Doctoral Thesis

Design and implementation of a concept of structured innovation strategy formulation

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DESIGN AND IMPLEMENTATION OF A CONCEPT OF STRUCTURED INNOVATION STRATEGY FORMULATION

A dissertation submitted to the

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presented by

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Preface

This dissertation is the result of my research activity at the ETH Center for Enterprise Science at the Swiss Federal Institute of Technology Zurich. It was a great pleasure to add a dissertation to what is known as management science. Although my name is listed as the author, numerous people in academia and practice contributed to this achievement. Day to day work with these people turned out to be an enormous pleasure. They are all gratefully acknowledged.

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Tim Sauber

Zurich, February 2004
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Management Summary

Innovation is considered beyond controversy as a key for competitive advantage and the long term success of a company. This means that a company has to have the ability to master future fundamental changes. However, at the same time companies often have a deficient ability to excel in innovation and master future changes effectively and efficiently. Through this alarming deficient ability, companies are gaining a broader interest in the domain of innovation management. In particular effective and efficient strategic decision making is of major interest, with the aim to increase the accuracy of innovation objectives and the paths to reach them. In short a concept for formulating an innovation strategy is required.

Although that management literature points out the importance of an innovation strategy there is no practice-oriented detailed and structured concept of formulating an innovation strategy, which represents a gap in literature.

For this purpose the aim of this thesis is to make a major contribution towards closing this gap. Therefore, the pertinent research question is: How could a structured innovation strategy formulation concept be designed and implemented for innovation driven enterprises?

Serving as guiding ideas for the development of an innovation strategy formulation process, working hypotheses are formulated on the basis of a literature survey. Then, this thesis adopts a two-stage research procedure. Firstly from interviews and based on existing theory, a process for formulating an innovation strategy is developed. Thereby this process is based on a novel tool, the so called innovation architecture. This innovation architecture can be seen as a blueprint of the innovation system that allows first of all understanding the innovation system of a company in terms of complexity, systemic interaction and evolution, which should be the basis for managing a company and taking decisions. Furthermore the innovation architecture is a tool for encouraging the creativity on strategic level in a company for deriving on the one hand technology and business innovations and on the other hand, organizational innovations. Integrating the innovation architecture into the designed innovation strategy formulation process is the basis for supporting practitioner oriented management in the innovation system. In a second phase the designed innovation strategy formulation process and the novel innovation architecture are implemented and validated in nine very different innovation driven enterprises.

Based on the generated and implemented elements of the innovation strategy formulation process, the working hypothesis are discussed, and an extensive set of management principles is presented in order to achieve a contribution to closing the gaps in management theory and innovation driven enterprises.
Zusammenfassung


Aus diesem Grund ist es das Ziel dieser Forschungsarbeit die genannte Lücke mit einem Beitrag zu füllen. Deshalb lautet die entsprechende zentrale Forschungsfrage: Wie kann ein Innovations-Strategie Formulierungs-Prozess für innovationsgetriebene Unternehmen gestaltet und implementiert werden?


Basieren auf den entwickelten und implementierten Elementen des Innovations-Strategie Formulierungs-Prozesses werden einerseits die Arbeitshypothesen diskutiert und andererseits wird eine ausführliche Reihe von 'Management Principles' aufgeführt. Damit wird ein Beitrag zur Schliessung der Forschungslücke aus theoretischer als auch aus praktischer Sicht geleistet.
1 Introduction

1.1 Research Focus and Relevance

Innovation, understood as the first successful commercialization of something new\(^1\), is considered beyond controversy as a key for competitive advantage and the long term success of a company (1998b: 246). This importance of innovation was recently analyzed in a quantitative survey in practice by Haapaniemi (2002: 1): “CEOs feel that innovation is critical to achieving competitive advantage. (...) More than 50 percent of respondents said innovation is one of the five most important factors in building competitive advantage, and more than 10 percent said it is the single most important factor. Executives in communication and high-tech industries, and those at companies with international operations, considered innovation especially important” (see Figure 1).

![Figure 1: Importance of innovation rated in a survey with CEOs (Haapaniemi, 2002: 1)](image)

However in the same study only one in ten of the CEOs strongly agreed that their organization excels at innovation (Haapaniemi, 2002: 1). These statements of deficient ability to excel in innovation, in practice, are alarming.

This deficient ability to excel in innovation is aggravated by the trend toward the increasing importance of innovation confirmed by several authors\(^2\). They relate the ability to

---

\(^1\) According to Schaad (2001: 15) this definition of innovation is in consensus with the actual literature. A more detailed discussion about innovation could be found in chapter 2.1.3.

master future fundamental changes with the ability to develop innovations. Representative examples of such future fundamental changes include:

- **Technological changes** are increasing the complexity of technologies (Iansiti, 1998: 2) and are increasing the dynamic of the technological environment (Tushman & Anderson, 1997: 43).

- **Cultural and social changes** are creating a greater awareness of sustainable development in terms of environmental, social and governmental issues (Schofield & Feltmate, 2003).

- **Economic and industrial changes** are identified by the globalization and saturation of existing markets (Nadler, 1994; Hamel, 2002). At the same time product life cycles are declining (Booz, Allen, & Hamilton, 1991: 26).

These described changes are multifaceted and appear in an increasing dynamic (Backhaus & Zoeten, 1992: 2025). In this context Braun (1994: 122) noted succinctly: “at present, more happens in five years than has happened in the past fifty years”.

The effect of these changes is that companies - settled in the past in continuously growing markets with stable conditions, have encountered these changes resulting in falling sales and returns (Sommerlatte, 1987: 5). They often reacted with organizational and cost cutting measures which at least temporarily improved their profitability (Call & Völker, 1999: 58). This reaction to cost cutting focused the companies more on saving the present rather than on saving the future (Sommerlatte, 1987: 5) and therefore an innovation gap arose. To solve the problem of this innovation gap, companies have to become more effective in innovating (Zahn, 1995: 17), which represents a first challenge to master. In this context of becoming more effective it is important to consider near incremental innovations especially radical innovations because their return is on average much higher while the flop rate is the same as Berth (2003: 18) found out in a long term survey. But not only the effectiveness of innovation is - due to the above describes changes - a resulting problem but also, costs and required time are increasing in innovation development. So the efficiency in developing innovations is a second challenge in mastering the above described changes (Zahn, 1995: 17).

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3 The term sustainable development was originally proposed by the United Nations in the 1987 publication “Our Common Future” (World Commission on Environment and Development, 1987). From corporate perspective, sustainable development refers to companies that are committed to minimizing the environmental footprint of their operation, while simultaneously contributing to the economic and social advancement of communities in which they operate (Schofield & Feltmate, 2003).

4 Effectiveness is a qualitative factor and is affected by culture, capital, organization, environment, quality of education and experience, science, technologies, knowledge base, quality of information and through meta skills (Zahn, 1995: 189f).

5 A more detailed discussion about the survey of Berth (2003) can be found in chapter 2.1.3.3.

6 Efficiency is related to costs, needed to implement a specific degree of effectiveness in the market proposition (Zahn, 1995: 190).
To improve the ability to develop innovation in an effective and an efficient manner, individuals and organizations in a company first have to be aware of changes in order to realize renewals early and anticipate. This means, in other words, that companies have to ensure a high degree of innovativeness (Tschirky, 1998a: 9). In this context Zahn & Weidler (1995: 359) claim that a company has to be aware in order to develop innovations, in terms of successful renewals, in the three different dimensions of business, technological and organizational related innovations. In doing so the resulting innovations have a broader innovation range, additional protection against imitation and thus companies gain sustainable competitive advantage by differentiating themselves. Such innovations are called “integrated innovations”.

To develop such “integrated innovations” an innovation management approach is required which considers the company renewals from a holistic point of view (Zahn & Weidler, 1995: 358f) and the activities of innovation management are according to Hauschildt (1997: 25) to develop in a anticipative manner the individual innovation processes. This means that innovation management is part of business management (Maurer, 2002: 55). Therefore innovation management in the context of business management is characterized by two questions to be answered (Hauschildt, 1997: 29):

1. What are the strategic decisions to take – in the form of an innovation strategy – in the context of innovation activities?
2. What are the consequence of the innovation strategy for the organization based on the defined innovation strategy?

In other words, innovation management is concerned with two major challenges: Firstly, with the formulation of an innovation strategy (see question 1). Secondly, with the organizational design of an innovation organization including the processes (see question 2) utilized to realize the innovation intentions. Splitting innovation management into two parts - innovation strategy formulation and organizational design - is done in this work, so the focus can be placed on innovation strategy formulation in the context of innovation management and the design of an organization will not be the focus of this work. For a more detailed discussion of organizational design in the context of innovation management the thesis written by Schaad (2001) at the “Institute of Enterprise Science” at the ETH Zurich can be referred to. Although that this work focuses on innovation strategy formulation, the

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7 A more detailed discussion can be found in chapter 2.1.3.4.
8 See “integrated innovation management” of Zahn and Weidler (1995: 358f)
9 The author has translated the German word ‘dispositiv’ used by Hauschildt (1997: 25) with anticipative.
10 An innovation strategy sets direction, focuses efforts, allows designing an organization and ensures constancy in the innovation system with considering integral innovations, innovation barriers, and degree of newness of the innovation as well as the required innovation relevant knowledge. A more detailed discussion can be found in chapter 2.1.4.1.
results are compatible with Schaad’s concept of organizational design ensuring a consistent innovation management concept.

Focussing on innovation strategy is done against the background of a survey in the “Chief Executive” (Kambil, 2002: 8) which found that nearly 40% of the interviewed CEOs indicate a clear innovation strategy as one of the most important success factors, in commercializing an idea (Figure 2). At the same time the survey results indicated, “that many [companies] lack a clear innovation strategy including a decision-making team to evaluate different ideas for commercial feasibility”. This lack of an innovation strategy affects - according to the study - all aspects of driving innovative ideas to commercialization; in particular it has the greatest impact on allocating resources necessary to innovate.

![Figure 2: Importance of innovation strategy related in a survey with CEOs (Kambil, 2002: 8)](image)

This importance of innovation strategy was confirmed in interviews done in the context of this work. The interviews were conducted in several innovation driven companies active in different industries. In these interviews - in addition to the above-described problems resulting from the lack of innovation strategy - the executives described the lack of an innovation strategy as a concern particularly because this lack often allows the absence of prioritization of innovation activities. This results in the situation where different organizational groups only work conditionally through the same strategic goal and coordination problems occurred. In particular coordination problems between market driven activities and R&D driven activities were accentuated in the interviews. Although the importance of an innovation strategy was recognized by the executives, few - if any - had a solution for systematically developing an innovation strategy. This is a gap in management practice.

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11 Innovation driven companies need successful commercialized renewals to gain competitive advantage and to be successful in the long term. Therefore these companies are especially interesting when analyzing the subject of innovation.

12 Interviews were made in companies in the following industries: component producer (3), production system producer (1), IT-provider (1), chemistry (2), apparatus producer (2), consultancy (1), communication (1). A more detailed discussion can be found in chapter 3.1.
Furthermore in literature, several authors\textsuperscript{13} point out the importance of a clear innovation strategy. From their point of view, an innovation strategy allows clear, innovation relevant strategic goals to be set and paths to be planned and realized in the innovation processes.

Although the literature points out the importance of innovation strategy there is no practice-oriented detailed and structured concept of formulating an innovation strategy. This lack of an innovation strategy formulation concept is a gap in literature.\textsuperscript{14}

Because in innovation strategy literature no solution to the above mentioned gap in practice was found, the author analyzed complementary literature. Based on the fact that the systematic formulation of an innovation strategy always needs a decision and therefore the understanding of the concerned innovation system\textsuperscript{15}, the literature about system thinking has been analyzed: According to Malik (2001b: 136ff) three aspects require serious attention to understand a system before taking a decision: Complexity\textsuperscript{16}, systemic interaction\textsuperscript{17} and evolution\textsuperscript{18}. Most of the basic problems in a system are based, according to Malik, on disregard for these aspects. Therefore complexity, systemic interaction and evolution are key aspects to consider in order to be able to understand - or at least to recognize - the specific system conditions. In addition to these three aspects it is important to develop a focusing and verbalizing model\textsuperscript{19} of the reality, because the reality is too multifaceted to be understood as a whole (Malik, 2002: 175). In a nutshell, to understand the innovation system in terms of innovation strategy it is important to develop a model considering the three aspects of complexity, systemic interaction and evolution.


\textsuperscript{14} A more detailed discussion of the gap in literature can be found in chapter 2.1.4.

\textsuperscript{15} A system is “a set of different elements connected or related so as to perform a unique function not performable by the elements alone” (Rechtin & Meier, 1997: 7). An innovation system is a subsystem of the company system. The innovation system defines the future values of a company (see chapter 2.1.3.5).

\textsuperscript{16} Complexity is the fact that real systems can have many different variations (Malik, 2002: 186). A more detailed discussion could be found in chapter 2.1.1.2.

\textsuperscript{17} Systemic interaction is the fact that variables or elements of a system are dependent and have effects on each other (Malik, 2001b: 139). A more detailed discussion can be found in chapter 2.1.1.2.

\textsuperscript{18} Evolution is the fact that complex interactive systems are always changing (Malik, 2001b: 139). A more detailed discussion can be found in chapter 2.1.1.2.

\textsuperscript{19} A model is an abstraction or representation of the system used to predict and analyze i.e. performance, costs, schedules, and risks and to provide guidelines for systems research, development, design, manufacture, and management (according to Rechtin & Meier, 1997: 13). A more detailed discussion can be found in chapter 2.2.1.
Such a model could be described as an architecture according to Rechtin und Meyer (1997). An architecture is a structure\textsuperscript{20} of a system visualizing existing and future elements and their interactions with the aim toward taking balanced decisions\textsuperscript{21}.

Applying the concept of architecture for the innovation system of an innovation driven company, Schaad (2001) already proposes, in the context of organisational design, the so called innovation architecture\textsuperscript{22}. This innovation architecture shows the innovation relevant connections between markets, products, technologies and scientific knowledge in a company. But this architecture only allows a visualization of the complexity and interactions of the elements in an innovation system. The modelling of the evolution of this concept is not mentioned in this innovation architecture, which is a gap in literature.

Nevertheless, Schaad’s (2001) innovation architecture is a promising basis for developing an innovation architecture representing complexity, systemic interaction and evolution of an innovation system. In Figure 3 the solution of such an innovation architecture is anticipated. A more detailed discussion on architectures can be found in chapter 2.2.1.2.

\textbf{Figure 3: Innovation architecture}

\textsuperscript{20} “A structure consists of a set of quantitative relationships existing among several sub-groups of a general category at one point of time” (Schiavo-Campo, 1978: 1).

\textsuperscript{21} A more detailed discussion about architecture can be found in chapter 2.2.1.2

\textsuperscript{22} A more detailed discussion about innovation architecture can be found in chapter 2.2.1.2
In a nutshell an innovation strategy is seen in management practice and literature as an important building block of innovation management. However, many companies lack an innovation strategy and literature can not provide a structured practice-oriented, detailed formulation concept nor can they provide a solution for understanding an innovation system, in terms of complexity, systemic interaction and evolution as basis to develop an innovation strategy. Therefore, the interest in systematically formulating an innovation strategy is an unanswered concern in management practice and literature.

1.2 Research Question

Based on current research in technology and innovation management at the Swiss Federal Institute of Technology Zürich at the Center of Enterprise Science\(^\text{23}\), the goal of this dissertation is to find solutions for the concerns in practice and to fill the gap in literature described above.

THE RESEARCH TOPIC OF THIS WORK IS A CONCEPT OF STRUCTURED INNOVATION STRATEGY FORMULATION AND ITS IMPLEMENTATION, AND THE RESEARCH OBJECTS ARE INNOVATION DRIVEN ENTERPRISES.

In order to be able to handle the topic, it is first of all necessary to understand the innovation system of an innovation driven enterprises. Therefore the first research question is the following:

1. HOW CAN A COMPLEX, SYSTEMIC INTERACTIVE AND EVOLUTIONARY INNOVATION SYSTEM BE MODELED IN ORDER TO UNDERSTAND THE SYSTEM SPECIFIC CONDITIONS OF AN INNOVATION DRIVEN ENTERPRISE?

The results of this first research question should be a model of a complex, interactive and evolutionary innovation system, the so-called innovation architecture. This innovation architecture has to be integrated in a second step, into a strategy formulation concept which has to be implemented in practice. Therefore the second and third research questions are the following:

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2. **How could a structured innovation strategy formulation concept be designed, based on the innovation architecture, for innovation driven enterprises?**

3. **How could such an innovation strategy formulation concept be implemented?**

In fact, the design of a concept and its implementation could not be strictly separated one from the other. The emphasis is, by the nature of organizational research, on the organization of structure, processes, and methods of innovation strategy formulation in innovation driven enterprises.

1.3 Research Design and Methodology

1.3.1 Proceeding of the Thesis

The emphasis of this work is dual faceted: Firstly it is on gaining insight into business reality by means of first-hand information in order to be able to develop solutions that are of use to practitioners. Secondly this solution is implemented actively in practice by application-oriented research. The output is a set of management principles rather than a simple description of innovation strategy formulation concepts in innovation driven enterprises. Therefore it is a practitioner oriented concept of an innovation strategy formulation concept based on a model representing the systems specific conditions of an innovation driven enterprise. This concept should represent a holistic approach to innovation strategy formulation.

Because of the significant shortcomings in literature (cp. Chapter 1.1), an empirical and explorative research design is to be preferred initially. Most current empirical and explorative studies are based on case studies. The choice of the case study research method can be explained by Kubicek (1975: 61). He argues that case studies are best for the very early stages in research of an organizational problem. They require relatively little effort and bring plenty of suggestions for further research on this topic. However, Lang (1998b: 132)

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24 Compare the discussion of differences between theoretic and application-oriented science in Ulrich (1988: 177)
points out some weaknesses of case studies, which are mainly that they provide an inadequate generalization of insight.

With regard to this concern, a research procedure has been chosen for this thesis, shown in Figure 4, based on Yin’s (1994: 49) multiple-case study approach: In the first stage, a theoretical concept of innovation strategy formulation is designed and several cases (innovation driven enterprises) are selected. In the second stage the theoretical concept is evaluated in terms of action research cases in the different enterprises. The following analysis is an interpretation of the action research case results done in a two level concept, which firstly provides an individual analysis of each case and secondly provides a cross-case overall analysis. Following this two level evaluation the theoretical concept is modified. On the basis of the collected insight it is possible to derive management principles, which allow the gained insight to be transferred into other business cases and therefore enables them to be multiplied. By this procedure “every case should serve a specific purpose within the overall scope of inquiry” (Yin, 1994: 45).

Figure 4: Multiple-case study (adapted from Yin, 1994: 49)

Nevertheless, this thesis does not claim an overall validation of the learning from the action research cases. This is not possible for two reasons: On the one hand the sample of action research case studies is always restricted by the number of companies studied and on the other hand the insight gained from action research case studies always reflects one company’s specific reality. Thus, the aims of this research is to explore how an innovation driven enterprise can develop an innovation strategy and implement an innovation strategy

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25 Yin talks about cases in general and not about action research cases. But the author wants to point in this thesis that the cases are done in a specific manner based on action research. Action research is an approach, in which practitioners and scientists jointly design and implement new concepts. Moreover, the involved scientists try in turn to systematize and generalize their experiences (cp. Kubicek, 1975: 70). A more detailed discussion could be found in chapter 1.3.2.

26 Van Maanen (1979: 539). The author speaks about “first-order and second-order findings”
formulation concept, and then to present management principles for guiding an innovation driven enterprise to an appropriate solution for an innovation strategy formulation concept.

The inclusion of the several action research cases is the result of close research cooperation between the author and the companies. These action research cases should build, in an explorative manner, a basis for the discussion of the elements of an innovation strategy formulation concept. Due to the fact that it was impossible to find a company that would build the basis for all decisions in the theoretical concept of innovation strategy formulation, the author worked with ten different companies. Subsequently, lessons learned from empirical research will flow into a set of management principles that guide innovation driven enterprises to design and implement an innovation strategy formulation concept. The proceeding of this thesis is depicted in Figure 5. It gives an overview of the major parts in this work. The step of action research is described in detail below.

Figure 5: Proceeding of this thesis

1.3.2 Action Research

The term action research is attributed to Lewin (1946). His work seems to be fundamental to the modern understanding of action research: “He created a new role for researchers
and redefined criteria for judging the quality of an inquiry process. Lewin shifted the researcher’s role from being a distant observer to involvement in concrete problem solving” (Greenwood & Levin, 1998: 19). Since the 70s, Kubicek (1975) has observed an intensified attention to action research and he paraphrases the term with research by development - in organizational research. He designates action research as an approach, in which practitioners and scientists jointly design and implement new organizational concepts. Moreover, the involved scientists try in turn to systematize and generalize their experiences (Kubicek, 1975: 70). Thus, action research is action oriented. This means that the researcher is able to actively influence the research object for making changing from inside (Popp, 2001: 401) and can pass through a learning process which allows the examination field to be changed during the analysis or to permit more information sources (Wollmann & Gerd-Michael, 1977: 445). In contrast, this is not possible through passive approaches such as pure case studies. In case studies, the researcher is limited to formulating questions and interpreting the empirical results. Three central terms in action research are (Greenwood & Levin, 1998: 6):

- Research (knowledge generation)
- Participation (participatory process in which everyone involved takes some responsibility)
- Action (jointly elaborated options of action)

According to Greenwood & Levin, one can only speak about action research in its proper sense if all of these aspects are considered in the study. To clarify the content of action research, two current definitions are given, and illustrated in Figure 6:

![Figure 6: Content and impact of action research (Savioz, 2002: 80)](image)

- Greenwood & Levin (1998: 4): “Together, the professional researcher and the stakeholders define the problems to be examined, co-generate relevant knowl-

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27 For organizational research in general compare Kubicek(1975), Kieser & Kubicek (1992) and Grochla (1978)
edge about them, learn and execute social research techniques, take action, and interpret the results of actions based on what they have learned”.

- Cunningham (1993: 4): “Action Research is a term for describing a spectrum of activities that focus is on research, planning, theorizing, learning, and development. It describes a continuous process of research and learning in the researcher’s long-term relationship with a problem”.

Facing the often cited contrast of qualitative and quantitative research methods, action research adopts a rather neutral position. In principle, action research allows any kind of method of social science. “Surveys, statistical analysis, interviews, focus groups, ethnographies, and life histories are all acceptable, if the reason for deploying them has been agreed on by the action research collaborators and if they are used in a way that does not oppress the participants” (Greenwood & Levin, 1998: 7). Thus, action research seems to be very promising for explorative studies in organizations. Both, the research community and the organizations benefit from the experience gained during common design and implementation of new concepts. The great opportunity of this kind of research lies in the two supplementary dimensions of action and participation. Therefore the action research projects in this thesis are based on a cooperative problem solving and learning approach. It is a tightrope walk of interests for scientists and practitioners. This is particularly challenging for the management of the conducted action research projects. In practice nevertheless, action research is normally restricted to a few companies because of the limited degree of readiness of organizations to cooperate (Kubicek, 1975: 71). Fortunately, nine companies were prepared to support this action research.

1.3.3 Empirical Research Methodology and Raw Data

Non-standardized interviews have an important place in this thesis. This qualitative empirical approach is justified by two arguments: Firstly, written questionnaires do not make sense because of the heterogeneous use of different terms in the field of innovation strategy formulation. Secondly, activities in this field of interest seem to be very informal, and therefore cannot be mapped by standardized methods. In general, written questionnaires often fail because of the complexity of the topic, and consequently the need for clarification is significant. The major disadvantages of qualitative, empirical research designs for organizational research are surely that the sample’s representative nature is always limited. Despite this problem, the main advantage lies in the opportunity to identify the neglected phenomena, coherence of causes and effects, processes etc. (Bortz & Döring, 1995), and thus to structure a very complex subject on the one hand, and on the other hand to bring new aspects of it to the surface. A detailed description of the methodologies (interviews, workshops, document analysis etc.) adopted for each stage, and indications from where the raw
Introduction

The author of this thesis is committed to honest and transparent research. Therefore, for each case it is clearly stated from where raw data originates. In addition, the author does not want to adorn himself with borrowed plumes: Raw data is part of projects, diploma and post-diploma theses at the ETH-Center for Enterprise Science, i.e. Finckh (2003), Flühmann (2003) Lincke (2004). They are all gratefully acknowledged for their collaboration.

1.4 Structure of the Thesis

The thesis is structured in nine principal chapters. Figure 7 provides the overview of the structure.

Figure 7: Structure of the thesis
2 State of the Art in Theory

The previous chapter showed the importance of the research subject of a structured innovation strategy formulation concept based on a model representing the innovation system of a complex, systemic interacting and evolutionary innovation driven company and a short outline about the actual literature was presented. In contrast this chapter introduces in detail the previous mentioned literature of the research subject and complementary literature and concludes with the gap in innovation strategy formulation (see Figure 8).

Figure 8: Structure of chapter 2

2.1 Innovation Strategy Formulation Literature

The aim in this chapter is to introduce the research subject in detail by showing representative concepts of the literature and the essential criteria to consider in each domain. Thereby four domains are presented: (1) strategic management, (2) strategy and strategy formulation, (3) innovation and innovation management, and (4) innovation strategy and innovation strategy formulation. These domains are presented against the background of the innovation strategy formulation, which is strongly based on the understanding of these subjects. Therefore the author has chosen a constructive bottom up approach to introduce the innovation strategy formulation. This bottom up approach is the underlying proceeding of this chapter as shown in Figure 9: After introducing strategic management, strategy and
strategy formulation the essential criteria of these domains are identified and strategy formulation concepts are evaluated based on these criteria. This first preliminary evaluation is done against the background that the research in literature about innovation strategy formulation concepts can be focused on the concepts that are consistent with the understanding of general strategy formulation in this work. After the preliminary evaluation of strategy formulation concepts, the terms of innovation and innovation management are introduced which leads to innovation strategy and innovation strategy formulation. With the additional identified innovation specific criteria the innovation strategy formulation concepts in literature are evaluated and a conclusion is pointed out with the aims to identify interesting concepts in the context of innovation strategy formulation and to define the subjects to be analyzed in complementary literature.

**Figure 9: Procedure in chapter 2.1**

### 2.1.1 Strategic Management

The strategic management issue is probably the most philosophical topic in management literature. As will be shown later, there are diverse schools and a series of approaches to dealing with the strategy question. From an initial point of view strategic management is understood as planning to run and change the business in order to achieve business mission and goals (Wright, Pringle, & kroll, 1992: 3)\(^28\). Terms like ‘thinking’, ‘acting’, and ‘decision-making’ are central tasks to this purpose (Gälweiler, 1990: 65).

\(^{28}\) Compare also Teece (Teece, 1990: 40); Welge & Al-Laham (Welge & Al-Laham, 1992: 2356); Hauschildt (Hauschildt, 1997: 25); Maurer (Maurer, 2002: 17); Hunger & Wheelen (Hunger & Wheelen, 2002: 2)
2.1.1.1 Tasks of Strategic Management

All the above mentioned ‘classical’ tasks of management can be summarized in three basic tasks of management: design, direct and develop (Ulrich & Probst, 1988: 260ff; Tschirky & Bucher, 2003: 25). These tasks are based on three vertical levels: normative, strategic and operational (vertical integration) as well as three horizontal levels: structures, behaviors and objectives (horizontal integration). The goal is to design, direct and develop the company with its potentials to influence the company as well as its environmental development process. This concept of management is shown in Figure 10.

![Figure 10: Integrated management (compare Ulrich & Probst, 1988: 260ff; Tschirky, 1998b: 268)](image)

In the following the above mentioned three essential tasks of management will be described in detail:

**Design** has as an aim to create a working system. For this purpose the required resources and institutional domains will be defined and merged into a consistent organization: Design as a management function means the draft of an institutional model, wherefore the designation of the targeted properties of the institution is essential. Therefore such a design can be called “design models”, which have to be clearly differentiated from scientific explanation models, which try to explain an existing reality, and differentiated from decision models, which display a specific problem situation in an existing system. In contrast, design models are analogous to construction drafts: The aim to create a not yet existing reality. The development of this design model is therefore an eminent constructive procedure (Ulrich & Probst, 1988: 260).
**Direct** means, that the company objectives are aligned in real time to the created objectives of the design model. This requires a constant debate with the conditions of the environment as well as with the situation of the company itself. The outcome of this is a constant need to evaluate changes of planned projects, which demand a further decision and its implementation. Direct is therefore a function, which is essential in a system so that this system can reach its objectives under changing conditions with concrete activities (Ulrich & Probst, 1988: 261).

**Develop** is an executive task, which is the cognizant constant change in the system and its direction. What is essential to this task are the social, technological and industrial changes\(^{29}\) which result in changed conditions and assumptions for designing and directing company’s systems. In the foreground is thereby the further development of the company in terms of the constant improvement or qualitative learning. In the short term it is essential, that the company learns to function better with given objectives, to subsequently eliminate deficiencies and not to repeat mistakes. In the long term it is essential to encourage the innovativeness\(^{30}\) of the company (Ulrich & Probst, 1988: 263).

In Figure 11 the three basic tasks of management are summarized. It is apparent that design and direct are primary concerned with thinking in continuities, meanwhile the development of the company requires thinking in discontinuities. The tasks design and direct are engaged with the “from today to tomorrow”, whereas the task develop is concerned with the “from today to tomorrow” (Tschirky & Bucher, 2003: 27).

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\(^{29}\)See chapter 1.1

\(^{30}\)A more detailed discussion about the term innovativeness can be found in chapter 2.1.3.2
To manage a company in terms of designing, directing and developing it is essential to understand the steering values of a company (compare Gälweiler, 1990: 35). Therefore it is of great importance to know firstly which are the real strategic orientation values, secondly which constraints exist between them, thirdly which sources provide information and fourthly what time frame they forsee (Malik, 2001a: 7). Gälweiler (1990: 34) presents a concept for answering these questions by analyzing the company from a steering- and regulation point of view. This concept is shown in Figure 12 and is explained in the following on the basis of Malik’s (2001a: 11ff; 2001b: 145ff) comments on this concept:

**Figure 12: Tasks of the company guidance based on their steering values (Gälweiler, 1990: 34)**

The principle steering value and at the same time the shortest term steering value is the liquidity. A lack of liquidity can force a company, even if it has a high level of performance, to fail because the company does not have the ability to pay their outstanding bills. Liquidity is the economic and juristically defined survival criteria. But indeed it is not possible to survive only with a liquidity oriented steering. The ability to pay is only a momentum based value. It is not possible to gain information about the success of the company by only looking at the liquidity. Furthermore a positive liquidity can be deceiving when the future development is negative. This is because a high level of liquidity can be apparent without success.

Therefore the second steering value, success, is required. It is an effective pre-steering of liquidity. This is because of the tendency that successful results lead to a high probability of a positive future, meaning a good position in liquidity. The measures for success are costs against earning. Therefore this value gives feedback on the efficiency of the company. But a company cannot be steered only with these values, because they provide no key figures about the future development of company’s success position.
As a result the third steering value is the existing success position. The aim is firstly to know the strengths, weaknesses, opportunities and threats of the existing success position and secondly to identify its evolution. Orientation values to identify the existing success positions are firstly the market share relation between the direct competitors and secondly the cost structure on the basis of the ‘learning curve’\(^{31}\). Nevertheless this third steering value does not actually allow steering a company because there is no information given about new success positions.

Consequently the fourth steering value, new success potentials, is required. This steering value gives input about future fundamental structural changes\(^{32}\) in markets, products or technologies. Such changes are often triggered by the existing or potential competitors, which have a substitutable technology and the resulting product. To identify such structural changes the ‘substitution time curve’\(^{33}\) gives a future orientation. In this context it is essential to identify possible substitutions by a solution neutral view of the customer needs which allows a detachment from actual solutions and faster identification of new, yet not considered, solutions (Malik, 2001a: 14). This important thought is very old but still has a high importance in management. Drucker (1956: 46f; 1965) was one of the first that pointed out this way of identifying new success potentials. He describes the solution neutral formulation and understanding of customer problems is the archimedic factor of every company strategy.

Summarizing Gälweiler’s (1990: 34) concept it is essential on an operational level to understand the steering values of liquidity and success and on a strategic level to understand that the steering values of the existing success position and new success potential are of primary interest. In this context it must be mentioned that the strategic steering values have to be taken into account in a pre-steering phase (Malik, 2001b: 143). This is because the operative implementations of specific decisions are delayed. So it is essential to pre-steer a system, such as a company, to be able to implement decisions early enough. With this understanding of pre-steering for the company the strategic steering value, the ‘existing success position’, is the basis for designing and directing a company in the context of Tschirky’s & Bucher’s (2003: 27) concept shown in Figure 11. Whereas the strategic steering value ‘new success potentials’ is crucial for developing a company. On the strategic level this leads to the main task of strategic management, which is differentiated because of the time horizon:

- Firstly, the actual system of a company and its changes, which are not structural, have to be designed and directed by using the existing success position a strategic steering value.

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31 The learning curve is discussed in detail by Henderson (2003: 40)
32 A structural change is according to Schiavo-Campo (1978: 1) a change of a set of quantitative relationships existing among several sub-groups of a general category at one point in time.
33 The substitution time curve is presented in Gälweiler (1990: 49)
Secondly, the evolution of the actual system of a company which implies structural changes has to be developed by using new success positions as strategic steering values.

The awareness of these two tasks of strategic management allows a sensible look at the essential strategic steering values mentioned above and allows a pre-steering therefore in terms of the strategic management in a company. But these strategic steering values still have a weakness according to Malik (2001b: 135): Steering values of a company, or for every system, can systematically misguide. This is because the perceptions of the significant basic data for the steering values, originating in the specific history of the company, are not changed during the time. Therefore it is important to understand systematically - and not traditionally - in the strategic management the system of a company for adapting the data of the strategic steering values. This is the subject of the next sub-chapter.

2.1.1.2 Understanding Systematically the System of a Company in Strategic Management

According to Malik (2001b: 135f) a system, such as a company, is often misunderstood in strategic management because of the disregard for three major factors:

- **The complexity** of companies and their relevant environment. Complexity stands in this context not only for “complicated”, but it marks the capability of a system, to adopt many different states. Complexity can be quantified and be measured with support of the term variability. “Variability is the number of different status of a system or the amount of a set of different elements” (Malik, 1992: 186). This understanding of complexity is in alignment with authors in the domain of cybernetic research, such as Hayek (1972; 1973) and Beer (1972; 1979). To get a more detailed feeling for complexity the example of playing chess is adequate: The chess game is considered as complex because an enormous number of different maneuvers and even a higher number of different possible configurations on the chess board is possible. This amount of number can neither be handled by a human brain nor by a computer. Therefore this game has a strategic character.

- **The systemic interaction** between the determining influential elements understood as variables. Thereby systemic means “pertaining to a system or systems” (Davis, 1980: 705). Therefore a systemic interaction means that the relations between elements are pertaining to a system and therefore that they have an influ-

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34 Translated from the German word „Systemhaftigkeit“ of Malik (2001b: 139); A concrete use of the term systemic interaction in the English literature can be found in Snyder et. al.(1980) and Evangelisty et. al. (2002);
ence on the system. The interactions are normally not only linear and monocausal but positive or negative back-coupled. If in these interactions a threshold of values is exceeded often the character of an element will change by generating an overturn of an effect or a step function. These changes make it difficult to evaluate and interfere into a system. Therefore it is essential to analyze the systemic interactions of elements to be able to predict, still with a definite uncertainty, the side effects.

- **The evolution of a system.** Based on evolutionary theories, evolution is understood as constant, not often predictable, changes which have in the long term the effect in a company of provoking structural changes (Malik, 2001b: 137). The evolution is based on the multilateral action and reaction of elements in a complex, systemic interacting system which consistently provokes new situations. These situations are in general the result of the interactions between two organisms, which have different objectives and therefore are acting reciprocally. During the reciprocal action a process of adaptation is activated which is cognizable in an increment in knowledge of the organisms (Bartley, 1987: 23). The cause of this adaptation is the dynamism of a system. Only if it is possible to identify the underlying objectives and processes of each element is it possible to orient them in one direction. It is essential to identify the process of adaptation which is seen by the development of the knowledge in the environment. Then it is possible in the circumstances to realize certain fixed basic structures in the future.

These three criterias are the starting point for understanding a system according to Malik (2001b: 138). How the understanding of these fundamental criteria are dependent on the strategic steering values and strategic management tasks mentioned in the previous chapter will be further discussed in the next sub-chapter.

### 2.1.1.3 Conclusion

As mentioned in chapter 2.1.1.1 an actual system of a company can be designed and directed by using the existing success position as a strategic steering value. To understand in a pre-steering phase the strategic steering value it is relevant to understand first of all the complexity and the systemic interaction of a company understood as a system. In contrast, the understanding of evolution supports new success positions to be derived and a future system to be developed. This relation between understanding a system, defining the steering values and accomplishing strategic management tasks is shown in Figure 13.

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35 For a more detailed discussion about evolutionary theories see Hannan & Freeman (1977); Nelson & Winter (1982); Baum & Singh (1994); Pherson & Ranger-Moore (1994) and Barron (2003)
To bring it all together it is essential for strategic management to understand first of all in a pre-steering phase the concerned system in terms of complexity, systemic interaction and evolution. Therefore this understanding of the system is according to Malik (2001b) a basic criteria to create strategic management concept: **Strategic management has to design, direct and develop a company based on a clear understanding of company systems’ complexity, systemic interaction and evolution.**

Based on this understanding of strategic management the terms of strategy and strategy formulation will be discussed in the next chapter.

### 2.1.2 Strategy and Strategy Formulation

#### 2.1.2.1 Strategy

A system, such as an electrical circuit, can be pre-steered in its voltage, because in the case that a reaction to an environmental effect comes, it is too late to steer the circuit in real time. Therefore it is attempted to anticipate future influences of the environment by submitting clear signals to the electrical circuit in terms of pre-steering. These signals contain a clear objective to decrease or increase the tension, and a path, by doing this with a current transformer.
Analogous to the pre-steering of an electrical circuit the system of a company can be pre-steered. A company tries to anticipate future influences of the environment to decide on strategic management level, to implement a decision by submitting a signal to the operational level of the company. This signal contains a clear objective and a comprehensive path, without defining in detail what to do at every step. More precisely this pre-steering signal is in general, in company terms, a strategy.

However in this description of strategy the term varies in its definition from author to author and it has become a key word in management practice and literature:” For a term so central, one even incorporated in the name of the filed, it might be expected that a common definition would exist for the word strategy. Yet the concept remains different for different users” (Schendel & Cool, 1988: 23). Nevertheless an important group of authors understand the term of strategy as defining strategic goals and paths as mentioned in the example above (see Figure 14). Some representative examples of this understanding of strategy are listed in the following:

- “Strategy is the determination of the basic long-term goals and the objectives of an enterprise, and the adoption of courses of action and the allocation of resources necessary for carrying out these goals": Chandler (1962: 13)
- “A strategy is a plan or a pattern that integrates an organization’s major goals, policies, and action sequences into a cohesive whole”: Quinn (1980: 7)
- “Corporate strategy is the pattern of decisions in a company that determines and reveals its objectives, purposes, produces the principle policies and plans for achieving those goals, and defines the range of business the company is to pursue, the kind of economic and human organization it is or intends to be, and the nature of the economic an noneconomic contribution it intends to make its shareholders, employees, customer, and communities”: Andrews (1987: 13).
- “A strategy of a corporation is a comprehensive plan stating how the corporation will achieve its mission and objectives. It maximizes competitive advantage and minimizes competitive disadvantage”: Hunger & Wheelen (2002: 7)

**Figure 14: Definition of strategy (adapted from Chandler, 1962)**
Beside this distinction between path and goal, which defines the strategic direction, Abell (1999) suggests the consideration of dual strategies, which are run in parallel: ‘today-for today strategies’ and ‘today-for tomorrow strategies’. “This distinction between a present and future orientation is not the usual short-term, long-term distinction – in which the short-term plan is simply a detailed operations and budgeting exercise made in the context of a hoped-for long-term market position. Present planning also requires strategy – a vision of how the firm has to operate new (given its competencies and target markets) and what the role of each key function will be. The long-term plan, by contrast, is built on a vision of the future – even more important, on a strategy for getting there” (Abell, 1999: 74). This dual term understanding of strategy is in alignment with the understanding of strategic management to consider today, tomorrow and after tomorrow presented in chapter 2.1.1.3 (Tschirky & Bucher, 2003) based on the understanding of complexity, systemic interaction and evolution of a company.

Based on the presented understanding of strategy, a strategy is according to Mintzberg et al. (1998: 15) associated with setting directions, focusing efforts, defining the organization and providing consistency. However in this context it has to be mentioned that this understanding of strategy is in alignment with many authors in literature but it is not an understanding without disadvantages. For every advantage associated with the shown understanding of strategy, there is an associated drawback or disadvantage. Mintzberg et al. (1998: 15ff) provide the following highly illustrative examples:

1. “Strategy sets direction.”

   **Advantage:** The main role of strategy is to chart the course of an organization in order for it to sail smoothly through its environment.

   **Disadvantage:** Strategic direction can also serve as a set of blinders to hide potential dangers. Setting out on a predetermined course in unknown water is the perfect way to sail into an iceberg. While direction is important, sometimes it is better to move slowly, a little bit at a time, looking carefully but not too far ahead, as well as to each side, so that behavior can be shifted at a moment’s notice.

2. “Strategy focuses effort.”

   **Advantage:** Strategy promotes coordination of activity. Without strategy to focus effort, chaos can ensue as people pull in various different directions.

   **Disadvantage:** “Groupthink” arises when an effort is too carefully focused. There may be no peripheral vision to open other possibilities. A given strategy can become too heavily embedded in the fabric of the organization.

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36 Based on the concept of "structure follows strategy" by Chandler (1962: 14)
3. “Strategy defines the organization.”

*Advantage:* Strategy provides people with a shorthand way to understand their organization and to distinguish it from others. Strategy provides meaning, plus a convenient way to comprehend what the organization does.

*Disadvantage:* To define an organization too sharply may also mean to define it too simply, sometimes to the point of stereotyping, where the rich complexity of the system is lost.

4. “Strategy provides consistency.”

*Advantage:* Strategy is needed to reduce ambiguity and provide order. In this sense, a strategy is like a theory: a cognitive structure to simplify and explain the world, and thereby facilitating action.

*Disadvantage:* Creativity thrives on inconsistency – by finding new combinations of so far separate phenomena. It has to be realized that every strategy, like every theory, is a simplification that necessarily distorts reality. Strategies and theories are not reality themselves, only representations of reality in the minds of people. No one has ever touched or seen a strategy. This means that every strategy can have a misrepresenting or distorting effect. That is the price of having a strategy.

Nevertheless these disadvantages should not be considered to avoid to set direction, focus efforts, define organizations and provide consistency but to be aware in a constructive manner of the disadvantage that can appear near all the advantages. Therefore a strategy sets strategic goals and strategic paths considering the today, the tomorrow and the after tomorrow for setting the company direction, focusing efforts, allowing the organization to be defined and providing consistency in a balanced manner. This represents the understanding of strategy in this work.

### 2.1.2.2 Strategy Formulation

Until this point the understanding of strategy in this work is clear. Nevertheless, there are varying ways of formulating strategies. Mintzberg & Lampel (1999) have analyzed different strategy formulation concepts and they have clustered them into ten different basic schools of strategy formulation. These schools emphasize that during the last decades, the understanding of strategic management was undergoing a great change, certainly based on the insight that the future is less planable than expected. Because these ten schools represent various attitudes to strategic management, they are summarized and constructively

1. Design School:

A process of conception. Strategy formulation achieves the essential fit between internal strengths and weaknesses and external threats and opportunities in terms of a SWOT analyses. Senior management formulates clear, simple and unique strategies in a deliberate process of conscious thought. This process is neither formally analytical nor informally intuitive. The chief executive takes in this formulation process the role of an architect (Mintzberg, Ahlstrand, & Lampel, 1998: 365).

Sources: Selznick (1957); Andrews (1987)

Critics:

• Because of the fact that mainly the executive management is part of the strategy formulation, the image of the situation could be distorted by the different hierarchy levels.

• Thinking and realizing are strictly divided, which hinders learning in the process.

2. Planning School

A formal process. This school of thought is close to the design school with a rather significant exception: Where the process is not just cerebral but formal and can be broken down into distinct steps. It is delineated by checklists and supported by techniques. This means that staff planners replace senior managers, de facto, as the key players in the process.

Sources: Ansoff (1965)

Critics:

• Strategic planning requires predictability and stability during strategy making. The world has to hold still while the planning process unfolds.

• The process of formulation uses categorizing “boxes” to solve a problem without using them creativity, which creates new perspectives as well as new combinations.

• Because analysis is not synthesis, strategic planning has never been strategy making.

37 A detailed description would go beyond the scope of this thesis. Development and comparison of the schools and further literature, i.e. the origin of the diverse schools, can be found in Mintzberg et al. (1998).


3. Positioning School

An analytical process. In this view, strategy is reduced to generic positions selected through formalized analyses of industry situations. Hence, the planners become analysts. This literature of this view has grown in all directions to include strategic groups, value chains, game theories, and other ideas, but always with this analytical bent.

**Sources:** Hatten & Schendel (1977); Porter (1980; 1985)

**Critics:**
- The focus of this school’s bias in favor of the economic over the political is especially noteworthy.
- Internal capabilities are neglected
- The message of the positioning school is not to get our there and learn, but to stay home and calculate. In this context Hamel noted (1997: 32): “Opportunities for innovative strategies don’t emerge from sterile analysis and number crunching – they emerge from novel experiences that can create opportunities for novel insights”.
- The developed strategies are generic strategies and not unique for the company.

4. Entrepreneurial School

A visionary process. Much like the design school, the entrepreneurial school centers the process on the chief executive; but unlike the design school and in contrast to the planning school, it roots that process in the mysteries of intuition. This shifts strategies from precise designs, plans or positions to vague visions or broad perspectives.

**Sources:** Schumpeter (1934); Cole (1959)

**Critics:**
- The process of formulating is a black box, buried in human cognition. Transparency about the reasons for this strategy are not always obvious
- The strategy formulation takes place in the office of the chief executive. If he or she has oversight operating details, with strategic influence, the strategy would be assailable

5. Cognitive School

A mental process. Strategies originate from mental processes of cognition by information processing, knowledge structure mapping and concept attainment. Thus, cognition is
used to construct strategy as creative interpretations, rather than simply to map reality in some more or less objective way, however distorted.

**Sources:** Simon (1947); March & Simon (1958)

**Critics:**
- This school is characterized more by its potential than by its contribution.
- It would be more useful to know not just how the mind distorts, but also how it is sometimes able to integrate such diversity of complex inputs.

### 6. Learning School

An emergent process. Based on ideas such as disjointed incrementalism, logical incrementalism, venturing, emergent strategies and retrospective sense-making, a model of strategy making as learning differs from the earlier schools. Strategies are emergent, strategists can be found throughout the organization, and so-called formulation and implementation intertwine.

**Sources:** Braybrooke & Lindblom (1963); Cyert & March (1963); Weick (1979); Quinn (1980); Hamel & Prahalad (1994)

**Critics:**
- The executive management has to take decisions to counteract the fact that people will maneuver at will, riding off in all directions
- The learning schools allow changing everything all the time, but to know specifically what to change when is more important
- Not wanted strategies can emerge by this time
- Learning is expensive. It takes time, sometimes resulting in endless meetings and floods of electronic mail.

### 7. Power School

A process of negotiation. Strategy making roots in power at two levels: micro power sees the formulation of strategies within the organization, macro power views the organization as an entity that uses its power over others and among partners in alliances, and vice versa.

**Sources:** Micro: Allison (1971); Makro: Pfeffer & Salancik (1978); Astley (1984)

**Critics:**
- Strategy formulating is about power, but it is not only about power
• Political dimension can have a positive role in organizations; this can also be the source of a great deal of wastage and distortion in organizations.

8. Cultural School

A social process. In parallel to the power school, which focuses on self-interest and fragmentation, the cultural school focuses on common interest and integration. Thus, strategy formulation is a social process rooted in culture. This school is particularly attributed to Japanese organizations.

Sources: Rhenaman (1973); Normann (1977)

Critics:
• By emphasizing tradition and consensus as well as by characterizing change as so complex and so difficult, this school can encourage a kind of stagnation
• This school explains too easily what already exists, rather than tackling the tough questions of what can come into being

9. Environmental School

A reactive process. Not strictly a strategic management school but always of strategic management concern is illuminating the demands of the environment. For example the contingency theory considers which responses are expected of organizations facing particular environmental conditions that claim limits to strategic choice.

Sources: Hannan & Freeman (1977); Pugh, Hickson, Hinings, & Turner (1968)

Critics:
• In this school organizations have no real strategic choice, and there is some sort of “environmental imperative out there.
• The dimension of environment are often abstract, vague and aggregated

10. Configuration School

A process of transformation. This school sees organizations as configurations - coherent clusters of characteristics and behaviors - and integrates the claims of the other schools; each configuration in its own place. Consequently organizations can be described by states, e.g. mature or start-up company, and change must be described as transformation that brings the organization from one state to another.
State of the Art in Theory

Sources: Chandler (1962); Mintzberg (1979); Miller & Friesen (1984); Miles & Snow (1978)

Critics:

- It is not realistic to say that firms are either static or changing rapidly. “Most organizations, most of the time, are changing incrementally” (Donaldson, 1996: 122)

- The configuration school easily allows the nuances of the complex world to be ignored by categorizing the company. To the contrary a fine-grained work that exposes the complex interrelationships among things is needed.

Blending Approaches

Across these ten schools of strategy formulation, various approaches become a hybrid by linking some or all of the elements of the different schools (Mintzberg & Lampel, 1999: 26) (see Figure 15). Examples are: Stakeholder analysis (linking the planning and positioning schools), chaos theory (being a hybrid of the learning and environmental schools), dynamic capabilities (being a hybrid of the learning and design schools) and resource-based theory (being a hybrid of the learning and cultural schools).

<table>
<thead>
<tr>
<th>Approach</th>
<th>School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic Capabilities</td>
<td>Design, Learning</td>
</tr>
<tr>
<td>Resource-based theory</td>
<td>Cultural, Learning</td>
</tr>
<tr>
<td>Soft techniques (e.g., scenario analysis and stakeholder analysis)</td>
<td>Planning, learning or Power</td>
</tr>
<tr>
<td>Constructionism</td>
<td>Cognitive, Cultural</td>
</tr>
<tr>
<td>Chaos and evolutionary theory</td>
<td>Learning, Environmental</td>
</tr>
<tr>
<td>Institutional theory</td>
<td>Environmental, Power or Cognitive</td>
</tr>
<tr>
<td>Entrepreneurship (venturing)</td>
<td>Environmental, Entrepreneurial</td>
</tr>
<tr>
<td>Revolutionary change</td>
<td>Configuration, Entrepreneurial</td>
</tr>
<tr>
<td>Negotiated strategy</td>
<td>Power, Positioning</td>
</tr>
<tr>
<td>Strategic maneuvering</td>
<td>Positioning, Power</td>
</tr>
</tbody>
</table>

Figure 15: Blending approaches of strategy formulation schools (Mintzberg & Lampel, 1999: 26)

Having illustrated various schools and approaches, the emerging question is if they represent different strategy processes or complementary parts of the same process. Mintzberg & Lampel (1999: 27) come to the conclusion that most schools partly represent aspects of what can be referred to as strategy formulation, which is in sum “judgmental designing, intuitive visioning and emergent learning; it is about transformation as well as perpetuation; it must involve individual cognition and social interaction, cooperative as well as conflict-
ual; it has to include analyzing before and programming after as well as negotiating during; and all this must be in response to what may be a demanding environment” (Mintzberg & Lampel, 1999: 27). Strategy formulation as a single process is depicted in Figure 16.

Figure 16: Strategy formation as a single process (compare Mintzberg & Lampel, 1999: 27)

Although that Mintzberg and Lampel point out to consider all aspects in strategy formulation, there are approaches that are more in alignment with the understanding of strategic management and strategy of this work than others. Therefore in the next chapter the ten mentioned schools will be evaluated to identify the essential schools which tend to be a basis for this thesis.

2.1.2.3 Evaluation & Conclusion

The evaluation criteria to evaluate the ten strategy formulation schools are based on one hand on the basic strategic management criteria to understand a company in terms of complexity, systemic interaction and evolution shown in chapter 2.1.1.3. On the other hand the criteria are based on the understanding of the term strategy setting direction, focusing efforts, allowing the organization to be defined and providing consistency in a balanced manner as shown in chapter 2.1.2.1. The evaluation of the ten schools with these seven criteria is shown in Figure 17 and discussed in the following:
Figure 17: Evaluation of strategy formulation schools

_Fulfillment of strategic management specific criteria:_ In Figure 17 it can be seen that there is no approach that fulfills the three criteria of strategic management explicitly. Only three schools implicitly support the strategic management criteria: The design school and planning school, which are very similar, have a procedure to understand the company with detailed process steps and checklists. This could allow having a good understanding of the company as a whole. Nevertheless the proceeding is not focused on an understanding of the complexity, systemic interaction and evolution. Therefore these two schools can only implicitly provide an understanding of the three strategic management criteria. The cognitive school does try to understand the company with models but does not explicitly try to understand the three strategic management specific criteria.

_Fulfillment of strategy specific criteria:_ These four criteria are not fulfilled by any one school completely. There are five schools that very nearly fulfill all the strategy specific criteria: The design school, planning school, positioning school, cognitive school and configuration school. These five schools are characterized by the fact that they have a similar understanding of a strategy. This signifies that the direction is clear, the focused efforts are defined and consistency is ensured. Despite this clear statement of a strategy there is no strategy formulation process that gives a clear understanding of how a strategy should allow defining the organization.

The design, planning and cognitive school have the most common regarding how a strategy formulation concept should be designed according to the seven criteria. The design and planning school are the most interesting because of their systematic checklists and the cognitive school is a good basis with its concept to model a system. Therefore in the further chapters only strategic concepts are presented in the innovation specific context that are based on the design, planning or cognitive school.
2.1.3 Innovation and Innovation Management

Before detailing the term innovation strategy and describing possible innovation strategy formulation processes it is first of all essential to describe the term innovation and innovation management to find out what the essential criteria are to notice in innovation management (see Figure 9) and which are essential for formulating an innovation strategy. On this note the term innovation is first of all defined in the following.

2.1.3.1 Innovation

‘Innovation’ is a modern term (Hauschildt, 1997), which due to its multiple use in everyday speech and research is defined and interpreted very different. However, the term is no invention in recent years. The application area of innovation has appeared in literature already for more then half a century. The sense of the term has steadily changed during this time. In following are selected definition approaches, which document the development:

- “If, instead of quantities of factors, we vary the form of the production function, then we have an innovation” (Schumpeter, 1939: 87)
- “An innovation is defined as any thought, behavior, or thing that is new because it is qualitatively different from existing forms” (Barnett, 1953: 7)
- “We suggest defining innovation as the first or early use of an idea by one set of organizations with similar goals” (Becker & Whisler, 1967: 463)
- “Innovations are the units of technological change” (Marquis, 1969: 1)
- Innovation is the first (economic) use of an invention. The invention should not necessarily have emerged from research and development in science, but comprehends also novel objects and processes of business administration and social science in the broadest sense. (translated from Witte, 1973: 17)
- “Technical innovation in industry is the development, commercialization, adoption and improvement of product and production processes” (Pavitt, 1980: 1).
- “Innovation is the effort to create purposeful, focused change in an enterprise’s economic or social potential” (Drucker, 1985: 67)
- “Innovation is the battle in the marketplace between innovators or attackers trying to make money by changing the order of things, and defenders protecting their existing cash flow” (Foster 1986: 20)
- “Innovation consists of the generation of a new idea and its implementation into a new product, process, or service, leading to the dynamic growth of the national economy and the increase of employment as well as to a creation of pure profit for the innovative business enterprise” (Urabe, 1988: 3)
• “Innovation is a new way of doing things that is commercialized. The process of innovation cannot be separated from a firm's strategic and competitive context” (Porter, 1990: 780)

• “Innovation is defined as adoption of an internally generated purchased device, system, policy, program, process, product or service that is new to the adopting organization” (Damanpour, 1991: 556)

• “Innovation is the purposeful implementation of new technical, economical, organizational and social problem solutions, that are oriented to achieve the company objectives in a new way (translated from Vahs & Burmester, 1999: 1)

The above definitions can be categorized according to their meaning. The differences are obviously due to the fact that the term innovation has changed over the years. When in the past one detail was considered, today many aspects are. Additionally nowadays the term innovation is much more success oriented than it was in the past.

The definition by Schumpeter (1939: 87) which describes innovation as variation of factors, was still a little vague. By the time the term of innovation was specified, such as could be seen in Figure 18. In this figure the definition of Witte (1973: 17) stands out. He was for his time very progressive and was already very near to the present understanding of innovation.

Figure 18: Evolution of the term innovation during time (adapted from Schaad, 2001: 14)
Additional is it possible to see, based on the listed citations, that in the sixties and seventies the term innovation was understood as a form of a changing process\(^{38}\). In the late seventies the term seemed to be more refined. More and more the preconditioned success of an innovation was part of the definition. This is reflected in the terms ‘effectiveness’, ‘profitability’, and ‘customer satisfaction’. The changes of the understanding of innovation are certainly influenced by the effect of new constellations in the environment that are caused through increased competition, the changes in the market environment and the dynamic technology change. A definition, appropriated today, of the term ‘innovation’ could be defined in agreement with actual literature according to Schaad (2001: 15):

*Innovation is a first successful commercial use of something new by an enterprise.*

This attempt to define innovation is understood as an underlying working definition and is used in this work.

In the next chapters the term innovation will be analyzed from several points of view. In doing so the author wants to explain on the one hand the term innovation more in detail and its importance for companies. On the other hand the discussion about innovation allows essential aspects to be considered in developing a strategy in the domain of innovation to be identified. The summary of these aspects to consider will be summarized in chapter 2.1.3.7.

### 2.1.3.2 Innovativeness and Innovation Barriers

To develop innovations, according to the above definition, the company has to be innovative. Whereas according to Tschirky (1998a: 9) innovativeness can be understood as the ability of individuals and organizations to be aware of changes in order to realize renewals early and anticipate. This means for a company that it should be able to use their potential capabilities\(^{39}\) to create new products and processes and for commercializing them (Wagner & Kreuter, 1998: 34).

For an innovation driven company a high degree of innovativeness is therefore essential. To reach this objective of a high degree of innovativeness, so called innovation barriers have to be mastered. According to Bond and Houston (2003: 125) such innovation barriers

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\(^{38}\) Compare for that purpose Marquis (1969: 1)

\(^{39}\) According to Sanchez (Sanchez, 2001) “capabilities are repeatable patterns of action that an organization can use to get things done. Capabilities reside in groups of people in an organization who can work together to do things. Capabilities are thus a special kind of asset, because capabilities use or operate on other kinds of assets (like machines and the skills of individuals) in the process of getting things done”.
can be regrouped in three groups that are presented in the following. This overview should be seen as exemplary and not as a complete overview of the literature:\footnote{The following literature could be taken for a more detailed discussion about innovation barriers: Stahl & Eichen (2003: 16f); Afuah (1998: 97ff, 217ff); Biermann (1997: 38ff); Bullinger & Auernhammer (2003: 34)}:

- **Technology and market barriers** address issues of whether a technology can be applied to meet a customer need at a profit. In this category of barriers there are on one side technology barriers to be mastered, such as the availability of the required technologies. On the other side it is essential to be aware of market barriers, such as developing the optimal business model to commercialize new products based on emerging technologies. These two more or less detached innovation barriers are accompanied by a more comprehensive barrier, the technology-market linkage, understood as the degree to which the technology can be matched to customer demand within a current or potential market opportunity.

- **Strategy and structure barriers** focus on the roles played by the firm’s technology capabilities, strategies, and supporting organizational structures in successfully deploying a technology to meet a market need. This means that problems in innovation can occur through the lack of capabilities to develop a technology, the limited resources or the missing link of innovations to companies and business unit strategy and therefore the missing link to their actual portfolios. These barriers could be enforced by a lack of an innovation strategy (see Figure 2) (Kambil, 2002). Exemplarily effects of a lack of strategy are where the resources are not focused and are therefore even more limited for important projects, and that very important capabilities are not systematically developed with a goal oriented focus.

- **Social and cultural barriers** account for the effects of differences in frames of reference, values, and goals in matching technologies to market opportunities. These innovation barriers have their origin in the different interpretation and communication of functional specialist, which have differences among their beliefs (Dougherty, 1992). This innovation barrier is especially important in the context of the functional units of marketing and R&D, because they are mainly responsible for innovation. In this context Souder (2004: 602) has identifies in a survey including 289 projects that the harmony between R&D, responsible for the future technologies, and marketing, responsible for the identification of customer demand, is not working optimally. In 59.2% a mild to severe disharmony between R&D and marketing was ascertained (see Figure 19). This disharmony is an innovation barrier in terms of aligning market pulls, understood as the development of technologies due to a concrete market need, and technology pushes, understood as the development of technologies creating a new market opportunity.
need. Whereas the alignment of technology push and market pull is very important in developing innovations (Tschirky, 1998b: 251f).

![Figure 19: Incidence of harmony and disharmony states between marketing and R&D (compare Souder, 2004: 602)](image)

These various and multifaceted innovation barriers often hinder companies from being able to reach a high degree of innovativeness. Furthermore, additionally to these innovation barriers, the companies are facing the fact that the required degree of innovativeness is increasing with time, to be able to successfully persist in the competition with competitors.\(^{41}\)

To develop nevertheless a high degree of innovativeness there is no single best way “however there are a number of consistent themes, which provide a blueprint from which to try and configure innovative organizations” (Bessant, 2003: 35). According to Bessant (2003: 35f) the essential factors to be aware of to create an innovative organization are multifaceted and summarized in Figure 20. In this context Meier et al. (upcoming 2004: 2f) propose a seven folded categorization of innovation enablers: strategy, resources, processes, methods, tools, organization and culture.

The augmentation of innovativeness is not accomplishable in short time and sensible interactions in the organizations have to be taken into account. In this context Sommerlatte et al. (1987: 57) points out that “innovativeness cannot be ‘bred’ like a truffle. It does not suffice, just when it is economically and politically opportune, wanting to turn on the innovation tap, by adapting one or another factor.”\(^{42}\) The long time horizon that is aligned with the innovativeness is additionally emphasized with the following statement from Gassmann et

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42 Translated from German
al. (1996: 39):” Successful enterprises know that innovation is no lucky chance, but the result of innovativeness – the ability, continuously and systematically developing new customer value and commercialize it”

<table>
<thead>
<tr>
<th>Factor</th>
<th>Influence on innovative behavior</th>
<th>Level of importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivation</td>
<td></td>
<td>Normative Strategic Operational</td>
</tr>
<tr>
<td>Availability of ‘slack’ resources</td>
<td></td>
<td>Operational</td>
</tr>
<tr>
<td>Leadership</td>
<td></td>
<td>Normative Strategic</td>
</tr>
<tr>
<td>Direction</td>
<td></td>
<td>Normative Strategic</td>
</tr>
<tr>
<td>Self-development</td>
<td></td>
<td>Operational</td>
</tr>
<tr>
<td>Enabling tools and resources</td>
<td></td>
<td>Strategic Operational</td>
</tr>
<tr>
<td>Communication and information exchange</td>
<td></td>
<td>Strategic Operational</td>
</tr>
<tr>
<td>Knowledge management</td>
<td></td>
<td>Operational</td>
</tr>
<tr>
<td>Cross boundary work</td>
<td></td>
<td>Strategic Operational</td>
</tr>
<tr>
<td>Appropriate structures</td>
<td></td>
<td>Strategic</td>
</tr>
<tr>
<td>Team work</td>
<td></td>
<td>Operational</td>
</tr>
<tr>
<td>Learning</td>
<td></td>
<td>Strategic Operational</td>
</tr>
</tbody>
</table>

**Figure 20: Creating an innovative organization (compare Bessant, 2003: 35f)**

The presented factors in Figure 20 are the basic factors for creating an innovative organization and therefore to increase the innovativeness on different company levels. The break up into normative, strategic and operational level allows the identification the essential criteria to consider on each level. Because this work focuses on the strategic level mainly the strategic criteria are essential for this work.

2.1.3.3 Newness of Innovation

Innovations are not always new in the same degree of novelty. As a “real” innovation we would primarily consider the development of the steam engine, the electrical motor or the telephone. But the walkman is also an innovation. Batteries, magnets and earphones already

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43 Translated from German
Innovation existed. The new element was the idea of portable entertainment, which allows music to be listened to anywhere. The development of the walkman is therefore a new combination of existing elements, a rearrangement. Is a cooker with a glass-ceramic surface, compared to the already existing resistance heater with the steel hob, a major or a small innovation? What about the inductive hob of the microwave oven? In this context Abernathy & Clark (1985: 4) noted that “some innovations disrupt, destroy and make obsolete established competence; others refine and improve”. They are different in their degree of novelty. This difference of their degree of novelty is defined by the qualitative difference of an innovation compared to the previous state (Hauschildt, 1993: 39). Innovations with a high or low degree of novelty can be distinguished by the innovation type. Theses so called innovation types are defined by different authors. The principle taxonomy of the innovation types is slightly different comparing the authors’ use of terminology. In Figure 21 some examples of this understanding are presented.

In the area of a high degree of novelty the definitions are basically in accordance. In the case of the definitions for a low degree of novelty it is important to note Mensch’s (1975: 54) definition, which points out with the innovation type ‘pretended innovation’, which is at the limit of not being a novelty, that the limit of innovations is flowing. Tushman and Anderson (1997: 157) establish furthermore the term of ‘architectural innovation’44, which

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44 “Architectural innovation is the reconfiguration of an established system to link together existing components in a new way” (Henderson & Clark, 1990: 12)
indicates a middle degree of novelty. Summarizing the three main degrees of novelty, they can be described as follows:

- **Low degree of novelty** are ameliorations or modifications of the actual performance

- **Middle degree of novelty** is a new combinations based on already existing elements

- **High degree of novelty** is a completely new performance

Behind these definitions of the degree of novelty are different viewpoints. Some authors are more influenced by a technology view, such as Rosenberg (1995: 180) and Tushman & Anderson (1997: 157). The authors with a market-based viewpoint are Knight (1967: 484) and Ehrer (1994: 8). Seibert (1998: 112) has a mixed viewpoint, in which he points out, that innovations with a high degree of novelty are based on a ‘technology push’ and should be defined therefore by a technology point of view. The more frequent lower innovations with a low degree of novelty are mainly ‘market pull’ and their definition should be done from a market point of view.

The question, for example of how innovative the implementation of the SBB Easy-Ride-Ticket is, after Swiss already implemented E-Ticketing and the fast-track more than three years ago. This is still in spite of the definition of the degree of novelty, not easy to answer, because it has to be taken into account from which point of view the question has to be answered: Without a doubt from Swiss’s and the SBB’s point of view their new ticketing generation is an innovation with a high degree of novelty. The answer to this question of the degree of novelty for both innovations has therefore to be analyzed from several points of view. The point is to detect, for which group a novelty is innovative. Basically the points of view must be differentiated.

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45 In the term ‘low degree of novelty’ ‘minor innovation’, ‘routine innovation’, ‘adopted innovation’, ‘pretended innovation’, ‘incremental innovation’ and ‘cost reduction’ shown in Figure 21 are summarized.

46 In the term ‘middle degree of novelty’ ‘architectural innovation’ and partly ‘ameliorated innovation’ as well as ‘further development’ shown in Figure 21 are summarized.

47 In the term ‘high degree of novelty’ ‘radical innovation’, ‘non-routine innovation’, ‘original innovation’, ‘new development’, ‘basic innovation’, ‘breakthrough innovation’ and ‘discontinues innovation’ shown in Figure 21 are summarized.

48 The SBB (Swiss national Railway) passengers should be able to go into the railway car without paying in advance. The passenger would be identified at the entrance or exit of the cars. Data is submitted to a central system that automatically collects the fee from the passengers.

49 The Swiss offers their customers the service of entering the airplane without taking a boarding pass from check-in. The passengers get an electronic boarding pass, which has an electronic key inside. With this key the check-in is done automatically at passport control. With this system, short connection times are very simple, because no “material” ticket has to be changed.
An initial differentiation is an evaluation of the degree of novelty of an innovation by doing it from inside of a company, which is also described as the micro-economic point of view. In doing so the degree of novelty is exclusively defined out of a subjective perspective of the considered company. A micro-economic innovation is therefore an innovation where a change for the specific company is new. For this reason imitations or adaptations of external developments are also considered as innovations. Therefore it is not important, how long the considered innovation has existed in other places.

A second differentiation of the degree of novelty is the macro-economic view (Kaplaner, 1986: 15). The degree of novelty is evaluated by comparing the innovation to the total offers on the market. The degree of novelty is in this case the highest when it is a worldwide successful renewal. A more restricted macro-economic view is proposes by Hausschildt (1993: 15), the industry-economic view. This view restricts the evaluation of the degree of novelty to the relevant environment. Therefore a high degree of innovation can be reached if in the same industry there is no comparable renewal. Swiss and the SBB, to come back to the examples of the new ticket machines, are both acting in the domain of transportation, but their environment is totally different, and therefore their industry-economics is different. Therefore from an industry-economic point of view both developments are innovations with a high degree of novelty.

![Figure 22: The degree of novelty of innovation from macro- and micro-economical point of view (adapted from Booz, Allen, & Hamilton, 1982: 9)](image)

Figure 22 presents selected innovations according to their degree of novelty from micro- and macro-economic point of view. This figure positions, in terms of conceptualization, the

different types of innovations adapted from Booz, Allen, & Hamilton (1982: 9). Figure 22 shows with which percentage companies are developing in tendency toward different types of innovation. It is obvious that from the micro-economic point of view 30% and from macro-economic point of view only 10% of all the activities have a high degree of novelty. Therefore 70% from micro-economic and 90% from macro-economic point of view indicated only middle to low degree of novelty in their innovation activities. Interpreting this result leads to the conclusion that companies do more often develop innovations with a low or middle degree of novelty, independent from which point of view.

Following in this work, the degree of novelty from the micro-economical point of view is used, because this view directly indicates the extent of influences on company level which has to be mentioned in strategic decisions. Therefore a strategic decision has to consider the degree of novelty. Especially because the higher the degree of novelty, the more changes have to be accepted in known elements, such as market needs, products of technologies and therefore the more extensive the strategic decision has to be taken. To understand this relation between the degree of novelty and the extent of the changes to be made, different innovation types, incremental and radical innovations, are analyzed on different levels according to Kroy (1995: 63) including customer needs, markets, products and services, capabilities and basic science (see Figure 23).

![Diagram](Figure 23: Effects on different levels of a company, activated by different innovation types (adapted from Kroy, 1995: 63))

For each innovation type it is possible to make an integrated connection between different company levels as shown in Figure 23. From the level of basic science, technologies are derived, which allow the company to develop products and services. With these products and services it is possible to enter into a market and satisfy a customer need. For each innovation it is therefore possible to find an explicit connection between different levels in the company, which represent a system.
An incremental innovation represents a novelty that is based on existing products and services. Different parameters are modified or optimized on each level. For example a subsequent technology is used to develop a new product or a product is changed in terms of new customer needs in a market. The connections between the different levels are therefore not detached, but only horizontally adjusted. Whereas radical innovations do not have all the vertically connections between the different levels from the beginning. The innovation challenge of radical innovations is therefore primarily to develop the connections between the different levels. From each level an innovation could be triggered, whereas Leifer et. al. (2000: 20) points out, that “the project [for radical innovations] often starts in R&D, migrates into some sort of incubating organization, and transitions into a goal-driven project organization”. The project duration is also longer for radical innovations, with an average of 10 years, then for incremental innovations, with an duration of 6 month to 2 years (Leifer, McDermott, O’Connor, Peters, Rice, & Veryzer, 2000: 19). These differences in the project duration are mainly explained by the fact that for incremental innovation a more detailed plan could be developed which has relatively few uncertainties, while radical innovation are developed slowly during different uncertain life cycles.

Despite the uncertainties of radical innovations, which makes a decision more difficult, it is essential for companies to develop incremental as well as radical innovations as Berth (2003) found through a survey. First he found that radical innovations have on the average a higher return then incremental innovation. But much more interesting is a second point mentioned in the survey, that although the uncertainties are higher of radical innovations the flop rate was the same then for incremental innovations (see Figure 24). Therefore a conclusion of the survey is that companies have to be more aware of radical innovations and include them in strategic decisions more explicitly.

<table>
<thead>
<tr>
<th></th>
<th>Appreciation of manager</th>
<th>Return expectation of manager</th>
<th>Real achieved return</th>
<th>Flop rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Incremental Innovations</strong></td>
<td>Adopted Innovations</td>
<td>high</td>
<td>14,9</td>
<td>6,9</td>
</tr>
<tr>
<td></td>
<td>Renewals</td>
<td>middle</td>
<td>15,1</td>
<td>11,8</td>
</tr>
<tr>
<td><strong>Radical Innovations</strong></td>
<td>Breakthrough</td>
<td>low</td>
<td>9,1</td>
<td>14,7</td>
</tr>
<tr>
<td></td>
<td>Vision, Mission</td>
<td>declining</td>
<td>3,2</td>
<td>19,9</td>
</tr>
</tbody>
</table>

*Figure 24: Survey of radical and incremental innovations (adapted from Berth, 2003: 18)*

51 Leifer et. al. (Leifer, McDermott, O’Connor, Peters, Rice, & Veryzer, 2000) differentiate between incremental and radical innovations in the dimension of the business case: „Business case [incremental innovation]: A compete and detailed plan can be developed at the beginning of the process because of the relatively low level of uncertainty. [Radical innovation]: The business model evolves through discovery-based technical and market leanings and likewise he business plan must evolve as uncertainty is reduced“.
Therefore a strategic decision has to mention radical as well as incremental innovations whereas in the case of radical innovation the planning is more extensive. A decision about radical innovation has to be detailed more extensively from the beginning, in order to connect Kroy’s (1995) levels as early as possible. Therefore the strategic planning of radical as well as incremental innovation has to be considered on a strategic management level. A concept of formulating an innovation strategy has to consider incremental as well as radical innovations, therefore the newness of an innovation has to be considered.

2.1.3.4 Object of the Innovation

After the characterization of innovations by their degree of novelty in the last chapter, the innovations will be categorized in this chapter by the considered object, in terms of its concerns in innovation development activities. The term of innovation does not generally consider only the product-market field, but also process, management and organizational aspects. Therefore the term of innovation is differentiated by their different objects. In the following the borders between the different categories of innovations are compared.

Thom (1980: 22ff) proposes a differentiation of innovation into “product innovation”, “process innovation” and “social innovation”. Kaplaner (1986: 9) adds to this triple the term of “structural innovation”. Knight’s (1967: 486) categorization encompasses near product-, process- and organizational focus also aspects of the human resources area by the definition of “people innovation”. “People innovation” comprises changes in company staff by acquisitions or dismissals, as well as the wanton change of behaviours. A classification into business, technological and organizational innovations is proposed by Zahn & Weidler (1995: 359). The authors cover a holistic and integrated approach with their definition of innovation (see Figure 25).

![Figure 25: Integrated innovation understanding of the innovation categories (Zahn & Weidler, 1995: 259)](image-url)
Zahn & Weidler (1995: 359) describe categories of innovation which show a differentiated categorization then the other presented authors. This is very clear in the integration of products and processes into one common innovation category, the ‘technological innovation’. Zahn & Weidler additionally integrate new – which was until this concept unappreciated - aspects, such as ‘business innovation’, and also the ‘culture’ and ‘system’. Mentionable is also the explicit achievement of ‘technological knowledge’ that is the basis for developing technological competencies in a company.

The differentiation of the innovation into these categories suggests that the innovations appear individually. But, for example, product innovations nearly in every case appear with process innovations (Rammert, 1988: 199). So a new product often also demands a modification or renewal of the processes. Utterback (1994: 217) proposes therefore that “success […] requires equal emphasis on production and process design, which must be closely integrated”. In this context Pfeiffer (1991: 43) found that companies posses excellent product innovations, but they do not actively profit in their competitive position. One reason for this could be according to Wheelwright & Clark (1992: 73) that “often [in] development projects, mean product development projects, the assumption being that process technology can be acquired easily if and when the need for it becomes obvious. Unfortunately, such a view results frequently in the full benefits of the product technology never being realized - the manufacturing process simply cannot deliver the quality, cost, or timeliness the product requires”.

To conclude, it is necessary to divide innovations into categories to be aware of the possibilities, but in terms of realization, all the innovation categories have to be considered and developed together. This consideration of the innovation categories together is called ‘integrated innovation’. This integrated innovation approach recovers any overlapping of business, organizational or technological innovations. In doing so the resulting innovations have a broader innovation range, additional protection against imitation and thus allow companies to gain sustainable competitive advantage by differentiating themselves (Zahn & Weidler, 1995: 359).

This integrated approach of innovations is an important element to consider in strategic decisions. Therefore an innovation strategy formulation concept should allow defining business, technological as well as organizational innovations to be defined in terms of integral innovations.

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52 In contrast to this strategy is the Japanese approach where they follow the contrary strategy in general according to Albach, Pay, & Okamuro (1991: 309ff).
2.1.3.5 Innovation Management

The term ‘innovation management’ is used often in literature, but the term changes in the understanding of its tasks and responsibilities (Hoffmann-Pipken, 2003: 91). Therefore the term innovation management is described in this sub-chapter in more detail.

In chapter 2.1.1 strategic management is described as having to design, direct and develop the company based on a clear understanding of systems complexity, systemic interactions and evolution. In the context of managing innovations it is also necessary to understand the complexity, systemic interactions and evolution of the system. At this point the question is coming up, what is the exact system to be understood?

In this context Brockhoff (1995: 986) distinguishes between an institutional and a functional view of innovation management. These two views are different in their system boundaries. The institutional innovation management says that the responsibility of innovation in a company is reduced to a group of people. This view is criticized because of the fact that innovation can be generated by every person in the company. Contrary to this view, the functional view can be taken into account which is divided into the system theoretical view and the process view (Hauschildt, 1993: 23; Brockhoff, 1995: 987). The system theoretical view is concerned with the system, in which innovations have to be developed and analyzed, such as the organization, the context and culture. The literature in this domain, which is concerned especially with organizational theory as well as cultural problems, is somewhat unmanageable. This is because the system theoretical view of innovation management is defined too broadly (Hoffmann-Pipken, 2003: 92). The process view of innovation management is primarily concerned with the decision about innovations, how innovations are implemented in the company and how innovations are developed. In this context Hauschildt (1997: 25) defines the task of innovation management as how to develop the individual innovation processes in an anticipative manner. These processes are the formulation of an innovation strategy and the organizational design of an innovation organization including the processes utilized to realize the innovation intentions.

Based on the process view, an understanding of the innovation system attempted: Innovation processes, part of the innovation system, define values (Tipotsch, 1997: 55), and the processes of sales, production and supply chain, as part of the delivery system, provide values (Tipotsch, 1997: 55). Therefore the ‘innovation system’ has the aim to define values and the ‘delivery system’ has the aim to provide values. These two subsystems create together new values which leads to the concept of value creation by Porter (1985: 37) (see 53

53 The author has translated the German word “dispositiv” used by Hauschildt (1997: 25) with anticipative.

54 Tipotsch (1997: 55) additionally mentions management processes and support processes. But based on the process view (Hauschildt, 1993: 23; Brockhoff, 1995: 987) innovation management is part of the innovation system. Therefore in this work the management and support processes are added to the innovation and delivery processes.
Figure 26). Therefore the sub-system in a company that is concerned with innovation, consists of value defining processes which conclude that innovation management has to design, direct and develop the innovation system, based on a clear understanding of innovation systems’ complexity, systemic interaction and evolution.

Figure 26: Value creation is the addition of defining value and providing value (based on Tippotsch, 1997: 55)

At first glance this description of innovation management could be seen as a complete definition, but there is still an open question to be answered before doing so: What elements have exactly to be understood in the innovation system in terms of complexity, systemic interaction and evolution? In this context Afuah (1998: 14) and Bessant (2003: 6) argue that knowledge is the essential element to consider in the innovation system. Therefore in the next sub-chapter a more detailed discussion about knowledge is presented.

2.1.3.6 Knowledge

According to Davis and Botkin (1994: 166) data comes to us in four different forms: numbers, words, sounds, and images. They are worthless until they are related in a particular context. Information is analyzed data that has been arranged into meaningful, object-oriented patterns. The value and usefulness of information depends on the absorptive capacity of the recipient (Cohen & Levinthal, 1990: 132). Once the recipient assimilates, interprets, evaluates and uses information, we can talk about knowledge (Koruna, 2001a: 100).

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55 This chapter is partly based on Savioz (2002: 10ff)
56 ‘Absorptive capacity’ is understood as “the ability to evaluate and utilize outside knowledge” (Cohen & Levinthal, 1990: 128).
57 For further discussion about knowledge see Koruna (1999: 43) and Wiegand (1996: 162)
In this thesis, knowledge is understood as the totality of experience, cognition and skills of individuals to solve a problem. Thus, knowledge is always action-oriented and personal. Speaking about the knowledge of the company, Probst et al. (1999: 46) defines “the organizational knowledge base as the totality of individual and collective experience, cognition and skills to which the organization can access in order to solve a problem, including all underlying data and information”.

The transfer and interaction of data, information and knowledge is shown in Figure 27. Accepting this model, a direct and formal transfer of knowledge from one individual to another individual, and therefore to the company, is not possible. In fact, parts of knowledge should be abstracted and decoded in order to be transferred at a lower level. This mechanism of interaction should be understood as a continuum between the different levels (Probst, Raub, & Romhardt, 1999: 39).

Since the receiver has to reinterpret the information in turn, a part of the original significance gets lost (Boisot, 1983: 165; 1998: 14). Furthermore, Polanyi (1966: 4) argues that just a part of knowledge can be articulated (explicit knowledge) and therefore be transferred as shown in Figure 27. Implicit knowledge, on the other hand, can be neither easily articulated, nor transferred via information or data, but can only be transferred through direct interaction between individuals via metaphors and analogies. Nonaka & Takeuchi (1995: 62) adopt this epistemology (theory of cognition) and describe in detail four modes of how knowledge can be converted: from tacit to tacit (socialization), from tacit to explicit (externalization), from explicit to explicit (combination) and from explicit to tacit (internaliza-
Innovation Strategy Formulation Process

In addition, they argue that an iterative interaction between tacit and explicit knowledge (the knowledge spiral) becomes larger in scale as it moves up the ontological levels from an individual to a higher level (see Figure 28).

Figure 28: Spiral of organizational knowledge creation (Nonaka & Takeuchi, 1995: 73)

This evolution of knowledge and knowledge creation enriches the organizational knowledge base in quality and quantity, and therefore could be interpreted as organizational learning (Probst, Raub, & Romhardt, 1999: 46). The effectiveness and efficiency of organizational learning depends on the absorptive capacity of the firm (Cohen & Levinthal, 1990: 131), on the company culture (Cook & Yanow, 1996: 448) and on the capability of the company to apply insight from mature to new concepts (Senge, 1990: 174). Junnarkar (1997: 32) argues that the company’s challenge is to be able to take the learning from successful, mature concepts and apply it to other mature concepts. He calls this adaptive learning. Concurrently, organizations need to foster generative learning. This will be manifested by the number of new concepts which are born in the organization and are nurtured. Moreover, he argues that these different types of learning need different skills within the organization.

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59 In its proper definition, knowledge is created by one individual. However, the organization supports this knowledge creation, which therefore, should be understood as process (Nonaka & Takeuchi, 1995: 74).


61 Adaptive learning might be understood as single-loop learning (Argyris & Schön, 1879: 18).

62 Generative learning might be understood as double-loop learning (Argyris & Schön, 1879: 22).

63 Compare (Mintzberg, 1994: 114)
to mature concepts needs both, more complete information and a higher clarity of understanding (Figure 29).

![Figure 29: Adaptive learning versus generative learning (adapted from Junnarkar, 1997: 135)](image)

According to several authors knowledge is the overwhelmingly important productive resource in terms of market value and the primary source of competitive advantage. In this context Warnecke (2003: 11) noted that the capability of managing this knowledge will be the competitive decisive factor in building the preconditions for economic success and to create innovations. Therefore in the innovation system of a company, knowledge is the essential element to consider. In this context Afuah (1998: 14) argues that “knowledge underpins a firm’s ability to offer products, a change in knowledge implies a change in the firm’s ability to offer a new product” and Bessant (2003: 6) noted that “knowledge provides the fuel for innovations”. Therefore “a company which wants to innovate needs knowledge” (Bullinger, 2003: 261). These insights about the importance of knowledge in the innovation system derives the conclusion that innovation management has to understand first of all the complexity, systemic interaction and evolution of the knowledge in the innovation system (innovation relevant knowledge). This understanding of knowledge is a major challenge because knowledge is characterized by a high degree of complexity (Schlaak, 1999: 42; Kuivalainen, Kyläheiko, Puimalainen, & Saarenketo, 2003: 242) and intransparency (Kroy, 1995: 77).

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64 See Machlup (1980); Nonaka (1991: 96); Krog et al. (1998: 126) and Grant (1996: 163; 2003: 201)
2.1.3.7 Conclusion

In a sum, innovation management has to design, direct and develop the innovation system of the company based on a clear understanding of the complexity, systemic interaction and evolution of the innovation relevant knowledge. Furthermore innovation management has to consider the strategic innovation relevant criteria mentioned in the chapters 2.1.3.1 up to 2.1.3.6. These criteria to consider are:

- Innovation barriers (see chapter 2.1.3.2)
- Innovation newness (see chapter 2.1.3.3)
- Integral innovation (see chapter 2.1.3.4)
- Innovation relevant knowledge (see chapter 2.1.3.6)

Before closing the innovation management chapter it is important to briefly analyze the boundaries between innovation management, technology management, research and development (R&D Management).

Technology management “links engineering, science, and management discipline to plan, develop, and implement technological capabilities to shape and accomplish the strategic and operational objectives of an organization” according to the US National Research Council (NRC 1987: 9). Therefore overlaps between innovation and technology management exist in the case that the subject are new technologies.

The management of R&D (Boutellier, Gassmann, & Zedtwitz, 1999; Brockhoff, 1999) is only one aspect of innovation management. In innovation management there are different projects whereas some of them are concerned with R&D tasks. Therefore R&D Management is exclusively the management of scientific technical projects (Hauschildt, 1993: 25).

2.1.4 Innovation Strategy and Innovation Strategy Formulation

In literature, the term ‘innovation strategy’ is rather a new term and was rarely used in the past (Hoffmann-Ripken, 2003: 94). In consideration of the fact that innovation is considered in the strategic context as important, on the business level as well as on the economic level, there is not published much about innovation strategy (Gilbert, 1994: 16). The reason for this is probably firstly the deficiency on methodological concepts that integrates strategy into innovation (Olschowy, 1990: 32). Secondly, theoretically developed concepts of integrated innovation management have not been accepted in practice (compare Thom, 1976).
In spit of the fact that the term innovation strategy is not commonly used in literature there are some indications that the subject of innovation strategy has been developing in the last five years. Many recent authors consider an innovation strategy as important (see chapter 1.1), and provide definitions of the term innovation strategy. These definitions are the subject of the next subchapter.

2.1.4.1 Innovation Strategy

In the following some definitions of innovation strategy are listed that differ in its extent. These definitions about innovation strategy do not claim to be complete, but they are representative for the understanding in literature of the term innovation strategy and related terms:

- “The innovation strategy is a description of the innovation process, which comprehends action oriented or/and action descriptions statements which are fitted to the organizational context of the innovation processes (objectives, members, structures, performances, boundaries and environment)”\(^{65}\): Aregger (1976: 118)
- “An innovation strategy tells us what actions a firm will take, when, and how it allocates its innovation resources”: Afuah (1998: 99)
- “An innovation strategy defines the long term objectives and fundamental directions of the innovation activities of the company and is therefore an integral part of the strategic fundamental direction of the company”\(^{66}\): Schlegelmilch (1999: 106)
- “An innovation strategy must cope with an external environment that is complex and ever-changing, with considerable uncertainties about present and future developments in technology, competitive threats and market (and non-market) demands”: Tidd, Bessant, & Pavitt (2001: 65)
- “Patterns of activities about when and how to use new knowledge to offer products of services”: Afuah (2002: 369)
- “An innovation oriented strategy creates new products and processes as well as new forms of client interaction. The objective is not to pass the competitors on the same path, but to pass him in an innovative way to ensure the company’s sustainable competitive advantage. (...) In the focus of the innovation oriented strategy are not only products, but also production processes and company structures have to be considered”\(^{67}\): Bullinger & Auernhammer (2003: 29)

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65 Translated from German
66 Translated from German
67 Translated from German
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- “An innovation strategy defines on a contextual level on the one hand the degree of newness and the direction of the aimed innovations. On the other hand the innovation strategy defines innovation type and its contribution to the company development. On a process level the innovation strategy is concerned firstly with the question of how innovation in the concept of the strategy can be integrated. Secondly, which factors the process affect that in their result will define the aimed conceptual as well as practicable application of the strategic induced and operative emergent different innovation types” 68: Hoffmann-Ripken (2003: 97)

It is obvious that these definitions of innovation strategy differ in part quite strongly. For example Schlegelmilch (1999: 106) includes only innovation activities and in contrast Bullinger & Auernhammer (2003: 29) include the change of companies’ structures as part of an innovation strategy. Because of this discord between the different authors it is difficult to find an appropriate definition of an innovation strategy. Therefore it is essential in a first step to know what the content of a general strategy is and to know the particular context of innovation which was done in chapter 2.1.2.1 for the term strategy and in chapter 2.1.3.7 for the innovation context. Based on this an innovation strategy should provide an understanding of direction, focus, organization and consistency as well as an innovation specific understanding of integral innovations, innovation barriers, innovation newness and innovation relevant knowledge. In Figure 30 these eight criteria are opposed to the above mentioned definitions of innovation strategies.

<table>
<thead>
<tr>
<th>Provide a strategy specific understanding of...</th>
<th>Direction</th>
<th>Focus</th>
<th>Organization</th>
<th>Consistency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explicit supported</td>
<td>● ● ● ●</td>
<td>● ● ● ●</td>
<td>● ● ● ●</td>
<td>● ● ● ●</td>
</tr>
<tr>
<td>Implicit or partly supported</td>
<td>□ □ □ □</td>
<td>□ □ □ □</td>
<td>□ □ □ □</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td>No support</td>
<td>○ ○ ○ ○</td>
<td>○ ○ ○ ○</td>
<td>○ ○ ○ ○</td>
<td>○ ○ ○ ○</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Providing an innovation specific understanding of...</th>
<th>Integral Innovation</th>
<th>Innovation barriers</th>
<th>Innovation newness</th>
<th>Innovation relevant knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explicit supported</td>
<td>● ● ● ●</td>
<td>● ● ● ●</td>
<td>● ● ● ●</td>
<td>● ● ● ●</td>
</tr>
<tr>
<td>Implicit or partly supported</td>
<td>□ □ □ □</td>
<td>□ □ □ □</td>
<td>□ □ □ □</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td>No support</td>
<td>○ ○ ○ ○</td>
<td>○ ○ ○ ○</td>
<td>○ ○ ○ ○</td>
<td>○ ○ ○ ○</td>
</tr>
</tbody>
</table>

Figure 30: Evaluation of innovation strategies definitions

68 Translated from German
Figure 30 shows first of all that the understanding of the term ‘innovation strategy’ differs strongly from author to author. It stands out that Afuah (1998: 99) does not especially consider innovation specific factors. On the other hand authors such as Hoffmann-Ripken (2003: 97) consider very strong innovation specific factors in their understanding of innovation strategy. A second interesting point is the trend that during the time the term of innovation strategy extended in its context. A third point is that there is one author, Afuah (2002: 369) that includes the innovation relevant knowledge in his understanding of innovation strategy.

Summarizing the different definitions of innovation strategy it can be said that the addition of these definitions considers all strategy specific and innovation specific criteria. Therefore the following definition of an innovation strategy is to be seen as a summary of the actual innovation literature and is based on the understanding of strategy (see chapter 2.1.2) and innovation management (see chapter 2.1.3) of this work:

*An innovation strategy sets direction, focuses efforts, allows the design of an organization and ensures constancy in the innovation system while considering integral innovations, innovation barriers, and the degree of newness of the innovation as well as the required innovation relevant knowledge.*

This attempt to define innovation strategy is understood as underlying working definition and is used in this work.

In the next sub-chapters the term innovation strategy will be analyzed from several points of view. In doing so the authors wants to explain on one hand the different types of innovation strategy (see sub-chapter 2.1.4.2) and on the other hand the formulation processes of an innovation strategy (see sub-chapter 2.1.4.3).

### 2.1.4.2 Types of Innovation Strategy

Neither in the innovation strategy nor in the general strategy research is there a unique understanding of the different innovation strategy types (Altmann, 2003: 44). The following overview shows different classification examples of innovation strategies in literature. It has to be mentioned that some of the following classifications are not based on the term innovation strategy but on related strategies, such as R&D strategy:

- Ansoff & Stewart (1967) (aggregation level: functional unit): First to market, follow the leader, application engineering, me-too
• Zörgiebel (1983) (aggregation level: business unit): General technology leadership, general cost leadership, segment specific technology leadership, application specialization

• Porter (1985) (aggregation level: product): First-to-market (fast follower), late-to-market (cost minimization), market segmentation (specialist)

• Servatius (1985) (aggregation level: functional unit): The combination of:
  General strategy: focus, differentiate, standardize
  Time of the market introduction: active leader, passive follower, technology position, presence, leadership
  Technology: product, operating resources

• Cooper (1985) (aggregation level: company): Technology induced strategy, balanced focus strategy, strategy with low technology risk, strategy with low capital investment, high risk diversification strategy


This heterogeneity should attempt to reduce these dimensions. Additionally this work focuses on the aggregation level of a product containing on the one side technologies and on the other side offered products for a market. This work therefore does not focus on the company, functional or business unit aggregation level. Therefore a simplified dichotomy categorization for an innovation strategy is chosen for this thesis⁶⁹:

• Market leadership
• Technology leadership

These two extreme dimensions of an innovation strategy are dependent and therefore they can be developed in one company in common. The challenge is to find the right company specific balance between these two categories in formulating an innovation strategy.

⁶⁹ According to Altmann (2003) who uses this categorization for defining a product strategy.
2.1.4.3 Innovation Strategy Formulation

Until this point the understanding of innovation strategy in this work is clear. Nevertheless there are different methods of formulating an innovation strategy. In the following, five different approaches to formulate an innovation strategy are presented\(^{70}\) that could be seen as representative but not complete in the context of innovation strategy.

Quinn (1985) assumes that innovation can and must be integrated in the concept of corporate strategy. The strategy has to be defined in which domain innovations are desired. With the aid of motivation and control systems it is possible to identify the general conditions for encouraging the creativity and entrepreneurial potential in the organization and to develop it in a goal-oriented manner (Quinn, 1985: 80f). Quinn recognizes that not all innovation activities can be planned and advises therefore a flexible strategic orientation, to identify and react spontaneously to emerging opportunities. But nevertheless it is important in the context of corporate strategy formulation to explicitly formulate an innovation strategy.

A similar approach for the formulation of an innovation strategy is presented by Martensen & Dahlgaard (1999)\(^{71}\). The underlying strategy understanding is the planning school presented in chapter 2.1.2.2. The innovation strategy is planned by the company top management in alignment with the vision and the corporate strategy. Subsequently acquisition plans and objective plans are developed, which are supported by an adequate management commitment that is communicated to all employees in the company. In this process the opportunities are evaluated with the aim to fill the innovation gap in the company. These results are part of the innovation strategy. An important point in this innovation strategy is the alignment of the objectives with the company specific culture. Therefore a loop is part of the formulation process which allows integrating feedbacks and to make corrections. For the formulation of the strategy it is essential that three questions are answered\(^{72}\):

- What are the firms’ capabilities – where are we and what can we do?
- What is wanted by the firm’s customers – product / market pull?
- What is technologically possible for the firm – technology push?

Not planned and operative emergent opportunities are not included in this concept.

Another perspective is the model proposed by Kawai (1992) who integrates strategic induced as well as emergent, understood as unplanned, innovations. Kawai starts from the

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\(^{70}\) In chapter 2.1.2.3 it was shown that the design, planning and cognitive schools have the most interesting understanding for the strategy definition used in this work. Therefore all other 7 schools are not presented in the context of innovation management. Some of these not mentioned concepts can be found in Hoffmann-Ripken (2003: 120ff) and Burgelman (1983a; 1983b).

\(^{71}\) This concepts is restricted for product innovations

\(^{72}\) Compare also Karlsson & Ahlström (1997: 481)
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point, that innovations have to be anchored in the strategy. Kawai identifies two environmental conditions which need different innovation mechanism. If the environment does not have too many uncertainties and does not have too many structural changes, middle management can decide about the innovation activities. In the case that the environment is highly uncertain and many changes in the structure are appearing, it is necessary to pass through a strategic analytical formulation process on a top management level. Both models are illustrated in a spiral model in Figure 31.

Figure 31: Managerial innovation: The spiral model (Kawai, 1992: 37)

The strategic trigger of the two presented circles in the innovation spiral (see Figure 31) demands different measures to be taken by top-management. In any case the two circles can be managed according to Kawai.

A fourth approach is presented by Tschirky (1998b: 294f; 2003d: 58f), which is more technology oriented. The author presents the formulation of a technology strategy that could be seen in the context of this work as a part of the innovation strategy. Tschirky sees the formulation of the technology strategy as a special issue in the process of formulating the corporate strategy and parallel to other functional strategies, as for example the finance strategy. Tschirky describes a six step process for formulating the technology strategy: (1) setting strategic objectives, (2) analyzing the environment, (3) analyzing the company, (4) elaborating strategic options, (5) taking strategic decisions and (6) implementing the strategy (see Figure 32).
A further concept of formulating an innovation strategy is presented by Afuah (1998; 2002). In this formulation process a firm sets mission and goals in a first step. “To achieve these goals, it (the company) scans its environment and other sources of innovation for any opportunities and threats where it can exploit some of these opportunities and threats, the firm then chooses a profit site – that is, whether to be a supplier, manufacturer, complementary innovator, distributor, or customer. Next the firm formulates several strategies. In its business strategy, it decides whether the product – outcome of the innovation process – will be low cost, differentiated, or both. In its innovation strategy, it decides whether to be the first to introduce the innovation or to be a follower of some kind. Business and innovation strategies help drive functional strategies – resource allocation and the actions taken by each function along the value chain (R&D, manufacturing, and so on). […] All these strategies constitute a strategic direction, which drives the implementation process that follows. Implementation entails having the right organization structure, systems or processes, and people” (Afuah, 1998: 335). This formulation concept of Afuah, the so called strategic innovation process, is shown in Figure 33.
The five presented concepts of innovation strategy formulation are obviously different. Therefore in the next chapter the five mentioned concepts are evaluated.

2.1.4.4 Evaluation & Conclusion

The evaluation of the innovation strategy formulation concepts is based on the essential criteria in strategic management (see chapter 2.1.1.3), strategy formulation (see chapter 2.1.2.1) and innovation management (see chapter 2.1.3.7) presented in Figure 9. In Figure 34 the evaluation is shown and will be discussed in the following.

The authors Quinn and Kawai are aware of the fact that innovation is a special subject of corporate strategy but they do not consider the subject of innovation as special. Therefore innovation specific criteria have a tendency to be neglected. Martensen, Dahlgaard and Tschirky also point out the importance of a special innovation oriented strategy, but contrary to Quinn and Kawai they mention in their strategy formulation concept the fact that innovation has specific criteria to consider. Despite Martensen & Dahlgaard focus only on products and Tschirky focuses only on technology, although that Tschirky points out in another context that it is important to consider integral innovations (Tschirky, 1998b: 254ff), innovation barriers (Tschirky, 1998b: 252) and the newness of innovations (Tschirky & Bucher, 2003: 27). Afuah presents a concept of strategy formulation that considers innovation specific criteria the best whereas the consideration of the newness of innovation is not considered especially. Also the strategy understanding is in high alignment with the understanding of strategy in this work. All the concepts do not explicitly consider
the understanding of the innovation system in terms of complexity, systemic interaction and evolution. This is a first gap in innovation strategy literature, that the complexity, systemic interaction and evolution of the innovation system are not considered especially in order to understand an innovation system to formulate an innovation strategy.

Figure 34: Evaluation of innovation strategies formulation concepts

Beside the evaluation done on the basis of the criteria, by a more exact examination of the concepts, the presented concepts describe major steps and criteria to consider but they present no - with exception of Tschirky’s concept - specific methods to use. This is a major lack in literature, because these concepts can not be taken by practice without investing effort. Only Tschirky’s concept presents specific methods to use in practice, such as the technology portfolio and the technology oriented industry analyzes (Tschirky, 1998b: 310ff). Because Tschirky focuses mainly on technology aspects, his tool set is not a complete set for designing an innovation strategy formulation process. Therefore a second gap in literature is a missing structured and practitioner oriented innovation strategy formulation process.
At this point of the thesis the gaps in the literature of innovation strategy formulation are clear. Therefore in the next chapter solutions in complementary literature are sought that fill the gaps partly or even completely. In doing so the research in related literature focuses on the first gap in literature, because the second, to build a practitioner oriented innovation strategy formulation process including specific methods, is very dependent from the solution of the first gap. More specific changes in style and information extension of the model to understand the innovation system in terms of complexity, systemic interaction and evolution will directly influence the methods that can be used in the practitioner oriented innovation strategy formulation.

2.2 Complementary Literature

Focusing in this chapter on the complementary literature to understand a system in terms of complexity, systemic interaction and evolution leads to a twofold procedure: As shown in Figure 13 strategic management has two tasks differing in their time horizon: Firstly to direct and design a company from “today to tomorrow” and therefore to understand mainly the existing success potential and therefore the actual system in terms of complexity and systemic interaction. The second task of strategic management is to develop a company from “today to after tomorrow” that requires a more specific understanding of future success positions in terms of the evolution of the future system. Based on this differentiation firstly literature is analyzed that has the objective to model and therefore to understand an actual system and secondly literature is analyzed that has the objective to understand the evolution of a system in terms of new success positions.

2.2.1 System Models

To understand a system it is first of all required to be able to describe a system. This can be done according to Whitehead (1997: 118) with a model. A model of a system is primarily a tool to communicate with clients, builders and users, they are the language of the system designer. “Models enable, guides, and help assess the construction of systems as they are progressively developed and refined. After the system is built, models, from simulators to operating manuals, help describe and diagnose its operation”. Summarizing, a model is according to Rechtin & Meier (1997: 13) an abstraction or representation of the system used to predict and analyze i.e. performance, costs, schedules, and risks and to provide
guidelines for systems research, development, design, manufacture, and management. With this understanding, a model has the following roles according to Whitehead (1997: 120):

- Communication with client users, and builders
- Maintenance of system integrity through coordination of design activities
- Assisting design by providing templates, and organizing and recoring decisions
- Exploration and manipulation of solution parameters and characteristics; guiding and recording aggregation and decomposition of system functions, components, and objects
- Performance prediction; identification of critical system elements
- Providing acceptance criteria for certification for use

All these roles of a model are supporting the understanding of a system in terms of complexity and systemic interaction. The existence of different kinds of models is shown in Figure 35.

![Figure 35: Schematic representation of six different model views (adapted from Whitehead, 1997: 122)](image)

To identify the right model it is necessary to know the objective of the intention to use a model. In the case of this work it is essential to understand a system and therefore the question “What are the elements retained in the system and its interaction?” has to be answered
which implies a data model. Before analyzing the literature about models the element to
represent in the data model has to be identified. This is knowledge as discussed in chapter
2.1.3.6. Therefore in the following the literature that represents knowledge in form of data
models will be analyzed.

2.2.1.1 Data Models in Literature

There are several accepted data models of knowledge representation according to
Gordon (2000: 74). Some of these are presented in the following.

Rules

Rules are reasonably easy to understand by humans and are also a powerful machine
based on knowledge representation scheme. Rule base systems that could apply human
knowledge and function at the level of a human expert were famously pioneered by
Shortliffe (1976). Rules require knowledge to be identified as attribute value pairs. They
take the general form:

If attribute A1 has value V1
And attribute A2 has value V2
The attribute A3 has value V3

Attributes can represent internal data items, they can represent input or output systems
or they can initiate a response from the user. Once knowledge is represented as a rule set, it
is relatively easy to construct an engine that can make use of the rules in an automated rea-
soning system.

In addition, the rules themselves can be archived and updated as necessary. This would
be a knowledge archive rather then an information archive since the rules can be directly
used in automated reasoning.

Frames

Frames are also a powerful knowledge representation system. A frame is a collection of
information and associated actions that represent a simple concept. It would be possible to
represent a person (in a simple way) by the use of a frame. In the example of a simple
frame in Figure 36, most of the slots have values but one slot requires an independent sys-
tem to be called to find a value. Frames are a mixture of information, calls to information
derivation functions and output assignment. Frames can be used to represent complex
pieces of knowledge and can also be achieved and edited as required.

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73 According to Gordon (2000: 74f)
74 According to Gordon (2000: 75)
Semantic Networks\textsuperscript{75}

Semantic Networks are easy to understand by humans and can be used in automated processing systems. This means that they can also become a vehicle to archive company knowledge. A typical semantic network that represents knowledge concerning an electric space heater is presented in Figure 37. In this simple network, nodes are specific items and links show relationships between items.

Figure 37: Semantic Network to describe an electric heater (Gordon, 2000: 76)

Concept Diagrams\textsuperscript{76}

Concept diagrams are closely related to semantic networks. Concept diagrams are also composed of nodes and arcs and the nodes and arcs have similar functions. Concept diagrams can be used to describe fairly complex concepts. They are seen as knowledge representation methods that employ graphical structures (Sowa, 1984). There is a body of work relating to concept diagrams and their use as a graphical logic (Sowa, 1993).

\textsuperscript{75} According to Gordon (2000: 75f)
\textsuperscript{76} According to Gordon (2000: 76)
Architecture

An architecture is a structure – in terms of components, connections, and constrains – of a system according to Rechtin & Meier (1997: 253). In doing so the activity of creating an architecture is called architecting (see Figure 38). The architecting activity transforms problem and solution know how into a new architecture. In doing so it is the objective to strive for fit, balance, and compromise among the tensions of all the components.

![Figure 38: Architecting = creating an architecture (adapted from Muller, 2003: 3)](image)

An architecture is not a detailed plan. It identifies the major components to be built, but does not specify exactly how they are to be built. This is the major difference to semantic networks. For example the semantic network of Figure 37 describes the effects in the electric heater. An architecture would show the heater as a overall system and its modules with their interaction, but does not show how they interact in detail. Therefore an architecture allows in the case of a complex and systemic interacting system - and to the disregard of the “how” – the reduction of the complexity. This is a major advantage of the architecture in the context of this thesis. For that reason the architecture seems to be the most interesting model to understand a system in terms of complexity and systemic interaction.

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77 Compare Rechtin & Meier (1997: 21)
78 Compare Hamel & Prahalad (1994: 108)
2.2.1.2 The Architecture as Data Model

After the short introduction into the subject of the architecture in the last chapter it is necessary to get a sense of the possibilities of an architecture. Therefore in the following, different perspectives of architectures are presented. This overview, in the form of transcriptions from several authors, does not claim to be complete but should be considered as exemplary and representative to the understanding of the extensive use of architectures:

**Building Architecture**

The term ‘architecture’ comes from the domain of building buildings according to Rechtin & Meier (1997: 7):“The process of creating architectures began in Egypt more than 4000 years ago with the pyramids [where] complexity […] was overwhelming designers and builders alike. This complexity had at its roots the phenomenon that as systems became increasingly more ambitious, the number of interrelationships among the elements increased far faster than the number of elements themselves. Pyramids were no longer simple burial sites; they had to be demonstrations of political and religious power, secure repositories of god-like rulers and their wealth, and impressive engineering accomplishments. Each demand, of itself, would require major resources. When taken together, they generated new levels of technical, financial, political, and social complications. Complex interrelationships among the combined elements were well beyond what the engineers’ and builders’ tools could handle.”

Already in this time the term of architecture in the domain of buildings was understood as holistic, containing technical, financial, political and social elements to be mentioned. This holistic point of view was enlarged until today. Exemplary is transcription of Castro (2003) defining the task of an architect of cities:\n
\[79\] Translated from German

"We have to make our cities as good as possible for our citizens. And this signifies constructing connections to what was good in the past, constructing buildings which suit and fit in, by which it is a pleasure to pass, which are easy to use and – of capital importance – that serve the requirements of the whole city. […] The city is the essence to consider, the buildings are secondary. The buildings are elements out of which the city is created. […] If we take care therefore that our buildings are parts of a city and we are planning carefully each building especially for its place in a particular city, for a particular purpose, then we will have fundamentally better cities”. This test shows that an architect of buildings or cities has to deal with many different factors of influence. To deal with these factors the architecture supports the architect in a structured manner. An example of a building architecture can be seen in Figure 39.
Product Architecture

According to Mikkola & Gassmann (2003: 410f) “the purpose of an product architecture is to define the basic physical building blocks of the product in terms of both what they do and what their interfaces are with the rest of the device\(^{80}\). Product architecture is often established during the product development process. This takes place during the system-level design phase of the process after the basic technological working principles have been established, but before the design of component and sub-systems has begun. Product architectures can vary from modular to integral. Modular product architectures are used as flexible platforms for leveraging a large number of product variations\(^{81}\), enabling a firm to gain cost savings through economies of scale from component commonality, inventory, logistics, as well as to introduce technologically improved products more rapidly. Modular architectures enable firms to minimize the physical changes required to achieve a functional change. Changes to product variants often are achieved through modular product architectures where changes in one component do not lead to changes in other components. Conversely, in integral product architectures, changes to one component cannot be made without making changes to other components. Costs of customized components tends to be higher due to the integral nature of product architectures where an improvement in functional performance can not be achieved without making changes to other components. Integral architecture designs enhance knowledge sharing and interactive learning as team members rely on each other's expertise. Integral architectures are designed with maximum performance in mind, and the implementation of functional elements may be distributed across multiple physical elements\(^{82}\). An example of a product architecture can be seen in Figure 40.

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\(^{80}\) A more detailed discussion can be found in Ulrich (1995) and Ulrich & Eppinger (1995)

\(^{81}\) A more detailed discussion can be found in Gilmore & Pine (1997), Robertson & Ulrich (1998) and Sanchez (1996; 1999)
Therefore product architecture breaks a product down into their component parts and the interactions of component parts to be able to define in a holistic way the interface specifications and to help an organization to “know what it knows” in the whole product (Sanchez, 2001: 22f).

**Software Architecture**

According to Bass, Clements, & Kazman (2003) a “software architecture of a program or computing system is the structure or structures of the system, which comprise software elements, the externally visible properties of those elements, and the relationships among them” The authors point out some implication of this definition of an software architecture: " First, [software] architecture defines elements. The architecture embodies information about how the elements relate to each other. This means that architecture specifically omits certain information about elements that does not pertain to their interaction. […] Second, the definition makes clear that systems can and do comprise more than one structure and that no one structure holds the irrefutable claim to being the architecture. For example, all non-trivial projects are partitioned into implementation units; these units are given specific responsibilities, and are the basis of work assignments for programming teams […] Other structures are much more focused on the way the elements interact with each other at runtime to carry out the system’s function. […] Third, the definition implies that every soft-
ware system has an architecture because every system can be shown to be composed of elements and relations among them. In the most trivial case, a system is itself a single element - an uninteresting and probably non-useful architecture, but an architecture nevertheless. […] Fourth, the behaviour of each element is part of the architecture insofar as that behaviour can be observed or discerned from the point of view of another element. This behaviour is what allows elements to interact with each other, which is clearly part of the architecture. This does not mean that the exact behaviour and performance of every element must be documented in all circumstances; but to the extent that an element’s behaviour influences how another element must be written to interact with it or influences the acceptability of the system as a whole, this behaviour is part of the software architecture. Finally, the definition is indifferent as to whether the architecture for a system is a good one or a bad one, meaning that the architecture will allow or prevent the system from meeting its behavioural, performance, and life-cycle requirements. Assuming that we do not accept trial and error as the best way to choose an architecture for a system - that is, picking an architecture at random, building the system from it, and hoping for the best - this raises the importance of architecture evaluation. An example of an software architecture is shown in Figure 41.

Figure 41: Example of a software architecture: Data flow view (Clements, 2002)

**Organizational Architecture**

According to Nadler & Tushman (1997: 7ff) an organizational architecture is essential for the strategic organizational design. Thereby an organizational design shapes the “overall

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82 A more detailed discussing can be found in Starke (2002) and Bass, Clements, & Kazman (2003)
look and feel of an organization – in short, the way it gets done. Those broad dimensions of structure, capacity and performance form the general outline of organizational architectures”. An organizational architecture involves a “fairly global perspective on strategic change” and it is the basic tool for a CEO and senior management team, understood as architects, to translate the vision into a concrete design of the organization at every level. In doing so it is essential for the success to “comprehend, embrace, and advance the redesign principles developed for the organization as a whole”. Additionally “an organizational architecture provides a conceptual framework for employing strategic design to develop organizational capabilities”.

Xerxes’ CEO Paul A. Allaire brings the description of an organizational architecture to the point: “The change we are making is more profound than anything we’ve done before. We have embarked on a process to change completely the way we manage the company. Changing the structure of the organization is only a part of that. In fact, the term reorganization doesn’t really capture what we are trying to do at Xerox. We are redesigning the organizational architecture of the entire company”.83

Figure 42: Innovation architecture (Schaad, 2001: 116)

A special case of the organizational architecture, is Schaad’s (2001: 113f) innovation architecture. The innovation architecture has the aim to show in a transparent manner a complex interrelated system for modeling a company specific innovation organization for deriving the organizational innovation processes. In this innovation architecture the interrelations of the basic knowledge for innovating, the functions of this knowledge, the resulting

83 Found in Howard (1992)
products out of the functions and the customer needs are shown and interrelated (see Figure 42).84

**Information Architecture**

According to Österle, Brenner, & Hilbers (1992: 69ff) an information architecture is a conceptual framework for the development of an organization, application and data base of a decentralized domain. It describes the required conditions of the information system, which should be achieved in the next three to five years.85 The objective of the information architecture is a model of the information system of each decentralized domain. This framework shows the organization, the data convention and the functional conventions. These conventions are the guidelines for the development of the information system in each project. Therefore projects have on the base of the information architecture, a clearly defined scope. The architecture shows the interrelations of the data and functions of an application to other applications. Therefore the information architecture allows the coordination of further developments between several projects. Concluding, an information architecture increases the transparency and therefore the ability to plan, increases the data and functional consistency, allows to identify business potentials and simplifies the maintenance of the system. An example of an information architecture is shown in Figure 43.

![Diagram of Information Architecture](image)

Figure 43: Example of an information architecture: A data model (Österle, Brenner, & Hilbers, 1992: 157)

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84 A more detailed discussing can be found in Schaad (2001: 113f)
85 Compare also Dickson & Wetherbe (1985: 122)
Strategic Architecture

The term strategic architecture is mainly shaped by Hamel & Prahalad (1994: 107ff). According to these authors the term “strategic architecture is basically a high-level blueprint for the deployment of new functionalities, the acquisition of new competencies or the migration of existing competencies, and the reconfiguration of the interface with customers. […] A strategic architecture is not a detailed plan. It identifies the major capabilities to be built, but does not specify exactly how they are to be built. […] A strategic architecture identifies what we must be doing right now to intercept the future. A strategic architecture is the essential link between today and tomorrow, between short term and long term. It shows the organization what competencies it must begin building right now, what new customer groups it must begin to understand right now, what new channels it should be exploring right now, what new development priorities it should be pursuing right now to intercept the future. Strategic architecture is a broad opportunity approach plan. The question addressed by a strategic architecture is not what we must do to maximize our revenues or share in an existing product market, but what must we do today, in terms of competence acquisition, to prepare ourselves to capture a significant share of the future revenues in an emerging opportunity arena. […] A strategic architecture does not last forever. Sooner or later tomorrow becomes today, and yesterday’s foresight becomes today’s conventional wisdom”. A strategic architecture should always be developed by mentioning the criteria foresight, breath, uniqueness, consensus and action ability. If these criteria are fulfilled the strategic architecture could be seen as the map. But the fuel to go the way aligned on the map is not yet identified. To summarize, “an architect must be capable of dreaming of things not yet created – a cathedral where there is now only a dusty plain, or an elegant span across a chasm that hasn’t yet been crossed. But an architect must also be capable of producing a blueprint for how to turn the dream into reality”. An example of an strategic architecture can be seen in Figure 44.

Summarizing the strategic architecture would serve the following purposes:

- outline the enterprise’s strategic vision, conceived in terms of combinations of existing competencies and acquisition or development of new ones
- reinforce a strategic focus on competencies, and ensure that all strategic decisions (such as investments, divestments, acquisitions and alliances) are consistent with the overriding imperative of maintaining and developing competencies
- discipline organizational behavior (especially business behavior) by constructing a uniform frame of reference and implicit decision rule - namely: “Does this action or decision contribute to or detract from our core competence?”
- assist with the alignment of culture, structure, human resource management and information management within the enterprise, again by providing a uniform frame of reference as an instrument of integration and coordination
• assist with organizational learning exchange (information flows focused on identifying business development opportunities) and promote strategic awareness throughout the enterprise

• enable identification of deficiencies in skills and technology, which would limit the ability of the enterprise to build new competencies

Figure 44: Example of a strategic architecture: Vickers map of competencies (Prahalad & Hamel, 1990: 88)

**Summarizing the different architectures**

To summarize the above presented architectures, in all the architectures a similar concept of architecting is used to solve context specific problems by using a specific style of architecting. Although the concept of architecting was similar, the result, the specific architecture type, was different as presented in Figure 45.
The concept of the architecture is for all the contexts the same, it is about building a structure – in terms of components, connections, and constraints – of a system. Only the context specific visualization of the architecture, in terms of the type of architecture is changing. For example a product architecture structures the product system and an organizational architecture structures the organizational system. Therefore the concept of structuring is the same. But the visualization of the architecture in the form of the context specific architecture is not at all the same. So the type of the architecture changes according to the context.

The style of architecting is therefore different. Each architect is using a different style, which is defined by its rules to be used. These rules of architecting are often the same in all the specific contexts as can be seen in Figure 46. More concrete there are eight rules of the architecture that are used in all the presented types of architectures: ‘reduce complexity’, ‘describe systemic interaction’, ‘define system objectives’, ‘visualize concept’, ‘define system to be model’, ‘ensure system consistency’ and ‘define operational interfaces’. This appearance of the eight main rules in every type of architecture is an indication that these rules are independent of the style of architecture. Simultaneous are some rules only playing a role in a few types of architectures. An example is the rule ‘identify knowledge gap’ which is used only in the context of ‘product architecture’, ‘software architecture’ and ‘strategic architecture’. These rules are additional context specific rules. In contrast to the main rules the author does not pretend that the context specific rules are all named. These findings based on the analyzes of the existing architectures indicate that there are main and context specific rules of architecting which allow a more detailed definition of the concept of an architecture:

The concept of an architecture is a procedure to structures a system by its components, connections and constraints to fulfill eight main rules (“reduce complexity”, “show system interrela-
In contrast, the definition of the type of architecture is the following:

*The type of architecture* is a context specific visualized solution of the concept of architecture to solve context specific problems by using a specific style of architecting which is defined on the one hand by the main rules and on the other hand by the context specific rules.

<table>
<thead>
<tr>
<th>Main rules</th>
<th>Types of architectures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Building architecture</td>
</tr>
<tr>
<td>Reduce complexity</td>
<td>X</td>
</tr>
<tr>
<td>Describe systemic interactions</td>
<td>X</td>
</tr>
<tr>
<td>Define system objectives</td>
<td>X</td>
</tr>
<tr>
<td>Visualize concept</td>
<td>X</td>
</tr>
<tr>
<td>Define system elements</td>
<td>X</td>
</tr>
<tr>
<td>Define operational interfaces</td>
<td>X</td>
</tr>
<tr>
<td>Define system to be model</td>
<td>X</td>
</tr>
<tr>
<td>Ensure system consistency</td>
<td>X</td>
</tr>
<tr>
<td>Identify knowledge gap</td>
<td>X</td>
</tr>
<tr>
<td>Assign task</td>
<td>X</td>
</tr>
<tr>
<td>Define processes / flows</td>
<td>(X)</td>
</tr>
<tr>
<td>Plan resources</td>
<td>X</td>
</tr>
<tr>
<td>Embed system in a holistic context</td>
<td>X</td>
</tr>
</tbody>
</table>

*Figure 46: The types of architectures*

2.2.1.3 Conclusion

The concept of the architecture corresponds to the needs to understand an actual innovation system in terms of complexity and systemic interaction. Additionally the architectures allow more functionalities than only reducing complexity and describing the systemic interaction as shown in Figure 46. In this context Schaad’s (2001) innovation architecture is a promising basis for developing an architecture representing complexity and systemic interaction of an innovation system. However there is still an innovation system specific gap in this literature: A *specific type of architecture for understanding the complexity and...*
system interaction by visualizing the innovation relevant knowledge is still missing. This is a gap to be closed.

2.2.2 Success Potential Identification

The second task of strategic management is to develop a company from “today to after tomorrow” that requires in addition to the understanding of the actual system a more specific understanding of the evolution of the future system to identify new success potentials. As seen in chapter 2.1.1.2 evolution can be understood if the process of adaptation of the environment is known or more precisely if the result of this process, the increment of knowledge in the environment is collected in the form of information. This collection of information about knowledge in the environment is in general, the task of intelligence combined with internal knowledge of the company to analyze it (compare Savioz, 2002: 12f). The interaction between information, knowledge and intelligence is represented in Figure 47.

![Figure 47: Interaction between information, knowledge and intelligence (Savioz, 2002: 13)](image-url)

Based on the fact that intelligence has the task to collect the information of knowledge in the environment to understand the evolution, the next chapter will focus on the description of intelligence in the special context of a company understood as business and competitive intelligence.

2.2.2.1 Business Intelligence

According to Ashton & Klavans (1997: 9) the terms Business Intelligence (BI) and Competitive Intelligence (CI) are often used interchangeably. Both BI and CI refer to “ac-

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86 The introduction of this chapter is based on Savioz (2002: 32f)
tionable information about the external business environment that could affect a company’s competitive position”. A similar overlap between Competitor and Competitive Intelligence, and between Business Intelligence and Environmental Scanning is observed by Choo (1998: 81). He argues that since Competitive Intelligence is a primary objective of activities within Business Intelligence, those two terms can be used more or less interchangeably (Choo, 1998: 76). Giving an order to the different terms is attempted in Figure 19.

Competitor Intelligence is information gathering about actual and future activities of competitors, whereas Competitive Intelligence’s focus is broader in order to embrace Porter’s (1980) five competitive forces model. Business Intelligence is: “the activity of monitoring the environment external to the firm for information that is relevant for the decision-making process in the company” (Gilad & Gilad, 1988: 14). Thus, Business Intelligence is concerned with exploring possible views of future competitive environments. This is almost the same scope as Environmental Scanning, which is “the acquisition and use of information about events, trends, and relationships in an organization’s external environment, the knowledge of which would assist management in planning the organization’s future course of action” (Auster & Choo, 1994: 607). According to Ansoff (1980), Issue Management tries to identify future trends in time to prevent crisis. “A strategic issue management system is a systematic procedure for early identification and quick response to important trends and events both inside and outside an enterprise” (Ansoff, 1980: 134). Finally, Social Intelligence is the broadest in scope and approach, and is concerned with the capability of society and institutions ability to identify problems, collect relevant information about these problems, and the ability to transmit, to process, to evaluate, as well as to ultimately put this information to use (Dedijer & Jéquier, 1987: 34).

This discussion shows that the limits of these domains are rather blurred. It would be confusing to deal with all these detailed definitions. Therefore, one single definition shall unify these slightly different scopes, and will be referred to within this thesis as Business Intelligence

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**Business intelligence are activities of collection, analysis and application of information describing relevant facts and trends. (Opportunities and Threats) from the organization’s entire environment used to support the strategy formulation process (compare Savioz, 2002: 33).**

In this definition the differentiation between facts and trends is very important for this thesis. While facts express a status, trends describe the evolution of this status. These trends are developed using quantitative methods to analyze the changes in technology and markets. The changes are based on historical key figures in order to extrapolate future devel-

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87 In addition to this Anglo-Saxon description of business intelligence, the German „Frühaufklärung“ matches well with this definition (compare Krystek & Müller-Stewens, 1993: 2).
opments. From these trends the company can identify in which direction a technology or market is going and if it is an attractive opportunity. This is an important basic tool for the identification of opportunities and threats looming in the future but it has two major weaknesses. Firstly, due to the extrapolation of key figures it is only an uncertain prediction of what might happen in future. Secondly, extrapolations can only be done in fields that are known, innovation opportunities in the future will only be identified in market and technology fields that are known to the industry. Therefore, according to Pfeiffer, Weiss, Volz and Wettengle (1997: 42), the exclusive use of quantitative identification methods is risky and leads to what they call “extrapolation trap”, meaning too much thinking ‘inside the box’ and failure to identify innovation opportunities in new market and technology fields necessary to sustain differentiation from competitors. Therefore beside quantitative identification methods also qualitative identification methods are important which are described in the following.

Qualitative methods are not based on documented key figures but on the creativity of individuals and organizations, especially that of gatekeepers working in inter-subjective teams. The most known methods of inspiring qualitative thinking include brainstorming, mind mapping, discussion 66, method 635, bionic, delphi method and the morphology method (Biedermann, 2002: 54). These methods encourage thinking out of the classical box of a company. Traditionally the basic question for these methods has been: “What will the opportunities be in the future?” The answer to this question could be information and communication technologies, new power systems, etc. But not many of these answers relate to the specific activities of the company. There might be a lack of focus in this question (Buggie, 2001: 37ff). To respond to this lack of focus, three different methods are identified in literature: functional, innovation field and core competencies based method. These methods are described in the following.

**Functional based method**

A function is a solution neutral description of an operation that describes the constraints between input and output variables (Meier, 2002: 6). Therefore a function describes according to Biedermann (2002: 39f), “What a product really does”. To analyze what a product really does a function is often visualized as an black box which comes from the system techniques (Daenzer & Haberfellner, 1999). The specific material, energy of signal transformations result of a causal difference between the attributes of the input and output values (Meier, 2002: 6). The function is verbal described with an input value consisting of a subject that is composed broad and an operation in form of a verb that is very specific, such as “transmit power”. However it is still complicated to define a function with this basic rule because the levels of abstraction and detail have to be defined appropriated to the system.

- Level of abstraction: The VDI (1996: 5) proposes in this context that a function should not be formulated in the real domain (see Figure 48) because this would
be only a verbal description of the reality containing the solution, but a function should be described between the frontier of the iconic and symbolic domain. A settlement to fare in the symbolic domain would be too abstract for defining the function.

![Figure 48: Two level progression of idea generation (VDI, 1996: 5)](image)

- Level of detail: According VDI (1996: 3ff) defining a function could be done on different levels of detail as illustrated in Figure 49. The main function describes what the considered product really does such as a hammer driller does remove material. This hammer driller can only work if the main function is supported by additional functions, such as supply energy. These two categories can be summarized in the main functions, which represent at the same time the “as is” situation of the product and the “to be” objectives of the product. This implies that this level of detail does not predefine conceptual solutions. The basic functions can be divided into detailed functions. For example detailed functions of ‘remove material’ are ‘disassociate material’, ‘scale down material’ and ‘take out material’. With these detailed functions the solution to use a drill is already predefined. As could be seen the level of detail of defining a function has to be appropriated to the needs. If it is necessary to rethink the whole concept of a product the level should not be too detailed. In contrast if an element of the product has to be redesigned the functions should be more detailed.
Figure 49: Functional tree (compare VDI, 1996: 3)

Defining a function with these fundamental guidelines leads to an abstract description which is of major benefit (Pahl & Beitz, 1993: 1). Such benefit is the support in the several following domains according to Meier (2002: 5f):

- To avoid a pre-fixation and fixed pattern of thought
- To structure an unstructured overall function in easy sub functions
- To conjunct a solution with its effect.
- To define a direction sign for allocating solutions
- To identify and define priorizations in the development
- To minimize the effort in the realization (minimal structure principal)
- To make acceptance analyses in the markets by functional value analyses
- To identify more solutions in the process of solution finding

As seen, the functions can be used for multifaceted tasks, whereby the last mentioned task is to identify new solutions which could be seen as a way to identify new success potentials. Therefore in the following the identification of new success positions based on the functional method will be the focus.

Based on the functional market concept of Pfeiffer et al. (1997: 69ff) a product is the fit between the identification of specific customer needs in markets and technologies consisting of product technologies supported by production process, R&D and infrastructural technologies (Tschirky, 2003c: 52). This is because a customer need has to be satisfied in every case with an adequate technology, to realize the technological use in a market. So a
specific customer need can be satisfied by different technologies or a technology can be used for the satisfaction of several customer needs.

Figure 50: Fit between technologies and customer needs (compare Pfeiffer, Weiss, Volz, & Wet tengl, 1997: 69)

The search for such a functional fit can be started from the potential side to find the right customer needs or from the demand side to find adequate technologies. In this context Pfeiffer et al. (1997: 70f) differentiates two principle induction mechanisms to identify potential innovations: The requirement induction and the potential induction:

• The requirement induction, also called market pull, describes the impulse chain which comes from the requirements, based on gaps and insufficiencies, to potential technologies that fill the requirements. An example: Car drivers expressed a requirement for more safety. Therefore the car industry developed the airbag technology to satisfy this requirement.

• The potential induction, also called technology push, describes the impulse chain which comes from an already existing technology to different potential application fields or problems that could be solved with this technology (Staudt, 1974: 31). An example: The identification of the X-ray technology was found by chance in laboratory tests. Until this point their was no expressed need for the X-ray technology (compare 1999: 27f).

The task of the company is to realize the fit between technologies and customer needs. Because of the continuous change of the disposal technologies and the demanded customer needs, is this a permanent task.

Such a functional approach allows on the one hand new business fields to be identified through the analysis of unfamiliar markets where this function could satisfy customer’s needs. On the other hand the approach allows new emerging technologies in unfamiliar technology platforms to be identified that fulfil the same function (compare Pfeiffer et al., 1997: 71f). For example the function of a photo camera is to store a visual image. To identify new business fields outside the photo industry the question needs to be asked: ‘Who
else needs to store visual images?’ The answer could be that people who want to copy something also need this function, so the new business field could be in the area of copying machines. To identify new technology fields the question must be asked: ‘Which other technologies store visual images?’ If in the past, the technology was based on photochemical technologies, now it is through new technology and digital technologies fulfil this function. This process helps to identify major changes in the environment in a timely matter (see Figure 51).

![Figure 51: An example of a company function](image)

**Innovation Field based Method**

Lang (1998a) proposes to define innovation fields to focus the question for identifying new success potentials. Such innovation fields can be understood as broader business fields (Silverstein, 2003: 111). An example is the business field ‘mobile phones’ which can be defined as innovation field ‘mobile communication’. Or ‘lacquers and colours’ would be changed into the innovation field ‘industrial coating’. This broader description of business fields allows to activate the creativity for new related innovations (Silverstein, 2003: 111). Therefore the management of innovation fields has the task to work out customer needs, product functions and technology platform where at least one of these dimensions is still unknown (Schlegelmilch, 1999).

Specifically an innovation field should fulfil four criteria according to (Schlegelmilch, 1999):

- An innovation field comprises the potential to identify at least a new potential business field, product function or technology platform
• An innovation field expresses a competitive advantage
• An innovation field shows an autonomous innovation potential
• An innovation field is independent from other innovation fields.

Such an innovation field is therefore on the one hand a starting point for a creative search for new success positions and on the other hand according to Savioz (2002) a future observation area for the intelligence.

**Core Competencies based method**

The seminal article ‘The Core Competence of the Corporation’ by Prahalad and Hamel (1990) has lead to a refinement in the management understanding of most academics and practitioners. Competencies, understood as bundles of knowledge, are those core attributes of an enterprise, which enable it to come up with unanticipated products and services, to invent and shape consumer demand and to enter new markets rapidly and successfully – in other words (Leonard-Barton, 1992: 111) “competencies are considered core if they differentiate a company strategically.”

In the case that the competencies and especially the core competencies are identified it is possible with the strategic (presented in chapter 2.2.1.2) to identify new success potentials by leveraging the competencies (Hamel & Prahalad, 1994; Tushman & Anderson, 1997). The several competencies are leveraged in a different way in order to identify new technology and product opportunities. This leveraging of competencies allows identifying new success potentials in a creative way that is based on existing competencies.

2.2.2.2 Conclusion

In the domain of business intelligence an extensive amount of different methods to identify potential innovations can be found. This could be done on the one hand with quantitative methods and on the other hand with qualitative methods, such as functional, innovation field and core competencies based methods. These methods are sufficient to identify potential innovations. However no concept was found summarizing all these identified potential innovation to understand completely the evolution of the future system. Prahalad’s and Hamel’s (1990) concept of strategic architecture is a basis for developing such a model of the future. **This lack of a model to understand the evolution of the future system is a further gap in literature that should be closed.**
2.3 Conclusion: Innovation Strategy Formulation (Theory)

Summarizing the state of the art in literature in innovation strategy formulation the first main gap identified is: (see chapter 2.1.4.4):

**Main Gap in Literature 1:** Complexity, systemic interaction and evolution of the innovation system are not adequately considered in order to understand an innovation system and to be able to formulate an innovation strategy.

Trying to close this gap, a more detailed research in complementary literature showed that on the one hand the innovation architecture from Schaad (2001) is a basis for understanding the complexity and systemic interaction of the actual innovation system. Nevertheless there is a more detailed gap still not closed in the domain of architecting (see chapter 2.2.1.3):

**Gap in Literature 1.1:** A specific type of architecture in order to understand the complexity and system interaction by visualize the innovation relevant knowledge is missing.

On the other hand quantitative and qualitative methods presented in literature are the basis identifying new success potentials for understanding the evolution. But also in this domain a gap to close was identified (see chapter 2.2.2.2):

**Gap in Literature 1.2:** There is a lack of a model to enable the understanding of the evolution of the future system.

A second main gap identified is (see chapter 2.1.4.4):

**Main Gap in Literature 2:** A structured practitioner oriented innovation strategy formulation process is missing.
3  State of the Art in Practice

The previous chapter showed the importance of research in innovation strategy formulation from a theoretical point of view. The aim of this chapter is to clarify the relevance of the topic in practice. It is not the goal to examine practices in companies but to examine interest in the topic. The practitioner’s voice is captured by means of interviews conducted in the beginning of an action research project, conducted especially to identify requirements in the domain of innovation strategy in practice. The results of these interviews are summarized in the following. The chapter closes with a conclusion of innovation strategy formulation from a practical point of view (see Figure 52).

![Figure 52: Structure of chapter 3](image)

3.1 Interviews

Interviews were held in innovation driven companies. Theses interviews were conducted specifically to obtain answers to the following questions:

- Is the need for an innovation strategy and its formulation process a real need?
- Are there any concepts already in place that explicitly formulate an innovation strategy?
- Are there are concepts for formulating an innovation strategy, what is the concept in terms of best practice in industry?
- If there are no concepts for formulating an innovation strategy, what are elements that could be interesting for the process of innovation strategy formulation?

Based on these questions the interview partners were selected to be heterogeneous in terms of their company size and industry. These selected companies are presented in Figure 53.
Thereby the company names are changes because the interview partners were more open to answering questions by knowing that the specific company name would note be published.

![Company Portfolio Diagram]

Figure 53: Sample of interviewed companies

In concrete terms, the following persons were interview partners in different companies:

- **RubTec** (6 interviews): CTO, Research and Development General Manager and 4 section managers.

- **Toll Revenue** (2 interviews): Head of Innovation and Marketing, Product and Business Development Manager.

- **Optic Dye** (2 interviews): CEO, Director R&D.

- **TecChem** (10 interviews): CTO, 9 Segment Research and Development Managers.

- **HighTec** (5 interviews): General Manager Technology and Innovation, Vice President Corporate Development, R&D Manager, Division CTO, Product Manager.

- **Info Exchange** (2 interviews): Head of Development of IT-Infrastructure, Head of New Business Solutions.

- **StockTec** (2 interviews): CEO, Head of Research and Development
• **MicroSys** (2 interviews): R&D Manager, Manager Advanced Technology
• **Built-up** (1 interview): Corporate Technology Manager

Additionally, the subject of innovation strategy formulation and its lack in practice was discussed in the ERFA-Conference. In this discussion eight representatives of the practice participated.

This sample of 32 interviews and the ERFA-Conference discussion made it possible to gain insight into the domain of innovation strategy formulation in practice. A major insight was that most companies have problems focusing their innovation activities in one direction for effective and efficient innovation. Some companies already focus their activities significantly by integrating the subject of innovation into the corporate or strategic business unit strategy. Nevertheless, in these companies, innovation aspects are also not well considered on a strategic level according to their statements. Most companies complain about difficulties in diverse stages in the strategy process considering innovation. To summarize, the most important problems and needs are the following:

1. **Importance of innovation strategy**: Companies insist that a clear definition of the innovation intentions through an innovation strategy, seen as part of the corporate or business unit strategy, makes it possible to steer and align the activities in the innovation processes consistently through:
   - A clear prioritization and synchronization of activities
   - An effective and efficient deployment of resources, such as infrastructure, rights, patents, financial capital and knowledge
   - A clear definition of responsibilities
   - A consideration of integrated innovations considering business, technology and organizational innovations
   - A strategic control of innovation activities through a comparison of the clearly defined aims in the strategy and the results

An additionally important point mentioned in interviews is that during the formulation process of an innovation strategy, the management team should be forced to think through all innovation opportunities and to evaluate them. This includes thinking about future required competencies, in order to ensure the success of the innovation and so to ensure the future success of the company.

2. **Lack of innovation strategy formulation process**: All of the companies confirmed that they do consider innovation activities in the corporate or business unit strategy formulation process. All the companies confirmed that their innovation activities are essential to gain competitive advantage for the future. However, practically no strategy was found where concrete innovation activities could be derived and there was no structured
strategy formulation process evident, which considered innovation activities in an integrated manner. In general, the top management and middle management of R&D gather the needed information about innovation activities together based on specific meetings in order to update one another on their intentions, unfortunately this is not coordinated in a holistic and structured way, including marketing, development and research activities. The mentioned reasons for this lack of structured innovation strategy formulation process are multifaceted and presented in the following:

- Innovation activities are very difficult to understand holistically and thus do not permit the formulation process to be done in a structured manner.

- Development activities are very dynamic; therefore a decision today can soon be obsolete. But at the same time, it was often mentioned that decisions are only obsolete because the decision was not well grounded.

- Some companies mentioned a lack of tools to support the building up of an innovation strategy. Other companies mentioned that they have a strategy process and strategic methods, such as portfolios, roadmaps and investment calculations, to prepare decisions but these methods in the domain of innovation are very difficult to use because structured information about the company’s’ innovation activities is not available.

This discussion has shown that companies are aware of the importance of innovation strategy. Furthermore, some activities are done to integrate innovation activities more into strategy processes but not on a required level. A pattern however, could not be identified for innovation strategy formulation. These findings show that an innovation strategy is important but at the same time the lacking formulation process is evident as well in most of the companies which is in alignment with the study done by Kambil (2002: 8) presented in chapter 1.1.

Beside the explicit requirement of an innovation strategy formulation process it has to be mentioned that companies do not have a need for a complete new innovation strategy process, but rather for a process that is integrated into the actual corporate or business unit strategy processes. Based on the statements from practice, a main focus should lie on structuring the information about innovation activities and intentions to integrate them into the existing strategy process with existing tools.
3.2 Conclusion: Innovation Strategy Formulation (Practice)

The aim of this chapter is to gain insight from practitioners about problems and needs of innovation driven companies in relation to innovation strategy formulation. Indeed, innovation strategy formulation is of concern in innovation driven companies’ reality. Several interviews (in 11 companies) showed that innovation strategy formulation is of serious interest to innovation driven companies. Apparently no systematically concepts of innovation strategy formulation could be found. Therefore one conclusion is:

**Most Companies agree that on the importance of an innovation strategy. However they had no explicit innovation strategy formulation process. Therefore there is a call from reality for a structured practitioner oriented innovation strategy formulation process for innovation driven companies.**

This call from practice will be compared in the next chapter with the gap in literature in order to define the focus and requirements of a solution concept.
4 The Dual Gap

This chapter is the bridging link between fulfilled and unfulfilled research in the field of innovation strategy formulation in innovation driven companies. Thus, the aim of this chapter is to briefly describe the dual gap based on the gaps identified during the study of theory and practical reality, to summarize the requirements of the solution concept and to present working hypotheses (see Figure 54).

Figure 54: Structure of chapter 4

4.1 Dual Gap in Innovation Strategy Formulation

The previous chapters showed a gap in the research of innovation strategy formulation in innovation driven companies from a theoretical and a practical point of view. The practitioner’s voice demands a practitioner oriented strategy formulation process. However, the literature in innovation strategy formulation does not present such a process and complementary literature has basic concepts, such as the innovation architecture, that are promising. This leads to the following two dual gaps, discovered in literature as well as in practice, which have to be closed in this thesis:

**First Dual Gap:** A CONCEPT TO UNDERSTAND THE COMPLEXITY, SYSTEMIC INTERACTION AND EVOLUTION OF THE INNOVATION SYSTEM IS MISSING.

**Second Dual Gap:** A STRUCTURED PRACTITIONER ORIENTED STRATEGY FORMULATION PROCESS IS MISSING AND ITS IMPLEMENTATION.
To close these gaps it is first of all necessary to define the criteria for a possible solution. These criteria were developed in the form of evaluation criteria in the chapter of the state of the art in literature. In the following these criteria are shortly presented:

- The innovation strategy formulation process should provide an understanding of the complexity, systemic interaction and evolution of the innovation system (see chapter 2.1.1)
- The innovation strategy formulation process should provide an understanding of direction focus, organization and consistency for the innovation system (see chapter 2.1.2)
- The innovation strategy formulation process should provide an understanding of innovation relevant knowledge, integral innovations, innovation barriers and the innovation newness (see chapter 2.1.3)

At the end of this thesis, these criteria will be included with the feedback from practice, to provide an evaluation of the solution of the innovation strategy formulation process developed in this thesis.

4.2 Working Hypotheses

Based on these gaps and insights gained from theory and practice, one can formulate working hypotheses which shall be strengthened in this thesis. These working hypotheses are not understood as tentative assumptions, which have to be tested, but as guiding ideas of this work to find answers to the research questions. Thus, the working hypotheses comply with the three research questions.

**QUESTION 1:**

**HOW CAN A COMPLEX, SYSTEMIC INTERACTIVE AND EVOLUTIONARY INNOVATION SYSTEM BE MODELLED WHICH CAN UNDERSTAND THE SYSTEM SPECIFIC CONDITIONS OF AN INNOVATION DRIVEN ENTERPRISE?**

**WORKING HYPOTHESIS 1:**

**THE CONCEPT OF ARCHITECTURE IS A SOLUTION FOR UNDERSTANDING THE COMPLEX, SYSTEMIC INTERACTIVE AND EVOLUTIONARY SYSTEM OF INNOVATION DRIVEN ENTERPRISES.**
Figure 55: Working hypothesis 1: Understanding the complex systemic interactive and evolutionary system

**QUESTION 2:**

How could a structured innovation strategy formulation concept be **designed**, based on the innovation architecture, for innovation driven enterprises?

**WORKING HYPOTHESIS 2:**

The innovation architecture applied in an adapted innovation strategy formulation process is a support for innovation driven companies to define an innovation strategy.

Figure 56: Working hypothesis 2: Innovation architecture as innovation strategy formulation support

**QUESTION 3:**

How could such an innovation strategy formulation concept be **implemented**?
**WORKING HYPOTHESIS 3:**

Implementing an innovation strategy formulation process in an innovation driven company is not realizable by implementing the whole theoretical process. However the theoretical innovation strategy formulation process is a basis for adding the missing steps that the company will be able to define an adequate innovation strategy.

Figure 57: Working hypothesis 3: Implementation of innovation strategy formulation process: Company specific implementation
5 Concept

In the last chapter the dual gap identified in literature and practice as well as the state of the art in closing this gap was shown. It was demonstrated that the state of the art does not offer solutions which would close these gaps. Therefore in this chapter a concept is presented to close the gap by answering the three research questions of chapter 4.

The first research question – modeling a complex, systemic interactive and evolutionary innovation system in order to understand the system specific conditions of an innovation driven enterprise – is answered with the concept of the innovation architecture (see chapter 5.1). The answer to the second and third research questions – to design and implement an innovation strategy formulation process – is presented in chapter 5.2 (see Figure 58). The two concepts are presented in different chapters. The innovation architecture plays also a major role in chapter 5.2 because the innovation strategy formulation process is based on this architecture.

Figure 58: Structure of chapter 5
As seen in chapter 4.1 the concept of the innovation architecture and the concept of the innovation strategy formulation both have to consider certain innovation specific aspects that were presented in the theoretical part in this thesis. In the following the most important aspects are shortly reviewed:

- The complexity and systemic interaction of the system has to be modeled to understand the actual innovation system. The evolution has to be visualized in order to improve the sense of the future development of the innovation system (see chapter 2.1.1).

- The architecture as well as the innovation strategy formulation process should allow innovation opportunities to be evaluated and consistent decisions to be taken with a clear and focused direction. Additionally the innovation strategy should allow an adequate organization for the innovation system to be derived (see chapter 2.1.2).

- The innovation relevant knowledge has to be represented in the architecture to identify the existing knowledge as well as the required knowledge to develop certain innovation opportunities. This is essential for developing an innovation strategy. Furthermore all kinds of innovation should be considered in terms of newness and the object itself. Additional attention should be paid to innovation barriers (see chapter 2.1.3).

These aspects are the basis for the development of the following presented concepts, the innovation architecture and the innovation strategy formulation process.

5.1 Innovation Architecture

5.1.1 Introduction

To answer the question of modeling a complex, systemic interactive and evolutionary innovation system, the architecture is the underlying concept as described in the first working hypothesis (see chapter 4.2). More specific Schaad’s (2001: 116) innovation architecture presented in Figure 42 and inputs from Tschirky (1999) in the specific context of innovation and technology management were the basis for designing a solution of an innovation architecture (Figure 59). This innovation architecture was redesigned for the specific requirements of this work and will be described in detail in the following sub chapters.
This innovation architecture is a three dimensional house of the innovation system analogous to the architecture of a building. In contrast to the architecture of a building the three dimensions of the innovation system are not spanned by the three steric directions but by three knowledge dimensions: object knowledge, methodological knowledge and meta-knowledge (see Figure 60).

![Figure 60: Three knowledge dimensions (compare Wagner, 2002)](image)

These three dimensions of knowledge are based on the knowledge understanding in the domain of semantics as defined by Wagner (2002). Wagner argues that when people communicate, they want to transfer knowledge. In doing so people have the intention of transferring knowledge about objects (object knowledge), about actions (methodological knowledge), and about backgrounds of the transferred knowledge (meta-knowledge). Wagner argues that these three knowledge groups categorize all the knowledge that people want to communicate. So it can be said that this regrouping can represent the essential knowledge of a system.

More specific object knowledge is the knowledge about objects and information in our environment. In innovation, the object knowledge is the knowledge about customer needs, products and services, modules, technologies and scientific insights applied. In contrast, methodological knowledge is the knowledge to act and to comply actions. Thus, it is the knowledge about how to proceed and behave, what specific steps and tasks to initiate and with which procedure to complete the tasks. Especially, the methodological knowledge enables the creation, processing and transfer of object knowledge. Meta-knowledge encompasses knowledge about the source, reliability, importance, and transferability of the knowledge as well as the cognitive capabilities available to the knowledge development (compare Wagner, 2002).
Combining the three dimensions of knowledge, the object knowledge is the result of creating, extracting, combining, modifying, integrating, modeling, applying, storing, and transferring of more general object knowledge by using methodological knowledge. Metaphorically speaking this understanding assumes an object knowledge flow which is similar to the material flow in production where specific stages are stated in materials, parts, components, assemblies and finished goods. Between the stages, there are varying activities which create process and transfer the objects from one stage to the next. Along the material flow, the division of work is represented by the logical flow of activities which are designed into the product (almost inherently) during its conceptual design, development and/or industrialization. Similarly, the object knowledge (e.g. products, technologies) is processed during a logical flow of activities towards its innovative purpose and represented by stages which are identifiable along its processing. Specific methodological knowledge (e.g. analytical techniques or integration know-how) is required for its creation, processing and transfer at each stage, guided by specific meta-knowledge (e.g. scientific reasoning, modeling and transferability).

This three dimensional knowledge concept is essential for the structure of the innovation architecture. Therefore each dimension is described in detail in the next three sub-chapters.

5.1.2 Object Knowledge Dimension

In the object knowledge dimension, the object knowledge and its systemic interaction are visualized. The objects are markets, products or services, modules, technologies, applied knowledge and scientific knowledge. The structure of these objects is based on the principles of the knowledge depth.

The knowledge depth is an indicator according to Schaad (2001: 109f) of how far a company advances its innovation efforts in the direction of new domains to make them accessible and to integrate them into concrete products. The entity of the knowledge depth is the generalization or the specialization degree of the object knowledge from a company’s point of view. A high degree of generalization, and therefore a great degree of knowledge depth, means that the object knowledge is more general, but is not directly linked with a specific product development intention. This is typically scientific knowledge. Whereas a high degree of specification of the object knowledge, and therefore a low degree of knowledge depth, means that the object knowledge is very specific and has a direct link to an product development intention of the company. A typical example is knowledge about a product which is highly specific. Based on this knowledge depth, the objects are vertically structured as shown in Figure 61 and described more in detail in the following.
The object knowledge of markets and market needs is the most specific object knowledge, because it is the knowledge about the requirements of an actual or potential customer. Typically it is the knowledge that is developed in marketing. These markets and market needs are regrouped in the innovation architecture by strategic business fields (SBF). These SBF represent an isolated functioning part of company’s market oriented activities (Müller-Stewens & Lechner, 2001: 115). According to Abell (1980) such a SBF should be defined based on a three dimensional raster: The function describes the customer need, the customer groups describe the specific buying attitude, and the technologies describe the technical solution to fulfill a specific function.

Products are final goods and services that are offered by a firm based on utilizing the competencies that it possesses (compare Teece, Pisano, & Shuen, 1997). The products relate to specific market needs and are linked directly with them in the innovation architecture. These products are divided into modules, which are uncoupled parts of products. These parts should be designed in terms of respecting the rules of modularity. According to Mikkola & Gassmann (2003: 407f) modularity refers to the scheme by which interfaces shared among components in a given product architecture are specified and standardized to allow for greater substitutability of components across product families. This increases the product variety and customization. When interfaces of components or modules within a system becomes standardized, outsourcing decisions can be made accordingly with respect
to a firm's long-term strategic planning of its NPD, manufacturing and supply chain management activities. Additionally, modularization is an approach for organizing complex products and processes efficiently (Baldwin & Clark, 1997), by breaking down complex tasks into simpler portions so they can be managed independently. Modularization permits components to be produced separately, or loosely coupled (Orten & Weick, 1990; Sanchez & Mahoney, 1996), and used interchangeably in different configurations without compromising system integrity (Flamm, 1988; Garud & Kumaraswamy, 1993, 1995). Therefore, in the innovation architecture modules make sense in principle, in the case that the product can be divided into modules.

**Technology**, according to Tschirky (1998b: 226), is “specific individual and collective knowledge in explicit and implicit forms for product and process-oriented usage based on natural, social and engineering-scientific knowledge.” These technologies can be divided into the groups of product technologies and process technologies. “**Product technologies** deploy scientific or engineering principles, dealing with a specific effect and determine how an effect occurs. This effect allows the fulfillment of a specific product function (...) which – from the point of view of the market – is towards expected customer needs” (Tschirky, 2003c: 51). For example the ‘liquid crystal technology’ is a product technology for fulfilling the product function ‘visualize data’. “**Process technologies** however, deploy the effects of an existing product technology. R&D process technologies are used to perform R&D activities and may include technologies such as microscopy, nano and atomic technology. Typical production process technologies include casting, milling, galvanizing, soldering and surface mounted technology. They also consist of logistics and quality assurance technologies. Administrative process technologies usually comprise office automation technologies and, finally, infrastructural process technologies typically may comprise security, elevator and air conditioning technologies” (Tschirky, 2003c: 53). These different technologies can be regrouped in **strategic technology platforms (STP)** which as a structure can be used to reduce the complexity of the usually large number of technologies to be handled (Tschirky, 2003a). Such a technology platform, in literature also called the technology field, is a relatively isolated part of the actual and future technological activity field (Ewald, 1989; Peiffer, 1992: 65). STP's are the counterpart to strategic business fields (SBF) (compare Brodbeck, 1999: 22). The definition of an STP is done along the three dimensions influencing a STP: technology, theory and know-how (Brodbeck, 1999: 22ff).

Applied knowledge and scientific knowledge are the objects with the highest knowledge depth in the innovation architecture. They are both the basis for developing new technologies and therefore new products. But they are different in one essential point. **Applied knowledge** is the result of applied research which is according to Picot et al. (1988) the application oriented search for knowledge for existing problems. In contrast **scientific knowledge** is the result of basic research which is mainly concerned with an application neutral search of basically new knowledge (Picot, Reichwald, & Nippa, 1988).
With this innovation architecture presented in Figure 61 it is possible to visualize and therefore to understand the innovation system. The innovation architecture visualizes the systemic interactions between the object knowledge. In doing so not only the existing innovation relevant knowledge is presented in the innovation architecture (white objects) but also the knowledge that is needed to be developed for realizing a concrete innovation opportunity (grey objects) is integrated. In other words, the knowledge that is already in-house is in this case a strength and the weaknesses is the knowledge that is not on the required level and where in future the innovation activities have to be focused.

In addition to the linked object knowledge in the innovation architecture the functions and innovation fields are also integrated. The functions are integrated into the object knowledge dimension because of several facts. Firstly they allow a solution neutral connection between technologies and products/modules, which helps in the strategic steering to coordinate the solution oriented product development on an abstract level and the effect-oriented technology development. Thus making it possible to ensure the handshake between technology push and market pull. Secondly the functions allow new business fields and technology platforms to be identified and integrated, which give an overview of future potential opportunities. Thirdly the definition of the function, which is a strategic decision, gives the direction of the future activities. For example companies that produce microwaves, can define a function as ‘heat meal’, which would define a strategic direction in the food business, which is not only limited to microwave technology. But it is also imaginable that the company would decide to define the function as ‘rotate dipole’ which is basically the technological effect of the microwave technology. This function would allow a strategic direction that is much broader than only for the food business. Therefore the function is a central element to mention in the innovation architecture.

Because of this fact, that the functions are so central to innovation management and especially in the innovation architecture three guiding lines – additionally to the more general guiding lines about functions presented in chapter 2.2.2.1 – for defining the functions in the innovation architecture are presented:

1. **The definition of the functions is related to the product properties.** For products that are process oriented, the functions are representing the different stations of the process flow. In the case that the product is not process oriented the functions are representing the modules of the product. (see Figure 62).
Figure 62: The definition of the functions is related to the product properties

2. The definition of the functions relates to the technology decision making perspective. In the case that the innovation architecture is made for a normative decision perspective the functions are more general, abstract and solution oriented. In the case that the innovation architecture is made for an operational decision perspective as steering instrument the function are more detailed, figurative and solution oriented (see Figure 63).

Figure 63: The definition of the functions relates to the technology decision making perspective
3. **The definition of the functions relates to companies strategic intentions.** In the case that the company is highly market oriented and wants to fulfill one specific customer need, the function has to express this strategic intention of fulfilling one customer need. Whereas the company is highly technology oriented and wants to enter into several markets, with different customer needs and with one single technology, the function has to express what the technology really does (see Figure 64).

<table>
<thead>
<tr>
<th>Market pull strategic intention</th>
<th>Balanced strategic intention</th>
<th>Technology push strategic intention</th>
</tr>
</thead>
<tbody>
<tr>
<td>The company focuses its strategic innovation intentions on a <strong>specific customer need</strong>. For fulfilling this need the best technology is looked for.</td>
<td>The company focuses its strategic intentions on the development of a <strong>specific product</strong> for fulfilling customer needs in mainly known markets based on mainly known technologies.</td>
<td>The company focuses its strategic intentions on the development of a <strong>core technology</strong> that is leveraged for satisfying different customer needs in independent domains.</td>
</tr>
</tbody>
</table>

**Example**

- The strategic intention is to develop products that satisfy the customer need of cooking.
- The strategic intention is to develop microwave ovens.
- The strategic intention is to develop products based on the microwave technology.

**Figure 64: The definition of the functions relates to companies strategic intentions**

The **innovation fields** in the innovation architecture have two main tasks. On the one hand they allow new, but related, strategic business fields and technology platforms to be identified and on the other hand they are a steering instrument for defining the search fields for the company intelligence (see Figure 65).

Additionally to all the objects described above, the innovation architecture provides the possibility to integrate **quantitative key figures**, which helps to understand the system in a more detailed view. Figure 61 shows an example of the object knowledge dimension, where on the left side of each object the amount of knowledge carriers is indicated. On the right side the budgeted costs for developing this object knowledge are integrated. These key figures can be completed by other quantitative information such as the required development.

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88 A detailed discussion about innovation fields can be found in chapter 2.2.2.1
time or percentage of R&D intensity. These key figures depend on the company specific context and needs.

![Innovation Fields Diagram](image)

**Figure 65: Innovation fields**

5.1.3 Methodological Knowledge Dimension

The methodological knowledge dimension visualizes the knowledge that is needed to generate cognition in scientific research, to develop it into an invention in the technical conceptualization and to introduce it into a market in the technical & business realization\(^9\) as shown in Figure 66. This figure is a conceptual and exemplarily demonstration of possible levels in the methodological knowledge dimension. It is obvious that some companies will not have a level of scientific research and other companies will divide the technical conceptualization into the level of applied research and technology development. Therefore the amount of levels depends on the amount of levels in the object knowledge dimension given by the knowledge depth.

In the methodological knowledge dimension the knowledge depth as well as the innovation width of the company is visualized. The innovation width is the variance of the knowledge to act and to comply an action (see Figure 66). For example, a company that does research has to have the knowledge about scientific research cascade to search for effects in experiments and the knowledge to search in literature for already discovered effects. This company has two different methodological knowledge segments on this specific cascade and this is therefore the innovation width of the company on this cascade.

\(^9\) Compare the concept of innovation process of Ropohl (1979: 272)
Figure 66: Methodological knowledge dimension

A visualization of the coherent combination of object knowledge and methodological knowledge can be seen in Figure 67.

Figure 67: Example of an innovation architecture including object and methodological knowledge
5.1.4 Meta-Knowledge Dimension

The meta-knowledge dimension is the fundament of the innovation architecture. It is the knowledge about the object and methodological knowledge. There are some authors that see meta-knowledge as the most important value of all knowledge categories (Ward, 1998: 10). To identify the meta-knowledge in a company four questions must be answered according to Ward (1998: 12ff):

- Know who? (e.g.: Who around has knowledge about liquid crystal technology?)
- Know how? (e.g.: How do we get the ideas of new innovations?)
- Know where? (e.g.: What conferences should be attend, in order to stay up to date?)
- Know why? (e.g.: What are the cultural values of this place? What is the baggage? What is the vision?)

In each case, effective knowledge is knowing how to go about assembling the relevant object and methodological knowledge to inform a particular decision or judgment (Ward, 1998: 13).

To integrate meta-knowledge in the innovation architecture specific meta-knowledge and general meta-knowledge have to be differentiated. Specific meta-knowledge is always linked to a specific or cluster of object or methodological knowledge represented in the innovation architecture. This meta-knowledge is a kind of an informational specification catalogue which can be directly integrated into the innovation architecture or is shown on a separate document which aims to detail the different objects. In contrast, general meta-knowledge is related to the whole innovation architecture. Therefore this kind of meta-knowledge does not give additional information for a decision about a specific object of methodological knowledge, but it is more the representation of how the company as a whole system develops innovations.

Both of the meta-knowledge groups consist of five aspects:

- The source of knowledge (e.g.: The liquid crystal technology knowledge comes from partner XY and Dr. Muller is our internal expert)
- The reliance of knowledge (e.g.: The journal XY is highly reliable in describing new insights in the domain of nano-technology)
- The importance of knowledge (e.g.: Knowledge about liquid crystal, installed in tablet PC’s, can provide a high return in five years)
- The evolution of knowledge (e.g.: Liquid crystal technology knowledge will be substituted by OLED technology)
• The cognitive capabilities to develop new knowledge (e.g.: Our internal development department is not capable of developing a Tablet PC, but our competitors are).

5.1.5 Conclusion

The innovation architecture visualizes the complexity, systemic interaction of the innovation system because of the linked integration of the innovation relevant knowledge consisting of object, methodological and object knowledge. Additionally the evolution of the innovation system can be understood by integrating the planned innovation relevant knowledge, defining the appropriated functions and innovation fields, which thus allow the identification of new potential activity fields.

![Figure 68: Major results of the innovation architecture](image)

As summarized in Figure 68, the innovation architecture is a basis for taking decisions based the visualized strengths (existing knowledge) and weaknesses (knowledge gap) of the company in the innovation system. Through defining the business fields, technology platforms, innovation fields and functions, a strategic direction is given and therefore it is a basic instrument for strategic steering. The innovation architecture also forces the management of innovation to think in detail, on every cascade, about the influence of a potential innovation opportunity. Therefore it helps to analyze the detailed extension of an innovation opportunity. Last but not least the innovation architecture is a kind of a strategic archi-
The Concept

In the terms of Prahalad and Hamel (1990: 88), which shows the core competencies of a company. Thereby competencies are understood as a bundle of knowledge – object, methodological and meta-knowledge –. Often these (core) competencies describe capabilities that result from organizational learning over years (Tschirky, 2003a) and can provide competitive advantage and generate rents (Teece, Pisano, & Shuen, 1997).

In spite of these multifaceted advantages of the innovation architecture, it has to be mentioned that the innovation architecture – as every tool in management – has to be updated regularly. Is this not the case, the innovation architecture will generate no describable advantage. To ensure that the innovation architecture is advantageous it is important to consider some basic guidelines (see also Figure 69):

- The innovation architecture has to be designed as simply as possible. Therefore it should not be the aim to integrate all details of the innovation system, but to integrate only the relevant elements for taking strategic decisions.
- The functions should be defined in detail without limits. If the functions are described too limited, the development activities are taking too limited of a focus. If the function is not detailed enough, they cannot be used as strategic steering or identification tool because of too high of a level of abstraction.
- The relations between the objects have to be loosely interconnected to ensure the autonomy of an object in taking a decision. When the objects are not loosely interconnected, a decision cannot be made about an object alone.
- The innovation architecture has to be flexibly designed. This means on the one hand that the tool with which the innovation architecture is designed (e.g.: PowerPoint) should allow changes to be integrated in a short time. On the other hand the innovation architecture itself should be designed by thinking ahead to integrate changes.
- The innovation architecture should integrate, on each cascade, the principles of modularity to give the R&D the possibility to leverage an object for another purpose.
- The innovation architecture is a detailed visualization tool considering innovation opportunities from a holistic point of view. Therefore it is important in the process of architecting, to integrate employees from marketing, from development as well as from research.

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90 For a more detailed discussion about ‘strategic architecture’ see chapter 2.2.1.2
91 The requirements of a core competence are described in chapter 2.2.2.1
92 See also chapter 2.2.2.1
In a summary the innovation architecture is a powerful tool for understanding the innovation system and for preparing strategic decisions. Such strategic decisions are mainly taken in the innovation strategy formulation process. This is the subject of the next chapter.

5.2 Innovation Strategy Formulation Process

In this chapter, an answer to the second and third research question of designing and implementing a structured innovation strategy formulation process including the innovation architecture based on the second and third working hypothesis (see chapter 4.2) can be found.

5.2.1 Introduction

Before developing an innovation strategy formulation process first of all this process has to be integrated into the company’s value defining processes\(^{93}\) to clearly see the interfaces with other processes and to develop a holistic and integrated strategy formulation process. Such holistic integration into the value defining processes is presented in Figure 70 and described in the following.

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\(^{93}\) See chapter 2.1.3.5
Figure 70: Value defining processes in a company

On a normative level, according to Tschirky (2003d: 47), “primary decisions must be made according to the long-term goals of the enterprise. This requires the development of a consistent company policy” and the derivation of an innovation policy. “At the same time an awareness of the culture permeating the company is essential. Company culture includes the values held collectively by its employees, which is expressed, for example, in how employees identify with company goals and in the company’s behavior towards the environment, and manifest themselves in the company’s ability to change and innovate. On the normative level it is not only the making of long-term decisions which is vital for the company’s future. Just as essential is who makes these decisions. This question involves the upper level decision-making structures of the company. […] The guiding principle for the normative level is the principle of meaningfulness. Criteria for meaningfulness refer to the potential of products and services to provide substantial contributions to societal and individual values such as organizational viability, quality of life and personality development”.

On the strategic level it is essential that company and innovation policy be transposed into comprehensible strategies (Tschirky, 2003d: 47). Therefore based on the strategic intelligence (see chapter 5.2.2), which formulates on the one hand the company’s information need and on the other hand analyzes this information, the innovation strategy formulation process is triggered. This innovation strategy formulation process starts with the ‘identify’ phase (see chapter 5.2.3), which revises the innovation portfolio for understanding the ac-
tual situation, identifies new opportunity fields\textsuperscript{94} and details theses opportunity fields in a cyclic procedure. In the ‘evaluate’ phase (see chapter 5.2.4) the innovation opportunities are evaluated by analyzing the strategic fit, assessing qualitative and quantitative key figures and setting the direction for ‘Make or Buy / Keep or Sell’. This evaluation is the basis for deciding and formulating the innovation strategy in the next phase (see chapter 5.2.5). With this innovation strategy, which should be based on the corporate strategy, the innovation strategy formulation process as itself is closed. Nevertheless it is still a strategic task to roll out this innovation strategy in a further phase (see chapter 5.2.6). In this ‘roll out’ phase it is firstly essential to redesign the operational innovation development processes to the new strategic requirements in terms of “structure follows strategy” (Chandler, 1962). Secondly the implementation has to be controlled and changed if necessary and thirdly the innovation strategy has to be updated if major external or internal changes occur.

Finally, on the operational level, according to Tschirky (2003d: 48), “responsibility is taken for transforming strategies into practice in the context of short-term goals. Operational management expresses itself, for example, in concrete R&D projects in which the necessary personnel, financial and instrumental resources are deployed according to a plan. Here the pointer is "doing things right", implying accordingly the principle of efficiency”. On this operational level the individual innovation processes are arranged in cascades and segments based on Schaad’s (2001: 104) concept. Thereby an innovation process represents an organizational responsibility domain. The cascades are based on an aimed decoupling of the field of activity. In Figure 70 the cascades are decoupled by business, product and technology field of activity. In contrast the segmentation of the processes is done due to the fact that on one cascade, there is a need two separate processes. For example on the business cascade it is essential to have a business development process for the market A and market B. Additionally to these operational innovation processes, it has to be mentioned that each process is steered and coordinated by the strategic level because of the asynchronous interface between the processes\textsuperscript{95}.

Additionally to the visualization of the innovation strategy formulation process of Figure 70, a rough overview can be used to outline its integral character linking the innovation strategy formulation process with the structures and methods in the context of innovation and technology management (see Figure 71). Especially the process steps and the methods will be described in detail in the following.

\textsuperscript{94} An opportunity field is an opportunity that has a major impact on company’s strategic goals and path. This term is introduced to make an explicit distinction between opportunities with less strategic impact major strategic impact.

\textsuperscript{95} For a more detailed discussion see Schaad (2001: 104)
Because the subject of this dissertation is ‘structured innovation strategy formulation’, the focus in the following chapters is set on the strategic level of the value defining processes, describing in detail the three phases of the innovation strategy formulation process shown in Figure 70. To ensure the integrity of the description of the strategy formulation process additionally the ‘strategic intelligence’ phase and the ‘roll out’ phase is described in separate chapters but on a more general level.

For a more practitioner oriented understanding of the strategy formulation process a virtual company which offers digital cameras, named Pixel AG, is used. This allows showing, from a practical point of view, how to proceed during the innovation strategy formulation process. The specific Pixel AG examples during the following chapters are always characterized by a box containing the Pixel AG logo on top left. In the same style is in Figure 72 the description of Pixel AG presented.
5.2.2 Strategic Intelligence

The ‘strategic intelligence’ step on the strategic level is an ongoing task that guides strategic management in the collection, analysis and application of information which describes relevant facts and trends (opportunities and threats) of the organization’s entire environment which is then used to support the strategy formulation process (compare Savioz, 2002: 33). Thereby it is not the task of strategic intelligence to find out these facts and trends by using several intelligence tools, such as the publication/patent frequency analysis, the S-Curve analyzes or delphi studies which is more the task of operational intelligence, but rather it is the task to formulate the information need and to analyze holistically the sampled information.

A tool that supports this management task of intelligence is the so-called opportunity landscape (OL) (Savioz, 2002: 123ff; 2003: 193ff) which is used with the aim to manage the fields of information need on a competencies based manner. The OL is based on the gatekeeper approach (Allen, 1986) and constitutes an organizational knowledge base of facts and trends in a company’s environment. Measures for the management of these competencies can then be derived from this knowledge base. The concept of the OL will be presented step by step in the following based on Savioz’s (2003) descriptions.

First, an inventory of the present knowledge domains has to be created. This should be complemented with domains that could be relevant in the future. The determination of the current and additional domains can be performed basically in two ways: top-down and bot-

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96 See also chapter 2.2.2.1

97 For a more detailed discussion about the intelligence tools, especially in the context of technology, see Savioz (Savioz, 2002: 62ff) and Lichtenthaler (Lichtenthaler, 2000: 330ff)
The Concept

In the top-down approach one derives, to the degree possible, the strategic knowledge areas and the constituent knowledge domains from the company strategy that are typically formulated by top management. In the bottom-up approach, employees from different departments (research and development, marketing, production etc.) and from different management levels are brought together in workshops, where via brainstorming they determine, consolidate and approve possible relevant knowledge domains. The knowledge domains are then broken down into knowledge fields.

The knowledge domains correspond to the competencies that should be built up in the future and the ones that should be maintained and further developed. Because at any given time not all knowledge domains are of the same level of importance, observation depths should be determined. That implies that knowledge domains, whose relevance is already quite high, should be observed more intently than the ones whose importance is only presumed. The OL foresees three observation depths, with a decreasing degree of intensity: the game field, the substitute bank and the offspring.

![Visualization of the opportunity landscape](image)

**Figure 73: Visualization of the opportunity landscape**

Visualization gives the OL a face. This promotes transparency and hence communication. A good visualization has three characteristics: Completeness, simplicity and sustainability. A possible visualization of the OL is shown in Figure 73, where the domains are introduced as ‘issues’.

The OL is based on what is inside the heads of the participants. Therefore, for each defined knowledge domain a gatekeeper is defined; the gatekeeper is responsible for having the most current state of knowledge about his or her issue at any given time. Thus responsibilities are assigned. The designated gatekeeper is ideally an expert in his own field, otherwise personnel, who has the necessary potential, has to be developed. Together, the gate-
keepers form the so-called gatekeeper network. The gatekeeper has the responsibility of observing facts and trends in his knowledge domain. The following three aspects should be covered in this respect: Technology, market and competition. What exactly should be observed and how precisely this observation should be made is determined by the gatekeeper, because he or she has the best knowledge to decide and he/she knows the strategic direction of the company as well as the areas in which it needs to act. In particular, the gatekeeper must define his information sources (e.g. journals, databanks, internet, formal and informal networks etc.), build them up and maintain them. Naturally, the gatekeepers should be supported. A person, for example the CTO, can coordinate the gatekeeper network and at the same time support the gatekeepers with the various tools needed. Co-workers should also support the gatekeeper by forwarding relevant information.

Communication from the gatekeeper should follow the information push and pull principle. The gatekeeper should inform the concerned decision makers on threatening or opportunity-creating events and anyone should be able to rely on the gatekeeper at any time for information in the gatekeeper’s knowledge area, because the gatekeeper should permanently be able to provide competent information (Figure 4).

The OL is primarily the organizational knowledge based on facts and trends in the company’s environment. Actions however, should be derived from this knowledge base. The first action could be the initiation of development projects, which should be initiated on the basis of the gatekeeper findings. Thus, the OL supports the idea generation in the early phases of the innovation process (Savioz, Birkenmeier, Brodbeck, & Lichtenthaler, 2002). The second action of the OL can be the support during the innovation process, since this organizational knowledge base can offer expert knowledge for problems in projects. The third action concerns the interaction with the strategy process. As shown in Figure 1, the knowledge from the OL can influence or update strategic decisions or the company strategy as a whole. The OL can in turn be updated through a new strategy, for example by observing and developing new technology fields in order to cover new market performance. This shows that the OL is a dynamic process, which should be properly managed. As a fourth action, one needs to mention the alarm function of the OL. The gatekeeper can recognize important developments (e.g. a discontinuity) in the company’s environment and they can, depending on the extent of the development, react, for example, by informing those concerned.

Concluding, the opportunity landscape is an organizational knowledge base of facts and trends in the company’s environment, it is an alarm system for discontinuities and it is a pro-active idea generator. Therefore the OL is a basic strategic intelligence tool that summarizes trends, internal ideas, customer needs, strategic requirements and competitor activities in the form of specific issues. In the case of Pixel AG such issues can be for example a 7 mio. pixel camera or a 12 mio. pixel camera to be developed as presented in Figure 74.
Concluding the OL is an ideal starting point for the ‘identify’ step in the innovation strategy formulation process which is presented in the following chapter.

5.2.3 Identify

The ‘identify’ phase aims at identifying new opportunity fields. To make it possible to identify these fields it is first of all necessary in the ‘revise innovation portfolio’ step to understand the information of the strategic intelligence, which is based for example on different trends, ideas, strategic requirements, customer needs and summarized as issues in the opportunity landscape. These issues have to be integrated into the innovation architecture (see chapter 5.2.3.1). Afterwards, in the ‘identify opportunity fields’ step, new potential innovation opportunity fields are searched by using creativity methods (see chapter 5.2.3.2). To close the identification, the opportunity fields have to be detailed to understand the impact on the innovation system of the company (see chapter 5.2.3.3). Therefore the result is, based on more or less unstructured facts and trends, to build up a structured innovation architecture consisting of all potential innovation opportunities (see Figure 75). In the following, the three steps in the ‘identify’ step are described in detail.

98 Definition of opportunity field see chapter 5.2.1
Innovation Strategy Formulation Process

Figure 75: Step 'Identify' in the innovation strategy formulation process at Pixel AG
5.2.3.1 Revise Innovation Portfolio

Based on the opportunity landscape, which represents the results of the strategic intelligence, and the corporate / business unit strategy, a first draft of the innovation architecture is to be built up in this step in order to understand the actual innovation system and to revise the innovation portfolio. Therefore the issues of the opportunity landscape, which represent ideas of concrete knowledge to be developed, have to be structured into the cascades of the innovation architecture. For example if there is an issue about the development of tablet PC knowledge, this issue is integrated into the product cascade. Or if the issue is about the development of liquid crystals, the technology cascade would be appropriate. Therefore all the issues are clustered into different groups: Market, product, module, technology, applied knowledge and scientific knowledge. Here has to be mentioned that not all companies have activities in scientific or applied knowledge, or that not all products have modules. In this case these cascades will not appear and can be ignored.

![First draft of the Innovation Architecture](image)

**Figure 76: First draft of an innovation architecture at Pixel AG**

After clustering the issues of the opportunity landscape they can be linked in order to provide a first draft of the innovation architecture. Thereby it will appear that some issues
can not be linked because some issues are missing in the opportunity landscape. This is because of two facts: Firstly in the opportunity landscape the objects are integrated, in term of issues, that need more effort in order to develop them, therefore issues that have been developed in the past are not integrated in the opportunity landscape. Secondly the opportunity landscape is a sampling instrument of the results in intelligence; therefore it is possible that objects, obviously missing in the innovation architecture, were not found to be important in strategic intelligence. Therefore these missing objects have additionally to be integrated into the first draft of the innovation architecture. In the case of Pixel AG such a draft of an innovation draft is presented in Figure 76.

Based on the first draft of the innovation architecture; the functions, innovation fields, business fields, and technology platforms have to be defined\textsuperscript{99}. The definition of these elements\textsuperscript{100} is a very important step in the innovation strategy formulation. This is because of the fact that the functions and the innovation fields define the direction of further investigation for steering the innovation system and for identifying new technology platforms and business fields. In the case that the function is too or not enough detailed or the function does not exactly represent the company, a wrong strategic direction would be defined. The definition of business fields and technology platforms is crucial for clustering the detailed objects, which will afterwards be the categorization of defining innovation orders. Therefore the definition of these elements should be done with the consensus of all the innovation strategy’s decision makers.

In Figure 77 is shown how, in the case of Pixel AG, the identified innovation field and functions can be integrated into the innovation architecture. Thereby the innovation field is in this special case the same as the vision and the functions are mainly the functions of a digital camera.

In the following a checklist for the ‘revise innovation portfolio’ step is presented:

• Is the corporate & strategic business unit (SBU) strategy integrated?
• Are the customer needs analyzed in detail?
• Are all the innovation relevant trends for products, markets, businesses, technologies known?
• Are the competitors’ new products and technologies analyzed and is their future strategic position known?
• Are the gatekeepers involved to identify internal ideas?
• Are the functions, innovation fields, business fields and technology platforms defined, appropriate to the company needs?

\textsuperscript{99} For a detailed discussion about the definition of functions, innovations fields, business fields and technology platforms
\textsuperscript{100} The process of defining these elements is described more in detail in chapter 5.1.2
If all the answers to theses questions are positive, new opportunity fields can be systematically identified as described in the next chapter.

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**Actual Innovation Architecture**

- **Innovation Field**
  - Capture & Share seen moments
  - Strategic Business Field: Amateur Photography

- **Product-System-Services**
  - 12 Mio Pix
  - 7.8 Mio Pixel
  - 6 Mio. Pixel Digital Camera

- **Modules**
  - Body
  - Lens
  - New Light Sensitive Chip Technology Platform
  - Storage System
  - Display

- **Functions**
  - Establish Man-Machine Interface (outsourced)
  - Guide Light Waves (outsourced)
  - Transform signal (Light to electrical signal)
  - Store Data (outsourced)
  - Visualize & Change Data

- **Technologies**
  - Light Sensitive Chip Technology Platform
  - Display Technology Platform
  - Image Editing Technology Platform

- **Applied Knowledge**
  - Optical Physics
  - Sensitive Chip Tech.

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**Figure 77: Actual innovation architecture at Pixel AG**

5.2.3.2 Identify Opportunity Fields

In contrast to the last step, which was about sampling and defining, this step is creative. Based on the innovation fields and functions, new business fields and technology platforms are identified. In doing so it is not the aim to identify a specific technology or a specific product, because this is the task of strategic intelligence, but it is more an aim to identify potential activity fields for the future which will provide the opportunity for developing specific innovations in the future.
For this purpose, a workshop regrouping the gatekeepers of the company’s innovation system is a suitable basis for finding opportunity fields. In this workshop different creativity methods can be used such as brainstorming, mind mapping, discussion 66, method 635. By using these methods it is essential that the quality is not decisive, but the quantity of the ideas of the workshop members is essential to enforce the creativity. The workshop should consist of two parts:

- Innovation fields analysis: Based on the preliminary definition of innovation fields primarily new business fields should be identified. For example in the case of Pixel AG the innovation field ‘capture & share seen moments’ allowed the new product full solution to be identified, which means nothing other then offering a digital camera with the service that the pictures can be uploaded onto a server to be managed in terms of changing, administrating, sending, etc. (see Figure 78).

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101 Other creativity methods are presented by Biedermann (2002: 54)
102 For a more detailed discussion about potential creativity barriers see Biedermann (2002: 52)
103 See in the context of innovation fields also chapter 5.1.2 and chapter 2.2.2.1.
• The functional analysis:\textsuperscript{104} Based on the already defined functions of the innovation architecture, the questions have to be answered of what technology platform fulfills also a specific function and also what business field requires this function. For Pixel AG the function ‘Visualize & Change Data’ made it possible to identify the technology platform of beaming the data on a flat surface (see Figure 78).

The identified opportunity fields can be evaluated roughly at the end of the workshop. Thereby it is not the aim to make a quantitative evaluation but more a qualitative evaluation which only considers if there is a realistic potential to meet a certain opportunity field. The potential opportunity fields should afterward be integrated into the innovation architecture as presented for Pixel AG in Figure 78.

The checklist for the ‘identify opportunity fields’ step is the following:

• Are all the gatekeepers involved in this identification workshop?

• Do the gatekeepers have enough information about the preliminary defined functions and innovation fields in order to be able to identify new opportunity fields?

• Are the identified opportunity fields integrated into the innovation architecture?

Until this point new opportunity fields are integrated into the innovation architecture, but they have to be detailed in order to evaluate them in a further step, as described in the following.

5.2.3.3 Detail Opportunity Fields

It is obvious that until this point the innovation architecture is incomplete and the level of detail is not the same for all the objects. Therefore this step aims to detail all of the objects in the innovation architecture to one and the same level. This can be done by considering three aspects.

Firstly the identified opportunity fields themselves have to be detailed by finding the markets and customer needs for the business fields and the products and process technologies for the technology platforms. And these specific objects have to be linked to already existing objects or if this is not possible the missing objects have to be identified and integrated.

For Pixel AG (see Figure 79) it is necessary to develop on the one hand for the beamer technology, a specific mini beamer technology and scientific knowledge in ‘diochric physics’ is required. On the other hand in order to develop the full solution of getting an additional homepage module for managing the pictures, a ‘wireless lan’ module for sending the

\textsuperscript{104} See in the context of functions also chapter 5.1.2 and chapter 2.2.2.1.
pictures to the server. These modules also require specific technologies. Furthermore this full solution product can be divided into a standard and flexible version. The standard would be for the hobby photographer and the flexible version would be for the professional photographer, which represents a new business field.

Secondly the innovation architecture has to be completed in terms of its object knowledge. This means that every object has to be evaluated by the level of knowledge that already exists in-house. For Pixel AG (see Figure 79) a twofold differentiation about object knowledge is made: On the one hand the objects where object knowledge exists in the company (white objects) are presented, representing the company’s strengths, and on the other hand objects where this knowledge is not available in the company is also presented (grey objects), representing the company’s weaknesses. This twofold differentiation can be expanded by a more detailed categorization. For example additionally a differentiation can be made for the particular object knowledge that exists in the company. The amount of levels of the object knowledge in the innovation architecture has to be adapted to the needs of the company.

Figure 79: Detailed innovation architecture with all potential innovation opportunities at Pixel AG
Thirdly the innovation architecture has to be completed with methodological knowledge and meta-knowledge. The methodological knowledge can be integrated as can be seen in Figure 80 and is described in chapter 5.1.3. The, meta-knowledge can only be particularly integrated into the innovation architecture visualization, as for example the quantitative key figures of every object. Other meta-knowledge, such as the source of the knowledge, has to be additionally sampled in attached documents. Thereby it is not the aim to identify all possible meta-knowledge, but it is more the aim to sample the meta-knowledge that is relevant for the company specific needs and for the evaluation phase.

Figure 80: Structured and complete innovation architecture with all innovation opportunities at Pixel AG

This final innovation architecture, presented in Figure 80, of the phase ‘identify’ is completely built up in terms of the described concept of innovation architecture in chapter 5.1. Because in the next phase, the evaluation phase, the emphasis is on the object, the methodological knowledge and the meta-knowledge are only secondary considered because they are often a constraint of the objects to be developed. In the following it was decided to only use the object knowledge dimension of the innovation architecture (see Figure 79) in order to present a less complicated model. Anyhow the methodological knowledge and meta-knowledge is considered in the evaluation phase as will be seen later.
To summarize the ‘detail opportunity fields’ step a checklist is presented in the following:

- Are all identified opportunities fields detailed on market, product, module, technology, applied knowledge as well as the scientific cascade?
- Are all the objects integrated to ensure the systemic interaction?
- Is the level of object knowledge about each object integrated into the innovation architecture and are therefore the strengths and weaknesses visible?
- Is the methodological knowledge and meta-knowledge analyzed and integrated into the innovation architecture?

After completing the innovation architecture the innovation system should be clearly understood in terms of complexity, systemic interaction and its evaluation. Therefore this is a highly structured starting point for conducting an evaluation of the innovation system which is describe in the next chapter.

5.2.4 Evaluate

The ‘evaluate’ phase has the aim to prepare a consistent decision on future innovation objectives and paths for focusing efforts. Therefore, based on the information of gatekeepers and the innovation architecture including all potential opportunity fields, the evaluation is conducted. Firstly a ‘strategic fit evaluation’ is done (see chapter 5.2.4.1), secondly a ‘quantitative and qualitative evaluation’ is done (see chapter 5.2.4.2), and lastly a ‘make or buy / keep or sell evaluation’ is done (see chapter 5.2.4.3). Thereby these three steps should be seen as a circular procedure aiming to prepare an innovation architecture that can be seen as a proposal for a strategic decision, as shown in Figure 81.

5.2.4.1 Strategic Fit Evaluation

The strategic fit evaluation has the aim to prove the consistency of the innovation opportunities as itself, with its environment, consisting of the value providing system of the company, and the whole environment of the company. To evaluate the consistency, there are three different types of strategic fits according to Porter (1996: 70f).
Figure 81: Step 'Evaluate' in the innovation strategy formulation process at Pixel AG
• First-order fit is simple consistency between each activity. Which means in the context of innovation strategy formulation of the consistency between the innovation opportunities in the innovation architecture.

• Second-order fit occurs when activities are reinforcing, therefore the innovation opportunities in the innovation architecture fit with the overall activities of the company.

• Third-order fit goes beyond activity reinforcement to optimization of effort. This would be in the context of innovation strategy the fit of the innovation opportunities with the future development of company’s environment.

Thereby “the more a company’s positioning rests on activity systems with second- and third-order fit, the more sustainable its advantage will be. Such systems, by their very nature, are usually difficult to untangle from outside the company and therefore hard to imitate” (Porter, 1996: 70f).

Based on these three types of strategic fit, possible tools are presented for each type. These tools are based on existing tools that are shown in alignment with the innovation architecture. The following tools are not claiming to be a complete tool set for each company but more a basic tool set, that has to be completed to the company specific needs.

1. **Tools for first order fit**

For ensuring a first order fit the innovation architecture as itself is a tool to identify the consistency between the innovation opportunities. Basically this consistency is already ensured in the step ‘detail innovation opportunities’ (see chapter 5.2.3.3) by ensuring that all the innovation opportunities are systemic interacting, and therefore that the objects are linked together over the cascades.

Additionally the **functional handshake** can be used to ensure the first order fit (compare Biedermann, Tschirky, Birkenmeier, & Brodbeck, 1998: 549ff). This tool aims to align the market pull and technology push based activities and ensures their coordination, which is according to several authors (see exemplary Leenders & Wierenga, 2002; Souder, 2004) a major challenge to master. More concretely the functional handshake is based on the alignment of the customer needs and the product technologies over the product functions. This is optimally done with members of marketing and R&D by answering the question if the functions of the product technologies can be used for a customer need or if functions, demanded by customers, can be fulfilled by product technologies in R&D. This functional handshake can be done in the innovation architecture, by linking the technology side with the market side by functions as illustrated in Figure 82.
2. Tools for second order fit

To ensure the second order fit and therefore the fit with the company as a whole, the key success factor analysis can be made. This tool’s objective is to analyze first of all company’s success factors. These success factors consist of the key consuming factors, which are the factors affecting the end customer in his buying decision, the key buying factors, which are the factors that are influencing the retail, and the key factors for success, which are the factors that differentiate the company from their competitors. For example in the case of Pixel AG (see Figure 83) the key consuming factors for professional photographers are that the homepage has to be adapted to the professional photographers system and that it has to allow a professional public appearance. The key buying factors, demanded by the camera shops, are eventually an IT support in the case that the homepage has to be adapted. Key factors for success are micro marketing and the innovation rate.

These three categories of key success factors have then to be broken down into competences that the company has or should have. For example based on the key consuming factor ‘Homepage has to be adapted on own system’, the company should have the competence in R&D to develop a flexible Homage generator and should supply the camera shop with an IT support. Therefore these necessary competencies express a need for knowledge in the innovation system which should be the same as the object knowledge in the innovation architecture. In the case this is not so, the innovation architecture has to be changed.
A second tool for enforcing the second order strategic fit is the **core competence analysis** of Prahalad and Hamel (1990). Because core competencies are a major base of competitive advantage they have to be enforced by the innovation system. Therefore innovation opportunities that enforce an existing core competence, that will also be a potential core competence in the future, is often more valuable for the specific company then other innovation opportunities. Therefore the object knowledge of the innovation architecture should be in alignment with the core competencies of the whole company (see Figure 84).

At this point it has to be mentioned that it is crucial that the methodological knowledge and the meta-knowledge should be oriented in alignment to the competencies and especially the core competencies. If this is done, the innovation opportunities are fitted in relation to its content to the company, therefore the second order fit is ensured.
3. Tools for third order fit

The third order fit consists of the alignment between the environmental development and the innovation system in terms of its innovation opportunities to optimize the effort for the future.

The scenario technique is according to Holt (1988: 139f), a first tool for understanding alternative futures, based on a discussion of the events which may lead to the situations depicted; thus an attempt is made to set up sequences of events which starting from the present situation show how future states might evolve, step by step. Scenario technique aim at providing pictures of future developments based on alternative sets of assumptions that serve as a context, in which the various options open to the decision maker can be placed, so that he can determine which one is the most satisfactory overall\(^{105}\). This scenario technique, adapted to the environment, especially the markets and technologies, should provide a sharper picture of the future. This picture of the future should be in alignment with the innovation opportunities of the innovation architecture (see Figure 85).

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\(^{105}\) For a more detailed discussion about scenario technique see Holt (1988: 139f)
In the resulting scenarios the following questions should be answered:

- Who will the customer be in the next 5 to 10 years? Which customer needs are to be satisfied? How will the customer’s needs change in the next 5 to 10 years? Which products are concerned?

- How is the market structured? How do the segments differ? What are the geographical differences?

- Which market trends are identifiable?

- How is the role of the suppliers defined? Could a supplier make a forward integration?

- How will technological development change the business in the next 5 to 10 years? What changes in production processes are expected? How will information and data flow change?

- Who will the competitor be? How have they changed in the last 5 to 10 years? Which strategic directions do the competitors have? What are the entrance barriers for the market? What is the importance of national barriers?

- What other restrictions are there? Are future competencies, ecological or labour based restriction visible?

Looking at these questions, it is clear that the scenario technique is a tool in this context which builds up Porter’s (1980: 26) five forces model. It is essential for this to be understood in the company context in order to develop innovations and gaining future competitive advantage.
A second tool for ensuring the third order fit is the **market portfolio analysis**. The aim is mainly to understand, into which market it is good to invest. There are several different market portfolio concepts, whereby two concepts, the ‘McKinsey Portfolio Matrix’ and the ‘Boston Consulting Group Product Matrix’ seem to be the most used. The ‘McKinsey Portfolio Matrix’ ‘is an aid for determining the relative position of product lines and diversification projects based on an analysis of their competitive strength and the attractiveness of their markets’, therefore it is ‘to provide an analytical basis for strategic decisions concerning resource allocation (including possible elimination) for existing product lines as well as for decisions concerning diversification into new business areas’ (Holt, 1988: 247). In contrast, the ‘Boston Consulting Group Product Matrix’ (Henderson, 2003: 42) is an ‘aid for determining the relative position of product lines based on their relative market share and the growth patterns of their markets’ and therefore it is ‘to provide an analytical basis for strategic decisions concerning support or elimination of product lines’ (Holt, 1988: 250). The results of the market portfolio analyzed – from the BCG as well as from the McKinsey Portfolio Matrix - should be in complete alignment with the innovation opportunities presented in the innovation architecture (see Figure 86).

**Figure 86: Market portfolio analysis at Pixel AG**

To summarize the three strategic fits, the following questions, in terms of a check-list, should be answered positively.

- Is the consistency between each innovation opportunity and the overall consistency ensured, especially the fit between market pull and technology push?
- Do the innovation opportunities reinforce each other and the company activities in terms of its competencies and especially its core competencies?
• Do the innovation opportunities optimize the efforts for the future, in terms of scenarios?

• Do the innovation opportunities conform to the corporate / business unit strategy?

At this point of the evaluation, the innovation opportunities are analyzed in terms of their fit. Additionally a quantitative and qualitative evaluation has to be done. This is the subject of the next chapter.

5.2.4.2 Quantitative and Qualitative Evaluation

The quantitative and qualitative evaluation aims to find out if innovation opportunities are feasible in terms of knowledge, in terms of time, and if they are profitable. For this purpose three tools are presented answering on the needs of feasibility and profitability. Additionally a summarizing tool, the dynamic technology portfolio, is presented.

To ensure the feasibility in terms of knowledge the knowledge gap analysis is a possible tool. The results of the knowledge gap analysis indicate to the management where they need to seek new insights, and direct their time and energy (compare Krogh, Nonaka, & Aben, 2001: 431). But before directly investing into an existing knowledge gap, it has to be determined if the knowledge could be developed in-house or if it externally exists, and if the knowledge is so strategically important that it has to be developed in-house. Combining the answers, leads to a direction of how every knowledge gap has to be managed. In combination with the innovation architecture this knowledge gap analysis would be done for each (or at least for a cluster of them) object, methodological and meta-knowledge element in the innovation architecture, to find out the direction of how to develop the knowledge for a specific innovation.

Pixel AG, for example, has no knowledge about internet providing technology. At the same time it is not possible to develop this technology in-house although the technology does exist externally. However, it is very important that the development of this technology is done in-house, to gain a sustainable competitive advantage (see Figure 87).
Figure 87: Knowledge gap analysis at Pixel AG

To ensure the feasibility in terms of time the **innovation roadmap**\(^{106}\), which is the combination of a technology, product and market roadmap, can be used. An innovation roadmap is therefore a tool which comprehensively depicts the assumed development of essential innovation opportunities over time. According to Tschirky (2003d: 78f) a roadmap\(^{107}\) helps to understand the future and synchronize R&D and marketing in terms of time. Based on the innovation architecture such a roadmap can easily be derived, by bringing the object knowledge, which is not completely developed, on a time axes as shown in Figure 88. This innovation roadmap shows then exactly how long R&D has to develop a technology or a product because the direct relation to the market introduction is visible. Additionally the innovation architecture helps to determine the influences if something cannot be developed in time. Another advantage of the innovation roadmap is the possibility of fixing the market introduction time, which is given based on customer needs, and then reversed backwards, to see how long a certain project can take from start to finish.

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\(^{106}\) For a detailed discussion about roadmaps see Bucher (2003)

\(^{107}\) Tschirky (2003d: 78f) discusses the roadmap subject especially for technology roadmaps. Nevertheless his findings are also applicable to the innovation roadmap.
To ensure the profitability of the innovation opportunities a resource allocation has to be made followed by a profitability analysis. The resource allocation can be made on the basis of the innovation architecture by allocating to a bundle of object, methodological and meta-knowledge resources. Thereby these resources include human resources as well as financial resources. To ensure that the definition of the amount of resources is maintained, a person in charge has to be designated for each resource bundle. Such a resource allocation can be visualized as shown in Figure 89.

Figure 88: Innovation roadmap at Pixel AG

Figure 89: Resource allocation at Pixel AG
In addition to this resource allocation the return on investment has to be analyzed. Therefore on the one hand the allocated resources are accounted for, so that a specific customer need can be reached. Thereby it has to be mentioned that the costs of developing technologies or products that are used in several markets have to be divided into the different markets. On the other hand the possible market income is analyzed over time. With this data an investment or pay-back calculation can be made, which is quite a common method, or the more recent method of the net present value calculation NPV (Tschirky, 1998b: 348; 2003d: 76), can be used on the basis of the discounted free cash flow analysis, according to Rappaport (1986). The NPV “represents numerical values referring to increases of decreases of the total company value. It is evident that, through this procedure, the interest of top management” in innovation strategies “and R&D projects is much higher than in financial project data which only expresses a local view from the R&D department” (Tschirky, 2003d: 76). The proceeding to develop the NPV is shown in Figure 90.

Figure 90: Establishing R&D projects net present values (Tschirky, 1998b: 348)

In addition to these calculation methods, several other key figures can also be calculated. The key figures that are actually used depend on the company specific context.

To conclude, the three tools – knowledge gap analysis, innovation roadmap and resource allocation with investment calculation – are a good basis for making a qualitative and quantitative evaluation. Nevertheless these results produce a large amount of information and therefore have to be summarized for presenting to top management. For this pur-
pose Tschirky’s (2003d: 68) **dynamic technology portfolio** is an appropriated tool (see Figure 91). “This portfolio rates and positions all major technologies according to their ‘technology attractiveness’ with respect to their innovation and market potential, and their corresponding ‘technology strength’, i.e. the resources currently available within the company” (Tschirky, 2003d: 67). The data for filling the portfolio should be available from the analysis done in the previous stage of the innovation strategy formulation process.

“Once the portfolio has been developed, its strategic evaluation can take place. This focuses on setting priorities as to the promotion or reduction of technology development resources or even the phasing-out of aging technologies. The latter decision usually follows intensive internal discussions. In particular, consensus has to be reached on core technologies. They constitute strategic knowledge assets of companies and are usually developed in-house with high priority” (Tschirky, 2003d: 68). Additionally the dynamic technology portfolio integrates technologies which are attractive despite the lack of company resources.

<table>
<thead>
<tr>
<th>Technology Portfolio</th>
<th>Ability to develop</th>
<th>Needed time</th>
<th>Application range</th>
<th>Diffusion process</th>
<th>Know how stability</th>
<th>Know how level</th>
<th>Budget continuity</th>
<th>Budget size</th>
<th>Financial strength</th>
<th>Know-how strength</th>
<th>&quot;Core Technologies&quot;</th>
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<td>&quot;Existing Technologies&quot;</td>
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<td></td>
<td>&quot;Obsolete Technologies&quot;</td>
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</tbody>
</table>

**Figure 91: Dynamic technology portfolio (compare Tschirky, 2003d: 68) at Pixel AG**

“The main merit of the technology portfolio lies in its high degree of condensation of strategic information and at the same in its ease in communicating strategic decisions. In addition, a successfully finalized technology portfolio reflects completion of a constructive collaboration between experts from R&D, production and marketing, which is a valuable goal on its own” (Tschirky, 2003d: 68).
Pixel AG’s simplified technology portfolio (see Figure 91) shows that the display technology based on LCD is today a core technology, but in the future will lose attractiveness. In contrast, the internet providing technology is already today quite attractive but this attractiveness will continue to increase in the future, so it would potentially be a core technology.

Concluding the technology portfolio summarizes the results of the ‘quantitative and qualitative evaluation’ step and gives therefore a proposition for strategic goals of the innovation system. The following questions should summarize the essential questions to be answered in the quantitative and qualitative evaluation:

- Is the knowledge gap and its strategic importance for each innovation opportunity known?
- Is the planning time necessary to develop an innovation opportunity known in detail?
- Are the financial key figures, required in the company context, for the innovation opportunities known?
- Is the dynamic technology portfolio meaningful?
- Can a decision be taken in terms of which way to go?

Nonetheless the evaluation of the strategic goal, which was the objective of this evaluation step, also the evaluation of the strategic path is essential for deciding and formulating a strategy. This is the subject of the next chapter.

5.2.4.3 Make or Buy / Keep or Sell Evaluation

In the last chapter the question ‘Which way to go?’ was central, now the question ‘Make or Buy / Keep or Sell’ is essential, meaning the decision of whether a part or a whole innovation opportunity is to be developed internally or externally, and if existing objects in the innovation architecture should be kept or sold.

The make or buy decision considers the following aspects according to Brodbeck (1999: 99): The limited resources, development time, fixed costs, coordination, sourcing alternatives and cultural fit to the cooperation partners, etc.. Many of these aspects to consider were already considered in the above mentioned steps which can be taken as support for the preparation of the make or buy decision. A summary of the reasons for a make or buy is presented in Figure 92.

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109 See chapter 2.1.2.1
110 Brodbeck (1999: 99) discusses the make or buy decision in the context of technology. Nevertheless these findings can also be taken in the context of innovation.
The keep or sell decision considers aspects, according to Brodbeck (1999: 114)\textsuperscript{111}, such as the internal return on investment, the possibility of selling as a basis for a higher market development, possible utilization alternatives, joint use of R&D learning curve, etc.. Some of the aspects were already treated in the chapters before. Therefore this results and some additional information are enough to propose a decision in this context. A summary of the reasons for a make or buy are presented in Figure 92.

![Figure 92: Reasons for make or buy / keep or sell (adapted from Brodbeck, 1999: 101, 116)](image)

In the case of Pixel AG such a strategic proposition based on make or buy / keep or sell is presented in Figure 93. Thereby the market of professional photographer’s, and therefore the flexible full solution is rejected mainly due to the fact that the IT services can not be developed by Pixel AG. It was decided to buy the function 'manage data' because it is important to have it in-house but at the same time there are nearly no available competencies in-house.

\textsuperscript{111} Brodbeck (1999: 14) discusses the keep or sell decision in the context of technology. Nevertheless these findings can also be taken in the context of innovation.
5.2.5 Decide and Formulate

5.2.5.1 Decide the Innovation Strategy

In the last chapter, the evaluation phase leads to a proposition for taking a strategic decision containing on the one hand strategic goals, in the form of the innovation opportuni-

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112 A more detailed discussion about ‘make or buy / keep or sell’ can be found in Brodbeck (1999)
ties that should be developed, and on the other hand a strategic path, consisting of a ‘make or buy / keep or sell’ proposition.

Nevertheless this mainly fact based strategic decision has also to be in alignment with soft factors (Hunger & Wheelen, 2002: 115). Such soft factors can be embedded by integration of the important interest groups of such decisions according. The most important interest groups to consider are presented in the following based on Hunger & Wheelen (2002: 115):

**Interests from Stakeholders**

The attractiveness of a strategic alternative is affected by its perceived compatibility with the key stakeholders in a corporation's task environment. Creditors want to be paid on time. Unions exert pressure for comparable wage and employment security. Governments and interest groups demand social responsibility. Stockholders want dividends. Management must consider all of these pressures in selecting the best alternative. To assess the importance of stakeholder concerns in a particular decision, strategic managers should ask four questions: (1) Which stakeholders are most crucial for corporate success? (2) How much of what they want are they likely to get under this alternative? (3) What are they likely to do if they do not get what they want? (4) What is the probability that they will do it? Strategists should choose strategic alternatives that minimize external pressures and maximize stakeholder support. In addition, top management can propose a political strategy aimed at influencing key stakeholders. Some of the most commonly used political strategies are constituency building, political action committee contributions, advocacy advertising, lobbying, and coalition building.

**Interests from the corporate culture**

If a strategy is incompatible with the corporate culture, it probably will not succeed. Foot-dragging and even sabotage could result, as employees fight to resist a radical change in corporate philosophy. Precedents tend to restrict the kinds of objectives and strategies that management can seriously consider. The ‘aura’ of the founders of a corporation can linger long past their lifetimes because they have imprinted their values on a corporation's members.

In considering a strategic alternative, strategists must assess the strategy's compatibility with the corporate culture. If there is little fit, management must decide if it should (1) take a chance on ignoring the culture, (2) manage around the culture and change the implementation plan, (3) try to change the culture to fit the strategy, or (4) change the strategy to fit the culture. Further, a decision to proceed with a particular strategy without a commitment to change the culture or manage around the culture (both very tricky and time-consuming) is dangerous. Nevertheless, restricting a corporation to only those strategies that are completely compatible with its culture might eliminate the most profitable alternatives from consideration.
**Interests from key managers**

Even the most attractive alternative might not be selected if it is contrary to the needs and desires of important top managers. People's egos may be tied to a particular proposal to the extent that they strongly lobby against all other alternatives. Key executives in operating divisions, for example, might be able to influence other people in top management to favour a particular alternative and to ignore objections to it.

People tend to maintain the status quo, which means that decision makers continue with existing goals and plans beyond the point when an objective observer would recommend a change in course. People may ignore negative information about a particular course of action to which they are committed because they want to appear competent and consistent. It may take a crisis or an unlikely event to cause strategic decision makers to seriously consider an alternative they had previously ignored or discounted.

At the point that all important interest groups, concerned with innovation management, are known and were involved a decision based on the innovation architecture can be taken.

In the case of Pixel AG the decision was taken as the strategic proposal targeted. This leads to the definitive innovation architecture as can be seen in Figure 94. This decision has then to be retained by formulating the innovation strategy in the form of an official document. This is the subject of the next sub-chapter.
5.2.5.2 Criteria for formulating an innovation strategy

Criteria have to be considered as presented in Figure 95.

**Figure 95: Criteria for formulating a strategy (Quinn, 1980: 165ff)**

- **Clear, decisive objectives**: Are all efforts directed toward clearly understood, decisive, and attainable overall goals? Specific goals of subordinate units may change in the heat of campaigns or competition, but the overriding goals of the strategy for all units must remain clear enough to guarantee the energy exerted and can decisively change strategic positions. No entity has sufficient resources to overwhelm all its opponents at all points. Hence the strategy must not only consciously respond to opponents' unexpected actions. Effective communication systems are essential to each of the key strategic components above.

- **Coordinated and committed leadership**: Precise, but they must be understood and be decisive—i.e., if they are achieved they should ensure the continued viability and vitality of the entity. Individuals must be assigned roles that create the unity of command necessary to carry out each key thrust in the strategy. In these roles they must be able to coordinate the full available resources of the enterprise toward the desired outcome. More important, they must be so chosen and motivated that their own interests and values match the needs of their roles. Successful strategies require commitment, not just acceptance. A prolonged reactive posture breeds unrest, lowers morale, and surrenders the advantage of timing and achieving sufficient success to ensure independence and continuity. Strategies require commitment, not just acceptance.

- **Maintaining the initiative**: Does the strategy preserve freedom of action of events rather than reacting to them? A prolonged reactive posture requires commitment, not just acceptance.

- **Security**: Does the strategy secure resource bases and all vital operating points for the enterprise? Does it develop an effective intelligence system effectively to extend the resource base and zones of friendly acceptance concentration. No entity has sufficient resources to overwhelm all its opponents at all points. Hence the strategy must not only consciously respond to opponents' unexpected actions. Effective communication systems are essential to each of the key strategic components above.

- **Communications**: Has the strategy developed clear, uncomplicated, broad plans and the communications networks to adjust these effectively? In retrospect many strategies have failed not because they lacked structural merit but because: (1) they were not sufficiently well understood, structural merit, and discipline which come from high morale and personal identity with and time likely to be decisive? Has the strategy defined precisely what will relation to its opponents. A distinctive competency yields greater success concentration. No entity has sufficient resources to overwhelm all its opponents at all points. Hence the strategy must not only consciously respond to opponents' unexpected actions. Effective communication systems are essential to each of the key strategic components above.

- **Process**

The formulation of the innovation strategy has firstly the aim to retain the essential aspects, why such a decision has been taken. And secondly this innovation strategy is the operational level in taking further decisions. In short the innovation strategy document is the plan for directing the innovation system to a future intended position. Thereby Quinn criteria have to be considered as presented in Figure 95.

An example of the content of the overall documents of an innovation strategy is presented in Figure 96 and Figure 97. For each of the six exemplarily chapters the content is presented on the left side and on the right side an abstract of Pixel AG’s innovation strategy. In Figure 98: The innovation strategy of Pixel AGFigure 98 a concrete example of an innovation strategy is presented.

<table>
<thead>
<tr>
<th>Initial Situation</th>
<th>Innovation Opportunities</th>
<th>Strategy &amp; Gaps</th>
<th>Innovation Objectives</th>
<th>Innovation Strategy</th>
<th>Strategic Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within the initial situation the current vision of the company is described. Furthermore its strengths such as core competencies and weaknesses in the past are shown as well as the environmental, social, technology,... trends are shown.</td>
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<tr>
<td>Vision: “Capture and share seen moments”</td>
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<td>Trends: The increasing demand for digital cameras with more Mio. Pixel can only be met by important R&amp;D investment</td>
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<tr>
<td>Strength: Pixel AG’s culture excels in developing uncommon ideas into innovations</td>
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<td>Weakness: Pixel AG is not in the position to hold for the long-term the price/performance for...</td>
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Information source: Strategic Intelligence

<table>
<thead>
<tr>
<th>Initial Situation</th>
<th>Innovation Opportunities</th>
<th>Strategy &amp; Gaps</th>
<th>Innovation Objectives</th>
<th>Innovation Strategy</th>
<th>Strategic Plan</th>
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</thead>
<tbody>
<tr>
<td>Specific and potential fields of innovation opportunities should be presented, to demonstrate and retain the potential varieties of future activities</td>
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<tr>
<td>Specific Opportunities:</td>
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<td>- A 7-8 Mio Pixel camera in the short-term and 12 Mio. Pixel camera in the middle-term</td>
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<td>- ...</td>
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<tr>
<td>Opportunity Fields:</td>
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<tr>
<td>- A full solution product that contains a camera as well as the service to manage the picture afterwards.</td>
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Information source: Identify Step

<table>
<thead>
<tr>
<th>Initial Situation</th>
<th>Innovation Opportunities</th>
<th>Strategy &amp; Gaps</th>
<th>Innovation Objectives</th>
<th>Innovation Strategy</th>
<th>Strategic Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>The gaps should be shown that are needed to develop the innovation opportunities. Thereby it is essential to show the gap between the opportunity and its strategy fit as well as the gap to develop it. Furthermore should be presented a consideration of make or buy / keep or sell options.</td>
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<tr>
<td>Gaps: A flexible full solution product for professional photographers will require an additional IT after sales service. Knowledge for developing a homepage for picture management, does not exist in-house.</td>
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<tr>
<td>Buy: The knowledge of managing pictures through a homepage has to be bought because of its high strategic importance.</td>
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<td>Make: ...</td>
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Information source: Evaluate Step

Figure 96: Innovation strategy content including a simplified example at Pixel AG (1/2)
The standard full solution product will be developed. This is based on the fact that competition in the pure digital camera business is increasingly dramatic. Therefore Pixel AG will differentiate its product with a full solution combining the camera and the homepage based picture management system.

Innovation Objective: standard full solution product
Strategic Contribution: The standard full solution product will support the strategic intention to extend activities based on actual products. The revenue will increase approximate by 0.3 Mio bn EUR until 2007.
Impact: A company, developing homepages and data mgmt systems will be bought.

To close the gap between innovation strategy and its implementation a detailed strategic plan should be derived for each innovation objective consisting of:
- Clear and Consistent Objectives
- Required Human Resources
- Required Financial Resources
- Detailed Innovation Roadmap
- Milestones
- Responsibilities

Figure 97: Innovation strategy content including a simplified example at Pixel AG (2/2)
**Innovation Strategy of Pixel AG**

**Our strategic objective:**
Recognizing photographer’s increasing need for managing photos our wish is to be the leader in the domain of providing a means of sharing and managing digital photos. This full solution product allows our customers to more easily share pictures. The aim is to share visual images as simply as possible by reducing the steps necessary to the minimum and increasing the possibilities of sharing to the maximum.

**Our strategic path:**
This strategic objective will change our understanding in developing new products. In the past the main performance driver for our products was the amount of pixel and the overall quality of the picture itself. In the future the main performance driver will be the amount of required steps and the increased possibilities of sharing visual images.

This new understanding has an impact on our innovation activities:

- The technological knowledge of developing management software, as part of our full solution product, has to be acquired. A possible solution to this problem is the acquisition of a company that is active in the domain of managing software and the internet. A second possibility is a strategic collaboration with such a company. The aim is to acquire the relevant knowledge before the end of 2004 and to develop the technology by the end of 2005.
- Since our competitors have successfully developed the 12 Mio. Pix chip we have definitely lost our third position in the market. Based on our strategic goal of offering a full solution digital camera, the importance of the amount of pixels is reduced for our future products. Therefore the development of technologies for transforming light signals into digital signals will be reduced in importance for the company. Nevertheless an important investment will still be necessary in order to not completely lose the contact with the competition. The aim is no longer to be the first in the high end market but to be present in the middle end market.
- In the middle of 2006 we want to offer a full solution product. This full solution product should contain a data transfer system (eventually Wireless Lan) with a connection to an online data management system with all photos managed directly from the camera.

In its quest to achieve excellence in capturing and sharing visual moments, Pixel AG is moving to build on the investments already made in R&D, to make our strategic goal possible. The realization of this strategy will allow our future basis to be built up for competitive advantage.

**Figure 98: The innovation strategy of Pixel AG**

5.2.6 Rollout

5.2.6.1 Redesign Innovation Development Processes

Based on the changed innovation strategy, the operational innovation development processes have to be redesigned if necessary. The aim is to develop in this step organizational innovations to increase the effectiveness and efficiency, additionally to the technological and business innovations. Thereby the processes and structures should be in alignment with the technological and business innovation opportunities. In this context Tushman
et al.(1997:13) said: “Management teams must be able not only to craft strategic intents, but also to directly couple their strategic intents to organizational architectures”.

The underlying concept of designing an innovation organization in this thesis is based on Schaad’s (compare Schaad, 2001) innovation process understanding. Thereby the processes are designed basically on the basis to ensure continuous process responsibility in the process and an order/deliver relationship between the processes. Designing such a process based organization, with the innovation architecture as a starting point that represents the innovation specific strategic intentions, a cluster of methodological knowledge is a process. At the same time the objects under the methodological knowledge are the input for the process and the output are the objects above the methodological knowledge. Therefore such an innovation process model has the same amount of cascades as the innovation architecture and additionally the segmentation of the innovation processes is the same as for the methodological knowledge. This cascading and segmentation concludes with different processes to be implemented, which are based on the innovation architecture and highly adapted to the intended innovation opportunities decided in the innovation strategy\textsuperscript{113}. Furthermore the innovation processes are steered by a strategic innovation management process, which is in fact the process on strategic level of Figure 70.

To illustrate this method of designing innovation processes the case of Pixel AG is briefly presented and shown in Figure 99. Due to the fact that Pixel AG has decided to develop an standard full solution product they require, additionally to mass product development methodological knowledge, also methodological knowledge for developing a standard IT solution. It is obvious that these two mindsets of methodological knowledge are completely different; therefore the processes should also be different. On the module development cascade a homepage should be developed which requires a different methodological mindset then the integration & testing of technologies for developing hardware modules. Homepage development needs software programming methodological knowledge. For this purpose also here the processes are segmented. For the market development as well as for research, segmentation is not necessary because the methodological knowledge is not to be different on each cascade. This conducts then to the macro model of the innovation process of Figure 99, which has to be detailed in further steps.

\textsuperscript{113} For a more detailed discussion about redesigning the organization and processes of the innovation system compare Schaad (2001)
5.2.6.2 Control, Implement Change, Update

Based on the innovation strategy and the redesign of the innovation development processes, the implementation can be started. According to Afuah (1998: 217) attention has to be paid to implementation barriers in the specific context of innovation strategy. These implementation barriers can be of economic nature, such as cannibalization of existing products, large costs, fear of being stranded, or organizational nature, as missing capabilities, politic power, emotional attachment to old products, dominant logic, etc Afuah (1998: 217). Optimally these implementation barriers were all outlined in one of the previous steps.

Therefore, according to Hunger & Wheelen (2002: 121f) strategy formulation and strategy implementation should thus be considered as two sides of the same coin. To begin the implementation process, strategists must consider three questions:

- Who are the people who will carry out the strategic plan?
- What must be done?
- How are they going to do what is needed?

Management should have addressed these questions and similar ones initially when they analyzed the pros and cons of strategic alternatives, but the questions must be addressed again before management can make appropriate implementation plans. Unless top management can answer these basic questions satisfactorily, even the best-planned strategy is unlikely to provide the desired outcome.

To support the implementation successfully it is also essential to implement an appropriated control system which gives the management a feedback that it can take updating
measures. According to Hunger & Wheelen (2002: 151) five-step feedback model is essential to design an control system:

1. **Determine what to measure.** Top managers and operational managers must specify implementation processes and results to be monitored and evaluated. The processes and results must be measurable in a reasonably objective and consistent manner. The focus should be on the most significant elements in a process — the ones that account for the highest proportion of expense or the greatest number of problems. Measurements must be found for all important areas regardless of difficulty.

2. **Establish standards of performance.** Standards used to measure performance are detailed expressions of strategic objectives. They are measures of acceptable performance results. Each standard usually includes a tolerance range, which defines any acceptable deviations. Standards can be set not only for final output, but also for intermediate stages of production output.

3. **Measure actual performance:** Measurements must be made at predetermined times.

4. **Compare actual performance with the standard:** If the actual performance results are within the desired tolerance range, the measurement process stops here.

5. **Take corrective action in terms of update:** If the actual results fall outside the desired tolerance range, action must be taken to correct the deviation. The action must not only correct the deviation, but also prevent its recurrence.

5.2.7 Conclusion

The presented innovation strategy formulation process was developed based on the identified gaps in literature as well as in practice. These gaps were identified based on eleven criteria that an innovation strategy formulation process should contain presented in chapter 2.1.2. Now these criteria should be the basis for validating — from a theoretical point of view — the developed innovation strategy formulation process which is based on the innovation architecture.

- The innovation strategy formulation process provides a strategic management specific understanding of complexity, systemic interaction and evolution. To provide this understanding, the innovation architecture is the basic tool. With its structured visualization of object, methodological and meta-knowledge the complexity is reduced and the systemic interaction is presented. The evolution is integrated into the innovation architecture by the functions and the innovation fields as well as the object knowledge that does yet not exist.
• The innovation strategy formulation process provides a strategy specific understanding of direction, focus, organization and be consistent. Because the decisions that are taken in the innovation strategy formulation process are based on a high level of understanding of the innovation system and because the innovation architecture shows all innovation opportunity in detail, it is possible to check the consistency, define clear objectives and set the path by giving a clear direction. Additional the focus can be defined in the innovation architecture and an adequate organization can be derived.

• The innovation strategy formulation process provides an innovation specific understanding of integral innovations, innovation barriers, innovation newness and innovation relevant knowledge. Because the process is based on the innovation architecture, the innovation relevant knowledge is integrated. The integral innovations are ensured due to the fact that business and technological innovations are mentioned in the innovation architecture directly and organizational innovations are derived in the roll out step. The newness of innovation is integrated by its level of knowledge for each object. The innovation barriers to consider are also integrated indirectly because the strategic decision is prepared in a holistic manner by using many tools for different purposes. These tools allow detecting many of the potential innovation barriers.

In a nutshell the innovation strategy formulation process seems from a theoretical point of view to be a solution for closing the gaps presented in chapter 4. But from a practical point of view the innovation strategy formulation process should be evaluated in terms of its practicality and its implementation based on action research. This is the subject of the next chapter.
6 Action Research

In this chapter nine action research cases\textsuperscript{114} are presented showing the implementation of the developed innovation strategy formulation process including the innovation architecture (see chapter 5). These action research cases were accomplished through consulting projects and academic industry projects. The focus of the action research cases is first of all on analyzing actively the practicality of the concept by implementing the concept. Additionally, documenting the modeling procedure of the innovation architecture and innovation strategy formulation process in terms of a practical handbook is an objective. Furthermore, the developed concept could be validated by an individual analysis and a cross-case comparison. This allows a conclusion to be derived and the working hypothesis to be rethought (see Figure 100).

\textbf{Figure 100: Structure of chapter 6}

In the following action research cases the company names are changes and data is abstracted because of two factors. Firstly including all the details would go beyond the scope of this work. Secondly the results of the cases are very sensitive regarding the content of the collaborating companies. Therefore changes of the companies’ names allow focusing on the

\textsuperscript{114} For a detailed discussion about action research see chapter 1.3.2
conceptual elements and results. Nevertheless the essential aspects of retracing the implementation of the concepts are not omitted.

6.1 Selection and Procedure of the Action Research Cases

To verify and analyze the usefulness of the developed concept of innovation architecture and innovation strategy formulation process enterprises or organizational entities were selected, that are different and cover a representative range of diverse industries. These enterprises and organizational entities differ for example in their industry affiliation, size (sales, employees) and financial success (income in percent of sales) (see Figure 101).

<table>
<thead>
<tr>
<th>Industry Affiliation</th>
<th>Size</th>
<th>Income</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sales</td>
<td>Employees (%) of Sales</td>
</tr>
<tr>
<td>1. Component Producer</td>
<td>2 bn. CHF</td>
<td>8,000</td>
</tr>
<tr>
<td>2. Chemistry</td>
<td>8 bn. CHF</td>
<td>20,000</td>
</tr>
<tr>
<td>3. Production System</td>
<td>1.5 bn. CHF</td>
<td>6,000</td>
</tr>
<tr>
<td>4. IT-Provider</td>
<td>700 mio. CHF</td>
<td>2,000</td>
</tr>
<tr>
<td>5. Chemistry</td>
<td>n.a. (1)</td>
<td>50</td>
</tr>
<tr>
<td>6. Apparatus Producer</td>
<td>3 bn. CHF</td>
<td>15,000</td>
</tr>
<tr>
<td>7. Component Producer</td>
<td>350 mio. $</td>
<td>800</td>
</tr>
<tr>
<td>8. Apparatus Producer</td>
<td>600 mio. €</td>
<td>4,000</td>
</tr>
<tr>
<td>9. Apparatus Producer</td>
<td>50 mio. €</td>
<td>430</td>
</tr>
</tbody>
</table>

(1): The company was newly founded in the year of the action research project. Therefore no financial data are available.

(2): The company does not make the financial key figures available to the public.

Figure 101: The nine action research cases at a glance

The following presented action research cases had a duration ranging from two intensive weeks to three months with a lower intensity. Numerous workshops, interviews, free access too many employees of all the hierarchical levels, analysis of previous innovation

115 The key figures are based on the project time.
activities were allowed to make a detailed and holistic analysis of the cases. The processing
of the action research cases, which is shown in the following chapters, is divided into five blocks:

- **Short introduction of the companies**: By a short introduction of every company
  the environment of the organizational entity or company could be presented. On
  the basis of general but important key figures it would therefore be possible for
  the interested reader to understand the situation of the company and to caompare
  it, eventually, to their own company’s situation.

- **Initial position**: In the ‘initial position’ block, the company is analyzed in the
  context of innovation. To analyze the company a set of criteria is chosen to show
  the important factors in terms of innovation strategy formulation\(^{116}\): strategic in-
  novation structures, strategic innovation objectives, strategic innovation behav-
  iors\(^ {117}\) and innovation decision processes\(^ {118}\) (see Figure 102). This set of criteria
  represents the underlying structure in the interviews. This procedure allows the
  initial position of the project to be demonstrated and the reasoning of the chosen
  project objectives to be illustrated.

  \[\text{Figure 102: The set of criteria for analyzing the companies (compare Brodbeck, 1999: 50)}\]

- **The innovation architecture**: On the basis of nine selected action research cases
  (compare Figure 101) the development of an innovation architecture will be de-
  scribed in detail.

\(^{116}\) Compare Brodbeck (1999: 50)
\(^{117}\) These three selected criteria were extracted from Bleicher’s (1992) concept of integrated manage-
ment of. A company, understood as a system, can be divided into structures, behaviors and object-
ives on normative, strategic and operational levels. Due to the fact that this work is located at stra-
tegic level and does focus on the innovation system of a company the criteria are restricted to this
scope.
\(^{118}\) The criteria, ‘innovation decision processes’, is selected because of the permanent interaction of
the strategic level with the decision process, which have in tendency an reciprocative influence in
terms of a constant reproduction of both (compare Becker (1996: 143ff), Giddens (1984: 288ff) and
Brodbeck (1999: 50)).
• *The innovation strategy formulation process:* In every action research case the company specific modules of the innovation strategy formulation were selected and implemented into the specific company context. These modules were then used with actual strategic innovation relevant concerns. The proceeding of this implementation is described in detail.

• *Conclusion:* The conclusion shows a first appraisal of the innovation architecture and the innovation strategy formulation process. Thereby is mainly presented the management feedback.

The action research case will be presented in the next chapters (from chapter 6.2 to chapter 6.10) and structured by the above described five blocks. The following cross-case analysis and conclusion will be found in chapter 6.11.

6.2 Case 1: Toll Revenue

6.2.1 Short Introduction

The following action research case was done in a division of a globally active corporate group. The group is active in the telecommunication, automation and energy systems segments. The group employs in total 8000 employees. The sector of automation, in which the division ‘Toll Revenue’ is embedded, provides in the service sector products, systems and services for the rationalization and automation of routine activities in the service sector, such as issuing entrance cards. The focus of this segment was, near the extension of the market position and restructuring of the organization, to integrate E-Solutions into the product portfolio.

Toll Revenue offers electrical apparatus to collect fees. The clientele comprises small, medium and large scaled enterprises as well as government agencies. The largest business volume is reached in the markets in Northern America, England, Germany, Switzerland, South Africa and Scandinavia. The sales figures decreased from 2001 to 2002 by 13% after a long period of constantly increasing sales. The result was that the loss increased from -6.5 % to -10 % of sales. The reaction to this negative trend was that in 2000/01 a comprehensive reorganization of the division was undertaken, which had in the short term a positive effect on costs.
The product portfolio of Toll Revenue is actually affected by a major change: In the past, the products were sold as stand alone solutions, mostly based on hardware developments, but in the future the essential element to gain competitive advantage will be to integrate the products into a communicating system, which is much more software based. This change was not optimally accomplished by the division because important products had delays in development and therefore in market introduction.

The R&D budget of Toll Revenue was about 30 Mio CHF (10%) and in the future it will decrease.

6.2.2 Initial Position

Strategic innovation structures
The development of new products is decentralized into two major locations. These two locations are independently developing new products without harmonizing their objectives. Important overlaps in their activities are the result. In 2001 a reorganization of the innovation system was implemented to increase the effectiveness and efficiency in the two locations but also to coordinate in a better way the activities more effectively. The coordination of this reorganizations has not yet shown major effects because of structural political barriers.

Strategic innovation behaviors
The management of Toll Revenue is because of the poor financial situation, is financially very short-term oriented. Therefore the R&D budget was reduced and only short-term effective projects are allowed. The communication between strategic management and operational developer is reduced to these short-term projects. This effect is enforced by the fact that the market side management is not coordinated with the technology side management for mid- and long-term product and technology projects. There is an important lack of transparency over the innovation system.

Strategic innovation objectives
The main innovation objective is to cut costs in development and in actual projects, and not develop innovative products. To do this the strategic management wants to have a transparent overview over the development activities on technology and product levels.

Innovation decision processes
The actual strategic decision process is very short-term market oriented which is the result of the financial situation. Therefore mainly the regional and product marketing is involved with the executive board in deciding on the different projects. R&D is mainly in-
Involved passively in this process to define the needed resources for the proposed projects of the marketing. R&D’s passive role in the innovation decision process is not optimal due to the fact that long and mid-term projects based on technologies are not integrated into the process. Therefore a major innovation step could not be realized.

**Project objectives**

To collect the above mentioned situation of the innovation decision process a two step procedure was decided: Firstly the coordination of actual and future innovation activities should be shown in a transparent overview by the innovation architecture in order to be able to detail technology push and market pull activities and to show the real strengths and weaknesses of the whole innovation system. In a second step these activities should be evaluated in terms of timing, feasibility and resource allocation.

![Diagram](image)

**Figure 103: Project objectives of action research case at Toll Revenue**

6.2.3 **The Innovation Architecture**

The innovation architecture of Toll Revenue (see Figure 104) was developed with the focus of getting on the one hand an overview of the actual innovation activities and ideas and on the other hand evaluating the object knowledge in a second step. Therefore the innovation architecture presents mainly the object dimension, partly the methodological knowledge dimension and omits the meta-knowledge dimension.

Four cascades were identified. On the basic cascade is externally acquired applied knowledge developed into technologies. These technologies are categorized into six strategic technology platforms. These technology platforms fulfill the six functions out of which the modules of the company are developed on a second cascade. The functions in the innovation architecture are defined based on the product function which is firstly the identification of a communication need of the customer. Afterward it is the proposition of a ser-

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119 In Figure 104 seven strategic technology platforms are visible, whereby one is ‘Other technologies’. Therefore there are actually only six strategic technology platforms.
service that the customer wants. Thirdly money has to be transferred and fourthly the service is offered. Additionally the product of Toll Revenue can, if desired, offer additional services other than collecting tolls, and product functions to operate the devices. These functions that are fulfilled by technologies are developed – on a second cascade – into the modules, which are integrated into the whole product/service on the third cascade. The fourth cascade is responsible for transferring the products to the customer and developing marketing concepts. For each cascade the specific methodological knowledge required is presented in Figure 104.

The innovation architecture shows the different levels of object knowledge for each object. Thereby a categorization of five different levels is done: ‘existing’, ‘planned to be available’, ‘not available’, ‘partly existing’ and ‘needs to be updated’. These five levels help to understand the actual position of the innovation system at Toll Revenue.

The innovation fields of the innovation architecture are ‘ticketing’, based on the fact that today all products of the company offer a service which is confirmed by a ticket and ‘system management’, based on the fact that all products of Toll Revenue are connected with highly complex system management tools.

6.2.4 The Innovation Strategy Formulation Process

6.2.4.1 Identify

In this step the innovation architecture was developed and afterwards detailed. This procedure was done in a cyclical process.

During the innovation architecture based revision of the innovation portfolio and detailing of the innovation opportunities three important weaknesses of the innovation system of Toll Revenue were found:

- Most planned innovation activities of Toll Revenue are based on activities of existing products which are adapted or changed.
- The innovation activities that are based on a technology push in the six strategic technology platforms are nearly not linked to the satisfaction of the customer needs identified by marketing. For example the products ‘other ticket machines’, ‘information systems’ and ‘P&R systems’ have not even a link to modules, functions or technologies as presented in the innovation architecture of Figure 104. At the same time the few linked technologies are only linked to existing and traditional modules and products which have a decreasing tendency in orders.
• The function ‘offer additional services’ is according to the statement of the head of innovation & marketing and highly increasing domain, but at the same time innovation activities are very rare.

Concluding the innovation architecture process helped the management in the identification step to get firstly an overview of the activities in the dramatically unstructured innovation system Secondly the awareness of the missing functional handshake between technology push and market pull was obviously visible and thirdly the management saw that the future of the company is not aligned to the customer needs.

6.2.4.2 Evaluate

In the evaluation the objective was to make a qualitative and quantitative evaluation of the innovation system. Therefore the aim was mainly to develop an innovation roadmap and optional a resource allocation. But due to the dramatic unstructured situation of the innovation system of Revenue Toll it was during the project, neither possible to get key figures about the duration of several projects nor it was possible to get key figures about the costs. Therefore the project aim to make an evaluation was abandoned.

6.2.5 Conclusion

Although that the evaluation step could not be done the management concluded that the innovation architecture showed the actual situation of Toll Revenue very well. They concluded that the situation is more dramatic than they thought before. Based on these newly gained insights the management decided to firstly formulate a new corporate or business unit strategy which was actually missing and resulted therefore in an important lack of coordination. In a second step the innovation architecture has to be aligned to this new strategy. Only after this step would a second possible evaluation step of the individual innovation opportunities seem to be realistic. Additionally the management defined the task to sample more data in order to develop an innovation roadmap.
6.3 Case 2: TecChem

6.3.1 Short Introduction

The TecChem action research case was worked out in a business segment of a world-wide chemistry producer. This company employs about 20'000 employees. Every business segment is responsible for its own sales, marketing, production, development and partly for research. Some research projects, based on core technologies, interesting for the whole company, are done on a corporate level. The focus of all activities in the different segments is based on the simplified strategy: ‘Expansion through innovative technologies’.

The specific business segment, TecChem, offers molecules for producing layers with different functions. In this market, the segment has a relative income of more than 20% of sales, which is above the industry average. This high income results from older product, in terms of “cash cows”\(^{120}\) that have not yet been copied by the competitors. But at this time potential new technologies will allow the same functions to be developed with a higher performance. These technologies could provoke a substitute of the actual ‘cash cows’ of the company.

6.3.2 Initial Position

**Strategic innovation structures**

The structures in innovation are mainly in alignment with the overall business segment structures. Therefore a very strict market orientation is present. For new emerging and high risk technologies that are important for the whole company special technology based group research projects were initiated (see Figure 105). The head of these group research projects is the CTO who has to coordinate the company activities with the different business segments.

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\(^{120}\) “Cash Cow” is a term used in the Boston Consulting Matrix. A detailed discussion can be found in Henderson (2003: 42)
Market driven development and research

Development of Business Segment 1
Development of Business Segment 2
Development of Business Segment 3
Development of Business Segment 4
Development of Business Segment 5

Technology based development and research

Core Technology 1
Core Technology 2
Core Technology 3

Figure 105: Strategic innovation structures of case at TecChem

**Strategic innovation behaviors**

The company has engaged chemists with a respected high international reputation in different technology domains. Therefore R&D is highly driven by these experts. For the company this expert driven development is an advantage as long a product is based on one of these technologies that is mastered by one of the experts. However in the case where it is not, the company reacts very slowly because of a lack in knowledge. Another important point to mention is the strong and effective network between the experts in the company. This allows the coordination of complex activities in an uncomplicated and effective manner.

**Strategic innovation objectives**

Because of the above described experts, who are specialized to a specific technology the company wants to base their innovation activities on their technology domains. The strategic innovation objective is primary to innovate, by leveraging actual technologies, for specific market needs. Nevertheless the company is aware of the need to monitor new emerging technologies.

**Innovation decision processes**

The innovation decision process of TecChem is dependent on the type of the intended project. If the project is located in a business segment the identification is done by the segment experts. In the case the evaluation is based very strongly on market evaluation tools. If the project is part of a research group the identification is mainly based on experts’ ideas or general technological trends and the evaluation is rather based on technology criteria, such as the future importance of the technology and the ability to leverage it in the company.

**Project objectives**

Because the innovation decision processes on strategic evaluation are already very sophisticated the management did not have a particular interest in new evaluation tools. Nev-
Nevertheless they wanted a tool to identify in-house existing competencies. Therefore it was decided to build up the innovation architecture. This would give the CTO the possibility to have an overview of actual competencies and their interaction for preparing decisions of future innovation activities. Furthermore the elaborated innovation architecture could be used in the future as a communication tool for the different business segments.

![Figure 106: Project objectives of action research case at TecChem](image)

6.3.3 The Innovation Architecture

A simplified innovation architecture of TecChem is presented in Figure 107. The innovation architecture is simplified due to the fact that firstly TecChem has many secret long-term innovation activities shown in the original innovation architecture and secondly because the original innovation architecture was very extensive. Nevertheless the essential elements are seen in the innovation architecture or will be described in the following.

During the project, five cascades were identified at the innovation system of TecChem. The first cascade does basically search in ‘scientific knowledge’, searching for new insights about molecules in several substance classes. This knowledge about molecules is used to design and synthesis molecules with an effect that could be interesting in the future. These effects, which are summarized in the functions (10 functions in the case of TecChem) are leveraged in a next cascade for developing specific products and scaled later up on another cascade. On the top of the innovation architecture these products are brought to the market by the application marketing cascade.

Based on the project objectives the innovation architecture should serve as a visualization and communication tool. Therefore the different objects were clustered by their departments, to see the responsibilities. Additionally, it was not possible to present the extensive innovation architecture on one overall paper. Therefore the visualization of the innovation architecture was done with hyperlinks, for zooming directly on one section.
6.3.4 The Innovation Strategy Formulation Process

6.3.4.1 Identify

During the ‘identify’ step, several interviews were conducted throughout TecChem. During these interviews it was quite easy to integrate the objects into the innovation architecture. Also the links between the different objects could be integrated in a very short time. However during the detailing of the innovation opportunities it appeared that the allocation of responsibilities between departments was not clear. This relates to the fact that some researchers were active in the cascade of searching chemical substance classes, which is solution neutral, and simultaneous to the cascade of leveraging specific modules, which is solution oriented. The disadvantage of this fact was that the research became solution oriented or that the development of products was not primarily based on a specific customer need but on an effect that was discovered in research.
Additionally it has to be mentioned that during the development of the innovation architecture the employees in the innovation system were somewhat astonished to learn about the project and competencies of their colleagues. Therefore the innovation architecture helped to align the objectives of the departments.

6.3.5 Conclusion

The innovation architecture of TecChem was mainly accepted by the management to visualize the knowledge which exists in-house and to better allocate responsibilities. Additionally the innovation architecture allowed weaknesses in the innovation system to be visualized, such as the unclear allocation of responsibilities. Although the innovation architecture revealed some interesting points in the company the management criticized the concept of innovation architecture. In the opinion of the management, the effort to build up the innovation architecture was too great, compared to the results.

Trying to explain these critics a major cause is certainly, that the innovation architecture was only used as a visualization and communication tool, but not as a tool to identify, evaluate or derive organizational processes. Due to this limited use of the innovation architecture, the effort was in fact very high. Therefore this action research case showed that the innovation architecture is not a tool that should only be used as a communication and visualization tool. The innovation architecture is more a tool for identifying, evaluating and deriving organizational processes, whereas an interesting side effect is that it is a good basis for the visualization of innovation activities and competencies.

6.4 Case 3: HighTec

6.4.1 Short Introduction

The company HighTec, is a leading provider of production systems, components and services for selected growth markets, focused on information technology and sophisticated technological applications. It employs approximately 6,000 people and achieved sales of about CHF 1.5 bn. with a loss of about 5% of sales. As produc-
tion system provider, the company is at the beginning of the value chain in this industry. Due to the bullwhip effect\textsuperscript{121}, this results in sales figures that are highly unstable. In addition to this effect the high tech industry is by nature very unstable and dynamic. Therefore HighTec sales can vary up to 50\% in a year. This is one of the major challenges to master for the company.

Two of seven independent divisions of HighTec were analyzed in terms of action research. Both analyzed divisions, each divided in several strategic business units (SBU), are active in the same industry with different markets and products. Both divisions do not vary basically in employees (both about 500), in sales (both about CHF 200 million) or in the challenges their need to master as described above. Therefore the introduction and initial position is done in common for both divisions.

In the last few years sales were constantly growing and broke down one year before the action research case. Due to this effect, many problems that had not been seen in times of high sales had begun to occur. For example a major concern was that new products had problems in quality and therefore a R&D team had been working for a long time for a customer. In good times these cost were not seen as important but nowadays these costs are compared to sales, a high amount of fix costs that can not be reduced in short time. These quality problems barely affect R&D, because resources are blocked and new products launches are delayed (R&D budget is 10\% of sales).

At the time the action research project started, the company-wide strategy was in formulation. The main question to be answered in this process was: ‘Is it better to focus on standard production system or on customized production systems for specific client needs in market niches?’

6.4.2 Initial Position

\textit{Strategic innovation structures}

R&D is organized in its structure, so that innovation projects are done by one team. This team has the task of doing research, technology development as well as product development. This organization allows on the one hand being highly flexible structured in terms of resources, but on the other hand the projects are very voluminous, long and change often over time, because the customer’s needs change. Therefore this structure of R&D needs a high level of transparency and much coordination effort of these projects, but this transparency and coordination effort is often lacking.

\textsuperscript{121} A detailed explanation about the bullwhip effect is described by Lee & Padmanabhan (1997)
**Strategic innovation behaviors**

Because the projects are often very voluminous the project leaders have no time to coordinate their activities with other SBUs, which is often not considered anywhere in the company. Furthermore the coordination between development activities and market introduction is not optimally done, which results in the above mentioned quality problems. In addition strategic mid and long term coordination is only rudimentary in place.

**Strategic innovation objectives**

Due to the fact that the sales were reduced in the last year, the strategy in innovation is mainly to strengthen the innovativeness, to implement a strategic steering, focus resources and focus on attractive customer needs with the main objective to increase market share.

**Innovation decision processes**

The innovation decision process is in theory aligned and therefore a sub-point of the general strategic decision process (Figure 108). The general strategic decision process is based on a three year strategy which is detailed every year by the different SBUs and accepted by the management to make an annual plan.

![Figure 108: General strategic decision process of case at HighTec](image)

**Project objectives**

![Figure 109: Project objectives of action research case at HighTec](image)
To support the general strategy process in terms of innovation relevant issues the following objectives were defined: (1) Revise and detail the innovation portfolio on the basis of the innovation architecture. (2) Conduct a quantitative and qualitative analysis in which a roadmap is determined to identify bottlenecks of the actual projects in term of resources and time (Figure 109). Based on the fact that the two analyzed divisions of the company HighTec are highly independent, the project was autonomously done in each division.

6.4.3 The Innovation Architecture

Based on the fact that the two divisions were separated, the different circumstances of the two projects led to two different visualizations of the innovation architectures as can be seen in Figure 110 for division one and in Figure 111 for division two. Therefore in the following, the two innovation architectures are described separately.

**Innovation architecture of division one**

At the beginning of the process of developing the innovation architecture it was clear that the company has a small amount of products and modules compared to technologies. Therefore a visualization of the innovation architecture (see Figure 110) was chosen that shows technology and science on different slides, which are segmented by the function they fulfill.

The elaborated innovation architecture has five cascades. The lowest cascade consists mainly of research knowledge which has to integrate new scientific insights into basic technologies. This research cascade only existed in four of the 12 segmented slides, because only there is it essential, according to the management, to do research. The basic technologies are then developed by the applied technology cascade. With the aim to develop concrete technologies which fulfill a specific function, such as for example the technology ‘sputtering’ fulfills the function to ‘depose material’. These functional based technologies are then developed on a next cascade into modules which are afterward integrated into a complete product line based on the methodological knowledge of the product line development cascade. This product development is in this case especially important because its main methodological knowledge consists of how to develop a product line architecture. On the top, the marketing cascade is charged with preparing the market introduction.

The objects were clustered into three knowledge levels (exists, planed, not available) and additionally it was mentioned that some objects are outsourced.

**Innovation architecture of division two**

The products of division two are marked by the fact that they are complex and extensive. Mainly this is because they consist of many different modules that are not leveraged
throughout the products. This fact led to a visualization of the innovation architecture where the slides were segmented by products, to ensure a focused and not too complex overview (see Figure 111).

The innovation architecture of division two consists of four cascades. The cascade on the bottom merges the research and technology development cascade, in contrast to the case of division one. This merging into one cascade is based on the fact that research in this division does not play a major role. On the next cascade a two fold segmentation of the methodological knowledge was done. Whereas the one segment consists of methodological knowledge to develop an autonomous module, the other segment consists of methodological knowledge to develop the handling system, which can be seen as the basic platform for all the modules. The cascade above these two segments is the solution development for developing the customer specific products and on the top the market introduction is prepared on a separate cascade.

The levels of knowledge were differentiated by four categories (exists, planned, not available, maintenance needed). Additionally to these four categories some objects are outsourced.

6.4.4 The Innovation Strategy Formulation Process

6.4.4.1 Identify

In both divisions is important to mention that during the process of revising the innovation portfolio and detailing the opportunity fields there was no problem to define all the objects that are needed to develop a certain innovation opportunity. Therefore the innovation architecture was built up in a very short time, compared to other projects. One reason for this phenomenon – in the opinion of the author – is the fact that the whole innovation system is vertically organized. This means that an innovation opportunity is mainly developed from scientific research to the market introduction by one project group. This group has therefore a very good overview of the elements that are missing. But at the same time, in the innovation architectures of both divisions it could be identified that technologies and scientific knowledge was in fact integrated but there were a tendency that for the integrated objects a low level of knowledge was existing. According to the project manager this lack occurs due to the fact that the project members were at the end of a product introduction, focused on perfection of these products, due to quality problems. But because of the vertical organization these project members could not concentrate on technology development and research for the next product generation.
### Conclusion and Working Hypothesis Rethought

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#### Object Knowledge

- Object knowledge already exists
- Object knowledge is planned to be available
- Object knowledge is not available
- Object knowledge that is outsourced

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**Figure 110: Innovation architecture at HighTec (division one): Segmentation by function**
6.4.5 The Innovation Strategy Formulation Process

6.4.5.1 Identify

In both divisions is important to mention that during the process of revising the innovation portfolio and detailing the opportunity fields there was no problem to define all the objects that are needed to develop a certain innovation opportunity. Therefore the innovation architecture was built up in a very short time, compared to other projects. One reason for this phenomenon – in the opinion of the author – is the fact that the whole innovation system is vertically organized. This means that an innovation opportunity is mainly developed from scientific research to the market introduction by one project group. This group has therefore a very good overview of the elements that are missing. But at the same time, in the innovation architectures of both divisions it could be identified that technologies and scientific knowledge was in fact integrated but there were a tendency that for the integrated objects a low level of knowledge was existing. According to the project manager this lack occurs due to the fact that the project members were at the end of a product introduction, focused on perfection of these products, due to quality problems. But because of the vertical organization these project members could not concentrate on technology development and research for the next product generation.

Another aspect that was found during the process of architecting was the fact, that – especially in division one – all the technologies, which were needed to fulfill the functions, were developed internally. Even the function ‘cool system’ was developed mainly in-house, whether it was known in the division that external companies could develop this cooling system better and cheaper. This is one reason that division one has such a large amount of technologies, which is difficult to manage.

In division two the innovation architecture was segmented by its products because of the different modules. But at the same time the different innovation architectures showed that, although the modules are different, the technologies are often the same for all the products. After a more detailed study it became evident that the products have different modules not because they needed to, but because a product was always completely redesigned. However some manager said that this had not to be necessary. Due to this fact the product complexity was enormous and difficult to handle.
6.4.5.2 Evaluate

Based on the innovation architectures of both divisions innovation roadmaps were generated\textsuperscript{122}. The innovation roadmaps were developed from a market viewpoint. This means that firstly the market introduction date was fixed and the projects were in a second step back planned. The result was that both divisions could not finish their innovation projects until the fixed market introduction date. The reason for this lack of planning was different for both divisions as described in the following:

In division one the identified lack of object knowledge in technology and science dramatic impacts had in the innovation roadmap (see Figure 112) that the management was not aware of. In one case a certain technology had to be available in-house until end of 2002 to begin with the module development. But in reality, with the given resources the technology could only be available until mid of 2003, which should be the deadline for the module development. But not enough, the market demanded that even this deadline of the module development should already the date of the market introduction. The company would only have finished the technology development when the market introduction should be done. The management knew that a delay was highly probably but not that it would be so dramatic.

The innovation roadmap of division two (see Figure 113) also showed that a technological knowledge gap would provoke a delay without changing the resources, but in their case this was not the major problem. More dramatic was firstly, that the management thought that a specific module could be developed in-house, but the project members knew that this was not possible. Secondly an old product, named in Figure 113 product A (V1.0) had quality problems which had to be solved. But the resources that were used to solve these problems could not develop the new products. However the innovation roadmap, and therefore the time planning of the project leader, was done with the belief that they had all resources available. Therefore the delays would increase compared to the innovation roadmap of Figure 113.

6.4.6 Conclusion

To conclude, the process of architecting helped in this specific action research case to find out the following aspects, affirmed by management:

- The knowledge gap, especially on technology side, turned out to be massive.

\textsuperscript{122} The theory for creating an innovation roadmap is described in chapter 5.2.4.2
The Product lines can not be delivered to the clients

The modules can not be developed on time

The Technologies are not in time controlled

Figure 112: Innovation roadmap at HighTec (Division One)

Figure 113: Innovation Roadmap at HighTec (Division two)
In division one the amount of technologies, which should be developed in-house, was very high, even that it was known that external partners could do it better.

In division two the amount of modules was much higher then it needed to be.

No divisions had enough resources for all the development projects. The resource planning had not been done systematically.

The innovation roadmap showed that the coordination, in terms of timing, between the market side and the technology side was in a dramatically manner, not aligned.

Thereby the management said that this innovation architecture, as basis for the strategy process, helped to find out several problems which can be now described based on facts. Thereby it was additionally mentioned that these problems were found out especially by the process of architecting, which forces the right questions to be answered.

6.5 Case 4: Info Exchange

6.5.1 Short Introduction

The division analyzed in this action research case is part of a company active in only one country. The Info Exchange provides services and products in the areas of international financial information, cashless payment instruments, electronic payment systems and IT services. All these activities are based on the business to provide specified IT systems with a high level of security and availability. About 2000 employees are employed and the sales had been stable at 10% of sales in the last three years.

The specific division of ‘Info Exchange’ is the internal IT provider for the other divisions. These internal orders comprise about 88% of total sales and they are the exclusive IT-providers to the other divisions. Therefore they can act as monopolists in an ideal market. But this ideal situation will change due to a strategic decision: The management decided that the division has to increase their sales by doubling its sales to external clients from 12% to 24% of total sales.

This challenge to double the external sales is complicated by the trend that the trust in IT-products is in general decreasing, originating from a poor level of service quality and insolvency in the IT industry. This trend provokes in tendency a loss of sales by 10 to 15%
by year. To react to this situation the aim of the division is to gain the trust of the customers by focusing on core competencies to develop new products with a high level of quality in new attractive markets.

6.5.2 Initial Position

**Strategic innovation structures**

The hierarchy is flat which allows, in innovation, an optimal lead and fast information flow. This flat hierarchy underlies a newly implemented process organization where a CTO (Chief Technology Officer) has the task of coordinating the innovation activities division wide.

**Strategic innovation behaviors**

The innovation culture is, due to the fact that the company could act for a long time as monopolist, not very innovation friendly. Additionally the resources for new investments are very restrictively handled. Therefore only innovation projects are accepted that are based on a specific customer demand. The technology department is not asked about future possibilities for new functions but only about the feasibility of the demanded innovations.

**Strategic innovation objectives**

Based on the division strategy, mentioned above, the rough innovation strategy has the aim to develop innovations for growth based on actual core competencies deployed in new markets. For this very rough innovation strategy there was not yet a defined path to reach the objectives. The technological core competencies were not with a focus defined for identifying new potential markets.

**Innovation decision processes**

The innovation decision process is implicit. Based on the initiative of the corporate management, the divisions have to formulate a realistic strategy containing mainly objectives but not paths. This development is based on financial key figures. A forwarding systematic identification phase is missing. The formulated strategy is then consolidated on a company level. A specific and detailed innovation strategy does not exist.

**Project objectives**

The project objectives were concentrated on the identification of new markets based on existing innovation activities. Therefore in a first step the existing innovation activities, including strengths and weaknesses, should be defined in the innovation architecture by revising the innovation portfolio. In a second step innovation opportunities in new markets
should be identified, based on related activities, and detailed. In a third step a preliminary strategic fit evaluation should be done (see Figure 114).

![Project objectives of action research case at Info Exchange](image)

**Figure 114: Project objectives of action research case at Info Exchange**

### 6.5.3 The Innovation Architecture

The innovation architecture of ‘Info Exchange’ (see Figure 115) has four cascades. On the first cascade the company needs methodological knowledge to screen for new technologies. Because Info Exchange is not developing new technologies, this is a very important element during the development of any new product to be nevertheless up to date in a rapid changing environment. This technology screening is done for six strategic technology platforms (STP) that were defined during development of the innovation architecture. These STP have the aim to fulfill the functions, which are needed in separated modules. This development of the modules, the next cascade, is segmented in five different methodological segments because of the fact that for example hardware design and software design are in their methodological knowledge completely different. All developed modules, consisting of hardware and software are integrated in the next cascade to a customer specific product or service. This product is then introduced into the different markets on the basis of the next cascade.

In addition to the innovation architecture of Figure 115 that represents the object and methodological knowledge dimensions, also the meta-knowledge dimension was analyzed in its five categories. In the following an example of Info Exchange’s general meta-knowledge is shown:

- The source of knowledge is based on internal employees, external education and a personal network.
- The insurance of the reliance of knowledge is based on statements of the employees.

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123 See chapter 5.1.4 for the background of the different categories
• The importance of knowledge of knowledge is mainly growing in the domain of integration knowledge. Therefore not the specific object knowledge but the methodological knowledge is and will be more important.

• The evolution of knowledge of knowledge will be ensured by having active contacts with suppliers, universities and experts.

• The cognitive capabilities to develop new knowledge are highly developed in the company.

6.5.4 The Innovation Strategy Formulation Process

6.5.4.1 Identify

Building up the innovation architecture at the ‘Info Exchange’ uncovered some interesting aspects. The integration of technology and scientific insights presented no big problem, but the integration of future modules and products was more difficult, because the company did not have a detailed overview over the markets. ‘Info Exchange’ had a lack of information of their products in the future. This lack of market information is based on the fact that the company had in the past, only a group of limited customers. Therefore the products were defined by these customers and a future market development was not seen as important. Nowadays, where the company has to develop products for other potential customers this lack of market information is a major disadvantage. An additional interesting point discovered during the process of architecting was the small amount of new ideas on the technology side. Under more detailed observation it came out that mainly technologies are developed for a specific product, ordered by a customer. Therefore ‘Info Exchange’ was in the past not directed by a technology push but mainly by market pull activities.

The identification of new business fields was based on innovation fields. Therefore a search was made to identify business fields, especially markets, that could have an interest in the innovation field ‘disaster precaution’, in the special context of IT. It came out in this creative workshop that the companies in the media, building, IT, health care, pharmaceuticals, chemistry, automobile, logistics, mechanical and retail areas could have an interest. These potential business fields were the basis for the following evaluation. Here it has to be mentioned that the identification of new activity fields, based on specific functions, was not done, because the company strategic direction defined only that activities in business fields are supported where nearly all the existing functions of ‘Info Exchange’ can be used.
Figure 115: Innovation architecture at Info Exchange
6.5.4.2 Evaluate

The evaluation focused on the strategic fit which should ensure that only new business fields are interesting that are based on existing functions in term of a functional handshake and existing core competencies. Therefore all the above mentioned potential business fields were analyzed to evaluate how well the functional fit between technology platform and business was done. After this first functional fit a second order fit was conducted, by identifying if the company has the competencies in each function for developing future innovations in the specific business fields. The results, which were calculated based on a catalogue of criteria, were summarized for each new business field in its functional potential. For completing the strategic fit, third order fit was done by evaluating if the environment would change positively in the future. Therefore for each function in each potential business field the functional attractiveness based on several criteria was analyzed, such as the market growth or the market size.

These different strategic fits, always based on a functional view were then summarized in a portfolio that opposes the functional potential to the functional attractiveness for each business field. The conclusion of the result of this functional portfolio was that the business fields of IT, pharmaceuticals, health care and mechanics were especially interesting.

6.5.5 Conclusion

The feedback from management about the innovation architecture and the process of identification and strategic fit evaluation was highly positive. It was said that this procedure supports the interdisciplinary teamwork in terms of showing the links between technology and market side. Additionally the creativity potential is increased. Nevertheless some employees expressed at the beginning of the project the feeling that procedure in this project was in some ways theoretic. However the results were presented to people that were not part of the project members and there it could not be found an argument to call the results into question. Therefore the overall feedback of management was highly positive.
6.6 Case 5: Optic Dye

6.6.1 Short Introduction

The fifth action research case was done in the small size enterprise (50 employees) ‘Optic Dye’, active in the optical storage industry. In mid 2002 ‘Optic Dye’ was created on the basis of an insolvent company. In comparison to the old company, that was active in all the domains of optical storage, the new company only focused on research and development for chemical products in the optical storage industry. The products are mainly laser reflecting dyes, process consulting for producing optical storage devices and forms for the injection molding of an optical storage device, so called stampers.

‘Optic Dye’ has a triple challenge to master. First of all the product was during the analyzed time still in development, therefore the company had no sales. At all time the investors had therefore to be informed. Secondly the chemical products are already offered, in a weaker performance, by large enterprises that are very powerful in the market and are also developing very intensively. Thirdly the product life cycle is very short (less than one year). These three challenges are forcing the company to develop higher focused in an effective and efficient manner combined with an aggressive marketing, to succeed in the future.

6.6.2 Initial Position

**Strategic innovation structures**

Due to the fact that the company is very small, the structures are very flat and implicit. But nevertheless there is a CTO in place, who has to coordinate all projects. The CTO was, contrary to the CEO, employed in the old company with technological responsibilities and has a much founded technological background. However the CTO coordinates all the activities, which makes it difficult to identify the concrete structure of the company.

**Strategic innovation behaviors**

The employees are very open for internal changes and sensitive to environmental changes. This highly unusual willingness for changes could be traced back to the insolvency of the old company. The actual employees have therefore already seen what can happen if internal changes are avoided and environmental changes are ignored. Summarizing the employees are mainly entrepreneurial, communicative and having a high degree of their
own responsibility. This is the great advantage compared to their competitors, which are in general large sized companies.

**Strategic innovation objectives**

The strategic objective of the company, concerning innovation, is much focused: Be the first in the market for the new laser reflecting dye. To reach this objective the company spotlights on one chemical molecule class and is open for strategic alliances with large size companies.

**Innovation decision processes**

An initial unimportant change in the environment could have a major effect on Optic Dye, because the focus of activity is very tight. The executive management is aware of this fact and decides therefore about all major technology issues in their executive management meetings. In these meetings the financial and marketing issues are aligned to the technology based innovation activities. But due to the fact that the CEO has no chemical background, a clear understanding of the technological impacts is difficult for him. However this understanding is in his mind a pre-condition for taking decisions in a strategic innovation decision process.

**Project objectives**

The executive management, especially the CEO, of the analyzed company does not have enough insight into R&D activities to take founded decisions. At same time the management has to react very quickly to environmental changes. For this purpose the following objectives were defined in a first phase: Revise and detail the actual innovation portfolio in terms of transparency with the innovation architecture and introduce tools for strategic as well as qualitative and quantitative evaluation for managing technologies in a small sized innovation driven company. In a second phase, six month later, the process should be redone to revise the results (see Figure 116).

![Figure 116: Project objectives of action research case at Optic Dye](image)
6.6.3 The Innovation Architecture

Figure 117: Innovation architecture at Optic Dye (simplified overview)

The innovation architecture was built in two levels of detail. Firstly, a more general innovation architecture (see top of Figure 117) has the aim to give an overview of how the R&D is structured. In this structure is presented that the company’s activities are based on
Conclusion and Working Hypothesis Rethought

four strategic technology platforms which are used in several functions. These functions are combined to offer a service (production consulting) and two products (dye & stamper) which are offered to customers in the optical storage production. Secondly, a more detailed innovation architecture (see bottom of Figure 117) is built up to support the management in understanding the details of the innovation opportunities and their interactions. This innovation architecture has three cascades. The first cascade contains methodological knowledge with the objective to search for new insights in the domain of science, and use these insights for designing and synthesizing new laser dyes. In the next cascade the laser dye is up-scaled and the production process is developed. Additionally, on the same cascade, the properties of the laser dyes are documented to gain the know-how of how the dye should be used optimal in the production process of optical storage media. The resulting products are introduced into the market on the basis of a marketing concept. The levels of knowledge were differentiated by three categories (exists, planned, not available).

6.6.4 The Innovation Strategy Formulation Process (first procedure)

6.6.4.1 Identify

The revision of the innovation portfolio and the detailing of all innovation opportunities showed some company specific aspects. The CTO is the person with the most technical knowledge about developing a specific dye. Therefore the CTO is, due to environmental changes, the only one that has the overview of all of the internal activities. But at the same time the CTO is under a lot of time pressure and is highly technical and less management oriented. Therefore the information about the almost developed objects in the innovation architecture can be identified very quickly and integrated into the innovation architecture. However due to the lack of the CTO’s management orientation there was no real awareness of how to develop the next generation of dye, the so called dye ‘New’. Therefore, before completing the innovation architecture, some researcher had to collect detailed information. At the end the innovation architecture could be developed and presented to the CEO.

6.6.4.2 Evaluate

The innovation opportunities integrated into the innovation architecture were analyzed firstly in terms of their strategic fit. Based on the fact that the company is highly focused and that the company has no choice of what innovation opportunity it has to develop, which is defined by the ‘big players’, the strategic fit is only made in terms of identifying missing elements. The result of this adapted strategic fit was that the management saw that they will need in the near future two new machines for developing the dyes and stampers. With these
machines the innovation opportunities could be developed and produced in the future, therefore a strategic fit is ensured.

Furthermore a basic quantitative and qualitative analysis was made by using an innovation roadmap. This roadmap (see Figure 118) was mainly made for the innovation opportunity of the Dye ‘New’, which is until this point not planned. Thereby some information had to be collected additionally before transferring the objects of the innovation architecture into the innovation roadmap. During this innovation roadmap the most important fact was that the R&D team was sitting together to discuss the time planning. Thereby the required human and financial resources were discussed in detail. According to the CTO, this innovation roadmap meeting was a very important step to synchronize the individual intentions in terms of the dye ‘New’.

Figure 118: Innovation roadmap at Optic Dye

6.6.5 The Innovation Strategy Formulation Process (second procedure)

Six months after the first innovation architecture was done and the innovation roadmap was approved by management, those results were to be reviewed. Thereby it was astonishing that this update was done in a half a day because of the fact that the innovation architecture did not change in its structure, only the level of knowledge changed and some new objects had to be integrated. Also the innovation roadmap could be updated easily, only some objects had to be adapted in terms of time or newly integrated. This case showed therefore explicitly that the innovation architecture and the tools related to it due to the innovation strategy formulation process are – once they are filled with information – very
easy to update as long as the basic structure is not changing completely, which is very rarely the case.

6.6.6 Conclusion

Finally this case showed that the innovation architecture and the related tools, adapted in some cases, are also helpful in small sized innovation driven companies. Especially this is the case when R&D is highly technology oriented and not market oriented. Also it has to be mentioned that the innovation architecture is a tool to communicate with the top management to explain constrains between specific technologies and markets, which is often not trivial. And last but not least this case showed that the innovation architecture could be updated with a minimum of effort, once the basic structure of the innovation architecture is elaborated.

6.7 Case 6: Built-up

6.7.1 Short Introduction

The sixth action research case was done in the company Built-up, which is a world leader in developing, manufacturing and marketing added-value for professional customers in the construction industry and building maintenance. The company operates in over 120 countries around the world and employs about 15’000 employees.

In 2002 the construction industry declined in parallel with the continued weakness of the world economy. Therefore the company’s results fell from an income of 10% of sales to 1%. Nevertheless the company strengthened its position compared to the competitors according their annual report. The future prognostics for the market development are in mostly positive.

The company strategy is to increase the profitability on the basis of innovations (40-60% of sales should be new products of the three last years), operational performance in-
crease and direct market sales. To ensure this corporate strategy in the innovation, the company invests about 5% of sales in research and development with an increasing tendency.

The different business areas are independent in their operational activities. In terms of strategic decisions, such as strategy formulation, organizational change or overlapping projects in marketing and technology, the corporate management takes at least the company wide aligning responsibility.

The analyzed business area develops and manufactures tools for setting bolts and nails with high force, efficiency and safety. The business area is one of the traditional business areas active in a matured market.

6.7.2 Initial Position

**Strategic innovation structures**

The analyzed business area is, like the whole company, highly market oriented. Many innovation projects, in particular short term projects, are based on a specific customer need. Therefore the marketing has a very strong position in the company. Nevertheless, in technology development, especially in the corporate technology research and development, technology based projects, in terms of technology push, are often initiated. These projects are not for short term purpose but ensure the innovations in the middle and the long-term. The strategic innovation structures are therefore market based as well as technology based. To ensure this balanced structure the company is forced to be organized in a complex matrix organization with many levels in their hierarchy.

The structure of the processes in the innovation system is divided into search, research, technology development, platform development (optional), product development, product care and phase out processes.

**Strategic innovation behaviors**

The company can be characterized as a team- and project-oriented company. In these projects the set of objectives to reach are often very high. Therefore the employees are strongly performance oriented. Decisions are very systematically prepared. The internal employee fluctuation is very high with a turnover of three years.

**Strategic innovation objectives**

The strategic innovation objectives are directly aligned to the corporate strategy. The main strategic innovation objective is to increase the percentage of sales of new products. This main objective is divided into coordinated strategic plans for each of the above mentioned processes of the innovation system.
Innovation decision processes

The strategy process of the analyzed business area, representative for the whole company, is already detailed as soon as the strategic innovation issues are part of it. In this process, decisions are based on market data (ex. sales, market trends) product data (ex. NPV, cost) as well as technology data (ex. technology trends). This data is systematically evaluated and a decision is taken.

This strategy formulation process is in terms of evaluation highly sophisticated, but due to the complex matrix organization the foregoing transparency overview over the whole innovation portfolio, essential for deciding, is often only partly present.

Project objectives

To allow the specific business area to get a clear overview of their innovation system, the innovation portfolio is revised and detailed with the innovation architecture (see Figure 119). In particular the link between the market-oriented side and the technology-oriented side should be made visible to see the overall coherence of different activities part of the innovation portfolio. Thereby the management decided, in contrast to all the other cases, to set up the innovation architecture themselves.

Identify & Formulate

Evaluate

Decide & Formulate

Figure 119: Project objectives of action research case at Built-up

6.7.3 The Innovation Architecture

The innovation architecture of the specific business area of ‘built-up’ is based on four cascades (see Figure 120). The first cascade, containing general research methodological knowledge, such as FEM analysis, has the aim of searching for scientific insight to develop basic technologies of applied scientific effects which are developed on the next cascade into ‘ready to use’ technologies. This technology development cascade consists of four different methodological knowledge segments, because for example the methodological knowledge for mechanical applications is different then for electronic applications. The ‘ready to use’ technologies, fulfilling the functions of the products, are developed in the next cascade into
Innovation architecture was set up very detailed for the technology side, but not on the market side. This is because the objective was to show the links between the specific technologies and the general market side. The levels of object knowledge are categorized into three levels (existing, planned to be available, not available).

6.7.4 The Innovation Strategy Formulation Process

6.7.4.1 Identify

The revision of the portfolio and the detailing of the innovation opportunities were done completely by the management, using the innovation architecture as basis. Thereby the feedback from the management was that they had no problem building up the innovation architecture from a methodological point of view as well as from a content point of view. The content could be easily integrated because the information already existed in the company, which is already very well structured. Therefore the big benefit of the architecting process was, not as in other cases to get a general overview, but more to identify the important innovation opportunities and createa basis for systematic evaluation.

In addition the definition of the functions was for the purpose of the management associated with many advantages. Firstly the functions allowed complex activities to be described by defining their functional objectives which allowed secondly focusing the activities on to this main functional objective. Thirdly the functions allowed finding out, based on a strategic discussion, a definition of the core functions which define the future direction of the innovation activities. And fourthly the functions are a basis for communicating between the market and the technology side without using a to specific technology or marketing language.

6.7.5 Conclusion

This case showed very impressively that the innovation architecture is a tool that management can use without studying long the rules, of innovation architecting. The feedback of management was positive and expectations in terms of the results were reached. However due to the fact that the company is already highly structured, the results of the innovation architecture were in comparison to the efforts not high enough. Nevertheless due to the advantages of the functional thinking, the management was highly satisfied with this action research case.
Additionally it can be said, that this company, which is known in the industry as one of the best in the domain of innovation, has cascaded their processes in the same manner as in the innovation architecture is cascaded the methodological knowledge. According to chapter 5.2.6.1 the alignment of the methodological knowledge cascades of the innovation architecture to the process cascades is an optimal solution for innovating effective and efficiently. Therefore this case could be seen as a best practice case for assisting the presented theory of designing an innovation organization based on the innovation architecture.

6.8 Case 7: RubTec

6.8.1 Short Introduction

The analyzed Japanese company in this action research case is developing and producing products in several different markets. The important products, in terms of sales, are mainly in the domain of belting, rubber joints, filter systems, mechatronics & sensor systems and hose & tubing systems. All of these products, with some exceptions, are in matured markets that are stable or even decreasing. The company employs about 800 employees and is globally active. The income in percent of sales is about 3%.

The company, due to its decreasing markets, is forced to identify new attractive markets, Therefore the company strategy is to strengthen competencies for present products in order to strengthen competencies for new product development.

6.8.2 Initial Position

*Strategic innovation structures*

The company is divided into six independent business segments. These segments are responsible for their sales, production and innovation. Additionally to these segments a technology center was formed for developing new businesses or risky projects in existing businesses where the responsibilities are not clearly defined.
Strategic innovation behaviors

The actual important products were in the past very successful, they were “cash-cows”. Therefore the need for new products was not recognized. This good situation has recently changed. Sales began to stagnate or even to decrease. This is one of the major reasons that the company today has difficulties mastering the new situation of entering into new domains. The innovativeness, in terms of being aware of changes, is not developed. This tendency of low innovativeness is enforced, from a European point of view, by a very institutional organization.

Nevertheless is the innovation domain very effective and efficient. A major reason for this effectiveness and efficiency is firstly the very high team orientation in projects, secondly the behavior that new technologies are systematically licensed from external companies. This allows the development of products to be very fast and requires less effort. The “not invented here syndrome” seems to not exist in this company.

Strategic innovation objectives

Based on the above mentioned strategy the strategic innovation objectives are to identify new markets, based on actual competencies or even to create new competences for existing or new markets. But due to the unclear definition of responsibilities between the technical center and the business segments in term of development of innovations, the specific strategic tasks to find new markets is not clearly allocated. Therefore no clear detailed innovation strategy containing objectives and path is defined.

Innovation decision processes

An implicit strategic decision process exists. But this strategic decision process contains neither the systematic identification of actual activities or new opportunities nor was a systematic evaluation of these elements found. This is a major weakness on the strategic level, in particular during these times, where the company has to decide about fundamental internal changes and new activities for the future.

Project objectives

Due to the fact that the strategic innovation decision process only implicitly exists the objective of the project is to implement a process for revising the innovation portfolio, identifying systematically the innovation opportunities and detailing these opportunities based on the innovation architecture in a first step. In a second stage the elements should be systematically evaluated on the strategic level for formulating, in a third step, an innovation strategy. In doing so the focus should be on implementing an innovation strategy formulation process. This implementation should be actively supported by applying essential tools in the process exemplary, in terms of “learning by doing”.

124 A detailed explanation about the bullwhip effect is described by Lee & Padmanabhan (1997)
6.8.3 The Innovation Architecture

The innovation architecture of ‘RubTec’ was done in two different levels of detail. The more general innovation architecture, which is presented in Figure 122, shows an overview of the activities fields of the company. Thereby twelve different strategic business fields could be identified that are based on nine strategic technology fields linked by functions. In the innovation architecture three different cascades are integrated. The first cascade, technology intelligence, is based on methodological knowledge that allows making patent analysis and joint venture negotiation to be made. This cascade is therefore a highly important element in the innovation system of the company, because it is a strategic decision that mainly all the technologies required to develop an innovation are bought externally. The next cascade is responsible for transforming the strategic technologies into specific products in one of the 12 strategic business fields. Based on these products, a marketing concept is developed on the next cascade to launch the products on different markets.

In contrast to the more detailed innovation architecture, indicated in Figure 123 for the technology side, the strategic technology platforms are detailed by specific technologies. These technologies vary in terms of products, material, design, evaluation or process technology. On the market side the specific actual and future products were identified and integrated into the different strategic business fields. Because of the fact that the detailed innovation architecture was very large, segmentation was done by the functions. Therefore for each function an innovation architecture was developed.
Figure 122: General innovation architecture at RubTec
6.8.4 The Innovation Strategy Formulation Process

6.8.4.1 Identify

During the process of architecting in the step ‘identify’ it was no problem to integrate the actual products and technologies as well as the future technologies. But at the same time it was obvious that in the traditional strategic business fields and strategic technology platforms only innovations were planned that are highly incremental. In these domains no innovation with a middle or high degree of newness could be identified. In contrast in the new business fields and technology platforms, where the first products are still in the phase of development, the innovations seem to have a high degree of newness. Therefore the company has to manage two different kinds of innovation opportunities. On the one hand developing highly incremental innovations for business units that create already an important volume of sales but with a low margin, and on the other hand developing innovation with a high degree of newness in business fields that create today no, or a minor, volume of sales, but with an high future potential.

![Figure 123: Identification of new business fields based on innovation fields at RubTec](image-url)

After the innovation architecture was developed, different innovation fields were defined through a creative brainstorming, to identify new potential business fields. An example of the identification of new business fields is shown in Figure 123. This innovation field of ‘pressure detection’, derived from the business fields, of ‘sensor systems’. During the
process of identification the rule was defined that only ideas in this innovation fields that are linked to actual strategic business fields were accepted. This rule would encourage the search to take place in traditional business fields that are today marked by incremental innovations, for the identification of potential innovation with a high degree of newness. The results were amazing: As presented in Figure 123 for the business field of belting the idea came up to develop a belt which allows the position of a specific object on it to be detected, that would allow for the elements on the belt to be retraced. This special ideas could be developed based on leveraging existing or planned technologies.

After the identification of potential strategic business fields these innovation opportunities were detailed and integrated into the innovation architecture. Thereby it was not possible during the project to detail all the innovation opportunity therefore only some pilot projects were done.

6.8.4.2 Evaluate

For the evaluation of the innovation opportunities in the innovation architecture, firstly a strategic fit was done. The first order fit was already done in the step ‘detail innovation opportunities’ to ensure that the innovation architecture itself was consistent. The second order fit was based on a core competencies check to identify if all the innovation opportunities supported the core competencies of the whole company. For example an idea was to develop a force sensible blanket for testing mattresses on their characteristics. This idea could be developed based on existing technologies, therefore the first order fit is ensured. But in terms of second order fit this innovation opportunity would require a new sales system to be built up, because the actual sales system is very strongly oriented to the mechanical industry, which is one of the core competencies of the ‘RubTec’. Therefore the second order fit is not ensured. The third order fit was done by identifying the future trends of the industry and combining these trends with the innovation opportunities. Based on these trends the employees could see that many innovation opportunities were leading in the right direction but at the same time same important trends were being ignored until this point.
After the strategic fit evaluation the innovation opportunities were evaluated quantitatively and qualitatively. The innovation roadmap was elaborated for several functions of the innovation architecture in the manner of Figure 124. This development of the innovation roadmap was seen by the project members as very important, because such a planning, in terms of an overview, had not explicitly been done in the past. This gave the management the possibility to see a realistic integrated planning of the innovation opportunities. Additionally in the process of roadmapping the employees have to communicate and align their activities more precisely. The innovation roadmap was completed by a knowledge gap analyzed to identify the importance of the planned objects.

The results of the evaluated innovation opportunities were partly summarized in the dynamic technology portfolio (see Figure 125). Thereby the results showed that for example, as can be seen in Figure 125, the technologies four and two, which are linked with quite new business fields, have a high potential in the future. But at the same time the technology three, which is a technology linked to a business field that is highly successful at these times, will in 7 to 10 years be dramatically less attractive. With this technology portfolio a first sense of urgency could be created.
6.8.4.3 Decide and Formulate

The ‘decide and formulate’ step could not be done completely because of the fact that the innovation architecture and the evaluation was not done for all activity fields of ‘Rub-Tec’. Therefore it could only be created a sense of urgency to close the gaps in the ‘identify’ and ‘evaluate’ step.

6.8.5 Conclusion

Concluding this action research case is one of the most important cases, because it showed – although that the identification and evaluation could not be done for the whole company – that the innovation strategy development process, based on the innovation architecture is a practical and structured solution for companies. This was clearly approved by statements of the company management which has accepted the implementation of this process of formulating an innovation strategy.

Additionally this case indicated that this concept is not only a solution for formulating an innovation strategy in the culture of western hemisphere but also in Asian companies, and in particular, in Japanese companies.
6.9 Case 8: MicroSys

6.9.1 Short Introduction

MicroSys is an independent company with 4000 employees with several business units. Its products are precision optical solutions based on microscopes and related instruments. MicroSys manufactures a comprehensive portfolio of products used in a wide variety of applications requiring measurement, analysis or lithography, the material sciences, industrial inspection and the semiconductor manufacturing industry.

The action research case was done in the business unit, active in the medical industry. The products are microscopes for the surgical and diagnostic applications, sold throughout the world. The revenue is about 100 Mio. €, with a continuous annual growth of 3%. The innovation budget is 4% of revenue, which is compared to the three main competitors below average. This low innovation budget is a concern for R&D, because the future success will mainly depend on the innovation ability for developing new products beside an active sales channel.

6.9.2 Initial Position

**Strategic innovation structures**

The analyzed business unit of MicroSys has a process oriented organizational structure. This allows management to have a very good overview over the several activities in the business unit. Especially it has to be mentioned that in the innovation system the structures for conducting professional technology intelligence and product development that are effective and efficient designed. Nevertheless the structure of the innovation system has according to the management the weakness that an explicit technology development is missing. This causes the problem that vague technology issues, discovered by the technology intelligence, are not analyzed in detail in a separate process. Therefore often it happens that the issues are no longer considered, although the importance is increasing.

**Strategic innovation behaviors**

MicroSys is known in the market as one of the companies with very high quality awareness. The developed products have often an unsurpassed level of quality. In addition the development of the products is driven by a very strong market oriented culture. Therefore
the development of new products is mainly driven by actual customer needs rather than driven by new technology performances. Although the information flow is on the market side very enlarged, the communication between the technology and the market side is not optimal.

**Strategic innovation objectives**

The strategic innovation objectives are in short and middle-term, to enlarge the innovation ability in the existing activity domains. In the long-term the objective is to enter into new markets that are related to the actual activities. To fulfill the short and middle term objectives a clear product strategy is defined. However a technology strategy or an over-spanning innovation strategy, containing technology as well as product aspects, is missing.

**Innovation decision processes**

As mentioned before, the specific business unit of MicroSys is very market oriented. Therefore also the decision processes in innovation are highly market oriented. New potential technologies are often not considered and a clear technology evaluation process is missing.

**Project objectives**

Due to the fact that at MicroSys the innovation decision processes for technologies is not highly developed, this process is updated especially with technology specific tools. Therefore firstly the ideas of the technology intelligence are more structured by using the opportunity landscape. Secondly the innovation opportunities are revised and detailed in the innovation architecture. Thirdly it was decided to conduct a strategic fit evaluation in terms of Porter’s three strategic order fits. This would allow showing the marketing the importance of some technological issues and improve the overall innovation decision process.

![Figure 126: Project objectives of action research case at MicroSys](image-url)
6.9.3 Strategic Intelligence

The strategic intelligence is completed by the opportunity landscape\textsuperscript{125}. The opportunity landscape is divided into four strategic sectors: ‘medical functionalities’, ‘optic & image property’, ‘handling and steering’ and ‘construction & additional functionalities’. In a workshop the opportunity landscape was filled with 26 issues in the different strategic sectors. The feedback from the workshop members was positive because it allowed a differentiated visualization of all the issues, which were mainly technology driven. In their mind this visualization would help to show the marketing the importance of several technology based issues. This opportunity landscape was used as basis for the innovation architecture which is the subject of the next sub-chapter.

6.9.4 The Innovation Architecture

The innovation architecture of MicroSys, presented in Figure 127, has four different cascades. The competence development cascade is basically driven by the monitoring of scientific research fields for identifying new technologies and developing competencies in these technologies. Based on these identified technologies, regrouped in nine technology platforms, the modules are developed in the next cascade. The methodological knowledge of this cascade consist mainly of construction, patent creation and creativity methods. The modules are integrated on the next cascade, the product development. This product development needs methods to define interfaces, analyze the user characteristics, create ergonomic designs and ensure quality certification. On the top cascade the products are introduced into the market by marketing.

In this innovation architecture the decision was taken to integrate a two detail level visualization of the functions. The more general level consists of four functions, which are the main product function. This more general definition allows the strategic direction to be defined in terms of future innovation activities on a more abstract level. But due to the fact that these four functions are too general for steering specific innovation projects, the decision was taken to detail the general functions into seventeen detailed functions.

\textsuperscript{125} At MicroSys the opportunity landscape was called opportunity pool.
Figure 127: Innovation architecture at MicroSys
6.9.5 The Innovation Strategy Formulation Process

6.9.5.1 Identify

The identify phase mainly consisted of revising the innovation portfolio based on the issues integrated into the opportunity landscape and detailing these new issues in the innovation architecture. During this process interviews were conducted with employees from marketing, product management and the R&D. Thereby in a first version of the innovation architecture it was attempted to realize the consistency of the different innovation opportunities from the market side as well as from technology side. In a second version of the innovation architecture the functions were defined. Thereby the technology oriented project members mentioned that this procedure helped them to visualize their ideas in a context. Therefore it was possible for them to show the link between the technology and what it can do specifically in terms detailed function. Therefore they concluded that it is a good communication tool to bring the technological issues better into the product development process.

6.9.5.2 Evaluate

The strategic fit evaluation began with the first order fit, which was already done mainly during the development of the innovation architecture. Thereby nearly all the objects in the innovation architectures could be analyzed in terms of their specific consistency and in terms of the functional handshake. Only some technologies that are fulfilling additional functions could not be integrated completely into the innovation architecture during the project as can be seen in Figure 127.

The second order fit was done by evaluating how the different innovation opportunities will fit into the whole company. The criteria for this evaluation were based on technological fit, organizational fit, strategic fit, and financial fit.

The third order fit was done with the scenario technique. Thereby the future scenarios were realized from two different points of view. Firstly a competition scenario was defined, based on the five forces model of Porter (1980: 26). Each force\textsuperscript{126} was analyzed in a creative workshop studying how the future could change. For example in the future it is possible that a substitution competitor will appear in the pharmaceutical industry because they reduce the diseases without making operations, where the microscopes of MicroSys are used. The second point of view was done from a market point of view. Thereby the changes in the markets were analyzed. One of the major changes for example would be, according

\textsuperscript{126} The five forces are: Existing competitors, new competitors, substitution competitors, suppliers and customers.
to the workshop members, that the market will be divided into a ‘forever young’ market and a ‘spartanic’ market. The ‘forever young’ market consists mainly of hospitals that are making plastic operations that are conducted with high tech instruments. The ‘spartanic’ market consists of the public hospitals that are under cost pressure by the results of the health reforms. The cost factor for the chirurgical instruments is the most important in this market. Based on the two different scenarios a preliminary discussion was done by comparing the scenarios to the innovation opportunities in the innovation architecture.

According to the management the strategic fit evaluation allowed firstly the technologies that were often in the past decoupled from the company context to be more precisely integrated. Secondly due to the scenario technique the innovation opportunities could be evaluated in long term. This is a major advantage for communicating with the marketing to show more precisely the importance of a technology. Thirdly it was noticed that the actual strategies of MicroSys do not respond completely to the scenarios that were identified as important in the future.

6.9.6 Conclusion

A conclusion of this action research is that the developed innovation strategy development process can be perfectly coupled with the strategic intelligence. Another major awareness was that scenario planning shows the importance of technologies in the long term. This tool is therefore especially important for companies that are highly market oriented and therefore the evaluation of innovation opportunities is often based on short term criteria.

The innovation architecture as basic tool as well as the linked opportunity landscape, and the scenario technique were found highly attractive by the management. Convinced by these tools the management decided to use the innovation architecture in the future more intensively by also implementing also the innovation roadmap.
6.10 Case 9: StockTec

6.10.1 Short Introduction

StockTec is a multinational company that is specialized in specific products for supply stock systems. With its products it is the world leader with a market share of approximate 50%. About 450 employees realized in 2002 an EBIT of 3.6%.

Stock Tec had three major challenges to master during the project time of the action research case. Firstly the complexity of the products is compared to the competitors very high. Secondly the transparency of the activities is very low. And thirdly the company processes are causing many problems. These problems were identified in the value providing system as well as in the innovation system as is presented in the following.

6.10.2 Initial Position

Strategic innovation structures

The innovation system consists of an R&D department without having a strategic marketing. This lack of strategic marketing leads to the fact that sales directly provides the innovation system with short term customer needs, and for middle or long-term innovation opportunities the R&D itself decides what to do. Because of the structural lack, it happened that a new product was obviously developed not according to the customer needs. Additionally in the company no person was found that is responsible for deciding if a new product is required or an old product can be taken out of the catalogue.

Furthermore the structure of the innovation system does not easily allow a distinctive development of standardized and flexible customer specific products. Therefore the standard products are often to expensive, because they are too flexible.

Strategic innovation behaviors

The employees in R&D are very technocratic. Into new products technological ideas were often integrated, without checking if the customer actually requires these technolo-
gies. This technocratic behavior allowed the company to get an international logistic award for its product but the customer did not buy the product as planned.

**Strategic innovation objectives**

The main strategic innovation objective is first of all to ensure in the future that a standard mass product can be developed that fulfills the requirements of most of the customer. Such a product should be obviously less expensive and less complex than today’s products. But at the same time StockTech wants to ensure that also customer specific products can be developed in the future.

**Innovation decision processes**

The decision process for deciding about the future innovation activities is not really in place. The fact of the matter is that StockTec has nearly no data to provide for such a decision process. Therefore decisions are taken based on opinions.

**Project objectives**

Based on the above mentioned problems of StockTec the main project objective is to define the required innovation processes and organization. This innovation organization should be in alignment with the strategic innovation objectives of today and should allow developing more market oriented products. The proceeding to reach this project objective is done in two step procedure: Firstly the innovation architecture is built up by revising and detailing the innovation opportunities for deriving in a second step the innovation processes and its organization.

![Figure 128: Project objectives of case at StockTec](image)

6.10.3 The Innovation Architecture

The innovation architecture of StockTec was firstly built up in a detailed version, and then reduced to the essential elements for deriving the innovation processes. The reduced innovation architecture is presented on the left of Figure 129. This innovation architecture is marked by three cascades. The first cascade is the module development, whereas a two-folded distinction in terms of its methodological knowledge is done which consists on the
one hand of knowledge to coordinate the external development of modules and on the other hand of knowledge to develop internally modules. Compared to other innovation architectures at StockTec there is no technology development cascade, because the company does not have the financial resources. Therefore new technologies are developed externally. The next cascade is the product development which is differentiated by mass product and customized product development methodological knowledge. This differentiation is based on the fact that the methodological background is different. For example the methods for mass product development require a very intensive consideration of the production costs. In contrast the development of a customized product requires more the consideration of development costs. These are two different methodological mindsets that cannot be done in one and the same process. The top cascade is the marketing cascade for ensuring the short, middle and long-term customer needs to be captured and the market introduction to be prepared.

6.1.0.4 The Innovation Strategy Development Process

6.1.0.4.1 Identify

In the ‘identify’ phase the innovation architecture was built-up. Thereby it was astonishing that in a first draft of the innovation architecture the future products were not differentiated between mass and customized products. R&D was even planning to develop highly flexible products that could be used for customized products as well as for mass products. This intention would have contributed to the effect that the mass products would have been too expensive and the customized products would have been too cheap. Therefore the innovation architecture was designed so that it is in alignment with the strategic innovation objectives. Therefore the future products to develop were differentiated into the two categories in order to have a consistent innovation architecture.

Normally at this point the different objects should be evaluated. But due to the fact that the management did not have enough data to be able to evaluate all the product ideas it was decided in a first step to directly design the organization. Thereby the management was adverted to the fact that for example the decision of not making any more customized products would also influence the organization.

6.1.0.4.2 Redesign Innovation Processes

Based on the innovation architecture of StockTec, which was strategically not completely decided, the innovation processes were derived. As shown in chapter 5.2.6.1 the
innovation processes are derived based on the cascading and segmentation of the methodological knowledge as shown in Figure 129.

Figure 129: Deriving the innovation processes based on the innovation architecture at StockTec

These innovation processes already define the organizational units. Therefore a ‘marketing’, a ‘customized product development’, a ‘mass product development’, an ‘external module development’ and an ‘external module development’ organizational unit were planned.

The innovation processes of Figure 129 needed to be detailed in a further step in terms of their interaction and process steps as shown in Figure 130. The interactions between the processes are always based on an order-deliver understanding. Therefore for example the marketing process decides to make a new mass product and gives this order to the mass product development process which has to deliver such a defined product. This mass product development process then decides to integrate a specific module, and gives an order to the internal module development process in the case that they can do it; otherwise the order goes to the external module development process. All of the processes are steered by a strategic innovation management process which is in fact consists basically of the strategic process phases of Figure 70.
6.10.5 Conclusion

This action research case at StockTec showed explicitly that the innovation architecture is not only a tool that allows strategic innovation opportunities to be identified in a structured manner, but also the organizational structure can be defined. Thereby the organizational structure is not defined based on a theoretical organization structure or a best case organization in the industry but based on the company specific activities. This is a major advantage and helps to ensure the efficiency and effectiveness of a company.

6.11 Cross-Case Analysis and Conclusion

6.11.1 Cross-Case Analysis of the Innovation Architecture

The different innovation architectures of the above presented action research cases show very well that for small and large companies as well as for turn-around and successful companies an innovation architecture could be built up according to the theory of chapter 5.1.
The **concept** of the innovation architecture ensures that the structure of the innovation architecture is aligned to the specific activities of the company. For example the companies that are active in research have more cascades than companies that do not. Also the segmentation of the methodological knowledge is adapted to the analyzed company. Both, object as well as methodological knowledge, was very important in all the cases in order to understand the structure of the innovation architecture. In contrast the meta-knowledge, which completes the image of knowledge in the innovation system, was in general not seen as so important in building up the innovation architecture. The reason for that is perhaps due to the fact that the meta-knowledge is today often not considered in strategic decisions.

The **visualization** of the innovation architecture was basically the same but varies in details from case to case. This is because the visualization of the innovation architecture had to be adapted to the specific requirements of each project. Therefore, based on the specific projects, some innovation architectures were built up on one page, others were segmented by products or functions, and others are more detailed or more general. This shows that the innovation architecture has on the one hand very strict rules to be built up but on the other hand these results left enough flexibility to adapt it to the specific project need.

The **usability** of the innovation architecture was in general considered in the action research cases as very high. The first creation of the innovation architecture is a step which is associated with an intensive work phase which is decreasing by the level of how good the company is already structured. However after the innovation architecture is built up once, the update can be done easily as proven in one case. Also one case showed that the management can easily develop the innovation architecture itself. Therefore in all the cases the innovation architecture seems to be a very practical tool.

The **results** of the innovation architecture seem to be, in the context of innovation management, highly multifaceted as presented in the following:

- The innovation architecture is a basic tool for structuring the innovation systems of companies that are highly unstructured as it is often the case in turnaround companies. At the same time the innovation architecture helps well structured companies to visualized the actual system as well as the possible future system by systematically integrating the potential innovation opportunities.

- The innovation architecture is a basic tool for aligning market pull activities, mainly initiated by marketing, and technology push activities, often initiated by research and development. Thereby the functional handshake between products/modules and technology is a major element. But also the fit between all the objects is important to ensure the alignment of all the intentions and activities in different domains of the company.

- The innovation architecture is a basic strategic steering tool in innovation management. Firstly due to the fact that the knowledge gaps are illustrated, it is
clearly illustrated that they have to be closed. Secondly the functions allow a solution neutral responsibility for the domains of technology development to be defined. Thirdly the innovation architecture supports the strategic steering to develop highly systematic and purposeful innovations from scientific science to the market introduction.

- The innovation architecture is a basic tool that integrates all innovation opportunities independent from its degree of newness or object. This allows in one visualization to gain an holistic overview over the whole innovation system.

- The innovation architecture is a basic tool for enforcing structured communication. Based on the innovation architecture a discussion, including market and technology oriented members, can be conducted in a more structured manner because of the fact that every one talks about the same elements while the innovation architecture is completely built up.

To conclude the innovation architecture is a basic tool for innovation management that was confirmed by most of the partners of the action research cases.

6.11.2 Cross-Case Analysis of the Innovation Strategy Formulation Process

The innovation strategy formulation process was accepted by management in mainly all the cases as presented in Figure 131. Seven of the nine action research projects were concluded with great satisfaction, which means that the results were above the expectations of management. One project ended with average satisfaction and one with no satisfaction. In both of these action research cases the management criticized mainly that the effort was greater than the results. Comparing the two cases with the other cases, these two cases were the only projects where the development of the innovation architecture was done only for revising the innovation portfolio and detailing the innovation opportunities. In all the other cases used, the innovation architecture was used for more purposes, which allowed more results to be gained. This leads to a first awareness, that the satisfaction for the innovation architecture is in tendency higher, when it is used more broadly in the innovation strategy development process.

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127 Business and technology innovations are integrated directly into the innovation architecture. The organizational innovations are only integrated indirectly because they are derived in the innovation strategy process out of the innovation architecture.
Conclusion and Working Hypothesis Rethought

For completing the cross case evaluation of the nine cases the innovation strategy formulation process is presented in the following by discussing the concept, the usability and the results.

The concept of the innovation strategy formulation process ensures that the management is directed through a procedure that allows all potential innovation opportunities to be identified and analyzed systematically and practically. Thereby the proceeding through the process seems to be more important than the results. Therefore all decision makers have to be involved. But it has to be mentioned as some cases showed that before beginning the process of innovation strategy formulation, a general corporate or business unit strategic direction has to be present. This allows the evaluation criteria to be determined in the evaluation step, especially in the strategic fit evaluation.

The usability of the innovation strategy formulation process was strongly confirmed by practice. The cases showed that the process could be used as a modular basic concept that completes the missing steps of company’s innovation strategy formulation process, as well as a complete strategy formulation concept. Also the cultural background of the company is not especially important, because the process was accepted in Europe as well as in Japan. This positive feedback of the management concerning the usability is probably based on two facts. Firstly the selection of the tools, consisting of the innovation architecture and
general management tools, helped to consider all the important aspects to formulate an innovation strategy. Secondly many tools integrated into the process were already known by management, which allowed the tools to be implemented much faster.

The results of the innovation strategy formulation process seem to be in the context of innovation management, highly multifaceted as presented in the following:

- The innovation strategy formulation process allows for the innovation system a clear strategic direction to be defined, consisting of objectives and path, without reducing the creativity of the individual person. This is because the innovation architecture allows evaluation to be made on a level that is detailed enough for evaluation but not so detailed that the complete product is already designed in detail.

- The innovation strategy formulation process ensures many gaps to be identified before starting the development of an innovation opportunity. These gaps are on the one hand knowledge gaps, time gaps and resource gaps. On the other hand gaps in terms of missing links between objects can be easily found as management often pointed out.

- The innovation strategy formulation process is not only a process of decision making but it is also a process which initiates the planning and implementation phase of specific innovation opportunities. For example the innovation roadmap is a tool that helps to prepare a decision, for identifying gaps in terms of timing, but also this innovation roadmap is a detailed input for the planning and the implementation. Therefore this innovation strategy formulation process does reduce the gap between strategic decision making and operational implementation.

- The innovation strategy formulation process allows, as seen in one presented case, deriving appropriated organizational processes in the innovation system. This ensures the efficiency of the organization in the innovation system.

- The innovation strategy formulation process ensures on strategic level, the required creativity to be able to identify all potential innovation opportunities but at the same time the evaluation is marked by a basically fact based reduction of the innovation opportunities.

Finally the innovation strategy formulation process was seen by a majority of management as a process that is very useful. Therefore the call from reality presented in chapter 3.2 can be answered:

THE INNOVATION STRATEGY FORMULATION PROCESS DEVELOPED IN THIS WORK IS A SOLUTION FOR A STRUCTURED PRACTITIONER ORIENTED INNOVATION STRATEGY FORMULATION PROCESS FOR INNOVATION DRIVEN COMPANIES.
7 Conclusion and Working Hypothesis Rethought

In the previous chapter it was presented that the innovation architecture and the innovation strategy formulation process is highly accepted by management practice. However it has still to be evaluated if the innovation strategy formulation process is in alignment with the theoretical requirements of chapter 4.1. This evaluation of the concept is shown in Figure 132 and described in the following.

![Evaluation Diagram](image_url)

**Figure 132: Evaluation of the innovation strategy formulation process of this work compared to the existing concepts**

The innovation strategy formulation process allows a **strategic management specific understanding** of complexity and systemic interaction to be provided because the innovation architecture integrates object, methodological and meta-knowledge in a visualization...
model, which ensures a reduction of the complexity and a visualization of the systemic interaction. The evolution is understood because the potential innovation opportunities are integrated into the innovation architecture and compared to the environmental trends.

Combining these theoretical insights and the above presented results of the action research cases the first working hypothesis presented in chapter 4.2 can be validated at this point.

**THE CONCEPT OF ARCHITECTURE IS A SOLUTION FOR UNDERSTANDING THE COMPLEX, SYSTEMIC INTERACTIVE AND EVOLUTIONARY SYSTEM OF INNOVATION DRIVEN ENTERPRISES.**

The innovation strategy formulation process allows providing a strategy specific understanding of direction to be provided because the resulting innovation opportunities were analyzed in terms of resources, time, knowledge gap and make or buy / keep or sell, which leads to a clear strategic objective and path. The focus is ensured due to the fact that firstly the resources are considered and secondly the innovation opportunities are aligned to the core competencies of the company. Based on the innovation strategy also the organization can be derived easily by using the innovation architecture as shown in the case of StockTec. In addition the consistency of the innovation strategy is ensured due to the strategic fit evaluation based on the innovation architecture.

The innovation strategy formulation process allows an innovation specific understanding of integral innovations to be provided, because technological and business innovations are integrated into the innovation architecture and therefore part of the innovation strategy formulation process. The organizational innovations can be derived based on the innovation strategy in a next phase. The innovation barriers which occur due to a lack of strategic fit, resources, time or knowledge are considered. But innovation barriers that are generated due to cultural or personal aspects, such as a lack of motivation are not explicitly analyzed. At this point the concept does not provide a complete solution. Innovations with a high degree of novelty and a low degree of novelty are in general considered in the innovation architecture. However some special potential innovation opportunities, where for example it is known that a technology such as nano technology will be important for the industry, but a specific product is still not known, are too soon rejected. This is because a major condition in the evaluation process is that all the innovation opportunities must be completely detailed, and therefore the nano technology will not be considered in the innovation strategy. In such cases the company has to pay attention. And last but not least the innovation relevant knowledge, as basis for all innovation, is understood completely by innovation architecture and the knowledge gap analysis.

Based on the fact that the actual theory can not provide a better solution in terms of considering explicitly all innovation barriers and especially innovations with an high degree of
novelty (see Figure 132), it can be said that this innovation strategy formulation process is in general an appropriated tool that respects the theory and is a practical and structured solution for practice. In a sum he innovation strategy formulation process, which is based on the innovation architecture, is also from theoretical point of view an appropriate solution for companies and therefore the **second working hypothesis** presented in chapter 4.2 can be validated at this point.

**THE INNOVATION ARCHITECTURE APPLIED IN AN ADAPTED INNOVATION STRATEGY FORMULATION PROCESS IS A SUPPORT FOR INNOVATION DRIVEN COMPANIES TO DEFINE AN INNOVATION STRATEGY.**

However the innovation strategy formulation process needs to be implemented in an adequate manner into the company specific conditions. In this context the **third working hypothesis** presented in chapter 4.2 can be validated based on the gained insights of the action research cases:

**IMPLEMENTING AN INNOVATION STRATEGY FORMULATION PROCESS IN AN INNOVATION DRIVEN COMPANY IS NOT REALIZABLE BY IMPLEMENTING THE WHOLE THEORETICAL PROCESS. HOWEVER THE THEORETICAL INNOVATION STRATEGY FORMULATION PROCESS IS A BASIS FOR ADDING THE MISSING STEPS SO THAT THE COMPANY WILL BE ABLE TO DEFINE AN ADEQUATE INNOVATION STRATEGY.**

In a nutshell the innovation strategy process based on the innovation architecture is from a theoretical as well as from a practical point of view a practitioner and structured solution for closing the dual gaps presented in chapter 4.1.
Towards a New Set of Management Principles

The aim of this chapter is to make a major contribution towards fulfilling the need in practice (see chapter 3.2). This need represents a call from reality for management guidelines, which could support the practitioner in designing and implementing a practitioner oriented and structured innovation strategy formulation process in innovation driven enterprises. Therefore, this chapter is the practical answer to the three research questions about how to understand a complex, systemic interacting and evolutionary innovation systems, and how to design and implement a practitioner oriented and structures innovation strategy formulation process.

The nature of this chapter is different from the character of the other chapters. While the latter follow scientific and sound argumentation, output in this chapter is normative and hands-on. Therefore, proposals in this chapter are not thoroughly argued, but quite straightforward. Any suggestions are based on practical experience gained during this research and a sound theoretical background in the field of innovation strategy formulation. This also implies that the principles do not strictly depict the elaborated solutions offered during action research case study. This would be contrary to the most important insight of recent research and this study, namely a strong dependency between the structure of the innovation strategy formulation process and the company’s context. Since the context differs from one enterprise to another, the management principles cannot be seen as recommendations on a very detailed level. Therefore, the management principles give general indications.

The following management guidelines seem to be promising for innovation strategy formulation in innovation driven enterprises (see Figure 133). They are listed in an order that corresponds logically to the concerns of innovation driven enterprises, when setting up an innovation strategy formulation concept.

The first three principles are basic statements to understand the strategic level of an innovation system. Then four clusters build a cluster of principles to formulate an innovation strategy for innovation driven companies. Furthermore, a cluster with three principles makes suggestion for the implementation of an innovation strategy formulation process. This discussion should be understood from the point of view of an innovation driven company. Therefore, key benefits and arguments are related to innovation driven contexts. However, some principles or parts of principles would be of interest to any company. To underpin the ten management principles, each principle underlies a citation of a known scholar in the domain of general management. Therefore the sample of these management principles in the context of innovation management is a main finding of this work.
8.1 Understanding the Innovation System

8.1.1 Principle 1: Design an Architectural Blueprint

*Innovation driven enterprises should understand their innovation system in terms of complexity, systemic interaction and evolution. For this purpose the innovation architecture is an appropriate tool.*

**Key benefits:**

- Management of innovation driven companies are able to understand their system and therefore they can improve the quality of their decision-making.
- Innovation opportunities can be analyzed more in detail.
- A concrete plan for the future development of the company can be developed.

The concept of architecture is always a blueprint of a system which aims to understand it as shown in chapter 2.2.2.2. Therefore especially in the case of complex, systemic interactive and evolutionary systems, which cannot be understood by one individual, its essential elements can be better understood by developing an architectural blueprint. Therefore the first step in the strategic decision process should be to develop an architecture.
Supporting citation of general management scholar:

“An architect must be capable of dreaming of things not yet created – a cathedral where there is now only a dusty plain, or an elegant span across a chasm that hasn’t yet been crossed. But an architect must also be capable of producing a blueprint for how to turn the dream into reality.” (Hamel & Prahalad, 1994: 107)

8.1.2 Principle 2: System Analyzed with Appropriate Effort Invested

Key benefits:

* The innovation strategy formulation process can be designed effectively and efficiently.

* Communication on a strategic level is based on the important elements.

To understand an innovation system, as well as a system in general, it is not essential to comprehend all details. It is often not even necessary to understand the functioning of each element of the system. Nonetheless, it is important to understand the interaction of the element with others and its evolution. In the case of formulating an innovation strategy it is not important to know the functioning of a specific technology, but it is important to know its potential usability, its costs, or its future attractiveness etc. Additionally for a corporate innovation strategy, the break-up of a technology platform into specific technologies need not to be done as detailed as for an innovation strategy of a smaller business unit, which results from the different requirements to a strategy.

Supporting citation of general management scholar:

“The central concept ‘system’ embodies the idea of a set of elements connected together which form a whole, this showing properties which are properties of the whole, rather than properties of its component parts.” (Checkland, 1993: 3)
8.1.3 Principle 3: Think in Functions

For developing an innovation strategy it is essential to know the product functions.

Key benefits:

- Functions allow a solution neutral alignment between market and technology oriented activities in terms of taking decisions as well as in communication.
- Functions allow responsibilities to be defined without decreasing the creativity for finding solutions.
- Functions allow new business fields or technology platforms to be identified based on existing activities.
- Functions, especially core functions, very clearly define the future direction of the innovation system.

In the innovation architecture the functions make the solution neutral link between market pull and technology push. The management of the action research cases found this to be an important link because for several reasons its definition helps to steer an innovation system. Firstly, the communication between marketing, research and development can be enforced through a solution neutral but very specific discussion of developing an innovation. Secondly, functions allow a solution neutral identification of possible future opportunity fields. Thirdly, functions allow new potential business fields as well as new potential technology platforms to be identified. Fourthly, the strategic definitions of core functions allow the company to direct the innovation system to a specific direction without repressing creativity.

Supporting citation of general management scholar:

“In reality a product should be considered simply as a physical manifestation of the application of a particular technology to the satisfaction of a particular function for a particular customer group.” (Abell, 1980: 113).
8.2 Formulating an Innovation Strategy

8.2.1 Principle 4: Ensure Strategic Fit

**Key benefit:**
- Innovations that are based on actual competencies have in general a higher probability of succeeding with less effort.

An innovation strategy that defines future innovation activities that are not supporting the companies actual activities or the environmental trends, are on the one hand not supporting the core competencies of the company which allow competitive advantage and on the other hand they need much more effort to be introduced into the market successfully. Nevertheless it has to be mentioned that innovation opportunities without strategic fit can also be successful. However in such a case the management must be clearly aware of the consequences of such a decision. Therefore, in general, innovation opportunities with a clear strategic fit are more interesting.

**Supporting citation of general management scholar:**

“Strategy is creating fit among a company’s activities. The success of a strategy depends on doing many things well – not just a few – and integrating among them. If there is no fit among activities, there is no distinctive strategy and little sustainability.” (Porter, 1996: 75).

8.2.2 Principle 5: Direct and Focus with Consistency

**An innovation driven enterprise should give its innovation system a direction in terms of a specific objective and a predefined path. This direction should allow activities to be focused and consistency to be ensured.**
Key benefits:

- Innovation driven companies can ensure their implementation of their strategic intentions.
- Duplications or inconsistencies are reduced to a minimum, and this ensures an effective and efficient realization of innovations.

A strategy that is unable to be communicated to every employee in the company will not be a lived strategy. Furthermore a lack in direction of the strategy will not allow the efforts to be focused on the major goal. This will result in inconsistency in the implementation or increase the inconsistency in the case where the strategy is not consistent. Therefore only when a strategy defines direction, in terms of objectives and path, ensures focus and is consistent will a strategy be a lived part of the company.

Supporting citation of general management scholar:

A strategy is a plan or a pattern that integrates an organization’s major goals, policies, and action sequences into a cohesive whole”: Quinn (1980: 7)

8.2.3 Principle 6: Define Clear Responsibilities

An innovation strategy of an innovation driven enterprise should point out clear responsibilities of identifying, evaluating and realizing opportunities.

Key benefits:

- Tasks are clearly allocated which ensure their efficiency.
- The controlling of the implementation of an innovation strategy can be simplified.

Defining clear responsibility in strategies is an essential element to ensure its implementation because of several effects. Firstly a strategy that defines no responsibilities will leave a major gap between strategic level and operational level, because the following question will be raised but not be answered: Who will do this? Secondly, responsibilities that are clearly defined ensure that for a project, a clear input is defined and more importantly a clear output is defined which focuses the work on realizing and not redefining. Thirdly a clear responsibility for tasks establishes control of the task.
Towards a New Set of Management Principles

**Supporting citation of general management scholar:**

“Responsibilities for accomplishing key tasks and making decisions must be assigned to individuals or groups.” (Andrews, 1987: 87)

8.2.4 Principle 7: Optimize the Organization

The organization of the innovation system should be adapted to the innovation activities.

**Key benefits:**

- An organization that fits to its activities has a high level of effectiveness and efficiency.
- An organizational redesign in terms of an organizational innovation ensures in the context of integral innovations sustainable development and therefore competitive advantage.

An innovation strategy describes what the company has to develop in the future. Therefore it is obvious that a changed strategy will influence the organization to some degree. For example the decision, of a company specialized in mass production, to develop products for special customer needs, will influence the innovation organization, because it is not possible to develop a mass product with a focus on production costs and a specific product with a focus on high flexibility in the same department. Therefore it is essential to design the company’s processes according to the strategic intentions and to design the structure of the organization according to the processes.

**Supporting citation of general management scholar:**

“Structure follows Strategy.” (Chandler, 1962)
8.3 Implementing an Innovation Strategy Formulation Process

8.3.1 Principle 8: Define Continuous Process Ownership

A PROCESS OWNERSHIP OF THE INNOVATION STRATEGY FORMULATION PROCESS IS ESSENTIAL FOR ITS SUCCESSFUL IMPLEMENTATION.

Key benefit:

- With ownership of a process, responsibility for its outcome and its practical use is enforced.

The definition of a continuous process ownership has in the context of this work a two-fold meaning: Firstly for the innovation strategy formulation process a member of the company board should take the ownership and the detailed output of this process has to be defined. Thus the innovation strategy is formulated or updated periodically and in the same structure and the innovation architecture is updated as well. Secondly, a continuous process ownership is also essential for all the processes in the innovation system. For example, one person should own the technology development process, and this person should therefore be responsible for every aspect from the intelligence to the development of a technology. This defines a clear responsibility and supports creativity in the process.

Supporting citation of general management scholar:

“Through a strict design of continuous processes in the company, through clearly defined process outputs and through a clear regulation of the responsibilities it is possible to gain (…) major benefits of economizing.” (Horsch, 2003: 14) \(^{128}\)

8.3.2 Principle 9: Nurture Participation

THE INTEGRATION OF IDEAS FROM MARKETING & SALES, DEVELOPMENT & RESEARCH AND PRODUCTION HELPS TO EXPAND THE HORIZON FOR INNOVATION STRATEGIES AND FACILITATES ITS IMPLEMENTATION.

\(^{128}\) Translated from German
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Key benefit:

- Ideas from marketing & sales, development & research and production help to provide a more holistic understanding for future innovation activities.
- When an innovation strategy includes internal ideas, the employees’ identification with the innovation strategy is stronger.

In a company many ideas are already internally available to prepare the formulation of an innovation strategy. Therefore it would be a pity to ignore all these ideas. However it is often a problem for management to have the time to hear all of the often unstructured ideas. Nevertheless there are tools, such as the opportunity landscape and the innovation architecture, which nurture participation on an operational level by summarizing the ideas. Afterward these ideas can be evaluated on a strategic level, and if it is necessary with further support from the operational level. This kind of participation allows new strategic directions to be found internally. Furthermore an innovation strategy that is based on internal ideas is supported by the company’s own employees, which helps to implement its adoption.

Supporting citation of general management scholar:

“On complex projects, the inner team cannot sustain itself and work effectively without constantly importing new information from the outside world.” (Allen, 1977: 122)

8.3.3 Principle 10: Develop a Culture of Discipline

A strong management commitment to a clear and focused innovation strategy is essential to ensure the innovation strategy formulation process and the implementation of the strategy itself.

Key benefit:

- A strong management commitment ensures a focus of the activities, which makes them more effective and efficient.

In the case that all the above-mentioned management principles for the innovation system were followed one highly important principle is still missing: The company has to have the culture of discipline to implement strictly, with all efforts, exactly what they have decided. If this is not the case the innovation strategy formulation process as well as the innovation strategy will not be implemented as decided. Therefore the presented innovation strategy development process based on the innovation architecture will only be successfully
– as it is the case for all management tools – if the company implements it by focusing on that which is essential for fulfilling the strategic goals.

**Supporting citation of general management scholar:**

“Everyone would like to be the best, but most organizations lack the discipline to figure out with egoless clarity what they can be the best at and the will to do whatever it takes to turn that potential into reality. They lack the discipline to rinse their cottage cheese.” (Collins, 2001: 128)
9 New Challenges and Issues for Further Research

This dissertation studied how innovation driven companies could formulate an innovation strategy based on a clear understanding of the innovation system. The pertinent research question was: ‘How can a structured innovation strategy formulation process be designed and implemented?’ The analysis of the state-of-the-art in strategic management, innovation management as well as related literature revealed the absence of an answer to this question and therefore, showed research gaps.

Action research in nine innovation driven companies allowed implementing and validating the generated solution of this work for innovation strategy formulation. Based on the generated and validated solution of the innovation architecture and the innovation strategy formulation process, working hypotheses could be discussed and a new set of management principles could be presented in order to achieve a contribution towards closing the dual gaps in theory and practice.

This solution for structured innovation strategy formulation is surely no guarantee for sustainable success in innovation driven companies; this simply is not possible because of the uncertainty of the future, the diversity of companies and the multitude of general success or failure factors. However, by consideration of the presented management principles the probability of being aware of the future is certainly improved, and therefore is promising for general company success.

Some new challenges and issues for further research in the field of innovation strategy formulation emerged during this study:

• **Broader validation of the generated solution**: The generated solution, in particular the innovation architecture and the innovation strategy formulation process, are based on action research in nine innovation based enterprises. Therefore, the empirical basis is, by the nature of action research, narrow. Implementing these elements on a broader basis would give deeper insight into strengths and weaknesses, and would allow variations to be tested.

• **Complete validation of the generated solution**: In the nine action research cases only modules of the innovation strategy formulation process could be implemented. To validate the whole solution of this work would require cases implementing the innovation strategy formulation process completely which would provide deeper insight into strengths and weaknesses of the overall solution.
• **Broader validation of management principles**: In addition to the generated solution of an innovation strategy formulation process for innovation driven companies, further validation of the management principles would be of scientific and practical interest. Hence, each management principle could be a hypothesis. While this dissertation’s research design did not plan to test hypotheses, but to be inspired by working hypotheses in order to guide the ‘search’ for an appropriate solution, further research could envisage empirically testing these new hypotheses derived from the management principles.

• **Broader insight into the interaction of the innovation strategy formulation process with other management processes**: It is hardly possible to set clear limits between different management issues (e.g. innovation management and technology management) and different management processes (e.g. innovation strategy formulation process and business unit strategy formulation process); they are nested and interrelated. A detailed examination of the interaction with and the impact on most current management processes of innovation strategy formulation would upgrade the holistic understanding of an integrated innovation management approach.

• **Broader insights into the interaction between innovation strategy and other strategy processes**: As in chapter 2.1.3.5 the value defining system and the value providing system are creating together value. The innovation strategy formulation process of this work was generated for the value defining system, but it has major influences on the future value providing system. This influence that provokes obviously intensive interactions between both, need to be analyzed more in detail in order to be able to describe the interactions of the innovation strategy and other strategies in innovation driven companies.

Even though the topic of this dissertation is a concept of structured innovation strategy formulation and the research objects were innovation driven companies, insight into challenges and issues in management disciplines that are related to innovation strategy formulation could be gained. This revealed other new challenges and issues for further research. Some of them are:

• **Enlarge the consideration of discontinuous innovations in innovation strategy formulation**: The solution concept of this work does in general consider all innovations independent from its degree of newness. However in chapter 7 it was found that innovation opportunities that could not be integrated into the innovation architecture because the links to other objects are not clear, were omitted in the further steps. Therefore the process of innovation strategy formulation should be enlarged to consider these innovation opportunities, in general called discontinuous innovations.
- **More systematically integration of the influence of innovation barriers into the innovation strategy formulation**: The solution concept of this work does consider potential innovation barriers that occur due to a lack of strategic fit, resources, time or knowledge. But innovation barriers that are generated due to cultural or personal aspects, such as a lack of motivation are not explicitly analyzed as described in chapter 7. Therefore the process of innovation strategy formulation should be enlarged to consider more explicitly the cultural and personal triggered innovation barriers.

- **Enlarging organizational innovation for the whole company**: In this work innovation management has the task of developing so called integrated innovations consisting of business, technological and organizational innovations. Thereby the organizational innovations were always understood as the redesign of the value defining system of a company. However an innovation can also be the redesign of the value providing system of a company. Therefore the strategic innovation management process should contain not only the redesign of the innovation system, but of the whole company in a holistic manner.

- **More implementation stories**: Implementation of management concepts is a moderately explored field. The major challenge is to compare different implementation strategies. It seems to be difficult to make a direct comparison of different implementation strategies, e.g. by implementing the same concept in a different manner in different companies, because implementation ideally runs in parallel to concept definition. Therefore, we need more individual implementation stories in order to learn from successes and failures.

These issues are challenges to both management practitioners and management scientists. If next to the inspiration for innovation strategy formulation in innovation driven enterprises this dissertation motivates practitioners and scientists to challenge these new issues, another main goal of the author is achieved.
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