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# **Technology and Innovation Management in New Technology-Based Firms**

## **Introducing the Pocke™ Concept**

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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 in Zürich. It was a great pleasure to add a dissertation to the field of 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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## List of Abbreviations

AG	Aktiengesellschaft (incorporation)	MCM	Multi Chip Module
ASIC	Application Specific IC	min.	minimum
BSC	Balanced Score Card	Mio	Millions
CEO	Chief Executive Officer	NIH	'Not invented here'
CFO	Chief Financial Officer	NTBF	New Technology-Based Firm
CHF	Swiss Francs	p.	page
COO	Chief Operating Officer	PCB	Printed Circuit Board
CoP	Community of Practise	OECD	Organization for Economic Co-operation and Development
cp.	compare	OEM	Original Equipment Manufacturer
CTI	Commission Technology and Innovation	P&L	Production and Logistics
CTO	Chief Technology Officer	Pocke <sup>TM</sup>	Pocket Technology Management
Dr.	Doctor (PhD or medical)	QM	Quality Management
e.g.	for example	R&D	Research and Development
EC	European Community	R&T	Research & Technology Department
EFQM	European Foundation for Quality Management	resp.	respectively
EIRMA	European Industrial Research Management Association	S&T	Science and Technology
EITM	European Institute of Technology Management	SBA	Small Business Administration
et al.	et alii	SCM	Supply Chain Management
ETHZ	Eidgenössische Technische Hochschule Zurich (Swiss Federal Institute of Technology Zurich)	SME	Small and Medium-sized Companies
ERP	Enterprise Resource Planning	SMT	Surface Mounted Technology
etc.	et cetera	SOP	Standard Operating Procedure
EU	European Union	β-TCP	beta-Tricalcium-phosphate
FH	Fachhochschule (University of Applied Science UAS)	TI	Technology Intelligence
HDP	High Density Packaging	TF	Technology Field
HES	Haute Ecole Spécialise (University of Applied Science UAS)	TMCS	Technology Management Control System
HRM	Human Resource Management	TPM	Technology Platform Management
HSA	Hand Shake Analysis	TRM	Technology Roadmapping
IA	Innovation Architecture		
IS	Information System		
ICT	Information and Communication Technology		
IDEFO	Integration Definition Language 0		
IP	Intellectual Property		
ISIC	International Standard Industrial Classification		
IT	Information Technology		
KTI	Kommission für Technologie und Innovation (english: Commission for technology and innovation CTI)		
M&S	Marketing and Sales		
max.	maximum		



## Management Summary

NTBFs are challenged by the lack of deep pockets, by the nature of their organization still being in formation and by being in a rapidly changing environment. For a successful management of technologies under these circumstances, a management system has to be compact, flexible and adaptable. The *PockeTM* concept (Pocket Technology Management or technology and innovation management for NTBFs) aims at supporting NTBFs according to their entrepreneurial needs, possibilities and opportunities.

To compete with larger competitors, New Technology-Based Firms (NTBFs) must develop advantages of flexibility and speed of response. In order to capitalize on these advantages, NTBFs require a technology and innovation management approach that enhances the NTBFs' competitive advantages in terms of entrepreneurial organizations, short communication paths and intelligent decisions mechanisms. However, virtually all the research on technology and innovation management has taken place in large firms, therefore in another context.

The *PockeTM* represents a holistic technology and innovation management system, which integrates NTBFs' internal and external aspects on the normative, strategic and operational management level. This is achieved through the five key elements of the *PockeTM* which form a minimal concept of technology and innovation management. *Technology intelligence* activities collect and process external information about technologies, competitors and markets. This information is essential for the *(technology) strategy formation and implementation*, which sets goals and allocates available resources. It is not sufficient to just create a strategy, there has to be some *technology management control*. The need for *knowledge management* emerges as a result of such strategies or organizational structures. Limited resources force NTBFs to cooperate with other firms, which increases the need for *cooperation management* in order to reduce transaction-costs. The integration of key elements in the firm context allows an NTBF to define a specific implementation of the *PockeTM* and to specify the most appropriate interactions between the different elements.

The *PockeTM* has been developed by means of an action research methodology in close cooperation with several NTBFs.



## Zusammenfassung

Für das Management von *jungen Technologieunternehmen* (JTU / NTBF) stellen sich spezielle Herausforderungen im Umgang mit Technologien durch eine knappe Ressourcendecke, eine Organisationsform im Aufbau und ein schnell wechselndes Unternehmensumfeld. Diese Umstände bedingen ein Managementsystem welches kompakt, flexibel und anpassungsfähig ist. Das Pocke™ Konzept (Pocket Technology Management oder Technologie- und Innovationsmanagement für JTU) unterstützt JTU entsprechend ihrer unternehmerischen Bedürfnisse, Möglichkeiten und Chancen.

Um mit multinationalen Firmen zu konkurrenzieren, müssen JTU Wettbewerbsvorteile gezielt aufbauen. Dabei spielen Flexibilität und Anpassungsfähigkeit eine entscheidende Rolle, um Technologie- und Innovationsvorsprünge zu erzielen und daraus einen langfristigen Gewinn zu ziehen. Zur effizienten und effektiven Nutzung der vorhandenen Ressourcen zum Aufbau von Kompetenzen sind formalisierte Strukturen, Prozesse und Methoden auch in JTU nötig. Das Pocke™ stellt ein ganzheitliches Technologie- und Innovationsmanagementsystem dar, welches interne und externe Aspekte von JTU auf normativer, strategischer und operativer Ebene betrachtet.

Das Pocke™ besteht aus fünf Schlüsselementen, welche ein minimales Technologie- und Innovationsmanagement Konzept darstellen. Mittels *Technology Intelligence* Aktivitäten werden externe Informationen über Technologien, Konkurrenten und Märkte gesammelt und verarbeitet. Diese Informationen sind essentiell zum Erstellen und Implementieren einer *Technologiestrategie*, welche Ziele setzt und Ressourcen alloziert. Eine Strategie muss auch betreffend ihrer Umsetzung und Wirkung in regelmässigen Abständen durch ein *Technologiemanagement Kontrollsystem* überprüft werden. Ein *Wissensmanagement* Bedürfnis entsteht oftmals als Resultat der strategischen Ziele und Planung. Limitierte Ressourcen zwingen JTU Kooperationen einzugehen, wodurch ein *Kooperationsmanagement* nötig wird, um Transaktionskosten gering zu halten. Die Einbettung in einen unternehmensspezifischen Zusammenhang erlaubt eine individuelle Implementierung des Pocke™ und spezifische Interaktionen zwischen den eingesetzten Schlüsselementen.

Das Pocke™ ist das Resultat einer explorativen Forschungsarbeit und hauptsächlich mittels Aktionsforschung in Zusammenarbeit mit mehreren JTU erarbeitet.

# 1 INTRODUCTION

“It has become increasingly clear that the competitive position of NTBFs in advanced economies - indeed of economies in their entirety - depends not just on research activities and the technological capabilities they have at their disposal but on their capacity to manage technology.” (Cannell & Dankbaar, 1996: 5)

## 1.1 RESEARCH FOCUS

In recent years, a growing awareness of the NTBFs<sup>1</sup> contribution to the global technological and economical development has penetrated theory as well as practice. This contribution is reflected in an augmentation of new ventures creation (Reynolds *et al.*, 2003: 4) and research dedicated to the field of entrepreneurship<sup>2</sup> (Jones-Evans & Klofsten, 1997: 1). Various definitions of entrepreneurship<sup>3</sup> underscore the ability of entrepreneurial organizations to perceive new opportunities and create innovations, both key ingredients for creating new companies and economic growth (Haour *et al.*, 2002: 5).

“Accelerated technological change has become a fact and will continue to challenge industrial and societal development in this new century.” (Tschirky, 2004: 1). Anticipating these changes seems to be crucial for success in technology-based companies. For NTBFs these changes have two sides: on the one side, the NTBF is an object of change and on the other side, it is subject to change. As an object of change the NTBF has to adapt quickly to new environments. This requires a high degree of flexibility and speed of response because of their limited resources. Employees and organization have to be open to new ideas and able to realize them quickly, because they cannot rely on unlimited financial resources and are often working in small, innovative niche markets.

- 
1. New Technology-Based Firm (NTBF): The term NTBF seems to have been coined by the Arthur D. Little Group, who defined it as an independently owned business established for not more than 25 years and based on the exploitation of an invention or technological innovation which implies substantial technological risks (Little, 1977). This can be considered a ‘narrow’ or restricted definition. For a further definition of NTBF see chapter 2.1.2 on page 13.
  2. Entrepreneurship has multiple definitions of which no single definition has been generally accepted. The lack of definition leaves open multiple paths of inquiry and various perspectives of what entrepreneurship actually is. For a detailed discussion about definition of entrepreneurship see chapter 2.1.1 on page 9.
  3. Cp. chapter 2.1.1 on page 9.

On the other side, NTBFs can be seen as a subject to change. Traditional multi-national enterprises often disappear in new consortiums through frequent reorganizations (Pleitner, 2001). This process releases resources that nurture initiation and growth of NTBFs. In this sense, NTBFs are actually a sign of change that stimulates and forces further adaptations in the NTBF's environment.

Research on product innovations shows that small independent firms produce 2.5 times more innovations per employee than large firms (Acs & Audretsch, 1991), in other words, NTBFs out perform their larger more established and resource rich cousins in the commercialization of innovations (Walsh & Kirchoff, 2002). Additionally, commercializing disruptive innovations is more promising in NTBFs when compared to established firms, because NTBFs can view disruptive innovation projects as being on their critical path to growth and success, rather than as being distractions from main business of the company (Christensen, 1997: 142).

Nevertheless, NTBFs have to overcome numerous obstacles, e.g. management deficits, insufficient capital, lacking experience in non-technical affairs, market entry barriers, etc. This results in a critical survival curve during the first years in business (Figure 1).

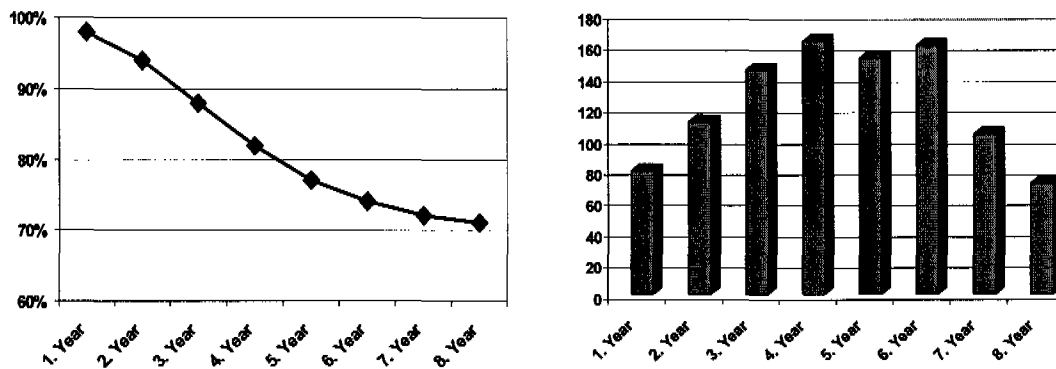


Figure 1 Left: Mortality of an NTBF during their first years in business. Right: Average age of NTBF dissolutions per year.<sup>4</sup> (Source Creditreform 2003)

The management of technology in products as well as in processes determines the NTBF's technical and commercial success. Nevertheless, successful innovators also focus on the development of organizational structures. Empirical research shows that the technology and

4. Database for both figures ranges from 1989 through 1995.

innovation management of innovative NTBFs differs in many ways from those with less innovation activity (Kohler, 1994: 220).

Requirements for a technology and innovation management system to successfully be able to cope with the challenges of incorporation, survival, growth and expansion of an NTBF may be described as follows:<sup>5</sup>

- Size and complexity have to be minimized so that the NTBF's management is able to implement and use the system, even with limited resources such as time, management knowledge, finances to hire consultants, etc.
- Processes, tools and methods have to be very flexible, so that they meet the demands of a (fast) growing company. Scale-ups from a start-up to a mature SME have to be supported.
- Entrepreneurial culture is known for by team spirit, learning ability and group dynamics. These preconditions enable adaptable objectives and structures to be formulated.

These NTBF specific requirements of being - *compact, flexible and adaptable* - should be underscored by the name *PockeTM*<sup>6</sup> which stands for a *technology and innovation management Concept for NTBFs*. The PockeTM is derived from the 'Integrated Technology and Innovation Management Concept' (Tschirky, 1998) and findings from the entrepreneurship literature emphasizing the NTBF's needs and possibilities in terms of objectives, structure and behavior (Figure 2).

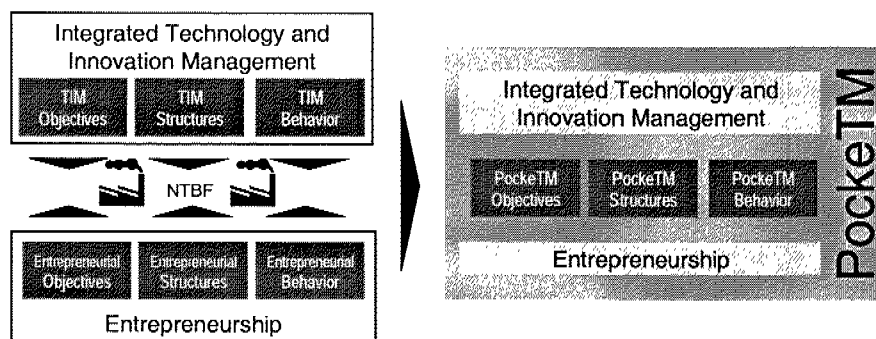


Figure 2 Combination of technology and innovation management with entrepreneurship

5. For a detailed analysis of these requirements see chapter 4.2 on page 94 and chapter 6.1 on page 161.

6. PockeTM: *Pocket Technology Management* (Luggen & Tschirky, 2003b)

## **1.2 RESEARCH QUESTIONS**

Based on current research in technology and innovation management at the ETH-Center for Enterprise Science at the Swiss Federal Institute of Technology (Zurich),<sup>7</sup> the goal of this dissertation is to find solutions, that contribute to the successful technology and innovation management in NTBFs. However, there is little insight, both from a theoretical and practical point of view, into how NTBFs cope with technologies. Formulated in strategic terms, there is a need to learn what key capabilities successful NTBFs use and how these can be designed, developed and directed, thus:

**THE RESEARCH TOPIC OF THIS DISSERTATION IS TECHNOLOGY AND INNOVATION MANAGEMENT AND THE RESEARCH OBJECTS ARE NEW TECHNOLOGY-BASED FIRMS (NTBF).**

In order to be able to handle the topic, the following two research questions have been formulated:

**1. HOW COULD A COMPACT, FLEXIBLE AND ADAPTABLE TECHNOLOGY AND INNOVATION MANAGEMENT SYSTEM BE DESIGNED FOR NEW TECHNOLOGY-BASED FIRMS, THAT FITS THEIR NEEDS, POSSIBILITIES AND OPPORTUNITIES?**

**2. HOW COULD A NEW TECHNOLOGY-BASED FIRM PROCEED TO IMPLEMENT A TECHNOLOGY AND INNOVATION MANAGEMENT SYSTEM, DESPITE AN NTBF HAS LIMITED RESOURCES, AN NTBF IS IN A ORGANIZATIONAL FORMATION PROCESS AND AN NTBF IS IN A RAPIDLY CHANGING ENVIRONMENT?**

In fact, the design of a system and its implementation cannot be strictly separated. Likewise, a double gap in the technology and innovation management for NTBFs, consisting of a gap in current literature and practice, should be closed by means of action research as a main objective of this work. Therefore, gaining insight into business reality by means of first-hand information is stressed by the explorative research that emphasizes the design and implementation of organizational elements, such as structures, processes and methods which are of use to practitioners.

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7. E.g. Kohler, 1994; Lichtenthaler, 2000; Savioz, 2002; Bucher, 2003; Jung, 2003

Additional to a detailed description of the research cases, the final output of this application-oriented research is a generalized technology and innovation management system in NTBFs. The output consists of two complementary parts:

- As a concept for *Technology and Innovation Management in New Technology-Based Firms - PockeTM*, represents a holistic approach for management of technologies in NTBFs.
- As set of *management principles* supports the entrepreneur to define, implement and run a firm-specific solution following the PockeTM concept.

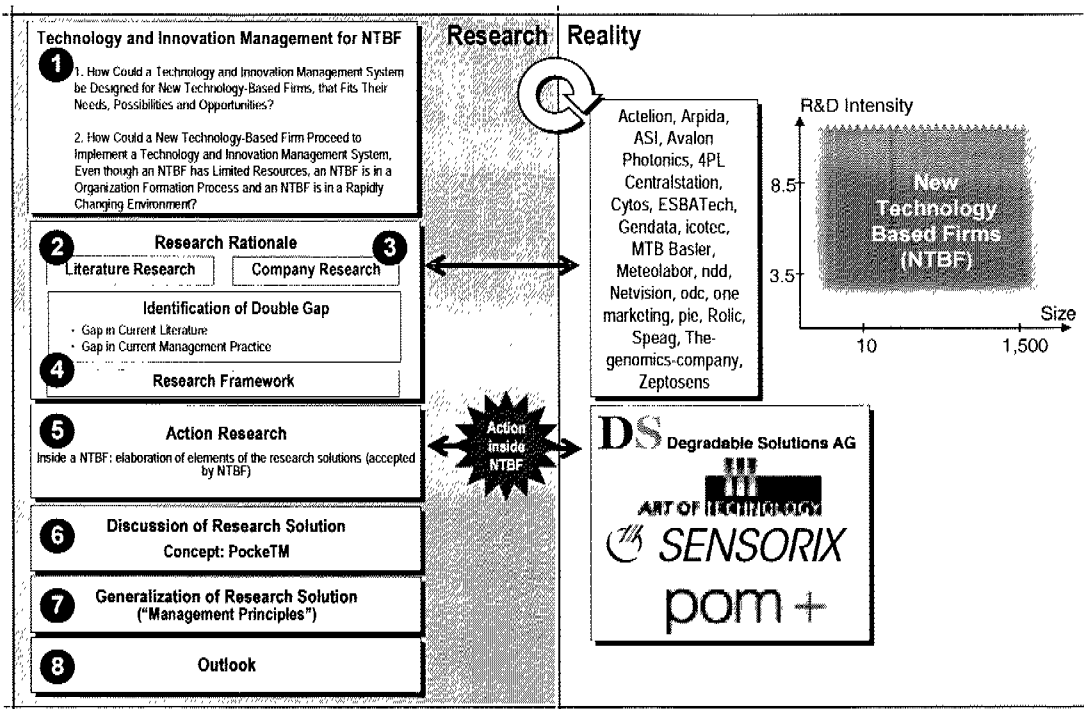


Figure 3 Design of thesis

### 1.3 DESIGN AND STRUCTURE OF THESIS

The design of this thesis is depicted in Figure 3. The figure gives an overview of the major parts in this work. The thesis is structured in seven principal chapters. Figure 4 provides a structural overview.

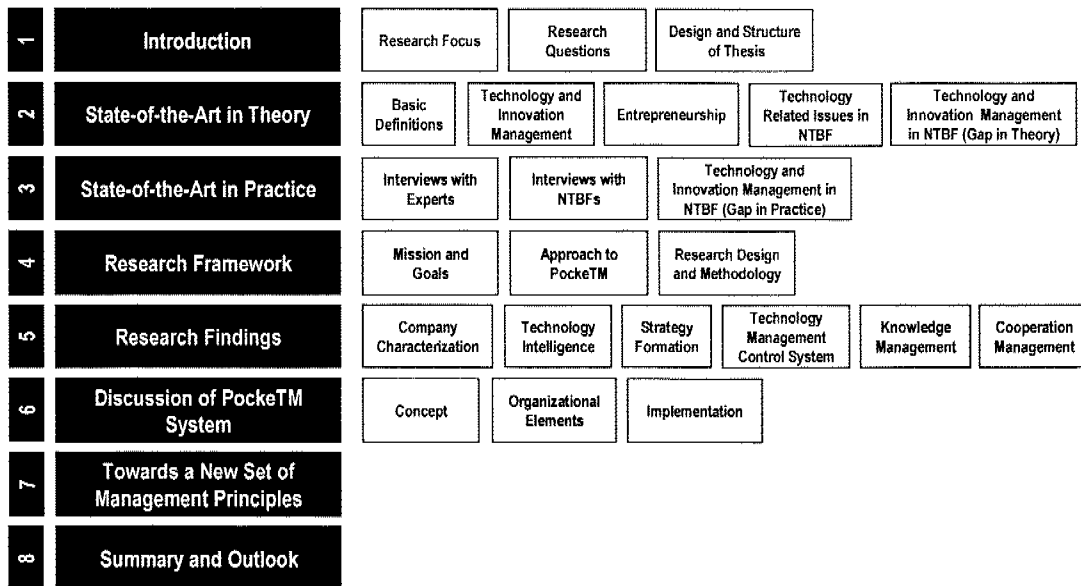


Figure 4 Structure of thesis

**Chapter one** sets the research focus and formulates the research questions in order to outline the content of this work. The formulation of the research questions is a 'feed-forward' process for the development of a technology and innovation management system for an NTBF.

**Chapter two** illustrates the state-of-the-art of technology and innovation management in NTBFs and builds the theoretical basis of this thesis. The goal of this chapter is threefold: Firstly, this chapter aims to illustrate current research of technology-related issues in the *field of entrepreneurship*. Secondly, analysis of recent research in the field of *technology and innovation management* and related topics will build the basis for further research. Thirdly, the *research gap* in current literature is shown. This chapter begins with some basic definitions. Then, the research object - *New Technology-Based Firms (NTBFs)* - and the research topic - *technology and innovation management and entrepreneurship* - are defined and analyzed extensively.

**Chapter three** delivers insight into the state-of-the-art in practice. This chapter points out the practical relevance of the topic in NTBFs and shows, at the same time, the gap in research from a practical point of view. Thus, this chapter is not solution-oriented, but shows challenges and needs of NTBFs' reality. The *practitioners' voice* is captured by means of first-hand information, i.e. obtained through interviews, seminars, and workshops.

**Chapter four** illustrates a *double gap* existing between published research in literature and current management practice in NTBFs. The first part of the research gap is deduced from the

literature review in the 'state-of-the-art' in theory and the second part of the research gap is deduced from the call from reality in 'state-of-the-art' in practice. Based on this double gap, research guidelines are formulated. These guidelines should be understood as guiding ideas to finding answers to the two research questions. In addition, this chapter outlines the empirical research design and methodology.

*Chapter five* contains action research conducted in a number of New Technology-Based Firms (NTBFs) in Switzerland. The aim of this chapter is to find, together with practitioners, a solution for the design and implementation of technology and innovation management system in NTBFs. In order to understand the context and the conditions in which both forms of action research are embedded, a case study of the initial situation begins each *action research* case. Then, insight is summarized and action requirements are formulated. This is the divide between the non-influenced and influenced action research environment. The third part aims to generate elements for a solution for technology and innovation management system in the NTBF. These elements will be explained extensively. Finally, this chapter concludes with a discussion of the generated solution with regard to practice and theory.

*Chapter six* discusses the designed *PockeTM system* in Chapter five in order to reach a theoretical conclusion. Because the designed PockeTM system helps to find answers to the research questions, the discussion arguments are based on insight gained during this study. Therefore, the PockeTM system is not simply accepted or refused, but adapted and extended where necessary.

*Chapter seven* points towards a new set of *management principles* in order to formulate a practical conclusion. Thus, in the discussion of the management principles the practitioner will find answers to the research questions.

*Chapter eight*, finally, describes new challenges and issues for further research.





## **2 STATE-OF-THE-ART IN THEORY**

The aim of this chapter to revise the state-of-the-art in literature. The first part introduces the field of entrepreneurship and New Technology-Based Firm (NTBF) with basic definitions. The second part considers technology and innovation management in general and the fourth part describes existing approaches to technology and innovation management in NTBFs. Between these two parts, the third part summarizes findings in the field of entrepreneurship. The chapter is concluded with an illustration of the gap in literature.

### **2.1 BASIC DEFINITIONS**

This chapter illustrates the difficulty in defining entrepreneurship and NTBFs by giving a literature overview of common definitions and aiming to find definitions suitable for this thesis.

#### **2.1.1 Attempt to Define 'Entrepreneurship'**

It is generally believed that entrepreneurship is difficult to define, and that entrepreneurs and entrepreneurial activities are often difficult to identify and study because the phenomenon is complicated, equivocal, and 'vaste'. Entrepreneurship is a multifaceted phenomenon that cuts across many disciplinary boundaries. Moreover, the studies on entrepreneurship have adopted different theoretical perspectives, units of analysis, and methodologies. The fact that there is no generalizable definition must not prevent from an attempt to build a definition. Indeed, as Gartner (2000) remarked: 'If you are going to talk about entrepreneurship, offer a definition. Yet, you recognize that a definition can never be definitive.' Morris (1998) found 77 different definitions in a review of journal articles and textbooks over a five-year period. Table 1 gives a short overview of a possible definition. The lack of one definition leaves open multiple paths of inquiry and various perspectives of what entrepreneurship really is.

	<b>Definition of Entrepreneurship</b>
(Schumpeter, 1934)	Entrepreneurship is seen as new combinations including the doing of new things or the doing of things that are already being done in a new way. New combinations include (1) introduction of new good, (2) new method of production, (3) opening of a new market, (4) new source of supply, (5) new organizations.
(Kirzner, 1973)	Entrepreneurship is the ability to perceive new opportunities. This recognition and seizing of the opportunity will tend to 'correct' the market and bring it back toward equilibrium.
(Drucker, 1985)	Entrepreneurship is an act of innovation that involves endowing existing resources with new wealth-producing capacity.
(Stevenson, Roberts & Grousbeck, 1985)	Entrepreneurship is the pursuit of an opportunity without concern for current resources or capabilities.
(Rumelt, 1987)	Entrepreneurship is the creation of new business, new business meaning that they do not exactly duplicate existing businesses but have some element of novelty.
(Low & MacMillan, 1988)	Entrepreneurship is the creation of new enterprise.
(Gartner, 1988)	Entrepreneurship is the creation of organizations, the process by which new organizations come into existence.
(Venkataraman, 1997)	Entrepreneurship research seeks to understand how opportunities to bring into existence future goods and services are discovered, created, and exploited, by whom, and with what consequences.
(Morris, 1998)	Entrepreneurship is the process through which individuals and teams create value by bringing together unique packages of resource inputs to exploit opportunities in the environment. It can occur in any organizational context and results in a variety of possible outcomes, including new ventures, products, services, processes, markets, and technologies.
(Kuratko & Hodgetts, 1998)	Entrepreneurship is a process of innovation and new-venture creation through four major dimensions - individual, organizational, environmental, process - that is aided by collaborative networks in government, education, and institutions. All of the macro and micro positions of entrepreneurial thought must be considered while recognizing and seizing opportunities that can be converted into marketable ideas capable of competing for implementation in today's economy.
(Sharma & Christman, 1999)	Entrepreneurship encompasses acts of organizational creation, renewal, or innovation that occur within or outside an existing organization.

*Table 1 Selected definitions of entrepreneurship (adapted from (Hitt, 2002: 22)*

The lack of a widely accepted definition justifies the use of a more general dominant paradigm, which for purpose of this study, according to Bygrave & Minniti (2000) consists of the following question: 'How, by whom and with which consequences are opportunities for the creation of products and services discovered, valued and used in new organizations?'

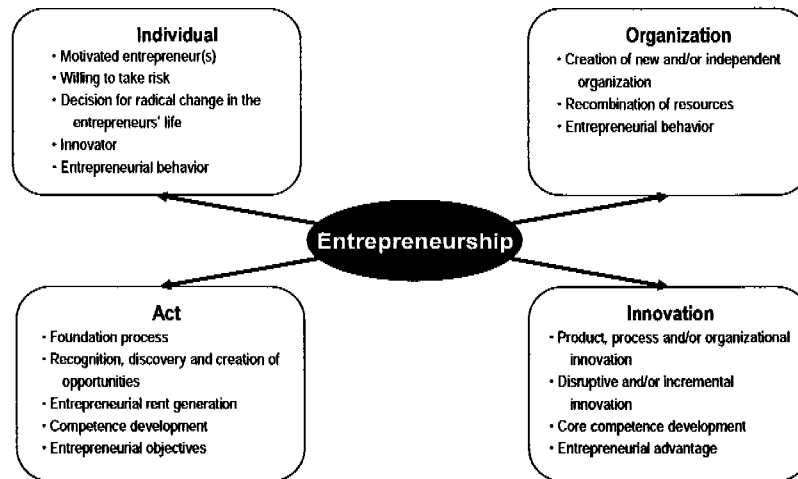


Figure 5 Defining factors of entrepreneurship (after Volery, 2000)

Much of the argument over the definition of entrepreneurship revolves around the four factors (Figure 5) considered necessary for entrepreneurship to take place (Volery, 2000):

- An *individual*: There is wide agreement that entrepreneurship is fully dependent on at least one motivated individual. An individual is often the dominant leader, at least in the early stages, but an entrepreneurial team usually becomes a key part of the success as the venture grows (Stearns & Hills, 1996).
- An *act*: Entrepreneurship involves an orientation toward action and a belief structure that drives the individual. Entrepreneurs, therefore, are individuals who are not only astute at identifying opportunities but who will do something to capitalize on them (Bird, 1988). Although everyone agrees that entrepreneurship involves an action, there is considerable difference of opinion as to exactly what this action must involve. Some scholars view only the creation of a new organization as an entrepreneurial act, others consider it sufficient to consider acts that produce an innovation, and still others believe that entrepreneurial acts are those which involve both a new organization and innovation.
- An *organization*: There has long been a school of thought that considers the creation of organizations as a condition for entrepreneurship (Gartner, 2000). Yet, there is no general agreement about what constitutes 'an organization'; particularly if it is considered that it must be new and independent. It is for example, common practice for Asian entrepreneurs to build what can be termed, 'extended organizations' by renting and borrowing from family and friends' organizational networks on a 'need basis'. Thus, it is difficult to identify the boundary of the true organization. Similarly, does the franchise constitute an organization?

Considering the creation of an organization as a necessary condition would also exclude the whole field of corporate entrepreneurship where innovation takes place within a corporation but does not necessarily lead to the creation of a separate organization.

- *Innovation*: Many believe that it is not sufficient to only launch an enterprise, but that it must represent innovation to constitute entrepreneurship. Innovation is traditionally defined as the successful implementation of creative ideas (Woodman, Sawyer & Griffin, 1993). Although many scholars support innovation as a necessary part of an entrepreneurship model or definition, the exact nature and extent of the innovation required varies greatly. There are substantial disagreements about the nature (or amount) of innovation and whether the creation of an economic entity is a necessary condition of entrepreneurship.

### **Definition of Entrepreneurship**

Based on the applied entrepreneurship paradigm and the presented factors, entrepreneurship is defined for this dissertation as follows: '*Entrepreneurship is a process of creating incremental wealth in new firms through four major dimensions - individual, act, organization and innovation. Entrepreneurial value creation encompasses the risky combination of unique resources as input to exploit opportunities in a new organization that can be converted into marketable products capable of competing in today's rapidly evolving economy.*'

This definition also encompasses the creation of a new organization, with a focus on the process of founding a new firm by an individual or group of individuals, acting independently or as part of a venture or corporate system. Renewal or rebirth of existing organizations and intrapreneurship<sup>8</sup> are excluded, even though this could also be considered entrepreneurial in the sense that it represents a radical departure from predominant and historic strategic or structural patterns.<sup>9</sup>

Creating wealth through rent<sup>10</sup> generation is a primary driver of entrepreneurial behavior. These entrepreneurial rents are generated as a reward for risk taking to discover new combinations of resources under uncertain situations. Resources are more likely to sustain value-creation when they are unusual, valuable, hard-to-replicate and not easily substitutable (Barney, 1991).

Leading edge technological knowledge can be a potent resource if it can be oriented towards commercial applications. The potential resource can only lead to the realization of a commercial opportunity if it is developed for market applications in combination with other types of resources, such as finance and manpower. Therefore, key tasks of the entrepreneurial process are centered around the recognition of a commercial opportunity in the light of the environment

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8. Intrapreneurship is defined as entrepreneurship within an existing organization.

9. Cp. Stopford & Baden-Fuller (1994) for entrepreneurial rebirth and renewal.

and the creation of economic wealth on the basis of access to and mobilization of complementary resources.<sup>11</sup> While the above definition recognizes the centrality of innovation to entrepreneurship, the extent varies according to the newness of the product, organization or process in a particular marketplace.

### 2.1.2 Definition of New Technology-Based Firm (NTBF)

The term New Technology-Based Firm (NTBF) seems to have been coined by the Arthur D. Little Group, who defined it as 'an independently owned business established for not more than 25 years and based on the exploitation of an invention or technological innovation which implies substantial technological risks' (Little, 1977: 13). This initial definition has been vastly extended in the last two decades.

For this reason the introduction of some similar forms of organizations might be helpful before defining NTBF. Figure 6 gives an overview.

#### Start-up

At the beginning, every firm runs through the initiation phase, which is generally called start-up. A wide definition of start-ups encompasses all firms in an early life-cycle phase. Sometimes start-up refers also to recently incorporated enterprises, which are characterized through a high level of dynamics and future orientation (Hommel & Knecht, 2002: 633). For this work, the term venture is used as a synonym to start-up.

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10. There is a distinction between Ricardian, Paretian, and entrepreneurial rents. The key to the existence of *Ricardian rents* is the presence of a fixed scarce factor. A standard way of presenting this notion is the increasing-cost industry. In this type of industry, it is possible to rank producers from least to highest cost, with the marginal cost of the least efficient producer equal to the market price. The marginal firm earns zero profit while the more efficient earns rents.

The rent concept due to Pareto (and Marshall) is the difference between a resource's payment in its best use and the payment it would receive on its next best use. Thus, the *Pareto rent* is the payment received above and beyond that amount required to call it into use. When resources in use all have the same value in their best alternative use, the Ricardian and Pareto concepts correspond.

Whereas the classical concepts of rent apply in a static world and focus on the productivity of different resources or of resources in different uses, *entrepreneurial rent* stems from uncertainty and the discovery of new products and ways of doing business. Entrepreneurial rents are defined as the difference between a venture's ex-post value and the ex-ante cost of the resources combined to form the venture. If one posits expectational equilibrium (ex-ante cost equals expected ex-post value), then expected entrepreneurial rents are zero. Hence, entrepreneurial rent springs from ex-ante uncertainty. Ex-post entrepreneurial rents are appropriable not by competitors but by the factors of production (Rumelt, 1987).

11. Cp. Grant (1991) for a list of entrepreneurial key tasks.

### Spin-off

A spin-off is a particular type of start-up, because it can be understood as any process that leads to a new firm out of an existing organization, such as originating in a university, a government agency or a commercial firm. Normally a spin-off is associated with a technology transfer, employees and other resources (Gassmann, Escher & Luggen, 2003).

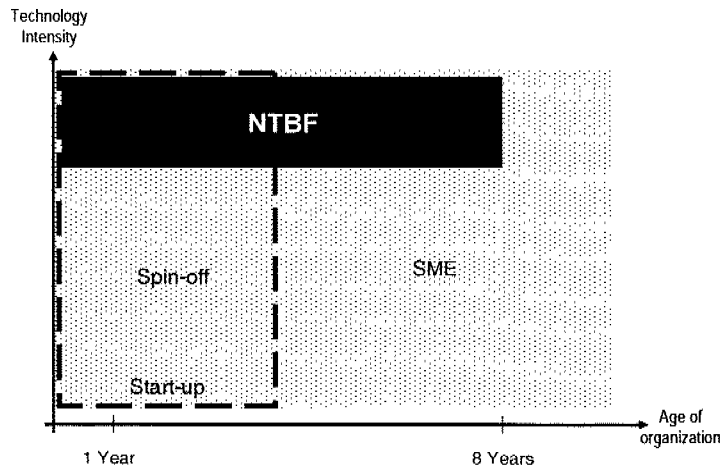


Figure 6 Different types of organizations from start-up to SME

### SME

If the start-up survives, it is transformed to an SME at some point of time, depending on the business field and technology-intensity. Quantitative criteria to define an SME ranges from size in terms of employees or turnover, to market shares. Because of its practical aspect, the number of employees and the company's turnover seem to be the most appropriate way to define SMEs. Table 2 gives an overview of different quantitative definitions in the USA, Europe, Germany and Switzerland.

USA <sup>a</sup>	Europe <sup>b</sup>	Germany <sup>c</sup>	Switzerland <sup>d</sup>
Different size standards for different industries SMEs: up to 500 employees for most manufacturing industries, US\$ 17 million of turnover Many exceptions exist: one-fourth of SBA subsidized SMEs had varying sizes ranging from 500 to 1,500 employees!	<b>Micro-enterprises:</b> 1-9 employees, (no statement about turnover) <b>Small enterprises:</b> 10-49 employees, max. US\$ 3 million of turnover <b>Medium-sized enterprises:</b> 50-249 employees, max. US\$ 17 million of turnover <b>Large:</b> 250 and more employees, more than US\$ 17 million of turnover	<b>Small enterprises:</b> up to 9 employees, annual turnover up to US\$ 0.43 million <b>Medium-sized enterprises:</b> 10 to 499 employees, annual turnover US\$ 0.43 to 43 million <b>Large:</b> 500 and more employees, annual turnover US\$ 43 million and more	<b>SME's:</b> less than 250 employees and max. US\$ 34 of turnover

a. SBA (2001: [www.sba.gov/size](http://www.sba.gov/size))

b. EU commission (1999: [www.journal-mittelstand.com/emsu](http://www.journal-mittelstand.com/emsu))

c. (Hauser, 2000: 3)

d. Federal Office for Education and Science (2001: [www.admin.ch/bbw](http://www.admin.ch/bbw))

Note: Currency conversion in July 2001.

Table 2 Quantitative definitions of SMEs (employees and turnover)<sup>12</sup> (Savioz, 2002: 15)

Even though quantitative definitions are very clear, the companies are considered as a black box. Qualitative criteria may help to strengthen the understanding of SMEs (Clemens *et al.*, 1997: 2):

- Identity of ownership and personal responsibility for the enterprise's activities
- Identity of ownership and personal liability for the entrepreneur's and the enterprise's financial situation
- Personal responsibility for the enterprise's success or failure
- Personal relationship between employer and employees

SME is the most general term, under which start-up and spin-off, as well as NTBF, can be included.

#### Definition of an NTBF in this Dissertation

To define the term New Technology-Based Firm (NTBF), it is useful to divide it in two independent sub-terms 'new' and 'technology-based'.

12. Some definitions are not 'official' because no law sets a limit (Habersaat, Schönenberger & Weber, 2001: 10).



## NEW

In literature, there is a quantitative and qualitative approach to describing the term 'new'. The age limit of the firm while it is considered an NTBF is the only qualitative criteria. The lower limit ranges from zero to one year and the upper from 6 to 25 years in business.<sup>13</sup>

The qualitative approach is based on the firm's activities where 'new' refers to the typical structure and behavior of firms in the early phases of their life-cycle, such as initiation, survival, growth and expansion phase (Quinn & Cameron, 1983; Artmann, Lechler & Wu, 2001). The initiation phase is dominated by the search for resources, little planning and coordination, plenty of ideas and the formation of a 'market niche'. During the survival phase, informal communication and structure are established, continuous innovation and a strong commitment with long hours spent are necessary. The growth phase needs more formalized rules and stable structures. Emphasis is placed on efficiency and maintenance. The last typical NTBF phase is the expansion phase, which focuses on elaboration of structure, decentralization and domain expansion. Not all NTBFs run through all these phases, some adapt typical SME-like behavior and structure already in the earlier phases. The phase model gives a good overview of the structure and behavior of new firms before they are considered to be established.

## TECHNOLOGY-BASED

Literature often uses terms like 'technology-based' and 'technology-intensive'.<sup>14</sup> However, it is surprising that there is not a generally accepted definition. Most contributions that are about technology-based firms do not define the term.<sup>15</sup> Chabot (1995) examines the use of the term 'high-technology', based on numerous authors. He thus differentiates between input-based and out-put-based definitions.

Two major factors drive input-based analyses: R&D expenditure and occupational profile statistics (Chabot, 1995: 6). The advantage of these approaches, if proper data is available, is that high technology analysis is fairly straightforward. By counting gross R&D expenditures in dollars or calculating the number of technical staff, it is not difficult to arrive at an ordered spectrum of technology-intensive companies. It remains only to select a certain percentage to set a limit separating technology-based and non-technology-based companies. One example for R&D expenditures could be the OECD classification. The limit between low-technology and high-

13. Selection of commonly used time ranges: 0 to 25 years (Little, 1977), 1 to 15 years in business (Fontes, 1998), 1 to 6 years (Artmann, Lechler & Wu, 2001).
14. Technology-base, technology-intensive, science-based, knowledge-based as well as high-technology, are synonymous in this thesis
15. E.g. Jones-Evans & Klofsten, 1997; Koschatzky, 1997; Storey & Tether, 1998; Artmann, Lechler & Wu, 2001; Fontes & Coombs, 2001

technology is 3.5%, the limit between high-technology and leading-edge-technology is 8.5%. Contrary to a definition at the company level, a precise definition at the industry level is tricky. Since, sometimes, one company cannot be attributed clearly to one single industry, the popular understanding of ‘industries’ differs from official industrial classifications. Figure 7 gives some examples of high-technology and low-technology industries following the OECD definition (OECD, 1997: 110), and some examples of typical high-technology industries in a popular context.<sup>16</sup>

OECD Definition	Typical Popular Definitions
<p><b>High-technology industries:</b></p> <ul style="list-style-type: none"> <li>• Aircraft</li> <li>• Office &amp; computing equipment</li> <li>• Drugs &amp; medicines</li> <li>• Radio, TV &amp; communication equipment</li> </ul> <p><b>Medium-high-technology industries:</b></p> <ul style="list-style-type: none"> <li>• Professional goods</li> <li>• Motor vehicles</li> <li>• Electrical machines excl. commun. equip.</li> <li>• Chemicals excl. drugs</li> <li>• Other transport</li> <li>• Non-electrical machinery</li> </ul>	<p><b>High-technology industries:</b></p> <ul style="list-style-type: none"> <li>• Aerospace</li> <li>• Automotive</li> <li>• Biotechnology</li> <li>• Chemicals</li> <li>• Defense</li> <li>• Electrical equipment</li> <li>• ICT (Information and Communication Technology)</li> <li>• New materials technology</li> <li>• Medical technology</li> <li>• Pharmaceuticals</li> <li>• Semiconductors</li> <li>• ...</li> </ul>
<p><b>Medium-low-technology industries:</b></p> <ul style="list-style-type: none"> <li>• Rubber &amp; plastic products</li> <li>• Shipbuilding &amp; repairing</li> <li>• Other manufacturing</li> <li>• Non-ferrous metals</li> <li>• Non-metallic mineral products</li> <li>• Metal products</li> <li>• Petroleum refineries &amp; products</li> <li>• Ferrous metals</li> </ul> <p><b>Low-technology industries:</b></p> <ul style="list-style-type: none"> <li>• Paper products &amp; printing</li> <li>• Textiles, apparel &amp; leather</li> <li>• Food, beverages &amp; tobacco</li> <li>• Wood products &amp; furniture</li> </ul>	<p><b>Low-technology industries:</b></p> <ul style="list-style-type: none"> <li>• Construction &amp; real estate</li> <li>• Food, beverages &amp; tobacco</li> <li>• Footwear and textiles</li> <li>• Metals &amp; Minerals</li> <li>• Paper &amp; Pulp</li> <li>• Transportation</li> <li>• ...</li> <li>• Banks</li> <li>• Insurance</li> <li>• Retail</li> <li>• Services</li> <li>• ...</li> </ul>

Industries considered in this dissertation

Figure 7 Examples of high-technology and low-technology industries (Savioz, 2002: 18)

Output-based definitions are those, which classify high technology, based on the productive value-added output of firms. They are less common than the input-based methodologies. The advantage of defining this by its ‘sophistication’, ‘complexity’ or ‘advanced technology’ content is that the actual products of intense R&D, rather than dollar input, drive the essential meaning of ‘high technology’. There are important disadvantages to the output based approaches, however, which explains in part the relative abundance of input-based methods. First, output-based

16. The list of popular high-technology industries is not exhaustive and is a subjective classification of the author, based on popular press and internet data.

definitions rely on data that is neither highly accessible nor easily processed. The second primary disadvantage of output-based definitions is the high degree of subjectivity (Chabot, 1995: 8).

An alternative definition would be Kodama's (1991: 49) model of more or less technology-intensive sectors. He defines industries by the cancellation rate in relation to the investment level of R&D programs. While the cancellation rate decreases the more the company spends on a R&D program in conventional sectors, the cancellation rate in science-based industries remains constant. The high-technology sector's behavior is the same as that for the conventional sector up to a certain investment level. Then, it remains constant as it applies to the science based sector.

Another interesting view comes from Dankbaar (1996: 103) who differentiates between technology-intensive and technology-contingent enterprises. While the first group anticipates technological change, the latter treats technology as a contingency which appears unexpectedly and needs to be dealt with if it cannot be avoided. This view provides two major insights: firstly, for every company technology, more precisely technological change is of concern. No company can escape this fact. As a consequence, every company should be aware of this, and should take appropriate measures. Secondly, as Dankbaar's study shows, there are apparently companies that anticipate better than others to technological change. Dankbaar questions whether technology-contingent enterprises will be able to survive in a rapidly changing technological environment. In order to survive, he says, it is crucial to learn to monitor technological developments, and to react quickly to relevant changes.

#### THE NEW TECHNOLOGY-BASED FIRM (NTBF)

In order to define and justify a certain sample of firms, a limit for both, age and degree of technology-intensity has to be set. The discussion about quantitative and qualitative criteria for the definition of firms to be considered 'new', shows that a generally accepted definition does not exist, and that limits have to be set in relation to the research focus.

Even though it is often difficult to measure a firm's life-cycle phase, the qualitative approach has been chosen to define 'new' for this work. The main advantage of the qualitative definition relative to the quantitative definition is the close correspondence with the research goal. The Pocke<sup>TM</sup> approach is optimized for firms in the survival and growth phase, which most firms reach between the first and the eight year (Lincke, 2003).

As for 'new', there is no generally accepted definition for 'technology-based'. The quantitative approaches such as R&D expenditure as percentage of turnover do not make sense in an NTBF, because there is normally no steady turnover. That is why, a qualitative definition is used. The main differentiation between technology-based and non-technology-based ventures, is the NTBF's strong R&D orientation. NTBFs run an innovation process which transfers scientific

research findings into technological products, which are then commercialized in a (niche)-market. According to the input-output based definition of technology-based, an NTBF has major research projects which lead to innovative new products. To make a link to the industry sector based definitions, it can be stated, that these innovations normally occur in high-technology industries (Figure 8).

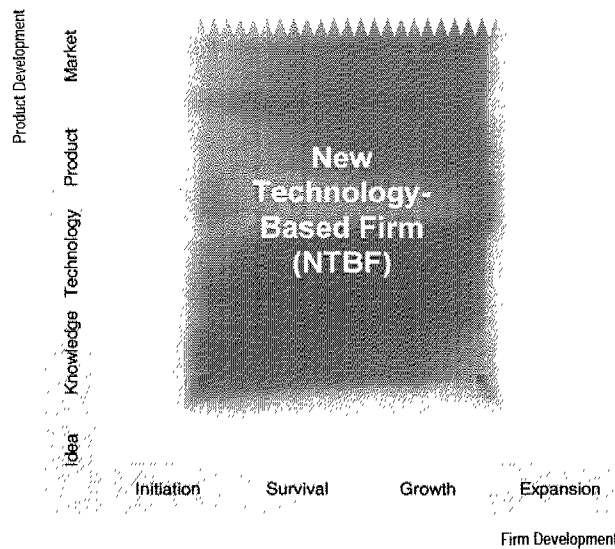


Figure 8 Definition of the NTBF

To summarize, a *New Technology-Based Firm (NTBF)* is an entrepreneurial organization in the survival or growth phase, which focus on the creation, development and exploitation of technological innovations through a strong R&D orientation in high-technology industries.

## 2.2 FOUNDATIONS OF TECHNOLOGY AND INNOVATION MANAGEMENT

Over the last few years, the rising importance of technology has lead to the demand for an integral consideration of technology and innovation. Based on the integrated management theory (Ulrich, 1984; Bleicher, 1991), the 'Integrated Technology and Innovation Management' concept (Tschirky, 1998) was developed. A distinct focus on technology management reflects, on the one side, the increasing dominance of technology and innovation in determining a company's real business viability. On the other side, it compensates for the severely underestimated impact of

technological change on a company's competitiveness as described in current management literature.

Technology Management itself adapts to this new environmental circumstances with a shift from managing technology towards managing technology-based firms, both established and new. This means that the metaphor of technology management being the missing link between S&T and general management has to be revised (Figure 9). Rather than being a missing link and thus an activity 'outside' general management, technology management ought to be considered as an integrated part 'inside' of general management (Tschirky, 2003: 24). This shift, which primarily occurs within large, multinational enterprises converges the scope of the 'Integrated Technology and Innovation Management' in large and new technology-based firms, because in NTBF, S&T and management are automatically closely linked.

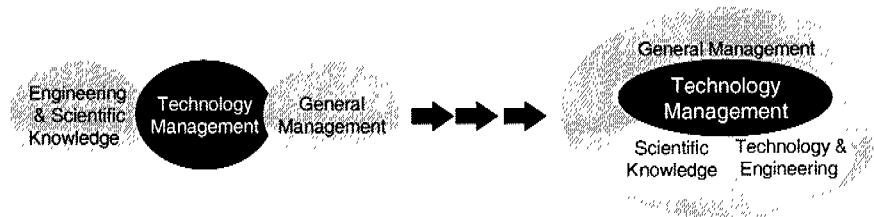


Figure 9 Technology and its management constituting integrated parts of general management (Tschirky, 2003: 24)

### 2.2.1 Understanding Technologies

The term technology as a basic unit of technology management is controversially discussed in literature. This thesis closely follows Tschirky's (2003: 29) definition: "Technology constitutes specific knowledge, abilities, methods and equipment, facilitating deployment of scientific and engineering knowledge". In order to remain competitive, companies are managing technologies with four purposes:

- To enable the development of new products and services
- To allow and improve performance of specific product functions
- To serve manufacturing
- To produce products and finally to ensure companies' administrative processes and infrastructure

The total of a company's deployed technology represents the technology potential being subjected to technology management.

Within the scope of technology management, the term technology has two fundamentally different forms (Tschirky, 2003: 30): *Product technologies* are those that deploy scientific or engineering principles to assure a specific technological impact, e.g. from optics, electronics, nuclear physics, aerodynamics, etc, deal with a specific effect and determine how an effect occurs. *Process technologies* however, deploy the effects of existing product technologies to enable and/or optimize the occurrence of the technological impact. R&D process technologies are used to perform R&D activities and may include technologies such as microscopy, nanotechnology and atomic absorption technology. Typical production process technologies include galvanizing, soldering and surface mounted technology (SMT).

To illustrate the difference between process and product technology, a comparison between a chemical product and process technologies helps. A chemical product technology corresponds to a molecule with a known constitution. The reaction that forms an educt to the desired product is a chemical process technology (Figure 10). Common to both cases is the fulfillment of a specific function, in the first case a product function, in the second a process function.

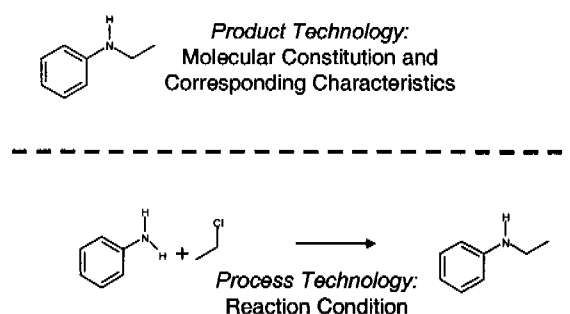


Figure 10 Example of product and process technologies in chemistry

The principle of 'Good Technology Management Practice' GTMP<sup>17</sup> suggests bringing about an optimum of applications with a minimum of technologies. Concretely speaking, this means the application of the same technologies in product functions of various firms, e.g. through strategic networks. Secondly, it implies the awareness necessary to assess the value of a technology in units which relate directly to the company's value, e.g. patents, knowledge or organization. Management-conscious understanding of technology means thirdly, a reflected and communicated interest in the basic functioning of strategically significant core technologies, their application potential and necessary complementary assets.

17. Adapted from Tschirky (2003: 32)

Figure 11 illustrates a network of interrelatedness between technologies beyond the product/market domains. Both product and process technologies are crucial for the firm's competitiveness and determine the social, financial and ecological quality of life in the firm's environment.

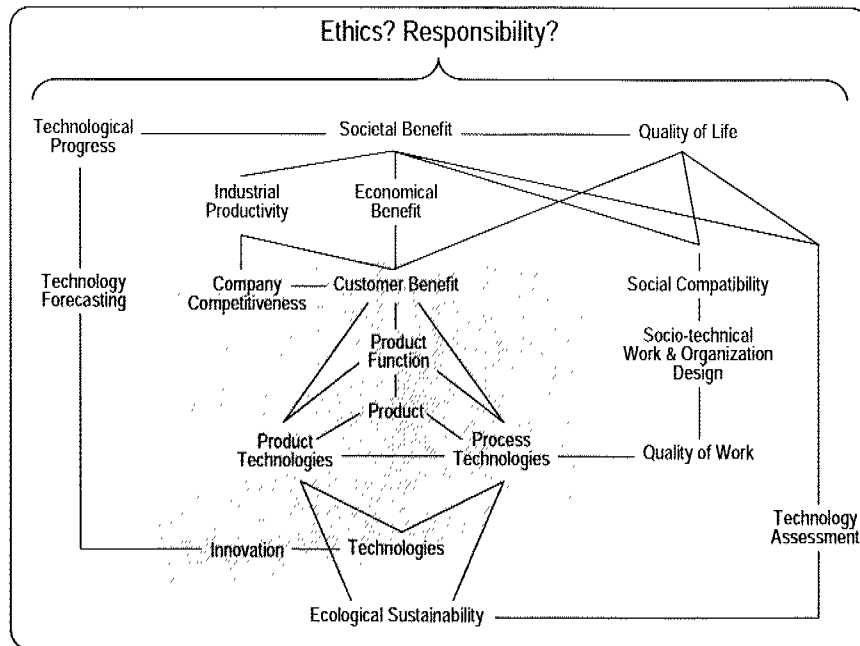


Figure 11 Holistic understanding of technology (Tschirky, 1998: 237)

### 2.2.2 Concept for Managing Technologies

A technology-based firm can be conceived of as an organization which transforms input (such as components, products and services) from suppliers and partners into output (such as products, systems and services) to customers and partners. To enable this transformation the firm has to dispose of certain assets, such as competencies and equipment. The combination and use of these assets allow competitiveness to be build up and sustained in the market place. Under this aspect the enterprise can be viewed as an entity containing a number of specific and mostly overlapping competencies whose activation occurs by means of performing distinct processes (Figure 12). An enterprise finally is existentially dependent on the integration of this into its environment (Tschirky, 2003: 25).

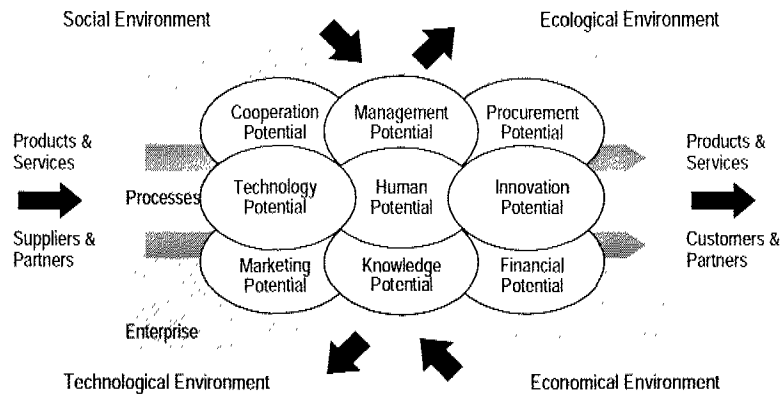


Figure 12 Potential and process approach to the enterprise (Tschirky, 1998: 216)

For the management of the technology enterprise, a restriction to the strategic and operational levels is unsatisfactory since factors beyond strategy play an important role. Primary among these are vision, company policy and organizational culture. This deficiency is taken into account in so-called ‘Integrated Management’ concepts (Ulrich, 1984; Bleicher, 1991), in which the strategic and operational levels are grouped under a higher normative level of management (Figure 13).



Figure 13 Three levels constituting general management (Ulrich, 1984: 329)

These two concepts can be summarized in the framework of ‘Integrated Technology and Innovation Management’ (Figure 14). Additionally this framework distinguishes between structural, objective-related and behavioral aspects on each management level. The formative feature of this framework is its encompassing view of technology and innovation as part of general



management, which clearly shows that basically every part of the firm could be affected by technology issues.

Its dynamic set-up emphasizes the fact that general management as well as technology and innovation management are always in a unique situation. Companies evolve from start-ups, by emphasizing product technologies and develop into mature enterprises, which are diversified and globally oriented. Along this process, there is a permanent challenge to reorganize structures and to build up new competencies.

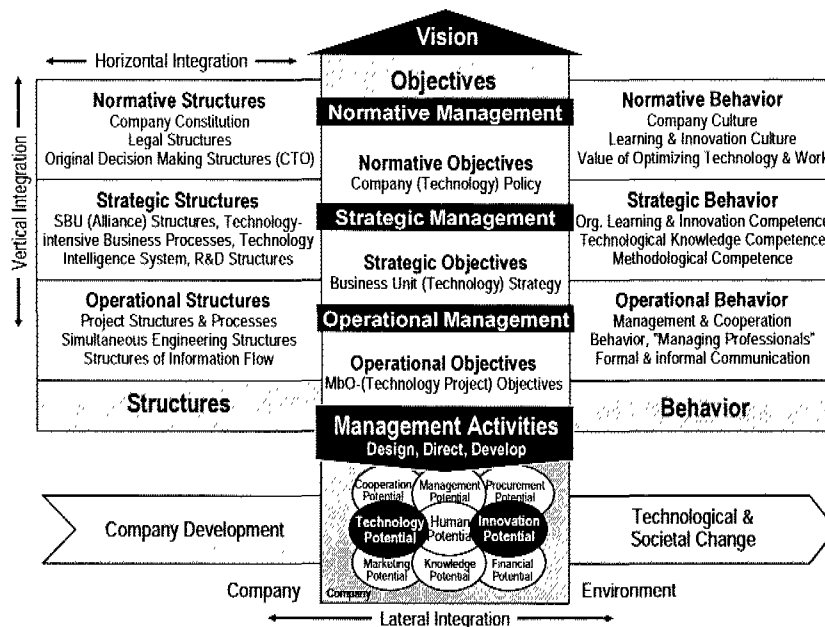


Figure 14 Framework of 'Integrated Technology and Innovation Management' (Tschirky, 1998: 270)

### 2.2.3 Normative Level

On the normative level, primary decisions must be made according to the long-term goals of the enterprise. 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 development of personality. Typical examples of normative activities are (Tschirky, 2003: 33):

- Long-term decisions taken by company management are expressed in documents such as *company vision, company policy and mission statements*. As a rule, these kinds of statements are generalized but nevertheless aim at verbalizing the company's uniqueness. The content

usually covers long-term objectives, main areas of activities, geographical dimensions of businesses, major resources and competencies, innovative ambitions, the desired relationship with customers, attitude towards societal and ecological expectations, the role and development of human capital and the values which determine communication and collaboration.

- The uniqueness of each enterprise is primarily defined by its *organizational culture*. Understanding the organizational culture is an indispensable prerequisite for the successful leadership of an enterprise. Only cultural characteristics can ultimately explain why a new strategy has been satisfactorily implemented or not. In other words: Working on a new strategy must aim at reaching a 'cultural fit', i.e. the behavioral pattern, organizational learning, group dynamics and communication capabilities (Sathe, 1983).
- It is not only the making of long-term decisions which is vital for the company's future, equally essential is who takes these decisions. The far-reaching nature of technology decisions requires that original technology expertise be applied to the decision-making process.

#### 2.2.4 Strategic Level

On the strategic level it is essential that company policy be transposed into comprehensive strategies. Strategies place emphasis on the selection of those resources necessary for the development and production of present and future technologies, products and services.

This encompasses the question of how to acquire technologies, how to boost innovations or how to monitor relevant internal and external trends. On the strategic level the *principle of effectiveness* - meaning 'doing the right thing' - is prime. The following list defines and illustrates strategic technology management of structures, processes and activities (Tschirky, 2003: 36):

- The pattern of the development of *integrated technology strategies* consist of a stepwise and iterative integration of technology issues into the typical steps of strategic planning, such as setting strategic objectives, analyzing the environment, analyzing the company, elaborating strategic options, taking strategic decisions and implementing the strategy (Figure 15).

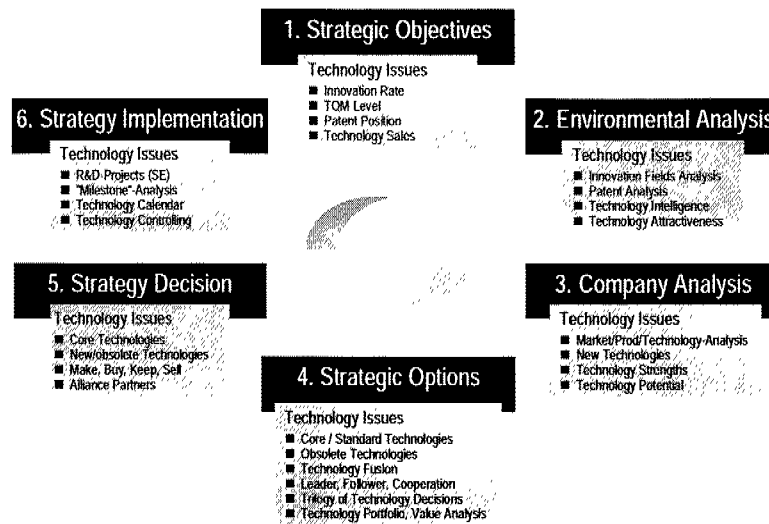


Figure 15 Development of integrated technology strategies (Tschirky, 1998: 295)

- Providing an adequate influx of relevant information is an enormous challenge for technology-based companies. Therefore companies make efforts to build systems, called (business) technology intelligence systems, in order to keep abreast with global knowledge production. The challenge consists of building up effective scouting, screening and dissemination of capabilities in order to supply the organization with up-to-date information as an indispensable basis for taking (business) technology decisions.
- Staying innovative may include a careful *analysis of the current and prospective innovation rate*, and a record of the amount of annual sales from new products. The long-range innovation rate will rise and the natural question has to be how the company is prepared to meet the prospective innovation requirements. It is in other words, the question about the appropriate content of the often cited 'pipeline'.
- Strategic technology planning implies making three fundamentally different but mutually complementary decisions, it is described as the *trilogy of strategic technology decisions* (Figure 16). The first decision (Which Technologies?) originates from an analysis of current and future products. The second decision (Make or Buy?) is concerned with the question of whether the required technologies are to be made available through acquisition, collaboration with other companies or through in-house development. The third decision (Keep or Sell?) deals with whether available technologies are to be applied exclusively for company purposes or can be made available to other companies (Brodbeck, 1998).

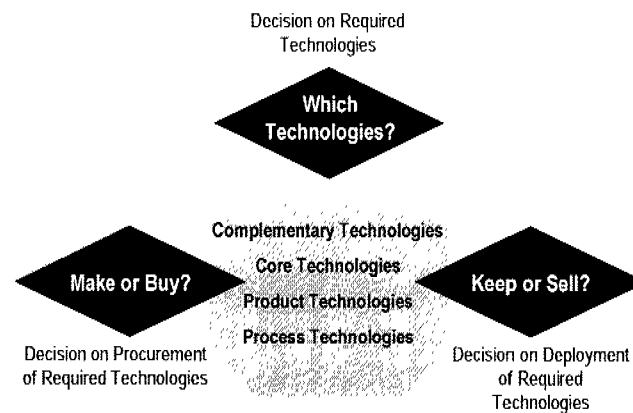


Figure 16 *Trilogy of strategic technology decisions (Brodbeck, 1998: 108)*

- The task of *technology marketing* is to integrate acquisition and exploitation activities according to the trilogy concept. Considering the emergent technology markets, existing know-how partnerships and buy-and-sell activities gain importance to increase the firm's profitability. Traditional marketing instruments support the sales process of products, systems and services whose prices are set according to market rules and which reach the customers via real distribution channels. In contrast, technology marketing involves complex knowledge whose value is difficult to estimate, but becomes known by its reputation and its distribution takes place in the form of situational technology transfer (Birkenmeier, 2003; Escher, 2004).
- The *Dynamic Technology Portfolio* is a matrix tool that provides an easily interpreted and communicated overview of current and future technology positions. Its popularity is attributed to the fact that thinking in terms of portfolios is fundamental to strategic business planning, where strategic product and business positions are to be dealt with. The strategic evaluation focuses on setting priorities as to the promotion or reduction of technology development resources. The merit of the technology portfolio lies in its high level of condensation of strategic information and at the same in its efficiency for 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. In order to include technologies which are attractive despite the lack of company resources in the technology portfolio, the use of the *Dynamic Technology Portfolio*<sup>18</sup> is recommended instead; in addition to the traditional

18. Cp. chapter A.12 on page 228

portfolio, it is extended by the column 'new technologies' and at the same time by the line 'obsolete technologies'.

- *Core technologies* are considered a backbone of strategic technology management. Core technologies are based on core competencies which are characterized by the following features: singular, difficult to imitate, not substitutable, and valuable (Barney, 1991). In contrast to company resources which can be acquired externally, core competencies normally result from heterogenic and imperfect mobile resources. Core competence development involves organizational learning, superior cognitive capabilities and rent appropriation.<sup>19</sup> As previously mentioned, core technologies are preferably original technologies developed with priority funds within the company. Whereas companies have to master hundreds of technologies, the number of core technologies is limited and may amount to a small proportion of all technologies, but usually give a company its unique competitive advantage.
- *Management control* for technology-based firms encompasses not only business but also technology strategy control. Strategic control aims to monitor the internal performance and the external environment, in order to provide a feedback on the strategy's success in the marketplace and to monitor the customer's and the competitor's responses. Furthermore, strategic control should check the on-going validity of the assumptions, which underlie the enterprise's strategic (technology) plan, in regard to external threats.

The strategic (technology) control process itself indicates to management any deviations from the strategic plan and the necessity to take corrective actions. Potential actions during the feedback process include revising organizational strategies, re-assessing planning premises and action plans, or rethinking managerial objectives. Thus, a (technology) management control system should distinguish between three types of strategies: intended, emergent, and realized strategies. A holistic strategic (technology) control approach is to upgrade Kaplan & Norton's (1992) widely accepted Balanced Scorecard (BSC) with a technology dimension.<sup>20</sup>

- *Technology roadmaps* aim to effectively visualize and communicate technology forecasts and strategic technology plans. Technology roadmapping is a powerful practice that supports managers taking on the challenges set by strategic technology planning. It is an integrative process that enables the organization (such as marketing, production, R&D, finance etc.) to be aware of the problem of technology forecasting and planning. Technology roadmapping enables realistic decisions to be taken more quickly and implementation to be done with more confidence and transparency.

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19. Cp. chapter 2.3.2 on page 37

20. Cp. chapter A.1 on page 211

The most common approach to roadmaps is encapsulated in the generic form proposed in figure 17. The generic roadmap is a time-based chart, comprising a number of layers that typically include both commercial and technological perspectives. The roadmap allows the evolution of markets, products and technologies to be explored, and to be interlinked.<sup>21</sup> It reflects a visualization of the firm's projected future that is easy to understand and to communicate throughout the organization.

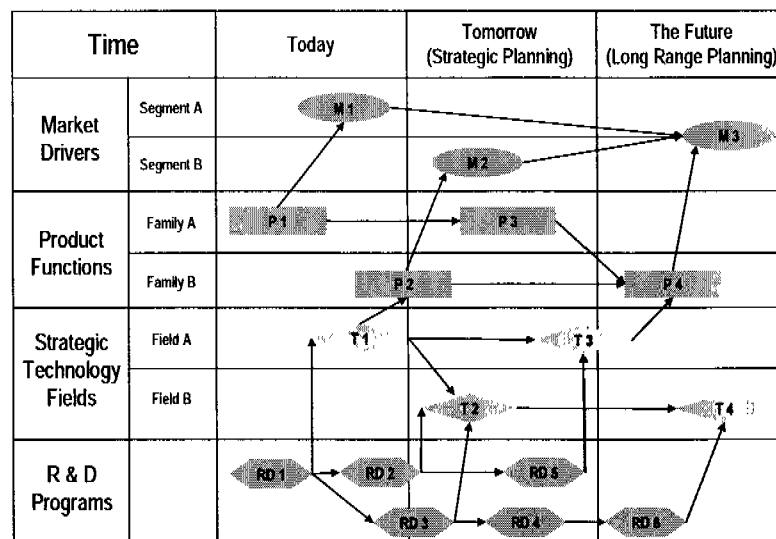


Figure 17 Generic technology roadmap (EIRMA, 1997: 39)

The technology roadmapping practice emerged because the people involved - general managers, research scientists, engineers, manufacturing managers, marketing and finance personnel, and others - recognized the management problems associated with a lack of coordination and the necessity of integrating strategic technology planning.

- In order to maintain competitiveness, *building optimal conditions for innovations* is crucial for technology-based firms. This requires a structured evaluation of new products and new business opportunities. A product or service can be conceived of as consisting of a variety of product functions, which correspond to specific customer needs. Each product function is realized through distinct product technologies which provide a structured set of knowledge from engineering and science. A functional comprehension of products or services to

21. Cp. chapter A.13 on page 232

innovate is supported by a set of management tools, e.g. 'fuzzy front end' innovation process<sup>22</sup>, innovation architecture (IA)<sup>23</sup> and hand shake analysis (HSA).<sup>24</sup>

The 'fuzzy front end' process supports radical innovations which emerge from an integration of internal and external information bases, detached from the classic innovation management. The innovation architecture (IA) groups around product functions which are on the one side products which belong to certain businesses and innovation fields and on the other side R&D activities within technology platforms. The hand shake analysis (HSA) 'translates' new needs, new technologies and new competencies into new products & services, new markets and new businesses.

### 2.2.5 Operational level

On the operational management level, strategies are transformed into practice in the context of short-term goals, in other words personnel, technological, financial and instrumental resources are allocated to concrete R&D projects. According the *principle of efficiency* 'doing things right', operational management comprises the following activities (Tschirky, 2003: 68):

- The *simultaneous engineering* project management concept aims at gaining time to market through a partial overlap of individual product development phases. This implies additional risks, since essential project information may be uncertain during these overlaps. But valuable project time may be gained, resulting in shortened R&D cycles and accelerated market entries.
- There are various *cultural barriers between different units of the firm*, e.g. when marketing people consider R&D people 'narrow-minded' and R&D people consider marketing people impatient, incapable of understanding technical problems and exclusively interested in short-term problems. These barriers result from the natural consequence of the fact that the cultural determinants of the two groups are fundamentally different. There are three ways to cross these barriers: (1) Building procedural bridges, (2) building structural bridges and (3) building human bridges (Wiebecke, Tschirky & Ulich, 1987).
- In order to effectively control the development of several projects, a *milestone trend chart* or a *network diagram* helps to manage the essential parameter of various projects. Product development processes are of a multidisciplinary nature incorporating several business

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22. Cp. chapter A.2 on page 212

23. Cp. chapter A.4 on page 216

24. Cp. chapter A.3 on page 213

processes, in particular R&D, manufacturing and marketing. These processes have to be coordinated and the exchange of information guaranteed.

- The *Not-Invented-Here (NIH)* syndrome is defined as the tendency of a project group of stable composition to believe it possesses a monopoly of knowledge of its field, which leads to rejection of new ideas from outsiders. To cope with the NIH, the changes that are likely to take place within the group as its team membership ages, have to be recognized and ways to keep a project effective and performing have to be developed (Katz & Allen, 1982).
- Sharing knowledge and profiting from experience may be enhanced through databases and other documentation practices, but more important is the concept of *communities of practice (CoP)*.<sup>25</sup> A community of practice consists in general, of a team of experts working in the same field with the aim to develop their own knowledge. At the same time, the organizational knowledge base is enlarged. To ensure long-term collaboration it is necessary that members are self-motivated. After a successful setup of a community of practice, the members should be known people, e.g. gatekeepers, to give support for general and complex problems. All activities are based on activities initiated by the core members and their particular interests (Wenger, McDermott & Snyder, 2002: 23).
- Reflecting *quality of work in a socio-technical approach* leads to an optimization of work and technology. Today's views of quality of work typically suggest a threefold integrity: physical integrity, psychological integrity and social integrity. In this context establishing semi-autonomous working groups plays a central role, since this setting allows the group members a high degree of self-organization in terms of decision and control, autonomy of interacting with up-stream and down-stream partners and internal work organization. Another postulate is 'optimizing technology and work' meaning the development of technologies including design criteria which focus on improving the quality of work (Ulich, 1994: 69).

## 2.2.6 Connecting Technology and Innovation Management

Linking technology management and innovation management seems to be reasonable because most innovations involve the deployment of technology, and technology management focuses clearly on technology and its deployment. On the other hand, innovation management extends beyond the scope of technology deployment in products and processes, e.g. it comprises social innovations which may involve new structures, processes and management approaches (Tschirky, 2003: 28).

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25. The term communities of practice seems to be coined by Jean Lave and Etienne Wenger context of studies of traditional apprenticeship (Lave & Wenger, 1991).



This view can be visualized using Porter's value chain: According to this widely known concept of general management, two different kinds of activities may be distinguished. On the one hand there are those activities which are directly involved in the value generation, on the other are those contributing indirectly to value generation (Figure 18).

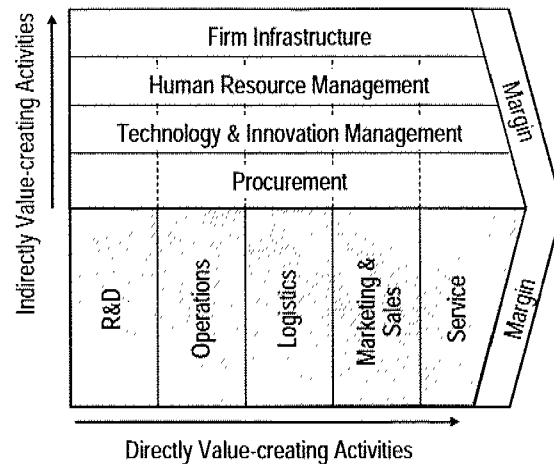


Figure 18 Value chain of an enterprise (Porter, 1985: 37)

Within the Value Chain concept, the activities and tasks of technology management may be positioned as follows (Figure 19, left): On the one hand, technology is deployed along the value chain via primary activities in the areas of product technology development and through logistics, production and service process technologies for products being manufactured or maintained. On the other, technology is deployed in indirect value-creating activities, i.e. infrastructural and R&D process technologies which make possible the development of product technology. The common denominator in both types of technology deployment is technology-oriented knowledge, expertise and experience.

A similar picture may be presented with respect to innovation management (Figure 19, middle). Innovation management covers all primary activities, including innovations which facilitate new ways of directly increasing product value. It also extends over all indirect value creating activities, including technological as well as social or business innovations. The link between technology and innovation management involves the fact that, in the majority of cases, innovations involve technology deployment, and technology deployment simultaneously involves, to a large extent, innovative creations. The scope of technology and innovation management may therefore be visualized as shown in figure 19 on the right (Tschirky, 2003: 29).

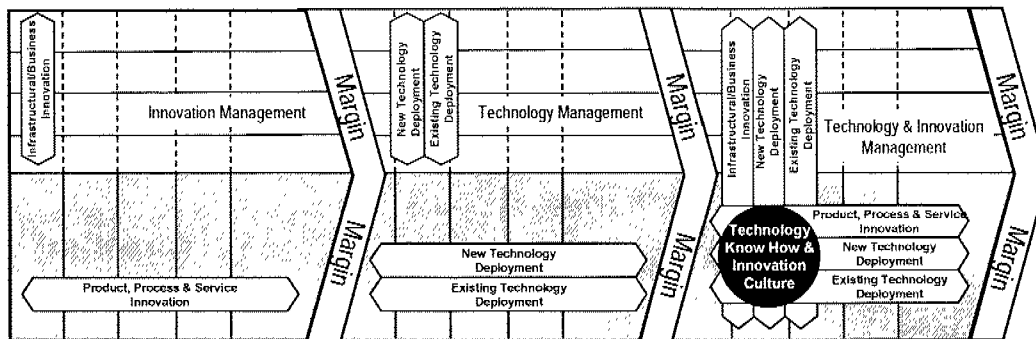


Figure 19 Scope of technology and innovation management within the value chain concept (Tschirky, 1998: 266)

*“According to this view, technology and innovation management can be conceived of as an integrated function of general management which is focused on the design, direction and development of the technology and innovation potential and directed towards the normative, strategic and operational objectives of an enterprise.” (Tschirky, 2003: 27)*

## 2.3 FOUNDATIONS OF ENTREPRENEURSHIP

Over the last few decades, the field of entrepreneurship has rapidly evolved and allows to better understand the situation of NTBFs. Therefore, after the definition of entrepreneurship and an introduction to the ‘Integrated Technology and Innovation Management’, the underlying concepts of entrepreneurship and typical influences on NTBFs are presented in this chapter. Typical entrepreneurial influences on NTBFs are classified in entrepreneurial objectives, structures and behaviors according to the management concept of Bleicher (1991). The chapter is concluded with a summary of classification models for new ventures.

### 2.3.1 Underlying Concepts of Entrepreneurship

Once the assumptions of neoclassical economic theory and the equilibrium state are relaxed, it becomes evident that theories of entrepreneurship are closely related to modern theories of the firm, such as transactions cost theories (Williamson, 1975) and resource-based theories (Penrose, 1959).

### Resource-Based Theory

The resource-based view examines the link between a firm's internal characteristics and performance (Figure 20). The firm's heterogeneity<sup>26</sup> and immobility<sup>27</sup> are assumed as possible sources of competitive advantage (Penrose, 1959; Barney, 1991). The concept of a firm heterogeneity is perhaps the most common ground between resource-based theory and entrepreneurship, whereas a central question in entrepreneurship is: Where do the opportunities to create goods and services come from? Certainly, one answer is through inventions and discoveries that produce new knowledge. The resource-based view emphasizes the firm's resources heterogeneity and immobility as possible sources for opportunities to build a competitive advantage (Penrose, 1959; Rumelt, 1984; Wernerfelt, 1984; Barney, 1991; Connor, 1991). However, what makes the firm's resources heterogeneous or immobile is what makes the study of entrepreneurship so difficult. If competitors know exactly what resources make a firm successful, these resources can be imitated (Lippman & Rumelt, 1982).

The frequency of judgment that has to be exercised within a firm is partly a consequence of its size, but is also dependent on the volatility of the environment in which the firm operates. Volatility creates for the firm a stream of new problems and of new opportunities. Volatility creates opportunities for the firm when it creates problems for other people that the firm can help them to solve - in other words, it creates new customers for its products (Casson, 2003: 234).

Problems and opportunities may well occur simultaneously. For example, an increase in local raw material prices may create problems for the firm because of higher costs. On the other hand, higher raw material prices may encourage customers to invest in new technologies to cut down on waste, and this may generate new orders for equipment. An entrepreneurial firm is constantly on the look out for opportunities of this kind.<sup>28</sup>

In terms of the 'resource-based' theory of the firm this argument suggests that entrepreneurship is the key resource possessed by the firm. Indeed, this is highlighted by the role of factors such as volatility in driving a wedge between the performance of average firms and the performance of highly entrepreneurial ones. In an industry with high volatility, differences in performance between firms will tend to be wider because differences in entrepreneurial endowments will have a greater impact on profitability and growth (Teece & Pisano, 1994).

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26. Heterogeneity refers to the quality of a resource that gives each firm its unique character (Penrose, 1959: 75).
  27. Resources are perfectly immobile if they cannot be traded. Imperfectly immobile resources are tradable but more valuable within the firm that currently employs them than they would be in another firm, e.g. culture (Peteraf, 1993).
  28. For a detailed definition of entrepreneurial opportunities see chapter 2.3.1 on page 33.

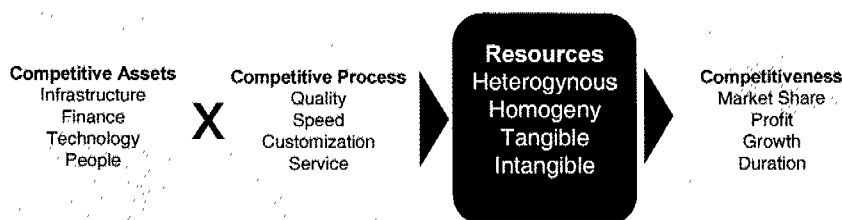


Figure 20 Overview of the resource-based theory of the firm

### Transaction-Cost Theory

Transaction cost theory (Williamson, 1975, 1985) describes the different ways in which transactions are formally managed. Williamson assumes that incentives for opportunistic behavior will be followed, thereby abusing trust (Williamson, 1985: 47). Hence, it makes sense for actors to invest in the management of transactions by choosing an appropriate 'governance structure' to prevent this kind of opportunistic behavior. The costs of this management are called *transaction costs*. These costs depend on the size of the opportunism potential of a transaction.

Opportunism potential depends on three key characteristics of the transaction (point 1 in figure 21) (Williamson, 1985: 47):

- *Asset specificity* refers to the degree to which investments in a transaction are of value only in transactions with the same actor. An example is the investment made by a buyer of tailor-made software in a particular software package. This investment is lost, at least to some degree, if the buyer switches to a package sold by another supplier.
- The second characteristic, *uncertainty*, refers to a lack of information on relevant parameters of the transaction. This may involve trustworthiness or difficulties in assessing the quality of a product, and even developments in the market or developments of new technologies concerning the product.
- The third factor is *frequency* which is important because detailed management is only profitable if it can be used in a series of transactions. If a transaction is executed several times in a comparable manner, routine reduces transaction costs considerably.

Two transaction cost-reducing strategies are particularly important for the entrepreneurial firm - namely intermediation and internalization. Both involve a significant measure of trust building.

For entrepreneurial firms, *intermediation* (point 2 in figure 21) encompasses initiatives ranging from the participation in local networks of information, involvement in strategic

production and distribution networks to suppliers, clients (salesman) and investors (business angels) (Ait-El-Hadj, 1992: 170).

A second factor to reduce transaction cost is *internalization* (point 3 in figure 21) which tries to bring the buying activity and the selling activity under common ownership and control (Coase, 1937). Internalization of the innovative market is particularly important for the entrepreneur. An entrepreneur can assure the technical quality of the solution most easily if it is generated by employed inventors working under his supervision. The entrepreneur therefore integrates backwards into R&D. Given the limitations of the patent system, it is often difficult to appropriate rents effectively by delegating exploitation to a licensee. He / she therefore integrates forward into production too. Thus transaction costs are minimized by establishing a firm which embraces several functional areas, rather than by simply arbitraging in an intellectual property market for innovations.

A limiting point for internalization is reached where the cost of organizing an extra transaction becomes equal to the market costs, either the market will organize the transaction or a new entrepreneur will enter and organize the new knowledge (Hitt, 2002: 111). The entrepreneurial knowledge of resource allocation that is critical to the transformation of inputs into heterogeneous outputs becomes lost as the firm grows (Coase, 1937) and the new large firm begins to resemble the market. This is a limit of entrepreneurship set by the transaction cost theory (Lippman & Rumelt, 1982).

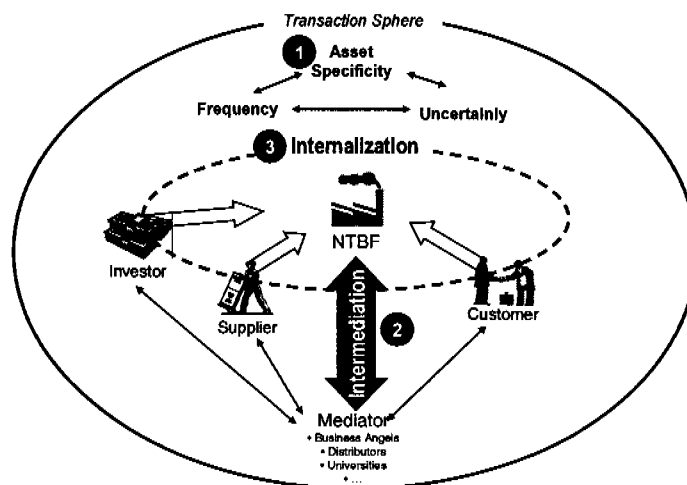


Figure 21 Overview of the transaction-cost theory

### Further Concepts

Profit opportunities are exemplified by *innovation* (Schumpeter, 1934) and *arbitrage* (Kirzner, 1973). In times of uncertainty, rapid *innovation*, and change, the economic competitive model should be a starting place to address innovation and entrepreneurship. Schumpeter's economic model, which assumes equilibrium until the entrepreneur 'shocks' that equilibrium, is perhaps one of the most useful theories in the study of entrepreneurship. In addition, Schumpeter's theory of disrupted equilibrium may link entrepreneurship to a dynamic study of strategy.

*Arbitrage* (Kirzner, 1973) deals with problems which lie purely in the domain of ownership. For example, one party may require resources urgently to resolve a pressing problem, but the relevant resources may initially belong to someone else. Alternatively, someone may be mismanaging resources which would be better placed under someone else's control. A single transaction can solve problems of this kind, and recognition of this solution provides an opportunity for arbitrage (Harper, 2003: 21).

For *entrepreneurial opportunities* to exist, people must not agree on the value of resources at a given point in time. For an entrepreneur to exploit an opportunity, he or she must believe that the value of resources, used according to a particular means-ends framework, would be higher than if exploited in their current form. In addition, profits are limited if the belief is universally shared (Casson, 1982). If all of the current resource owners share the entrepreneur's belief in the correctness of the proposed new framework, then they would hold the same beliefs about the value of resources as the focal entrepreneur. If they based their decisions on the same beliefs, this situation would limit the ability for the focal entrepreneur to obtain the resources at a price that would allow profitable use (Shane & Venkataraman, 2000; Eckhardt & Shane, 2003).

### 2.3.2 Entrepreneurial Objectives

Objectives define all qualitative and quantitative goals that are pursued by companies. They are considered as the basis for the management activities of designing, directing and developing (Bleicher, 1991: 72). Entrepreneurial objectives summarize goals that have typical entrepreneurial characteristics and typically correspond to the entrepreneurial management philosophy that promotes strategic agility, flexibility, creativity, and continuous innovation. The most important entrepreneurial objectives are the formation of a new firm, the seeking of entrepreneurial opportunities and developing core competencies (Amit, Brigham & Markman, 2000).

#### Formation of New Firm

The objective of entrepreneurial management is not simply to develop a smarter or more intelligent firm (Stearns & Hills, 1996). Rather, it is to develop a firm in which individuals think

and act with entrepreneurial autonomy. In other words, the aim of entrepreneurial management is to develop an organizational context with incumbents who proactively emulate entrepreneurs' cognitive styles and behaviors, which ultimately translates into the development of strategic assets and competitive advantage. Thus, all employees of a firm keep the visionary goals as well as the benchmark objectives of the entire business in mind. They are also empowered to build their autonomy and accountability by engaging in judgments and decision making that involve calculated risks and by taking responsibility for those outcomes (Amit, Brigham & Markman, 2000).

### Seeking Entrepreneurial Opportunities

In order to describe entrepreneurial objectives, a more profound look at entrepreneurial opportunities is necessary. As mentioned in the previous chapter, entrepreneurial opportunities are a key driver to entrepreneurship and may be summarized as follows (Sarasvathy *et al.*, 2003: 146):

- *Opportunity recognition*: If both sources of supply and demand exist rather obviously the opportunity for bringing them together has to be 'recognized' and then the match-up between supply and demand has to be implemented either through an existing firm or a new firm. This notion of opportunity has to do with the exploitation of existing markets.
- *Opportunity discovery*: If only one side exists i.e. demand exists, but supply does not, and vice versa, then the non-existent side has to be 'discovered' before the match-up can be implemented. This notion of opportunity has to do with the exploration of existing and latent markets either through market-pull or technology-push. Examples include: Cures for diseases (Demand exists; supply has to be discovered) and applications for new technologies such as the personal computer (Supply exists, demand has to be discovered).
- *Opportunity creation*: If neither supply nor demand exist in an obvious manner, one or both have to be 'created', and several economic inventions in technology, marketing, financing, etc. have to be made, for the opportunity to come into existence. This notion of opportunity has to do with the creation of new markets.

In order to realize entrepreneurial opportunities, an entrepreneur has to mobilize and allocate the proper resources with the purpose to develop and use core competencies.<sup>29</sup> These core competencies build the basis for any competitive advantage that would secure the firm's survival in the long run.

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29. Core competence: That capability at which a company does better than other firms, which provides them with a distinctive competitive advantage and contributes to acquiring and retaining customers. In other words, a core competence must be rare, valuable, not easily imitable and strategically equivalent substitutes must be lacking (Barney, 1991).

Penrose (1959) and other researchers (e.g. Wernerfelt, 1984; Barney, 1991; Teece, Pisano & Shuen, 1997) emphasize the importance of the (heterogeneous) resources that firms possess as the primary source of competitive advantage.<sup>30</sup> Four criteria determine whether a firm's resources fulfill the criteria of heterogeneity. To generate economic rents a resource must be *rare, valuable, not easily imitable and strategically equivalent substitutes must be lacking*. Rare and valuable resources exist when the number of firms within an industry is smaller than the number necessary to create oligopolistic competition. To defend the value of a resource it must be not easily imitable and it must lack strategically equivalent substitutes. This means competitors not only lack similar resources that could be used to create products with a similar performance but it also means that there are no similar resources available to create products or services of the same or superior quality (Barney, 1991).

There are situations in which strategic resources are not available on the market because they are imperfectly mobile. Examples of such resources are organizational culture, unique stakeholders, organizational networks, company reputation or customer loyalty (Peteraf, 1993). A large number of these highly specialized and intangible assets nurture a company's success.

#### **Development of Core Competencies**

The question arises of how the resources that lead to core competencies can be distinguished and what complementary assets are necessary to commercialize the products that are developed on the basis of the firm's core competencies.

The development of core competencies is inherently linked to the realization of an entrepreneurial opportunity and the willingness to take a risk. This is primarily because what might look promising from a marketing or research point of view still might not pass the most crucial test of core competence development: market introduction.

The following process describes the development of core competencies (Figure 22):

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30. This stream of research is known as the resource-based view.



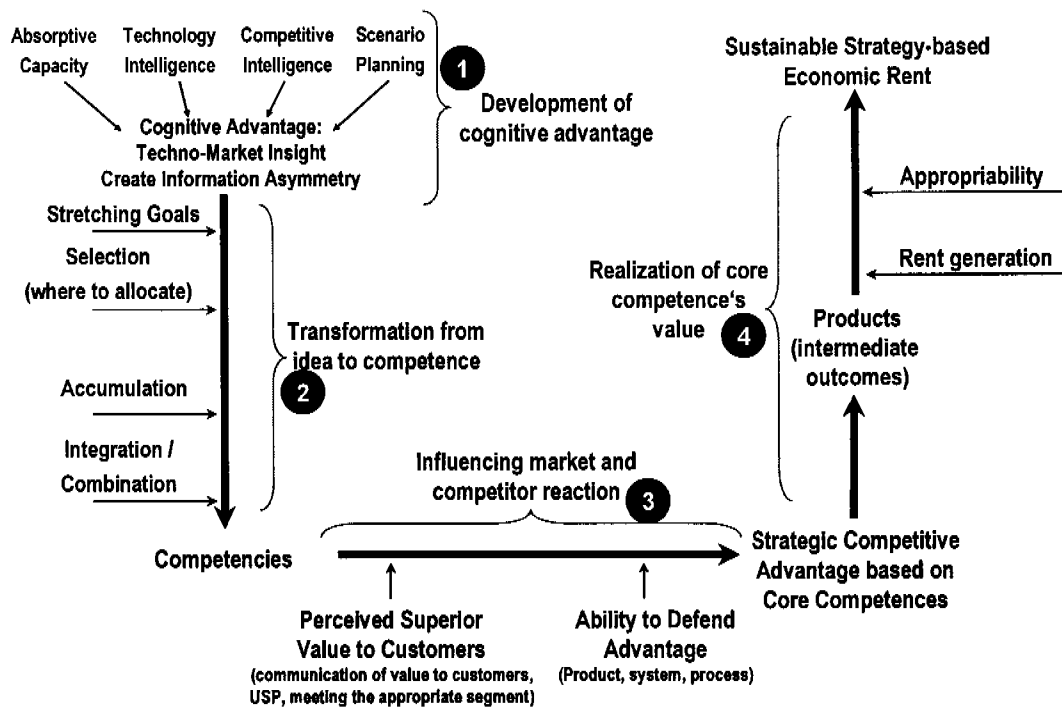


Figure 22 Framework for core competence development (Koruna & Luggen, 2003)

*Development of cognitive advantage (1):* One contributor to a firm's cognitive capacity is the firm's absorptive capacity. Absorptive capacity is the firm's and its members' ability to "recognize the value of new information, assimilate it, and apply it to commercial ends" (Cohen & Levinthal, 1990: 128). Each organizational member disposes of specific information based on his/her education, professional experience and knowledge. The firm's absorptive capacity can be regarded as the yardstick indicating to which level the firm is able to recognize, value and assimilate new information.<sup>31</sup> Thus, a firm's absorptive capacity becomes an important source in creating information asymmetries by predicting ex ante which resources are valuable, i.e. which resources will lead to rent generation (Mosakowski & McKelvey, 1997).

*Transformation from idea to competence (2):* To build (core) competencies, stretch goals play an important role, because they lead the firm to achieve ambitious goals and therefore also boost the inclination to take a project's risks and accept the danger of failure. Without risk taking it is not possible for the firm to create a product well distinguished from a competitor's product (Koruna, 1998: 31). Furthermore, stretch goals provide substantial support for double loop

31. Cp. chapter 2.4.1 on page 54 and chapter 2.4.4 on page 73

learning.<sup>32</sup> The various streams of knowledge, essential for technology and product development projects, have to be integrated (Grant, 1996). Such integrative capability impacts the final product's performance in significant ways (Iansiti, 1998).

*Influencing market and competitor reactions (3):* From a resource-based view, products play a highly important role as products and services are the source for rent generation. Also, they can be seen as proxies for the firm's underlying resources, capabilities and core competencies (Mosakowski & McKelvey, 1997). This relationship becomes evident when the focus of research is put on technological core competencies where product supremacy can be measured by objective product performance indicators. However, product supremacy seen as the joint characteristic of rarity, value, non-substitutability and imperfect limitability, is inadequate as long as the product's performance (quality) is not put in relationship to the price customers are willing to pay for it.

*Realization of core competence's value (4):* A product's value can only be appraised if it is introduced to the market. Innovation, however, is subject to market failures which outnumber market successes by far (Farson & Keyes, 2002). Only at this stage does a firm finally know whether a product and its underlying (core) competencies are of value to its customers or not. Finally, the firm needs to appropriate rents<sup>33</sup> from its generated products and technologies. Without possessing the necessary complementary assets for rent appropriation a considerable part of the rents may be lost to the providers of complementary assets.

Christensen (1997: 142) argues that the commercialization of disruptive innovations is more promising in small organizations that will view the projects as being on their critical path to growth and success, rather than as being distractions from the main business. The markets whose emergence is enabled by disruptive technologies all began as small ones. The first orders that the pioneering companies received in those markets were small and the companies that cultivated those markets had to develop cost structures enabling them to become profitable at small scale.

The development of core competencies grasps entrepreneurial opportunities systematically by offering a framework to allocate entrepreneurial resources.

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32. Single-loop learning is primarily concerned with effectiveness, that is how to achieve existing goals and objectives and how to keep organizational performance within the range specified by existing norms. Double-loop learning connects the detection of error not only to strategies and assumptions for effective performance but to the general norms which define effective performance. In double-loop learning cycle organizational norms themselves are modified (Argyris & Schön, 1978: 20).
  33. The envisioned business must be able to resist appropriation of rents by buyers, sellers, owners of co-specialized assets and government.

### 2.3.3 Entrepreneurial Structures

Structure encompasses the organization of the elements of a system and their relations, additionally structure describes processes which generate order (Bleicher, 1991: 74). Entrepreneurial structures describe structures with typical entrepreneurial characteristics. The structure of the entrepreneurial organization is characterized by a small managerial hierarchy and minimal degree of formalization. Power tends to be focused on the entrepreneur, who exercises a high personal profile. Decision making is likewise flexible, with a highly centralized power system allowing rapid response. Generally, the creation of strategy involves a great deal of intuition and is oriented to the aggressive search for opportunities (Mintzberg & Quinn, 1998: 244).

NTBFs tend to remain in entrepreneurial structures until growth forces added structures. Product offerings increase, new markets are entered, and additional staff resources are required. With time, additional employees are hired to manage the growth and the new venture becomes departmentalized by product, market or function. Growth continues, and the struggle to fight the transitions from an entrepreneurial firm to a structured organization ensues (Brown & Eisenhardt, 1998).

#### Edge of Chaos

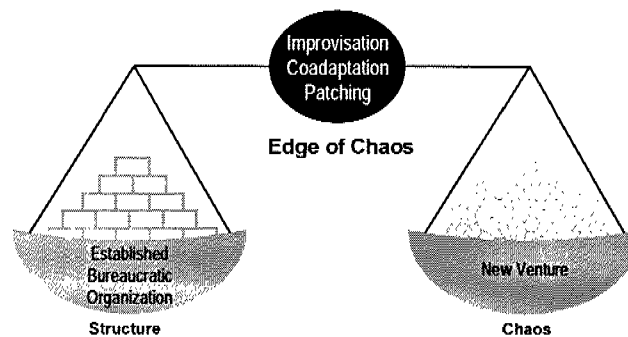


Figure 23 Entrepreneurial structure on the edge of chaos (Eisenhardt, 2000: 55)

Entrepreneurial structures are subject to a constant balancing act (Figure 23). On one side of the scale is the well-developed structure often characteristic of bureaucratic organizations. Bureaucracy emphasizes structure, tight control, and risk aversion regardless of environmental uncertainty (Ross & Unwalla, 1986). The lack of flexibility and the inability to adapt quickly to changes in the competitive environment can often be the demise of these organizations. The

stability, size, and structure often associated with the bureaucratic organization also create resistance to change (Kelly & Amburgery, 1991).

On the opposite side of the scale lies chaos, which is the prototypical state of organization in many emerging new ventures where few structures and processes are in place. In this type of firm, managers often find themselves going in many directions, trying to seize multiple opportunities, overcoming staff and financial problems, establishing a presence in the marketplace and managing growth (Brown & Eisenhardt, 1998).

### Edge of Time

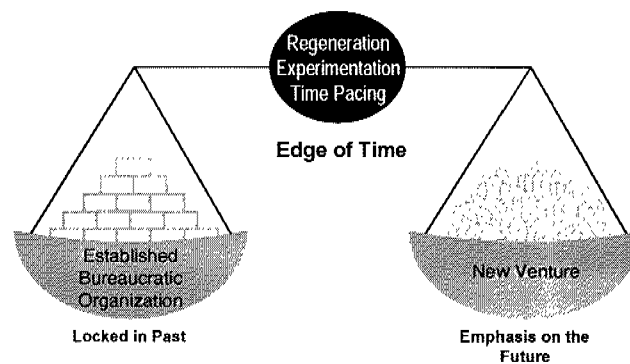


Figure 24 Entrepreneurial structure on the edge of time (Eisenhardt, 2000: 56)

Competing on the edge is also a temporal balancing act (Figure 24). One side of the scale is the orientation toward the past that is typical of established firms. These firms have often experienced past success, and their structures and processes reflect that success in the path-dependent processes that lock history into contemporary organization. Although this emphasis on the past can be an advantage that saves time and lowers risk, it also can be a straightjacket that blocks flexibility in facing new conditions for which past solutions are obsolete.

At the other end of the scale is an orientation toward the future that is typical of new ventures. Many of these companies are founded by people who are focused on the need to escape the past and to grab a place in the exciting future that is unfolding. In these kinds of companies, what is new is what is best. With a mesmerizing future, there is often a profound lack of interest in learning the lessons of the past.

Neither side of the scale is the optimal place to operate when competing in the continuously shifting states of disequilibrium that characterize the new competitive landscape.<sup>34</sup> On the one hand, a rigid structure creates an organization that cannot easily adapt to change and that cannot move forward. On the other hand, a chaotic organization with little or no structure does not have

the mechanisms in place to effectively coordinate change and flounders in a flood of mistakes. As a result, the ideal position lies in the middle at the so-called 'edge of chaos' and 'edge of time' (Eisenhardt, 2000).

### Key Structural and Temporal Processes

Figure 23 and figure 24 represent the balancing acts of the edges of chaos and time, and shows three key temporal processes (improvisation, coadaptation and patching) and three key structural processes (regeneration, experimentation and time pacing) (Brown & Eisenhardt, 1998).

*Improvisation*<sup>35</sup> refers to operating very flexibly within the constraints of minimum structure or rules, which means that design and execution of novel action converge. Organizations may not only improvise tactical adjustments in response to unexpected problems, but may also improvise strategically (Eisenhardt & Tabrizi, 1995; Moorman & Miner, 1998 b). Strategic actions are those that affect or determine the fate of the firm as a whole (Quinn, 1980). Strategic improvisation influences the founding and evolution process of an NTBF in two contexts: firstly, the improvisation of the firm itself through its start-up processes; and secondly circumstances in which tactical improvisation rises to the level of strategy. (Baker, Miner & Eesley, 2003)

The second structural process is *coadaptation*. At the core of coadaptation is collaboration among firms. Even though managers need autonomy to address the unique characteristics of their own business, collaboration is also important, so that the sum of the network units will be greater than its parts. In other words, each business is unique, yet capturing the synergy of being a part of the network determines success as well.

The third structural process is *patching*. Patching refers to the fluid realignment of businesses to market opportunities. Without a patching process, firms tend to remain fixed in dated alignment with markets. In other words, as markets change and opportunities emerge, managers must remain aware of the changes and the 'holes' that form in their respective organizations from the market shifts. It is the manager's responsibility to 'patch' the holes and realign business activities to match the market.

*Regeneration* is a temporal process that is concerned with combining the old and the new. The goal is to find a balance between old opportunities that are often very profitable and

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34. New competitive landscape: In the new competitive situation, there seems to be nearly universal agreement among theorists that the focus on product-market competition (Porter's five forces) no longer suffices. Product-market competition needs to be supplemented with other forms of competition with different time horizons and characteristics in order to cope with the hypercompetitive dynamics of the new competitive landscape. These new forms are competition to shorten migration paths and competition on industry leadership (Drejer, 2002: xxvii).
35. Bricolage and improvisation are used as synonyms (Baker, Miner & Eesley, 2003).

comfortable and new, often risky opportunities, but those offering a potential higher rate of return. Regeneration creates a flow of incremental changes.

At the core of *experimentation* is the development of a wide variety of low-cost samples such as experimental products, market-making alliances and scenarios. The resources spent on these samples, even ones that fail, such as a poor experimental product or a failed prediction, are minimal when compared with those required for entering a new market with a full product rollout that may well fail or with those required to catch up with technology leaders who create the future.

*Time pacing* triggers actions proactively at predetermined transition points rather than reactively triggering actions when events occur. Many traditional firms are event paced. That is, an unpredictable event occurs such as a competitor's introduction of a new product or a government regulation changes, and then firm acts in response to that event (Brown & Eisenhardt, 1998). Time paced transition adds the minimum structure necessary to encourage continuous innovation and 'helps managers avert the danger of changing too infrequently' (Brown & Eisenhardt, 1998: 67).

### 2.3.4 Entrepreneurial Behavior

Behavior encompasses on the one side, internal social and cultural aspects, and on the other side type and extent of the firm's integration in its socio-technical environment (Bleicher, 1991: 76). The lens of sociology divides a community into two types of distinct human relations: sociability and solidarity. Briefly, *sociability* is a measure of sincere friendliness among members of a community. *Solidarity* is a measure of a community's ability to pursue shared objectives quickly and effectively, regardless of personal ties. These two dimensions allow the whole range of human behaviors to be captured. Plotting these two dimensions against each other results in four types of community: networked, mercenary, fragmented, and communal (Figure 25). These four communities correspond to four basic types of culture (Goffee & Jones, 1996).

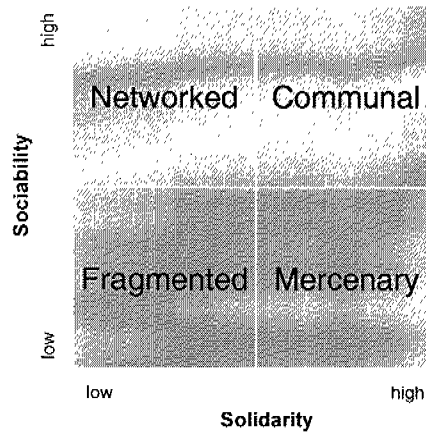


Figure 25 Two dimensions, four cultures (Goffee & Jones, 1996: 135)

Organizational culture encompasses the behavior of a collection of people within an organization, which basically consist of one or more group cultures (McGavin, 1993). The behavioral characteristics of an entrepreneurial firm are often close to a single group which is why entrepreneurial culture may be described in terms of sociality as the culture of a young group. The challenge to perform as an entrepreneurial firm against established rivals, demands a high degree of solidarity. Therefore, the entrepreneurial culture corresponds typically to the communal culture (Lee & Peterson, 2000).

### Organizational Culture

Figure 26 shows the three fundamental layers of organizational culture. Each level varies in terms of outward visibility and resistance to change, and each level influences another level (Schein, 1992: 17):

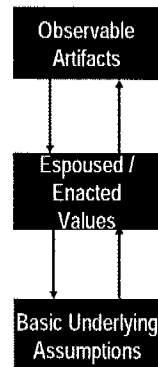


Figure 26 Layers of organizational culture (Schein, 1992: 17)

- *Observable Artifacts*: At the more visible level, culture represents observable artifacts. Artifacts consist of the physical manifestation of an organization's culture. Organizational examples include acronyms, manner of dress, awards, myths and stories told about the organization, published lists of values, observable rituals and ceremonies, special parking spaces, decorations, and so on. This level also includes visible behaviors exhibited by people and groups. Artifacts are easier to change than the less visible aspects of organizational culture.
- *Espoused/Enacted Values*: Espoused values represent the explicitly stated values and norms that are preferred by an organization. They are generally established by the founder of a new or small company. Enacted values, on the other hand, represent the values and norms that actually are exhibited or converted into employee behavior. It is important to reduce gaps between espoused and enacted values because they can significantly influence employee attitudes and organizational performance.
- *Basic Assumptions*: Basic assumptions are unobservable and represent the core of organizational culture, that is highly resistant to change. These assumptions are taken for granted and guide the organizational behavior.

The four main functions fulfilled by organizational culture are illustrated in figure 27.



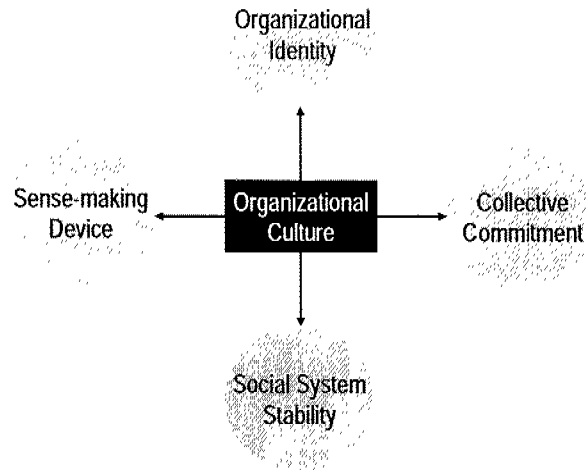


Figure 27 Functions of organizational culture (Smircich, 1983: 350)

The culture of an entrepreneurial group or organization can now be defined as, 'a pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems' (Schein, 1992: 12).

Implications of this definition for entrepreneurial firms are:

*Shared assumptions* which derive their power from the fact that they begin to operate outside of awareness. Furthermore, once formed and taken for granted, they become a defining property of the firm that permits the group to differentiate itself from other groups, and in that process, value is attached to such assumptions. The process by which shared basic assumptions evolve may be summarized as the learning process of the group that starts with one or more members taking a leadership role in proposing courses of action and as these continue to be successful in solving the group's internal and external problems (Schein, 1992: 12).

*Values*<sup>36</sup> are reflected in the formation of objectives. Since different values legitimate different objectives, and different objectives generate different kinds of problem, societies with different cultures will tend to focus on distinctive types of problem-solving and learning effects. This allows a firm to build a competitive advantage due to superior culture. For example, one

36. In this context ethic and not monetary values.

culture may see scientific progress as an important collective endeavor, while another may see it as a purely utilitarian exercise (Casson, 2003: 235).

The group's *beliefs* about the social and technological dominantly shape the firm's societal interactions, e.g. the question of who can be trusted? When few people can be trusted, transaction-costs become very high. It is only high-trust societal cultures that sustain an industrial structure based on a large number of small highly productive firms. Complex interdependencies between firms can be sustained by arm's length contracts, and within each firm the owner can rely on the loyalty and integrity of employees (Casson, 2003: 236).

*Integration of new group members:* There is an eminent difference between what new members of groups are thought of, and what is at the core of a culture (Figure 28). The assumptions that are at the core of a culture will only be revealed to members as they gain permanent status and are allowed to enter the inner circles of the group. When a new member enters a group, he or she has to decipher the operating assumptions through a teaching process of long-time members. If the group does not have shared assumptions, the new members' interaction with old members will be a more creative process of building a culture. (Van Maanen & Kunda, 1989; Kunda, 1992).

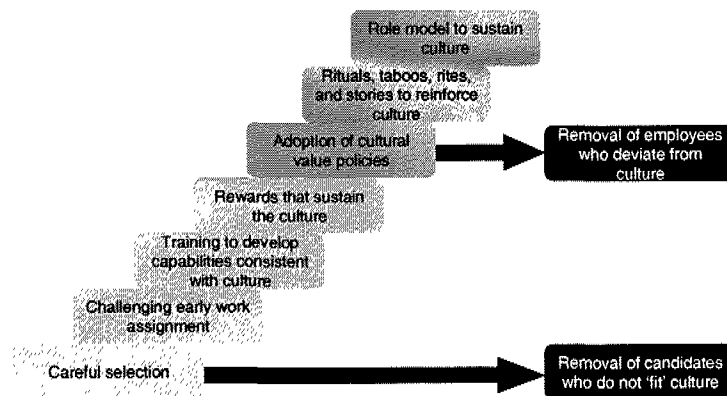


Figure 28 Steps in integration of new employee (Kreitner, Kinicki & Bulens, 1999: 268)

*Growth of organization:* The definition provided does not specify the size of social unit to which it can legitimately be applied. If certain assumptions are shared across the entire organization, then an organizational culture exists, even though there may be some discrete sub-cultures. With time, any social unit will produce sub-units that will produce sub-cultures as a normal process of evolution. Some of these sub-cultures will typically be in conflict with each other, as is often the case between the R&D and marketing group. The cultural challenge of

growth is therefore to keep the organizational culture as homogeneous as possible (Schein, 1992: 14).

### **Development of Culture**

All human systems attempt to maintain equilibrium<sup>37</sup> and to maximize their autonomy vis-a-vis their environment. The set of shared assumptions that develop over time in groups or organizations serves as stabilizing and meaning providing functions. The evolution of culture is therefore one way in which a group or organization preserves its integrity and autonomy, differentiates itself from the environment and other groups, and provides itself an identity (Schein, 1992: 298).

Cultural changes as the organization or group grows and develops are an image of group dynamics.<sup>38</sup> Once an organization is ready to change or create its culture,<sup>39</sup> e.g. through internal or external disequilibrium, the change process proceeds through different distinct steps. Intensive new learning as well as trial and error are typical behaviors along the change process. The essence of the new learning is in a radical case, the redefinition of core concepts in the basic assumption. Once the new assumptions are found, the new behaviors have to be reinforced (Schein, 1992: 299).

The culture in young growing firms is likely to be strongly adhered to because (1) the primary culture creators are still present, (2) the culture helps the organization define itself and make its way into a potentially hostile environment, and (3) many elements of the culture have been learned as a defense against anxiety as the organization struggles to build and maintain itself (Schein, 1992: 305).

For the development of culture in an NTBF, teamwork is also a critical factor. Teamwork is based on communication as its trunk and with mutual respect and recognition of common goals as its major root structure. The leadership to nurture teamwork starts with the entrepreneur and group leaders. Although each employee is measured independently, they must realize that they form a team and that the results of the total team are what counts (Bell & McNamara, 1991: 19). Without an integrated team effort, the NTBF will be unable to understand and resolve all the critical issues on its growth path.

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37. The equilibrium of cognitive structures such as concepts, beliefs, attitudes, values, and assumptions is reached, when not disconfirming data is generated (Schein, 1992: 298).

38. Group dynamics encloses the behavior of a group of people under certain conditions, and the way they change with the situation.

39. According to Schein (1992: 298) is cultural change a three step process: unfreezing, cognitive restructuring, refreezing.

### Characteristics of Entrepreneurial Culture

Entrepreneurial characteristics, such as outstanding communications, overlapping responsibilities, immediate decision taking and rapid resource deployment, are reflected in the *entrepreneurial culture* as learning behavior and ability to deal with high risks.

As learning organizations, entrepreneurial firms foster a culture of feedback and disclosure to harvest daily opportunities in order to learn from experience. Employees are expected to learn not only skills related to their own jobs, but also the skills of others in their unit. Employees have responsibility for their own learning-as well as the learning of others. They must also understand how their responsibilities relate to the goals of the organization as a whole. Finally, employees are expected to teach, as well as to learn from their coworkers. The entire workplace culture is geared to organizational learning (Marquardt & Reynolds, 1994: 54).

Entrepreneurial firm's superior ability to deal with innovative and disruptive technologies, as well as with the resulting risk has several cultural reasons. Firstly, there are very few organizational barriers that are major impediments to the innovation process. Secondly, decisions are made immediately by the people who first recognize a problem, not by someone who barely understands the issue. Thirdly, short communication paths and high-trust allow a rapid allocation of resources. (Maidique & Hayes, 1988: 696)

### 2.3.5 Categorization of New Ventures

To the study of NTBFs, there is a need for underlying categorization concepts. Categorization of new ventures is especially challenging, because of their continuously evolving objectives, structures and behaviors. A review of categorization studies reveals that there are in fact four broad categories of venture creation models: *static frameworks*, *stage models*, *quantification sequences* and *process dynamics* (Figure 24). The models within these four categories offer diverse perspectives that enhance the understanding and study of venture creation and growth (Hsiao & Chong, 2002).

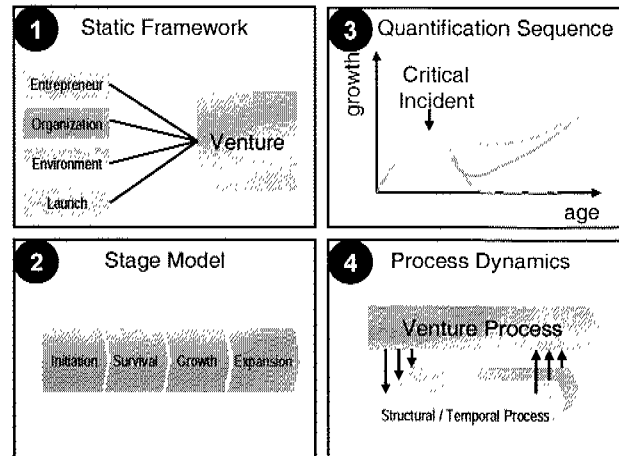


Figure 29 Four broad categories of venture creation

First, *static frameworks* (1) characterize the overall process of venture creation without examining the sequence of activities involved. Typically, this type of process model consists of a set of linked variables such as the characteristics of entrepreneurs, the organization of the new venture, the environment around the new venture, and the new venture launch (Gartner, 1985). Static frameworks are also used to explain why some individuals across different cultures tend to be more prolific than others in starting new ventures.

Secondly, some researchers<sup>40</sup> divide the venture creation process into a priori *stages or phases* (2). Today's widely accepted stage model from Quinn & Cameron (1983) proposes a life-cycle model which contains an entrepreneurial stage (early innovation, niche formation, creativity), a collectivity stage (high cohesion, commitment), a formalization and control stage (stability and institutionalization), and a structure elaboration and adaptation stage (domain expansion and decentralization). Based on this model, Artmann, Lechler & Wu (2001) has elaborated the overview of the different management activities and their evolution along with the venture (Table 3). This table presents a generalized picture of the venture creation evolution process. A major disadvantage of this models lies in the fact that there is a considerable lack of precision in the classification of management activities depending on the venture's environment and objectives.

40. E.g. Quinn & Cameron, 1983; Dodge, Fullerton & Robbind, 1994; Gupta & Chin, 1994; Artmann, Lechler & Wu, 2001; Ndonzuau, Pirnay & Surlemont, 2002; Steinle & Schumann, 2003

	Stage 1 - Initiation	Stage 2 - Survival	Stage 3 - Growth	Stage 4 - Expansion
<b>Management Focus (Functional Emphasis)</b>	R&D, Production, obtaining customers (Technology)	Efficient operations, revenues, expenses	Management growth, ensuring resources (marketing, production)	Market expansion, maintaining control (marketing, sales)
<b>Strategy</b>	Niche strategy, substantial risk taking	Exploration of market niche	Broadening of product-market scope into closely related areas	Expansion of market (product, geographic)
<b>Innovation</b>	Product/service development	Process innovations (production, sales)	Incremental product line innovation	New products / services
<b>Top Management Style (Required Skills)</b>	Entrepreneurial, individualistic (originator, inventor)	Entrepreneurial, administrative (planner, organizer)	Delegative, coordinative (developer, implementer)	Professional, administrative (strategist, coordinator)
<b>Organization Structure</b>	Informal direct supervision	Simple supervised supervision	Functional, centralized delegation	Decentralized, divisional
<b>Politics</b>	Symbolic management alignment of firm and private goals	Control of decision premises and resource allocation	Standardization of rules and operating procedures	Institutionalization of power and ideology
<b>Control System</b>	Market results, simple bookkeeping	Advanced bookkeeping, cost centers	Accounting systems, profit centers	Budgeting systems, regular reports
<b>Management Reward System</b>	Ownership benefits	Salary, merit increases	Individual bonus	Profit sharing, stock options

Table 3 Stages of entrepreneurial development (Artmann, Lechler & Wu, 2001)

The third approach uses *quantification* techniques to examine the *sequences* (3) of events that occur over a venture's history. The analysis of event sequences allows researchers to describe the processes that actually lead to the realization of opportunities. Studies of different entrepreneurs reveal various activities initiated during the startup process and three profiles are identified: up-and-running, still-trying, and given-up (Carter, Gartner & Reynolds, 1996). Another research stream<sup>41</sup> identified critical incidents of new ventures. Most critical incidents occur in the field of financing, finding the first customer and technological failures.

The fourth approach is called *process dynamics* (4), which often employ qualitative methods to examine contextual and process influences on the firm's performance. For example how and why variations in the environment and the business process shape the outputs of NTBFs (Pettigrew, 1992: 7). Typical processes are three key structural processes (improvisation, coadaptation and patching) and three key temporal processes (regeneration, experimentation and time pacing), identified in the previous chapter (Eisenhardt, 2000).

41. E.g. Hemer, 1997; Kaulio, 2001

## 2.4 APPROACH TO TECHNOLOGY AND INNOVATION MANAGEMENT IN THE NTBF

The aim of this chapter is to summarize current literature on technology and innovation management applied in NTBF. The structure of this chapter is divided in technology intelligence, technology strategy formation and implementation, technology management control, knowledge management and cooperation management as explained in chapter 4.2 on page 94.

### 2.4.1 Technology Intelligence Systems

An NTBF has to estimate today, which competencies will be needed tomorrow. Therefore it is very important to think about future trends coming from market, competitors and the technology itself. The goal of *Technology Intelligence* (TI)<sup>42</sup> is the accumulation and distribution of relevant information about the firm's environment in terms of markets, competition and technology (Figure 30). Technology intelligence involves activities that support technological and general management by taking advantage of well timed preparation of relevant information about technological facts and trends (opportunities and threats) in the organization's environment by means of collection, analysis and dissemination (Savioz, 2002: 36).

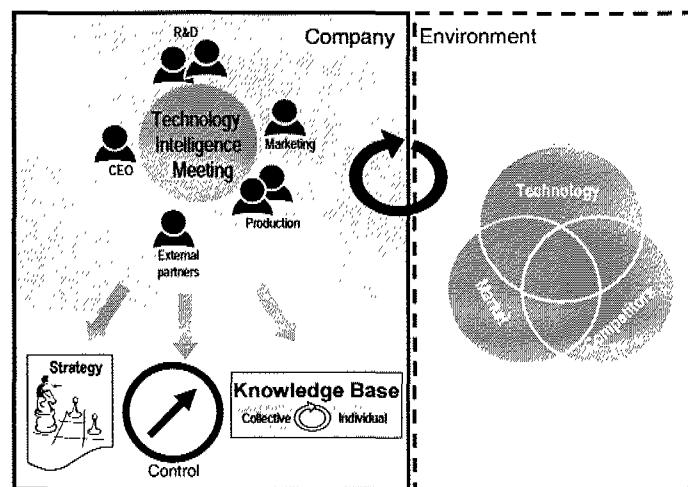


Figure 30 Overview of technology intelligence in the NTBF

While most studies assume that NTBFs tend to have little formal intelligence activity (Hambrick, 1982; Johnson & Kuehn, 1987; Lesca & Lesca, 1995), more recent studies e.g.

42. For a detailed description of technology intelligence in SME cp. (Savioz, 2002)

(Pollard & Hayne, 1998; Savioz, 2002) show that these activities are nonetheless emerging in NTBFs, thus are not reserved for large firms.

Technology intelligence<sup>43</sup> for NTBFs needs to adapt to the entrepreneurial environment,<sup>44</sup> therefore a classification in correspondence to the development of the NTBF<sup>45</sup> makes sense. Jain (1984) shows four phases of the technology intelligence evolution:

- 'Primitive phase' (no specific effort)
- 'Situational phase' (awareness of the need to scan but no formal system introduced, or sporadic scanning)
- 'Reactive phase' (unplanned, unstructured activities)
- 'Proactive phase' (rigorous, intensive practices)

One must also realize that NTBFs, hence also technology intelligence activities, do not evolve in a linear fashion, meaning that certain stages can be bypassed when required by a rapidly changing situation. For instance, technology intelligence can take on added importance and become more complex when the firm's environment becomes more uncertain or hostile (Milliken, 1987), and particularly when strong threats emerge (Daft & Weick, 1984). Other factors such as the type of competitive advantage to be obtained by a firm (Aaker, 1989; Robertson, 1992), its level of technological development (Oughebbi, 1993), the quality and level of education of its leaders (Julien, 1995), and its active participation in information networks (OECD, 1993) can differentiate the type or level of technology intelligence done by NTBFs. In other words, a 'primitive' or a 'situational' intelligence system can be perfectly justified if the information obtained allows the NTBF to maintain or increase its competitiveness in a specific economic environment.

It is helpful to classify technology intelligence in NTBFs in four steps as a value creating process with their most dominant influential factors (Figure 31). However, this is not a step-by-step process, but a parallel assembly of diverse interacting technology intelligence activities.

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43. Technology monitoring, technology forecasting, technology scouting and competitive intelligence are summarized under technology intelligence. For a detailed description see Savioz (2002: 34).

44. Cp. chapter 2.3 on page 33

45. Cp. to life-cycle model phases initiation, survival, growth and expansion (chapter 2.3.3 on page 42)



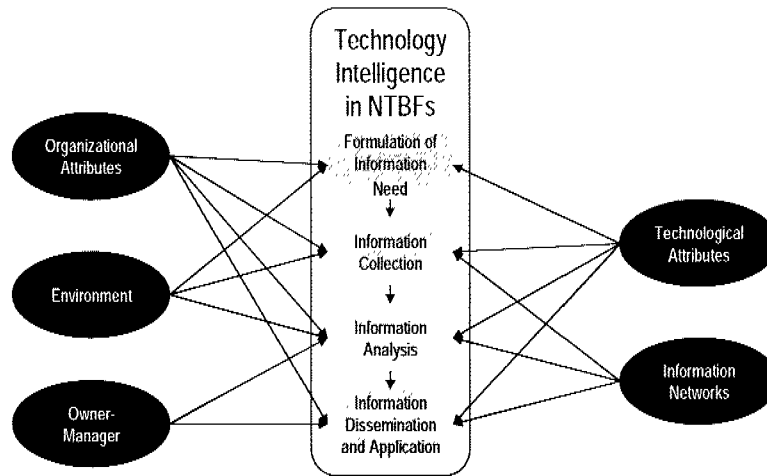


Figure 31 Dimensions and influential factors of technology intelligence in NTBFs (adapted from Raymond, Julien & Ramangalahy, 2001; Savioz, 2002; Savioz & Luggen, 2003)

#### Formulation of Information Need

NTBFs can have various purposes and strategic orientations when scanning and monitoring their environment. Some researchers suggest that performance is the primary motivation for scanning (Fann & Smeltzer, 1989; Bruschi, 1992; Radnor, 1992), while others insist on objectives related to competitiveness and strategic advantage (Aaker, 1989; Robertson, 1992), or production and productivity objectives (Johnson & Kuehn, 1987; Kobe, 2001). Depending upon these objectives, various types of information needs will be formulated in an explicit or implicit formulation.

An explicit formulation of an information need is normally the result of a top-down initiative. This 'input' in the technology intelligence system<sup>46</sup> causes the system to react.

An implicit formulation of an information need may occur as a result of emergent strategies<sup>47</sup> as well as improvisational behavior or bricolage (Baker, Miner & Eesley, 2003).<sup>48</sup>

46. Technology intelligence system for SME contains the following elements: TI management, TI mission and goals (Savioz, 2002: 38)

47. Mintzberg (1978) describe the phenomenon of emergent strategies as realized strategies that are not congruent with intended and deliberated strategies. In addition to these, there seem to be emergent strategies which can originate from anywhere within the company. Argyris, Putman & McLain-Smith (1987: 83) strengthen this view with their observations of 'espoused theory' and 'theory-in-use' (See also chapter 2.4.2 on page 59).

48. Cp. chapter 2.3.3 on page 42

**Information Collection**

Determining the scope of information collection is the first stage meeting as described above. Two main questions arise up: who does it, and what are the information sources?

The question of who collects the information depends on its purpose. NTBFs that are doing intelligence based on implicit impulses leave it primarily to the CEO to collect the information (Raymond, Julien & Ramangalahy, 2001). As soon as there are more explicit impulses, information collecting activities start being shared between different employees depending on their competencies and on availability. The assignment of the collecting task strongly depends on competencies,<sup>49</sup> which can be distinguished between internal and external technology competencies (Savioz, 2002: 184), and at the same time making a distinction between formal and informal sources seems to be appropriate (Figure 32).

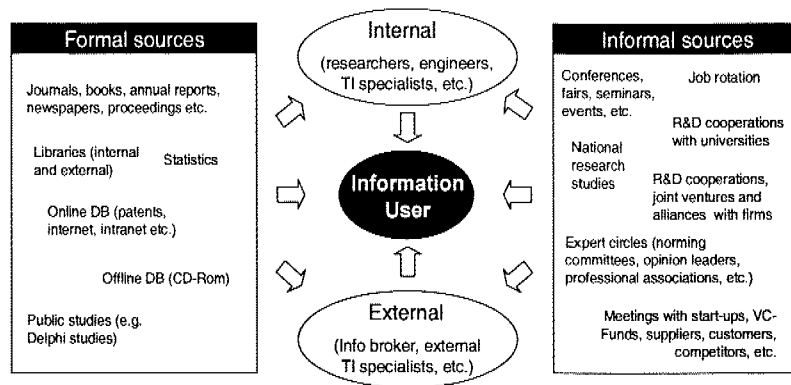


Figure 32 Formal and informal source of information (Savioz, 2002: 56)

Principally all formal and informal sources of information are accessible for NTBFs. Fann & Smeltzer (1989) found that NTBF managers collect information from suppliers, vendors, customers, employees as well as periodicals, and Specht (1987) additionally emphasizes the importance of personal contacts (telephone, discussions, etc.). The limiting factors for information collection are not restricted access to information sources (formal or informal), but the resources (human, financial, etc.) to actually harvest these sources (Savioz, 2002: 184).

49. Competence is the ability to sustain coordinated deployment of assets in a way that helps a firm achieve its goals. Here we use the word ability in the ordinary language meaning of a 'power to do something.' (Sanchez, Heene & Thomas, 1996: 8).

### Information Analysis

The goal of analysis is to give the information a meaning (Daft & Weick, 1984). The degree of the analysis effort depends strongly on the clarity of information and on the desired insight (Lichtenthaler, 2000: 327). Some collected information already comes to the decision-maker in an appropriate and interpreted form. Thus, no analysis is necessary. In contrast, there may be only very fragmented pieces of information which require a lot of effort to analyze. Therefore, the use of different analysis tools<sup>50</sup> and the decision by whom analysis should be done depend on the context, e.g. on technology strategy (leader vs. follower) and environment complexity (Daft & Weick, 1984).

Literature names different functions of the analysis stage. Lang (1998: 99) names three functions: filter, integration and assessment. The filter function is to reduce the quantity of information by checking the relevance of the information to the company, and to assess the quality of information. This function is partly fulfilled implicitly in the collection stage. The integration function is expected to integrate information into the company context, which requires appropriate background knowledge. Then, the assessment function's role is to estimate the strategic meaning of information to the company. It is in this stage that information becomes intelligence (Lang, 1998: 100).

### Information Dissemination and Application

The last dimension of technology intelligence in NTBFs refers to information dissemination and application. Information dissemination is the stage where intelligence reaches potential users, either through a information-push or information-pull<sup>51</sup> channel (Lang, 1998: 101). Both channels function primarily through participation at technology intelligence meetings. Very favorable for communication seems to be transparency on 'who knows what' and there are different ways to establish the necessary transparency, for example the use of an opportunity landscape.<sup>52</sup>

Both, use for decision making and use for learning are key aspects of information (or intelligence) application. Management decisions are always made when intelligence input is judged. Therefore, intelligence workers and intelligence users converge, if the intelligence tasks were shared. If technology intelligence processes are participative, organizational learning<sup>53</sup> is supported by providing a useful structure (Savioz, 2002: 138).

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50. Cp. chapter A on page 211

51. Cp. chapter 2.4.4 on page 73

52. Cp. Savioz & Blum (2002) and chapter A.10 on page 223

53. Organizational learning may be defined as the acquisition of new knowledge by actors who are able and willing to apply that knowledge in making decisions or influencing others in the organization (Miller, 1996)

### **Influence Factors on Technology Intelligence**

Next to the dimensions of technology intelligence in NTBFs, Raymond, Julien & Ramangalahy (2001) identifies five influential factors (Figure 31):

- Organizational attributes concern staff participation versus the entrepreneur hoarding information, the methods used (simple or complex), the organization of technology intelligence management, the level of formalization and frequency of intelligence activities, and the inclusion of intelligence in strategic management (Raymond & Lesca, 1995).
- Technological attributes such as the sophistication of the firm's production and its research and development (R&D) capability are also deemed to play a determining role (Rothwell, 1990; Raymond, Julien & Ramangalahy, 2001).
- In regard to the owner-manager attributes, the level of education is less influential than the professional management experience and experience in the sector (Julien, 1995). The founder's behavior strongly influences the NTBF's culture, and therefore also the technology intelligence management practices (Welsch & Young, 1982; Schafer, 1990).
- Uncertainty and turbulence in the environment are found to be exogenous factors of the environmental attributes affecting scanning objectives, types and sources of information (Raymond, Julien & Ramangalahy, 2001).
- The presence of and access to information networks (inter-firm networks, universities and governmental agencies) has a positive impact on technology intelligence, especially for types and sources of information.

In literature, technology intelligence in NTBFs is normally treated as a special part of SMEs' intelligence. This assumption is not entirely wrong, but neglects some important circumstance due to the highly entrepreneurial environment. The question has to be raised whether this adaptation is true, in terms of possibilities, purpose and processes of technology intelligence in NTBFs.

### **2.4.2 Technology Strategy Formation and Implementation**

When thinking about strategies for NTBF, the saying 'one product order is worth more than thousand strategies' sets clear limits how an NTBF technology strategy has to function. There is no need for highly sophisticated strategic approaches, but every NTBF needs product orders and the technology strategy should indicate how. Therefore, the attempts of this section is to generally define (technology) strategy and (technology) strategy formation and implementation, secondly

to highlight relevant aspects for NTBF technology strategies and finally present NTBF-types of technology strategies.

### Introduction to Strategy

A correct and exhaustive definition of strategy does not exist and will probably never be found, because strategy is a vital not a theoretical affair (Hinterhuber, 1994). It is for this reason that only a fitting definition of strategy is depicted in Figure 33.

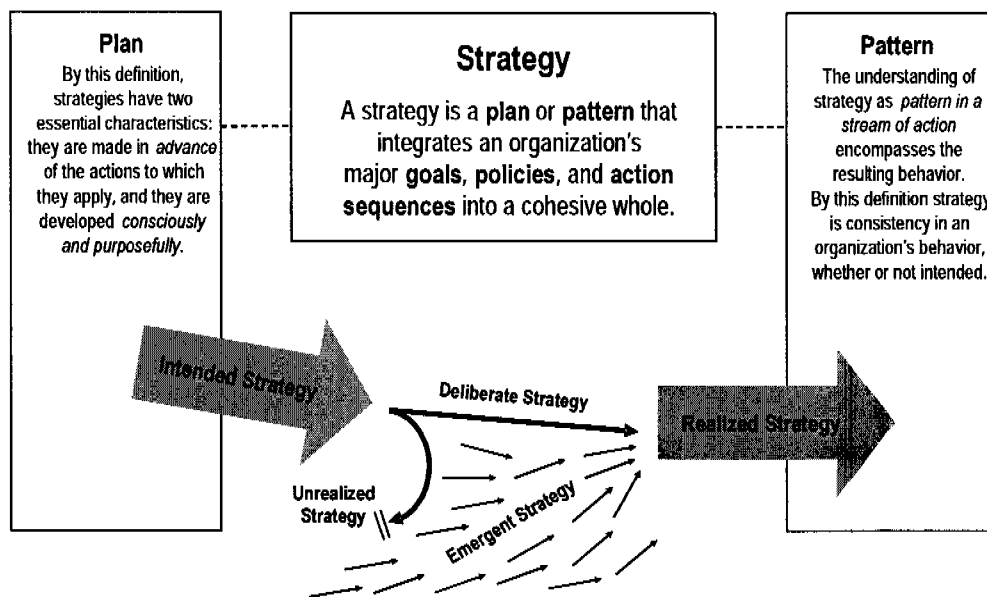


Figure 33 Definition of strategy (adapted from Quinn (1980: 35) and Mintzberg (1987))

Strategy formation is considered to be one of the most sophisticated tasks and various schools of thought are identified in literature.<sup>54</sup> The suggested aspects of those schools can be summarized and referred to as strategy formation, 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 conflictual; 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).

54. Mintzberg, Ahlstrand & Lampel (1998) identified twelve different schools strategy formation: Design school, planning school, positioning school, entrepreneurial school, cognitive school, learning school, power school, cultural school, environmental school and configuration school.

Abell (1999) presents an alternative view and makes strategy formulation more concrete by suggesting 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 now (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).

The technology-based enterprise finds itself in a field of tension between fundamental mid- and long-term trends and discontinuities and short- and mid-term issues and uncertainties. While the first includes changes in culture and social values, scientific advance and technological change as well as in industry transition, the second comprises social-psychological trends and paradoxes, industry and economic fluctuations as well as changes in politics and regulatory systems. Dealing with these two types of change requires differing approaches. On the one hand, fundamental changes have to be anticipated; reacting to these changes is generally not crowned with success. On the other hand, upcoming issues are comparably easier to react to by means of strategic issues' management. Therefore, managing with dual strategies requires company wide development of strategic projects for long-term concerns and competitive strategic projects for mid-term concerns (Tschirky & Bucher, 2003). Figure 34 shows the two types of strategic programs and projects to be considered.

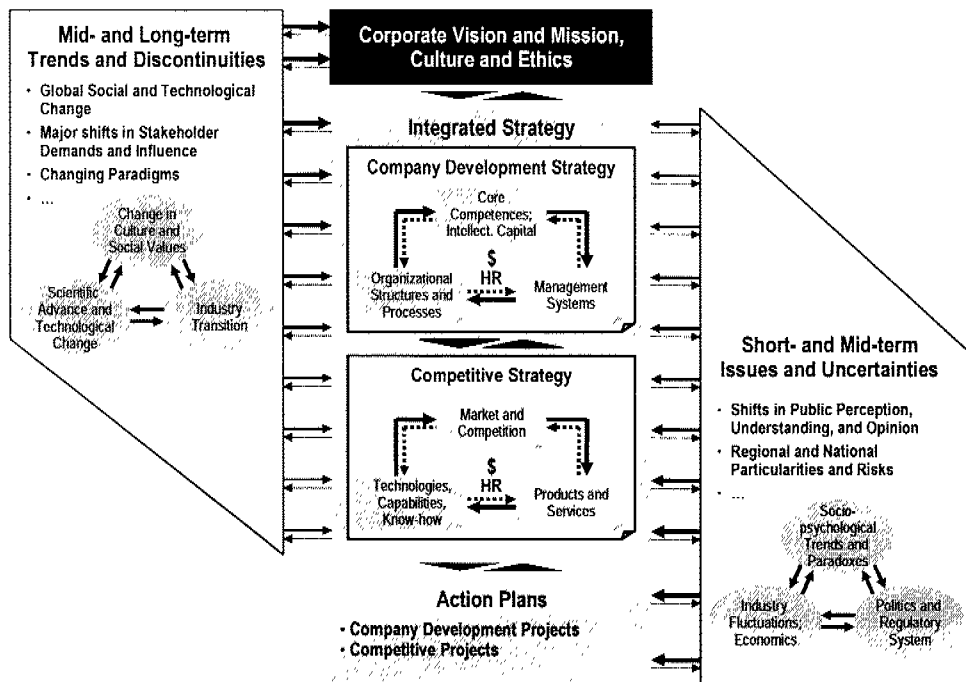


Figure 34 Different focuses of the company development and their dominant influence factors (Tschirky & Bucher, 2003: 29)

### Technology Strategy

Building on the definition of strategy, a technology strategy is a plan or pattern that integrates an organization's *technology goals, policies, and action sequences* into a cohesive whole. Tschirky (Tschirky, 1998: 293) states more precisely that the purpose of technology strategies is twofold: On the one hand, technology strategies draw up a *solid foundation for decision making* in order to enable the selection of technologies and strategic technology fields that are suitable for the creation and maintenance of an enterprise's competitive position. On the other hand, technology strategies have to illustrate the *appropriate paths leading to the mastery and deployment of the selected technologies*.

	Strategic Technology Objectives	Strategic Technology Paths
Content	<ul style="list-style-type: none"> <li>• Core Technologies</li> <li>• Standard Technologies</li> <li>• Support Technologies</li> <li>• Obsolete Technologies</li> <li>• Strategic Technology Fields:                             <ul style="list-style-type: none"> <li>- Theories</li> <li>- Core Technologies</li> <li>- Product / Process Technologies</li> <li>- Support Technologies</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Leadership Strategies</li> <li>• Follower Strategies</li> <li>• Fusion Strategies</li> <li>• Cooperation Strategies</li> <li>• Independent NTBF Oriented (<i>Type A</i>)</li> <li>• Growth Oriented (<i>Type B</i>)</li> </ul>
Tools	<ul style="list-style-type: none"> <li>• Technology Monitoring</li> <li>• Technology Intelligence</li> <li>• Technology Road Maps</li> <li>• Technology Assessment</li> <li>• Market / Product / Technology Analysis</li> <li>• Innovation Audit</li> </ul>	<ul style="list-style-type: none"> <li>• Handshake Analysis</li> <li>• Trilogy of Decisions</li> <li>• Technology Portfolios</li> <li>• Fuzzy Front End Innovation</li> <li>• Innovation Architecture</li> <li>• Technology Portfolios</li> </ul>

Figure 35 Strategic goals and paths (Tschirky, 1998: 294)

**Technology Strategy in NTBFs**

NTBFs, as well as larger enterprises, must adopt a strategic approach to managing the organization as the business grows, as the initial innovativeness of core technologies wanes and marketing imperatives become dominant.<sup>55</sup> In order to support the required corporate transformation from a technology-driven to a market-led enterprise, managers must implement more formal strategic planning systems within the company where coherent and integrated (technology) strategies are developed to guide the long-term growth of the business (Berry, 1996). For NTBFs, as purely technology driven ventures, technology strategies play a key role because technology issues have a major impact on all the other management issues, such as finance, marketing, HRM, etc. As well as other management issues, technology strategies evolve with the maturing of the NTBF. Therefore, a wide range of technology strategies exist, starting from some product ideas (often just in the entrepreneurs imagination) to systematically established technology strategies.

For technology strategy aspects, learning plays an important role. The competitive advantages of NTBFs over large firms often lie within their organizational learning capacity, organizational flexibility and speed of response (strategic cohesion). A major feature of technology strategies is learning about these advantages and deriving the best from them by

55. Selection of authors who underline the importance of strategic planning in NTBF: Dogson & Rothwell, 1991; Roberts, 1991; Rothwell, 1994; Hemer, 1997; Klofsten, 1997; Berry, 1998; Dankbaar, 1998; Smith, 1998; Kakati, 2003



creating an organization staffed by people adept at dealing with new and changing circumstances (Dogson & Rothwell, 1991).

The corollary to this learning aspect is that NTBF may find their greatest market advantage through offering proprietary (disruptive) technologies to replace or augment the continuous innovations offered by large firms (Kirchhoff & Walsh, 2000; Kassicieh *et al.*, 2002: 329).

NTBF strategies may be classified in the following framework (Gans & Stern, 2003):

*Attacker's advantage:* Consider an environment with poor intellectual property protection and where incumbents do not control the complementary assets necessary for effective commercialization. In this environment, start-ups and established firms face off on a 'leveled' playing field. Start-up investments in the product market need not be duplicative and are often modest in size. However, technological leadership will likely be fleeting: established firms have the opportunity to imitate once they recognize the nascent threat. Under these conditions, competition is likely to be intense, with continual entry challenges by start-ups aimed at undermining the value of existing market leadership positions. While entrepreneurs have an opportunity to overturn established positions, easy imitability gives most start-ups a very small share of the value over the long-term.

Ultimately, an environment with high imitability and low dependence on existing complementary assets implies tight integration between research and commercialization. Intense competition forces firms to invest in risky R&D and take advantage of 'competency traps' in order to establish a novel value proposition for the industry. Technological leadership results in temporary market leadership, which is itself vulnerable to additional waves of entrepreneurial innovation via creative destruction.

Examples are hard-drive producer in the 1980's,<sup>56</sup> who entered the market with the disruptive innovations.

*Idea factories:* Standing in complete contrast is an environment where successful invention precludes effective development by more established firms but those firms control the complementary assets required for effective commercialization. In this environment, we expect the emergence of 'idea factories'; technological leaders focusing on research and commercializing through reinforcing partnerships with more downstream players. Not only would the start-up innovator need to undertake duplicate investments under a competition strategy, but negotiations with established firms do not unduly threaten the start-ups control over the technology. The key issue is no longer whether to pursue a cooperation strategy but when and how. In this environment, the return on innovation will depend on the bargaining power of the start-up innovator.

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56. Cp. Christensen, 1997

Examples are innovative outputs of research-oriented biotechnology firms in collaboration with an incumbent pharmaceutical firm in the commercialization process.

*Reputation-based ideas trading:* Consider an environment where the disclosure problem is severe but incumbents possess the complementary assets necessary for effective commercialization. Though a market for ideas would confer a potential mutual gain (since the start-up innovator avoids investing in duplicative assets and the established firm reinforces their advantage by controlling the technology), a cooperative solution is difficult to achieve. In capital-intensive industries such as automobiles or aircraft, established firms are tempted to expropriate technology revealed to them. This expropriation discourages start-ups from pursuing collaboration as a strategy and additionally discourages research in the first place (since competition is also likely to be unprofitable). Though the automobile industry invests heavily in internal R&D, very little innovation results from technology entrepreneurship. Since entrepreneurs and investors (rationally) expect start-up innovators to face great difficulties in appropriating the returns from their innovation, the auto industry has been bypassed in the venture investment boom of the past decade.

*Greenfield competition:* The patterns of commercialization are similarly subtle in the final environment, where incumbent complementary assets are unimportant but start-up innovators can preclude effective imitation. While established firms set the terms for ideas trading when excludability is weak, the power to determine the most effective commercialization strategy lies with the start-up innovator under Greenfield competition. While the potential for returns in the product market are high (since imitation is difficult), this market power will be reflected in increased bargaining power with potential partners. As a result, the relative returns to competition over cooperation will depend on factors distinct from the intrinsic value of the technology. In this environment, technology entrepreneurs enjoy the freedom to evaluate competition and cooperation options in the absence of the risk of expropriation or the inability to overcome established firm market power.

Overall, this environment offers a tremendous opportunity for start-up innovators. However, this potential raises the possibility of a first-stage 'race' to secure a first-mover position, e.g. Nintendo's game platform business which was based on the widespread licensing of its software development tools to independent game developers.

Figure 36 shows standard strategies for each competitive setting.

		Overturns Existing Competitors Asset Value (Accessible Complementary Assets)	Reinforces Existing Competitors Complementary Assets (Complementary Assets Held by Existing Competitor)
		Attacker's Advantage	Reputation-Based Ideas Trading
Non-Excludable Technology (Poor Intellectual Property Protection)	<b>Start-Up Strategies</b>	<ul style="list-style-type: none"> <li>• Few opportunities for effective contracting</li> <li>• Opportunity to exploit technical leadership to capture market leadership</li> <li>• Performance depends on 'stealth' product market entry</li> </ul>	<b>Start-Up Strategies</b> <ul style="list-style-type: none"> <li>• May be few opportunities for contracting</li> <li>• Product market entry risky due to high costs and imitation risk</li> <li>• Performance depends on existence of established firm's commitment to ideas trading</li> </ul>
	<b>Expected Competitive Dynamics</b>	<ul style="list-style-type: none"> <li>• Market leadership determined by technological leadership</li> <li>• Established firms face competition from entrants in 'niche' markets</li> <li>• Start-ups will make new investments in complementary assets as part of establishing a novel value proposition</li> </ul>	<b>Expected Competitive Dynamics</b> <ul style="list-style-type: none"> <li>• Relative market and technological stability</li> <li>• Established firms face few competitive threats from start-up firms</li> <li>• Start-ups may play a greater role if incumbent chooses reputation strategy</li> </ul>
Excludable Technology (Good Intellectual Property Protection)	<b>Start-Up Strategies</b>	<ul style="list-style-type: none"> <li>• Ideal opportunity to choose between contracting and product market entry</li> <li>• Opportunity to use temporary monopoly power to build future positioning</li> <li>• Performance depends on strength of technological competition</li> </ul>	<b>Start-Up Strategies</b> <ul style="list-style-type: none"> <li>• Contracting with established firms</li> <li>• Product market entry is very costly and perhaps impossible</li> <li>• Performance depends on securing bargaining power</li> </ul>
	<b>Expected Competitive Dynamics</b>	<ul style="list-style-type: none"> <li>• Technological leadership drives rent distribution along the value chain</li> <li>• Start-ups and established firm compete for technological priority</li> <li>• Substantial investments in new platforms and complementary assets</li> </ul>	<b>Expected Competitive Dynamics</b> <ul style="list-style-type: none"> <li>• Frequent changes in technological but not market leadership</li> <li>• Start-ups compete with one another for priority in negotiations with established firms</li> <li>• Start-up innovation will reinforce existing platforms</li> </ul>
		Greenfield Competition	Ideas Factory

Figure 36 Framework for strategic content in the NTBF (Gans & Stern, 2003: 343)

### Typical Technology Strategic Paths for the NTBF

Mangematin *et al.* (2003) identifies two basic paths of technology strategies according to the NTBF's business model (Figure 37).

One path (Type A) is the NTBF that operates small projects and targets market niches, i.e. small and segmented markets in a small geographic areas. Although innovation is crucial for these firms, the need to maintain profitability forces them to limit investments in research. In other words, they realize incremental innovations whose value can often be explained by the entrepreneur's early intuition and launch of a research program which transforms that intuition into an innovation. These firms sell both products and services.

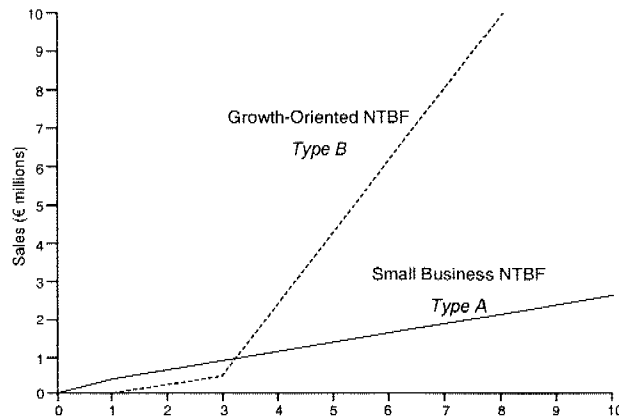


Figure 37 Type of technology strategy in relation to growth

A second path (Type B) is the research-intensive NTBF that targets broader markets, i.e. niche markets that cover a large geographic area or large national or international markets. Well known NTBFs that have made their mark in history are often firms with extensive research programs. The profitability of such programs is credible only if the markets targeted downstream are very broad.

**Strategy Formation Process**

According to (Berry, 1998: 388) a ‘formal strategic planner’ should consider the following list of essential factors: “Stress the importance of the formal and explicit strategy formulation process; be focused on long term objectives and strategies developed in relation to products, markets and technologies over two to five year planning horizon; be sure to review projects on a semi-annual or annual basis by a multidisciplinary management team; be committed to formal written strategic planning.” Keogh, Stewart & Taylor (2001) proposed the strategy formation process shown in Figure 38.

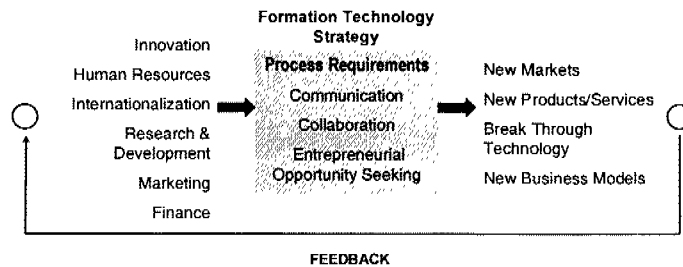


Figure 38 Strategy formation process in NTBF (Keogh, Stewart & Taylor, 2001: 51)

Literature describes well how strategies are classified and used, but there is little literature describing the precise strategy forming process in NTBFs, which would give an overview of possible tools to use, etc. Several authors consider the entrepreneur as the only important strategy defining factor, but this view excludes all possibilities of integrating strategy formation and implementation into an integral technology and innovation management and therefore all improvements that would result from the holistic view of the PockeTM. The combination of entrepreneurial strategy and technology strategy formation and implementation is not yet explored.

### **2.4.3 Technology Management Control**

Management control is divided into different sub-units, one of which is technology management control. The purpose, scope and methods for strategic management control are not clearly defined,<sup>57</sup> therefore a variety of different approaches exist in current strategic literature.

#### **Importance of Management Control in the NTBF**

The management control in NTBF plays an important role, just as much as in established firms. Comparisons<sup>58</sup> between the controlling activities in NTBF and their performance showed that high performers<sup>59</sup> demonstrate a superior willingness to be adaptable by modifying their business practice based on their internal evaluation and control. High performers had also established financial measures for gauging the success or failure of a new strategy, but they also considered the well-being and satisfaction of their staff as another indication of how well they were doing. For example, they would ask themselves, 'does it fulfill the financial targets and budgets we have set, and do people enjoy working here?' These firms also used fairly detailed methods of evaluating business performance in general, setting targets and comparing experience over different time periods. For example graphs of growth, mix of products, number of information meetings held, etc. were plotted. Thus the use of accounting information by high performing firms was acknowledged to be important, and used on a regular basis to a good effect. These findings underline the importance of strategy implementation, which includes management control as an essential component. According to the definition of a high performer and the sample of firms for this study, technology plays an important role. Surprisingly, technology control was not explicitly mentioned, nevertheless (Smith, 1998) concludes that for high performers:

- Total quality management systems are beneficial

57. Band & Scanlan (1995) provide the following groups for management control approaches: Traditional approach, critique approach, focused alignment approach and composite approach.

58. These findings are based on a detailed study, carried out by Smith (1998) in the UK.

59. Performance index based on growth, profitability and productivity (Smith, 1998).

- Formal quality approval gained for products, operations, personnel, business as a whole is valuable
- Regular appraisal of strengths, weaknesses, opportunities and threats must be made and reaction to those carried out
- Quality must be monitored on a regular basis, either through internal or external systems
- Regular self-critical analysis of strategy must be conducted

To introduce technology management control in NTBFs, a differentiation between a control system and control understanding is helpful. A lot of entrepreneurs cannot afford to implement complex systems. Such systems may even be dangerous, because they convey a pseudo-confidence and because they are too detailed they consume too many resources. Often the implication for the gained information to management decisions is low or the management decides on information, which did not actually originate from the technology control system (Nadig, 2002).

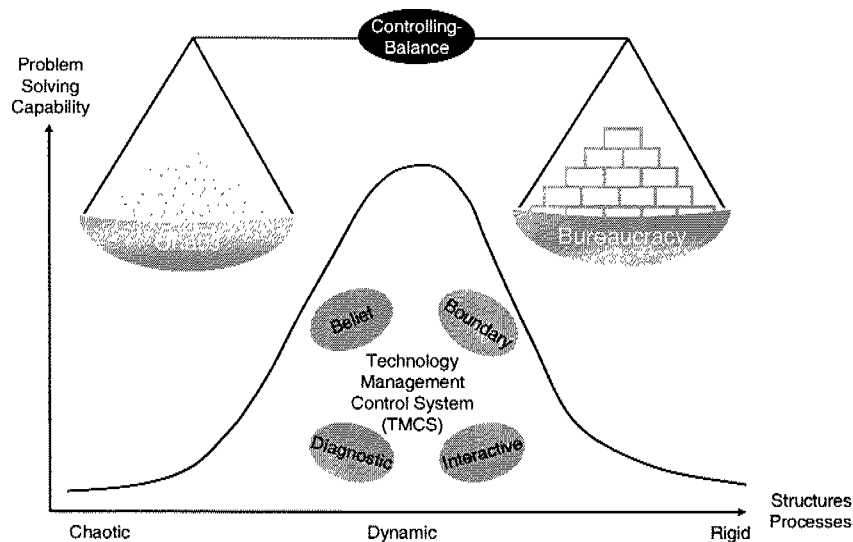


Figure 39 Technology management control balance between chaos and bureaucracy (Nadig, 2002: 53)

### Technology Management Control Systems

In a top-down approach, a generic technology management control system is introduced which is intended to lead at least to a better control understanding in the NTBF. One suitable generic system is Simons' the strategic control approach.<sup>60</sup> This *Technology Management*

60. Simons (1995: 29), adapted to TMCS by Jung (2003)

*Control System (TMCS)* enables an integration of technology aspects into management control and consist of four control levers (Figure 40):

	Purpose	Control Focus	Control of Technology Strategy
Technology Beliefs System	Empower and expand search activity	Vision / Mission	Perspective
Technology Boundary System	Provide limits of dissipating resources and risks	Strategic technology fields	Position
Technology Diagnostic Boundary System	Control of planned technology strategies	Plans and goals	Plan
Technology Interactive Control System	Stimulate and guide new technology decisions	Strategic uncertainties	Patterns of action

Figure 40 Relating the four technology management levers to technology strategy (Simons, 1995: 156)

- The *Diagnostic Technology Control System* is the essential instrument for transforming planned technology strategy into realized technology strategy. It focuses attention on goal achievement. The diagnostic technology control system relates to technology strategy as a *Plan*.<sup>61</sup> The diagnostic technology control system allows management to measure outcomes and compare results to technology goals.
- The *Interactive Technology Control System* is different from the diagnostic technology control system. It gives management an instrument to influence the experimentation and opportunity-seeking that may result in emergent new technology decisions. This system relates to the technology strategy as *Patterns of Action*.<sup>62</sup>
- The *Technology Beliefs System* inspires both planned technology strategy and new technology decisions. It provides guidance and inspiration for opportunity-seeking. This system relates to the technology strategy as a *Perspective*.<sup>63</sup>

61. Cp. chapter 2.4.2 on page 59

62. Cp. chapter 2.4.2 on page 59

63. Cp. chapter 2.4.1 on page 54

- The *Technology Boundary System* ensures that planned technology strategy as well as new technology decisions which fall within the defined strategic technology fields and are sure that activities occur at acceptable levels of technological risk. This system controls technology strategy as a *Position*.<sup>64</sup>

The power of the technology control levers is not only located in how each is used alone but rather in how they complement each other when used together. These interplays create a dynamic tension between the opportunistic innovation and predictable goal achievement that is necessary for an enterprise's technology performance. The interplay of the different technology control levers enables management to control the enterprise's technology portfolio as well as the technology strategy and its performance. These interplays shape the TMCS to make it an integrated part of an enterprise's management system and let it not be an isolated system (Figure 41).

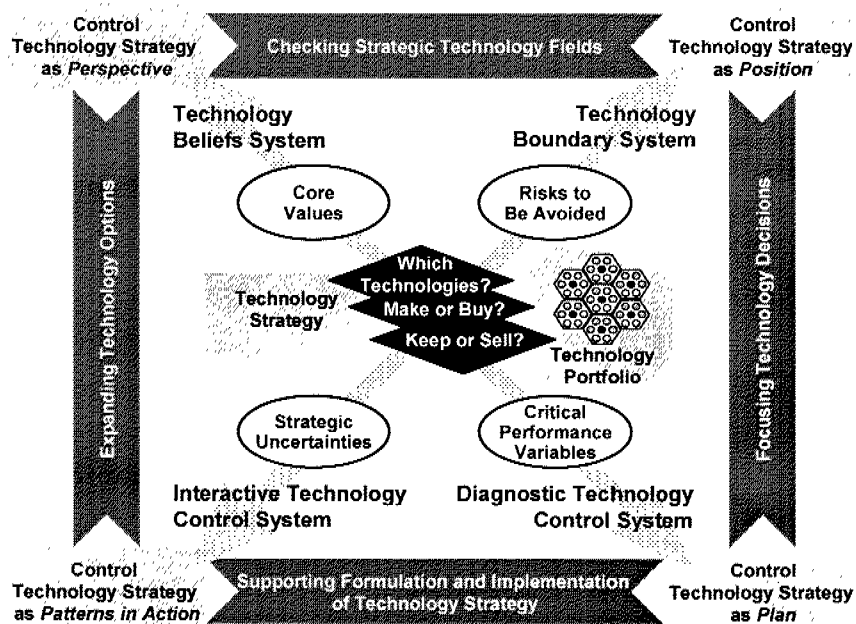


Figure 41 Controlling technology strategy and its performance (Jung, 2003: 212)

The TMCS has the following functions (Jung, 2003: 212):

64. Cp. chapter 2.4.1 on page 54



- The TMCS supports technology management to check strategic technology fields.
- The TMCS supports technology management to formulate and implement technology strategy and to measure its performance.
- The TMCS supports technology management to find and expand new technology options.
- The TMCS supports technology management to focus technology decisions.

The dynamics for controlling technology strategy and performance are derived from inherent tensions among and within the four technology control levers. The technology beliefs and the interactive technology control levers motivate to creatively search and expand opportunity space. The technology boundary system and the diagnostic technology control lever are used to constrain resource allocation.

Thus, technology management control is achieved when the tension between creative innovation and predictable goal achievement is transformed into profitable growth. These tensions imply that effective organizations must achieve high degrees of learning and high degrees of control simultaneously (Deci & Ryan, 1985).

#### Technology Management Control Systems in the NTBF

A research project<sup>65</sup> recently conducted at the ETH-Center for Enterprise Science concluded that large enterprises as well as small and medium-sized enterprises improve decision-making quality with a TMCS. Accordingly, depending on the life-cycle phase of an enterprise, different technology control levers should be applied.

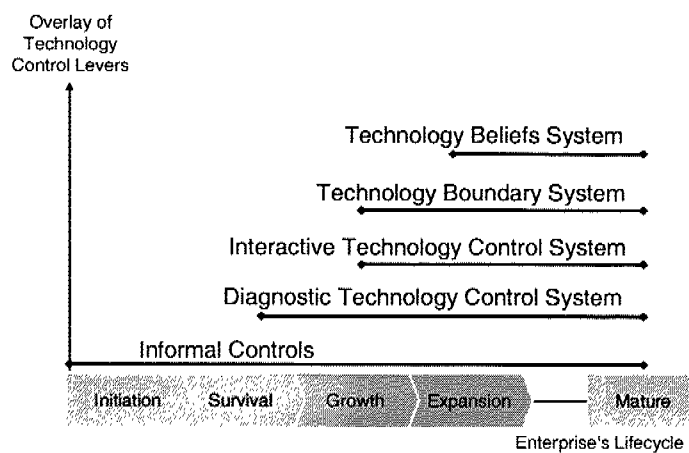


Figure 42 Evolution of Technology Control Levers (Jung, 2003: 216)

65. Jung (2003: 215)

In the *initiation and survival phase*, there is little demand for formal control systems. Because employees are in constant face-to-face contact with each other, it is possible to control key aspects of the business without formal reporting structures.

In the *growth and expansion phase*, increasing size requires that more decision-making authority must be delegated to lower levels. As a result, formal measurable goals and the monitoring of activities become increasingly important. Early diagnostic technology control systems are improved to meet top management information and control needs. By the end of the growth phase, the enterprise operates in some markets with a variety of product technologies based on numerous process technologies. At this stage, an interactive control system should be implemented. The management team learns that certain types of technology activities should be declared off-limits. Bad investments and failed technology projects result in new technology boundaries that delineate opportunity space.

In the *expansion phase*, the management team begins to use selected control systems interactively. Technology beliefs system, technology boundary system, diagnostic technology control system and interactive technology control system work together to control the formation and implementation of technology strategy, to check strategic technology fields, to expand technology options and to focus technology decisions.

To conclude this chapter, it has to be underscored that there is very little literature on management control in NTBFs, an even less on technology management control. Based on the statement 'systems are good, but comprehension is more important', the field for research on a comprehensive control system is vast.

#### **2.4.4 Knowledge Management**

Competitive advantages of the NTBF are in many cases based on a knowledge advantage, where the knowledge flow is quite efficient because of the small size of the firm. Relative to the size of the company, knowledge management in the NTBF is based on simple efforts (Keogh, Stewart & Taylor, 2001: 48).

##### **Knowledge Management**

Knowledge has been described as a central defining characteristic of firms and their ability to compete. Firms are social communities that specialize in the creation and internal transfer of knowledge. This is increasingly important, as capital-intensive and labor-intensive firms are replaced by knowledge-intensive firms and routine work is replaced by knowledge work (Dogson, 2000: 35).

The definitions of knowledge management range from narrow, utilitarian views to much more conceptual and broad perceptions (Raisinghani, 2000: 107). Minder (2001: 61) discusses three aspects of the definition:

- Textual definitions: the goal of knowledge management is to create and use knowledge in order to increase and maintain added value (Schneider, 1996: 41). Chrobok (1998: 184) sees the task of knowledge management as selecting, collecting, analyzing, summarizing and using internal and external knowledge to serve the organization in any area. The Gomez (1996: 1) definition is broader: Knowledge management shows how to process and use corporate knowledge in an optimal way.
- Knowledge management as a continuation of organizational learning: Knowledge management tries to give management instruments for intervention in the organizational knowledge base<sup>66</sup> by means of concepts and tools. Of particular interest is the learning process which is manageable (Probst, Raub & Romhardt, 1999: 46).
- Operational and technical aspects: Becker (1995: 16) defines knowledge management as designing business processes and building ICT-infrastructure<sup>67</sup> as an environment within which knowledge develops.

Knowledge management and organizational learning are highly relevant for integrated technology management, because the entire knowledge for the acquisition, development and use of technologies is subject to change. Organizational learning can be understood as the change in the organizational knowledge base, which consists of individual and collective knowledge in an explicit and tacit form (Probst, Raub & Romhardt, 1997). The organizational knowledge base builds the foundation for active and directed exploitation of technologies. This allows focusing on the necessary knowledge, through setting knowledge goals to master core technologies and nurture core competencies (Probst, Raub & Romhardt, 1997).

#### **Knowledge Management Challenges for the NTBF**

The organizational knowledge base challenges the NTBF management in different ways. Firstly, the organizational knowledge base corresponds to the sum of individual knowledge, which is stored only in a few heads. Experts who leave the firm are therefore a continual and existential danger for NTBFs (Koruna, 2002). Additionally, due to turbulent daily business, knowledge preservation is often not well structured. So even if certain information is not lost, it is difficult to

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66. Cognitive structure which is dominated by tangible and specific competencies, which has been elaborated over the entire business operations (Nonaka & Takeuchi, 1997).

67. ICT = information communication technology

locate in the organizational knowledge base, because the person knowing its location is not necessarily still working at the NTBF.

Secondly, limited resources force management to carefully design the organizational knowledge base. Internal knowledge has to be optimally used and external knowledge has to be acquired with the limited available resources (Geschka, 1997). Several transfer channels are open to NTBFs such as staff transfer, cooperations, licences and mission oriented research. It is therefore important to identify and foster suitable knowledge transfer partners (Fichtel, 1997).

Thirdly, knowledge impulses that stimulate innovations originate from the enterprise as well as through its integration into economy, science and other organizations. R&D-relevant knowledge is however often linked to the phenomenon of tacit knowledge, which is not particularly transferable to other persons and institutions. Thus, the efficiency of a knowledge management largely determines the NTBF's innovativeness (Autant-Bernard, 2001).

**Process to Manage Knowledge**

The approach to knowledge management over the organizational knowledge base, allows a management process to be formulated that fosters the organizational knowledge base through a manageable organizational learning process (Probst, Raub & Romhardt, 1997). The following process<sup>68</sup> consists of eight independent sub-processes (Figure 43).

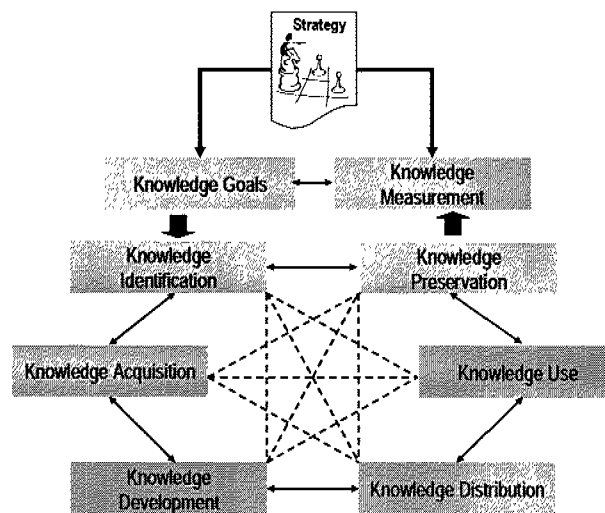


Figure 43 Process to manage the organizational knowledge base (Probst, Raub & Romhardt, 1997: 51)

68. Adapted from Probst, Raub & Romhardt (1997: 51) and Minder (2001: 171)

The knowledge management sub-processes are described as follows (Probst, Raub & Romhardt, 1997: 52):

*Knowledge goals* give direction to management activities. They determine which knowledge represents a strategic relevant resource and which abilities should be developed. These goals can be of a normative, strategic or operative nature.

*Identifying knowledge* is about retaining existing knowledge that is available both internally and externally. Often it is discovered that not everyone knows which knowledge is available. There is no clarity regarding neither the experts who are available and where they are, nor the skills which are available, or which experiences have already been gained and where. The rapid progress of the ICT does not automatically lead to more transparency, but floods the individual with data and information.

The *acquisition of knowledge* is frequently used to build future competencies more quickly than it would be the case by means of internal potential and growth. Especially NTBFs' circumstances do not permit the internal development of all necessary knowledge. That is why, if a knowledge deficit is identified, it has to be decided how to acquire the necessary knowledge through the following channels:

- Acquisition from external knowledge carriers
- Acquisition from other firms
- Acquisition of stakeholder's knowledge
- Acquisition of knowledge products such as patents, software and licenses

In this context it has to be underscored, that these acquisition channels are only usable in a knowledge-friendly culture, otherwise a 'not-invented-here' (NIH) syndrome may erode all knowledge transfer activities.

Central to *knowledge development* is the production of new capabilities, new products, better ideas and performance-enhancing processes. Knowledge development involves all kind of efforts in which management deliberately concerns itself with the production or the creation of both internal and external capabilities that do not yet exist. Therefore, five conditions for a good practice with new ideas and the use of the employee's creativity are essential (Minder, 2001: 191):

- *Intention*: The NTBF's concerns are to be pursued
- *Autonomy*: Employees should be encouraged to cultivate the knowledge and to be open for new opportunities
- *Instability*: Routines and customs should be questioned regularly

- *Redundancy*: In this context, redundancy encompasses the exchange of similar knowledge among employees, which accelerates the knowledge creation process
- *Variety*: The cultivation of flexibility and adaptable culture helps employees to cope with new and unexpected situations

The *distribution and sharing of experiences* is the most important prerequisite for making isolated, available experience useful to the organization as a whole. The main questions are, who should or does know what to which extent? And, for whom can I facilitate the processes of knowledge distribution? Not everyone needs to know everything, but the economic principle of labor division demands a meaningful description and control of the extent of knowledge distribution and sharing. This is either achieved by a pull or push mechanism<sup>69</sup> and removal of knowledge sharing barriers. Possible tools are: Intranet, teamwork, groupware, workshops, pin-board, knowledge café and job rotation.

*Knowledge use*: The purpose of all knowledge management activities is the productive exploitation of the organizational knowledge base. Successful knowledge identification, development and acquisition does not mean that the use in everyday business has been guaranteed. In the end the willingness of a colleague to share knowledge with others must be complemented by the willingness of other colleagues to actually use this knowledge. A key aspect of an efficient knowledge use is the removal of psychological, structural and cultural barriers for the utilization of external knowledge. To use other's capabilities or knowledge is often an 'unnatural act' which a lot of people try to avoid. That is why a user friendly infrastructure (simple application, speed, standardization, immediate availability, etc.) is essential to avoid from running into the spiral of death for digital knowledge sharing (Figure 44).

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69. Two sub-processes can be observed in the management of knowledge: Pull and Push of tacit and explicit knowledge. Knowledge is 'pull' when a receiver gathers technical knowledge from a source. Knowledge is 'push' when a source disseminates technical knowledge. Therefore, the process of gathering knowledge entitles the knowledge-seeker as a receiver, and the knowledge-provider project as a source. Both sub-processes together (pulling and pushing knowledge) describe ideal knowledge dissemination (Kotnour & Landaeta, 2003).

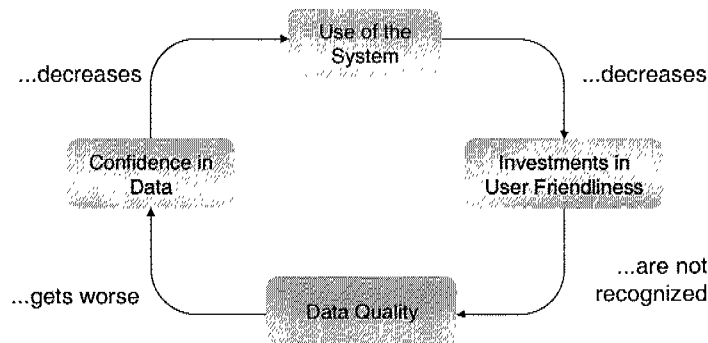


Figure 44 Cycle of death for knowledge sharing

Skills, once gained, are not automatically available for future use. The intended *preservation of experiences* requires management efforts. Knowledge may be lost for example through fluctuation of staff or by falling into oblivion and is therefore no longer accessible to the firm. The goal of knowledge preservation is to avoid uncontrolled information loss.

- *Selection*: Future relevant knowledge has to be filtered out
- *Updating*: In order to keep control over adequate knowledge in later challenges, the stored knowledge has to be regularly updated
- *Storage*: Every storage system (human, organizational or digital) has its limits which have to be addressed

*Knowledge measurement*: Contrary to financial management, there are no sharp levers of control for knowledge management. Hence it is so much more important to define measurable knowledge management criteria while setting knowledge goals. Firstly, knowledge management consumes resources which have to be justified and secondly, knowledge measurement serves also as feed-back system for future knowledge goals and thirdly, knowledge measurement functions as a feed-forward system to access new opportunities. Useful tools are a knowledge portfolio or a balanced scorecard.<sup>70</sup>

### Organizational Aspects of Knowledge Management

To manage the organizational knowledge base according to the process suggested by Probst (1997), it is useful to look at three organizational dimensions (Lucko & Trauner, 2002):

- *Human*: Design of a company culture, which supports a continuous knowledge flux

70. For a detailed description see chapter A on page 211

- *Technological*: ICT as elements of a flexible knowledge management
- *Organizational*: Integration of knowledge management processes into business processes

Figure 45 shows influential factors in the creation of an organizational knowledge base.

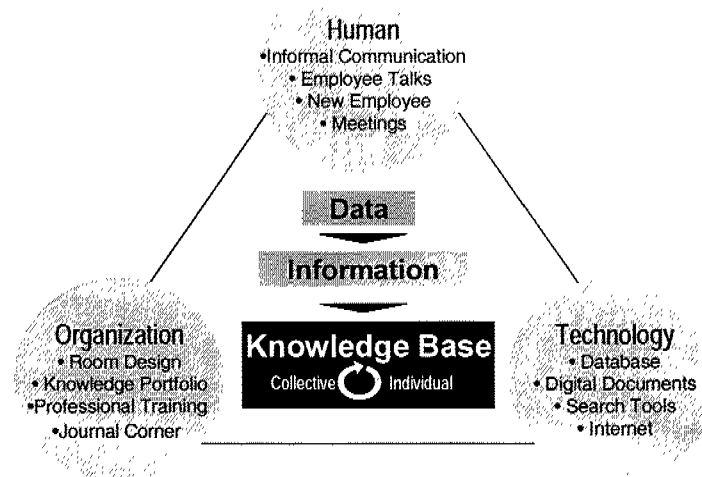


Figure 45 Concept of creating an organizational knowledge base

As a conclusion, it may be stated that knowledge management challenges for small and large firms are enormous, but not comparable. In order to develop a management system for NTBFs, the knowledge management process from Probst (1997) serves as a generic basis to develop organizations, methods and tools to manage knowledge in NTBFs, which is a white space in literature.

### 2.4.5 Cooperation Management

A common characteristic of entrepreneurial firms is rapid growth and a common problem for their managers is obtaining enough resources to support firm growth as discussed in the chapter about technology strategies.<sup>71</sup> One of the most efficient weapons used by entrepreneurial firms to gain market share from larger, more powerful organizations is through flexibility. But the progressive accumulation of resources that growth often entails, almost necessarily brings a loss of that very flexibility that made the firm successful in the first place.

71. Cp. chapter 2.4.2 on page 59



'Networking' practices are a way of overcoming these problems. Cooperation permits the entrepreneurs to tap resources that are 'external' to them. In its simplest form, cooperation consists of the use of all personal relationships to obtain advice, financing, 'insider' sales, etc. In a more sophisticated form, entrepreneurs set up an elaborate network of relationships between companies, most of them with similar entrepreneurial characteristics, that are extremely efficient and flexible at delivering a product or service. This is especially attractive for complementary assets because most partners are primarily strategically and not monetarily driven (Jarillo, 1989).

### Strategic Networks

In this dissertation, cooperation management focuses on the management of strategic networks with partners of comparable size. Other important aspects, such as alliances, outsourcing, etc. are not dealt with. Depending on alternative sets of preconditions, patterns of entrepreneurial networks differ. Generally, a business network is a formal alliance between companies, as more or less equal partners in the collaboration beyond the scope of normal contractual arrangements for procuring products and services, but stopping short of mergers and acquisitions (Picot, Reichwald & Wigand, 1996: 20). Four types of patterns can be distinguished which comprise *subcontracting business*, *co-operative economic interfirm relations*, *human interaction based on non-economic relations*, and the *relations of private-public or semi-public institutions* (Schmidt, 1998: 52); (Figure 46).

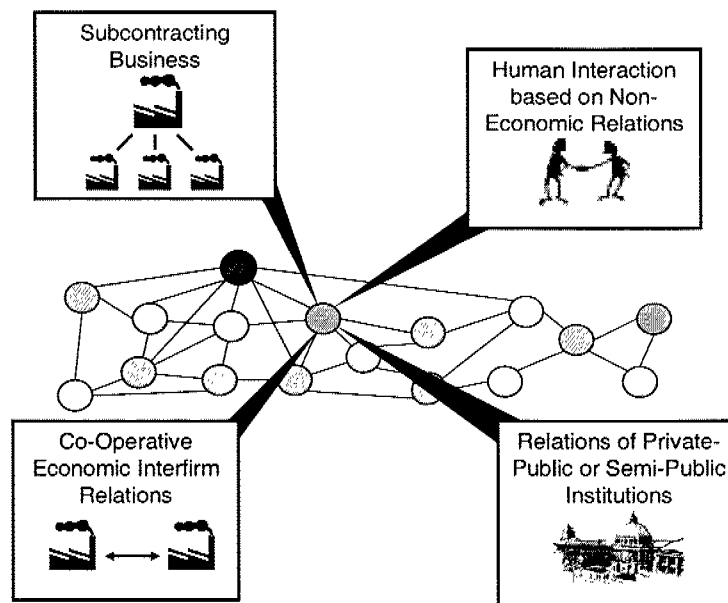


Figure 46 Network patterns for NTBFs

Network management is defined as composition, maintenance and use, as well as termination of interorganizational company networks. The intention of network management is to integrate resources unavailable internally, but essential for the firm's purpose. This integration process demands a strong change in the role and function of management. For example, the management has to face a switch from a company based strategy, to a strategy which integrates all network partners. In other words, the management task is to develop a collective business strategy for the network out of different company strategies. A lot of networks rely on a firm which takes the lead in the network development<sup>72</sup> (Wallner, 1999: 28).

### Drivers for Collaborating in Networks

A very general set of goals is given by Doz & Hamel (1998: 30) where two drivers for network organizations are described: to race for the world and to race for the future (Figure 47).

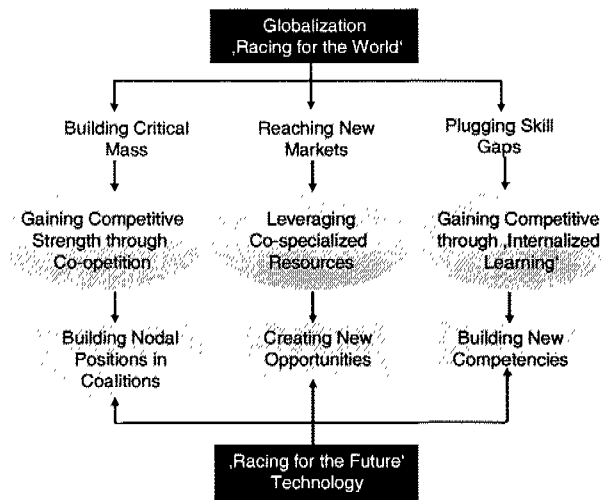


Figure 47 The logic of alliance value creation (Doz & Hamel, 1998: 36)

Companies that are 'racing for the world' intend to:

- Build critical mass globally or in a specific new market
- Learn quickly about unfamiliar markets and become an insider
- Access skills concentrated in another geographic location

And those that are 'racing for the future' want to:

72. If one firm has the lead in a network, it is often referred as a focal network with a focal firm.

- Build nodal positions in coalitions aimed at creating new markets
- Create new opportunities by combining skills and resources
- Build new competencies faster than would be possible internally

To enter cooperations, NTBFs can suffer from a serious lack of confidence. Whereas large firms create trust and legitimacy because of their size, brand name and/or documented innovative projects, small firms, and especially NTBFs, do not have this option. NTBFs have to prove themselves worthy and valuable. The creation of trust, and persuading customers and partners that they are a legitimate innovative firm is a process involving, not only the firm owners, but wider personal networks. The ability of the partners is examined through a combination of personal relations, person-based recommendations and scientific information (Monsted, 1998).

In a socially developed network, firms act for the benefit of each other because of the loyalty and involvement developed through friendship and strong personal ties. Socially developed networks provide the basis for parties to develop confidence in the stability of their relationships (Allen & Meyer, 1990). Another important aspect of network collaboration is partner learning. Explicit and tacit knowledge is shared and accumulated through experience and refined practice (Nelson & Winter, 1982).

Although there are numerous advantages of interfirm collaboration, they also bear a serious risk by weakening the firm's competitiveness through the loss of independence and involving carelessly core competencies (Egelhoff & Haklisch, 1994).

Networks among SMEs and NTBFs in Northern Italy have been famous for a long time and are internationally respected in for the design and use of network systems. The key features of the Italian networks are Murphy, Lewis & Brown (2003):

- The close relationships between the entrepreneurs and their employees
- Spontaneous interfirm networks
- Service centers that are present to support the SMEs
- Informal communication mechanisms
- High levels of trust

Based on these key features, the following network management process has been elaborated.

#### **Cooperation Management Processes**

The network management process has to support the creation and maintenance of network relations. For networks among NTBFs, the generic process from Sydow & Windeler (1997: 151)

seems to be appropriate. It consists of four basic tasks during the network life-cycle: Creation, coordination, support and closure of relations. These tasks are manageable through four management functions: Selection, allocation, regulation and evaluation (Figure 48).

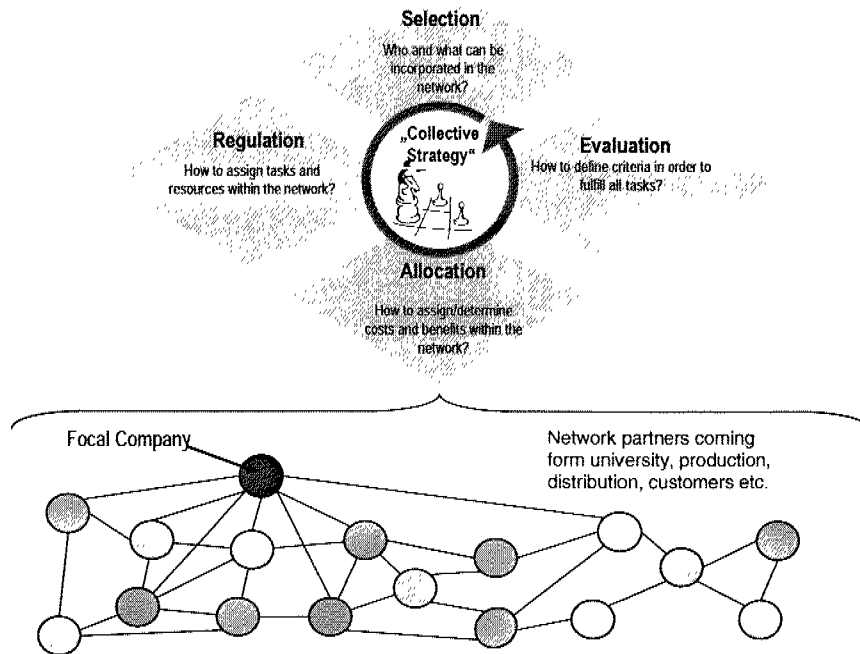


Figure 48 Basic functions of network management (Sydow & Windeler, 1997: 151)

The *selection* of the partners and assessment of the options concerning the ideal resource-mix are critical tasks in the management process. It is essential to choose partners that fit well in respect to their competencies and intentions (consistency of cooperation and corporate strategy, sharing of knowledge, confidence, commitment, trust etc.).

*Allocation:* Once the organization has been designed, resources and responsibilities need to be allocated. Obviously, this must occur in accordance with the company’s core competencies and power.

*Regulation:* In order to ensure successful networking, rules and principles of collaboration need to be established especially in terms of communication, preservation of knowledge (initiation of support process) and handling of conflicts. It further sets up the incentive system that helps to encourage proactive cooperation behavior and maintain interpersonal relations.

*Evaluation:* Costs and benefits of each individual partner must be evaluated. It helps to check whether the partnership is sufficiently successful and whether it is running smoothly (partner's satisfaction). The establishment of a clear and measurable indicator-system is essential in order to facilitate the management's ability to take decisions on sustaining or terminating the collaboration.

Literature indicates that collaborating in networks is crucial for NTBFs and offers some management processes. However, these processes focus on operational aspects of cooperations. There is a gap concerning strategic aspects of cooperations. Literature offers no holistic perspective on the integration of cooperations into NTBFs.

## 2.5 CONCLUSION: TECHNOLOGY AND INNOVATION MANAGEMENT IN THE NTBF

Even though New Technology-Based Firms (NTBFs) are considered economically important for the renewal of traditional industrial patterns and the creation of successful innovations, only a few studies about the technology and innovation management for NTBFs have been conducted in literature. What are the reasons for this discrepancy?

One reason might be that there are two major research areas, which touch the management of NTBF from two completely different sides, as show in figure 49. On the one side is the research in technology and innovation management and on the other side the research about entrepreneurship. Since there is no generally accepted definition of an NTBF, research on NTBF issues is carried out in either of those complementary research fields.

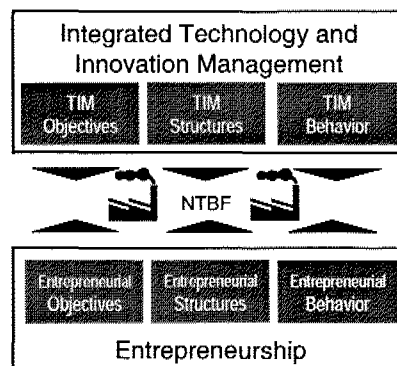


Figure 49 Position of the NTBF between entrepreneurship and technology and innovation management

The literature on technology and innovation management contains a large amount of processes, methods and tools, which have been developed for large technology-based companies.

These processes, methods and tools have been integrated to holistic management systems, which are an integral part of large enterprises' general management, e.g. the 'Integrated Technology and Innovation Management' described in chapter 2.2 on page 19.

There have been several authors who started looking not only at large multinational companies, but also on small and medium sized enterprises. Those efforts were normally carried out within a specific domain of technology and innovation management, for example technology intelligence (Julien & Raymond, 1999; Savioz, 2002), technology strategy (Berry & Taggart, 1998), technology management control (Nadig, 2002), knowledge management (Minder, 2001) or cooperation management (Schmidt, 1998; Murphy, Lewis & Brown, 2003).

Although these approaches often do not explicitly include entrepreneurial conditions, as they are found in NTBFs, they are still a very useful backbone for deeper research on NTBF.<sup>73</sup> The limitation of these approaches may be summarized as follows:

- Legitimation of downsizing large enterprises' technology and innovation management from large companies to NTBFs is not given, because downsizing a large enterprise's technology management is neither a solution for the SME nor the NTBF, but a selection of elements applied in large firm may be a solution for a SME or an NTBF (Savioz, 2002: 209).
- The entrepreneurial spirit within an NTBF has a major influence on its objectives, structures and behaviors. Compared to established SMEs, the entrepreneurial environment gives NTBFs new chances because of short communication paths, adaptive culture, opportunity seeking objectives and rapid resource allocation.<sup>74</sup> Likewise, NTBFs are faced with more pronounced limits than SMEs in terms of limited resources, missing reputation and constant disequilibrium due to growth.

To adequately manage technologies and innovations in NTBF, management systems have to be adapted. Therefore an integration of entrepreneurial thoughts into technology and innovation management is required.

The discussion about diverse aspects of technology and innovation management in NTBF reveals two gaps:

#### **1. CONVENTIONAL TECHNOLOGY AND INNOVATION MANAGEMENT FOR SMEs DOES NOT SUFFICIENTLY CONSIDER ENTREPRENEURIAL OBJECTIVES, STRUCTURES AND BEHAVIORS IN NTBFs.**

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73. Cp. chapter 2.4 on page 54

74. Cp. chapter 2.3 on page 33

**2. THERE IS A LACK OF HOLISTIC APPROACHES TOWARDS A TECHNOLOGY AND INNOVATION MANAGEMENT CONCEPT IN NTBFs, THAT CONSIDERS MANAGEMENT OF TECHNOLOGY ISSUES AS AN INTEGRATED SYSTEM.**

The entrepreneurship perspective offers a complementary view on NTBFs. One research stream develops foundations for entrepreneurial objectives, structures and behaviors<sup>75</sup>, a second stream puts its focus on the evolution models of young firms<sup>76</sup> and a last stream covers macro-economic impact and success factors of entrepreneurship.

Economic theories of the firm provide a sophisticated fundament for the *design* of entrepreneurial objectives, structures and behavior, but concrete hints on how to *direct* and *develop* these issues are exceptional. Even if authors write about technological entrepreneurship<sup>77</sup>, useful recommendations about the management of technology are lacking.

Likewise, evolution models provide useful insights into the development process of the NTBF and the changing management challenges, but no explicit recommendations.

Different authors<sup>78</sup> empirically demonstrated the importance of the NTBF for the macro-economic performance of countries and regions, and call for private-public funding projects and venture incubators. Other authors<sup>79</sup> have focused on the internal performance on new ventures. Their results underscore the importance of technology and innovation management, but concrete recommendations are rare.

Therefore, a third gap in relation to the field of entrepreneurship can be summarized as follows:

**3. THERE IS A LACK OF APPLICABLE PROCESSES, METHODS AND TOOLS IN ENTREPRENEURSHIP LITERATURE TO DESIGN, DIRECT AND DEVELOP TECHNOLOGIES AND INNOVATIONS IN NTBFs.**

From a research point of view, these gaps should be closed and the challenge of the Pocke™ system is to integrate *entrepreneurial implications* into the *technology and innovation management*.

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75. Cp. chapter 2.3 on page 33

76. Cp. chapter 2.3.5 on page 51

77. E.g. Phan, 2002; Autio, 2003

78. E.g. Frank & Sturn, 2001; Pleitner, 2001; Haour, Leleux, Surlemont & Volery, 2002; von Zedtwitz & Marmier, 2002; ReynoldsBygraveAutioCox & Hay, 2003

79. E.g. Roberts, 1992; Daschmann, 1994; Jones-Evans & Klofsten, 1997; Meier, 1998; Almus & Nerlinger, 1999; Graf *et al.*, 2001; Hoffmann & Schlosser, 2001; Kakati, 2003; Steinle & Schumann, 2003

### 3 STATE-OF-THE-ART IN PRACTICE

In the previous chapter, technology and innovation management for the NTBF was described from the perspective of current literature. The aim of this chapter is to clarify the relevance of the topic in practice. The practitioner's voice is captured by means of interviews, through seminars and workshops. The chapter closes with a conclusion for Pocke™ from a practical point of view.

#### 3.1 INTERVIEWS WITH EXPERTS

##### **Federal Councilor Prof. Joseph Deiss**

Federal Councilor Joseph Deiss is the head of the Swiss Federal Department of Economic Affairs. The Swiss applied and fundamental research ranks among the best in the world. A lot of new discoveries are made at the university level, but are not transferred to the industry. NTBFs play an eminent role in this technology transfer. Hence a favorable environment for NTBFs in terms of social acceptance and NTBF management knowledge is aimed at as part of the federal economic policy. Councilor Deiss is considering creating networks to universities and research laboratories as prior management task for NTBF and calls for a knowledge combination, e.g. science and economics for leaders.<sup>80</sup>

##### **Dr. Thomas von Waldkirch, Technopark Zurich**

Dr. Thomas von Waldkirch is CEO of the Technopark in Zurich. He points out that Switzerland is superbly positioned to compete internationally because all the necessary scientific and technical know-how, financial resources and management competencies are available. What really counts, however is how effectively scientific discoveries can be rapidly commercialized and brought to market as successful products and services. NTBFs are a key factor for the timely implementation of innovations at the marketplace. In his opinion, Switzerland has the basics to be Europe's «Silicon Valley» or «Route 128». The question is what does it need to gain this reputation? How can the Swiss entrepreneurial environment be enhanced?

Von Waldkirch identifies a demand for improving NTBF's management to increase growth rates and speed to be the first in the market place. Therefore the formation of a solid technology strategy that links technological opportunities with market demands, is crucial for every entrepreneur.<sup>81</sup>

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80. Interview held on 28. May 2003 at the Bundeshaus Ost, Berne, Switzerland



**Dr. Urs Althaus, CTI Start-up**

Dr. Urs Althaus is CEO of the CTI-Startup, the venture division of the CTI (Commission for Technology and Innovation). The entrepreneurial thinking of founders has to be well focused on world wide markets and not local market. Because a focus on local market means for technology-based firm nothing more than losing valuable time. He states, that an entrepreneur must be able to explain his business idea in an elevator ride. This means nothing more than being constantly conscious of the technology and market chances. The position of value proposition within the value chain should be evident. He remarks that a lot of entrepreneurs consider 'their' technology as too important and complex and that the market demands often less.

In current management practice there is a need to value and deploy technologies more efficiently in terms of time-to-market and industrialization. Market opportunities should be not only located as soon as possible, but also integrated into technology planning and control. This integrated view is important, because a startup's success lies not in the product, but in a combination of vision, strategy, core competencies, intellectual property, communication, market access and sufficient liquidity.<sup>82</sup>

**Alain Vaucher, Centredoc**

Alain Vaucher, information consultant at the centredoc company, is responsible for the search, analysis and interpretation of scientific, commercial and patent-related information as well as technology and patent monitoring. Services are based on thorough knowledge of international online databases, as well as on a high-performance and proven network of worldwide partners. Their clients are NTBFs as well as SMEs. Based on his experience, a lot of NTBFs miss the link between the strategy and the information collection. This results in a permanent lack of management knowledge, even though information would be easily accessible to the NTBF. He asks for management methods to define knowledge goals, acquire the targeted knowledge and disseminate it in the NTBF. A lot of NTBFs underestimate the value of qualified knowledge and overestimate the efforts to maintain a sophisticated organizational knowledge base.<sup>83</sup>

**Dr. Christoph Meier, Centre CIM Suisse Occidental**

Dr. Christoph Meier is director of the CCSO - CIM Centre of Western Switzerland in Fribourg. Here the current situation is very fragmented. It has a lot of the characteristics of an emerging business: many actors with heterogeneous structures and services, many of them with insufficient size for a viable business. There is pressure to consolidate: the complexity of

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81. Interview held on 14. November 2001 at the Technopark, Zurich, Switzerland.

82. Interview held on 26. November 2001 at the ETH, Zurich, Switzerland

83. Interview held 4. November 2002 at the centredoc in Neuchâtel, Switzerland

innovation and the increasing quality requirements of investors are creating a need for highly adaptive and professional innovation business.

Networking is a promising solution to meet this challenge. The key issue of network management is the interface between the process and the large number of partners. Networking interfaces are not just a question of logistics and financial control, they are to a certain degree a question of quality assurance. If every partner uses different terms or different definitions of the same terms, they will have a problem in networking. For example, if one defines market volume or market potential differently, problems will already arise in the business plan and have to be solved.<sup>84</sup>

### 3.2 INTERVIEWS WITH NTBF MANAGERS

Several interviews with CEOs, CFOs and others about how NTBF cope with technologies and innovation were held as integral part of this research work.<sup>85</sup> Major insights from these 33 interviews are summarized as follows:

*Technology Intelligence:* Three basic practices of coping with 'getting external information' could be observed. Some start-ups are aware of executing technology intelligence activities and they are organized systematically. Others undertake TI activities, but they are not aware of doing so, i.e. there is no system of organized technology intelligence activities. A third group has no technology intelligence activities at all. The question about who pursues technology

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84. Interview held on 29. april 2002 at the CCSO in Fribourg, Switzerland

85. Information originate from interviews with the founders and directors of the examined NTBFs. Special thanks to Harry Welten, CFO, Arpida AG, 7.1.2002; Rolf Schmid, CEO, Art of Technology AG, Project; Dr. Kurt Tiefenthaler, CEO, Artificial Sensing Instruments AG, 20.12.2001; Dr. Frank Radke, CEO, Chemisch-Physikalische Messtechnik AG, 21.9.2001; Dr. Willi Glettig, CEO, Chemsupply GmbH, 7.3.2003; Jakob Schlapbach, CFO, Cytos AG, 9.1.2002; Dr. Kurt Ruffieux, CEO, Degradable Solutions AG, Project; Markus Fanta, Enotrac AG, 20.3.2003; Dr. Dominic Escher, CEO, EsbaTech AG, 11.12.2001; David Arnold, CEO, Flying Null Ltd., 30.1.2002; Dr. Kim Jungfer, Head Software, Genedata AG, 16.11.2001; Roger Stadler, CEO, Icotec AG, 28.7.2002; Adrian Lucas, CEO, Imerge Ltd., 30.1.2002; Samuel Basler, CEO, Medizintechnik Basel AG, 22.1.2002; Paul Ruppert; CEO, Meteolabor AG, 20.1.2002; Martin Häberli, M&S, MIXPAC Systems AG, 20.2.2003; Dr. Lukas Howlad, CEO, Nanosurf AG, 21.11.2002; Georg Harnoncourt, Vice President, nnd Medizintechnik AG, 22.1.2002; Christian Fehrlin, CEO, NetVision AG, 12.12.2001; Jörg Meye, CEO, NiuTech AG, 8.1.2002; Dr. Dominik Beck, CEO, Ophthalmic Development Company AG, 13.12.2001; Martin Maschek, CEO, and Heinz Bollhalder, project leader, PI Electronics AG, 8.1.2002; Dr. Peter Staub, CEO, Pom+ Consulting AG, Project; Andrew Parkes, CEO, quantumBEAM Ltd., 30.1.2002; Dr. Martin Schadt, CEO, Rolic AG, 16.1.2002; Dr. Fin Bomholt, Head R&D, and Heinrich Kisker, CEO, Schmid & Partner Engineering AG, 25.1.2002; Mark Howard, CEO, Sensopad Ltd., 30.1.2002; Dr. Markus Rothmaier, CEO, SENSORIX AG, Project; Helmut Teichmann, CEO, Spectrosolutions AG, 24.3.2002; Dr. Mario Jenni, COO, The Genetics Company AG, 12.12.2001; Alasdair Rawsthorne, Transitive Ltd., 9.7.2003; Markus Schneider, CEO, Tribeca Imaging Ltd., 17.7.2003; Dr. Markus Ehrat, CEO, Zeptosens AG, 23.1.2001 & 21.2.2001.

intelligence activities showed that either responsibility for technology intelligence activities is delegated to one single person, who is typically the CEO, or it is up to more than one or even all employees to fulfill this task. Most firms consider intelligence as very important, however, lack the means to pursue it efficiently.

*Formation of Technology Strategies:* Every interviewed firm indicated that they have some kind of 'technology strategy'. These range from some product ideas to systematically established business strategies. Depending on the business area, different types of strategies were applied. A typical strategy puts its focus on generating resources (financial-, knowledge-, human-, production-resources) to achieve a long-term strategic goal. Another approach is to enter the market via a niche strategy, with very intensive customer relations, very specific products etc. The formalization degree of strategic planning varies widely depending on the character of the NTBF. The use of a strategic planning tools is considered helpful, especially 'simple' tools such as portfolio, benchmarking or SWOT analyses. The implementation of the strategy is often a very rapid process because of the short communication path. Most NTBFs indicated that doubts over the quality of the chosen strategy exist. They desire a strategy formation process that is easy to use and provides confidence.

*Controlling Technology Strategies:* In the case study different behaviors could be observed, from the purely intuitive approach up to a project-based approach with scientific or economic criteria. Several NTBFs mentioned, that it was very difficult to establish a management control system because they had no references from the market side or experience from previous years. That is why scientific criteria is often relied upon to judge the progress of current activities. Management control competencies are often not clearly assigned and depend strongly on the financial structure of the NTBF. Venture founded firms are normally intensively controlled by the venture capitalist's control approaches while employee owned firms look more at the quality and intensity of work done. There is a demand for a management control, that corresponds with the other technology management elements.

*Knowledge Management:* Because of growth and not yet established structures, knowledge seems to seep away constantly. On the other side, organizational knowledge is easily generated by an informal knowledge sharing culture. Three typical elements mentioned in the interviews are: Firstly, technology transfer is managed by the transfer of professionals. New employees are often recruited directly from universities and sometimes they are already familiar with the company. Secondly in a few structured meetings, it is possible, to guarantee a flow of information throughout the company and nurture the organizational knowledge base. Thirdly the other side of being a small enterprise is the fact that only few persons have responsibility for essential functions. If even one leaves, the firm can run into existential problems. Because daily business

of technology-based firms is dominated by knowledge work, the call for knowledge management is articulated in every firm.

*Cooperation Management:* Rapid change (technological, political, economical, etc.) and limited resources are a major challenge for NTBFs. Cooperation enable NTBFs to react faster and cope better with change. Vital network information and services are identified and allocated to a network partner. Rules and objectives of interorganizational relations build the fundamentals for feedback and control systems. It is crucial that every partner possess good network skills and an honest commitment to the cooperation idea in order to provide trust. Creating and leveraging a cooperation requires a systematic approach.

### **3.3 CONCLUSION ON TECHNOLOGY AND INNOVATION MANAGEMENT IN THE NTBF**

The aim of this chapter was to gain insight from practitioners about problems and needs of NTBFs in relation to technology and innovation management, which is indeed of concern to NTBFs. Several interviews, workshops and projects<sup>86</sup> confirmed the NTBFs' serious interest in improved management of technologies and innovations. Apparently there are no concepts that cope with NTBFs' specific needs, however there is also not a complete lack of technology and innovation management. Therefore one conclusion for the Pocke™ is:

**SOME NTBFs ALREADY PURSUE (IMPLICITLY OR EXPLICITLY) TECHNOLOGY AND INNOVATION MANAGEMENT ACTIVITIES, BUT THESE ARE RARELY COORDINATED. MOST NTBF WISH TO STRUCTURE THESE ACTIVITIES TO A TECHNOLOGY AND INNOVATION MANAGEMENT SYSTEM: POCKE™ – A CALL FROM REALITY!**

There is a general skepticism about the transfer of 'big' solutions designed for large firms. In reality, these solutions seem to be simply too resource intensive, considering both knowledge and capital. Thus, from a practical point of view, there is a need to design a Pocke™ System which meets the NTBF's specifications.

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86. Projects not explicitly mentioned concerning the management of startups, e.g. Symphony, Harmony, TheArk, THISS



## 4 RESEARCH FRAMEWORK

This chapter is the divide between fulfilled and unfulfilled research in the field of technology and innovation management in NTBFs. Thus, the aim of this chapter is to briefly describe the gaps identified during the study of theory and practical reality, to describe the empirical research design and methodology, as well as to generate a research framework for the PockeTM.

### 4.1 MISSION AND GOALS

As shown in chapter 2.2 on page 19, there is a holistic approach to technology and innovation management which neglects the concerns of small businesses. Even though efforts have been devoted gaining insight into technology and innovation management in SMEs and partially in NTBFs, unfortunately a holistic view has not yet been achieved (chapter 2.4 on page 54). Research on entrepreneurship emphasizes by definition, new ventures, but is not sufficiently concerned with technology issues as seen in chapter 2.3 on page 33. Moreover, there is a need from NTBFs to have an appropriate technology and innovation management, as outlined in chapter (chapter 3.3 on page 91). Closing the gaps in theory and fulfilling NTBFs need, leads to the following overall mission for this thesis:

#### BRINGING A POCCKETM INTO NTBF'S MANAGEMENT SYSTEM

Two steps are necessary to realize this mission. The *first step* includes the design of the PockeTM concept.<sup>87</sup> As shown in chapter 2.5 on page 84, downsizing large companies' technology and innovation management systems is no solution for the NTBF. The PockeTM has to correspond to the NTBF's needs, possibilities and opportunities which mostly are rooted in the fact that NTBFs are entrepreneurial firms. Therefore entrepreneurial attitudes and approaches have to be considered and integrated into the design of the PockeTM. This means that selection and adaptation of elements from large companies' technology and innovation management in the design of the PockeTM only works if those elements may be aligned with the entrepreneurial environment.

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87. According to the first research question in chapter 1.2 on page 4

The *second step* involves the implementation<sup>88</sup> of the designed concept. In order to implement the PockeTM concept, the NTBFs need technology and innovation management structures, processes and methods that are transferable to entrepreneurial firms. Those structures, processes and methods have to be able to be integrated into the NTBF management systems, and be able to cope with limited resources, organization in formation and a high degree of cultural disequilibrium. The whole set of structures, processes and methods has to support the PockeTM in a pragmatic way that takes the NTBFs' size and complexity into account.

Therefore, the newness of the field requires an explorative research design with action research as the most important source of information.

## **4.2 DETERMINING A SUITABLE APPROACH TO POKETM**

A framework for the PockeTM is determined as an initial step, by considering all technology and innovation management issues in NTBFs and forming categories of similar management issues. The main objective of these categories is to break down the research area into logical elements that can be considered individually. Since all management issues are considered when building these categories, the generated framework covers the whole range of technology and innovation management in NTBFs. Several sources are used to identify NTBF management issues, on the one side research findings from empiric studies and on the other side, interviews conducted as part of this research project.

Research on success factors and critical incidents has identified different activities, that are important for NTBF management and therefore determine NTBFs' success. A brief overview of this literature is provided in the next paragraphs.

Knecht (2002: 116) summarized general management concerns for NTBF in the following categories: (1) Person/team, (2) product/technology, (3) clients, (4) industry/market, (5) strategy, (6) facts/financials and (7) network/transaction.

A research project to identify NTBF success factors concludes with a list of requirements (Meier, 1998: 166), including 'concentration on strategy, planning, and efficiency', 'completeness of the new product development process', 'market knowledge and market focus', 'market forces', 'market analysis', 'marketing expertise and market selection', 'environmental analysis and focus on market segmentation', 'product acceptance', 'formal technology and employee orientation', 'simple technology and customer orientation', 'customer benefits' and 'customer closeness'.

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88. According to the second research question in chapter 1.2 on page 4

Millier (1997: 21) identified additional activities, such as a 'high degree of market knowledge combined with a strong market focus', 'legal coverage (patents)', 'fit to the firm's production skills and resources', 'fit into firm's production lines', 'fit firm's engineering skills and resources', 'a high-level proficiency and experience' and being 'proactive in market need identification'.

Additional issues originate from interviews<sup>89</sup> conducted with different NTBFs. Those issues encompass relations to investor, technology planning, technological alliances, technology control, quality management, coaching of staff, project management, resource allocation, technology transfer, knowledge management, publication activities, external representation (congresses, fairs etc.), external commercialization, control of market and customer situation.

The issues derived from literature on success factors and from the interviews have to be grouped into a reasonable research framework to carry out action research. This framework contains several categories between which interactions can be defined, nevertheless this categorization does not claim to be complete or unique. In order to establish such a framework, through an iterative process the management issues were put into various categories until a best fit was reached, implying that all issues are covered and logically linked (Figure 50). The aim of this dissertation study is not to validate the composition of this framework, but to design and implement a corresponding management system.

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89. See footnote 85.



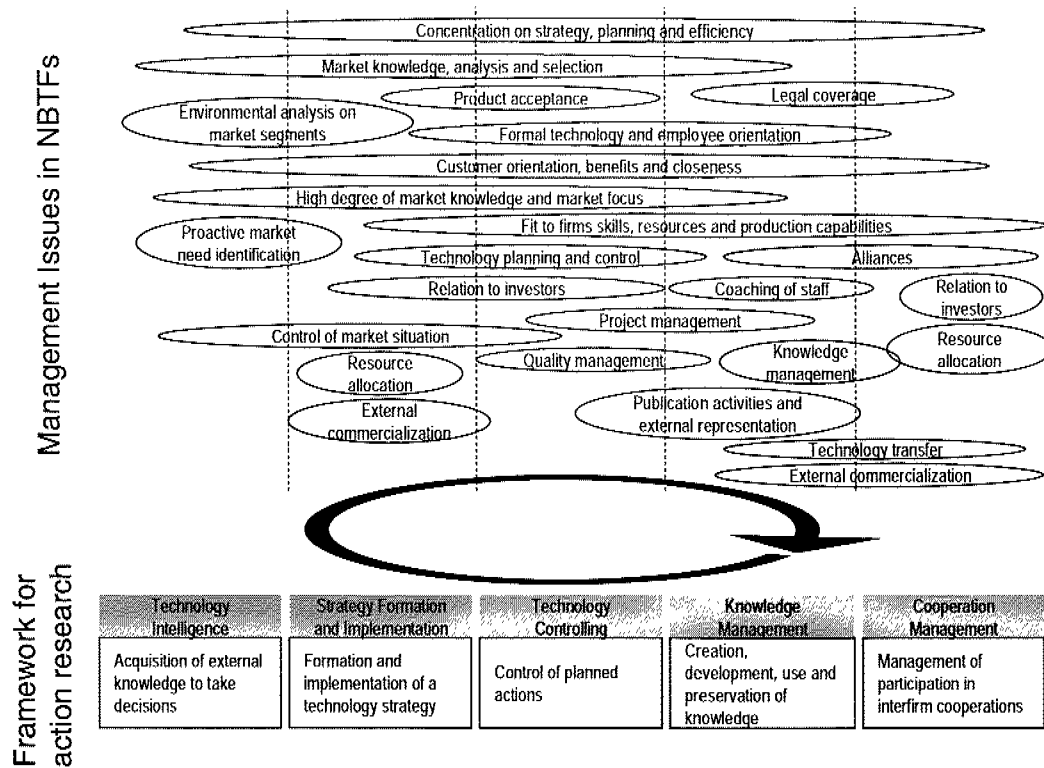


Figure 50 Derivation of framework for action research

*Technology intelligence* activities collect and process external information and knowledge about technologies, competitors and markets. This knowledge is essential for the *(technology) strategy formation and implementation*, which sets goals and allocates available resources. It is not sufficient to just create a strategy, there has to *some technology management control*. A need for *knowledge management* emerges as a result of most strategies or organizational structures. Limited resources force NTBFs to cooperate with other firms, which increases the need for *cooperation management* in order to reduce transaction-costs (Luggen, Savioz & Tschirky, 2003; Luggen & Tschirky, 2003a). Unfortunately, a complete and unquestionable distinction between each category is not possible, because of vague and altering definitions of management activities. Figure 51 summarizes typical management issues and applied tools for each category. Since these five categories play a key role in the Pocke™ concept, they are referred to as key elements of the Pocke™.

	Technology intelligence	Technology strategy formation and implementation	Technology controlling	Knowledge management	Cooperation Management
Management Issues	<ul style="list-style-type: none"> <li>Market knowledge, analysis and selection</li> <li>Environmental analysis on market segments</li> <li>Customer orientation, benefits and closeness</li> <li>High degree of market knowledge and market focus</li> <li>Proactive market need identification</li> <li>Control of market situation</li> </ul>	<ul style="list-style-type: none"> <li>Concentration on strategy, planning and efficiency</li> <li>Market knowledge, analysis and selection</li> <li>Product acceptance</li> <li>Environmental analysis on market segments</li> <li>Formal technology and employee orientation</li> <li>Customer orientation, benefits and closeness</li> <li>High degree of market knowledge and market focus</li> <li>Fit to firms skills, resources and production capabilities</li> <li>Proactive market need identification</li> <li>Technology planning and control</li> <li>Relation to investors</li> <li>Control of market situation</li> <li>Resource allocation</li> <li>External commercialization</li> </ul>	<ul style="list-style-type: none"> <li>Concentration on strategy, planning and efficiency</li> <li>Product acceptance</li> <li>Environmental analysis on market segments</li> <li>Formal technology and employee orientation</li> <li>Customer orientation, benefits and closeness</li> <li>High degree of market knowledge and market focus</li> <li>Fit to firms skills, resources and production capabilities</li> <li>Technology planning and control</li> <li>Relation to investor</li> <li>Control of market situation</li> <li>Project management</li> <li>Quality management</li> </ul>	<ul style="list-style-type: none"> <li>Concentration on strategy, planning and efficiency</li> <li>Market knowledge, analysis and selection</li> <li>Legal coverage</li> <li>Formal technology and employee orientation</li> <li>Customer orientation, benefits and closeness</li> <li>High degree of market knowledge and market focus</li> <li>Fit to firms skills, resources and production capabilities</li> <li>Alliances</li> <li>Coaching of staff</li> <li>Project management</li> <li>Quality management</li> <li>Publication activities and external representation</li> <li>Technology transfer</li> <li>External commercialization</li> </ul>	<ul style="list-style-type: none"> <li>Concentration on strategy, planning and efficiency</li> <li>Legal coverage</li> <li>Customer orientation, benefits and closeness</li> <li>High degree of market knowledge and market focus</li> <li>Fit to firms skills, resources and production capabilities</li> <li>Alliances</li> <li>Relation to investors</li> <li>Resource allocation</li> <li>Technology transfer</li> <li>External commercialization</li> </ul>
Selection of applicable tools and methods	<ul style="list-style-type: none"> <li>Lead user and supplier analysis</li> <li>Opportunity landscape</li> <li>Technology monitoring</li> </ul>	<ul style="list-style-type: none"> <li>Business plan</li> <li>Portfolio analysis</li> <li>Roadmapping</li> <li>Handshake analysis</li> <li>Quality Function Deployment</li> <li>SWOT analysis</li> <li>Scenario analysis</li> <li>Value chain</li> </ul>	<ul style="list-style-type: none"> <li>Balanced scorecard</li> <li>Benchmarking</li> <li>DCF analysis</li> <li>Milestone trend analysis</li> <li>Target costing</li> <li>Portfolio analysis</li> </ul>	<ul style="list-style-type: none"> <li>Managing professionals</li> <li>Mind mapping</li> <li>Appraisal interviews</li> <li>Conferences and fairs</li> <li>Knowledge portfolios</li> </ul>	<ul style="list-style-type: none"> <li>Presence at conferences and fairs</li> <li>Relationship management to academics and industry partners</li> </ul>

Figure 51 Typical management activities for each key element

### 4.3 EXPLORATIVE RESEARCH DESIGN AND METHODOLOGY

The budding journalist is admonished to cover who, what, why, when, where and how in writing the news. Process research can be defined as being obsessed with ‘how’ technology management is formulated and implemented, whereas ‘what’ is being decided has been claimed as the province of content research. Questions of ‘who’ is involved in technology management and ‘why’ technology management arises have been addressed by both groups, but in different ways. The NTBF as a whole is the focus of content research, whereas process research has tended to be obsessed by the individual and the group. ‘Why’ has been seen primarily as a question of economic performance by content researchers, and process researchers have looked either to logical or behavioral rationales for action. Context and timing, the ‘where’ and ‘when’ questions, on the other hand, have tended to be equally neglected by both groups, although some attention is beginning to be given to these questions as well (Huff & Reger, 1987).

Consequently, Huff and Reger arrive at the general conclusion that the distinction between content and process is becoming an impediment to progress in technology management research.

This consequence implies that the story of technology management cannot be properly written until all of these issues (who, what, why, when, where and how) are included in the research design.

In this context, five pieces of specific advice for future research are given that do not separate recommendations for *theory-building* from recommendations for *empirical research*. The following five recommendations may therefore be regarded as, to a varying degree, valid for both theory-building and empirical research. In the technology management area, researchers should: (1) build on existing theory and research. Progress in the field has generally been limited by independent articles which do not build on already existing work; (2) import concepts and research from related areas such as organizational theory and organizational behavior; (3) consider the organizational and environmental context. The need for further research is emphasized which explicitly considers the effect of context (such as the economic context) on process; (4) reflects on the content of the strategic decision being studied; and (5) varied research methods, e.g. between qualitative and quantitative studies or rational and political assumptions. No method is seen to be inherently superior (Huff & Reger, 1987).

To follow these suggestions contributing to the interdisciplinary field of technology and innovation management, a combination of the multiple case study research (Yin, 1994: 44) and action research (Lewin, 1946) as primary data source has been chosen. Figure 52 illustrates the overall research methodology.

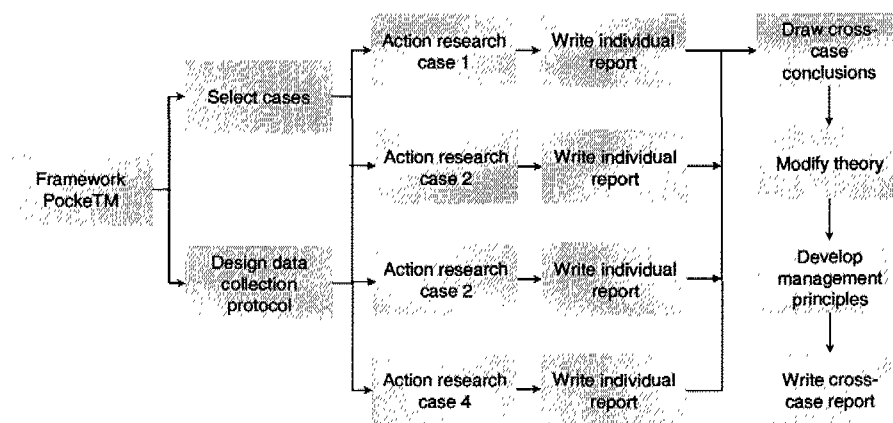


Figure 52 Multiple action research design (adapted from Yin, 1994: 49)

### 4.3.1 Multiple Case Study Design

In a multiple case study each individual case consists of a 'whole' study and conclusions are then considered to be the information needing replication by other individual cases (Yin, 1994: 49). An indication of replicating and contrasting results depending on the NTBF's specific surroundings is elaborated through a search of cross-case patterns. Searching cross-case patterns is driven by the fact that NTBF's people tend to process information depending on the current stage of the firm, what may result in premature and even false conclusions. Three possible tactics to improve the accuracy of research findings (Bourgeois & Eisenhardt, 1988):

- One tactic is to *select categories or dimensions*, and then to look for within-group similarities coupled with intergroup differences. Dimensions can be suggested by the research problem or by existing literature, or the researcher can simply choose some dimensions.
- A second tactic is to select pairs of cases and then to list the *similarities and differences* between each pair. This tactic forces researchers to look for the subtle similarities and differences between cases. The juxtaposition of seemingly similar cases by a researcher looking for differences can break simplistic frames. In the same way, the search for similarity in a seemingly different pair can also lead to more sophisticated understanding. The result of these forced comparisons can be new categories and concepts which the investigators did not anticipate initially.
- A third strategy is to divide the data by data source by *integrating different researchers and data types*. One researcher carries out the collection of raw data within the firm and implements suggested actions, while another reviews the evidence. Or different data sources are combined, e.g. interview research and action research. This tactic exploits the unique insights possible from different types of data collection and allows the strongest and best grounded source to be selected.

Overall, the idea behind these cross-case search tactics is to force investigations to go beyond initial impressions, especially through the use of structured and diverse views on the data. These tactics improve the likelihood of accurate and reliable theory, which is a theory with a close fit to the data. Also, cross-case search tactics enhance the probability that the investigators will capture the novel findings which may exist in the data (Eisenhardt, 1989).

### 4.3.2 Action Research

The term action research is attributed to Lewin (Lewin, 1946), a psychologist who became interested in human groups and their dynamics. 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 1970s, Kubicek (Kubicek, 1975) has observed an intensified attention to action research - he paraphrases the term with 'research by development' - in organizational research. He designates action research as an approach, in which practitioners and scientists jointly plan 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, which in contrast is not possible with passive approaches like 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 and learning)
- Participation (participatory process in which everyone involved takes some responsibility)
- Action (jointly elaborated options of action)

According to Greenwood & Levin, one can speak about action research in its proper sense only if all of these aspects are considered in the study. To clarify the content of action research, two current definitions are given, and then illustrated in figure 53:

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

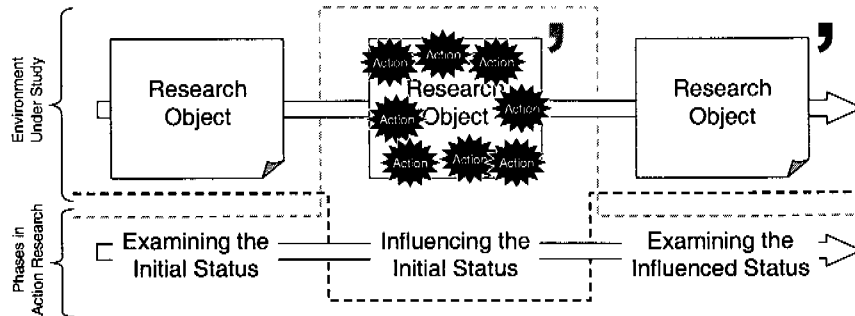


Figure 53 Content and impact of action research (Savioz, 2002: 80)

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 situation of action research and how the scientific and industrial community can benefit is presented in figure 54.

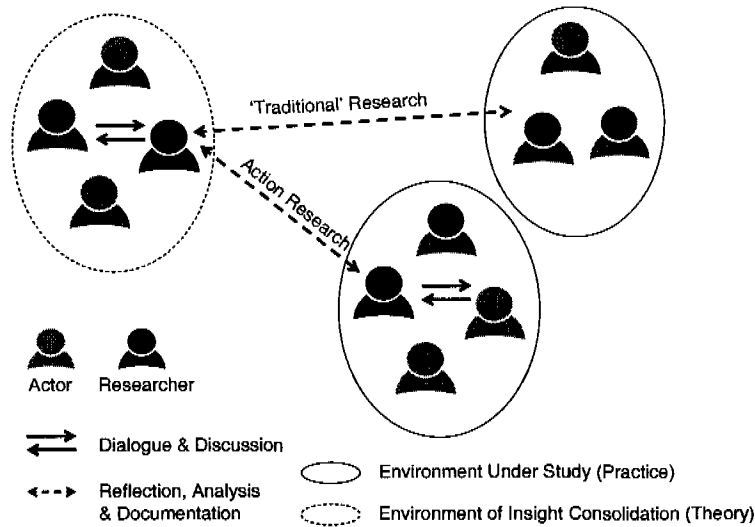


Figure 54 Benefit to scientific and industrial community from action research (adapted from Ottosson, 2003)

Each action research case begins with a description of the firm's reality. This description allows a comprehensive presentation of action to be presented. In a last section, action and impact are reflected concerning their plausibility and recoverability (Checkland & Holwell, 1998).

### 4.3.3 Empirical Research Methodology

Non-standardized interviews have an important place in this thesis.<sup>90</sup> 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 Pocke™. Secondly, activities in this field of interest seem to be very informal, and therefore cannot be mapped by standardized methods (Lang, 1998: 133). 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 is 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: 357), 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.

90. Together with written questionnaires, this is the most frequently used research method in social science research (Martin, 1998: 172).

#### 4.3.4 Raw Data

A detailed description of the methodologies (interviews, workshops, document analysis etc.) adopted for each stage (action research and validation cases), and indications from where the raw data stems will always be presented at the beginning of each sub-chapter. The author of this thesis is committed to honest and transparent research.<sup>91</sup> 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: Some raw data is also part of other dissertation works at the ETH-Center for Enterprise Science, i.e. Koruna (1998), Savioz (2002), Jung (2002) and Escher (2004), i.e. diploma theses of Thomas Aebischer, Andreas Biedermann, Christian Bürgin, Marcus Dapp, Dominik Fluri, Elmar Grüter, Stefan Haas, Dominic Hauser, Ivan Heutschi, Stefan Kessler, Mathias Lincke, Alexander Luft, Robin Maly, Daniel Uhlmann, Bernhard Wicki. All these documents are stored in the archive of the group for technology and innovation management at the ETH Zurich, BWI building.

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91. See the discussion of (Fischer & Zigmund, 1999).





## 5 ACTION RESEARCH

In this chapter the research results from various action research cases and case studies are illustrated. Following the company descriptions, the chapter is divided into the five pillars of Pocke™.

### 5.1 COMPANY CHARACTERIZATION

In this section, the four companies where the action research was carried out, are briefly characterized.

#### 5.1.1 Art of Technology

“Let’s take on this opportunity. Together!”

Art of Technology (AG) is an independent company in Zurich, Switzerland, holding partnerships and alliances with major players in the electronics industry that allows the handling projects of all sizes and complexities. Art of Technology has worked extensively on the miniaturization of electronic systems in a myriad of challenging projects with a team of highly skilled and experienced engineers. They hold both the theoretical and practical expertise, to successfully cope with extremely demanding tasks.

##### History

Initiated from the EC-project ‘Europractice MCM’ (Dissemination of HDP/MCM<sup>92</sup> technologies in Europe) in 1995 and promoted through the electronics laboratory of the Swiss Federal Institute of Technology in Zurich (ETHZ), the company was founded by Rolf Schmid, Geert Bernaerts and Werner Schmid in October 1999 in Zurich, Switzerland. In December 2001 it moved into larger office and laboratory facilities and obtained ISO 9001:2000 and ISO 13485:2000 (medical applications) certifications in September 2003. Several dissertation and diploma works have been carried out at Art of Technology. Currently Art of Technology is successfully working on assignments in the fields of medicine, aerospace, fixed and wireless telecommunications and computer applications.

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92. HDP/MCM: High Density Packaging / Multi Chip Module

### **Competencies and Technologies**

Art of Technology's research is enabled through both, internal personnel and close external relations with leading universities. The core technology is the development of HDP/MCM-modules (figure 55) for various applications. These modules are built using bare dies (un-housed ICs), chip-size packages, highly integrated circuit boards (substrates) and different assembly technologies. An HDP-Module is either a complete system or part of a system mounted on a PCB<sup>93</sup>.

The HDP/MCM technology has multiple advantages:

- Shorter development times and overall faster time to market than an ASIC<sup>94</sup>
- Increase in functionality while size and weight are reduced
- Increased performance with reduced power consumption
- Cost reduction at system level

A range of reasons have led to less expensive overall system designs, these are:

- Easier protection against electromagnetic interferences
- Higher degree of reliability
- Increased modularity and reusability of subsystems

These advantages open a wide application field, especially for small, lightweight and low power devices under extreme environmental conditions such as temperature, electromagnetic interference, vibration etc.

### **Products and Services**

With this HDP/MCM technology Art of Technology provides its customers with a broad range of solutions and services. The most important part is the development of customer specific HDP/MCM. Furthermore, detailed technology courses and seminars are offered on a regular basis to support and promote the use of HDP. Other market segments where Art of Technology is involved include conducting feasibility studies for system development and design as well as technology, manufacturing and test evaluation.

Another example is the wrist wearable vital signs monitor (EU AMON Project), where Art of Technology was responsible for the integration of the electronics using advanced biosensors to measure vital signs (Figure 55). The link to the tele-medicine center provides online diagnostics

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93. PCB: Printed Circuit Board

94. ASIC: Application Specific Integrated Circuit

over a bi-directional GSM connection. The sensors measure pulse, blood pressure, temperature and ECG regularly and send the data to a telemedicine centre for further analysis by medical personnel or interpretation of an alarm.

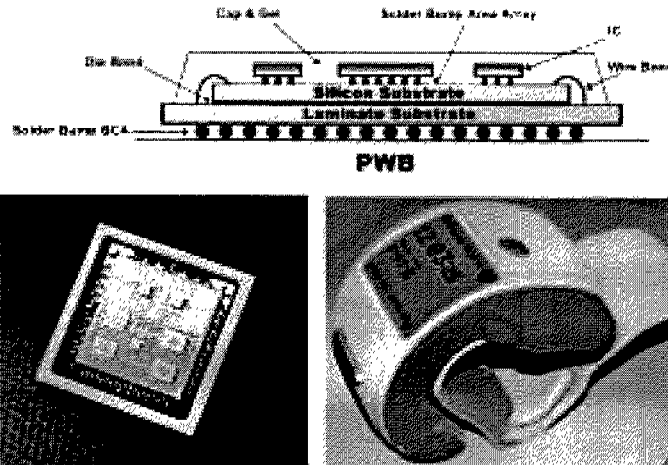


Figure 55 Products Art of Technology (top: HDP/MCM scheme, bottom left: HDP chip bottom right: product with HDP technology)

### Market and Competitors

Art of Technology's market is segmented in medical instruments, automotive and space. Every segment has its own behavior and expectation. Since Art of Technology produces highly innovative components for traditional enterprises, their customers have great demands for product quality and certification. Useful market estimations are limited because the HDP market is not yet fully established. Thus, Art of Technology's main competitors offer the same functionality with different technologies, e.g. the traditional ASIC technology. On the other hand, many firms are able to internalize the Art of Technology's value proposition.

#### 5.1.2 Degradable Solutions

"It is our goal to develop innovative medical therapies and to substitute permanent implants through the use of Degradable Solutions for the benefit of patients"

Degradable Solutions (AG) specializes in the development and manufacturing of biodegradable medical implants. A balance between pursuing product ideas and contract development is maintained. Their most important clients are medical companies throughout the world.

### History

The roots of Degradable Solutions AG are found in the chair of biocompatible materials science and engineering (professor Wintermantel) at the ETHZ. The initial product idea was born in 1995, when a dentist developed a method to close bone wounds after tooth extractions, the application of the future RootReplica<sup>®</sup>. The first generation of RootReplica<sup>®</sup> (solid polymer) was developed alongside regular work in the evenings and on weekends. The company was founded by Dr. Kurt Ruffieux at the beginning of 1999 as a spin-off company from the ETHZ. Dr. Ruffieux had worked at this point for over seven years in the field of degradable biomaterials. The founding of Degradable Solutions was supported by the CTI-Startup-program.

The first business activities of Degradable Solutions concentrated on scientific consulting and production initialization of ResorbX, another implant developed at the ETHZ and produced by the customer. The firm applied and received an ISO 9001 and EN 46000 certification, hence it is working with a detailed management system.

In 2001 Degradable Solutions moved to larger facilities in the same building and the second generation of RootReplica<sup>®</sup> was developed.

The second generation of RootReplica<sup>®</sup> still did not fulfill the desired product functions and the development of a third generation of RootReplica<sup>®</sup> (combination of polymer and calcium phosphate) was launched. The third generation of RootReplica<sup>®</sup> was certified in August 2003 and was presented at the IDS dental fair and rated among the top ten new dental products. Sales began in the third quarter of 2003.

### Competencies and Technologies

Degradable Solutions has developed a broad range of process technologies for degradable biomaterials, from injection molding to ceramics sintering. Its core technology is the processing of degradable polymers and calcium phosphates into innovative products.

To summarize, Degradable Solutions has competencies in the following areas:

- Development of new processing technologies, e.g. organic solvent free processing of polymers
- Synthesis of high purity  $\beta$ -tricalcium phosphate ( $\beta$ -TCP)
- Analysis of biodegradable components
- Influence of process parameters on implant properties, e.g. absorption time
- Design, manufacture and characterization of load bearing implants
- In vitro-degradation testing of degradable implants at 37°C or at elevated temperatures

- Manufacturing and characterization of open porous scaffolds for tissue engineering

Degradable Solutions has patented several technologies, which are essential for the development of the company.

### **Products and Services**

Degradable Solutions sells two products and has developed different OEM products.

The initial product calc-i-oss<sup>®</sup> is a granulate consisting of bioresorbable high purity  $\beta$ -TCP for filling bone defects. The purity of the beta-phase is greater than 99%, allowing complete degradation of the implant material present in the body. No undesirable inflammatory effects or immunological defence reactions are known for pure  $\beta$ -TCP in their appropriate form. When filling in the defect, the granules create a macro-porous structure which conducts bone regeneration. calc-i-oss<sup>®</sup> is manufactured by a sinter process at temperatures  $>1000^{\circ}\text{C}$  from synthetic raw material and does not contain any animal or human derived substances. The material is applied in non-stressed, multiple-walled bone defects of the skeleton.

The second product and initial driver for Degradable Solutions is RootReplica<sup>®</sup> (Figure 56). With the extracted tooth a mould is fabricated and filled with the granular biomaterial, a combination of calcium ( $\beta$ -TCP) and a biopolymer. Under compression, the biomaterial fuses, forming a mechanically stable copy of the root. Finally, RootReplica<sup>®</sup> is placed in the extraction hole (alveolus).

The RootReplica<sup>®</sup> seals the alveolar wound and supports the surrounding bone structure. Due to the porosity and the accuracy of the copy of the tooth root, an immediate contact to the surrounding bone tissue is achieved, allowing bone tissue in-growth. The implant optimizes the wound healing process and preserves the anatomy of the alveolar ridge.

RootReplica<sup>®</sup> represents an efficient wound treatment and compared to current techniques, simplifies the clinical procedure significantly and creates optimal conditions for prosthesis.

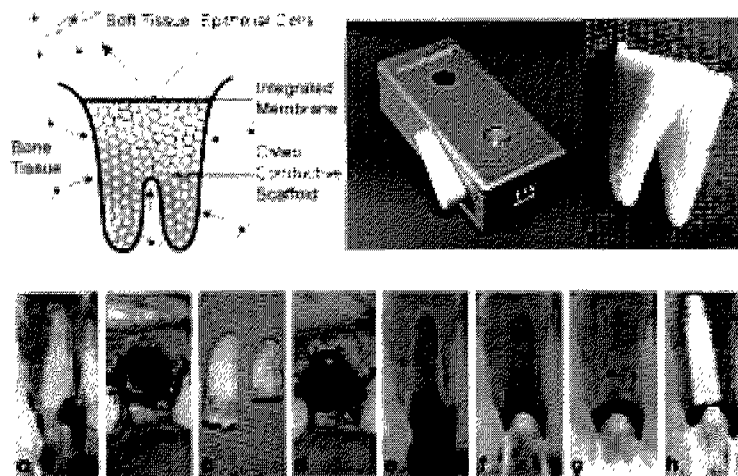


Figure 56 *Product RootReplica<sup>®</sup> (top right: scheme of bone hole, top left: apparatus to press implant, bottom: process from tooth extraction over bone regeneration to prosthesis)*

### Market and Competitors

The global dental market generates a turnover of approximately 145 billion US\$ with a growth rate of 6% to 7% annually. Swiss firms have a market share of 1%. In spite of the present difficult economic situation, the entire medical technology market is performing above average.<sup>95</sup>

The market potential for RootReplica<sup>®</sup> and calc-i-oss<sup>®</sup> correlates with the market volume for dental implants. Due to rising number of elderly and their buying power, annual growth rates greater than 10% are to be expected.<sup>96</sup>

The competitor situation is difficult to estimate, since the product is not yet on the market. Generally, the market segment tends to be too small for multinational companies, such as Johnson & Johnson. Small competitors exist, but the RootReplica<sup>®</sup> is an totally innovative product with no direct competitors. For Degradable Solutions it is more challenging to convince dentists and patients of the advantages of RootReplica<sup>®</sup> than to get along with competitors.

### 5.1.3 pom+

“We inspire our customers”<sup>97</sup>

95. Health point, Orthopedic Weekly Fact Sheet, <http://www.healthpointgroup.com>

96. Merrill Lynch. Orthopedic Industry September 2003

97. “Wir begeistern unsere Kunden”

Pom+Consulting AG<sup>98</sup> is an independent, privately held company in Zurich, Switzerland. Pom+ focuses on very specialized management consulting in the facility management area.

### **History**

Pom+ was incorporated in 1996 by professor Hans-Rudolf Schalcher (head of the administrative board) and Dr. Peter Staub (CEO). The future CEO's PhD focused on new developments in the field of facility management. As a result of cooperation with external experts and research projects, the business idea for pom+ was born. The company started with only a CEO and two employees at the Technopark in Zurich. The market potential allowed permanent growth bringing the total number of 35 employees within eight years. During these eight years, the organizational structure was continuously elaborated and adapted, and a certified management system was implemented.

### **Competencies and Products**

At its foundation, competencies of pom+ partially existed at the chair of Prof. Schalcher for construction, engineering and management. More importantly pom+ continues to develop and improve existing as well as new competencies and technologies. This process has led to competencies in the construction field for portfolio, construction and facility management, including competencies in the area of:

- Concepts for automatized and mobile communication buildings
- Process analysis and optimization
- Analysis of information and data flows
- Risk management and feasibility studies
- Benchmarking for construction projects
- Troubleshooting for construction projects

These competencies allow pom+ to offer its customers real estate portfolio management, management of construction projects and maintenance of existing buildings.

### **Market and Competitors**

The facility management market is continuously growing with the potential for future growth. At the same time the customers' needs are becoming more sophisticated as well. Pom+ has several competitors that are attacking from three sides. Competitors in the first category are companies working in the same market niche. Most of these companies are larger and less

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98. Consecutively pom+



knowledge intensive. Secondly, pom+ is being attacked by multinational management consulting companies that offer similar services, but are not able to accommodate special customer needs. Thirdly, construction companies have decided to offer integrated construction management services in addition to their basic construction work. The unique selling proposition that pom+ offers is its superior service quality, adaptability to special customer needs and a lean cost structure.

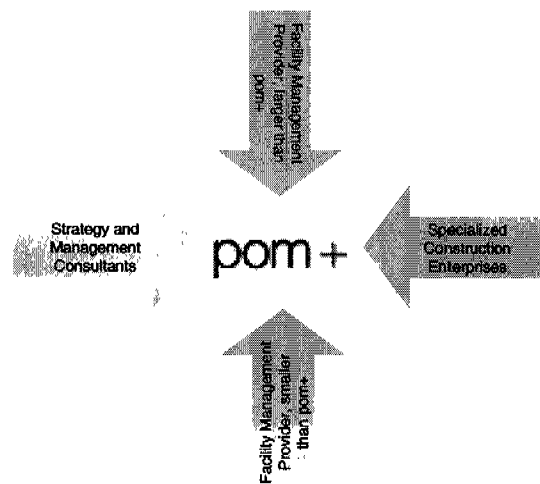


Figure 57 Competitive situation of pom+

#### 5.1.4 SENSORIX

“SENSORIX is committed to being the leading analytical solution provider for the Life Science industry, in particular biotechnology. Our goal is to supply the best quality analytical solutions for our customers to enable them to better control and optimize their processes.”

##### History

The roots of SENSORIX AG are located in the Center for Chemical Sensors at the ETHZ, where a remarkable knowledge about chemical and biological sensors is accumulated at the chair of professor Ursula Spichiger. In 1998 the business ideas was born and a feasibility study conducted, that gave promising results. In 1999, Dr. Markus Rothmaier and Fritz Tschop decided to incorporate SENSORIX and enter the market with core competencies based on the Center for Chemical Sensors' expertise. Additional spin-off partners were Prof. Spichiger and two partners

from industry. The industry partners' contribution to SENSORIX was in the form of tools, know-how and capital. At the end of 2002 the first sales in Europe were realized to lead users and sales offices in Europe and USA were opened.

### **Technologies and Competencies**

Chemical and biological sensors offer a great opportunity to monitor online processes without extensive sample preparation. Therefore several sensors technologies with various signal transduction principles have been developed that quantify changes in current, potential or in light absorbance. These sensors are integrated into a flow-through cell which is mounted to the analytical platform with a capacity of up to nine different sensors.

The core technologies of SENSORIX are the construction of very compact sensors and the installation of up to four sensors in a cartridge to simultaneously measure multiple parameters. This sensors platform offers amperometric, potentiometric and optical measurement for online process analysis in chemistry, biotechnology and waste water treatment.

Chemical and biological sensors offer several advantages over other analytical methods:

- Real time measurements
- No need for expensive chemicals
- No sample preparation necessary

A continuous process analysis permits the immediate recognition of disturbances and the appearance of unwanted products. Appropriate countermeasures can be taken immediately to avoid damage and cost.

### **Products and Services**

SENSORIX provide three product groups for a wide application:

- *Analytical hard- and software:* The analytic apparatus SENSORIX MC is designed for the online observation directly at the production site. Continuous measurement captures all relevant data for process and quality control of biochemical processes online. The flexibility of the platform enables up to nine different simultaneous measurements. Proprietary software runs the measurements on this apparatus and guarantees a user friendly interface (Figure 58).
- *Consumables:* SENSORIX also delivers a maintenance kit. Each sensor kit consists of the sensor and the corresponding standard-, wash- and buffer-solutions for a working period of 4 weeks to guarantee an optimal performance.
- *Third Party Products:* A series of products to realize customer specific solutions complements the product and service portfolio of SENSORIX.

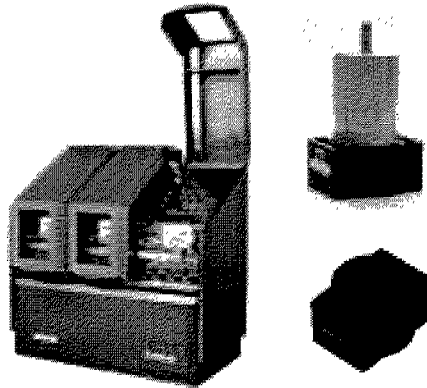


Figure 58 Analytic apparatus with flow through cell

### **Market and Competitors**

For their initial entry in the market, SENSORIX has focused on the biotechnology and pharmaceutical areas, because both are growing and demanding multiple measure process control. Future sales activities also concentrate on the chemical, nutrition and waste water treatment market. SENSORIX occupies its market niche alone. They have no competitors with the same product, nevertheless the analytic market is an old market and a lot of competitors offer analytical solutions. For SENSORIX's market niche and the market as a whole, there are no market studies available. Growth estimations are based on competitors' growth and the increased tendency to install bioreactors.

## **5.2 TECHNOLOGY INTELLIGENCE SYSTEMS**

Action research on the technology intelligence systems was conducted at SENSORIX and confirmed with findings from other cases.

### **5.2.1 Enter the Real World Challenge at SENSORIX**

An informal technology intelligence-process was in use at the beginning of this action research project. Intelligence activities were limited to the information search by various employees in the areas that they considered relevant. Information was gathered by means of scientific literature, fairs and conferences, patents analysis and relations to universities. A small informal expert network with universities and consulting companies exists and it is a strategic objective to extend and formalize this network.

Employees from every department have to participate in the monthly ICM,<sup>99</sup> where information about business development and general company news are shared and the different functional units of the firm (R&D, S&M, P&L, management) are coordinated. In these meetings, changes in the firm's environment are discussed.

The starting point of this project was SENSORIX's strategic<sup>100</sup> intention to establish more formalized management processes.

SENSORIX developed a detailed strategy involving different technology issues, where other core technologies, were identified, professional training encouraged and a technology transfer established.

Therefore, the goal for technology intelligence at SENSORIX might be summarized as follows:

- Acquisition of relevant information from the firm's strategic technology planning
- Optimal use of available and inexpensive information resources
- Technology intelligence concept that can be implemented and operated by SENSORIX without external assistance

Together with the employees of SENSORIX a technology intelligence concept based on current literature was adapted to SENSORIX by combining and adapting existing technology intelligence elements. Martin Luggen and Alexander Luft<sup>101</sup> spent approximately 60 days in the company for interviews,<sup>102</sup> workshops, presentations, meetings, desk research and analysis work.

### 5.2.2 Solution for SENSORIX

The raw concept for this solution was adapted from literature.<sup>103</sup> Around the existing Interdepartmental Coordination Meeting (ICM) new technology intelligence elements (opportunity landscape with gatekeeper network, external expert network, TI report, Technology Intelligence Meeting TiM) were implemented (Figure 59).

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99. This meeting was named ICM for Interdepartmental Coordination Meeting

100. SENSORIX does not differentiate between business and technology strategy.

101. The technology intelligence system is part of his diploma theses at the ETH-Center for enterprise science (Luft, 2003).

102. Interviews conducted during this action research case varied broadly.

103. Cp. chapter 2.4.1 on page 54

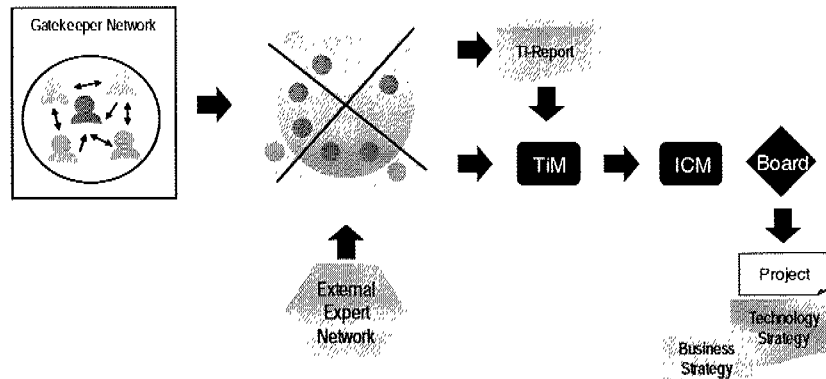


Figure 59 Overview of technology intelligence

The opportunity landscape<sup>104</sup> is considered the core of the system, the gatekeeper and an external expert network are information sources. TI report, ICM and TiM are support elements.

#### Elements of the Technology Intelligence System at SENSORIX

In following section the elements and their configuration for SENSORIX are illustrated.

The *external expert network* serves as a reliable source, not only as an information collection function but also as an information processing function. Information processing by expert occurs when non-specific information is evaluated and weighted in the context of SENSORIX. A small core network is already established and can now be included in the intelligence system. The enlargement of the network with other research laboratories, distributors, universities etc. is now possible because of the better integration in the management system.

The core element of the technology intelligence system is an adapted *opportunity landscape*, with the same functionality but reduced scope. The reduction from three to two observation areas makes sense, because a break down between 'current' and 'future' is sufficient. The use of functions instead of strategic fields allows SENSORIX to profit from its small firm size and a logical and reasonable configuration for the opportunity landscape includes the following functions of the firm: market, technology, competitors, network and production.<sup>105</sup>

Within the functional segments, different observation fields ('bubbles') were defined through a bottom-up process in participation with R&D, S&M, P&L and the management. At the same time the gatekeepers for each field were appointed. Since every function of the firm already

104. Cp. chapter A.10 on page 223

105. Results of a meeting with the technical director.

had its leader, the appointment of the gatekeepers was carried out quite efficiently by assigning these leaders to the corresponding ‘bubbles’ on the opportunity landscape. Figure 60 shows the generalized opportunity landscape of SENSORIX.<sup>106</sup>

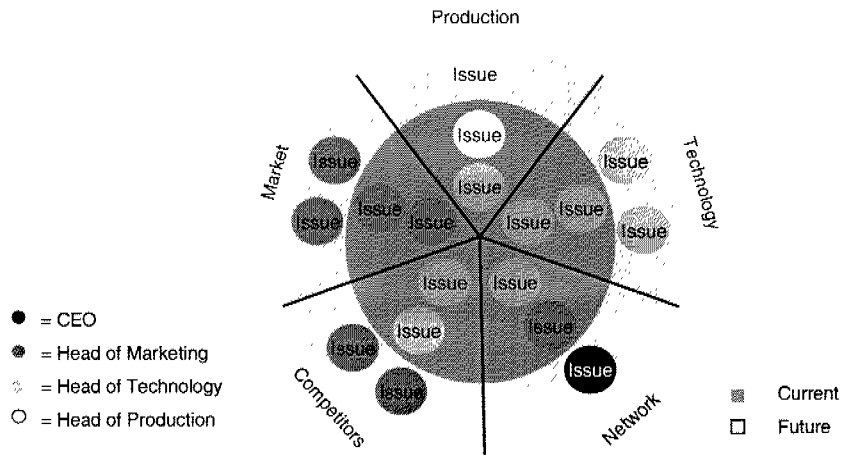


Figure 60 Opportunity landscape for SENSORIX

A technology intelligence matrix (Figure 61) was created in order to keep track of the intelligence work done within the opportunity landscape. Every ‘bubble’ (observation field) is summarized and under ‘remarks’ additional information is stored.

NTBF Function	Observation Field ('Bubble')	Observation Depth	Gatekeeper	Remarks
Production	Issue 1	Current	CEO	
	Issue 2	Future	Head Technology	
	Issue 3	Future	Head Production	
Network				
Market				
Technology				
Competitors				
	Issue n	Current	Head Marketing	

Figure 61 Technology intelligence matrix

106. Results of a workshop with the technical director and the CEO.

The *technology intelligence report* is the primary document for knowledge sharing and conservation. Every gatekeeper has to write a structured report according to the template shown in figure 62.

**TI Report**

Observation field:  
Gatekeeper:  
Date:

Description of insight:

Source / Contact:

Changes:

Potential applications:

Access to capabilities:

Gatekeeper's point of view:

Recommended action:

Attachments:

Figure 62 Technology intelligence report

This report contains the following information for each observation field ('bubble'):

- *Description of insight*: Which trends, signs or market chances were observed? Are they an opportunity or threat for the firm?
- *Source / Contact*: Which source could be used? How reliable are they?
- *Changes*: What kind of changes could be observed? Which future changes are expected?
- *Potential applications*: Which competencies may be affected by this insight? Does this insight call for new competencies?
- *Access to capabilities*: Disposes the firm over means to profit by these insights? Have new capabilities to be acquired (internally or externally)?
- *Gatekeeper's point of view*: What are possible strategic impacts for the firm?
- *Recommended action*: Which actions have to be taken? How can the firm react in order to profit from a new opportunity or how can the firm avoid a threat?

A *technology intelligence directory* on the company server ensures the knowledge conservation. All data from the single 'bubbles' has to be stored in the corresponding directory.<sup>107</sup>

The intelligence generating elements are now defined and necessary elements for organizational implementation have to be set up. To coordinate the gatekeeper's actions, a *technology intelligence project manager* is appointed, this task consists of organizing the technology intelligence meetings, nudging the gatekeepers to do their investigations and disseminating the results.

Two meetings deal with technology intelligence issues, the Technology intelligence Meeting (TiM) and the Interdepartmental Coordination Meeting (ICM).

In the semi-annual TiM meeting all gatekeepers participate and present news from their observation field. In the following discussion, insights from the gatekeepers are evaluated and the most important ones sorted out. In second step, the opportunity landscape itself is analyzed by removing obsolete 'bubbles' and introducing new ones. The technology intelligence project manager acts as a mediator in the TiM meeting and communicates the conclusions. After every TiM meeting the conclusions are shared in the ICM and reach every employee on this path.

#### **Technology Intelligence Process at SENSORIX**

This section describes the technology intelligence process. This process steers the information flow through the technology intelligence system consisting of the previously described elements.

*Formulation of information need:* Each 'bubble' in the opportunity landscape links specific information need with a responsible gatekeeper. Therefore it is about an explicit information need originating from a strategic need (formulated by the management) or from bottom-up stimulation through any employee, e.g. when a gatekeeper is asked for advice. Moreover, the gatekeeper may encounter additional information deficits on the search through various information sources.

*Information Collection:* It is the gatekeeper's responsibility and choice from which sources to acquire information. SENSORIX uses a broad range of formal sources, e.g. subscriptions to scientific and trade journals, internet publications, libraries etc. Often more specific and therefore more valuable informal sources are also more expensive to use. SENSORIX attends seminars, fairs and conferences. Very important information is gained from customers and thus motivated SENSORIX to open different sales offices worldwide. Another important source is the expert network, which is nurtured primarily by the management. SENSORIX also taps the investors' knowledge and experience.

*Information analysis:* The acquired information is analyzed individually by the gatekeeper and collectively in the TiM meeting. Beside the technology intelligence report, the use of analysis tools is up to the gatekeepers, however due to the limited area of analysis, sophisticated tools are

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107. Results of a third workshop with the CEO and the technical director.



seldom necessary. For the collective analysis in the TiM meeting the opportunity landscape is applied to create transparency and structure the intelligence effort.

*Information dissemination and application:* The technology intelligence project manager is responsible for disseminating of intelligence insights out of the TiM. Over the ICM channel all employees are reached in a knowledge push process. It has to be considered, that about a quarter of the whole staff participates in the TiM resulting in a considerable knowledge dissemination and organizational learning process. Since the management is fully integrated in the intelligence process, the application of the generated insights occurs either right at the TiM meeting or in the following board meeting.

The entire technology intelligence process is depicted in a flow chart (Figure 63), that is compatible with the ISO 9001 process oriented management system.

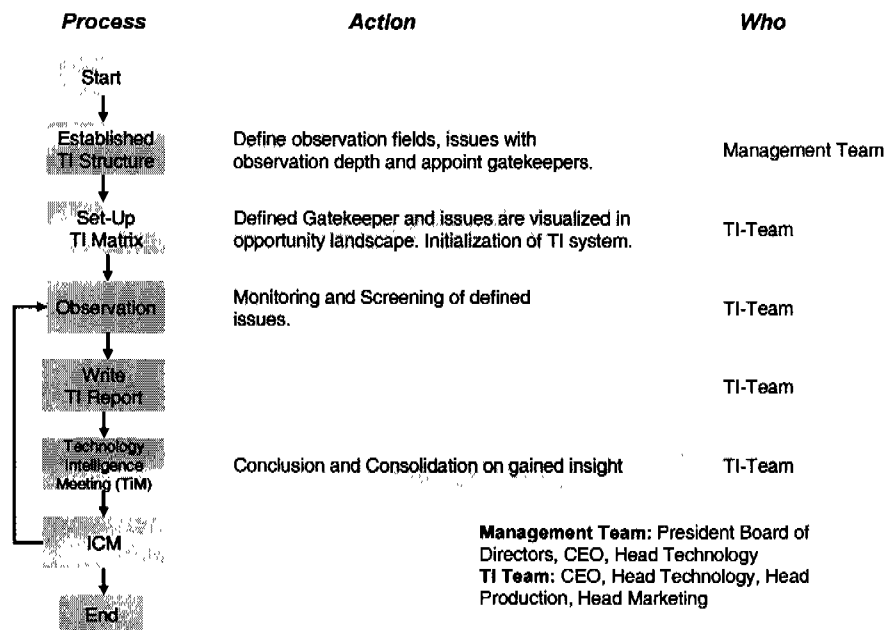


Figure 63 Flow chart of technology intelligence process at SENSORIX

### Implementation of the Technology Management System

As already mention, the technology intelligence system was developed in close cooperation with the technical director and the CEO of SENSORIX. To implant this system, in an initial workshop, the concept was explained to all gatekeepers and remaining overlaps were removed. The system was then operable and the next meeting was already a true gatekeeper meeting.

### **Interaction with the Business Strategy**

The technology intelligence system interacts in two ways with the business strategy:

- The business strategy defines the purpose of the technology intelligence. In the technology part of the strategy it is stated, that SENSORIX works with cutting edge technologies based on internal competencies and network relations. Therefore a technology intelligence system makes current and future trends available to support cutting edge technologies and network relations.
- The intelligence system delivers essential information to develop future strategies. Emergent trends from various sources have to be captured and integrated in the decision making process. Therefore, the technology intelligence project manager is part of the management team in order to guarantee a smooth information flow.

### **5.2.3 Reflection on the Technology Intelligence System**

In this research project, the technology intelligence in SENSORIX shifted from a reactive to a proactive system. The starting point of this project was where reactive technology intelligence activities were analyzed. SENSORIX checked its environment whenever information was needed. The new system allows SENSORIX to observe its environment more systematically. Information needs are explicitly defined and sought.

The fact that SENSORIX works with a sophisticated technology in global markets requires more than just a reactive look around. Therefore it was a strategic concern to improve the scanning activities and at the same time use existing networks more efficiently.

The question of whether such a system is worth the investments of time and other resources is probably the most important one for every management system. The invested resources may be quantified in time spent on the project. For every TiM meeting about five gatekeepers devote time for the meeting and its preparation. Even though, this time cannot be considered additional, because people were already seeking for information. So in an overall consideration, a structured technology intelligence system does not really consume more resources but the result is of much higher quality, therefore justifying the investment by better quality for the same effort.

As a final reflection on this technology intelligence system, the question of whether it is plausible and recoverable has to be raised. As a matter of fact, this system was accepted by SENSORIX and smoothly integrated in to the firm's management system. Therefore it seems to be a plausible solution. The development process had no particular specialty and is supposed to be recoverable under comparable circumstances.

### 5.3 TECHNOLOGY STRATEGY FORMATION AND IMPLEMENTATION

Research on strategy formation and implementation took place in three different companies. The pom+ case focuses on annual repetitive strategy process and its integration into NTBF management. The Art of Technology case illustrates especially how strategic ideas are transferred into an action plan which is in alignment with the NTBF's resources. The last case at Degradable Solutions shows how decisions about disruptive technologies are prepared and realized. These three cases illustrate technology strategy formation and implementation (process and content) within NTBFs. A cross case comparison and reflection on findings conclude this section.

#### 5.3.1 pom+

##### 5.3.1.1 Enter the Real World Challenge at pom+

The starting point for this action research was the existing management system at pom+ that defines the scope of all management processes. The goal of this project is to enhance the strategy formation and implementation process.<sup>108</sup>

Initially, all involved parties have to be identified. The final responsibility for changes in the management system is borne by the administrative board (company co-founder and investors). Therefore, changes affecting the strategic and normative level have to be accepted by the board. For the executive board, the CEO who is co-founder and four additional members, it is important to possess an efficient management system. Both sides have to contribute to a successful strategy formation and implementation; logically they have to be integrated in the management system. Entrepreneurial strategy formation and implementation is achieved by blending the administrative and executive board's effort.

Together with the employees of pom+, a strategy formation process based on current literature was adapted to pom+ by combining and adapting existing strategy process elements. Martin Luggen, Stefan Kessler and Bernhard Wicki<sup>109</sup> spent approximately 110 days in the company for interviews, workshops, presentations, meetings, desk research and analysis work.

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108. The most important factor in the pom+ strategy is the deployment of capabilities to provide the customers new superior services, therefore its strategy is basically a technology strategy.

109. The strategy formation process is part of their diploma theses at the ETH-Center for Enterprise Science (Kessler, 2002; Wicki, 2003).

### 5.3.1.2 Solution for pom+

The solution for pom+ consists of a strategy process with tools to operate it.

#### Strategy process

The presented solution is the result of several meetings with the administrative board and leading employees of pom+. The solution represents four elements: Timetable, entry in the management system, document templates and instructions with tools and methods (see figure 64).

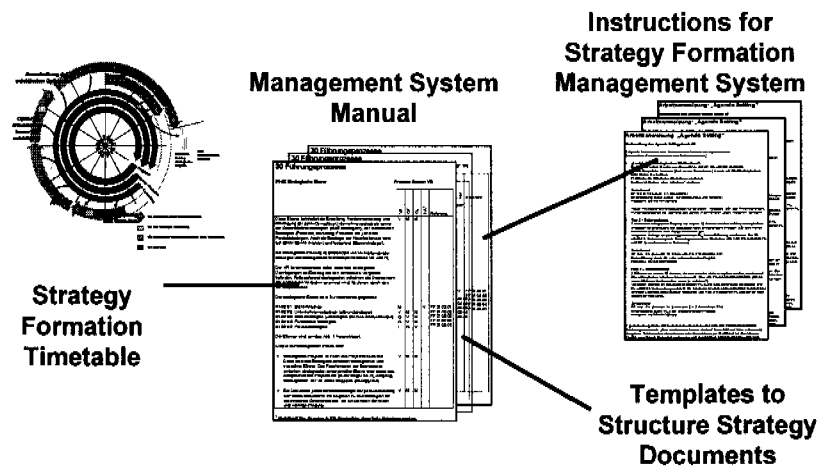


Figure 64 Elements of strategy formation and implementation

The core of the solution constitutes the *management process manual*,<sup>110</sup> which contains the regulation of responsibilities, process structures, management control, inclusion of emergent strategies and strategic reactions. This manual also defines the interfaces between the normative, strategic and operative management.

The second element are *instructions* that include a detailed description of the process with adapted tools and methods. These instructions are additional working guidelines for the required tasks in the management system and may be summarized as follows:

- *Agenda setting*: This step defines strategic priorities and sets meetings and deadlines.

110. This document is named 'FP 31' for 'Führungsprozess 31'. It is located in the company planning section of the management system.

- *Strategic goals:* Strategic goals are defined in relation to the company's vision and external trends. Trends are captured by the executive board through different technology intelligence methods.<sup>111</sup> With the strategic goals, possible paths are formulated.
- *Analysis:* In this step, the internal and external environment concerning the strategic goals is analyzed and resulting strategic options are formulated. Possible analysis tools are SWOT, portfolio analysis, scenario analysis, mystery shopping etc.<sup>112</sup>
- *Valuation and selection of strategic options:* Strategic options are validated and selected with the EFQM-model, to value options objectively.
- *Development of the selected options:* For each selected strategic option, resources are allocated and projects are defined. Because this is the only step that shows the consequences of the selection of a strategic option, changes in the previous steps are possible.
- *Implementation:* The defined projects are fed to the existing project management at pom+. If there is a resource shortage, resources are shifted from strategic projects to customer projects until the administrative board decides to change priorities.

Strategic control, immediate strategic reaction and inclusion of emergent strategies are discussed in chapter 5.4.2.2 on page 136.

Element of Strategy	Current State	Objective (3-5 years)	Path
Core Competencies			
Unique Selling Propositions			
Strategic Business Fields			
Key Products			
Strategic Projects			
Human Resource Strategy			
Marketing			
Finance			
Organization			

Figure 65 Template for collection of strategic relevant information

111. Cp. chapter 5.2.2 on page 115 (case SENSORIX)

112. Cp. chapter A on page 211

The third element is a *template* (Figure 65) to structure knowledge about important aspects of the strategy such as competitive advantage, technologies, target markets and core competencies. Each aspect is divided in a description of current state, a description of future state (3-5 years) and strategic path. The idea behind this document is to force the management to write down the strategy. Regular discussions about these strategic aspects allow gaps to be discovered and new ideas to be generated.

The last element is a *timetable* (Figure 66) that shows all process steps and milestones in the course of the year. It is an orientation permitting the management to pace strategic decision and provide the necessary background information.<sup>113</sup> During the 'jour-fixe' every employee is asked to contribute to the strategy out of his or her experience.

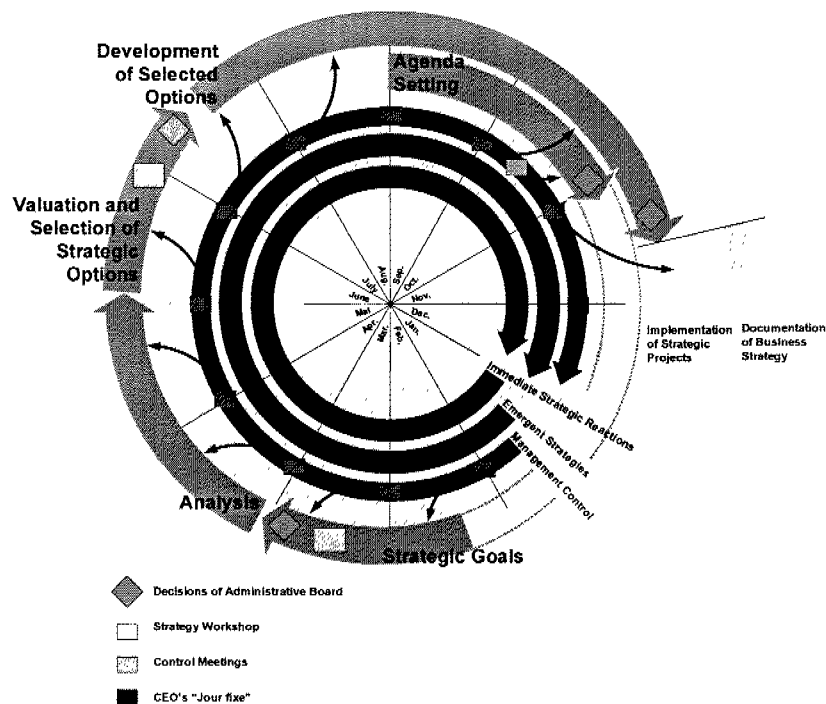


Figure 66 Timetable for the strategy formation process

### Priorities of the CEO

When thinking about strategies for NTBFs, the saying that 'one product order is worth more than a thousand strategies' is normally very true. A similar question was raised within pom+,

113. Providing background information is part of the intelligence task.

namely what pom+ should do first. Do client projects have priority over strategic projects, implying that resources from long-term strategic project would be shifted to temporary customer projects. The other extreme is giving strategic projects priority over short-term customer projects.

Giving priority to strategic projects does not correspond with the customer orientation of pom+. On the other hand, if customer projects are prioritized, strategic projects will struggle, because there are always customer projects, and if not, there is a need for more acquisition. This puts the management in a permanent dilemma. Therefore, customer projects have priority in the case of a resource shortage. The administrative board then gives a priority rating to each strategic project and decides which projects have to be pursued. In this way, the administrative board actively coaches and controls the management.

### **5.3.1.3 Implementation of the Strategy Formation Process**

One important question for the implementation is what the time period should be when the company has to pass through a strategy process cycle. Too long of a cycle reduces the flexibility and entrepreneurial advantage, while too short of a cycle consumes too many resources. A strategy cycle of twelve month seems to be most appropriate.

It is planned that the CEO will spend about 15% (32 workdays) of his work-time on strategy formation and 5% (16 workdays) on the implementation of strategic projects. These 32 CEO workdays for strategy formation and implementation also include technology intelligence activities. The rest of the executive board (four members) also spend a certain number of workdays working four strategic purposes.

This process was accepted by the involved persons and now serves as a backbone of pom+'s strategy formation and implementation.

## **5.3.2 Art of Technology**

### **5.3.2.1 Enter the Real World at Art of Technology**

Strategy as a plan that contains Art of Technology's goals and actions exist since the foundation and every year new actions are integrated. In the meantime various patterns have evolved within the company such as organizational behavior, firm structures, technological knowledge etc. The need for a more extensive strategy formation and implementation has emerged. Therefore, the annual strategy meeting has been extended to a day-long strategy workshop.

This workshop was prepared and moderated by the CEO Rolf Schmid and by Martin Luggen during several meetings.<sup>114</sup>

### 5.3.2.2 Solution for Art of Technology

Before the actual strategy elaboration is initiated, a reflection on the previous year's strategy meeting is very important. This allows every participant<sup>115</sup> of the workshop to recapitulate strategic concerns of the NTBF and at the same time important information is analyzed. Everybody's experiences and current sales performance are aggregated. Looking backward is the most copious part of the workshop, because a lot of unstructured information is processed and prepared for the more creative looking forward part.

As an initial step, *strategic goals* are defined according to the Art of Technology's mission and the findings from the strategy review. Therefore, the position in the value chain, the market segmentation and organizational structures are revised.

In the next step, *strategic options* are proposed. A SWOT analysis<sup>116</sup> serves as an argumentation basis, where Art of Technology's strengths and weaknesses (technology, products, marketing, company culture, organization etc.) are confronted with opportunities and threats (customer behavior, market development, competitors, interfirm network, politics etc.).

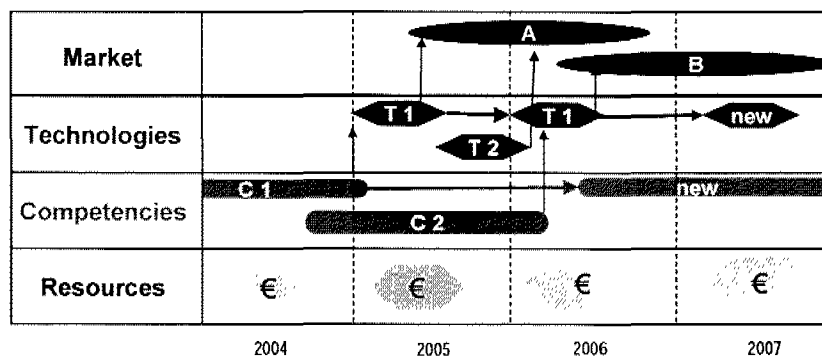


Figure 67 Product roadmap for Art of Technology

114. Those meeting were carried out in an informal and creative way The results are integrated in the proceeding strategy workshop.

115. Executive board (three members), representative of the administrative board and partially the sales agent.

116. Cp.chapter A.11 on page 227



Now a *strategy* can be formulated with the strategic options. A technology roadmap facilitates aligning resources, competencies, technologies and markets (Figure 67). It is only in this step that the complicated nature of strategic planning is demonstrated in an NTBF. High market uncertainties, due to project dependencies, render detailed planning complicated. Nevertheless, important connections between markets and technologies are recognized and appropriate measures are defined. It is also during the roadmapping processes that strategic options are reformulated or dropped because of resource shortage or limited feasibility.

As a last step, an *action plan* to implement strategic decisions has to be formulated which will transfer strategic insight into executable projects. These projects are grouped in competitive and firm development projects. Competitive activities deal with relation with buyers and suppliers, new competitors, substitute products and competition amongst established firms. Firm development projects consider organization, quality management, infrastructure, human resources and administration. For every planned project, logical steps are formulated and milestones set. This action plan and the roadmap are the only physical results that are carried away from this strategy workshop.

### **5.3.3 Degradable Solutions**

#### **5.3.3.1 Enter the Real World at Degradable Solutions**

The mission of Degradable Solutions contains a precise technology statement that not only underscores the importance of technology, but also describes which technologies to use for specified purposes. This mission serves to reach long-term firm objectives.

Degradable Solutions has a lot of project ideas. Project selection occurs ideally according to the mission. Unfortunately, the resource situation often requires decisions based upon customer demands, e.g. a customer wants a specified solution and hence pays for the development. This fact narrows the range of strategic possibilities.

The Degradable Solutions technology strategy has to account for both, long-term strategic objectives and short-term project decision. In the best case, these two drivers are perfectly aligned.

Technology strategy for Degradable Solutions was developed in several workshops with the CEO and leading employees over a period of six month. Martin Luggen spent about 30 days at Degradable Solutions.

### 5.3.3.2 Solution for Degradable Solutions

The given circumstances require very flexible technology planning in the short term because customer projects change often. On the other side, technologies and products to be developed in the long term have a disruptive character and consume a lot of resources. Degradable Solutions grows with the long-term technology objectives, the short-term projects generate resources to pursue long-term objectives. Therefore the short and long term objectives have to be classified and aligned, to enhance the overlap. Product functions are a useful common denominator between those two focuses. Two management tools are examined that work with product functions.

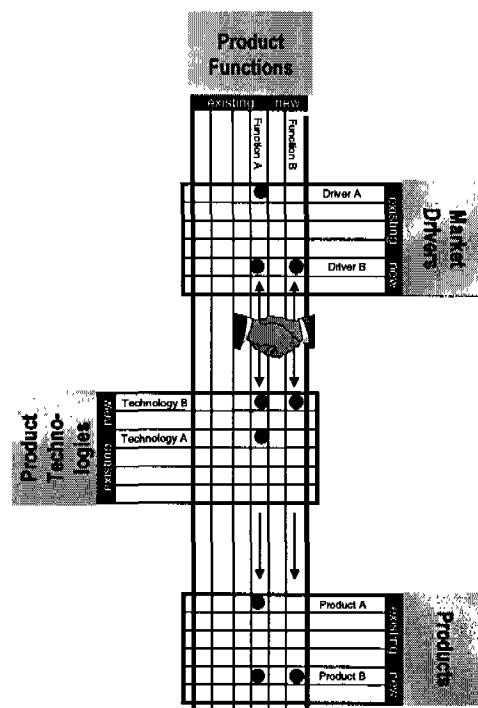


Figure 68 Hand Shake Analysis (HSA) for NTBF

The first tool is the hand shake analysis (HSA).<sup>117</sup> All product functions with the corresponding product and process technologies are listed and product functions are defined. For a technology-driven firm, market knowledge is normally very rare and contains a lot of assumptions. The translation of technology functions to market needs over product functions allows a more precise market / customer inquiry. It turned out that it is not necessary to elaborate

117. Cp. chapter A.3 on page 213

the technology side of the HSA because the results present no new findings. This leads to a simplified HSA for technology-based NTBFs that links only product technologies with market needs (Figure 68).

As second tool, a technology roadmap was developed. The starting point was a standard roadmap<sup>118</sup> which could be filled in with the findings from the HSA. Additional to the HSA the roadmap enables the consideration of resources and future developments (Figure 69). The roadmap approach was quite straight forward without being too detailed. In this step, existing projects were rethought and structured. New projects were set-up and integrated in the flow of existing projects. Setting milestones and allocating resources were the most difficult part of the project. Out of their past experience, the development of a technology project is difficult to estimate because it contains a lot of uncertainties that greatly influence milestones and necessary resources.

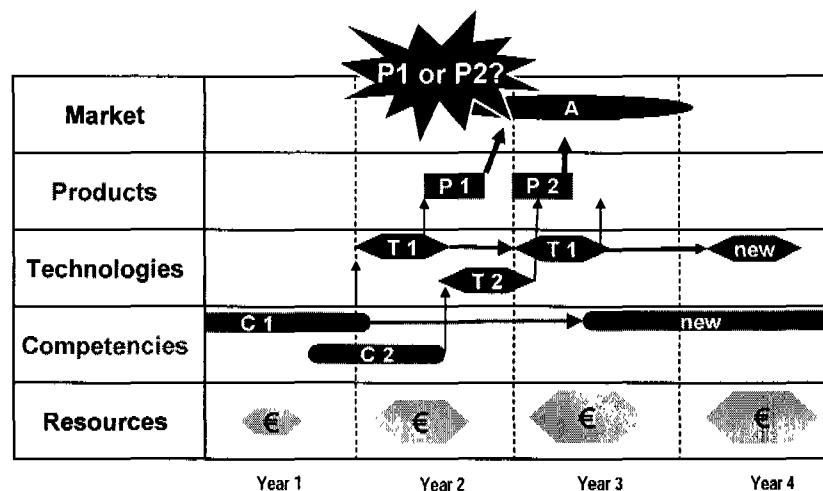


Figure 69 Roadmap for Degradable Solutions

Here again, missing information from the market side leads to several assumptions. This information is now collected in a tedious way from outside experts, such as clinicians, opinion leaders etc, and added continuously to the roadmap. The roadmap was very useful for accomplishing a better understanding of R&D development. The contribution to an on-going in-depth market analysis is even more important.

### 5.3.4 Reflections on Technology Strategy Formation and Implementation

These three cases show different strategy formation and implementation in NTBF processes. Table 4 compares the different cases.

Dimension	Pom+	Art of Technology	Degradable Solutions
Communication	Formalized communication path along strategy formation	One workshop with all involved persons invited	Informal
Learning	Learning possibilities stated in the process	Strategy formation as learning process	Strategy formation as learning process
Entrepreneurial Opportunity Seeking	Every employee is asked to contribute ideas (journ-fixe). Emergent strategies are explicitly considered	Permanent; the best opportunity is always chosen	Permanent; most actions are a result of found opportunities
Collaboration	Executive and administrative board	Management team	CEO and most affected employees
Support processes	Technology intelligence and control	Action plan to control strategic decisions	Implicit technology intelligence requirements as a result of strategy formation
Strategic Path	Slow growth with own resources (type A)	Customer project oriented growth with own resources (type A)	Technology leadership approached in a market niche (type A)
Expense	20% of CEO work time devoted to all strategy related work, including technology control and intelligence	One day workshop for the management team (4 persons) with preparation and postprocessing	On the spot. No estimation possible

Table 4 Comparison of important dimension across the three cases

#### Strategy Formation and Implementation Process

Pom+ has a highly elaborated formation process, which is a permanent concern for the management team. The CEO is supposed to spend about 20% of his work time on strategy formation and implementation. This process includes not only strategy formation itself, but also acquisition of intelligence information and management control.

The Art of Technology approach focuses on the development of the strategy itself. After refreshing one's knowledge about the last planning cycle, the adapted strategy set-up quite straight forward. As a matter of fact, during the roadmapping process, more questions are raised than answered. This might lead to question the tool, but in a closer look, the new questions are the key to the future development of Art of Technology. This corresponds to an explicit formulation of technology intelligence needs.

The action plan fulfils a double function. Allocating resources to different projects indicates whether the strategy is feasible or not. If the resource cannot even be allocated on paper, it is almost impossible for it to be allocated in daily business. The second function of the action plan is the diagnostic control function.<sup>119</sup> In defining the impact and deadline of projects, they become controllable. At the same time responsible persons for each project are assigned.

The Degradable Solutions case underscores the challenges of obtaining and reacting to reliable market information. Technologies are well understood and do not need any formalization effort, but management tools that are based on product functions accomplish a better market understanding.

#### **Particularities of Each Case**

Pom+ has a remarkable strategy formation and implementation organization with a permanent year round strategy concern of the NTBF management. A year-long strategy development cycle with different meetings has a lot of space for organizational learning. The CEO considers this new process as very useful because it helps to keep strategy going along with the daily business. Responsibilities are clearly defined.

Art of Technology shows that for an NTBF it is also worth making the effort to formulate a solid systematic strategy with an action plan. Even though existing ad-hoc approaches were accurate, they could not cope with rising complexity due to the growth of the firm. A more systematic approach helps to optimize the price / performance ratio for strategy formation and implementation.

In the Degradable Solutions case, the NTBF has to operate within the dilemma between generating resources and executing a long-term product strategy. Simultaneously, possesses the firm plenty of technological knowledge but not enough market knowledge. During the strategy formation process this gap has to be closed with tools, that help to understand customer needs.

The used strategy formation and implementation processes were adapted to the needs of NTBFs from standard processes.<sup>120</sup> The successful application in the context of the NTBF implies that this adaptation is plausible and recoverable as basic criteria for validity of action research.

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119. Cp. chapter 2.4.3 on page 68

120. Cp. chapter 2.2.4 on page 25

## **5.4 TECHNOLOGY MANAGEMENT CONTROL**

Action research on technology control system was carried out at SENSORIX and pom+. The first case illustrates the integration on control systems in the firms' management systems, while the second case describes detailed control processes.

### **5.4.1 SENSORIX AG**

#### **5.4.1.1 Enter the Real World at SENSORIX**

As illustrated in chapter 5.2.2 on page 115, SENSORIX is about to formalize its technology intelligence process. SENSORIX has a strategy with a detailed action plan and strategic projects. The logic consequence is the question: How can SENSORIX evaluate the efficiency of these measures? How can an NTBF judge its management actions?

These questions indicate the need for a simple management control system for strategic issues, with the primary functions being to acquire monitoring information and compare strategic targets with effective impacts. The developed system synthesizes existing concepts<sup>121</sup> and preconditions at SENSORIX. In order to optimize the price / performance ratio, overlapping management practices are integrated in the controlling concept, e.g. a technology intelligence system. This system was elaborated in close cooperation with the management of SENSORIX. Martin Luggen and Alexander Luft<sup>122</sup> spent about 60 days in the company for interviews, workshops, presentations, meetings, desk research and analysis work.

#### **5.4.1.2 Solution for SENSORIX**

The management control system focuses on the objectives fixed in the action plan in the sense of a diagnostic control system. On the other side an interactive management control system includes the output of the technology intelligence system and relates it with the strategic intentions. The two system are depicted in figure 70.

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121. Cp. chapter 2.4.3 on page 68

122. The technology management control process is part of his diploma theses at the ETH-Center for Enterprise Science (Luft, 2003).

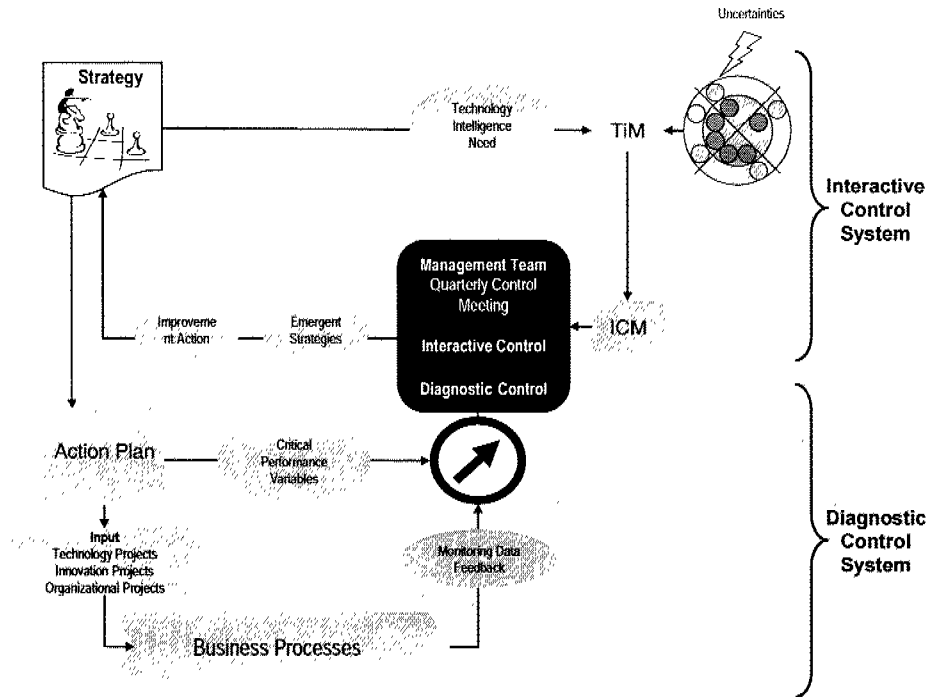


Figure 70 Interactive and diagnostic control system

Included in the *diagnostic technology control systems* are business process activities monitored by the management team and a feedback is generated that reports on the improvement of critical performance variables, which are defined in the action plan.

In a quarterly control meeting the management team analyzes the collected feedback. The goal of this meeting is to compare current and planned advancement according to the critical performance variables defined in the strategy and action plan. If major deviations occur, adequate actions to reach the planned objectives are taken in the form of new actions or changes in the resource allocation.

The *interactive control system* pays attention to strategic uncertainties (internal and external) and guides emergent bottom-up strategies or actions. Business process activities are evaluated with the diagnostic control system to determine if they support a successful strategic positioning of SENSORIX. The interactive control system includes the following actions:

- Possibility to *abandon* technology projects
- Possibility to *learn*, for example by means of cooperation

- Possibility to *extend* by enabling future growth, for example through R&D-measures and new applications
- Possibility to *consolidate*, for example in the case of technological risks or new customer situations
- Possibility to *change*, for example the substitution of technologies
- Possibility to *delay*, for example in case of a resource shortage

The management has to clarify which options increase the competitive position of SENSORIX

most. The flow chart in figure 71 illustrates the entire control at SENSORIX.

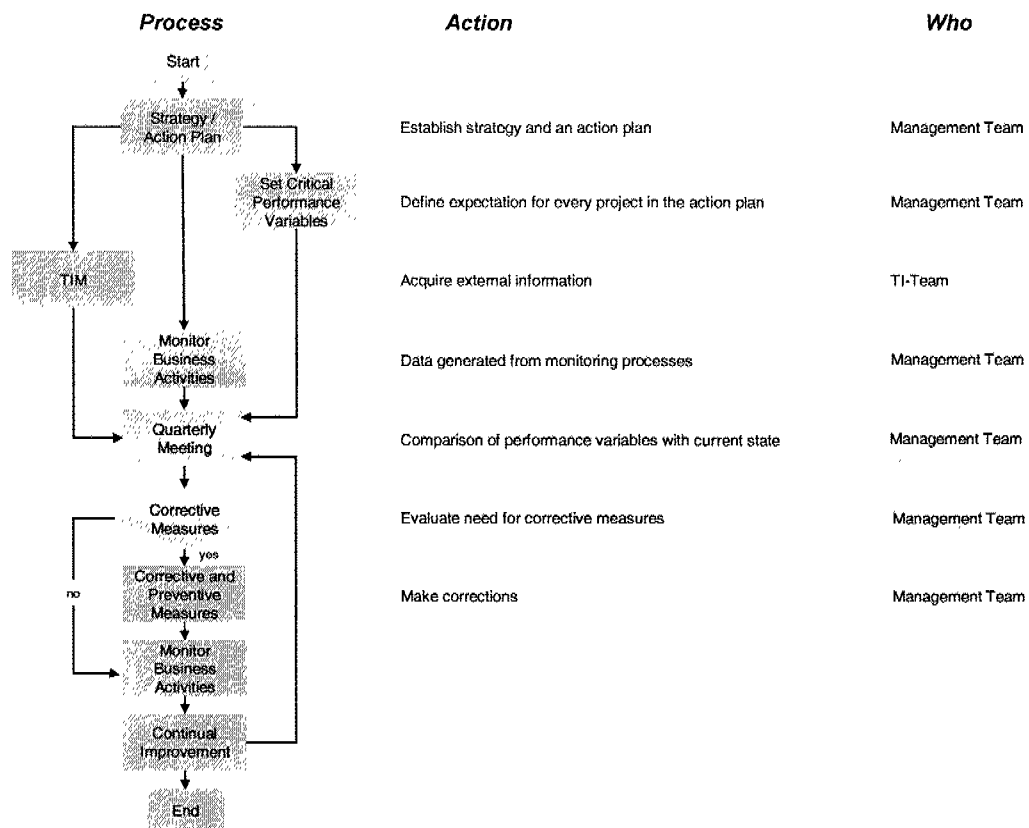


Figure 71 Flow chart of technology control process



## 5.4.2 pom+

### 5.4.2.1 Enter the Real World at pom+

Pom+ possesses a well formalized strategy formation and implementation process as illustrated in chapter 5.3.1 on page 122. Consequently, parallel to the strategy formation and implementation process, a continuous controlling process has to be set up, which is the starting point for this research project. The focus of the control system is to support strategic activities by monitoring key figures and taking appropriate actions, e.g. develop emergent strategies. As matter of fact, the reality of an NTBF can only basically be described in key figures, therefore qualitative reports that also include soft factors are much more valuable.

Together with the management team of pom+, a technology management control process based on current literature was adapted to pom+ by combining and adapting existing control elements. Martin Luggen, Stefan Kessler and Bernhard Wicki<sup>123</sup> spent about 110 days in the company for interviews, workshops, presentations, meetings, desk research and analysis work.

### 5.4.2.2 Solution for pom+

The management control (which includes technology control) of pom+ distinguishes between three different levels: Strategic planning control, strategic project control and strategic impact control. In addition to these control levels, pom+ developed a process for immediate strategic reactions and the integration of emergent strategies. The management control system is depicted in figure 72.

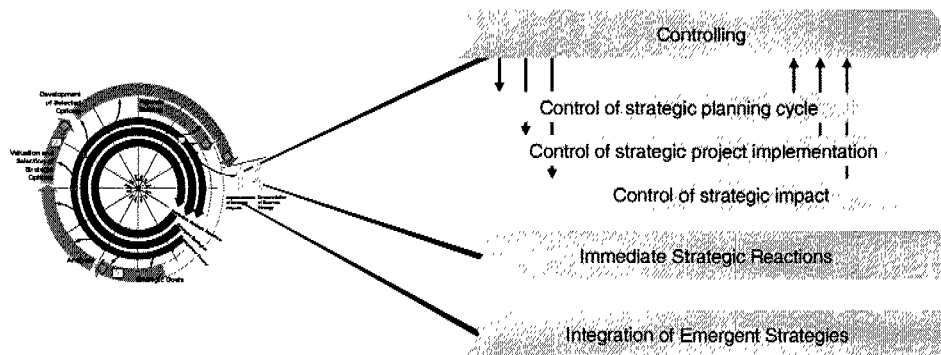


Figure 72 Management Control System at pom+

123. The technology management control process is part of their diploma theses at the ETH-Center for Enterprise Science (Kessler, 2002; Wicki, 2003).

*Control of the strategic planning cycle:* This control level looks at the development of the strategic planning cycle, including the detection of delays and deviations from the initial agenda.<sup>124</sup> This job is done by the CEO through frequent checks on the different steps. For as long as possible, the CEO tries to keep the planning process running. Only when this is no longer possible, is the administrative board consulted.

*Control of strategic project implementation:* This control level monitors the implementation of strategic projects. At the initiation of strategic projects, deliverables are defined that enable a qualitative judgement of project improvements. Additional quantitative key figures are the number of new customer contacts, the number of new work orders and the number of customer projects that profit from the strategic projects. The state of every strategic project is reported to the administrative board.

*Control of strategic impact:* This control level gathers the impact of the strategy in relation to its expectations. For every strategic option, the administrative board sets some objectives to evaluate its impact. On this level, the administrative board rethinks the underlying beliefs of the strategy. To do this, the administrative board controls the strategy once a year by comparing expectations and outcome.

*Immediate strategic reactions* are necessary if internal or external changes occurred that make the parts of the existing strategy obsolete. If unexpected occurrences are registered, the CEO and the administrative board have to react, either with temporary actions or with the initiation of new strategy projects. As an on-going process, the business intelligence process observes the following business fields:

- *Markets:* Through customer contacts and projects, a permanent flow of information is generated.
- *Competitors:* Activities of every potential competitor are observed through reports, lost work orders, mystery shopping, etc.
- *Technologies:* Relevant technological trends are reported to the management by the knowledge champions. Knowledge champions are employees who are expert in certain domains.
- *Customer satisfaction:* Fact finding is done through questionnaires at the end of every customer project.
- *Employee satisfaction:* Three annual appraisal interviews capture the mood among the employees.

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124. Cp. chapter 5.3.1.2 on page 123

- *Resource availability:* Available and used resources are constantly monitored.

*Integration of emergent strategies* allows new opportunities which occur in contradiction to the intended strategy to be immediately realized. Purely predicted strategies are uncommon for NTBFs, therefore entrepreneurial opportunities have to be recognized and a pattern of actions established. With the business intelligence process described above for strategic reactions, pom+ tries to recognize emergent opportunities and exploit them with a pattern of actions. The CEO has the competence to reallocate the necessary resources to set up an adequate pattern of action.

### 5.4.3 Reflection on Technology Management Control Systems in NTBF

The technology management control system at SENSORIX represents a simple system that integrates all important control elements. In order to minimize the expense in management time, the technology control activities are organizationally closely linked to the technology intelligence activities, e.g. the same persons involved, same meetings etc. Lean control and intelligence structures allow SENSORIX to take efficient and effective strategic reactions to internal and external changes which is essential for NTBFs. The existing informal control activities are replaced by a diagnostic and interactive control system.

The technology control system at pom+ is based on five processes that are closely linked to the strategy process. This allows, as at SENSORIX, expenses in management time to be minimized. Important are the explicitly mentioned strategic reaction and inclusion of an emergent strategies process. Those processes underscore the importance of flexible and adaptive behavior for NTBFs in order to cope with established competitors. The control system at pom+ includes not only diagnostic and interactive control levers, with the 'control of strategic impact' process pom+ disposes of a control lever that looks at the firm's boundary system.

Table 5 shows a cross case pattern search between technology control systems at SENSORIX and pom+.

Dimension	SENSORIX	pom+
Planning control	SENSORIX does not need planning control, because it designs its strategy in one workshop	Control process that checks on planning activities
Realization of strategy control	Diagnostic control system that controls whether strategic intentions are realized and how they advance	Control process for the advancement of strategic projects
Strategic impact control	no	Process that questions strategy itself

Dimension	SENSORIX	pom+
Strategic reactions	Action as soon as changes are recognized. Partially formalized process	Explicit processes for strategic reactions and integration of emergent strategies
Control parameters	Critical performance variables as defined in the action plan, e.g. number of workshops, number of customer contacts, orderliness on the file server, etc.	Pace of the planning cycle, number of new customers, number of work orders, number of strategic relevant customer projects, customer satisfaction, employee satisfaction, resource availability, performance of markets, competitors and technologies
Linkage with other technology management elements	Technology intelligence and technology control systems are organizationally not separated	Technology control system builds on strategy formation process and technology intelligence
Expense	Quarterly control meeting for management team	Part of the 20% CEO work time for strategy formation and implementation

*Table 5 Technology control system cross case pattern search*

The action research cases at SENSORIX and pom+ revealed interesting findings about control activities in NTBFs. The two systems are integrated in the firms' management system, what leads to the conclusion that they are recoverable and plausible.

## 5.5 KNOWLEDGE MANAGEMENT

It is probably not very reasonable to approach the wide field of knowledge management with single approach. Therefore, the following three action research cases describe different solutions based on a generic process of managing organizational knowledge (Probst, Raub & Romhardt, 1999).<sup>125</sup> The solution for SENSORIX is composed of an overall process with different formal and informal sub-processes. Art of Technology utilizes of a knowledge management matrix and Degradable Solutions builds on a house of knowledge management.

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125. Cp. chapter 2.4.4 on page 73

## 5.5.1 Art of Technology

### 5.5.1.1 Enter the Real World at Art of Technology

Art of Technology already performs several knowledge management activities and it also has a process based management system. Art of Technology wants to consider knowledge management aspects as part of their management system, therefore elements of knowledge management have to be integrated in management, support and value creation process.

The management process directs the activities by setting strategic knowledge goals, setting priorities and defining action in the action plan. Knowledge management activities in the support and value creation process are driven by object and cost orientation. Hence key requirements are:

- Integration in daily business
- Good price / performance ratio for all participants
- Adaptation to NTBF circumstances

To elaborate a knowledge management system for Art of Technology, Martin Luggen and Stefan Haas spent therefore about 60 days in the company for interviews, workshops, presentations, meetings, desk research and analysis work.<sup>126</sup>

### 5.5.1.2 Solution for Art of Technology

As an initial step towards developing a knowledge management system, a matrix to categorize existing and new knowledge management activities, processes, methods and tools were established. This matrix is spanned by the human, technology and organizational dimensions versus the management of the organizational knowledge base process (Figure 73).<sup>127</sup>

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126. The knowledge management system is part of his diploma theses at the ETH-Center for Enterprise Science (Haas, 2003).

127. Both dimensions are illustrated in chapter 2.4.4 on page 73.

	Knowledge Goals	Knowledge Identification	Knowledge Acquisition	Knowledge Development	Knowledge Distribution	Knowledge Use	Knowledge Preservation	Knowledge Measurement
Human	Appraisal Interview	Employee Profile	Journals Conferences Partners	Projects	Meetings, informal talks	Know How Action Workshop	Project files	Appraisal Interviews & group control
Organi- zation	N/A	N/A	Journal Corner	Projects	Coffee room, lunch, meetings	ISO Checklists	Lessons learnt	N/A
Technol- ogy	N/A	N/A	Database, internet	Shared project files	Shared project files	Shared project files	Search engine	N/A

Figure 73 Knowledge management matrix at Art of Technology

The knowledge management system is illustrated along the process of managing the organizational knowledge base.

**Knowledge Goal**

The organizational knowledge goals exist primarily in the heads of the management team. To formulate these goals explicitly, Art of Technology differentiates between normative, strategic and operative knowledge goals. Normative goals support the company culture, strategic goals nurture the technical knowledge and operative goals optimize the value creation and support processes.

On the *normative level*, guidelines to sustain a knowledge culture are set and checked in an annual meeting. These guidelines deal with issues such as importance of professional training, fault tolerance, innovation efforts, common values etc. On the *strategic level*, a knowledge portfolio<sup>128</sup> is elaborated in alignment with the technology strategy.<sup>129</sup> On the *operative level*, with the ‘know-how action workshop’,<sup>130</sup> employees’ knowledge interests are balances with the goals. Additionally, during annual appraisal interviews personal knowledge goals are evaluated.

**Knowledge Identification**

The management team and the employees know quite well about who knows what. A knowledge profile is generated for every new employee and is updated in the appraisal talks.

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128. Cp. chapter A.7 on page 220  
 129. Cp. chapter 5.3.2.2 on page 127  
 130. Cp. chapter A.6 on page 219

### Knowledge Acquisition

Conferences, fairs, project partners and journals are an important knowledge sources. There are no responsibilities set to classify gained information, in other words, information is not transferred into organizational knowledge. Therefore two measures are taken. Firstly, a central database to store customer, supplier and partner contacts is established. Secondly, a system to capture relevant scientific journal content is designed. Basically, all subscribed journal are available in the coffee room. But an efficient use of journals needs four steps: Journal selection, individual reading, filing and retrieving (Figure 74).

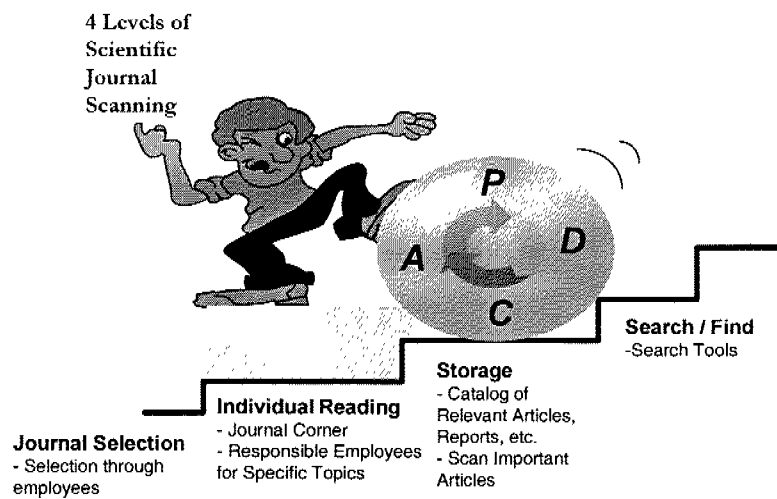


Figure 74 Four levels of scientific journal scanning

Once a year, journals are selected and for every journal a person in charge is set. Journals are available for individual reading with a circulation list. On this list, interesting articles may be mentioned and suggested for digital filing. After a full circulation, the person responsible for each journal scans the interesting articles and stores them on a central file server. With a search engine, digital documents may be relocated for later use.

### Knowledge Development

Work is considered as very interesting and knowledge is developed within various projects. Project meetings and shared files allow everyone to profit from the advantage of being small with an efficient knowledge development.

### Knowledge Distribution

Common lunch and coffee breaks are an important informal platform to share knowledge, regular meetings are on a more formal platform to share knowledge. Additionally, a communication and learning culture is encouraged.

### Knowledge Use

Efficient internal knowledge dissemination and sharing is one key advantage of the NTBF. Implicit and explicit knowledge is shared through different files and manuals, but even more through intensive communication. Most documents exist also in a digital copy that is why search tools to find files on the company server are necessary. Most commercial search engines are too expensive and offer too many unnecessary features. The most appropriate search engine based on price / performance was SerGlobalBrain.<sup>131</sup>

### Knowledge Preservation

Knowledge preservation is explicitly defined in the ISO 9001 management system with project files, data sheets, SOP<sup>132</sup> and improvement actions. Additional to those mandatory elements, a 'lessons learned'<sup>133</sup> concept to improve project handling has been implemented, consisting of:

- Learning before: Considering previous experience
- Learning during: Consolidating new experience
- Learning after: Rethink project experience and make conclusions for future projects

*Learning before* the project helps identifying hurdles and roadblocks through a search for new technical challenges, identification of human tensions within the project team and the project partner.

The main idea of the *learning during* concept is to keep the project on track and identify upcoming challenges. Therefore the project team discusses not only technical aspects, but also some time is spent to gain a general idea of the whole project in the firm context.

*Learning after* is a project review to extract relevant information from the whole project experience. This may be competence considerations, cost of specific project parts, soft skills and hard facts.

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131. SERglobalBrain (<http://www.ser.de>)

132. SOP: Standard Operating Procedure

133. For a detailed description see chapter A.8 on page 221.



### Knowledge Measurement

Knowledge measurement requires an evaluation of the taken measures. Appraisal interviews render qualitative data about how employees feel about the development of the organizational knowledge base. Putting all knowledge management activities in an indicator system (as shown in figure 75), allows price and performance estimations.

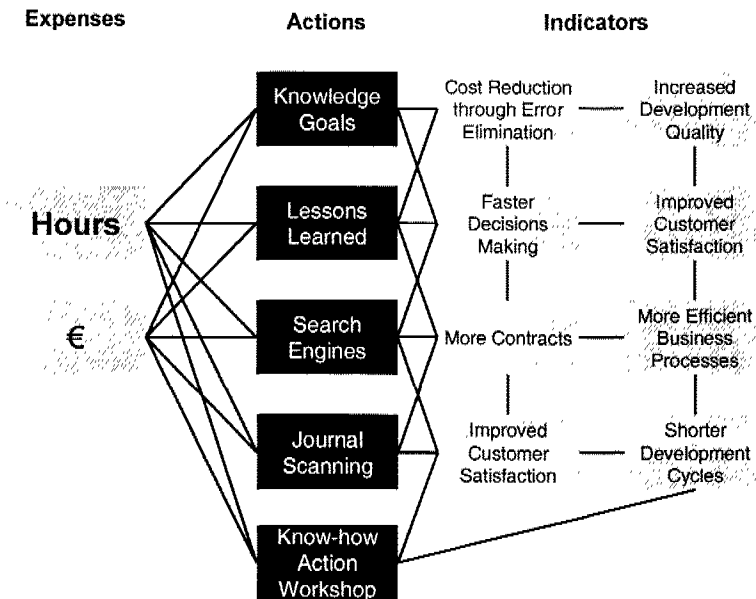


Figure 75 Indicator system for knowledge management activities

Figure 76 provides a comparison of the various activities based on the assumptions from figure 75.

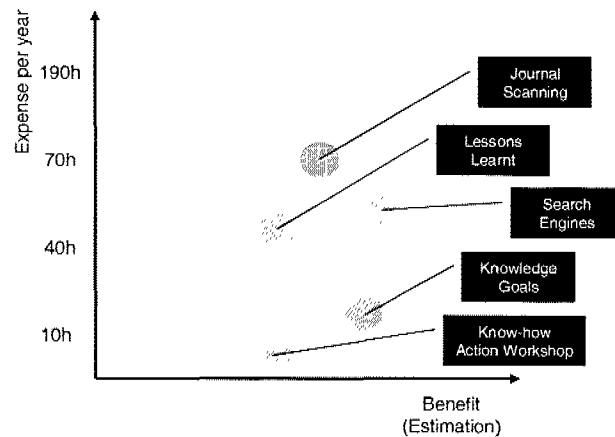


Figure 76 Validation of knowledge management activities

## 5.5.2 SENSORIX

### 5.5.2.1 Enter the Real World at SENSORIX

SENSORIX's strategy states that SENSORIX aims at working in a knowledge-based industry profiting from its small firm size. Employees know each other and all relevant information is shared informally. Nevertheless, the management team pointed out that due to various distractions, SENSORIX is faced with a permanent drain of knowledge. This occurs through oblivion, fluctuations or ideas that fail to be captured. As a result, SENSORIX needs a knowledge management that enlarges and sustains its organizational knowledge base. On the other hand, SENSORIX disposes of limited resources, e.g. a knowledge manager's job has to be just a small part of a full time job.

The current knowledge management is already aware of various activities such as standardized documentation, journal circulation, file server, intranet, regular meetings etc. As part of the new management system, Martin Luggen and Dominik Fluri<sup>134</sup> elaborated a systematically structured knowledge management process and spent therefore about 60 days in the company for interviews, workshops, presentations, meetings, desk research and analysis work.

134. The knowledge management system is part of his diploma thesis at the ETH-Center for Enterprise Science (Fluri, 2003).

### 5.5.2.2 Solution for SENSORIX

As an initial step, an overall knowledge management process was established that is compatible with the management system at SENSORIX. Based on the generic structure from Probst (1999), the embedded process as shown in figure 77 was derived.

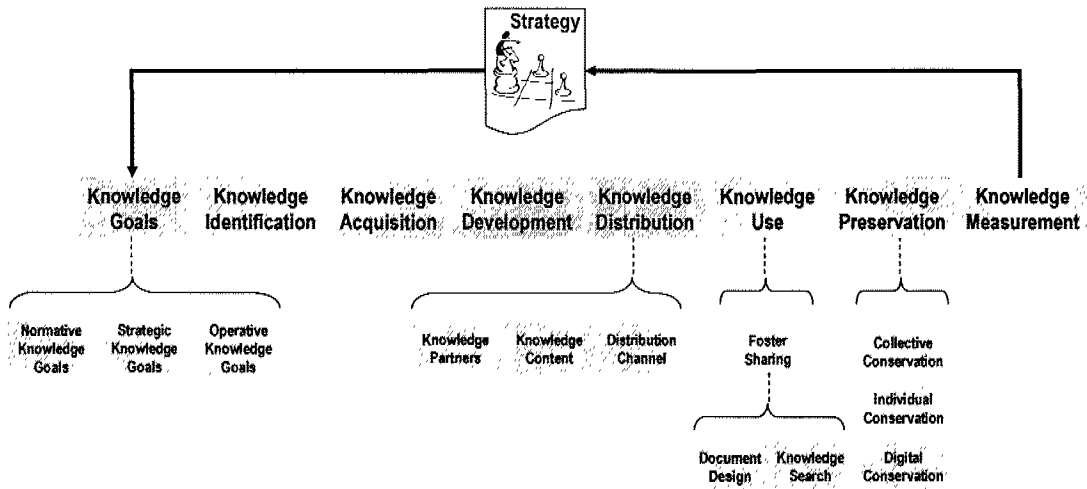


Figure 77 Management process to sustain and enlarge the organizational knowledge base

Only four of the eight sub-processes were formally integrated in the management system. The other four processes are handled well enough, so that expected improvements do not correspond with the price / performance ratio.

*Knowledge goal:* The application of a knowledge portfolio allows knowledge goals to be set in alignment with the strategy. The application of a knowledge portfolio allows different knowledge fields to be set.<sup>135</sup> The portfolio is accessible to everybody and is used to implement the mission and strategy in the long run.

*Knowledge identification:* Knowledge is identified continuously and there is no need for measures to make knowledge more transparent. Existing meetings and file servers are sufficient.

*Knowledge acquisition:* Everybody in the firm collects information.

*Knowledge development:* R&D management is responsible for this issue.

135. Cp. chapter A.7 on page 220

*Knowledge distribution:* Basically, knowledge distribution requires a knowledge carrier, a distribution method and knowledge. For some standard situations (Table 6), SENSORIX defined an explicit knowledge distribution process.

What situation?	Who is the knowledge source?	How is knowledge disseminated?
New employee	Other group members	One employee with a similar function is responsible for the integration of the new employee and takes a mentor role.
Conference / Fair	Exhibitors, competitors etc.	After every event, participants write a report with attachments of useful documents; content of this report is similar to the TI report. <sup>a</sup>
Product idea	Anybody (internal and external)	Simple database (e.g. Excel); ideas are discussed in the ICM. <sup>b</sup>
Project termination	Project members	Lessons learned have to be summarized in a concluding meeting. At the same time project related data is prepared for storage.
R&D meets application group	Application group	In meeting with users, R&D staff learns about customer needs. Minutes are stored on the file server.

a. Cp. chapter 5.2.2 on page 115

b. ICM = Interdepartmental Coordination Meeting

**Table 6** Typical knowledge distribution tasks

*Knowledge use:* The focus of this step is on promoting a better use of existing knowledge, where document layout and storage determine the efficiency of knowledge use. Entrepreneurial culture enables successful use of individual and collective knowledge. Digital storage offers numerous possibilities for data sharing with little resource usage. This is guaranteed with a logic file server structure and search engines.<sup>136</sup>

*Knowledge preservation:* SENSORIX underscores the importance of knowledge preservation by motivating its staff to continuously transferring knowledge and learning about the firm.

*Knowledge measurement:* There is no need for an explicit knowledge measurement at SENSORIX. Group control is adequately efficient.

136. See comparable solutions at Degradable Solutions or Art of Technology.

### 5.5.3 Degradable Solutions

#### 5.5.3.1 Enter the Real World at Degradable Solutions

It is a major concern of the CEO to provide efficient information flows. Even though Degradable Solutions is quite small, there is a need for a minimal knowledge management system that helps Degradable Solutions reach the following knowledge goals:

- Sustainability through the quality of developed knowledge which determines the success of a learning organization. This requires a high level of accuracy, low costs and compatibility with the company culture.
- Improvement of existing strengths such as high innovation rate and flexibility.
- Exploitation of non-project knowledge available through literature, personal contacts etc. meaning that better knowledge preservation and knowledge use methods are necessary.
- Knowledge transparency and sharing culture to handle growth.
- Knowledge strategy to locate gaps and set directions of impact.

To elaborate a knowledge management system for Degradable Solutions, Martin Luggen and Daniel Uhlmann spent about 60 days in the company for interviews, workshops, presentations, meetings, desk research and analysis work.<sup>137</sup>

#### 5.5.3.2 Solution for Degradable Solutions

To support these different needs, a 'house of knowledge management' was developed for Degradable Solutions (Figure 78).

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137. The knowledge management system is part of his diploma theses at the ETH-Center for Enterprise Science (Uhlmann, 2002).

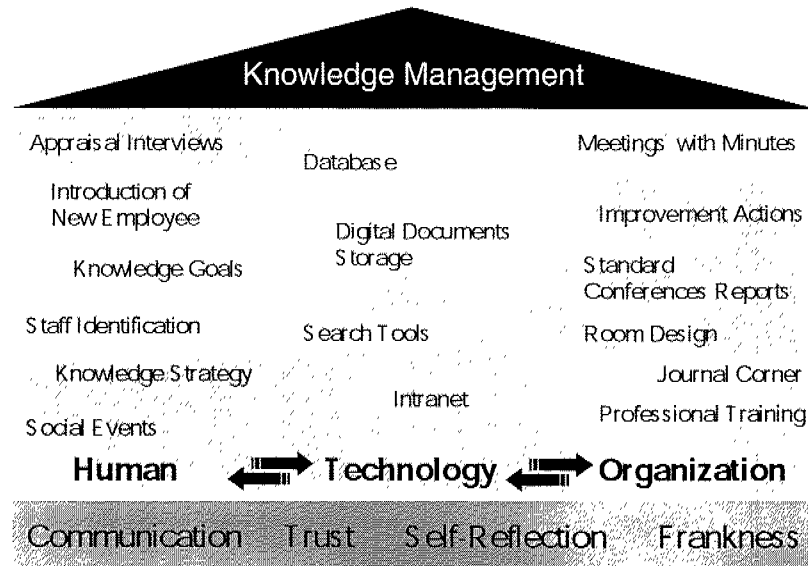


Figure 78 Degradable Solutions house of knowledge management

The ‘house of knowledge management’ has three pillars involving different activities. Appraisal interviews, introduction of new employees and staff identification constitute the human pillar. Staff identification summarizes all activities that improve identification with the company to support knowledge sharing. Further examples are knowledge goals for employees, commitment to knowledge culture, knowledge strategy, social events, etc.

A second pillar contains technological aids to nurture the organizational knowledge base. Examples of these include a simple database, intranet, search tools, etc. Digital storage of documents improves the performance of the database.

Organizational measures are the last pillar with activities such as regular meetings with minutes, improvement actions, conference documents, room design, journal corner, professional training etc.

### 5.5.4 Reflection on Knowledge Management

Knowledge management is a very general and broad field where a lot of soft factors finally determine its success. Therefore, the partial solutions presented are important building blocks for a working system. These building blocks may be integrated into the management system. Results

from knowledge management efforts are delayed because the improved nurturing of the organizational knowledge base is a long-term process.

	<b>Art of Technology</b>	<b>SENSORIX</b>	<b>Degradable Solutions</b>
Knowledge Goals	Defines normative, strategic and operational knowledge goals	Knowledge goals are summarized in knowledge portfolio	House of knowledge management; knowledge strategy
Knowledge Identification	Personal knowledge profiles	Continuously with informal communication and meetings	
Knowledge Acquisition	Four levels of journal scanning	Everybody	Improvement actions
Knowledge Development	Informal	Especially R&D	Informal
Knowledge Distribution	Common lunch and coffee break	Some standardized processes, e.g. project termination	Room design, network, meetings
Knowledge Use	Search engines and digital documenting	Documentation on company server	Digital document storage
Knowledge Preservation	Learning before, during and after projects	Everybody is inspired to conserve knowledge	Improvement actions
Knowledge Measurement	System of knowledge indicators and validation (Figure 75)	Group control	Informal
Used Tools	Knowledge portfolio Know-how action workshop Search engines Database	Knowledge portfolio Database	Knowledge portfolio Database
Motivation	Skilled and motivated team all in one place	Staff in different locations and functions	Working on a highly innovative product
Culture	Entrepreneurial	Entrepreneurial	Entrepreneurial
Expense	75 workdays (2.2% of work time) are estimated in a detailed calculation for all knowledge management activities.	Additional expense to formalize knowledge management is about five working days. Total of all knowledge management activities is much higher.	Additional expense to formalize knowledge management is about three working days. Total of all knowledge management activities is much higher.

*Table 7 Cross case pattern search for knowledge management*

Beneficial contributions to the organizational knowledge base depend on the staff's motivation. A clear-cut commitment from the management team and the cultivation of a strong identification with the firm are important success factors. This is especially important as the firm grows and new employees have to be integrated in the firm's organizations and culture.

As a matter of fact, most measures have rather cultural and organizational characteristics than being an application of a complex and expensive technological solution. The competitive advantage of NTBFs partially lies in possessing optimal preconditions for successful knowledge management. These preconditions are:

- Simple and quickly realizable solutions
- Solutions that motivate employees by making their job easier
- High commitment to participate by all employees
- Integration of existing activities and structures

A cross case pattern search is presented in table 7.

## 5.6 COOPERATION MANAGEMENT

In this chapter, the management of strategic cooperations is analyzed in five in depth case studies and twenty other cases. The research methodology for description of the network management was changed because the integration of several companies in an action research project is likely to produce results which are not recoverable or plausible.<sup>138</sup>

### 5.6.1 Research Proceedings

This chapter consists of theory development with IDEF0<sup>139</sup> methodology based on literature findings and case studies. The empirical basis contains five in depth case studies.<sup>140</sup>

Each individual case consists of a 'whole' study and conclusions are then considered to be the information needing replication by other individual cases (Yin, 1994:49). An indication of replicating and contrasting results depending on the NTBFs' specific surroundings is elaborated by a search of cross-case patterns among the findings of the interviews (Eisenhardt, 1989). Searching cross-case patterns is driven by the fact that NTBF's people tend to process information depending on the current stage of the firm, which may result in premature and even false conclusions. The resulting theory is more accurate and reliable, because it has a close fit with the data.

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138. Cp. chapter 4.3.2 on page 99

139. IDEF0 = Integration DEFinition language 0 (Feldmann, 1998)

140. In depth case studies through interviews at ADEQUASIS Inc., Geneva; dotBase SA, Lausanne; ExoSonic, Geneva; Fastcom Technology, Lausanne and LogObject, Zurich.



The cooperation management process resulting from literature review and case studies is transferred in a flow model in IDEF0-syntax. This allows a systematic observation of several cases and generalized conclusions are drawn.

The modeling language IDEF0 provides a functional view of processes and it consists of five different syntactical elements (Figure 79). The functions performed in the process to be described are illustrated by a *box* with the corresponding label in it. Arrows denote different flows connecting the various functions: The *input flow* consists of resources processed / consumed by the function, the *control flow* comprises constraints and objectives restricting/directing the function and the *means & methods flow* contains any knowledge and methodologies that support the execution of the function. An *output flow* shows what is transferred to another function (Feldmann, 1998).

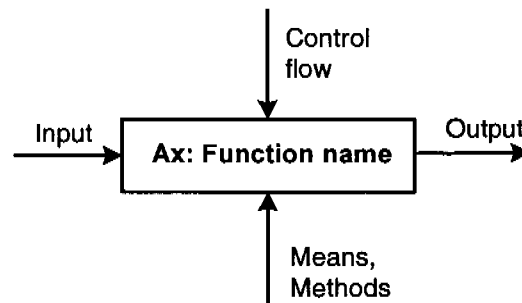


Figure 79 Syntax of the IDEF0 modeling language (Feldmann, 1998)

## 5.6.2 Case studies

The following section describes three in depth case studies that were used to understand cooperations between NTBFs of the same size. All cases may be considered as a network collaboration.

### 5.6.2.1 Case LogObject

LogObject (AG) was founded 1998 in Zurich with a focus on logistics. Situated in a niche market, it now employs about 20 people. It produces highly specialized logistic solutions. LogObject's core competencies are informatics, telecommunications, robotics and logistics. Since its products demand competencies not available internally (such as production, software development, design, marketing, etc.), LogObject was forced to search for partners with complementary competencies.

LogObject distinguishes between sales, solution and technology partners. Sales partners are not only responsible for product distribution, they also collaborate actively on the development of new ideas and products. They furthermore act as market antennas, identifying market needs and elaborating 'rough' market studies. Solution partners provide complementary resources for R&D and production in a collaborative manner to the business process. Technology partners are mainly software developers whose modules contribute to the final product. Their role is to provide quick access on emerging technologies in the software sector.

Typical product innovations start for LogObject with the check of the technical feasibility. Discussions among network partners and experts support LogObject in this process step. A rough product concept (product positioning, required / involved (network) resources, customers, etc.) is derived afterwards and presented to the sales partners. In these meetings, a market estimation (customer needs, market volume, competitors, estimated ROI) is done and the corresponding collective strategy is determined. During the next step a software prototype, which is developed mostly by LogObject is presented to end customers. After assigning and binding network resources (which were identified earlier), the correspondent collaborations (responsibilities and benefits) are regulated in contracts. The involved partners develop a physical prototype that again is presented to end customers. Final adjustments are made and the actual business process is shaped. Parallel to this, the sales documents are elaborated collaboratively, whereupon the distribution and sales processes are initialized.

Since most network partners contribute complementary resources and are experts in their domain, each network partner has to allocate the required resources in its specific domain. If a new (external) resource has to be found, all the concerned partners are involved in the assessment and the choice.

The knowledge sharing is supported by common meetings and discussions. This is the only formality for centralized knowledge management; however, partners themselves may record experiences and lessons learned. Although a central node or a suitable tool would be assumed to be very valuable, the network could not afford one, since the maintenance resources are lacking.

#### **5.6.2.2 Case Fastcom Technology**

Fastcom Technology (AG) was founded 1998 in Lausanne, Switzerland. About 20 people work for Fastcom Technology, whose major work areas are image processing, multimedia, process automation and software development. Signal processing, embedded system design, automatic meta-data creation and integrated events belong to Fastcom Technology's core competencies. The company's activities are strongly focused on these competencies which make

it necessary to collaborate with partners in order to outsource non-core-parts of the value chain (marketing, distribution, etc.) and to acquire complementary competencies.

This network is highly flexible and its organization depends on specific products. Besides the 'classical' buyers and sales collaboration, Fastcom Technology also maintains strategic alliances with the following main goals: reach new markets, outsource parts of the value chain that are none of Fastcom Technology's core competencies, acquire competencies for an extensive product development and gain new knowledge / know-how. For these purposes Fastcom Technology works with a number of different companies and research institutes, occupying different roles in the network.

The interview partner outlines that the actual processes for network collaborations vary greatly; however, for creating a new business a certain number of defined steps have to be processed. At the beginning there is the identification of market needs through workshops with partners and customers. This process results in product ideas for which the financial and the technical feasibility are examined. After this a brief market analysis (customers, market volume, etc.) is done with the partners, product specifications and the strategy are drawn. The next step is the identification of required resources / partners. These have to be found and the collaborations need to be regulated. Then the development projects are planned and thereafter executed. The last step is the integration of all components into a joint end product.

The subsequent selection of the resources is influenced by the network strategy, the firm strategy, personal relationships and many other factors. This can lead to a variety of different forms of collaborations such as supplier collaborations, license agreements, joint ventures, etc.

The creation and sharing of knowledge is supplied by common workshops and collaborative research projects. Although an ERP<sup>141</sup> system makes the work history available for Fastcom Technology, there is no formal process for the documentation of knowledge and experiences on the network level. Case specific platforms are established on demand.

The primary documentation tool is the archive of correspondence, which works well as long as the relevant data can be surveyed by individual project managers. There is a latent need for knowledge management, emerging as soon as the network reaches a certain size.

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141. ERP (Enterprise resource planning) is an industry term for a set of activities supported by software that helps a firm manage the important parts of its business, including product planning, parts purchasing, maintaining inventories, interacting with suppliers, providing customer service, and tracking orders. ERP can also include application modules for the finance and human resources aspects of a business.

### 5.6.2.3 Case ExoSonic

ExoSonic (AG) was founded in July 2001 in Geneva, Switzerland and currently employs six persons with advanced levels of education. ExoSonic developed the 'financial server', a framework to access financial content from various providers through a single unified interface. It tried to establish this product as a standard for financial end user applications. ExoSonic's strategy (open source code for any partner) implies strong collaborations with partners in different areas.

System integrators provide financial software solutions, wherein ExoSonic's 'financial server' is the basic platform. Besides the distribution of ExoSonic's product, system integrators may extend the 'financial server' (the source code of this product is completely open), owing a royalty to ExoSonic. ExoSonic's main source of revenue originates from after sales, which can be carried out together with the service integrator.

If ExoSonic lacks of resources or knowledge (foremost finance) they collaborate with technical colleges, such as the HES (Haute Ecole Spécialise) Geneva whose students then work on projects for them.

To disseminate and further develop the 'financial server' and additional components, ExoSonic sustains a network, inheriting the focal role of the network coordinator.

In contrast to the two other firms mentioned above, ExoSonic positions itself as a focal node in the network, whereas LogObject and Fastcom Technology consider their role derived from the actual business process. Therefore the latter networks have a more informal touch while ExoSonic's relationships are designed more formally.

The creation process of ExoSonic's network contains the following phases. If new market needs are discovered (mostly by system integrators), ExoSonic examines whether and how they can be satisfied. The needed resources are identified and the optimal network organization is derived. Contracts define the collaboration between network partners on a case by case basis. Then the development projects are planned and carried out by each partner under global control of ExoSonic.

Knowledge sharing is ExoSonic's task, as is the management of the network. Since the programming code of the 'Financial Server' is completely open to any partner, knowledge is shared in this formalized manner. Furthermore, ExoSonic provides news and important information via a web platform.

### 5.6.3 Strategic Network Management Process

Figure 80 illustrates the strategic network management process as a whole, in its economic environment. It provides a non-extensive list of important interactions between the function 'manage a strategic network' and its surroundings.

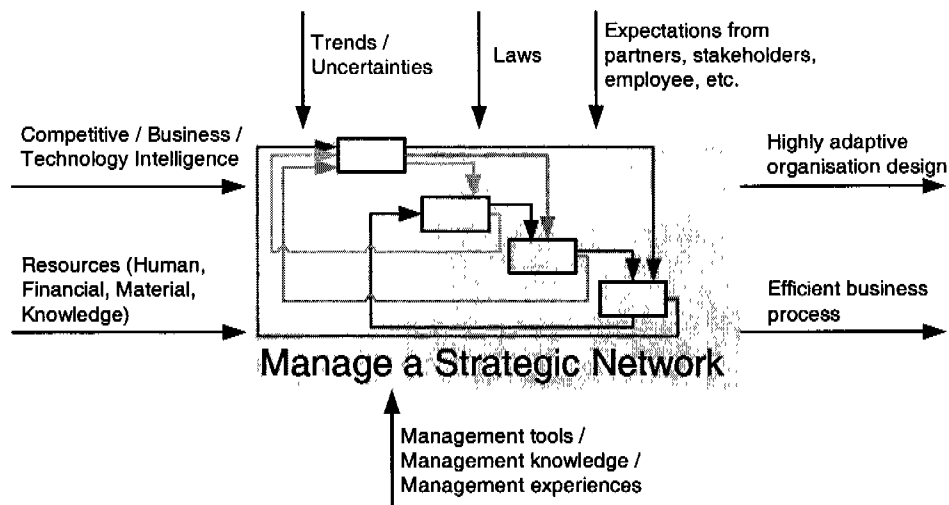


Figure 80 Model of the economical environment of the strategic network management process

Studying the model and functions described in figure 81, it must be considered that the flows listed in figure 80 were neglected in order to keep the figure 81 comprehensible. So any flows from outside and all means and methods that can be used to perform the functions (e.g. strategic decision making methodologies, customer relationships methodologies, etc.) are suppressed. Especially inputs such as 'market-needs' and 'partner-expectations' are assumed crucial and must be taken into account on various functions.

For the management of a strategic network four main functions with their relations were identified (Figure 81). The model shows a distinction between the strategic level (make strategic decisions), the operational level (operate business process) and the levels in between (allocate resources and deploy resources).<sup>142</sup>

Furthermore, it must be considered that the NTBFs degree of formalization varies widely and this model offers a rather extensive view.

142. The generic model was develop in collaboration with the Centre CIM Suisse Occidentale (CCSO) in Fribourg, Switzerland (Grüter & Heutschi, 2003).

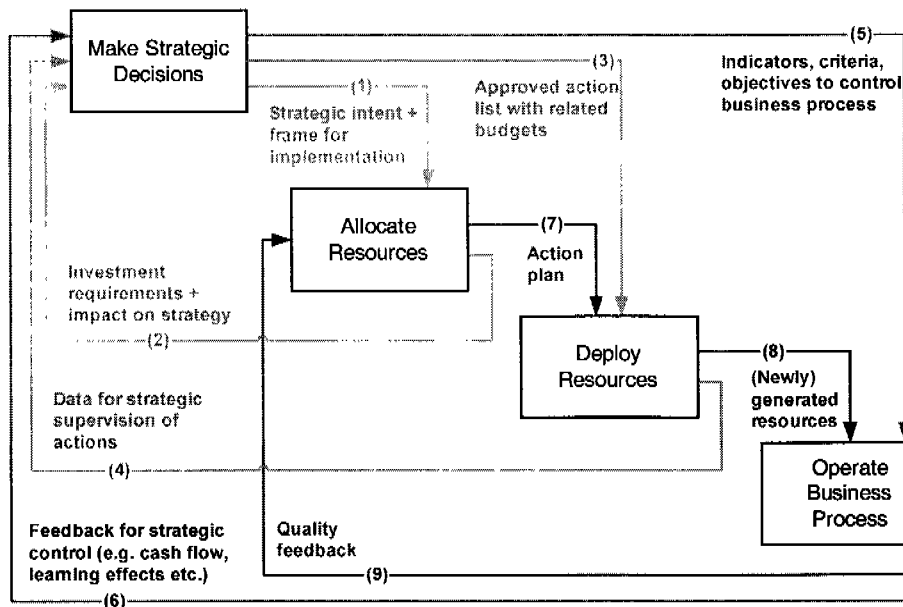


Figure 81 IDEFO model of the strategic network management process from a resource-based view

### 5.6.3.1 Make Strategic Decisions

To create a new business process, the first thing that must be done is to elaborate a strategy. There are numerous inputs to be considered such as market data, information about internally or externally available resources, control flows such as network strategy, corporate strategies, values shared by all network partners, financial constraints, stakeholders' expectations, etc.

Within this function all of this data has to be analyzed and strategically evaluated. Different strategic options are elaborated. After strategic decisions have been taken, a framework for the implementation is elaborated. If the network already exists, monitoring functions as well as optimization processes are also considered in this step.

The final results of the first step are the strategic intent with the corresponding frame for the implementation (output 1), the approved action list (output 3) or indicators and objectives of strategic relevance respectively (output 5). These outputs are modeled as control flows for the following functions.

The loop 1 – 2 designates an iterative cycle to implement the network strategy and allocate resources. Latter findings may lead to strategic adjustments. This loop is repeated until the investment requirements are satisfied and the proposed action list is approved.

### 5.6.3.2 Allocate Resources

The second main activity is a planning phase that is directed by the strategic objectives. Main inputs are financial resources and information from resource data bases. The better the network resources and available knowledge are documented, the easier it will be to execute this task.

Firstly, the needed resources and competencies to fulfill the strategic intent have to be identified. Secondly, the needed resources have to be assessed. These resources define the organization and the roles network partners have to fulfill. Parallel to this step, technical and economic feasibility are checked (e.g. by means of simulation or prototyping) and the future business process is modeled. Responsible persons are identified for the different actions. Thirdly, an action list is elaborated with the previously allocated resources to implement the planned business process. For supervising purposes, it is reasonable to determine performance variables that supervise these planned actions.

If the planned actions impact the collective strategy of strategic relevance, for example if they affect core competencies or important investments, then these findings must be delivered to the strategic level together with the project request and the related resource requirements.

The output (project request with planned actions, requirements, indicators and estimated effects) is fed to the strategic level. Once this request is approved, the action plan (projects for development and allocation of resources with responsible persons) is routed to the function 'deploy resources'.

The loop 3 – 4 can be understood as project control. As soon as the action plan is approved, the corresponding actions / projects are executed and data for strategic supervision (state of the project, remaining budget, etc.) is fed back so that the network managers always have an overview of the current state of the project.

### 5.6.3.3 Deploy Resources

The third function aims at bringing together the allocated resources from the different partners. The interfaces between the network partners have to be coordinated to minimize transaction-costs. Once interfaces between partners are specified, the network partners can proceed to the implementation of the resources into the real business processes. To the approved action plan, resources from the various network partners are deployed.

Another important task is the organizational learning. Experiences (best cases) and generated knowledge have to be documented in the knowledge/resource database. This is

supposed to facilitate/support the learning effect and knowledge sharing between network partners.

The outputs of this third function are appropriate monitoring data of the actions to the strategic level (output 4) and the deployed resources for the business process.

Loop 3 – 4 illustrates a supervising process to monitor resource deployment. The management needs to define clear objectives and indicators to supervise resource deployment (e.g. productivity, workload, price etc.).

Loop 7 – 8 – 9 indicates an 'improvement cycle'. It is assumed that within a certain (well-defined) framework, those responsible for the concerned unit may react directly, without consulting the strategic level. This learning cycle (7 – 8 – 9) shows an improvement loop that contributes much to the optimization of operational routines. Proposals for improvement normally emerge out of the operational level (i.e. the business process); however, for the optimization all responsible persons must be involved. Through these discussions, information must be shared between partners so that the desired partner learning is benefited.

#### **5.6.3.4 Operate Business Process**

On the operational level the defined business processes are executed. The function 'operate business process' generates cash flow, fulfills the strategic objectives and provides monitoring data to the strategic level respectively. The business processes is carried out by various partners, all of them providing their core competence to the whole process. Additionally to the processes, the partner-interfaces within the network must be monitored continuously in order to identify potential optimization fields (cp. loop 7 – 8 – 9).

#### **5.6.4 Reflection on Cooperation Management**

The proposed model shows decision and information flow from a strategic network level to the business process of the network. Various demands and responsibilities need to be considered on a network level as well as within individual companies. The responsibilities for the functions often vary within different networks; however, it is crucial that they are clearly regulated.

The model stands out for its illustration of flows (resources, directives, data) and for the implementation of strategic decisions into operational actions through the integration of different company and network levels into a single model. Interviewing numerous NTBFs, a strong correspondence between practice and model could be observed.



The proposed concept is applicable for minimal formalized networks, whereas for informal / project-oriented alliances it is assumed too complicated, since many of the described flows are not generated at all. Also micro-networks usually do not need a method for relationships, since only a few people are involved and the information generated can be handled by specific individuals.

Although the model mostly matches the case studies, there are some issues that must be considered:

- For single network participants, the process might differ from the model due to their role within the network. E.g. LogObject and Fastcom Technology check the technical feasibility of a product idea prior to the development of the network strategy. This can be explained by their special role as 'innovators of the network'.
- In some of the cases, processes on the network level were lacking, (above all monitoring and feedback loops), however, a majority of interview partners said this was because they lacked the resources or a suitable tool. This circumstance furthermore shows that NTBFs (above all) focus on technical matters rather than on managerial or marketing subjects, that are often neglected by the responsible managers.

The most important concern for collaboration and sharing is trust between partners. The second most important concern is a clear market orientation. Additional lessons learned concerning the management of strategic networks mentioned by the interviewed NTBFs include:

- Many of the interview partners pointed out that formalized network processes and increased sharing (knowledge, resources, experiences, etc.) would be assumed suitable to handle responsibilities and the huge amount of information, however, they lack the resources and a suitable method for doing so.
- Networks with a focal enterprise acting as a coordinator or integrator seem to have more formalized processes and more comprehensive sharing of resources.
- Managers of SMEs and NTBFs emphasized that all network partners ought to be about the same size and they should provide complementary competencies. In this way influence on the network level would be ensured and the risk that a partner could become a competitor would be minimized.

## 6 DISCUSSION

In this chapter, the Pocke™ concept is further developed building on the existing literature and company research. The concept aims at providing complete answers to the two research questions and closing the identified gaps in the management of technologies in NTBFs. Particular emphasis is placed on the design of a Pocke™ that represents a minimal concept of technology and innovation management. The following sub-chapters are structured with regard to answering the research questions on the design of the concept, the key elements and the implementation of the Pocke™.

### 6.1 CONCEPT POCKE™

The question of how to design and implement a minimal concept of technology and innovation management refers to the context of organizational research. Designing the Pocke™ for a perfect fit with the NTBF requires a fit with the current and future dominant logic,<sup>143</sup> that defines the organizational characteristics and the 'macro-design'<sup>144</sup> of the Pocke™.

Figure 82 depicts the Pocke™ concept representing an integrated technology and innovation management system, with five key elements constituting a minimal concept of technology and innovation management. The synthesis of the Pocke™ in figure 82 reflects an attempt to visualize the core of the concept. This concept is based on the framework that was derived from management issues in NTBF in chapter 4.2 on page 94. The purpose of this framework was to carry out action research in order to design and implement the Pocke™, therefore it was not systematically tested whether it is complete or unique. However, there were no contradictions found in the action research cases, what allows at least to conclude, that the main purpose was reached (carry out action research) and that it was probably a good guess for a management system under entrepreneurial preconditions.

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143. A dominant logic is defined as the way in which managers conceptualize the business and make critical resource allocation decisions.

144. The macro-design has an interdisciplinary orientation to provide approaches to building conceptual models that are ordered, logical and rational. It has an orientation towards understanding relationships and the effects of given processes, attitudes or objects upon people and events. Different micro-systems are integrated to a macro system.

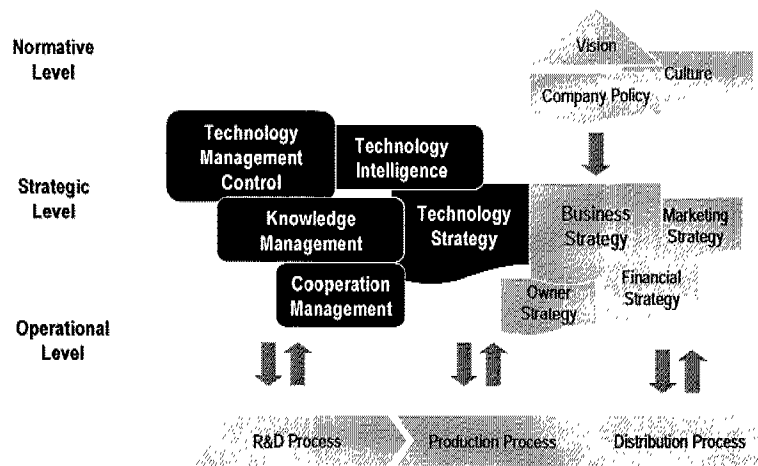


Figure 82 PockeTM – a minimal technology and innovation management

### 6.1.1 Design of PockeTM

The five *key elements* of PockeTM depicted in figure 82 have been identified individually in chapter 4.2 on page 94 and address all technology concerns. In this sense, the PockeTM represents a holistic technology and innovation management system. The integration in the firm context allows an NTBF to define a specific configuration of the PockeTM and to specify interactions between the different elements in the form of a macro-design. At the same time, it represents a basic concept of technology and innovation management, which can be minimized according to the firm context. The interdependencies of these key elements vary depending on the macro-design of each NTBF. Basically, technology intelligence provides external information, which is used for technology strategy formation and implementation. A well defined strategy is a solid backbone for a sustainable growth and may be controlled with different qualitative and quantitative indicators. The main purpose of knowledge management is to provide structures and foster motivation for knowledge sharing and storage. Cooperation management regulates relations with external partners.

Conceptually, the PockeTM is an interaction of the *three main management levels* – normative, strategic, and operational. Generally, the normative level provides the long-term mission and policies and thereby sets boundaries for the PockeTM on the strategic and the operational level. The organizational culture represents another important aspect which greatly affects the PockeTM. On the strategic and normative level, primarily the management team is

involved, while on the operative level the whole company works with the Pocke™ processes. Activities with great influence and broad usage are owned by the management team on each level.

The Pocke™ integrates *internal and external perspectives* of the NTBF. The successful evolution of an NTBF without intensive external relations in today's increasing economic pace and complexity is nearly impossible. In fact, environmental change comprises major business opportunities for entrepreneurial firms because they are more able to react to new conditions than their larger competitors. External collaborations are a common practice and favor the enthusiasm of NTBFs to promote product innovations, as well as R&D, distribution and marketing. The NTBFs also pay careful attention to their relationship with venture capitalists and investors. An important aspect of external relations for the NTBFs is the gathering of information about future trends. For NTBFs to play all of these necessary roles, the Pocke™ supports the formation and usage of cooperations with partners of the same size as well as cooperation with much larger firms.

### **6.1.2 Adaptation of Pocke™**

An NTBF is basically faced with the four management decisions 'create, adapt, leverage and remove' (Figure 83). The decision to create involves the allocation and deployment of resources on a new business process. If an existing business process insufficiently delivers the expected results or not at all, the decision to adapt rearranges resources and organizational structures. The leverage decision corresponds to the scale up of an existing business process. More of the same resources are allocated in the same manner. The 'remove' decision implies the voluntary or involuntary stop of a business process. Every strategic decision may be reduced to these options. Once a strategic decision is taken, the implementation requires receptive processes, methods and tools. Within those four paths, resources have to be allocated, organizational structures planned and business process operated. The Pocke™ concept allows any of the four options to be executed, ensuring efficient resource allocation, exploitation of experience and continuous monitoring.

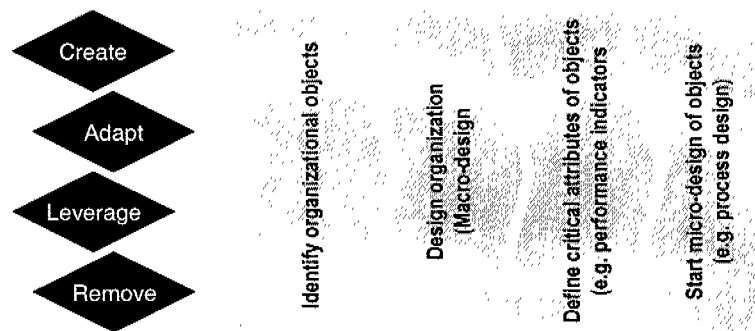


Figure 83 Four basic management decisions and their implications on management system

The adaptation of the Pocke™ is an on-going process because of the continuously changing challenges for the NTBF. Therefore, the application Pocke™ concept does not imply a single, very large implementation effort, rather a stepwise elaboration of the different elements. This incremental process allows an optimal configuration of the Pocke™ according to the NTBF's current needs. This means that strategically relevant issues may be introduced immediately and other elements may be held back.

### 6.1.3 Integration of Entrepreneurial Objectives into the Pocke™

The starting point of the Pocke™ concept is a debate about the successful incorporation of an NTBF. Of utmost concern for an NTBF's management is the fact that it must ensure the survival and growth of the new firm for the long run. Therefore, seeking entrepreneurial opportunities and developing core competencies play a crucial role in the NTBF's daily business and have to be reflected in the Pocke™.

The main function of the Pocke™ is to exploit the technological potential in NTBFs. This involves an amelioration of the development, acquisition, propagation, sharing, integration and utilization of technologies. Bearing the aims and strategies of technology and innovation management in mind, the Pocke™ has three sub-functions: the first one is to promote the internal production of innovations; the second one is to be a bridge between the company and the outside world in terms of technology, markets and competitors; the third is to provide management with a system which propagates, shares and integrates new and old, internal and external technologies.

Incorporating an NTBF bears a lot of risk. To balance those risks for the entrepreneur's and investors' investments, an NTBF has to generate an economic rent that is superior to less risky investments. To generate this economic rent an NTBF aims to realize as many entrepreneurial

opportunities as possible and to develop core competencies. The rent may be generated in the form of firm growth and knowledge accumulation, what finally results in an adequate return on investment as increased market value of the NTBF.

Finding the right application and market (realization of an entrepreneurial opportunity) is an essential and crucial process in the development of core competencies, because a not yet sophisticated technology has to be matched to a not yet known market. Finding the right application determines the success of core competencies and indicates whether resources have been accurately allocated. In other words, resources are properly allocated if the firm possesses applications that are valuable, rare, difficult imitable and non-substitutable core competencies (Figure 84).

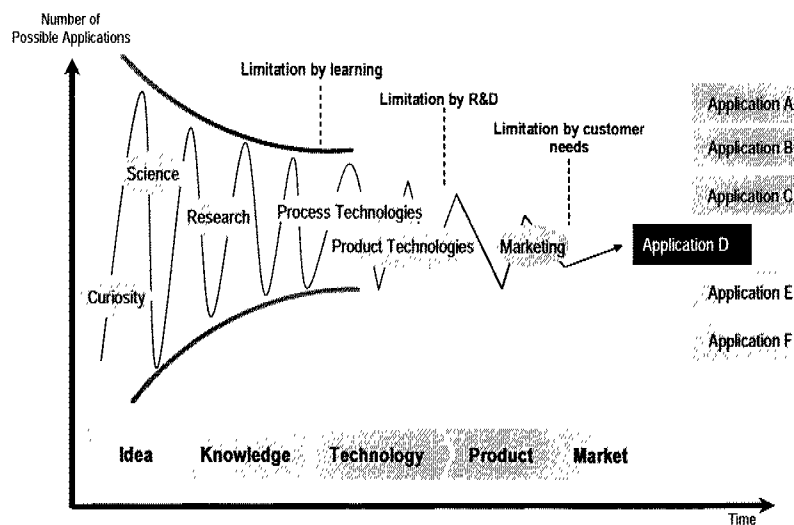


Figure 84 Application finding process

This process joins the whole founding process. The most challenging part is in finding the first application and customer. This process is made easier by conceiving of technologies as functions. The most critical phase is reached, when products are commercialized, as it is up to the customers to decide whether the core competency based value proposition is real or not. The five key elements of the Pocke™ support every step in application finding process.

Since any incorporation of an NTBF is accompanied with risk for investors, the management team strives for a transparent communication of the firm’s goals, activities and results. This communication depends on the investors needs. The ‘family-friends-fools’ type of investors focus more on the firm’s activities, while the venture capitalist’s primary interest lies in

the financial result. In both cases the Pocke™ helps the management team to provide more transparency about the NTBF.

#### 6.1.4 Integration of Entrepreneurial Structures into the Pocke™

The Pocke™ aims at building entrepreneurial structures that support technological and organizational development. This process is settled between a purely opportunistic focus with a short term perspective and the commitment to long-term development.

Depending on the NTBF's current management needs, structures of Pocke™ have centralized or decentralized characteristics. The key elements are basically the same, but in a centralized Pocke™, management activities are focused on a few (in the extreme of just one) persons, sometimes only the entrepreneur himself. A decentralized Pocke™ aims at distributing management task on several shoulders and in the extreme case on the entire staff. Decentralization is more likely to occur in NTBFs which have been founded by a team.

All these macro and micro processes,<sup>145</sup> as well as the management system itself, are subject to continual change (Figure 85). The main directions of change are on the edge of chaos and edge of time.<sup>146</sup> Generally, the Pocke™ drives the system towards more structures on the edge of chaos, and towards a future orientation on the edge of time.

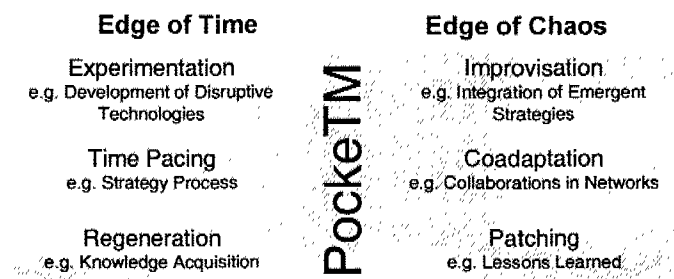


Figure 85 Pocke™ on the edge of chaos and time

The firm's size and age have a major influence on the structure, in other words, a major influence on the position on the edge of time and chaos. Growing size pushes the management to a more formalized management (e.g. pom+), as well as when firms get older (e.g. pom+). In the first case, formalization is an absolute necessity to keep the NTBF efficiently running, while in

145. Cp. chapter 6.2 on page 169

146. Cp. chapter 2.3.3 on page 42

the second case, formalization emerges in the course of time as intuitive activities are replaced with routines. If an NTBF is quite homogenous (e.g. one location or similar origins of the employees) the need for formalization is less intensive. On the other hand, if the NTBF is more heterogeneous (e.g. R&D and marketing people) more formal procedures are needed to develop the NTBF.

### 6.1.5 Integration of Entrepreneurial Behavior into the PockeTM

Entrepreneurial behavior plays a crucial role in the design and implementation of the PockeTM, perhaps it reflects the most important dimensions of the company, because finally cultural factors determine an NTBF's learning and innovation capabilities. As a matter of fact, most NTBFs function in a communal culture<sup>147</sup> with a high degree of sincere friendliness and the ability to pursue objectives quickly and effectively. This allows the design and implementation of a less formal management system and leaves a lot of room open for structural and temporal processes, such as improvisation.

The interaction between the entrepreneurial culture and the PockeTM constitutes an interactive process depicted in figure 86. Top-down influences from underlying basic assumptions of the entrepreneur(s) and staff epitomize the characteristics of PockeTM. Bottom-up influences from the characteristics of the PockeTM such as process design, the extent of applied key elements, integrated external partners etc., change the culture in the long run.

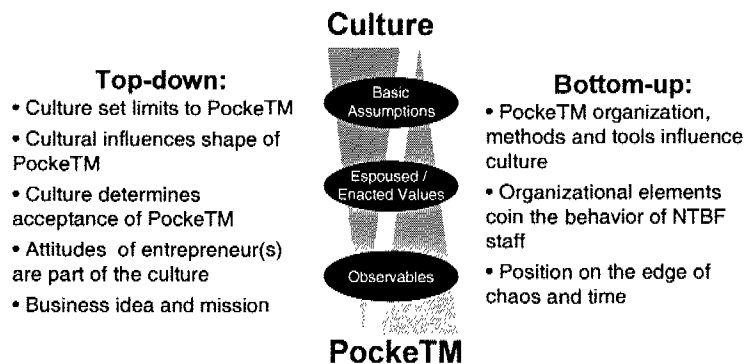


Figure 86 Interaction between the PockeTM and organizational culture

147. Cp. chapter 2.3.4 on page 45



Top-down and bottom-up processes are divided into different sub-processes (Figure 87). The precondition for the bottom-up processes is a disequilibrium in the employees' perception,<sup>148</sup> which is an almost constant factor for growing firms. Without this disequilibrium, the motivation for cultural changes does not arise. Therefore, NTBFs have the chance to permanently alter their cultural characteristics. The top-down process sets preconditions and boundaries for the design and implementation of the PockeTM. Outside these boundaries the application of the PockeTM system is complicated and the staff acceptance is limited.

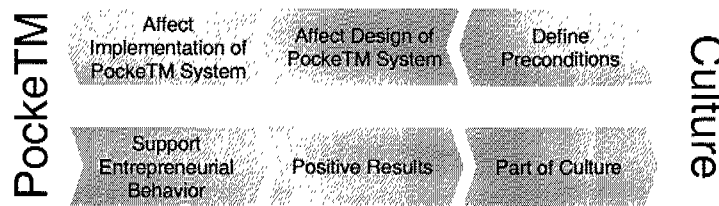


Figure 87 Cycle of cultural change in NTBFs

PockeTM activities such as a 'Know-How Action Workshop'<sup>149</sup> (Art of Technology) aim at creating new behaviors. During this workshop, the employees are asked to develop ideas and goals for future knowledge management challenges. Another example of typical entrepreneurial behavior is the integration of new employees because on the one hand, people often do not have enough time to introduce new employees adequately. New employees are often integrated in the business process at once and lack important information about the NTBF, even after a standard introduction time. On the other hand, founder teams and early employees have an extremely strong commitment to the NTBF, which cannot be shared with new employees to the same extent.

Another aspect of entrepreneurial behavior is that NTBF management teams encompass various roles, including researcher, innovator, salesman, entrepreneur and manager; the skills required for each role are likely to be different. Despite this complexity, three types of skills appear to be essential, namely technical, entrepreneurial and managerial. Whilst the significance of each skill is phase-related, elements of all the three types are a precondition for successful company formation.

148. Cp. chapter 2.3.4 on page 45

149. Cp. chapter 5.5.1.2 on page 140 and chapter A.6 on page 219

## 6.2 KEY ELEMENTS OF THE POCCKETM

The macro-design of the PockeTM involves the design of structures to coordinate the operations of the individual key elements. These structures embed lower level activities and create the context for their operation, mainly in terms of resource allocation, coordination and managerial processes (Figure 88). There are many potential paths that might be followed, because the general principle is breaking the overall process into a set of sub-processes that create value and are logically connected to enable the NTBF's objectives. In this way the resource commitments can be managed and flexibility retained.

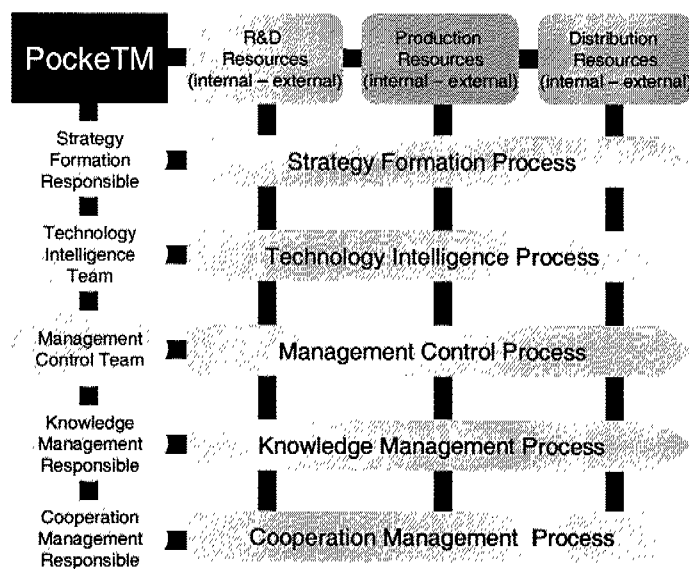


Figure 88 Macro-design of the PockeTM

The micro design of the individual elements is discussed in chapter 6.2 on page 169. Placing the different processes of the PockeTM macro-design in the NTBF's management system allows a complete integration of technology and innovation management in the general management. This leads to a distribution of processes with 'technology management' character to the management and the support process. The processes with 'innovation management' character normally fit best in the value creation process (Figure 89).

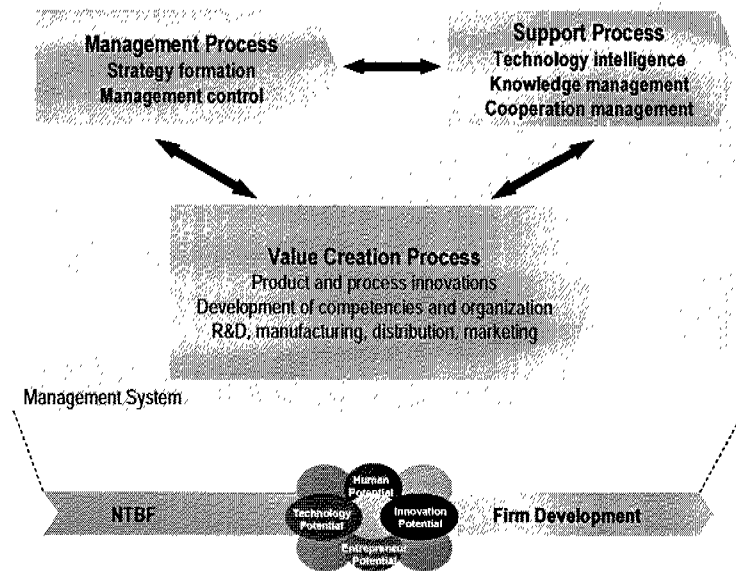


Figure 89 PockeTM in the NTBF management system

In the following sections, the five key elements of PockeTM are described in an enhanced and summarized form.

### 6.2.1 Technology Intelligence

Entrepreneurial competitive advantage is based on a superior ability to develop valuable competencies. Flexibility and speed of response allow NTBFs in particular to benefit from entrepreneurial opportunities. Therefore, NTBFs need to be aware of trends and must be able to react to their environment. A systematic technology intelligence approach aims to provide external information to the NTBFs' management team. It is necessary to react at the earliest possible moment because the NTBFs' resource situation does not allow expensive catch-up activities.

A technology intelligence system for NTBFs brings together external information sources and analysis necessary to gather information. The difference between an informal and a systematic technology intelligence system are located in the quality of the output. There is always an external information need that has to be satisfied. If there is no systematic approach, employees automatically start doing it on their own in order to execute their day to day responsibilities (e.g. SENSORIX).

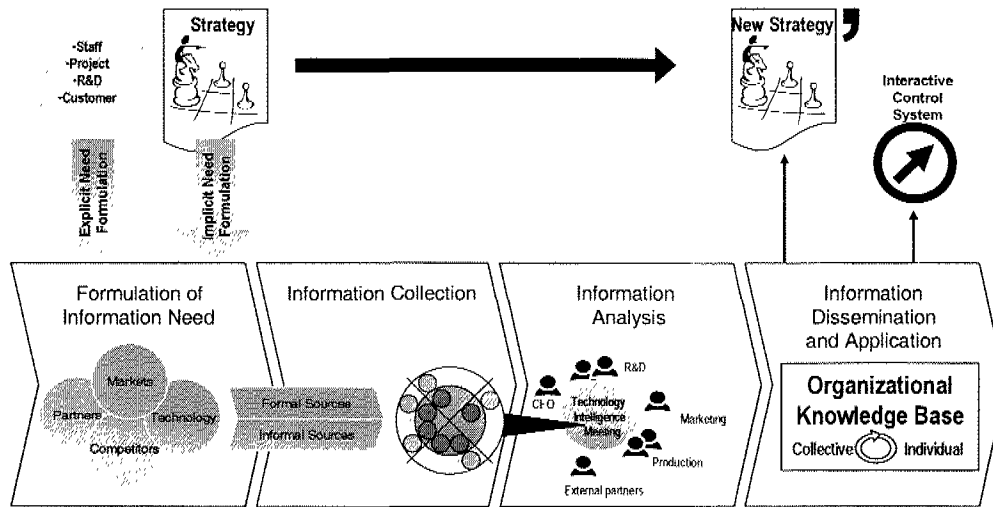


Figure 90 PocketM technology intelligence

The systematic technology intelligence process starts with the formulation of an information need. Explicit needs result from the strategy formation process (e.g. Degradable Solutions, pom+). There are also implicit information needs that emerge from different employees' tasks (for example acquisition at pom+). The idea behind a formalized technology intelligence system is to provide a high quality of information through gatekeepers, who scout for information in domains where they have particular strengths. Therefore, the application of an opportunity landscape improves the structure of the intelligence process. Observation fields are defined and assigned to internal or external experts. Another advantage is the integration of external experts, for example as part of a strategic network. Typical fields for observation are markets, competitors, technologies, partners, etc.

The most important part is an in-depth search analysis to satisfy the formulated needs, as well as to discover new trends that are not yet known in the NTBF. The analysis work can be done as part of company meetings (e.g. pom+) or in special technology intelligence meetings (e.g. SENSORIX). It is also possible, to combine the information analysis and strategy formation (e.g. Art of Technology). The use of sophisticated quantitative analysis tools is normally not necessary for NTBFs, nevertheless simple qualitative tools may be very useful.<sup>150</sup> In the last step, the generated information is disseminated and applied in the NTBF. Possible dissemination channels are coordination meetings (e.g. SENSORIX) or strategy meetings (e.g. Art of Technology). As important as the dissemination, is the useful storage of the information, that provides fast access

150. E.g. opportunity landscape, portfolios, mystery shopping (see also chapter A on page 211)

to relevant information. This may be accomplished with standard forms for intelligence information (e.g. technology intelligence report at SENSORIX). For an efficient use of technology intelligence, the integration into the technology control systems is possible.

Depending on the type of technology intelligence system utilized, the number of people involved in technology intelligence activities varies from a single person effort to a whole network of experts. The additional expense for a systematized technology intelligence system is rather low, because the company environment is scanned in any case, however the quality of the gained information is far better.

In the Pocke<sup>TM</sup> macro-design, technology intelligence taps different resources, especially if it is decentralized. In this case, all areas of the company are asked to contribute to the system. Technology intelligence is also a service process in the sense that it provides information for the strategy formation, implementation and control.

Technology intelligence may also be considered as a contribution to the organizational knowledge base, as part of the knowledge development process. Because of its focus on external information and its importance for the strategy formation process it is reasonable to consider technology intelligence as an independent key element of the Pocke<sup>TM</sup> and not as a knowledge management element.

### **6.2.2 Technology Strategy**

The formation of a technology strategy plays an important role in every NTBF, even though the strategy formation and implementation process varies widely. The formation of a technology strategy is integrated in the strategy formation and many NTBFs do not make an explicit differentiation between technology and business strategy. For example, if the firm grows with the technology (e.g. Degradable Solutions, SENSORIX), the overall company development (business strategy) is determined by the technology development (technology strategy). In these cases, the integration of the technology strategy is necessary, because the most important part of the business strategy is the technology element. The integral consideration of technology and business strategies supports the efficient and effective management of technologies, which differentiate NTBFs from their larger competitors.

The systematic strategy formation, that is more sophisticated than just an extrapolation of research findings, is important because an NTBF's strategy also has to consider market potential, competitor's reactions, customer's needs, etc. A technology strategy also directs an NTBF away from a short-term (customer) project orientation (resource generation) and more toward a long-term product orientation (rent generation / firm development).

The Pocke™ strategy formation process considers two methods of strategy development, the intended strategy development and the emergent strategy development (Figure 91).

Intended strategies are the result of a planning process that normally starts with the vision of the NTBF, then considers internal and external analysis, resulting in the strategy and implementation plan (e.g. pom+, Art of Technology). Strategy formation at Degradable Solutions emphasizes the importance of technology by taking technology as the focal point for the strategy development.

In the daily business process, emergent strategies play an important role in realizing new opportunities. Because of the short communication paths, emergent decisions are taken with very little delay. As soon as the strategic issue is recognized and considered valuable, resources are allocated and deployed. Examples are at pom+ where the process is explicitly defined or at SENSORIX where the technology management control system operates in a loop to identify emergent issues.

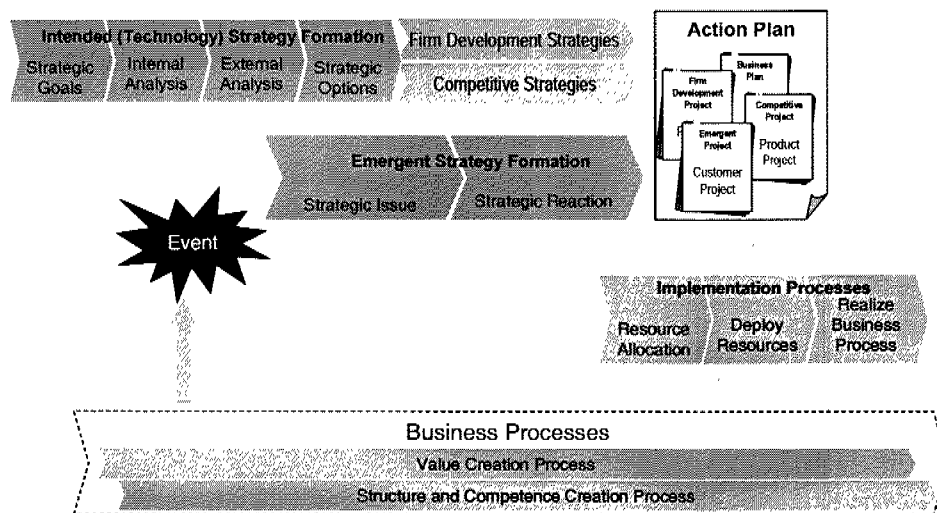


Figure 91 Pocke™ technology strategy formation and implementation

Strategy formation is the management team’s concern. The involved people range from the entrepreneur almost alone to the whole management team, where it has to be considered, that sometimes over half of the company is part of the management team. Art of Technology and SENSORIX have an annual strategy meeting, where intended strategies are developed. For pom+ strategy formation and implementation is a year long, step by step process.

On the other side, emergent strategies do not have to be planned, but they have to be acknowledged. As soon as a business opportunity is discovered, recognized or created, the decision to allocate the resources necessary to exploit this new opportunity is usually taken quickly by the management team (e.g. Art of Technology, Degradable Solutions).

The macro-design perspective, the strategy process itself consumes very few resources but regulates the resources allocation. The quality of the strategy depends strongly on the reliability of information about internal and especially external trends. This information acquisition often consumes more resources than the strategy formation itself.

Strategy formation occurs at any stage of the foundation process. With the growing age and size of the company, expectations about the quality of the strategy quality increase. To meet these requirements, the sophistication of strategy formation increases as well.

### **6.2.3 Technology Management Control**

NTBFs are beset with high dynamics, little constancy and minimal group control. Nevertheless, a management control system has important functions. The first function of a technology management control system is to force the management to define deliverables and clear project definitions. The second function is to provide an independent controlling process. Independent means in this context that there is a clear differentiation between competencies and responsibilities, between the strategy developing process and the control process. This differentiation may just be different meetings or minutes (e.g. SENSORIX). With this differentiation the discipline within the NTBF and the transparency for investors, partners and customers are increased. The third function is to react about changes in the environment. This function may be part of the technology intelligence.

The basic control system for an NTBF is group control. To enhance group control, diagnostic or interactive control systems are implemented. More sophisticated control levers such as technology boundary and beliefs system are possible, but rare.

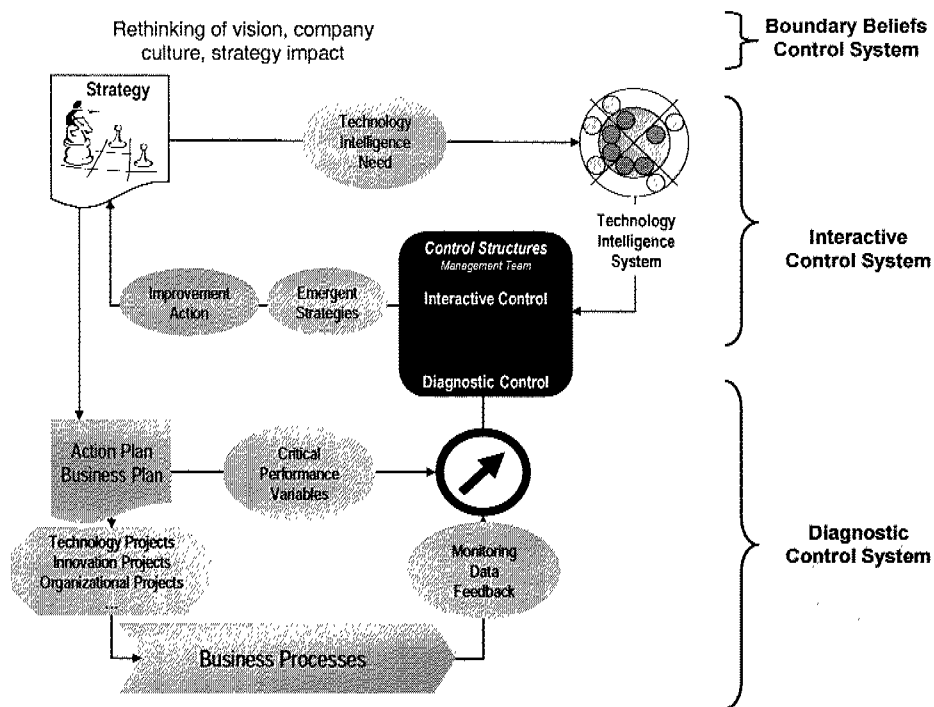


Figure 92 The Pocke™ technology management control system

As soon as the NTBF has defined the (technology) strategy, the implementation has to be considered. The diagnostic control system starts with the definition of critical performance variables such as new customers, new projects, learning effects, advancements in strategic planning, etc. Deliverables from strategic projects according to the action plan are other possible critical performance variables. Those performance variables are monitored (as simply as possible) and compared to the expectation of the strategic planning, e.g. SENSORIX has quarterly control meetings. The diagnostic control system increases the transparency of the NTBF by forcing the management team to question its efficiency and efficacy.

The idea behind interactive control systems is to recognize changes in the environment. The environment is scanned by a technology intelligence system (e.g. SENSORIX has a gatekeeper system) that delivers trends from the NTBF's environment. If those trends affect the strategic decision, reactions are necessary. Those decisions, if they are not taken immediately by the management team, may be discussed as part of the control meeting (e.g. pom+, SENSORIX).

It is not necessary to formalize the technology beliefs and boundary system in an NTBF. Nevertheless, an NTBF should also once in a while raise the question of whether the business idea,



vision and strategy still correspond with the environment. The pom+ administrative board thinks about this issue once a year.

Technology management control systems mostly involve the management team. Depending on the degree of decentralization, the CEO or the whole management team is involved. In the Pocke™ macro-design, the management control process checks, on the one hand, all other processes according to pre-defined variables, and on the other hand the control system integrates issues, which are outside the firm (interactive control part). The resources needed for the control system vary according to its intensity, e.g. SENSORIX has a quarterly meeting and the pom+ CEO spends several workdays each year on control issues.

As already mentioned in chapter 2.4.3 on page 68, (technology) control systems evolve as NTBFs grow and get older. At the beginning, a control system apart from a good group control does not make sense. As soon as the survival phase is left behind, control systems such as diagnostic control make sense. In other words, as soon as an NTBF possesses a control system, it has entered the growth phase. The need for control corresponds to the entrepreneurial behavior in the sense of the management team's self-discipline. If the management team is disciplined (e.g. deadlines, budget, management jobs etc.), the need for a diagnostic control system is considerably less. A (technology) belief and boundary systems is often just a concept of mind and not a systematized process. This means that an NTBF should think about these issues, but at the same time, it need not devote a lot of resources to them.

#### **6.2.4 Knowledge Management**

Sharing knowledge and maintaining transparency is absolutely a major strength of NTBFs. The organizational knowledge base is the foundation for NTBF's competitive advantage and deserves therefore special attention through an efficient and effective knowledge management.

Systematic nurture of the organizational knowledge base is of concern for most NTBFs, because firstly, for NTBFs that do not generate a notable turnover, the main deliverable is an increase in the knowledge base. The added value of the firm comes from a value added to the organizational knowledge base and not from generated cash flows. Therefore, every increased value of the organizational knowledge base has to be realized later in the market place. Secondly, the organizational knowledge base is permanently endangered. This is due to the NTBF's limited possibilities for external knowledge acquisition, as well as a small number of knowledge carriers and turbulent daily business. Thirdly, production of knowledge is a main business activity for many NTBFs.

Knowledge management is considered as a process to manage the organizational knowledge base. Data has to be analyzed to generate information that needs a context in order to become knowledge, that will provide value to the firm. The organizational knowledge base is divided between a collective and individual part, both containing tacit and explicit knowledge. Figure 93 shows the influential factors on the organizational knowledge base and its change.

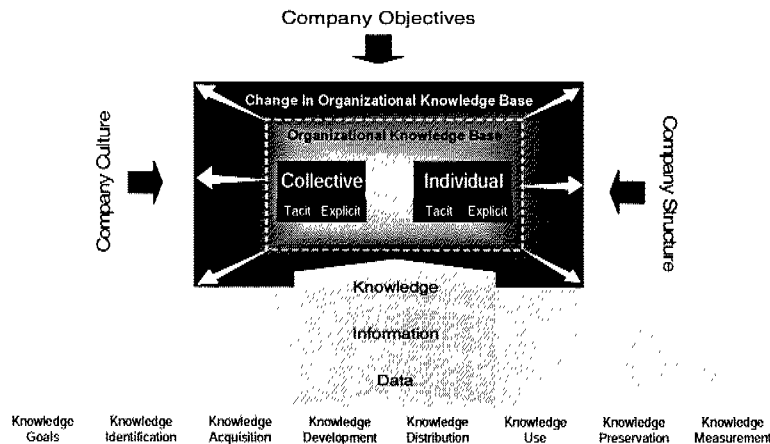


Figure 93 PockeTM knowledge management

Knowledge management, in contrast to the strategy formation and implementation, is a true concern for the whole NTBF staff. Culture and motivation influence the characteristics and success of knowledge management more than structures and organization.

Since knowledge management is an individual and collective process, it is not reasonable to describe it as a holistic process and to integrate it into the macro-design as a total process. Therefore, the most important sub-processes and tools are summarized:

- The definition of knowledge goals for the whole NTBF is an efficient mean of implementing strategies and keeping people motivated. Knowledge goals also underscore the management team's concerns about the knowledge development in the firm. To communicate knowledge goals, they may be separated into normative, strategic and operational goals (e.g. Art of Technology), put the goals into a knowledge portfolio (e.g. SENSORIX) or depict the goals as a house of knowledge management (e.g. Degradable Solutions).
- To identify, acquire and develop knowledge, informal activities are normally sufficient. Knowledge distribution may be considered as a challenge to infrastructure (room design, file server etc.).

- Knowledge use and preservation challenge NTBFs in particular. Knowledge preservation is important for NTBFs (e.g. experts leaving the firm, small knowledge base, need for organizational learning), but it is also difficult to establish, because there is no tradition. Firm specific solution may be a lessons learned concept (e.g. Art of Technology), or a call to everybody to store the generated knowledge (e.g. SENSORIX). The existence of a file server for digital storage is crucial.
- To determine if the knowledge flows are really stored in the formulated way, a system of indicators may be used as knowledge management control (e.g. Art of Technology). Often good group control is sufficient to keep employees motivated to do their job.



Figure 94 Summary of possible knowledge management activities

The proper staff integration is the most important factor in the design of a functional knowledge management system, because the management team can only set limits and encourage participation. Knowledge management is of concern for NTBFs of any size and age, because the sensibility towards knowledge management has to be continuously cultivated and fostered. The sensitivity towards knowledge management also includes the ability and willingness to share knowledge, which is considered an entrepreneurial precondition.

## 6.2.5 Cooperation Management

The emergence of the knowledge era has put NTBFs in a more demanding environment. The abundance of information placed at the disposal of companies, availability of knowledge-

intensive products and increased product application domains have become the norm. These markets become more and more dynamic and unpredictable.

In this turbulent environment, NTBFs with knowledge intensive parts in their value chain have to cope with the enormous challenge of developing a competitive advantage. In order to face this increasing knowledge complexity, NTBFs have to develop and use superior organizational learning capabilities through cooperations. The goal of external relations are firstly, to maintain the entrepreneurial flexibility, secondly to increase the responsiveness and adaptation in a turbulent economic environment and thirdly to develop competencies.

Strategic cooperation management in NTBFs involves the creation of trust and allocation of resources as a primary functions. To create trust, external relations have to be in close alignment with all NTBF processes. This guarantees continuity in the behavior, communication and commitment towards any partner. External relations always effect the NTBF's resources. Therefore, the allocation of resources in cooperation with partners has to be clearly defined in order to avoid discord.

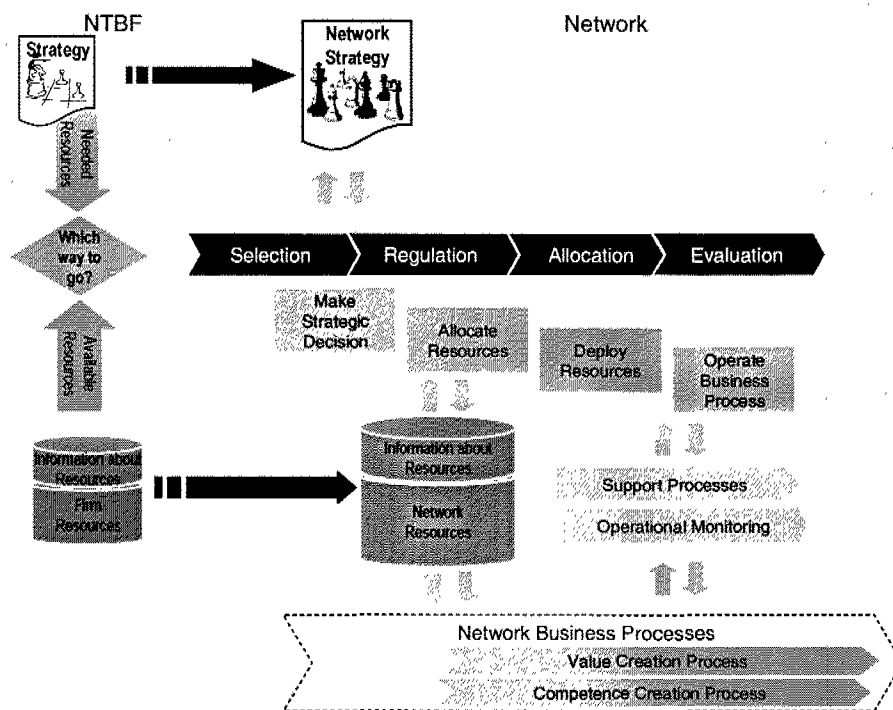


Figure 95 PocketM cooperation management

Strategic intentions that cannot be realized with the firm's own resources are the drivers for cooperations. External resources have to be acquired through networks, alliances, etc. The following concept is dedicated to managing cooperation between firms of the same size.

The starting point for most cooperations are gaps between the strategy intent and resources. The integration of external resources is evaluated, if the management team of an NTBF has identified these gaps. Appropriate partners have to be found and a collective strategy has to be developed. The development of common business processes integrates resources from all partners. To deploy these resources in alignment with the collective strategy, the declaration of each partners' resources (quantity and quality) is mandatory. Declaring and deploying resources involves a lot of trust between the different partners. Normally, additional to the business processes, support processes and monitoring processes are established. The monitoring processes are often separated between the collective monitoring and the individual monitoring of the business processes by each NTBF. Technology transfer between partners and development of new competencies may be an additional output of cooperations.

The negotiations about cooperations and collective strategies are done by the management team. Because creating trust among different partners is a key issue, the CEO plays an important role, especially if the initiation of the collaboration originates from the CEO's personal contacts. In the macro-design of the PockeTM, cooperation management enables new strategic possibilities by allocating resources in combination with partners.

External relations play a key role in any NTBF because at the foundation there are not enough resources available to develop, produce and distribute a technology, therefore every NTBF strategies involve external resources. The management of these resources varies widely. The proposed model focuses on the integration of strategic issues. The potential of collective strategies is enormous, because they are necessary to successfully develop shared new knowledge and competencies. Efficient collective strategies and control mechanisms allow NTBFs to bridge the important gap between the cooperation potential and the missing confidence in NTBFs as business partners.

### **6.3 IMPLEMENTATION PROCEDURES FOR THE POCCKETM**

This chapter aims to demonstrate how an NTBF proceeds to implement a PockeTM system, even though an NTBF has limited resources, an NTBF is an organization in formation and unstable environments are complicating factors. Activities for implementing the PockeTM include introduction, diffusion and improvements within the NTBF. The characteristics of the implementation procedure depend on implementation objectives, implementation teams and

supportive preconditions as indicated in figure 96. An appropriate alignment of these influential factors with the implementation procedure determines the success of the Pocke™ as an efficient and effective technology and innovation management system.

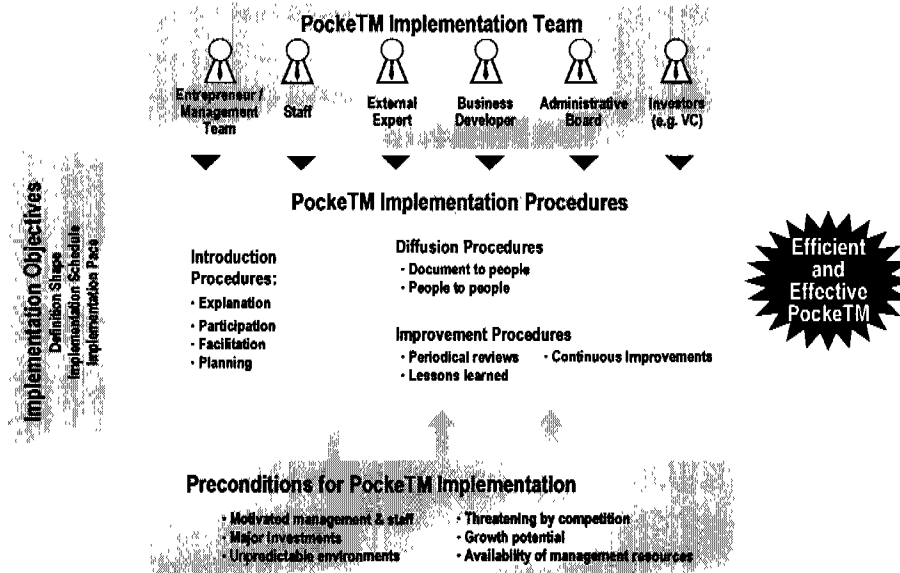


Figure 96 Aspects of Pocke™ implementation

### 6.3.1 Implementation Objectives

Not only their environment, but also NTBFs are subject to a continuous change. A management system for an NTBF therefore needs to be adaptive and flexible. Before the implementation of the Pocke™ is initiated, its shape has to be defined. The *shape of Pocke™* is defined by the chosen key elements and their characteristics. Key elements are selected depending on existing activities and future needs. It is possible to start the implementation of the Pocke™ with every one of the five key elements, even though the formation of a strategy or the knowledge management themselves are excellent elements to start the implementation procedure. This flexibility is important because depending on the evolution phase of an NTBF, different preconditions and needs exist. The different elements may be implemented step by step, allowing in each iteration, to redefine existing elements and introduce new ones.

If the technology strategy formation is chosen to be the starting point for the Pocke™ in the survival phase, the need for technology intelligence and technology management control arises automatically to build a solid strategy. Another starting point to Pocke™ is knowledge

management. Formalization efforts in the area of knowledge management, e.g. knowledge goals, lead to the formation of a better technology strategy and improved external relations.

The Pocke™ matrix (Figure 97) serves as a grid to shape the implementation of the Pocke™. Depending on the different challenges in each phase, appropriate structures are offered.

	Initiation	Survival	Growth	Expansion
Technology Intelligence	Awareness of need to scan but no formal system	Various scanning activities depending on information need	Proactive structured technology intelligence system	Improvement of intelligence system
Technology Strategy	Single product strategy, straight forward	Elaboration of strategy based on internal and external analysis	Improvement of strategy formation	Improvement of strategy formation
Technology Management Control	Group control	Group control	Improved strategy requires technology management control system	Improvement of technology management control system
Knowledge Management	Intuitive knowledge management	Planned activities to manage knowledge	Knowledge management to systematically enlarge organizational knowledge base	Improvement of knowledge management
Cooperation Management	Search for partners	First collaborations	Cooperation management to integrate external resources in business process.	Improvement of cooperation management

Figure 97 Grid to shape the implementation - Pocke™ matrix

Based on the implementation shape, an implementation schedule is developed that states which elements are to be developed and what the expected deliverables of the Pocke™ are. A clear definition of implementation expectation makes the Pocke™ measurable and eases the acceptance of measurements. Along with the implementation schedule, the implementation pace is fixed. Most NTBFs chose a stepwise implementation of Pocke™ in an annual iteration rhythm. Higher pace allows an NTBF to react faster to new circumstances, while a slower pace consumes fewer management resources.

### 6.3.2 Implementation Team

Basic requirements for a successful definition and implementation of Pocke™ are technology management competencies and 'political power' within the organization. Those

requirements may be found in the entrepreneur(s) or the management team, but the integration of external competencies is also possible. Thus, people who may be involved in the design and implementation of PockeTM are:

- *Entrepreneur(s) / Management team*
- *Administrative board:* Management competencies are often integrated through the administrative board, as investors, voluntary consultants, etc.
- *Business developers:* Assist the entrepreneur, often bringing a broad management background.
- *External expert:* Entrepreneurs often do not feel comfortable hiring consultants because they are expensive and do not offer guaranteed solutions.
- *Investors:* Especially professional venture capitalist work experts.

Definition and implementation of the PockeTM is a participative process. Therefore, in addition to the management team, the staff is integrated in PockeTM implementation projects in an early phase. If concerned people are involved in the design, the acceptance increases and people feel responsible for the system. Secondly, since these people are also users, they are very competent in the design of appropriate structures.

### **6.3.3 Implementation Preconditions**

Implementation of PockeTM reflects a non-routine processes which imply additional efforts have to be made. Favorable preconditions providing the necessary momentum for the implementation of PockeTM are:

- *Motivated management and staff* are the basis of implementing the PockeTM. The management team has to be convinced of the advantages of the PockeTM and be able to motivate the staff to contribute.
- *Major investments* in technologies or infrastructure serve as drivers to improve the NTBFs structure.
- *Unpredictable environments* increase management attention and force the management team to take well grounded decisions.
- *Threats from competition* increases the level of management attention. A correct reaction to external threats with the aid of the PockeTM might result in a success story with a catalytic effect for higher implementation objectives.



- *Growth potentials* leverage effects of investments in methodologies that systematically improve management performance.
- *Availability of management resources* determines whether a project to improve management systems is to be launched. For example in the period of market entry, free resources will not be readily available.

These preconditions largely determine the success and objectives of the Pocke™ implementation.

### 6.3.4 Implementation Procedure

Implementation procedures for the Pocke™ are classified in introduction, diffusion and improvement actions which span the broad space of implementation procedures. The challenge of the implementation task is convincing employees to apply the Pocke™ system in terms of being not only able but willing to use it.

#### Introduction Procedures

The introduction procedures describe how to initiate the implementation project.

*Explanation* of the possibilities and improvement potential of Pocke™ creates a sense of urgency and a desire to act. The inhibition threshold to using the Pocke™ is lowered if the management team knows that comparable NTBFs use it as well.

*Participation* means bringing teams or employees together to support the introduction of the Pocke™. Potential improvements and learning effects are a primary motivation for participative introduction.

*Facilitation* involves bringing experience to the NTBF through knowledge transfer, e.g. management seminars, transfer of professional (e.g. via the administrative board), coaches, etc. However, good facilitation requires a high degree of organizational insight in order to be effective.

*Project planning* starts with defining the shape of Pocke™ according the Pocke™ matrix (Figure 97). Before the project is launched, the schedule and pace have to be set considering the resource situation in the NTBF.

#### Diffusion Procedures

For a successful implementation of the Pocke™, structures have to be accepted and used in various processes of the NTBF. Therefore the following diffusion procedures are possible:

For a *document to people* type of diffusion, guidelines (e.g. manuals, SOP,<sup>151</sup> process descriptions) transfer explicit knowledge. Guidelines are developed or adapted by the person responsible for the implementation.

More important are *people to people* type diffusions. Meetings, presentation and informal talks are important when implementing the PockeTM, because implementation involves not only the dissemination of information, but also the discussion, persuasion, finding of solutions, etc. To initialize new management processes, training, coaching and controlling of the involved people (management team and staff) improves the implementation discipline.

### **Improvement Procedures**

*Periodic reviews* of the PockeTM system aim to encourage either revising existing procedures or starting the next implementation iteration. The formal character of periodical reviews allows experiences to be shared with responsible persons (e.g. administrative board, coaches) that are not directly involved.

*Capturing lessons learned* allows the implementation team to discuss, reflect and make adjustments concerning various aspects applying the PockeTM.

Implementing a management system comes along with a lot of changes in the NTBF and therefore not all initial assumptions turn out to be correct. *Continuous improvements* allow the design and implementation of the PockeTM to be corrected and improved.

These are the factors shown in figure 96 which should enable the implementation of an efficient and effective PockeTM.

## **6.4 POCKETM COST**

PockeTM costs are determined by human resource and infrastructure costs, thus costs vary widely depending on the implementation objectives and the NTBF preconditions. As indicated in the different action research discussions, costs to install or alter a management process are not to be neglected; especially where the rare management resources are concerned. The availability of management resources during the implementation period is essential.

Well coordinated meetings, reliable information and trusted external partners are crucial for the PockeTM and basic achievements for NTBFs. In most cases, these achievements had to be improved for the intended functions of PockeTM, consuming a great deal of resources in the short term. A detailed description of the implementation costs is found for each case in chapter 5. On

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151. SOP: Standard Operating Procedure

the other hand, results from the Pocke™ are often only visible in the long run (e.g. successful strategy, development of reliable network, etc.). This requires a management commitment to the Pocke™ implementation and a sufficient resource deployment in the long run.

Even though long-term experience is not yet available, implementation of different NTBFs have shown very promising results considering the price / performance ratio of the Pocke™.

## **7 MANAGEMENT PRINCIPLES TO SUMMARIZE SUCCESSFUL APPLICATION OF POCKE™**

The aim of this chapter is to contribute a viable solution to the successful application of Pocke™ in NTBFs. This chapter is the practical answer to the two research questions in chapter 1.2 on page 4 about the design and implementation of a Pocke™ in NTBFs, therefore the nature of this chapter is different from the character of the other chapters. While the latter follow scientific argumentation guidelines, output of this chapter is normative and hands-on. Thus proposals in this chapter are not on an argumentative basis, but quite straightforward.

However, any suggestions are based on practical experience gained during this dissertation work and reflect a theoretical background in the field of Pocke™. This also implies that the principles do not strictly depict the elaborated solutions offered during action research and the validation cases. This chapter reflects the realistic situation of an NTBF that wants to design, direct and develop a minimal technology and innovation management system.

### **7.1 PRINCIPLE 1: RELATION TO ENTREPRENEURIAL OBJECTIVES**

**THE POCKE™ SHOULD REPRESENT ENTREPRENEURIAL OBJECTIVES WHICH EMBODY THE DRIVERS BEHIND THE NTBF INCORPORATION.**

Key benefits:

- The direct link between Pocke™ and entrepreneurial objectives enables as well as enforces effective managerial activities.
- This link justifies Pocke™ activities and therefore, resource expenditures on these activities are also legitimized.
- Entrepreneurial objectives determine the design and implementation of Pocke™ elements.

Entrepreneurial objectives serve as basis for the Pocke™ system. Different entrepreneurial opportunities require different Pocke™ characteristics to exploit the technological potential within NTBFs. These characteristics correspond to drivers behind the NTBF foundation process. These drivers often aim at developing technological core competencies to build a unique selling proposition and enable a sustainable incorporation of NTBFs. Therefore technological opportunities have to be recognized, discovered or created.

## 7.2 PRINCIPLE 2: CONSIDERING ENTREPRENEURIAL STRUCTURES

A POCKE™ SYSTEM SHOULD BENEFIT STRUCTURAL AND TEMPORAL ENTREPRENEURIAL PROCESSES SYSTEMATICALLY AND SYSTEMICALLY.

Key benefits:

- Involved people are aware of the Pocke™, which makes their work more effective and efficient.
- Managing Pocke™ systematically allows consistent development of key elements in order to respond to change.
- A systemic approach to Pocke™ improves transparency and therefore, assures thoroughness and avoids redundancies.

Management decisions in NTBFs are based on the balancing act on the edge of chaos and time. Improvising, to solve daily business challenges and patching together incomplete management processes is a good description of the development of structures in NTBFs. Making those structures more efficient and effective through regeneration and experimentation leads to very promising results. This principle states, that the Pocke™ should be approached in a holistic way, implying that all key elements should be considered within the Pocke™ system ('systemic'), and then organized in an appropriate systematic manner. The company should however, be attentive that some elements not become over-emphasized, while other elements are neglected. It is recommended to consider the elements according to the Pocke™ matrix in figure 97.

Managing the Pocke™ refers to a systematic design / definition, direction and development. The difference between design and definition is that the definition refers to an existing concept or parts of a concept, e.g. tools in chapter A on page 211. Existing approaches should be considered whenever possible. If such concepts are not useful to the NTBF, which is possible because of differing contexts, they have to be newly generated. This is equal to designing concepts. Directing and developing the system emphasizes the fact that once the Pocke™ system is designed/defined and implemented, it has to be maintained. Maintenance includes proactive and reactive adaptations to 'new' situations, e.g. growth, strategy change, personal change. In fact, the best system seems to be the one that permits continual change.

### **7.3 PRINCIPLE 3: FIT WITH ENTREPRENEURIAL BEHAVIOR**

THE POCCKETM SOLUTION SHOULD BE COMPATIBLE WITH AND ENHANCE POSITIVE ENTREPRENEURIAL BEHAVIORS.

Key benefits:

- The PockeTM is well understood and accepted by the employees.
- Potential conflicts are minimized.
- The PockeTM gains importance through enhancing functions of organizational culture.

Entrepreneurial behaviors summarize how employees behave, communicate and are committed within NTBFs, in other words, these represent the organizational culture. A special characteristic of the NTBF is their culture-orientation that is based on common basic assumptions supporting knowledge sharing and innovativeness. Such a uniform business understanding over all hierarchical and functional levels describes companies with a proportionally high number of scientists and engineers, which is also reflected in the composition of the management. Innovations do not follow strict processes with clear gates, i.e. decisions, but follow a participative and evolutionary process. Resource allocation is seldom a clearly defined process with specific requirements.

The PockeTM system should enhance organizational culture to be more efficient and effective. Enhancing organizational culture involves giving the NTBF an identity that functions as a sense making device. For example, a transparent strategy increases the confidence of staff and partners in the NTBF and thus gives the NTBF an identity that makes sense. These conditions are important for the employees collective commitments' to the NTBF. Building on this commitment enables the NTBF management to go through difficult and uncertain times. Finally, sustaining stable social conditions are also a demand of the organizational culture in NTBFs.

### **7.4 PRINCIPLE 4: PARALLEL DEFINITION AND IMPLEMENTATION**

THE IMPLEMENTATION PROCEDURE OF THE POCCKETM SYSTEM IS INSEPARABLE FROM THE SYSTEM DEFINITION.

Key benefits:

- The PockeTM system meets the company's requirements and can be adapted when necessary.
- The solution is practical.

- The interdependent implementation and definition procedure allows mistakes immediately to be corrected.

The implementation procedure introduced in chapter 6.3 on page 180 underscored the different influence factors of the PockeTM implementation. The definition of the PockeTM system as part of the implementation objectives and the different implementation procedures (introduction, diffusion and improvement) are iteratively linked. Definitions of the PockeTM system may be altered in every iteration loop.

The preconditions for the PockeTM implementation normally do not allow a one-shot solution, in the sense that the entire PockeTM is implemented at once. This would not be reasonable, because the PockeTM should support the evolution of NTBFs, and therefore adaptations to previous system definitions are necessary. Logically, the next iteration loop certainly follows.

## **7.5 PRINCIPLE 5: TOOL DEPLOYMENT**

**TO INITIATE AND PERFORM THE POCCKETM, AN NTBF SHOULD APPLY USEFUL TOOLS (METHODS AND INFRASTRUCTURE) WHICH ARE APPLICABLE FOR NTBFs.**

Key benefit:

- Appropriate tools support the PockeTM system and therefore, make the system more effective.

A deployment of expensive and complicated tools (methods and infrastructure) is not a major concern of the PockeTM in the NTBF reality.

Considering PockeTM methods, it is highly recommended to avoid or, at least, simplify quantitative 'technical' methods, such as S-curve analysis, frequency analysis, bibliometrics etc. Accurate application of such methods is knowledge and time-intensive, and therefore not affordable for most NTBFs. Simplifying methods is a solution if the result is still significant.

Accordingly, these results should be interpreted bearing this simplification in mind. For example, if an S-curve is based on assumptions rather than on facts, the result is also an assumption and does not precisely reflect reality. In turn, the application of qualitative 'soft' methods, such as multidisciplinary and inter-subjective opinion forming, is highly recommended. Such methods are applicable during all evolution phases of NTBFs. Mostly, emphasis is placed on communication, analysis, searching and performance measuring.

Reverting to qualitative approaches (portfolios, roadmaps etc.) assures a common understanding and therefore, improves discussion and analysis quality. In a conclusion, Pocke™ tools should be used in NTBFs with a focus on qualitative rather than quantitative methods. An appropriate Pocke™ toolbox for NTBF is given in chapter A on page 211. This toolbox contains standard tools which are useful for NTBFs, as well as tools that have been adapted to or developed for NTBFs.

## **7.6 PRINCIPLE 6: THE POCCKETM AS A MINIMAL CONCEPT OF TECHNOLOGY AND INNOVATION MANAGEMENT**

**THE POCCKETM IS A MINIMAL CONCEPT OF ELEMENTS NECESSARY TO OPERATE A HOLISTIC TECHNOLOGY AND INNOVATION MANAGEMENT.**

Key benefits:

- The content of Pocke™ is reduced to the maximum making it affordable for NTBFs.
- The price performance ratio is optimized.
- NTBFs improve the quality of their management with Pocke™.

Technological change embodies for NTBFs a challenge and an opportunity at the same time. Technology and innovation literature offers answers to deal with this change for large companies. However, those solutions are not applicable in NTBFs.

Design and implementation of the Pocke™ has shown that basically all technology-based firms should systematically perform a systemic technology and innovation management. The Pocke™ aims to offer the NTBF an applicable solution considering their needs and possibilities. In this sense, the Pocke™ may be considered as a minimal concept of activities, tools and methods necessary to possess a functional, consistent and effective technology and innovation management.





## 8 NEW CHALLENGES AND FUTURE RESEARCH

This dissertation studied how New Technology-Based Firms (NTBFs) apply a minimal concept of technology and innovation management to increase the technological performance of the firm. The analysis of literature and empirical research in NTBFs revealed a lack of answers to the questions “How could a Pocke™ concept be designed for NTBFs, that fits to their needs, possibilities and opportunities?” and “How could a NTBF proceed to implement a Pocke™ system, even though an NTBF has limited resources, an NTBF is in an organization formation process and an NTBF is in a rapidly changing environment?”

Empirical research in over thirty NTBFs and action research in four NTBFs allowed the study of NTBFs and the generation of the Pocke™ concept. In a first step, the research framework with five key elements of Pocke™ was generated. In a second step, processes, methods and tools to apply the Pocke™ system were developed. A set of six management principles could be presented in order to achieve a contribution towards closing the gaps in theory and practice.

This solution for a Pocke™ System is surely no guarantee for sustainable success in NTBFs, because of the uncertainty of the future, the diversity of companies and the variety of success factors. However, by consideration of the presented management system and principles, the probability of being aware of the future is certainly improved, and therefore is promising for general firm success.

Some new challenges and issues for further research in the field of the Pocke™ emerged during this study:

- *Broader validation of the insights and generated concept:* The insights and generated Pocke™ system are based on four action research case studies. Therefore, the empirical basis is still quite narrow. Implementing the Pocke™ on a broader basis would give deeper insight into strengths and weaknesses, and would allow more variations to be tested.
- *Broader validation of management principles:* In addition to the generated concept, which represents a possible solution for the Pocke™ in NTBFs, 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 do empirical testing, further research could envisage empirical testing of these new hypotheses derived from the management principles.

- *Broader insight into interaction of PockeTM with other complementary management processes:* It is not possible to set clear limits between different management issues (e.g. technology management and production management) and different management processes (e.g. management process, support process, value generation process); they are nested and interrelated. The concept of the PockeTM provides a first picture, but a detailed examination of the interaction impact with other management processes would upgrade the holistic understanding of an integrated technology and innovation management.

One of the conclusions of this research is that the role of PockeTM will continue to be crucial for the competitiveness of NTBFs. This thesis concentrated on the design and implementation of a minimal concept of technology and innovation management. However, some open questions remain:

- *Adaptability of the PockeTM for other management methods:* The presented management system emerged primarily from practical experience gained from NTBFs during this dissertation work. However, it seems that almost all insights would be of interest for the design and implementation of other management functions, e.g. marketing. Adapting the PockeTM to a truly holistic management system would gain additional value for potential users.
- *Importance of external relations:* There seems to be an especially great potential in the area of cooperation management. Every NTBF has external relations and is worried about the trustworthiness of its partners, which raises the transaction cost considerably. Design structures to cultivate external relations looks very promising.
- *Adaptability of PockeTM to larger and older firms:* PockeTM is considered as a minimal concept of technology management resulting from research in NTBFs. However, it seems that similar preconditions exist also in the case of intrapreneurship or in SMEs with a potential and willingness to grow.
- *Development of an IT solution:* According to today's tendency toward integral IT solutions, the development of an IT solution for PockeTM seems to be promising. This would not only facilitate the dissemination and implementation of the system, but through better feedback loops, more system improvements could be realized.

These issues are challenges to both management practitioners and management scientists. If due to the inspiration of PockeTM in NTBFs this dissertation motivates practitioners and scientists to challenge these new issues, another main goal of the author is achieved. The author hopes that the PockeTM will be useful in both practice and theory to close the remaining research gaps.

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## **A APPENDIX: TOOLBOX**

### **A.1 BALANCED SCORECARD**

The balanced scorecard (BSC)<sup>152</sup> is a control method used to translate the firm's mission and business strategy into specified and quantified goals, as well as to define action plans to reach the goals. The strategies then become operationalized and measurable.

The firm's performance is measured in terms of finance, measured from the customer's perspective, with a view of internal processes and overall learning / growth (Figure 98). Specific indicators applicable to the firm and specific influence factors are considered for each perspective. NTBFs may use turnover while the cash flow is not yet measurable as a financial perspective. Useful indicators for customer perspectives are the number of customer contacts, number of new customers, market share, market segments, customer relation and satisfaction, turnover per customer, etc. Internal processes consider all business activities necessary for market performance, e.g. product development, production, market access and / or distribution; measured are cycle times, meeting delivery dates, etc. The perspective on learning and growth considers personal resources and organizational learning. Corresponding indicators are number of meetings / workshops, innovative ideas, professional training, changes in the knowledge profile, customer satisfaction, productivity, fluctuation rates, etc.

The strengths of the method are the correlation between goals and parameters over a cause-effect relationship. Additionally, a sharp definition of performance indicators and drivers leads to a more transparent strategy.

To develop a BSC, every perspective is listed in a table with columns defining goals, key data, defaults and measures. The BSC process contains the following steps:

- Strategy check and elaboration of strategic goals
- Set indicators
- Set defaults (future indicators)

Elaborate action plan

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152. (Kaplan & Norton, 1997, 2001)

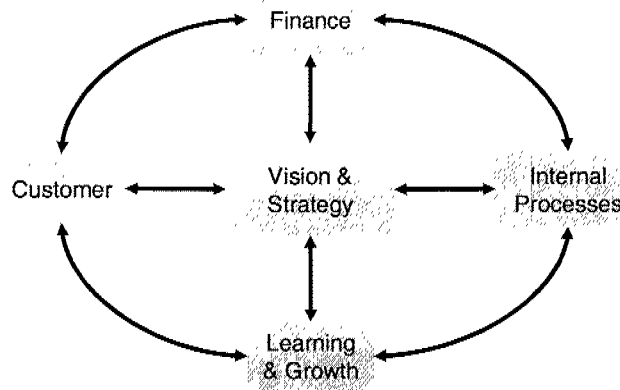


Figure 98 Visualization of the balanced scorecard

The major advantage of the BSC is not necessarily the BSC as a result in itself, but the process of developing the BSC, because the management has to answer strategic questions, define actions and measures and communicate with the staff.

## A.2 FUZZY FRONT END INNOVATION PROCESS

In particular for radical innovations, which are not simply initiated by a market need, it is challenging to build optimal innovation conditions. The fuzzy front-end of innovations is the stage where ideas emerge from an integration of the internal and external information base.

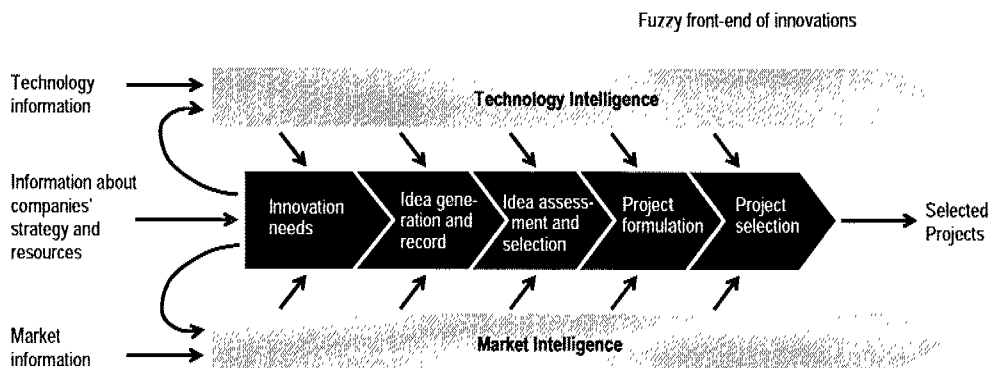


Figure 99 The system of fuzzy front-end of the innovation process (Savioz et al., 2002: 10)

The process of the early phases of the innovation process in a strict sense, may consist of the sub-tasks 'determination of the innovation need', 'idea generation and collection', 'idea evaluation and selection' and 'project formulation', which certainly are performed in an iterative way. The step 'determination of innovation need' combines the results of the market and technology intelligence and stores them in the organizational knowledge base. The knowledge base is created through their coupling with the knowledge of the competence areas of the company.

On this basis goal-oriented ideas can be developed. With a focused steering of this knowledge basis, for example in the form of a participatory planning process, the type of ideas generated and communicated, as well as the intelligence gathered on technologies and markets can be influenced.

Of course the detailed appearance and handling of the tasks during the early stages of innovation depends on various factors, such as company culture (e.g. process or culture driven), business strategy, formal and informal structures, resources allocation etc. Therefore, management of the early stages of innovations means to define optimal conditions by enabling the integration of an internal (e.g. strategy, resources etc.) and an external (e.g. technology and market intelligence) knowledge base (Savioz, Lichtenthaler, Brodbeck & Birkenmeier, 2002).

### **A.3 HAND SHAKE ANALYSIS (HSA)**

On the one hand, today's technology-intensive enterprises have to orient themselves toward their customer needs and on the other hand there is a constant need to improve their technological abilities. The handshake analysis (HSA) has been developed to bridge the gap between market- and technology-orientation through bringing about a better understanding of the interactions between markets and capabilities of the firm. After having created an overview of these interactions, new business opportunities may be more obvious.

The impacts of the HSA can be identified as follows:

- Providing clarity of the company's position from a technological point of view
- Providing clarity of the situation of the customer is needs
- Showing intelligence needs to find out more about customers and competitors
- Understanding true value drivers
- Showing new business opportunities

The HSA is a framework that requires input from the market and technology side. The 'handshake' occurs between product technologies and customer needs as *product functions* (Figure 100). The formulation of these product functions is not only the most difficult part, it is also the most important one because customers finally think in terms of product functions. The handshake analysis is applicable in NTBFs to align difficult technology decisions with (new) customer needs.

Figure 100 depicts the workflow and dimensions of the HSA. The main handshake takes place in the interaction matrix between customer needs and product technologies which gives answers to the question "Which technologies do we need to provide specific *functions* of our *products*? Customer needs, product functions and product technologies are essential dimensions of the HSA. Optional dimensions are products & services, markets & SBUs, R&D processes and manufacturing processes (Biedermann *et al.*, 1998).

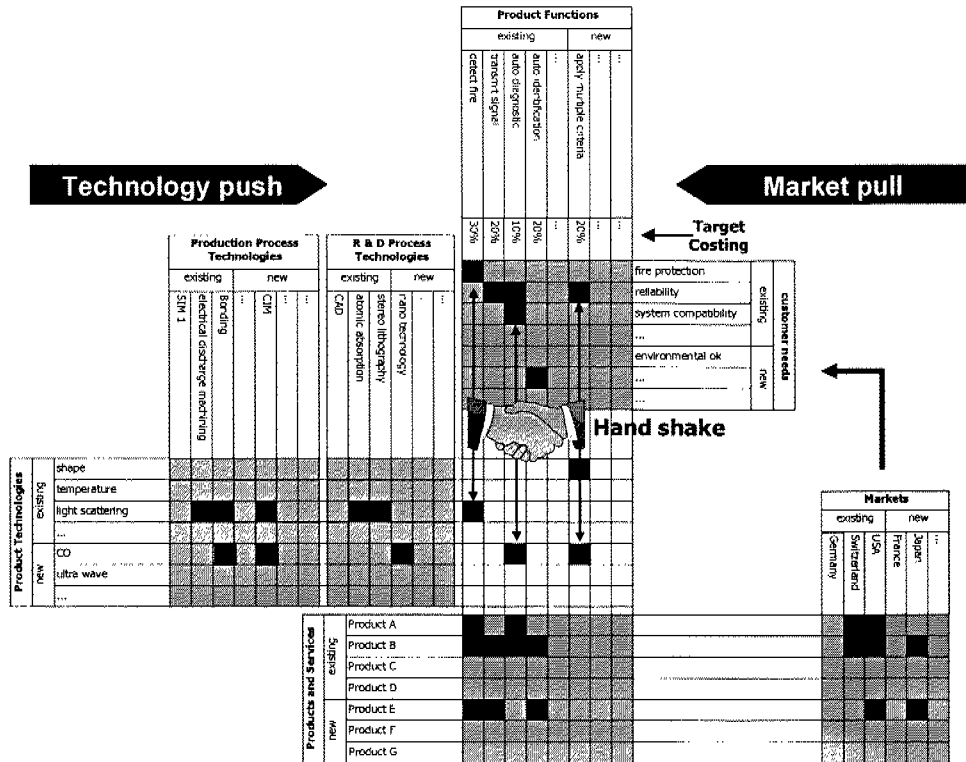


Figure 100 Overview of complete Hand Shake Analysis (HSA)<sup>153</sup>

153. For a compact HSA, see chapter 5.3.3 on page 128

To fill in the pattern of the Handshake Analyses, two main approaches are known: Approach from the market side and the approach from the technology side. These two approaches correspond to the ‘market pull’ and the ‘technology push’ philosophy of product innovations.

*Product functions* answer the question “What does the product do?” Unknown customers, exaggerated technology focus and competition often prevent the company from formulating accurate product functions. To counteract this problem, product functions should be formulated by using two terms: a rather general noun and a verb, which should be as precise as possible. Product functions may be divided in different types (Figure 101) or sub-functions. “How do we achieve a certain function?” and “Why do we need a specific sub-function?” are questions which prove whether product functions are properly formulated. In order to gain an appropriate distance from the problem, the phrasing of the product functions must not precisely predefine how to meet these functions.

Type	Technical functions	Constraining functions	Service functions		
Origin	Result from a conceptual choice	Imposed by the environment	Use functions (User aspects)		Estimation functions
Characteristics	Define relation between components of product	Default that the product should not have	Primary functions	Secondary functions	Psychological aspects

Figure 101 Types of functions (Millier, 2002: 168)

A product may correspond to existing *customer needs* or emerge as new products become available. To identify customer needs, NTBFs rely on several methods, e.g. mystery shopping, interviews with lead users / opinion leaders, top-flop analysis, customer satisfaction, etc.

*Product technologies*<sup>154</sup> result from research, development and production based on various process technologies. Often product technologies are defined by the question “What are the features of our technologies?”

The optional dimensions are normally not used in NTBFs.

154. For a detailed description of product and process technologies see chapter 2.2.1 on page 20.



## A.4 INNOVATION ARCHITECTURE (IA)

The innovation architecture is a tool used to understand the firm's innovation potential from a customer perspective. The basic elements of the innovation architecture are functions, understood as solution neutral descriptions of an operation that describes the constraints between input and output variables. Functions of a company are fulfilled by technologies or technology platforms with the aim of satisfying customer needs. In this way the function describes, 'what a product really does' (Figure 102).

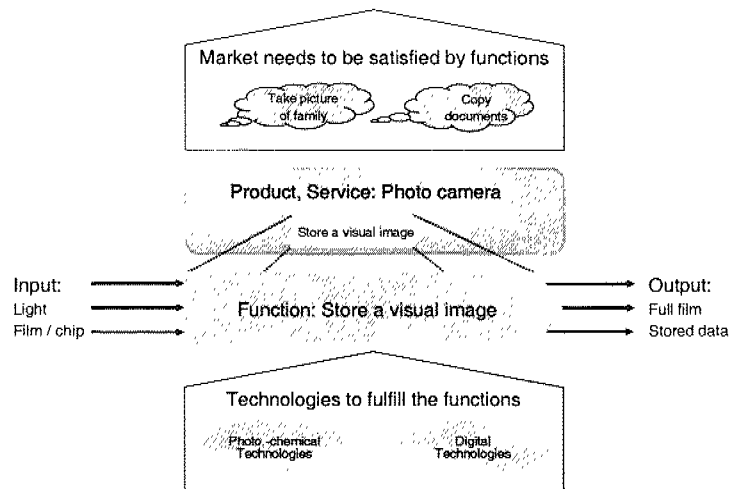


Figure 102 An example of a company function (Sauber, 2003: 277)

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 (identifying market pulls). On the other hand, the approach allows new emerging technologies in unfamiliar technology fields to be identified that fulfill the same function (identifying technology pushes). 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 fulfill this function. This process helps to identify major changes in the environment in a timely manner.

Defining proper product functions is a precondition to identify new opportunities. A function always consists of a subject and a verb. The subject has to be as general as possible and the verb as detailed as possible, describing the effect of the operation. For example, if the function of a printer is defined as 'print pictures', the subject is too detailed and would only allow picturing related business or technology fields to be found. The verb does not describe the solution of the printing operation, which in fact is actually the process of 'making thin layers'. With this function it could be possible to identify innovation options in other business and technology fields that are not focused on picturing or printing but focused just on making thin layers. To define such functions it is necessary to know about all related technologies, and in which products they belong. In a complex environment such as a big company this is, because of a lack of transparency, not a trivial task. Therefore, the first step in defining the functions is to analyze a transparent visualization of the scientific knowledge, technologies, products and market needs to be certain of all possible functions and to define them accurately. Such a transparent design can be developed by means of the innovation architecture (Figure 103). With these defined functions it is now possible to identify new innovation opportunities based on the company's competencies (Sauber, 2003).

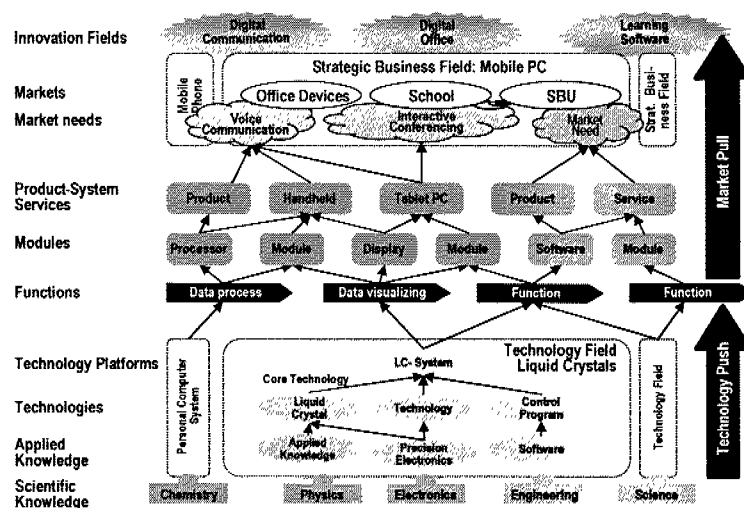


Figure 103 The functions of the company shown in the innovation architecture (Sauber, 2003: 278)

## A.5 JOURNAL READING AND STORAGE MANAGEMENT<sup>155</sup>

Especially for technology-intensive firms, staying up to date about current developments and research projects is an important and on-going task. Often, enterprises have a certain number of subscriptions to business or technology related journals and newspapers. However, normally these information sources are insufficiently exploited for various reasons:

- No assigned working time specifically allocated for reading
- Redundant reading
- Uncoordinated reading
- Difficulty in finding suitable articles in the archives

The workflow between the journal reading and storage management aims to institutionalize the integration of knowledge into the organization in different steps:

- *Selection of Journals:* Once a year, the staff determines the journals that the company will subscribe to. Through the participation of all the employees, the motivation to read the articles increases. For each journal, a specific person is assigned for the reading and the archiving of the articles from 'his/her' journal.
- *Personal Reading:* All subscribed journals are available for individual reading with a circulation list. On this list, interesting articles may be mentioned as well as suggestions for digital filing. The person responsible for the particular journal attentively reads through his/her journal and selects additional articles to be archived.

Three ways for journal reading are differentiated. Firstly, every journal has a list of *internal recipients* who pass the journals to each other. The time needed for full circulation is high. Often, journals are stuck on a busy person's desk and therefore, are not accessible for other employees. Secondly, for each subject a person is assigned as *subject responsible*. This method demands from each 'subject responsible' person to read through several journals systematically, which is a time consuming job. Thirdly, a *journal responsible* person reads the whole journal and decides which articles are relevant for the company.

- *Storage and searching:* Selected articles are scanned and read with a text recognition software. Afterward, the files are stored on a server. The expense is low and the articles can be accessed instantly via search terms, thanks to state-of-the-art search engines.

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155. This method has been developed at Art of Technology, Zurich (Haas, 2003).

## A.6 KNOW-HOW ACTION WORKSHOP

The know-how action workshop<sup>156</sup> serves to define and implement knowledge goals in NTBFs. Knowledge goals help the NTBF to realize long term strategic objectives.

The workshop contains the following elements:

- During the yearly strategy meeting, the management team identifies strategic knowledge goals according to normative preconditions. Using the knowledge portfolio, knowledge areas are classified by knowledge attractiveness and strength of resource. Based on these knowledge goals, guidelines for knowledge and company culture are defined and audited.
- In an annual workshop with the whole company, strategic knowledge goals are presented. At the same time the employees have the opportunity to present their knowledge areas of concern. As a result, operative knowledge goals are formulated as an action plan.

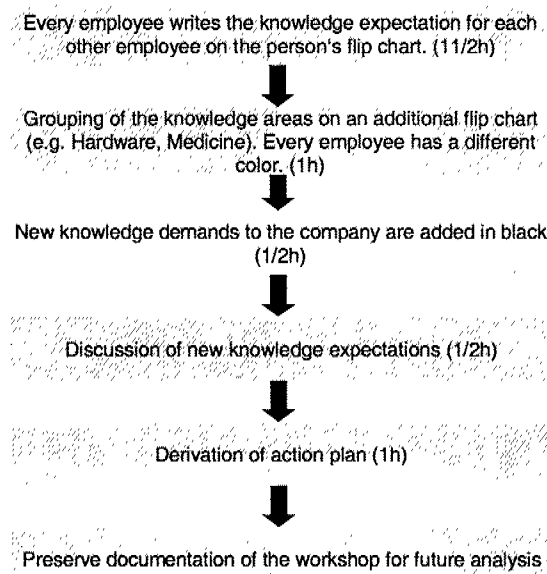


Figure 104 Workflow of the know-how action workshop (Haas, 2003: 54)

156. The know how action workshop was developed in collaboration with Art of Technology, Zurich (Haas, 2003).

## A.7 KNOWLEDGE PORTFOLIO

Global competition demands efficient development and maintenance of competencies and knowledge. A knowledge portfolio is used to translate business objectives into knowledge goals and finally organizational knowledge. Knowledge goals can be subdivided into three categories:<sup>157</sup>

- Normative knowledge goals, which enable the identification of strategic and operational knowledge goals
- Strategic knowledge goals, which define the desired ability portfolio and allow the strategic orientation of organization structures and management systems
- Operational knowledge goals, which translate the normative and strategic knowledge goals into applicable sub-goals and ensure the application of knowledge management on the operational level.

The knowledge portfolio supports the NTBF in setting knowledge goals on every level. The knowledge portfolio may be combined with other tools, e.g. a know-how action workshop to implement organizational knowledge goals.

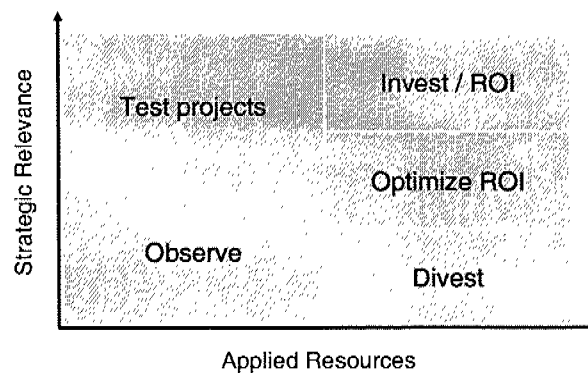


Figure 105 Knowledge portfolio (Voit, 2002: 81)

Five steps to develop a knowledge portfolio:

- Preparation includes making the NTBF's strategy documents, quality management guidelines, internal and external analysis available.

157. According to the St. Gallen management concept (Ulrich, 1984).

- 
- Initiation of the workshop begins with the question: “What has to be accomplished in this particular workshop?” Another important point is the clarification of knowledge terms and the definition or rehearsal of core competencies.
  - The knowledge portfolio is created along the NTBF’s own resource strengths and the strategic relevance. Useful questions are whether projects, customers, suppliers already exist, which processes, technologies and customers gain importance, which products are about to enter the market etc. The generated ideas are categorized in the knowledge portfolio.
  - Afterwards the portfolio has to be evaluated and oriented toward the strategic orientation of the NTBF. The knowledge assets and goals have to be in alignment with the core competencies.
  - As a last step, the conclusions of knowledge portfolio have to be summarized in an action plan and implemented. If possible, useful success indicators are defined (Voit, 2002).

## **A.8 LESSONS LEARNED**

In each project, team members gain experience, which could be of use for future teams dealing with similar questions. Often, these experiences are not systematically collected and made available for the whole organization. ‘Lessons learned’ is a tool to face this problem.<sup>158</sup> A structured and implemented ‘lessons learned’ concept ensures the following points:

- Experience gained during previous projects can be used to improve efficiency of the new project.
- Experience gained during the new project is strengthened.
- The procedures of the project are reviewed and the findings are documented.
- Documented knowledge is archived and is easily accessible.

The ‘lessons learned’ tool includes ‘learning before’, ‘learning during’ and ‘learning after’ a project.

*Learning Before*, which means reflection and preparation before a project starts. A phase of assignment analysis, reflection and preparation takes place, meaning that experience from previous projects are searched for useful hints to prevent negative experience and useless actions. In a first step, the project assignment is analyzed regarding potential sticking points, hurdles and barriers.

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158. The lessons learned tools was developed in collaboration with Art of Technology, Zurich (Haas, 2003).

Learning Before Procedure						Proceedings:
Analysis of the assignment: What lies ahead?						First meeting (30 min) with the entire project team as part of the kick-off meeting
OK		Attention		Sticking Points		
Specialized	Human	Specialized	Human	Specialized	Human	Second meeting as part of the internal kick-off meeting: Analysis of lessons learned
Which parts of the problem are already solved?		What is lacking and what are hidden dangers?		Where to expect problems? Preventions? Measures?		
What has already been dealt with?						
Identical		Similar		Different		
How to integrate previous findings into the new project?		How to adapt the already known facts and use them in the new project?		Where are differences? How do these differences hinder a comparison?		
Seek for Information						
Ask Persons		Project Files		Literature		
Who might know an answer?		Did we seek all relevant project files?		What has already been published?		

Figure 106 'Learning Before' process

*Learning During*, means continuous assessment of recent experience made during a project. During the realization of a project, regular 'learning during' meetings have to be held to record positive and negative experience from the project. Moreover, the current situation of the project may be compared to the desired situation and potential sticking points can be discussed.

Learning During Procedure				
Why?	How?	When?	Who?	Method?
<ul style="list-style-type: none"> <li>• Evaluation of good / bad experience</li> <li>• What did the NTBF learn?</li> <li>• Acknowledge new hurdles</li> </ul>	<ul style="list-style-type: none"> <li>• Analysis of project proceedings</li> </ul>	<ul style="list-style-type: none"> <li>• Always at the same time, e.g. as part of the monthly project meeting</li> </ul>	<ul style="list-style-type: none"> <li>• Entire project team</li> </ul>	<ul style="list-style-type: none"> <li>• Short standardized meeting (approx. 30 min)</li> <li>• Storage the lessons learned with the project files</li> </ul>

Figure 107 'Learning during' process

*Learning After*, is where conclusions are drawn from the finished project to improve the efficiency of future projects. 'Learning after' corresponds to the wide-spread process of project reviews with special focus on knowledge-related questions. Information that is of use for other employees is recorded and published.

Learning After Procedure			
	Process	Comments	Method:
1.	Reflect the achievements	Short introduction review to clarify project outcome	The entire project team holds a meeting shortly after the project is concluded to store project files and lesson learned files.
2.	What turned out well? Why?	Consider soft skills and hard facts	
3.	What did not turn out well? Suggestions for improvements?	Also successful procedures may be improved	
4.	Did the project goals change?	The better the initial planning, the fewer changes are necessary later on	
5.	Overall reflections of competencies and projects	Valuation in percent for every dimension to compare projects	

Figure 108 'Learning After' process

## A.9 MYSTERY SHOPPING

'Mystery shopping' reveals information about the NTBF and its competitive environment. An external (person unknown in the NTBF) contacts the NTBF to find out about the efficiency and friendliness towards customers. Systematic evaluation of the customer's experience involving a product and/or service provides the NTBF with an opportunity to identify potential needs and benchmark with competitors.

Someone contacts the customer contact as well as the competitors. The goal of this process is to find out how customers are treated.

## A.10 OPPORTUNITY LANDSCAPE

Technology intelligence includes activities that support decision-making of technological and general management concerns by means of collection and dissemination. The opportunity landscape<sup>159</sup> supports well timed preparation of relevant information about technological facts and trends (opportunities and threats) in the organization's environment.

The main goal of the opportunity landscape is to identify and anticipate relevant future trends and developments in the company's technological environment by constant and systematic observation. The originating knowledge is stored and maintained in a knowledge base. The idea is to link these observations to the business strategy and vice versa. The opportunity landscape is intended to be an affordable, yet effective management support system for NTBFs.

159. This tool was developed at the ETH-Center for Enterprise Science (Savioz, 2002; Savioz & Blum, 2002).



### **Workflow**

The first step is to identify strategic fields and issues to be observed. This can be done either by a top-down or bottom-up approach. Having a list of issues, the next step is to define the observation depth for each issue, meaning the intensity of observation and the required actions to provide the accurate and necessary information. Afterwards, for each issue a responsible person has to be assigned as 'gatekeeper'. Gatekeepers are responsible for observing trends and changing facts related to 'their' issues concerning technology, market and competitors. To facilitate and to encourage the information flow between the gatekeepers, a company-internal, formalized and coordinated gatekeeper network is useful. This information is summarized and visualized in the opportunity landscape.

### **Defining Relevant Issues**

The workflow to set up an opportunity landscape starts with the reflection about relevant topics. There are two basic approaches to define the list of issues: top-down and bottom-up. The first approach takes the business mission and strategy as the starting point to define strategic observation fields, within which several relevant issues are allocated. This task should be accomplished by the management team in order to reflect which fit the business mission and strategy best. In the bottom-up approach, staff from all departments with correspondingly varying views, e.g. R&D, marketing or production, are brought together in strategic workshops. The results are then discussed, consolidated and grouped into strategic fields that have to be checked for alignment with business mission and strategy.

Not all of the issues found are of the same importance to the company. Therefore, the opportunity landscape has two or three focus areas: players, substitutes, and juniors. This classification of observation depth gives the opportunity landscape an additional dimension. The visualization of the gatekeeper's activities is an important task to provide them with an identity, improve transparency and communicate results.

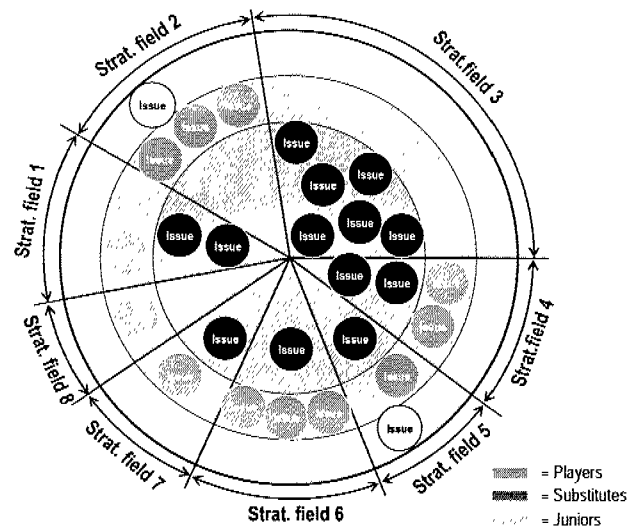


Figure 109 Opportunity landscape (Savioz, 2002: 125)

### Linking Issues with Gatekeepers

For each defined issue, the most competent person has to be identified and is then referred as a gatekeeper. Normally an expert, who has been known for some time to be familiar with all aspects of an issue, is labeled as the gatekeeper for this issue. Sometimes though, hidden experts first have to be discovered.<sup>160</sup>

The gatekeepers are responsible for appropriate observation of their issues. Thus, they organize themselves, especially to define the information sources. However, other employees are also asked to provide relevant information. The gatekeeper network is partly formalized and each gatekeeper's issue is known in the firm.

The gatekeeper has to consider three main aspects such as 'technology', 'market', 'partners' and 'competitors'. The gatekeepers are responsible for information collection, analysis and communication.

It is difficult to estimate the additional time exposure of gatekeepers. Basically, gatekeepers keep doing their jobs and information collection is part of their daily business. Properly analyzing information could mean an additional effort. But overall, improved development of the organizational knowledge base justifies the formalization effort.

160. In fact, the gatekeepers in the opportunity landscape are 'instilled' gatekeepers, and thus differ slightly from the original definition (Allen, 1986: 144). They actually do not necessarily present all the gatekeeper's skills described before, but they are supposed to.

### Gatekeeper - in a nutshell

- most competent person for a specific issue
- gatekeepers' dedication is the most crucial success factor
- responsible for appropriate observation of the corresponding issue
- responsible for information collection, analysis and communication
- presents insight from his/her observations proactively
- gets information from other employees
- considers technology, market and competitors
- self-organizing
- well-known by the employees
- keeps doing his/her 'normal' tasks
- might become an irreplaceable employee

*Table 8 Gatekeeper characteristics in nutshell (Allen, 1986: 144)*

The opportunity landscape follows information push and information pull logic at the same time. On the one hand, the gatekeeper can present insight from observation at regular meetings. On the other hand, the gatekeeper can be contacted anytime when information about her/his topic is needed. Thus, the gatekeeper network, i.e. the opportunity landscape, is the corporate knowledge base for facts and trends from the company's environment.

All gatekeepers together build the gatekeeper network, which can additionally be animated and coached by a coordinator. The coordinator should not be considered a technical supervisor of the gatekeepers' work, nor as a central communication node. She/he is another participant in the gatekeeper network with another focus of her/his contribution. For example, she/he provides supporting tools, i.e. methods and infrastructure and typically, the coordinator is a member of the technology management group.

### Updating the Opportunity Landscape

There are two major possible impulses to update the opportunity landscape: First, a revision of business mission and strategy makes changes in the opportunity landscape indispensable.

Another update input comes from gatekeepers themselves. Since, they are the experts with contacts to external experts and opinion leaders, they are most competent to decide which issue might be added and which existing issue are becoming obsolete.

Regular opportunity landscape revision workshops may help to ensure accuracy of the opportunity landscape.

## A.11 SWOT ANALYSIS

The SWOT analysis<sup>161</sup> (Strengths / Weaknesses / Opportunities / Threats) combines the strengths and weaknesses with opportunities and threats enabling a company to visualize its potential in its own environmental context. The analysis points out the strategic possibilities for decision making by spanning a matrix with strengths and weaknesses versus opportunities and threats.

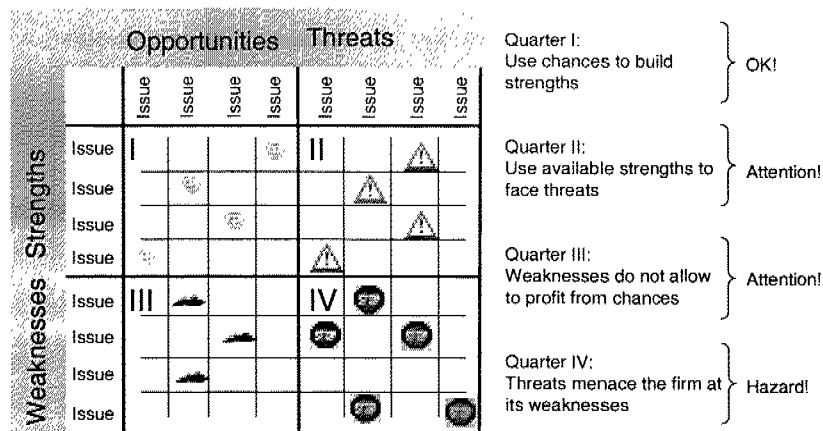


Figure 110 SWOT analysis

The SWOT analysis integrates the results from internal strengths and weaknesses with an environmental analysis that searches for future opportunities and threats found through analysis of technologies, customers, markets and competitors. The consolidation of the SW and OT part allows the firm to judge optimal allocation of resources and potential concerning expected external changes.

The workflow of the SWOT analysis starts with the collection of strengths, weaknesses, opportunities and threats and the definition of indicators to judge them, because only the five most important ones are normally considered in the SWOT analysis. External information sources are competitor analysis, market analysis, technological trends, lead-users etc., internal sources used are process management, considerations of the value chain, distribution channels, quality management etc.

161. The SWOT analysis was developed by different authors, e.g. Andrews, 1971; Wolfrum, 1994; Gerpott, 1999.

In a second step, the matrix of the firm's most important characteristics (approximately five) is spanned in a SW and OT dimension. In a third step, the interaction between those two dimensions are located and grouped in different clusters. Depending on the quarter in the matrix, different standard actions are proposed (Figure 111). This may lead to a reconsideration of the previous judgment.





	Opportunities	Threats
Strengths	 The available strengths in the system permit the firm to exploit existing opportunities.	 The value of existing strengths in the system is limited. Strengths may be absorbed by facing threats. <i>Actions: Face threats and build new strengths.</i>
Weaknesses	 Weaknesses in the system do not allow the firm to exploit opportunities. <i>Actions: Work on weaknesses to profit from opportunities.</i>	 Weaknesses of the system do not allow to cope with threats. Without action, the firm is endangered. <i>Actions: Immediate effort to transfer weakness into strengths.</i>

Figure 111 Standard actions of the SWOT analysis

## A.12 TECHNOLOGY PORTFOLIO

By planning technologies, companies ensure that their abilities meet tomorrow's requirements of the manufacturing and the (further) development of existing and new products. Technology portfolios are an established tool for formulating technological goals and the path to achieve them. Continuously, new technologies, which might be of value for the company, appear inside and especially outside of the enterprise itself. To base strategic decisions on these technologies and also to visualize the company's technological situation, technology portfolios<sup>162</sup> can be deployed.

Technology portfolios are two-dimensional matrixes. Normally, external factors, which cannot be influenced by the company, are compared with internal factors. In the following

162. Various types of portfolios are known, however in the context of this dissertation the dynamic technology portfolio is most useful (Tschirky, 1998)\_ 315).

example, the portfolio shows the position of technologies or technology fields on the two axes of technology attractiveness and technological competitive strength. To rank the single items along the axes, different criteria is used.

The impacts of the technology portfolios can be identified as follows:

- Understandable visualization of the technological position
- Possibility of a technology strategy to be derived
- Prioritization of R&D efforts
- Recommendation of standard procedures for prioritization

Technology portfolios are deployed during the process of strategy development and also during the planning of new products.

Stumbling blocks towards the successful implementation and application can be:

- The projection of the real technological situation of the company on the two axes of the technology portfolio might be a simplification, which is too strong. Important interdependencies of the different technologies could be ignored.
- Customer needs might be neglected, because they do not occur in the technology portfolio explicitly. Other methods (like the handshake analysis) have to be deployed in parallel.

The workflow starts with a ranking of technologies along the technology attractiveness and technology strengths axes. To position the technologies in the matrix along the two axes, different criteria can be applied. The selection of the criteria depends on the priorities of the company.

The following list contains some possible questions useful for determining the criteria to best judge technology attractiveness:

- Potential for further development: To what extent is technical advancement and reduction of costs possible in these areas?
- Time need: How much working time will be used to realize or maintain the technology?
- Kinds of application: How is the propagation of the possible technical advancements to be assessed regarding the number of areas of application and the overall quantity?
- Course of market penetration: How long will the market penetration last and what resources will be required?
- Compatibility and cannibalism: Do the technical advancements affect our existing products, services or technologies in a positive or negative way?

- Degree of technological mastery: Do we master the technology on an industrial production volume (scale-up)?
- Resources: Are financial, personnel, material and legal resources available to exhaust the potential for further development?
- Technical position: Is the technology compatible with the production methods and the abilities of the customer? Does the technology correspond to international and national standards?
- Type of application: How complex is the technology? How do the customers accept innovations?

The following list contains some possible questions for criteria to determine the competitive technology strength:

- Total financial resources: How much capital can be invested for the technology in total?
- Continuity of financial resources: Can the financial resources be used at the right time?
- Current knowledge: How much technology-related knowledge is currently available within the company?
- Continuity of knowledge: How long will the technology-related knowledge be available within the company? Is the knowledge strongly related to individuals who may leave the company?
- Technological achievement: How is our achievement to be assessed from a technical-economical point of view compared to the solutions of our most important competitors?
- Delay for action and reaction: How quickly can we exhaust possible technical advancement, compared to our competitors?
- Patents, licenses, and accreditation: What is the patent situation? Is an accreditation available or what would the expenditure be in order to attain such an accreditation?

There are different methods to value technologies. One possibility is to consider the weighted average as shown in the figure 112. Criteria for technology attractiveness are potential for further developments, time-to-market, kinds of application, course of market penetration etc. Criteria for competitive technology strength are financial resources, current knowledge, continuity of knowledge etc.

	Criteria 1 Estimated Value * Weight	Criteria 2 Estimated Value * Weight	.	.	.	Criteria n Estimated Value * Weight	Total
Technology 1							Scale 1 - 9
Technology 2							
.							
.							
Technology n							

Technology Attractiveness or  
Competitive Technology  
Strength

Figure 112 Matrix to evaluate technology attractiveness of competitive technology strengths of various technologies

With these estimated values, the technology portfolio is drawn. To be aware of obsolete and future technologies, an additional row and column are added. Arrows indicate the expected future position of the technology (Figure 113). The technology portfolio is a valuable tool for discussions and workshops concerning technology strategy formation.

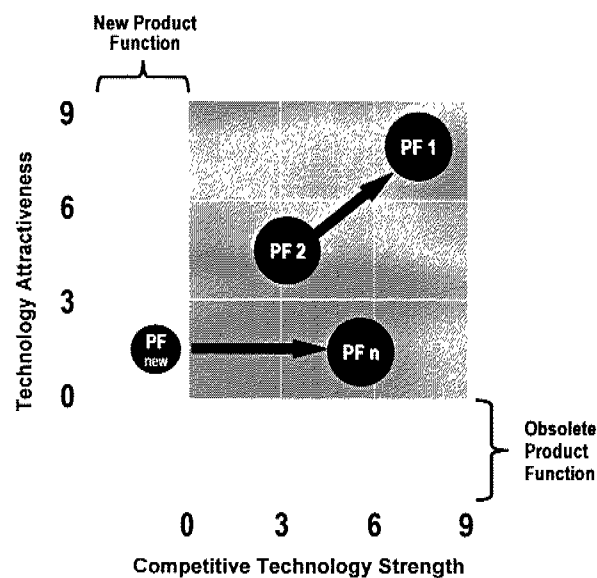


Figure 113 Dynamic technology portfolio (Tschirky, 1998: 315)



Depending on the position in the matrix, standard technology strategies are defined, such as invest, act selectively or retreat.

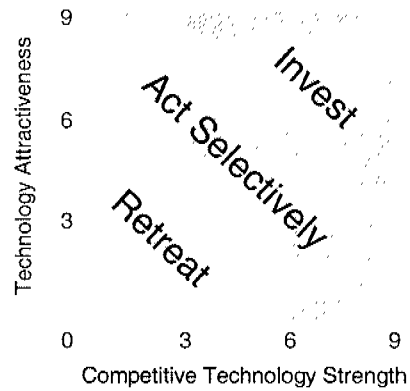


Figure 114 Standard technology strategies (Pfeiffer et al., 1982:99)

### A.13 TECHNOLOGY ROADMAP

The technology roadmap is the view of an NTBF on how to get where. A roadmap contains information about how to achieve desired objectives. The integration of market demands, products, technologies, competencies and resources allows the integrated visualization of the NTBF with resulting objectives for R&D, manufacturing or marketing.

Roadmapping as a process favors organizational learning within the NTBF and supports internal and external communication.



Figure 115 Different stages in roadmap development process (Albright & Kappel, 2002: 35)

A typical roadmap distinguishes between markets, product, technologies, competencies and resources. Technology roadmaps can be used as communication tools to illustrate strategic intentions as well as planning tools during the strategic planning process. To generate and maintain a technology roadmap, different processes and tools are applied. Some tools originate from project management,<sup>163</sup> such as Gantt charts, activity networks, project scheduling, milestone charts etc. Other processes and tools to roadmap originate from technology management, such as scenario planning, technology intelligence, hand shake analysis, etc.

Establishing a roadmap is an iterative process that is either *market pull* or technology push. When applying the market pull methods, the market demand is the starting point. Being aware of the needs of the customers, and therefore being aware of the demanded product functions, allows the company to derive future needs for technologies and competencies. Since the market introduction of products is situated at the end of the product innovation process, the market pull approach results in a backward planning process. New products for example require further development of product technologies, as shown in the following diagram.

163. Detailed descriptions of project management tools is given in standard project management literature.

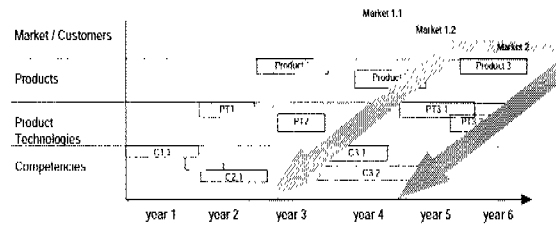


Figure 116 Roadmap for market pull

On the other hand, the *technology push* starts at the technology side with the main question “Which products help us to capitalize our competencies on the market?” As results, new potential products or market areas are identified. To ensure a successful market introduction, the integration of the marketing staff is crucial. The technology push approach leads to a forward planning process, where for example mastered product technologies lead to new product functions and consequently to new products.

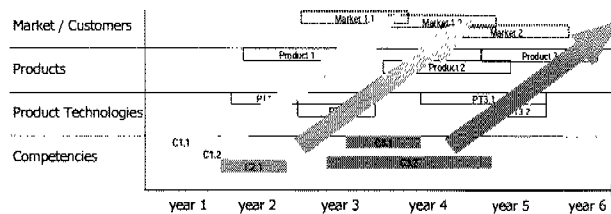


Figure 117 Roadmap for technology push

The main roadmapping task is to connect products and technologies through functional thinking. Helpful tools are the handshake analysis, functional market analysis, innovation architecture, etc.

After the identification of the required competencies and technologies for each product, they are aligned along the time axis. Setting estimated time consumption for components shows temporal interdependencies and resource consumption. The activity network is a suitable project management tool for visualizing temporal connections. The critical path in the activity network determines the duration of the whole project.

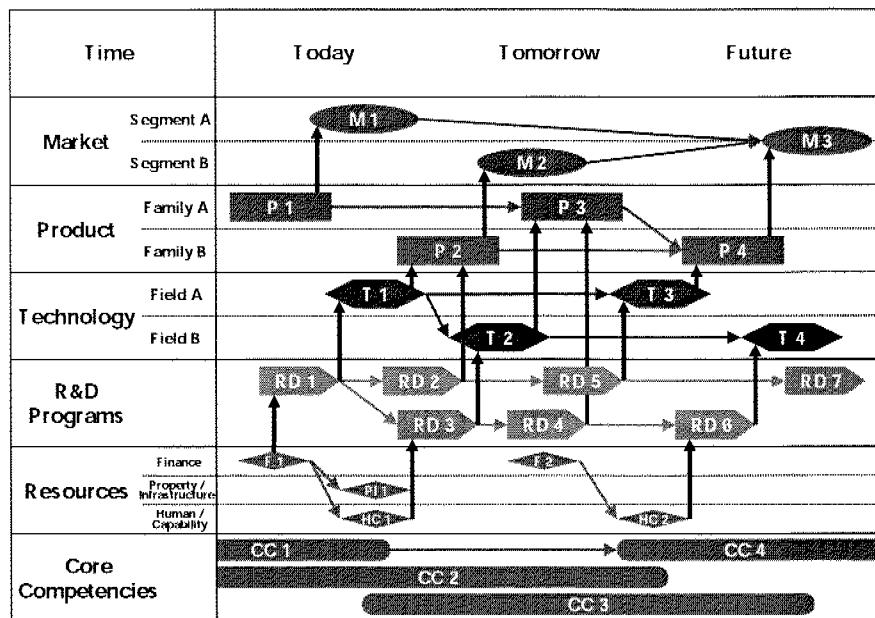


Figure 118 Integrated Technology Roadmap (Bucher, 2003: 246)

## Curriculum Vitae

Martin Luggen, born on October 18th, 1975 in Zürich, citizen of Ried-Brig/Termen, Switzerland.

### Education

- 2004            PhD Thesis in Technology and Innovation Management at the Swiss  
Federal Institute of Technology Zurich (ETHZ)
- 2001            Master of Chemistry at the Swiss Federal Institute of Technology  
Zürich (ETHZ)
- 1996            Maturity Type C at Gymnasium Spiritus Sanctus in Brig (VS)

### International Experience

- 2003/2004      Student exchange year in Angola, Indiana, USA. Diploma of  
attendance from the Angola High School.
- 1998/1999      Erasmus exchange at the Ecole Supérieure de Chimie et Physique  
Industrielle de la Ville de Paris, France

### Work Experience

- 04/2001-03/2004   Research assistant at the ETHZ Center for Enterprise Science,  
Technology and Innovation Management, Prof. Dr. Dr. Hugo  
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