketches in creative processes

13.9.4.1 Researching & Analyzing

First, it is necessary to understand the company's own abilities, resources, and situation (e.g., possible actions, goals, strategies). It is required to analyze the competitive situation. The company must understand the needs and desires of its customers—their functional, symbolic, and experiential needs. It must define how all these factors, even the barriers and limitations, can be framed as opportunities for creative solutions.

13.9.4.2 Conceiving

Second, ideation is the capacity to conceive a range of possible ideas, i.e., solutions. This includes the generation, evaluation and communication of these ideas. All stages of the thought cycle are included: innovation, development and actualization [43].

13.9.4.3 Drafting/Sketching

Third, drafting and sketching makes the ideas visually apparent. Sketches act as a way of thinking and playing with ideas (Fig. 13.4). Sketches act as easily and cheaply constructed prototypes that communicate core elements of solutions to others [44].

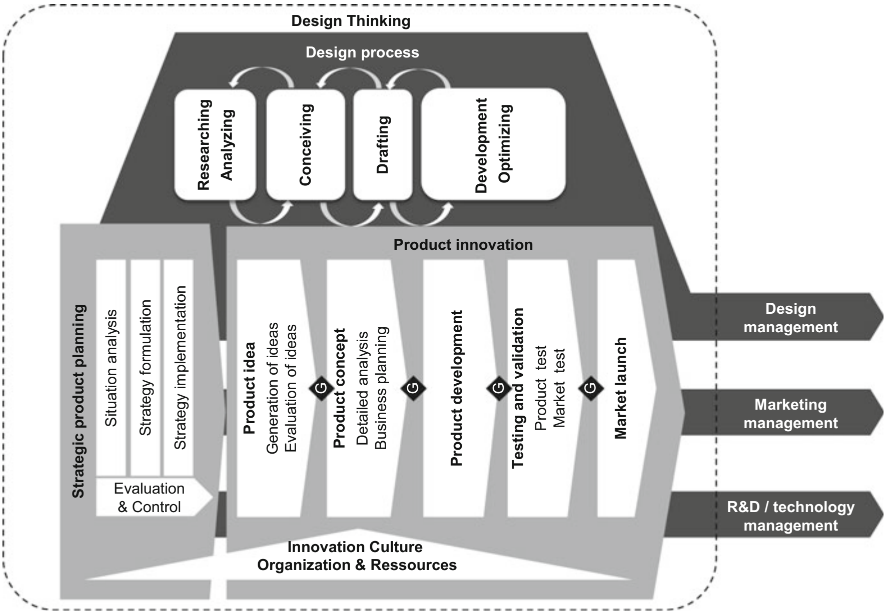


Fig. 13.5 Integration of design thinking within the innovation process

13.9.4.4 Developing and Optimizing

Fourth, solutions need to be developed further and optimized. Testing and validation are required both for the product and market. Companies learn what works and where improvements to the solutions must take place.

To sum up, Fig. 13.5 shows the integration of this design process into the holistic innovation and product management framework.

13.9.5 Setting up a Design Innovation Center

One of the most practical steps you can take to use design in order to innovate is create a center. Ben Bretton [45] says there are key features of a *Design Innovation Center* [45]:

- *They can bring customer insights to life*: Make sure there is plenty of room to put research, images, data on display, simultaneously, on the walls.
- *They can replicate the customer usage experiences*: Help the consumer be immersed so that real behaviors can be observed.
- *They can replicate the selling experience*: For example, create a store layout in which to test prototype ideas related to a grocery store.
- *They have the ability to bring customers into the space*: A center that cannot bring in consumers will be unlikely to bring in insights.

- *They have space for ideation*: Innovation is a loud, messy, and exciting process. You need to have room to move around, build, and think big thoughts. The need is for white boards for walls, a big screen TV for showing AV materials and overall flexibility. Having display cases with items to spark creativity is helpful.
- *They have space and materials for prototyping*: You need Post-it notes, cardboard, tape, markers, several sizes and colors of paper, glue, and tools to use for cutting, art supplies and some work benches that you can get dirty. A sink for clean-up is nice.
- *They have a refreshment center*: All that sweat equity being invested in innovation requires some sugar-laden and caffeinated motivation. A working kitchen could be used to serve dinner, replicate user experiences or create prototypes.
- *They have a creativity/innovation library and private area for research and reflection*: Books, magazines, study materials along with a few comfortable chairs in a niche out of the way (but not necessarily out of earshot from all the excitement going on in the center). Anything you can do to bring the outside world in (bring nature in) will be fantastic.
- *Most also have a product display, an awards area, a patent display and a history display*: There is great benefit in physically seeing what has been accomplished. It renews, motivates, excites, reminds and helps tie-in new ideas. The process works even though we may not always know where it is going to lead. Great outcomes are an article of reasonable faith when follow the process.

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