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The Discontinuous Innovation Process at Established SMEs

An exploration of the discontinuous innovation process as experienced by established SMEs

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discontinuous innovation lab

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Preface

This thesis was written to complete my Masters degree in Business Administration with a specialization in innovation and entrepreneurship at the University of Twente. During my studies I received special interested in innovation management, more specifically how to manage discontinuous innovations. Aligned with my interest I was given the opportunity to write a thesis for the Discontinuous Innovation Lab (DILab) at the University of Twente. DILab is an international and interdisciplinary group of innovation researchers of which the University of Twente is a member. The objective of DILab is to generate knowledge on the discontinuous innovation process within organizations. I hope that my research will contribute to the existing knowledge base and I am thankful that I was given the opportunity to do so.

The objective of this thesis was to investigate how established small and medium sized enterprises (SMEs) manage the discontinuous innovation process. In order to analyze the latter, five established SMEs were involved in this research. I would like to thank these SMEs for their cooperation, the pleasant conversations and the interesting views.

During my research I received valuable guidance and input from my supervisors. At first I would like to thank Dr. Dries Faems for his interesting remarks, guidance and conviction. I would also like to thank my second supervisor Dr. Ir. Rick Middel for his views and involvement. I enjoyed writing my thesis at the university and appreciated the comments of fellow graduates, PhD students and lecturers. Finally, I would like to thank my family and friends for their support and incentives.

Desie Lenferink

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Management Summary

The world is moving at a fast pace, requiring firms to respond to short product life cycles and frequently changing customer demand by innovating. Innovations can either be of continuous or discontinuous nature. Continuous, or incremental innovations are concerned with ‘doing something better’ as described by Tidd et al. (2005b). Discontinuous innovation goes a step further and refers to doing something different, which requires high levels of creativity and out-of-the-box thinking to achieve.

Discontinuous innovations are triggered or caused by a wide of variety sources, such as the emergence of new markets, new technology, new political rules, a change in market sentiment, market behaviour and unthinkable events (Bessant & Tidd, 2007). Discontinuous innovations are a powerful tool to secure competitive advantage, a strategic position, retain market shares and increase profitability, but the drawback is that it does not guarantee success (Tidd et al., 2005b). The discontinuous innovation process is far from easy; it is complex, messy, takes long and is above all unpredictable in nature, due to many uncertainties. Examples of these uncertainties are ambiguity about market acceptance and initial uncertainty about the viability of the technology.

Current research on the discontinuous innovation process has mainly focused on large established firms and start-ups, but a knowledge gap remains on established small and medium sized enterprises (hereafter SMEs). In the Netherlands 99,7% of all firms are SMEs and a large part of this figure must represents established SMEs (mkbservicedesk, 2009). Firm age and size influence the firm’s ability to innovate, thus the ability to innovate varies per firm type. Many large established firms have difficulty developing discontinuous innovations, due to established routines causing structural rigidity and they are often constraint by the influence of shareholders and end-consumer preferences. Start-ups often lack resources compared to large established firms, but do not have an existing consumer base and are free in their choice to pursue new markets. Start-ups are often seen as the driving force behind disruptive technologies (Kassicieh & Walsh, 2002).The agility and entrepreneurial capabilities of start-ups enable them to cope with a greater extent of uncertainty and provides space for creativity.

Given the importance and difficulty of innovating, the objective of this thesis was to decrease the knowledge gap on the ability of established SMEs to develop discontinuous innovations, more specifically to analyze how established SMEs experience the discontinuous innovation process. This thesis was written for the Discontinuous Innovation Lab (hereafter DILab). DIlab is an international and interdisciplinary group of innovation researchers, who aim to generate knowledge on the discontinuous innovation process at organizations. In order to do so DILab applies a discontinuous innovation process model, which start with the search for a discontinuous idea, the selection of the idea and the implementation (development and commercialization) in which the idea is turned into a discontinuous innovation by the firm. To explore how established SMEs (existing for at least 10 years) experienced the discontinuous innovation process the following central question was applied;

How do established SMEs manage the discontinuous innovation process, in terms of search, select and implement?

The focus of the thesis was not on the technical aspects of the innovation, but rather the management perspective in terms of the problems and challenges experienced by the established SMEs and the mechanisms applied during the process. To explore this subject case study, research was performed on five established SMEs that experienced the discontinuous innovation process. The data was gathered in three stages to allow for a structured data gathering process; first unstructured interviews were conducted, followed by semi-structured interviews and last but not least the respondents were given the opportunity to provide feedback on the case study reports. The findings retrieved from the case studies provide interesting insight into the ability of established SMEs to develop discontinuous innovations. The findings are presented underneath per stage of the discontinuous innovation process.

The Search Stage

The discontinuous innovation process starts with the search stage, which is usually structured by large established firms that apply several mechanisms, such as innovation hubs and sending out scouts to find innovative ideas. The established SMEs studied did not structure the search stage, instead ideas were triggered by potential legislative changes, dissatisfaction about existing systems or by problems of others. Those established SMEs that were approached with innovative ideas, may have benefited from social legitimacy in the region or industry through which inventors or problem owners approached them. Overall the most important facet in the search stage for established SMEs is the entrepreneurial mindset, which enabled the established SMEs to generate innovative ideas by linking inventions to the market. One of the established SMEs studied applied a mechanisms, named before-the-box thinking, which entails brainstorming about solutions without taking existing solutions into account. By combining this mechanisms with out-of-the box thinking established SMEs may be able to generate discontinuous solutions to problems and discontinuous ideas.

The Select Stage

Once ideas have been generated the established SMEs move to the selection stage. This is where established SMEs differ from start-ups. Start-ups are generally founded on an idea that emerged from a university or a parent organization, hence start-ups are not faced with the selection decision. In comparison large established firms generally have procedures for the selection of new project and long decisions lines, which negatively influence the time required to select an idea. Selection in the established SMEs is mainly based on subjective judgement.

Opposed to the DILab model, selection in the established SMEs does not solely take place after the search stage, instead the unpredictable nature of discontinuous innovations creates an emergent selection environment. The established SMEs need to select an innovative idea by taking its core business into account, but none of the established SMEs applied financial selection mechanisms, instead established SMEs seem to prefer mechanisms based on subjective judgement, thus entrepreneurial instinct. Throughout the discontinuous innovation process the established SMEs applied more mechanisms to decrease the uncertainty and further prove the selection decision. These mechanisms can be referred to as further selection mechanisms, examples of these are a business case and feasibility tests. The owners of established SMEs should therefore allow for an informal selection stage gate process, which will decrease uncertainty throughout the discontinuous innovation process.

The Implement Stage

The implement stage has the largest scope because it entails turning the idea into a physical reality. The main problems and challenges experienced by the established SMEs during this stage are the lack of capabilities and resources (among others, financial and manpower) resulting in a competency gap to develop the discontinuous innovation. The majority of the established SMEs were granted subsidies and closed the competency gap by outsourcing activities it could not perform itself. Preferences in outsourcing for knowledge in the initial stage of implementation goes out to universities, as these are great knowledge domains and less threatening to the established SMEs compared to large established firms. In most of the established SMEs the owners had to simultaneously manage core business and the discontinuous innovation process. The established SMEs generally lacked the resources to implement mechanisms to ease these tasks.

Established SMEs wanting to develop a discontinuous innovation should organize additional financial means, as bank do not prefer to support discontinuous projects. Accordingly subsidies may be required, but they also entail a lot of administrative work which should be taken into account. The established SMEs should implement a clear and structured process- and meeting- schedule (framework); to allow for clear milestones and discussion on various facets of the process. If possible they should assign a project manager. Outsourcing can be applied to close the competency gap and established SMEs could establish multidisciplinary team to streamline the varies outsourced activities. Depending on the innovation, involvement of end-consumers in the innovation process can be very valuable in terms of product experience, preferences and consumer reactions. Established SMEs should organize IP-rights (and patents) in the early stages of the process, but only solicit for patents when the innovation can be legally substantiated. When wanting to pursue global commercialization the established SMEs should anticipate that additional (financial) resources, social legitimacy and capabilities may be required.

Throughout The Discontinuous Innovation Process

The owners of the established SMEs can be depicted as ambidextrous and entrepreneurial individuals, thus multi-taskers. Owners of established SMEs should have the ability to make choices between daily business and the innovative activities, be alert to opportunities beyond their direct tasks and able to build internal and external linkages (Birkinshaw & Gibson, 2004). The entrepreneurial skills that are important are the ability to recognize a means-end framework for the recognition of opportunities, the courage to enter the discontinuous innovation process, the networking skills to close the competency gap and the conviction to complete the discontinuous innovation process. The owners should also network and engage on innovation platforms throughout the discontinuous innovation process, as valuable competencies or information can be extracted.

Table of Content

List of Tables

List of Figures

List of Textboxes

1. Introduction

This first chapter will provide an explanation on the general purpose of the thesis, which is focused on the discontinuous innovation process at established small and medium sized enterprises (hereafter, established SMEs). The thesis is written for Discontinuous Innovation Lab (hereafter DILab), which is an international and interdisciplinary group of innovation researchers. The aim of DILab is to generate knowledge on the discontinuous innovation process at organizations.

1.1 Initial Background Information

The world is moving at a fast pace, requiring firms to respond to short product life cycles and frequently changing customer demand by innovating. Tidd et al. (2005b, p. 3) argue that innovation is driven by the firm's ability to *"see connections, to spot opportunities and to take advantage of them."* Innovation is not just about opening new markets, but also about offering new ways of serving established and even mature markets. The difference can be best described using the terms continuous and discontinuous innovations. Continuous, or incremental innovations are concerned with 'doing something better' as described by Tidd et al. (2005b). Discontinuous innovation goes a step further and refers to doing something different, which requires high levels of creativity and out-of-the-box thinking to achieve.

Discontinuous innovations are triggered or caused by a wide of variety sources, such as the emergence of new markets, new technology, new political rules, or by running out of the road, a change in market sentiment, market behaviour, deregulation or shift in regulatory regime and unthinkable events (Bessant & Tidd, 2007). The triggers cause firms to react and change the rules of the game in a given industry, which obviously makes unprepared firms vulnerable. This fact stresses the vital importance of developing discontinuous innovations, which when introduced to the market can help capture and retain market shares and increase profitability. One may therefore view innovating as a powerful tool to secure competitive advantage or a strategic position, but the drawback is that it does not guarantee success (Tidd et al., 2005b).

The discontinuous innovation process is far from easy; it is complex, messy and above all unpredictable in nature, due to many uncertainties. Examples of these uncertainties are ambiguity about market acceptance and initial uncertainty about the viability of the technology. Discontinuous innovations change the rules of the game and create new markets, they may take longer to develop and to become profitable and make it difficult to predict ex-ante whether the technology will be disruptive at all (Danneels, 2004).

The importance of developing discontinuous innovations to attain competitive advantage and the difficulty of developing these innovations makes it a very interesting topic to study. To analyze how discontinuous innovations emerge, one should study the process through which firms develop discontinuous innovations. According to DIlab, the discontinuous innovation process starts with searching for a discontinuous idea, selecting an idea and implementing the idea to develop it into a final product or service. Firms may experience problems and challenges during such an innovative process. These problems and challenges may vary according to the firm's nature.

Many large established firms have difficulty innovating, due to established routines, which cause structural rigidity and inertia. Large firms are often constraint by the influence of shareholders and end-consumer preferences, but have the resources to develop innovations. Large established firms may use various mechanisms to cope with the problems and challenges of the discontinuous innovation process, e.g. they may set up innovation hubs to prevent rigidity. Nevertheless many large established firms seem to be reluctant to develop discontinuous innovations and prefer to develop incremental innovations to better adhere to consumer preferences.

Start-ups on the other hand, often lack resources and capabilities to develop innovations singlehandedly, e.g. lack of financial resources. Start-ups generally use different mechanisms to cope with the problems and challenges of the discontinuous innovation process, such as subsidies to sustain the development costs. The advantage of start-ups is that they do not have an existing consumer base and are free in their choice to pursue new markets. The agility and entrepreneurial capabilities of start-ups enable them to cope with a greater extent of uncertainty and provides space of creativity. Start-ups are often seen as the driving force behind disruptive technologies (Kassicieh & Walsh, 2002).

As can be depicted most literature either focuses on the innovative capabilities of large established firms or start-ups, but there is a serious knowledge gap concerning the innovative capabilities of established SMEs. Established SMEs comprise an important part of the economy. In the Netherlands 99,7% of all firms are SMEs and a large part of this figure must represents established SMEs (mkbservicedesk, 2009). Established SMEs hold a workforce smaller than 250 individuals and are therefore expected to be more flexible than larger firms. Compared to start-ups established SMEs are also assumed to experience resource shortages, but do have an existing consumer base restricting their innovative capabilities as their attention may be focused on their existing consumer base. Nevertheless, as no research has been conducted concerning the ability of established SMEs to develop discontinuous innovations many questions remain, e.g. are established SMEs negatively influenced by structural rigidity due to their age similar to large established firms, or do they benefit from their size and enjoy the agility and creativity similar to start-ups.

It is evident that established SMEs comprise an important part of the economy and that discontinuous innovations are required to achieve a sustainable competitive advantage, but despite the growing interest in the discontinuous innovation process, many scholars fail to investigate the problems and challenges experienced by established SMEs and the related mechanisms. As a result the aim of this thesis will be to investigate how established SMEs experience the discontinuous innovation process. More specifically the thesis will analyze the challenges and problems experienced during the discontinuous innovation process by established SMEs. The thesis will also analyze the mechanisms applied to address the problems and challenges during the discontinuous innovation process, which enabled the established SMEs to successfully develop the discontinuous innovations.

1.2 Research Objective

The objective of this thesis is to explore how established SMEs (existing for at least 10 years) experience the discontinuous innovation process. More specifically the objective is to analyze how established SMEs experience the discontinuous innovation process in terms of search, select and implement. The focus is not on the technical aspects of the innovation, but rather the management perspective in terms of the problems and challenges experienced by the SMEs and the mechanisms applied during the process. To explore how established SMEs experience the process, case study research will be performed.

1.3 Central Question

To receive insight on how established SMEs experience the discontinuous innovation process case study research will be performed. Definitions of the key terms in the central question are presented in table 1. The aim of the research will be to answer the following central question:

How do established SMEs manage the discontinuous innovation process, in terms of search, select and implement?

Concept	Definition
Established SMEs	The category of micro, small and medium-sized enterprises (SMEs) is made up of enterprises, which employ fewer than 250 persons and which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million (Communities, 2003). Established in respect to this study refers to SMEs existing over ten years.
Discontinuous Innovations	Innovations that may create new lines of business for the firm itself and for the market (O'Connor & Veryzer, 2001) and that may be opaque to customers (Abernathy and Utterback 1988). These innovations either have new to the world performance features (fundamentally new product/service), five-to ten-fold (or greater) improvement in performance features or reduce the costs by 30% or more (Rice et al., 2002).

Table 1 Definitions Concepts Central Research Question

Sub-Questions

The sub-questions are aimed at the three stages of the discontinuous innovation process, namely search, select and implement. The general sub-questions will be the same for all three stages;

- What challenges and problems were experienced during the three stages?
- What mechanisms were used in the three stages to address the challenges and problems?

1.4 Thesis Structure

The next chapter of this thesis is the theoretical overview, which is mainly based on literature concerning the discontinuous innovation process. The third chapter explains the methodology applied and highlights the appropriateness of conducting case study research and the specific data collection and analysis techniques applied. The fourth chapter presents the results in case study reports per established SME. The case study reports are written in chronological order and describe how the established SMEs experienced the discontinuous innovation process in terms of challenges, problems and mechanisms applied. At the end of each case study report a within case analysis is presented. The fifth chapter is a discussion on the theoretical and cross case and findings. The last chapter is the conclusion, which answers the research questions, provides managerial advice, suggestions for further research and discusses the limitations.

2. Theoretical Overview

This chapter will provide a theoretical background on the concept, importance and difficulty of the discontinuous innovation process. The discontinuous innovation process model by DILab (figure 1 on page 9) is used as a blueprint to explain the challenges and problems firms experience during the process and the mechanisms applied. The theoretical overview is mostly structured on literature focused on large firms and start-ups, due to the lack of literature concerning this topic on established SMEs.

2.1 The Concept of Innovation

The world is moving at a fast pace, requiring firms to respond to short product life cycles and frequent changing customer demand by innovating. Tidd et al (2005, 3) argue that innovation is driven by the firm's ability to "*see connections, to spot opportunities and to take advantage of them."*

Innovations can be distinguished as Tushman and Anderson (1986, p. 441) do by the form of the innovation, thus product (new product classes, product substitution, fundamental product improvements) and process discontinuity (process substitution and process innovations resulting in radical improvements in the industry). Tidd et al. (2005b) go a step further in their categorisation and introduce four forms in which innovations can take place, namely, product, process, position and paradigm innovation. Product, process and position innovations are quite straight forward, in comparison to paradigm innovation, which refers to changes in the underlying mental models framing an organization (Tidd et al., 2005b).

Innovations are not just about opening new markets, but also about offering new ways of serving established and even mature markets. The difference can be best described using the terms continuous and discontinuous innovations. Continuous, or increment innovations are concerned with 'doing something better', hence slightly improving the product or service, whereas discontinuous innovations are about 'doing something different' (Tidd et al., 2005b).

2.2 Discontinuous Innovation

Discontinuous innovation is still a relatively new research domain, but can be traced back to Schumpeter (1970s), who introduced the concept of creative destruction. The essence of creative destruction is the *"ability of breaking away from routine to destroy existing structures, to move the system away from the even, circular flow of equilibrium"* (Kirzner, 1999, p. 7). Creative destruction can be compared to discontinuous innovations, as these innovations have the ability to change the rules of the game and go against the steady state trajectory of the firm. Discontinuous innovations can *"create an entirely new market through the introduction of a new kind of product or service"* (Christensen and Overdorf 2000, p.72) and may even "*permit entire industries and markets to emerge, transform, or disappear"* (DeTienne & Koberg, 2002, p. 352).

Creative destruction is according to Schumpeter initiated by an entrepreneur, who is referred to as the *"force that dislodges the market from the somnolence equilibrium"* (Kirzner, 1999, p. 7), thus steady-state. In comparison, discontinuous innovation are generated by individuals with high levels of creativity and the ability to perform out-of-the-box thinking. The development of discontinuous innovation may take considerably long ranging from two to ten years and so will the time it takes before profits are generated.

Discontinuous innovation is an ambiguous concept, due to the wide array of terms used interchangeably to refer to the same concept, such as breakthrough, radical or disruptive innovations. Nevertheless to a great extent the authors tend to refer to the same concept, namely innovations that may create new lines of business for the firm itself and for the market (O'Connor & Veryzer, 2001) and that may be opaque to customers (Abernathy and Utterback 1988). Some discontinuous innovations[1] may focus more on the high performance, high value segment and aim to penetrate the mainstream market. These innovations are often driven by technological breakthroughs or ideas that require dramatic behavioural changes to existing markets and accordingly take a long time to develop (McDermott & O'Connor, 2002). Other discontinuous innovations[2] may focus more on the low end market and offer low performance. These type of innovations require good-enough technologies with special features not yet appreciated by an established market. According to Kassicieh and Walsh (2002) they require market development or expeditionary marketing.

Although existing literature has provided us with a multiplicity of definitions concerning discontinuous innovations, this thesis will structure the element of discontinuous innovation around the definition provided by Rice et al. (2002). For an innovation to qualify as discontinuous it must have; new to the world performance features (fundamentally new product/service), five-to ten-fold (or greater) improvement in performance features or reduce the costs by 30% or more. Innovations fulfilling one of the above criteria may be named discontinuous and create new markets.

2.2.1 The Importance of Discontinuous Innovations

Discontinuous innovations are triggered or caused by a wide variety sources, such as the emergence of new markets, new technology, new political rules, or by running out of the road, a change in market sentiment, market behaviour, deregulation or shift in regulatory regime and unthinkable events (Bessant & Tidd, 2007). The triggers cause firms to react and change the rules of the game in a given industry, which obviously makes unprepared firms vulnerable. It is important that firms prepare and realise the importance of discontinuous innovations to sustain long term survival. Discontinuous innovations can help capture and retain market shares and increase profitability. More specifically one may consider discontinuous innovations as a powerful tool to achieve competitive advantage and to secure the firm's strategic position (Tidd et al., 2005b). Nevertheless the drawback is that it does not guarantee success, but it may take firms "*out of the 'zero sum' game that characterizes many industry battlegrounds"* (Bessant et al., 2004).

2.2.2 The Difficulty of Discontinuous Innovations

The discontinuous innovation process is far from easy, it is complex, messy and above all unpredictable in nature. Discontinuous innovations change the rules of the game and create new markets. They generally take longer to develop and to become profitable. It is also difficult to predict ex-ante whether the technology will be disruptive at all (Danneels, 2004).

The unpredictability of discontinuous innovations increase the difficulty to anticipate for the future. Rice et al. (2002) studied the uncertainties, which firms experience when faced with discontinuous

[1] Many authors tend to use the term radical innovation for innovations that focus on high performance and on the need to deliver high value to penetrate the mainstream market.
[2] Many authors tend to use the term disruptive innovation for innovation that serve a new low-end market and offer low-performance initially.

innovations. The complexity of dynamic and shifting discontinuous projects create four types of uncertainties, besides the traditional technical and market uncertainty, firms are also faced with organizational and resource uncertainties (Rice et al., 2002). Since discontinuous innovations are unpredictable it is difficult to anticipate the exact resources required, the organizational impact, the exact technological competencies required and whether there will be sufficient demand to sustain the innovation. The latter uncertainties often negatively influence the firm's decision to engage in discontinuous projects.

Besides the given uncertainties, which are mainly concerned with influences from the market and the innovation itself, organizational characteristics may also enhance the difficulty of engaging in discontinuous innovation processes. Corso and Pellegrini (2007) provide reasons for inertia towards innovation from an organizational perspective. Among the reasons are, a cognitive representation of the management restricting search activities and putting constraints on the development of new capabilities, a dominant logic limiting the ability to see new opportunities and the impact of disruption on competencies, which can either be destroying or enhancing. More specifically one may refer to core rigidities causing inertia. Core rigidities are a negative side effect of core capabilities, which are not neutral, but deeply imbedded in the organization (Barton, 1992). As a result, managers are faced with a paradox: *"core capabilities simultaneously enhance and inhibit development",* accordingly managers have to manage the conflict of *" the need for innovation and the retention of important capabilities"* (Barton, 1992, p. 112).

Core rigidities negatively influence a firms' agility, flexibility and learning capacity and one can imagine that the longer a firm exist the stronger and more persistence the dominant logic. Similarly Tidd et al. (2005b, p. 23) state that "o*rganizations build capabilities around a particular trajectory and those who may be strong in the later (specific) phase of an established trajectory often find it hard to move into the new one".*

Firms with inadequate behaviour towards discontinuity, may suffer from the not invented here syndrome. This syndrome causes firms not to opt for an innovation, because in the firm's perception the innovation does not fit to the firm. Another common factor influencing the firm's decision to innovate is how they perceive the market, which usually is too messy, too uncertain and too small.

Generally many firms seem to rely on maverick individuals pushing discontinuous project through the funnel by working with senior management against the organizational 'immune system'. Unfortunately not every organization can rely, or even has maverick individuals who push discontinuous innovation forward. As a result many organizations fail to "*recognize and address organizational and resource uncertainties triggered by project discontinuities, resulted in slow or inadequate responses to discontinuities, resulting in jolts that diminished corporate support for the project survival and success"* (Rice et al., 2002).

As has been mentioned before discontinuous innovation processes generally take longer and cost more to develop. Besides the patience such processes require from firms, they also require large investments. In a project by the European Union, named Disrupt-IT the barriers to disruption were investigated and four main barriers were found, among which indeed the difficulty of finding appropriate funding. The other barriers refer to the ignorance of the strategic importance of discontinuous innovations ,the inability to generate disruptive ideas and inappropriate new product development (hereafter NPD) processes (DILab 2003). The inappropriate NPD processes will be discussed more thoroughly in the next section.

Perhaps one of the least expected barriers to discontinuous innovation are the practices of good managers as proposed by Christensen (2003). Christensen (2003) provides two reasons why according to him good managers prevent firms from successfully identifying and pursuing discontinuous innovations. The first refers to the firm's dependence on the consumers, investors and senior management, which will result in performance improvements, but not in discontinuities. The second reason can be related to the time it takes before consumers get acquainted to discontinuities, hence the initial market is small. Managers will often not opt for smaller markets and tend to wait until the market is attractive enough. At that point, the firm will be too late to develop a product itself.

To conclude one may state that firms experience various barriers when wanting to develop a discontinuous innovation. Some of the barriers are more of an external nature, such as uncertainty about the market in terms of acceptation and the presence of the required technology and workforce. Other barriers are more of an internal nature, thus when firms are trapped in their own immune system. To describe the latter one may relate to Christensen (1997, p. 187), who states that a combination of "*incompetence, bureaucracy, arrogance, tired executive blood, poor planning, and short-term investment horizons obviously have played leading roles in topple many companies*". Acknowledging the various barriers, it seems obvious that firms wanting to engage in discontinuous innovation need to prepare for the future, thus extend their view to the periphery and allow for a degree of uncertainty.

2.3 The Discontinuous Innovation Process

This section will discuss the nature of the discontinuous innovation process, which is different from the continuous innovation process, due to the inherent differences between discontinuous and continuous innovations.

Discontinuous innovations "*involve an extremely high degree of technological uncertainty, a sequence of innovations and long development times*" (Veryzer, 1998, p. 316,7). The additional *"uncertainty of suitable applications for the technology of the greater distance from the market in terms of time and customer familiarity with the product also affect the nature of development process"* (Veryzer, 1998, p. 316,7). The process is influenced to such an extent that there are fundamental differences between the process by which discontinuous innovations are developed and the more routine evolutionary NPD processes (Mascitelli, 2000).

Bessant and Tidd (2007, p. 236) have established a list of archetypes for discontinuous innovations, which are directly related to the process. One of the most obvious archetypes is the fact that there are no clear rules, these emerge over time when the uncertainties decrease. Similar notions are presented by De Tienne and Koberg (2002, p. 361) as they characterize the innovation journey *" by trial and error learning and making it up as you go along."* And by Lynn et al. (1996, p. 28) who characterize the process as *"a process of successive approximations that has to be managed not through analysis, but by experimental or quasi-experimental design"* (Lynn et al., 1996, p. 28). The experimental nature creates momentum for change and enhances the capacity of the firm to react to changes while maintain a focus on the present (DeTienne & Koberg, 2002).

The fuzzy nature of discontinuous innovations creates an emergent selection environment, in which firms must be willing to take risk, place multiple parallel best and have a tolerance for failure. Firms engaging in discontinuous innovation projects, should consider a process which is path-independent, emergent and apply probe and learn activities. As the operating patterns are emergent and fuzzy, the firm should be able to create a peripheral vision. The difficulty however remains that discontinuous innovation process is inherently messy and uncertain. The sequence of steps and the emphasis on activities often differs during the development of discontinuous innovations (Mascitelli, 2000), as a result "*the development of discontinuous products does not seem to proceed in the manner described by either conventional or stage-gate-like development systems, nor does it seem particularly amenable to being managed according to such approaches"* (Veryzer, 1998, p. 316,7).

The crux of managing the discontinuous innovation process may lie in the firm's ability to "*recognize the different orientations of the flow of activities inherent in discontinuous innovation and adapt management practices to accommodate the demands of the process"* (Veryzer, 1998, p. 321). The number of stages in the process may be arbitrary, but each stage should involve the search for answers to different managerial imperatives and require clear decision points and stage-reviews (Debackere, 1997). Although some coordination is pivotal, the firm should not try to coordinate the process too tightly as it impedes the capacity for innovation, given the complexity and above all the uncertainty of discontinuous innovations (DeTienne & Koberg, 2002).

To summarize one may state that the uncertainties involved the discontinuous innovation process cause it to be inherently messy, with far less structure and formalization than the evolutionary NPD processes (Mascitelli, 2000). Although the process for more conventional new project development is well understood, "*questions remain concerning how the link between advanced technologies and market need occurs for radical innovation"* (O'Connor & Veryzer, 2001, p. 231).

To make discontinuous innovations more feasible and the uncertainties less intimidating, firms should try to gain information about the innovation and market. According to Chesbrough (2006) useful knowledge is widely distributed and even the most capably R&D firms should have the objective to be connected to external sources of knowledge. More specifically Chesbrough (2006) argues for an open innovation paradigm. If firms apply such an open innovation approach, it will obviously influence the way they structure their discontinuous innovation process, in terms of the influence of the external environment and the external mechanisms applied. For example whether the external environment will be used as a valuable source of ideas, or as mentioned before whether probe and learn is seen as a valuable tool, thus "*take a step into the market with an early version of the product, gain experience about both the technology and the market and then modify the product and approach to the market based on that experience"* (Lynn et al., 1996, p. 30).

To be able to structure the thesis and provide a comprehensive framework on the challenges and problems of the discontinuous innovation process within the selected established SMEs, the discontinuous innovation process will be analyzed from a managerial perspective, using the innovation model by DILab (Tidd et al. 2005) as a blueprint (see figure 1). Nevertheless throughout the theoretical framework the complex, multi-stage, cross-functional and multidisciplinary nature of the innovation process will be taken into account (Debackere, 1997). The model consists of three main stages namely, search, select and implement, which will be discussed according to the most apparent problems and challenges. Once the firm has experienced the three stages (search, select, implement) the firm can decide to learn from previous decisions and actions by reflecting upon the previous stages and reviewing experiences of success and failure. The next sections will discuss the innovation process from idea generation until the actual development of a finalized and launched innovation. Probable problems and challenges during the innovation process and frequently used mechanisms will be discussed per stage .

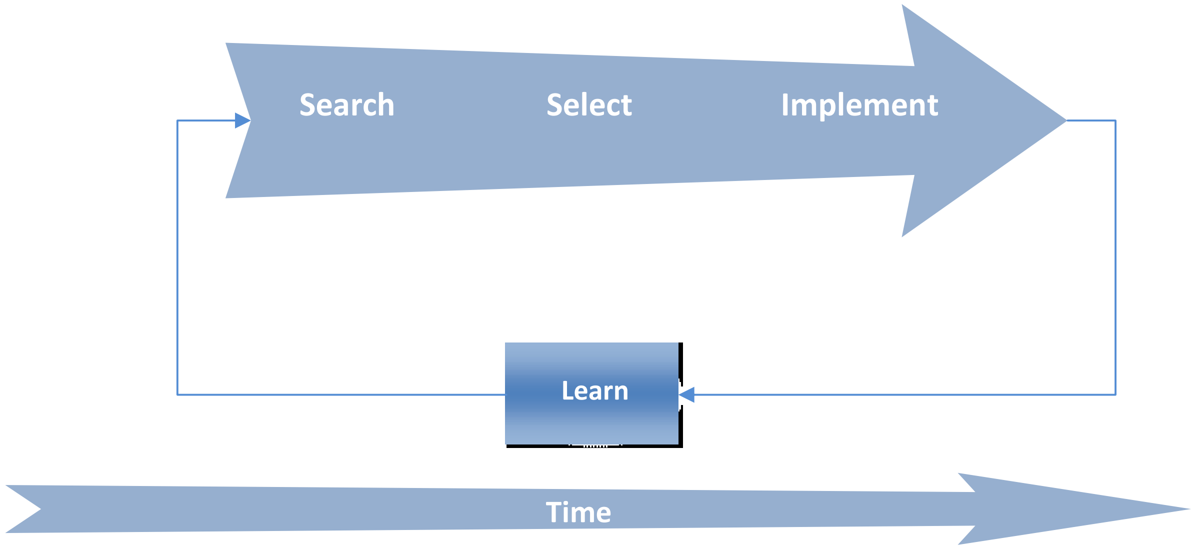

Figure 1 The innovation process Tidd et al. (2005b, p. 68)

2.3.1 The Search Stage

The main objective of the search stage is to find an idea for a potential innovation, or even a set of potential innovations. Searching and recognizing ideas requires an essential link to be made between the 'pool' of inventions and the 'market' (Debackere, 1997). Such a link can be made by the entrepreneur, the manager or other employees, but external individuals may also approach firms with ideas.

To find ideas, hence potential innovations *"firms need to scan and search their environments, both internal and external, to pick up and process signals about potential innovation"* (Bessant & Tidd, 2007, p. 243). Ideas can stem from "*needs of various kinds, or opportunities arising from research activities somewhere, or pressures to conform to legislation, or the behaviour of competitors, but they represent the bundle of stimuli to which the organization must respond"* (Bessant & Tidd, 2007, p. 243). One can categorize the origin of ideas and opportunities for innovations more generally when distinguishing between innovations originating from the supply-side (technology) and the market-side as discussed by Debackere (1997).

Searching for truly discontinuous innovations requires a different and more creative approach. Individuals searching for discontinuous ideas are generally "out-of-the-box thinkers", who have "*deep technical knowledge and who think outside the constraints of the firm's current business"* (Leifer et al., 2000, p. 33). The individuals are usually triggered by their *"curiosity, by challenges from the firm's management, or by specific techniques that firms employ to encourage and support them"* (Leifer et al., 2000, p. 33). Nevertheless not all creative individuals are so passionate and irrepressible about pursuing their idea and firms who *"lack a systematic approach for capturing radical ideas play a waiting game"* (Leifer et al., 2000, p. 35).

Firms can use various mechanisms to stimulate creativity and enhance the chance of discovering discontinuous ideas. In order to do so, firms need to consider that conventional management tools and techniques are less appropriate for searching for discontinuous ideas. Nevertheless, as argued before firms have difficulty changing their routines and often do not recognize the value of new mechanisms, because the old routines worked well in the past.

To tackle the firm's embedded routines and allow for creativity, the firm should try to create a more innovative culture, hence build *"an environment inside the company that supports individuals in their innovative endeavours"* (Bessant et al., 2004, P. 35). The ultimate goal should be to change the way individuals behave on a day-to-day basis, which is a complex task. To achieve this complex task and to stimulate discontinuous idea generation firms may use motivational tools and organizational mechanisms (Leifer et al., 2000).

Motivational tools can be applied by the management to expand the search for discontinuous ideas by articulating the strategic intent (Leifer et al., 2000). Management can motivate by actively encouraging the search for new ideas, or can implement technology-push and market-pull policies as proposed by Debackere (1997). Technology-push oriented policies "*allocate considerable sums of money to R&D, hoping that heroic entrepreneurs will tap the pool of knowledge, thus generated and create new products and processes that ultimately service markets"* (Debackere, 1997, p. 6). Controversially market pull policies *"stimulate innovation through creating a demand for new products or processes. This demand will trigger innovative behaviour"* (Debackere, 1997, p. 6).

In order to translate the strategic intent into action organizational mechanisms are required, these *"aim at getting idea generators out of standard routines and connecting them to new pockets of knowledge"* (Leifer et al., 2000, p. 34). DILab performed research on the mechanisms applied to search for discontinuous ideas and found twelve search mechanisms. DILab's findings are based on the research results from the UK, Denmark and Germany. The results are based on case studies and experience-sharing workshops (Bessant & Stamm von, 2007). Before discussing the specific mechanism, one has to distinguish between internal and external mechanisms. Internal mechanisms try to stimulate search activities using internal resources. External mechanisms also rely on the internal resources, but simultaneously take the firm's external environment into account, hence external sources of knowledge. Firms can decide to apply several internal and external mechanisms. Some scholars argue that it is important to combine both internal and external mechanisms, as Bougrain and Haudeville (2002), who state that *"innovation capabilities depends on the ability to exploit external knowledge and in-house R&D efforts"* (Bougrain & Haudeville, 2002, p. 743).

Internal Mechanisms

- Corporate Venturing[3]. Many firms rely on routines and follow the same path for years, yet such an environment generally does not allow for the emergence of creative ideas. By creating venture units more freedom and resources can be created, so that employees will become more motivated to search for discontinuous ideas. The venture unit can enhance the

[3] This mechanism and the others have been extracted from a paper by Stamm and Bessant B. Von Stamm and J. J. Bessant. (2007) Beyond the lamp-post: Innovation search strategies for discontinuous conditions.

creation of an innovative culture and can serve as a repository for cumulative learning about managing discontinuous innovations (Leifer et al., 2001).

- Idea generators. Use creativity tools to encourage creativity, for example systematic innovation programs (Bessant et al., 2004).
- Exploring multiple futures by applying scenario planning techniques to envisage possible futures. As a result actions have to be taken.
- Deliberate diversity in teams. Diverse teams, thus "*overlapping knowledge across individuals is crucial to ameliorate internal transfer while diversity of knowledge elicit 'learning and problem solving that yields innovation"* (Bougrain & Haudeville, 2002, p. 743).
- Probe and Learn. This mechanism is concerned with getting *"the hands dirty early on, by prototyping quickly and often rather than spending ages planning"* (Bessant & Stamm von, 2007). The extent to which this mechanisms is a search mechanism is arguable, since an idea must have emerged prior to prototyping. Prototyping may be quite costly in more advanced innovation, accordingly one may argue that when applied as a search mechanisms it is more appropriate for low tech innovations.
- Corporate entrepreneuring and intrapreneuring. Entrepreneurs are known for their creativity and it is therefore important to discover and nurture the entrepreneurial talent inside the organization.

External Mechanisms

- Sending out Scouts. Dispatch idea hunters to track down new innovation triggers. This does not only stimulate idea generation, but also provides the idea generators with the opportunity to validate the ideas with professional colleagues (Leifer et al., 2000).
- The internet. The internet can be used as a powerful tool to consult online communities and virtual worlds to detect new trends.
- Lead users. Work together with lead users to identify their view on existing products or services. Lead users are often capable of giving valuable input concerning future product needs.
- Mobilise the mainstream. To mobilise the mainstream lead users within the workforce should be included in the discontinuous innovation process. The aim is to analyze how they view the resources and of the resources could be better re-allocated.
- Deep diving. Study the behaviour of consumers, instead of asking how they use products or services.
- Use brokers and bridges. Identify new industries to generate ideas. Combining knowledge fields increases the change of innovating.
- Network orientation. Networking is a powerful mechanisms bringing a degree of collective efficiency into play by picking up relevant signals (Tidd et al., 2005b). Networking can extent and cover a richer environment of opportunities.

2.3.2 The Select Stage

The objective of this stage is to choose to what potential innovation the firm will commit its resources. It is obvious that even the best-resourced organization cannot do everything, therefore the *"challenge lies in selecting those things which offer the best chance of developing a competitive edge"* (Bessant & Tidd, 2007, p. 243). Using conventional management tools and techniques to select discontinuous innovations is difficult, *"because disruptive technologies rarely make sense during the* *years when investing in them is most important, conventional managerial wisdom at established firms constitutes an entry and mobility barrier that entrepreneurs and investors can bank on"* (Christensen, 1997, p. 210).

One can imagine that the high risk and uncertainties of discontinuous projects require firms to use alternative selection mechanisms and criteria. Nevertheless McDermott (2002) discovered that many firms have not been sensitive to the need for a different system to impose on discontinuous innovation project. As mentioned, many firms seem to rely on maverick individuals pushing discontinuous project through the funnel by working with senior management against the organizational 'immune system'. Unfortunately not every organization can rely, or even has maverick individuals who push discontinuous innovations forward, therefore many firms fail to innovate. It seems that managers fail to see the value of discontinuities, due to the uncertainties and high risks, which blindfold them. More specifically, it seems that "*managers are more sensitive to threats than opportunities"* and that senior teams over-weighing current threats, fail "*to adjust their mindset and entertain new business models"* (O'Reilly & Tushman, 2008, p. 190). Another cause may be the lack of courage of managers and the board of directors. This aspect was brought forward by Perel (2002, p. 11) that *"most boards of directors give scant attention to innovation levels in companies for which they have legal oversight.*" Especially *"many large companies adopt a strategy of waiting until new markets are 'large enough to be interesting"* and less uncertain (Christensen, 1997, p. XX). As a result organizational resources tend to go to the most important customers and projects rather than to discontinuous projects. Alternatively firms may also choose to remain focused *"on their existing businesses, often to capitalize on large investments already made."* (Charitou & Markides, 2003, p. 58).

Failure to recognize value may stem from a lack of capabilities to act upon innovative ideas, such as strategic insight, having vision, strategy and being able to timely allocate resources. According to O'Reilly and Tushman (2008, p. 191) firms may sense opportunities and threats without these capabilities, but will *"be unable to act on them in a timely manner".*

Charitou and Markidez (2003) claim that the ability of an established firm to respond to discontinuous innovation, does not solely depend on the portfolio of skills, its resources and the time at disposal, but also on the nature and size of the conflict between the new and traditional business. The higher the degree of the conflict, the lower and more difficult the ability to respond to innovations. Along the same lines, DILab argues that "a*s options move towards the more radical end so the degree of resource commitment and risk rises and decision making resembles more closely a matter of placing bets – and emotional and political influences become significant."* Accordingly there is a need to make the selection process more feasible by adjusting it to fit to situations of discontinuous innovations, because "o*rganizations cannot afford to innovate at random, they need some kind of framework which articulates how they think innovation can help them survive and grow and they need to be able to allocate scarce resource"* (Tidd et al., 2005b, p. 363). As a general note, one should keep in mind the findings of Christensen (1997, p. 97), that as long as innovations address the needs of the firms' customers, "*established firms were able to muster the expertise, capital, suppliers, energy, and rationale to develop and implement the requisite technology both competitively and effectively."*

Finding appropriate selection mechanisms is an extremely challenging task, one which is still being scrutinized by researchers. To receive an overview of possible selection mechanisms one should not solely consider discontinuous innovation literature, because it is still in the early stages of development. The scope of this section will therefore reach beyond the periphery of discontinuous innovation literature and take into account literature on NDP, stage gate models and portfolio management.

Firms wanting to decide whether to continue with an innovative idea usually perform a selection procedure. The type of procedure applied depends on various factors, but one of the most obvious factors is whether there are more ideas to choose from or not. Stage-gate systems are the most appropriate when there is one idea to choose from, as "*a stage-and-gate process focuses on one project at a time; in contrast, portfolio management considers all projects together. That is, stage-gate processes deal with the fingers (individual project) whereas portfolio management deals with the fist"* (Cooper, 1999, p. 130). When there are more ideas portfolio management is the most appropriate choice, but one should be aware of the need to undertake a capacity analysis. *"Portfolio management is the dynamic decision process, whereby a business's list of active new products (and R&D) projects is constantly up-dated and revised. In this process, new projects are evaluated, selected and prioritized"* (Cooper et al., 2001, p. 362). Portfolio methods deal with reviewing across potential innovations by constructing multiple charts to develop an overall picture, for example by constructing matrixes measuring risks versus rewards (Tidd et al., 2005a). As this method considers more projects (discontinuous and continuous), the mechanisms in the procedure may require alteration, in terms of criteria and scores to give discontinuity a chance. DILab, for example proposes parallel track to stage gate systems and different gates and criteria for selecting discontinuous innovations.

The specific mechanisms applied in the latter methods can be of financial or non-financial nature. Among the financial mechanism are (Cooper et al., 2001);

- Financial calculations, such as NPV, ROI, payback period calculations
- Benefit measures, for example using bubble diagrams (risk-reward diagrams) or portfolio maps.

The non-financial mechanisms relate more to subjective judgments and are the following (Cooper et al., 2001);

- Scoring models, in which project are rated on questions or criteria.
- Checklists, in which projects are evaluated on yes and no questions.
- Constructing a business case
- Intuition and experience
- Business strategy and customer appeal

The mechanisms above are options to select an idea, but the question concerning which mechanisms is best still remains. The appropriateness of the selection mechanisms depends on the triggers of the potential innovation, the type of innovation and the amount of available technical information and market information. Cooper et al. (2001) conducted a study that focused on the mechanisms used in portfolio management for product innovation. The results indicated that *"financial methods,* *although the most popular and rigorous, yield the worst results overall, while top performing firms rely more on nonfinancial approaches"* (Cooper et al., 2001, p. 374).

The study of Cooper et al. (2001, p. 374) discovered that the best businesses "*tend to rely much less on financial models and methods as the dominant portfolio tool than does the average business."* The findings of Cooper et al. (2001) are supported by Roussel et al. (1991, p. 97), stating that "*the range of uncertainties for research reaching out more than a year or two is so substantial rigor implied by NPV or DCF considerations that it becomes not only meaningless, but possible harmful."* Given the findings of Roussel et al. (1991) and Cooper et al. (2001) and the fact that discontinuous processes generally take long than two years one may state that non-financial methods are superior for selection discontinuous innovations.

2.3.3 The Implement Stage

Once the firm selected an idea with which it wants to continue, the implement stage starts. The implement stage has the largest scope, because the key objective is to move "*from a collection of ideas, conscious or unconscious, to some physical reality"* (Tidd et al., 2005b). In order to develop the idea into an innovation, it must pass through various stages to become a final products or service.

In order to start this stage the firm must acquire the required resources and knowledge to start the development process. Acquiring knowledge *"involves both generation of technological and market knowledge (via research carried out within and outside the organization) and technology transfer (between internal sources or from external sources)"* (Tidd et al., 2005b, p. 372). Acquiring resources may be a simple matter of buying of the shelf, exploiting the results of previously performed research or it might involve an extensive search for the appropriate resources.

Acquiring knowledge and resources should not be underestimated, because it often involves "*surrounding a bundle of knowledge, often in tacit form, which is needed to make technology work"* (Tidd et al., 2005b, p. 41). Companies need to be careful when acquiring and allocating resources and should try to avoid tilting the resources either to the core activities or to the new growth initiatives (Anthony et al., 2008). Finding a balance to appropriately allocate the required resources is essential.

Once all the resources have been gathered or arranged for, the firm can move on to the execution stage, which according to Tidd et al. (2005b) is the heart of the innovation process into which the inputs are some initial ideas and a clear strategic concept. The output of the executing stage is *"a developed innovation and a prepared market internal or external, ready for final launch"* (Tidd et al., 2005b, p. 93). As Tidd et al. (2005b, p. 93) explain, this "*process is about weaving together different knowledge sets coming from groups and individuals with widely different functional and disciplinary backgrounds."* There may be a need to apply a system approach when dealing with teams, to successfully weave together the different knowledge sets and analyze what activities must be completed to develop the innovation (Leifer et al., 2000). When the knowledge sets are not woven together and the firm has not established a close link with manufacturing the development of the innovation is doomed to go wrong. As a result information about the basic make ability of a new design may not get back to the design area and it may be too late to change and improve the product.

Once the firm has successfully turned the idea into an innovation, thus a physical reality, it can be launched on the market and the initial adoption process can start. In some cases product development can blur into the process of commercialization, for example when firms applied mechanisms such as customer co-development (Tidd & Bodley, 2002).

Prior to launching the discontinuous innovations on the market, the firm has to decide where to locate the business within the firm and how to build an effective business model to benefit from the market launch (McDermott & O'Connor, 2002). Once those internal decisions have been made, the firm faces the challenge to launch the innovation. As in the rest of the discontinuous innovation process, the firm is again faced with uncertainty. Even if the innovation is technically excellent there is no guarantee that consumers will adopt the innovation and continue to use it long term (Tidd et al., 2005b). Consumers may also have difficulty understanding or appreciating the innovation (Veryzer, 1998). McDermott and O'Connor recognize three challenges that firms face when targeting innovations on unfamiliar markets. The three challenges all revolve around countering resistance and breaking down barriers, either or both within and outside the firm's boundaries. The three challenges are the following; *"1) Ensure the delivery of a perceptible benefit, 2) Manage the threat of cannibalization, and 3) Overcome market resistance to the technology"* (McDermott & O'Connor, 2002, p. 427).

If a firm experiences a lack of marketing knowledge, motivation, financial means or a lack of reach to the potential customers, it may become prone to cannibalization or external exploitation. *"External exploitation essentially involves selling the technology to a third party so that they can exploit it"* (Smith, 2006, p. 168). The firms that originated the innovation will often want to retain an interest in the innovation, e.g. the technology (Smith, 2006).

Once the innovation has been launched, the firm has to sustain the product or service. The lessons learned during the innovation process are of great value. Discontinuous innovation processes rarely occur, making it difficult to generate sufficient trial and error experience to build routines (Tidd et al., 2005b). The learning experiences gathered during the discontinuous innovation process are therefore of great value, nevertheless it also highlights the importance of flexibility.

The implement stage has a large scope and there are several mechanisms, which can support the implementation of discontinuous innovations. The mechanisms can again be distinguished by referring to internal and external mechanisms. The internal mechanisms try to stimulate the implementation process by using internal resources, whereas the external mechanisms rely on both the internal and external resources.

Internal Mechanisms

Discontinuous innovations tends to take longer to develop than continuous innovations, the development may easily span over a 10 to 20 years (Veryzer, 1998). Discontinuous innovations tend to be further removed from the market, customers lack product understanding and familiarity compared to continuous innovations (Veryzer, 1998). To overlap this time period, which is recognized by various uncertainties many successful innovators tend to operate under some form of structure, because *"breakthrough innovations need both 'light bulbs (ideas) and ' flow-charts' (processes)"* (Perel, 2002, p. 16). As mentioned before, there is still an ongoing discussion on the appropriateness and actual use of process models to discontinuous projects. In that view the question posed by O'Connor (1998, p. 153) is still valid and requires investigation, hence *"are there systematic processes in place, or is market learning carried out on an ad hoc basis, along the lines of improvisation and probe and learn as the more recent literature reflects?"* What can be distinguished from literature is that applying for example stage-gate models does allow for more structure and evaluation periods. Many scholars have designed stage-gate systems of new product development, such as Cooper (1990). Analyzing the appropriateness of applying stage-gate models is outside the scope of this research, but it should be acknowledged that some scholars, such as Mascitelli (2000, p. 187) do argue that *"extensive use of models and prototypes throughout the design process provides rich opportunities for individuals to take a physically active approach to learning and experimentation."* Mascitelli (2000, p. 187) believes that models and prototypes play a vital role in adapting innovations to local needs, which are robust enough to maintain a common identity across disciplines. Considering the former, one should keep in mind the statement by Christensen (1997, p. 147), namely *"strategies and plans that managers formulate for confronting disruptive technological change..should be plans for learning and discovery rather than plans for execution."*

Forming diverse teams is one of the mechanisms named in the search stage, but also applicable in the implement stage. Tidd and Bodley (2002, p. 131) refer to product development as the stage where *" the individual R&D staff, designers, engineers and marketing staff must work together to solve specific issues and to make decisions on the details."* To receive most benefit from forming diverse teams requires extensive investments in team-building, training to solve problems and conflicts, interaction with other parts of the organization and outside stakeholders (Tidd et al., 2005b). Even though the latter activities are performed, the team may still experience problems concerning gaps between the current design and the requirements. To decrease the probability of such situations *"clearly articulated goals qualitative or quantitative in the fuzzy arena of breakthrough innovation will empower people to address and persevere with unusual opportunities and provide an objective basis for accountability"* (Perel, 2002, p. 13). But in many cases such situations require solving problems using iterative design-test-build cycles. Tidd and Bodley (2002) recommend several mechanisms for dealing with the iterative design-test-build cycles, some requiring external mechanisms, others relying on internal mechanisms. For example, computer aided techniques. *"Computer based tools, particularly computer-aided design and manufacturing permit extensive simulation and shared exploration of concepts and also accelerate the acutely development process by automating key tasks"* (Tidd et al., 2005b, p. 392). The benefits of computer tools include" *reduction in development lead times, economies in design, ability to design products too complex to do manually"* (Tidd & Bodley, 2002, p. 132). Nevertheless regular prototyping will also have to be performed, as it is *"the core element of the design-build-test cycle, and can increase the rate and amount of learning that occurs in each cycle"*, it also is "*significantly more effective for high novelty projects and may help reduce technological or market uncertainty"* (Tidd & Bodley, 2002, p. 132).

Instead of solely forming diverse teams, some firm opt for setting up a venture unit, which can as previously mentioned also function as a search mechanism. A venture unit may also be referred to as a radical innovation hub, which according to Leifer et al. (2001, p. 104) "*can serve as a repository for cumulative learning about managing radical innovation, and is a natural home base for those who play pivotal roles in making radical innovation happen".* Radical innovation hubs can provide large firms with more oversight and management from the initial stage to the commercialization of the project (Leifer et al., 2001).

External Mechanisms

Not all firms have the competences or the financial means to develop the innovation itself. As a result a trend for overlapping the competency gap is the strategic implementation of venture strategies, more specifically "*collaborative partnerships among firms are growing dramatically, involving new linkages with universities and ties with young high-technology companies"* (Debackere, 1997, p. 21). Similarly Smith (2006, p. 184) found that external knowledge and expertise are often extracted from institutional arrangements, which *"might well take the form of a strategic alliance such as a joint venture or collaborative agreement"*. It seems that the main objective has changed, in that it is not necessary to obtain all the technological and knowledge resources internally, but one of knowing how, where and when to obtain them from external and complementary sources (Tidd et al., 2005b). This emerging facet can be referred to as open innovation.

Firms aiming to close their competency gap should *"ensure an appropriate match between the sources selected and the context of the firm in terms of its resources and its absorptive capacity"* (Tidd et al., 2005b, p. 376). Along with the latter challenge Leifer et al. (2000, p. 127) identified three challenges, specifically for new technologies. The first challenge relates to *"the time required to identify candidate partners and to consummate the partnering agreement",* the second challenge concerns controlling the intellectual property and the third is concerned with "*decision making about ownership of segments of the value chain."* Once an agreement has been made, the partners have to learn to work with each other, which involves keeping the network up-to-date, engaging in a specific executing challenge, along with understanding the firm's own position in the network, but *"business networks, like ecosystems, cannot be controlled by any single player in them"* (Birkinshaw et al., 2007, p. 70).

If the challenges are approached correctly, partnering can resolve the competency gap, reduce time to market and avoid *"the risk of missing a window of opportunity in cases where internal development of competencies or acquisition takes too long or, worse, never produces the competency"* (Leifer et al., 2000, p. 127).

When firms do have sufficient capabilities, but solely lack funding they may solicit for subsidies or other forms of external funding. Nonetheless external funding hardly ever leads to satisfactory outcomes, meaning that firms need to outweigh the benefits and the downsides of acquiring external funding (Leifer et al., 2000).

Another external mechanism aiding the development process is customer involvement, which has also been mentioned for the search stage. In this stage one may refer to quality function development, which relates to *"a set of planning and communications routines, which are used to identify critical customer attributes and create a specific link between these and design parameters"* (Tidd & Bodley, 2002, p. 131). Tidd and Bodley (2002) specifically highlight the effectiveness of using focus groups, customer partnerships and user developers for high novelty projects, hence discontinuous innovations. Von Hippel (1988), Prahalad (2004) and Veryzer (1998) recognize that the customers ultimately decide the fate of the product and thus should be contemplated throughout the development process. Veryzer (1998, p. 319) however does acknowledge that difficulties may arise when applying customer-testing to promote reliance on general and market knowledge, because discontinuous innovations are "*are often developed in an environment that is much more focused on technical as opposed to market issues."* Further difficulties may arise when working with lead users, concerning secrecy and consumer understanding. To offset the latter problem firms may lean on product visionaries, who can intuitively make sense of technology and market uncertainties (Veryzer, 1998). An aspect specifically recognized in established firms, is that they have the proclivity to innovate according to their best customers. This makes the firms blind for the impact that the discontinuity may have on the core business (Anthony et al., 2008, P. viii). As a result these firms may end up producing innovations that are too good for more mainstream customers.

Firms can also combine customer involvement and prototyping, thus apply probe and learn, which has been mentioned briefly as a search mechanism for low tech ideas. Probe and learn refers to firms that probe the early versions of the products, learn from the probes and probe again (Lynn et al., 1996). *"Probing with immature versions of the product only makes sense if it serves as a vehicle for learning about the technology… the market and which applications and market segments are most receptive to the various product features, and about the influence of...changes in government regulations and the need for regulatory approvals"* (Lynn et al., 1996, p. 17).

2.4 Firm Type and Innovation Ability

The discontinuous innovation process has been discussed thoroughly in the previous sections. This section will highlight the disadvantages and advantages per firm type related to the ability to engage in innovation processes. This thesis is focused on established SMEs, but given the knowledge gap concerning the ability of established SMEs to engage in innovation processes this section will also take into account the disadvantages and advantages of other firms types. The firm types to be discussed are presented in figure 2. The firms types illustrated in figure 2 differ in size and age. Existing research has not merged the influence of age and size (established SMEs) in discontinuous innovation research to analyze the ability of established SMEs to engage in discontinuous innovation processes. This is a unfortunate factor, because size and age definitely influence the ability of firms to manage the discontinuous innovation process.

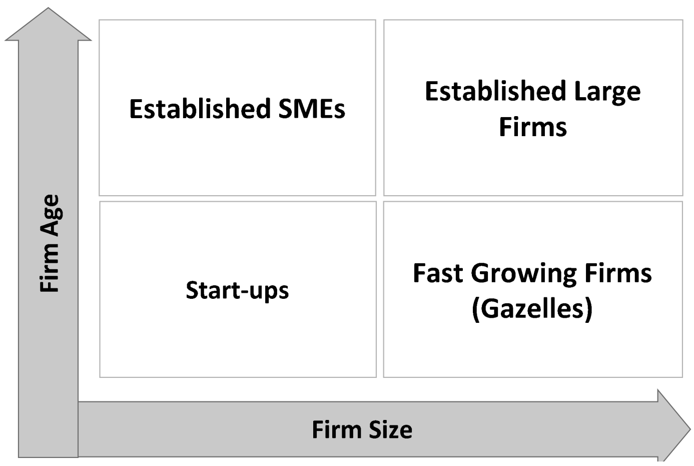

Figure 2 Firm Types

Besides the lack of knowledge on established SMEs so is there a lack of knowledge concerning the innovation ability of gazelle firms. Gazelles are a special kind of SMEs, also known as fast growing firms (hereafter FGFs) that expand rapidly and are important drivers of employment (Hölzl, 2008). FGFs are named gazelles, due to their capabilities, which enable them *"to be nimble, quick off the mark, responsive to predators, and adaptive to changes in environmental conditions"* (Birch 1995 in Tan & Smyrnios, 2005, p. 2). Gazelles are only a temporary phenomenon, firms either *"settle to down to remain SME, some become large firms and others fail and disappear"* (Hölzl, 2008, p. 2). There are various definitions and criteria for firms to be categorized as gazelles, the criteria range for employment growth to sales figures. Tan and Smyrnios (2005, p. 2) state that "*FGFs are companies that achieve a minimum of 20% annual compound sales growth over a 5 year period."* In practice, gazelles will typically be young, "*this is partly a function of the learning and expansion process the young businesses typically undergo, grow to reach some optimal size or die"* (Ahmad & Gonnard, 2007, p. 10). The age of gazelles is according to the OECD a question of convention, but "*the OECD framework sets this convention at 5 years of age"* (Ahmad & Gonnard, 2007, p. 10). The majority of research on gazelles is focused on job creation, nevertheless "*not much is known about the R&D behaviour of these high growth firms*" (Hölzl, 2008, p. 2). As a result, the general disadvantages and advantages of gazelles cannot be categorized for the ability to engage in innovation processes. This leaves two firm types to analyze, namely start-ups and established large firms, table 2 provides an overview of the related disadvantages and advantages towards the ability of these firms to engage in innovation processes.

Firm Type	Advantages	Disadvantages
Start-up	✓ Nimble and flexible ✓ Adaptive to the environment and receptive to change ✓ Communication ✓ Stronger commitment due to frequent ownership stake. ✓ Not associated to existing product and consumer base ✓ Shorter decision making lines	✓ Fewer resources (e.g. financial, manpower) and greater chance of experiencing a competency gap ✓ Lack social legitimacy ✓ Less access to complementary assets ✓ Still need to build a network ✓ Weaker marketing skills ✓ Owner responsibility (negative influence when risk averse)
Established Large firm	✓ Greater environmental control ✓ Bargaining power (with suppliers, distributors, regulatory agencies) ✓ Development experience ✓ Resources to develop and launch technological capabilities (e.g. financial, distribution, manufacturing, marketing)	✓ More bureaucratic, due to standardized authority, routines and formulized procedures ✓ Less flexible and stronger inertia ✓ Lower managerial commitment ✓ Due to age ossification communication patterns ✓ Internal resistance (R&D employees, shareholders) ✓ External resistance from consumers ✓ Associated to existing product and consumer base

Table 2 Advantages and disadvantages for discontinuous innovations per firm type

Start-ups are recently set up firms and therefore do not suffered under the negative side effects of aging, such as increased rigidity and ossification of communication patterns (Sorensen & Stuart, 2000). Similar statements are provided by Tushman and Anderson (1986, p. 354), as they state that *"older organizations often are less able to innovate because they have formalized procedures, centralized authority and standardized routines."* As result most scholars argue that start-ups are more innovative than large established firms. Kassicieh and Walsh (2002) for instance argue that small entrepreneurial firms are the driving force behind disruptive technologies. Sorensen and Stuart (2000, p. 110) argue that many great innovations are pioneered by start-ups, but that the success depends to large extent on "*the inability of established firms to enter important, emerging market niches and out-compete the new ventures."* Start-ups are said to be more capable of pursuing emerging growth markets, as their values can embrace small markets and their cost structures can accommodate low markets. *"Their market research and resource allocation processes allow managers to proceed intuitively; every decision need not be backed by careful research and analysis. All these advantages add up to the ability to embrace and even initiate disruptive change"* (Christensen & Overdorf, 2000, p. 73). In comparison established SMEs are a bit more bound, due to an existing consumer base to which they have to adhere, more specifically established firms are known to have difficulty with innovating and simultaneously ensuring profits through other products (cashcows) (Kaufmann & Tödtling, 2002). Accordingly Christensen (1997) argues that start-ups are more successful at innovating, because they are not associated to an existing product and customer base. The start-ups are therefore able to pursue opportunities that do not result in immediate returns

In the start-up stages of a firm, much of what gets done is attributable to the employees (Christensen & Overdorf, 2000, p. 73), similarly employees in SMEs often have a significant ownership stake and *"have very strong incentives to successfully develop new technologies at the lowest costs. Large firms usually do not have these same strong incentives in place, and are often less efficient in developing new technologies"* (Alvarez & Barney, 2001, p. 140). The drawback is that the managers often bear the responsibility regarding decisions of technical change, therefore risk adversity may impede the innovation process (Bougrain & Haudeville, 2002). Nevertheless there may be managers that do accept risk and try to take advantage of every new opportunity, to enhance performance and growth of the SME (Bougrain & Haudeville, 2002). This type of entrepreneurial behaviour, which is often recognized by courage, motivation, social skills (e.g. for setting up a new network) and efficacy to pursue their ideas is one of the advantages of smaller firms. Entrepreneurs are often *"confident of their intuition in evaluating innovations that cannot be caught by traditional indicators that tend to focus, for example on R&D expenditure"* (Massa & Testa, 2008, p. 401). Such entrepreneurial behaviour increases the chance of developing discontinuous innovations and some entrepreneurs even minimize the interferences of bureaucracy to create a favourable environment (Massa & Testa, 2008, p. 403).

Besides the mentioned advantages, start-ups also experience a number of disadvantages regarding their ability to innovate. The disadvantages are mainly related to the size of the firms and include a lack of resources and competencies. As these are related to the size of the firm, one finds resembles in the disadvantage for start-ups and SMEs[4] in literature. One of *"the most frequently indicated barriers constraining innovation are financial – lack of funds for innovation, too high risk of innovation projects, too expensive technology"* (Kaufmann & Tödtling, 2002, p. 151). According to Kaufmann and Tödtling (2002) this barrier applies to small and large firms. The second most frequent barrier found in the study of Kaufmann and Tödtling (2002) is manpower, which is either caused by a lack of time available for innovative activities, or simply because adequately personnel is missing. This barrier particularly applies to SMEs, as the daily work-overload of employees often impedes and delays innovative projects (Kaufmann & Tödtling, 2002). This obviously specifically applies to existing SMEs that are engaged in other activities preoccupying the key individuals also responsible for the innovation projects.

Another size related factor that negatively influences the ability of start-ups and SMEs to innovate is a competency gap. A competency gap may be experienced when the resources available are not sufficient to develop an innovation, for example in terms of knowledge. Leifer et al. (2000, p. 110) found in their study that many companies *"lacked one or more competencies critical to the successful*

[4] Literature referring to SMEs is focused on SMEs in general and does not specifically relate to established SMEs, accordingly this section is based on SMEs in general. The important aspect of size remains, but the age factor cannot be accounted for.

pursuit of their respective opportunities. As a result, project teams – and especially their champions – spent extraordinary amounts of time dealing with resource and competency activities". To battle the competency gap start-ups and SMEs could try to solicit for subsidies, but they *"are generally less informed about the mere existence of such instruments"* (Kleinknecht, 1989, p. 216). Alternatively SMEs could try networking to find additional financial means or ways to use the *"technology generated by others or to complement internally generated core technologies with a wider set drawn from outside"* the firm (Tidd et al., 2005b, p. 373). *"Creating and fiercely guarding separate pools of resource is critically important*" (Anthony et al., 2008, p. 33) and one can recognize a *"rise of networking, the emergence of small firm clusters, the growing use of 'open innovation' principles and the globalization of knowledge production"* (Tidd et al., 2005b, p. 411). "*Networks allow SMEs to decode and appropriate flows of information. They reinforce SMEs competitiveness by providing them with a window on technological change, sources of technical assistance, market requirements and strategic choices made by other firm"* (Bougrain & Haudeville, 2002, p. 739). Nevertheless a disadvantage of many SMEs is that they do not network outside their business sector, due to the lack of employees able to act as nodes establishing and maintaining links to innovative networks (Kaufmann & Tödtling, 2002).

When SMEs do consider to cooperate with external partners, universities are often considered important, yet only at the very beginning of R&D (Massa & Testa, 2008). Alliances with large firms are often required in the later stages of the innovation process, e.g. for marketing the innovation. Large firms often provide SMEs with the social legitimacy required to successfully launch the innovation (Alvarez & Barney, 2001). Further advantages relate to the resources of large firms, such as distribution, manufacturing resources, marketing and financial capabilities required to bring the innovation to the market (Alvarez & Barney, 2001). In return, large firms can benefit from the inventiveness of entrepreneurial firms (Alvarez & Barney, 2001). The disadvantage regarding these alliances was put forward by Alvarez and Barney (2001), who studied 121 alliances between entrepreneurial and large firms. They found that *in almost 80 percent of these alliances, managers from entrepreneurial firms felt unfairly exploited by their large firm partners"* (Alvarez & Barney, 2001, p. 140). In such an alliance both parties want to learn from each other, but the entrepreneurial firms often lose this learning race (Alvarez & Barney, 2001, p. 142).

Large established firms differ both in size and age from start-ups and therefore experience different disadvantages and advantages from start-ups as indicated in table 2. One of the most obvious advantages is that resource allocation is said to be easier for large established firms, because they often have more resources available and more means to invest in R&D. Large established firms are even deemed more innovative, in terms of continuous innovations than small firms, due to the ability to *"finance large research and development staff, leading to economies of scale in R&D"* and due to their enhanced ability "*to exploit unforeseen innovation given their diversified product lines"* (Debackere, 1997, p. 6). Even though *"most big, established firms have deep pockets…"*, most of the*"resources are committed to lower-risk efforts of incremental innovation. Further resources are not unlimited" (Leifer et al., 2000, p. 112).* In comparison SMEs do not have such deep pockets and face a greater challenges when experiencing a competency gap.

The disadvantages experienced by large established firms can be related to both the age and the size of the firm. As firms grow larger they usually implement more structure and formalized activities. Many large established firms have formalized R&D activities, in comparison to SMEs. Most SMEs "*carry out their R&D activities, without a formal R&D department or a formal budget and often even outside regular hours"* (Bougrain & Haudeville, 2002, p. 744). The informal R&D activities are "*often based on the creative talents of a few individuals including the owner/chief executive officer (CEO) himself"* (Lefebvre & Lefebvre, 1992, p. 298). Size may also negatively influence the communication among employees, thus in smaller firms the communication among employees is typically informal and flexibly, such as in SMEs, facilitating technical inventions, which are less common in larger firms (Alvarez & Barney, 2001). As a result SMEs are less hampered by organizational inertia and have greater capacity to react quickly to internal and external pressures, because the managers are often less isolated by organizational hierarchy and play a greater role in the innovation process (Lefebvre & Lefebvre, 1992).

Besides disadvantages related to size, large established firms also experience disadvantages, which are related to age. Large established firms are often restricted to pursue those opportunities, due to internal (R&D employees, shareholders) or external resistance (customers) (Christensen, 1997). The repeated success in established innovative domains, may also negatively influence the ability and desire of established firms to move into new areas of innovation. Accordingly, many established firms are better suited to produce incremental innovations along their existing trajectories (Sorensen & Stuart, 2000). Whether the same is true for established SMEs is not depicted in literature, but one may assume that the existing customer base may influence the ability to innovate.

This section provided an overview of the advantages and disadvantages per firm type concerning the ability to innovate. Both age and size influence the firm's ability to engage in innovative activities in a different way. Unfortunately there is insufficient literature on established SMEs to present an overview of the ability of this firm type to innovate, which highlights the importance of this research.

2.5 Conclusion of the Theoretical Overview

This chapter introduced the challenges and problems that can be experienced during the search, selection and implementation of discontinuous innovations and referred to the applicable mechanisms to ease and strengthen the discontinuous innovation process. However this chapter is mainly based on literature focused on start-ups and large established firms. Accordingly questions remain concerning the challenges and problems of established SMEs and the most appropriate mechanisms for this group of firms.

The management of discontinuous innovations has been referred to as an art, rather than a science by Leifer et al. (2000). The long development times, great number of uncertainties and risks prevent many firms from engaging in a discontinuous innovation process. Tidd et al. (2005b, p. 15) believe that *"managing innovations is about turning the uncertainties into knowledge",* which can only be done by committing resources to reduce uncertainty and creating a balancing act. Accordingly, one may argue that the development of discontinuities impose pivotal importance on serendipity, but *"firms need more than luck, they need to be prepared and equipped to do something about unexpected opportunities when they emerge"* (Bessant & Tidd, 2007, p. 238).

To anticipate for discontinuity established firms need *"to develop ways of managing innovation not only under 'steady-state' but also under the highly uncertain, rapidly evolving and changing conditions, which result from a dislocation or discontinuity"* (Tidd et al., 2005b, p. 24). The way in which firms manage the process, is dependent on the nature of the firm and its capabilities and resources. To effectively manage the discontinuous innovation process, large established firms may send out scouts in the search stage, apply procedural benefit measures for the selection of the innovations and set up innovation hubs for the development of discontinuous innovations in the implement stage. Nevertheless, these mechanisms are often too complex and expensive for small firms (Tidd et al., 2005b) and questions remain about the appropriateness of mechanisms for established SMEs. In order to anticipate about appropriate mechanisms for established SMEs one must evidently know about the problems and challenges experienced by the established SMEs, but unfortunately even though established SMEs comprise an important part of the economy there is a knowledge gap about how established SMEs experience and manage discontinuous innovation. One may expect established SMEs to be more flexible and nimble, but simultaneously more bound by their existing product and consumer base. Yet, these are only assumptions and research is needed to decrease the existing knowledge gap.

The discontinuous innovation process entails searching for ideas, selecting an idea and implementing the idea to turn it into a product or service, which can be launched on the market. Problems and challenges experienced during such a process may impede the development, or cause firms to discard ideas. To provide insight on how established SMEs manage the latter, an inductive approach is required. Given the holistic nature of the discontinuous innovation process and the fact that no prior research has focused on the established SMEs, this approach will enable an analysis of the problems, challenges and mechanisms applied by established SMEs.

3 Methodology

This chapter provides an explanation on the methodology applied in this research. At first the reader will be introduced to case study research itself, after which a justification will be given on the applicability of case study research for the purpose of this thesis. The chapter continues by providing an elaboration on the specific type of case study research applied and on the process of data collection and analysis.

3.1 The Choice for Case Studies

This section will explain the concept of case study research and why it is suitable for the research aims of this thesis. The technical definition of Yin (2003, p. 13) provides the basis for this section, in that it refers to a case study as *"an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident."*

When required to make a choice on the research design there are three conditions to consider, namely the type of research question, the control the researcher has over the events and the focus on contemporary as opposed to historical phenomena (Yin, 2003). Case studies can be used for various purposes, for example to provide descriptions, test theory or generate theory (Eisenhardt, 1989). Researchers generally tend to opt for case study research when they have little control over the objects being studied and when the focus is on contemporary phenomena within real-life contexts (Yin, 2003). Most case study research answers "how and "why" questions and thus seems to be explorative (Yin, 2003).

Reasons for choosing explorative research are provided by Babbie (2004). Explorative research can be chosen *"to satisfy the researcher's curiosity and desire for better understanding", "to test feasibility for more research"* and *"to develop the methods to be employed in any subsequent study"* (Babbie, 2004). Similarly Leifer et al. (2001, p. 112) argue that case study research is especially appropriate for exploratory research, *"with a focus on documenting a phenomenon within its organizational context, exploring the boundaries of a phenomenon, and integrating information from multiple sources".*

Case study research can involve multiply sources, hence both quantitative and qualitative data or one of the methods. This research will only apply qualitative field research, because it is flexible, relatively inexpensive and it can provide in-depth understanding of a phenomenon (Babbie, 2004). In-depth understanding is necessary to be able to highlight the problems and challenges experienced by the established SMEs. Flexibility will aid this process, by allowing the researcher to ask additional questions. Furthermore *"field research seems to provide measures with greater validity than do surveys and experimental measurements, which are often criticised as superficial and not really valid"* (Babbie, 2004, p. 307). Nevertheless, the disadvantage of qualitative field research is the potential problem of reliability, due to the ability of the researcher to influence the results (Babbie, 2004).

The objective of this thesis is to obtain more knowledge about how the established SMEs manage the discontinuous innovation process, in terms of the problems and challenges they experiences and the type of mechanisms they use. In order to gain more understanding of the latter the research question is a 'how' question, which influences the research method, which must be of explorative and inductive nature. To further justify the choice of case study research, one can refer to the statement by Van de Ven (2007, p. 76), namely that *"the more you can ground a research problem in reality from a users perspective the more you learn to appreciate the multiple dimensions and manifestations of a problem and its solution space. Grounding a problem in reality entails an exploratory study into the nature, context, and what is known about the problem domain."*

3.2 Research Design

This section will elaborate on the choice for including multiple cases and on the selection of the actual cases.

Multiple Cases

The receive a better understanding of the innovation process at established SMEs multiple cases were studied. The prime reason for including more cases is that, *"the evidence from multiple cases is often considered more compelling and the overall study is therefore regarded as being more robust"* (Yin, 2003, p. 46). Similarly, as Miles and Huberman (1994, p. 172) discuss, *"multiple cases not only pin down the specific conditions under which a finding will occur but also help us form the more general categories of how those conditions may be related."* Including multiple cases will therefore increase external validity and may up to a certain extent allow for analytic induction. According to Eisenhardt (1989) there is no ideal number of cases, but a number between four and ten usually works well, thus this will be used as a guideline for this research.

Sampling and Selection Criteria

This thesis includes five cases, more specifically five established SMEs having experienced the discontinuous innovation process. The main aim of applying multiple case study research is to generate a more reliable understanding of the discontinuous innovation process. The cases were selected according to theoretical sampling , which requires the researcher to select cases likely to replicate or extend the emergent theory. One may choose the cases randomly, but this is not necessary or even preferable (Faems, 2006).

The unit of analysis in this thesis is the discontinuous innovation process within established SMEs. To find innovative established SMEs an entrepreneurial magazine named Bizz was consulted and the nominees of the Overijssel Innovation Award were taken into account. Bizz publishes a yearly SME innovation top 100, in which they present the most innovative SMEs in the Netherlands. The Overijssel Innovation Award is an initiative by the province of Overijssel and Ontwikkkelingsmaatschappij Oost Nederland (Oost NV, Development-society east Netherlands) to stimulate the innovation capacity in Overijssel. The Overijssel Innovation Award nominates firms according to the innovativeness of their products or services. In order to find appropriate cases (SMEs) selection criteria were applied.

Criterion 1

The first selection criterion is 'age'. The focus is on established SMEs, existing over ten years or longer. The criterion of ten years is chosen to make sure that the SME is an established firm, having experienced a product life-cycle and therefore being far more experienced than start-ups.

Criterion 2

The second criterion is concerned with the innovation, which should be discontinuous. In order to select established SMEs on the discontinuity factor, the criteria by Rice et al. (2002) are applied. The innovation should at least fulfil one of the criteria as presented in table 3. This criterion is far more difficult, but to make it more comprehensive two steps were followed to make sure that the innovations adhere to the criteria in table 3. In the first step, the SMEs were selected from the Bizz Magazine or the Overijssel Innovation Awards by comparing the criteria to the innovation information given in the magazine or on the website. In the second step, the established SMEs were asked to provide feedback on the innovation, in terms of the criteria. As a result, one may state that the criteria were accounted for as perceived by the firm.

Selection Criteria for Discontinuous Innovations by Rice et al. (2002)
• New to the world performance features (Fundamentally new product/service) • Five-to ten-fold (or greater) improvement in performance features. • 30% to 50% (or greater) reduction in costs.

Table 3 Selection criteria for discontinuous innovations by Rice et al. (2002)

Access to Cases

From the Bizz magazine four SMEs were selected that fit criteria by Rice et al. (2002) and one of the four companies decided to participate. The Overrijssel Innovation Award nominated eight firms. Three of these eight firms were contacted for the sake of this research. All the firms fulfilled the selection criteria, were enthusiastic and decided to cooperate. Next to the firms selected from the Overrijssel Innovation Award and the Bizz magazine one more firm joined the research. This firm is not nominated so far, but does fulfil the selection criteria.

All the selected firms were first contacted by e-mail. The e-mails were addressed[5] to the person in charge of the innovation, thus mostly the owner himself. Either a reply was received from the firm or the firms were called about the purpose of the research and given further information. This procedure provided access to five cases, which are presented in table 4.

Established SME	Core business	Number of employees	Established in	Discontinuous Innovation
Ambriose	Development and production of orthoses	10	1994	Dynko, orthosis for children with club-foot deformity
Doorgeest Koeltechniek	Development of innovative climate control systems	15	1965	EPC Pakket, heat pump for heating and cooling using air
Scheepswerven Bodewes (Shipyard)	Ship repairs, maintenance, construction	15 to 20 (Depending on workload)	1928	Fuel Cell Boat, functions on fuel cells and has zero CO_2 emission
Shemat	Sheet metal, machining and engineering	120	1978	Hyperthermia apparatus to treat cancer
Machine Fabriek Sonder (Machine factory)	Development, construction and maintenance of production lines	28	2000[6]	Production line for sauces by radiofrequency heating

Table 4 Overview of the selected cases

[5] The e-mail addresses were retrieved by contacting the firms by phone.
[6] Machine Fabriek Sonder does not fulfil the first criterion of ten years. This criterion was chosen to make sure that the SMEs have an existing product base and are more experienced than start-ups. Given that Machine Fabriek Sonder has existed for nine years, thus almost ten the established SME was incorporated in the thesis.

3.3 Data Collection

To decide on the method of data collection one must take the objective of the research and the scope of the thesis into consideration, both in terms of time and the demanded extent. The development of discontinuous innovations may take over five to twenty years and is obviously too long to monitor by conducting a longitudinal study. Most of the selected established SMEs have experienced the innovation process already, therefore retrospective data collection seems to be the most appropriate and it has some advantages. As Faems et al. (2006, p. 12) state retrospective data collection *"allows for a more focused data-gathering process, because it reduces the danger of data overload and collecting much unusable data."* Similarly Van de Ven (2007, p. 208) states that *"retrospective studies provide the advantage of knowing the 'big picture'- how things developed and the outcomes ensued. This post hoc knowledge is helpful for interpreting events that unfolded, and for constructing a narrative of the process."* To conclude one may state that retrospective data is more target specific and less time consuming, but the obvious drawback is that the researcher may have the "*tendency to filter out events that do not fit or that render the story less coherent"* (Van de Ven, 2007, p. 208).

To decrease the possible negative side effects of retrospective data and to improve construct validity two sources of evidence are used, namely interviews and documents. Using multiple sources is known as triangulation and can provide the advantage of converging lines of inquiry (Yin, 2003, p. 97). The aim is to converge the evidence to explore how the innovation process was managed. For true triangulation to take place the events or facts must be supported by more than a single source of evidence (Yin, 2003).

Interviews

The type of interviewing applied in this research is qualitative interviewing, which *"is based on a set of topics to be discussed in depth rather than based on the use of standardized questions"* (Babbie, 2004, p. 300). More specifically *"a qualitative interview is an interaction between an interviewer and a respondent in which the interviewer has a general plan of inquiry but not a specific set of questions that must be asked with particular words and in a particular order"* (Babbie, 2004, p. 300). This study includes unstructured interviews and semi-structured interviews. The *"semi- structured interviews have a sequence of themes to be covered, as well as suggested questions"* (Faems, 2006, p. 68). An interview protocol was established for the semi-structured interviews, which increases the reliability and guides the interviewer collecting case study data (Yin, 2003). The interview protocol can be found in the appendix on page V.

The advantage of qualitative research is that it is relatively inexpensive and it can provide in-depth understanding (Babbie, 2004). To enhance the latter advantage, the interviews were face-to-face to create *"ideal circumstances for gaining in-depth responses"* (Faems, 2006, p. 64). Qualitative interviewing also provides flexibility as questions can be redesigned throughout the project Rubin and Rubin 1995 in Babbie (2004, p. 300). To take advantage of the given flexibility key notes were made during the interviews, which allowed additional questions to reflect on answers given during the interview. Nevertheless reliability may be a potential problem, as field research is relatively prone to personal interpretations and alterations by the interviewees. To diminish this factor all the interviews were recorded and transcribed.

Documents

Van de Ven (2007, p. 154) argues that researchers wanting to analyze processes will utilize "*any methods that can help make sense of change and development processes"* (2007, p. 154). In this case the most appropriate additional data source are documents. Reasons for the latter are that documents aid in identifying the problems and challenges of the innovation process in a chronological order, thus documents can provide additional sense making, when respondents do not remember the chronology of events (Faems, 2006). Furthermore documents can aid to decrease the disadvantages of using retrospective data, such as the "*tendency to filter out events that do not fit or that render the story less coherent"* (Van de Ven, 2007, p. 208).

3.4 Process of Data Collection and Analysis

This section is focused on the process of data collection and the corresponding data analysis performed. The process of data collection and analysis was divided into four stages and is explained accordingly. An overview of the four stages is presented in table 5. Table 6 on page 29 provides an overview of the data collected.

Stage	Data Collection Technique	Data Analysis Technique	Output
1	- Unstructured interviews with the key person (initiator) involves in the innovation - Analysis of Documents	Mapping of the innovation process	Representation of the chronology of the innovation process at the SMEs
2	Semi-structured interviews	Narrative strategy	Case study report that describes the problems, challenges and mechanisms applied during the innovation process
3	Feedback on case study reports by respondents	Within case analysis	Adjusted case study reports and within-case analyses
4	All data has been retrieved	Cross case analysis	Cross case findings to be incorporated in the discussion

Table 5 The stages of data collection and analysis

Stage 1

The aim of this first stage was to receive a general understanding of the established SME, the innovation itself and the innovation process. This data was collected by conducting unstructured interviews with the key person in the innovation process (in some cases the key person was the owner, in others the project manager). The interviews were face-to-face and took approximately one hour.

The available documents were analyzed (either the documents had to be analyzed at the established SME itself or the documents were allowed to be taken to the office). Unfortunately not all established SMEs granted access to documents, or the established SMEs did not document the innovation process. Eventually two established SMEs granted access to documents. Once the available documents were analyzed and the interview transcripts re-read, the innovation process was mapped in chronological order, to illustrate the problems and challenges. Obviously new questions arose while constructing the chronological order and these questions were integrated into the general interview protocol of the second stage (The general interview protocol can be found in the appendix in Dutch on page V. The interview protocol was constructed on the overall facets of the discontinuous innovation process)

Stage 2

In this stage semi-structured interviews were conducted with the same key individuals. In cases where more individuals were active in the innovation process and /or other established SMEs participated in the development of the innovation, these were asked to contribute to this research. Unfortunately not all could find the time and only one additional interview was conducted. A general interview protocol was established to function as a guidance tool. The general interview protocol (in appendix on page V) was adjusted per established SME to reflect on the findings from the previous stage.

A narrative strategy was applied to construct the case study reports in a chronological order per established SME. *"Narrative explanations employ efficient causality to explain the influence imparted by particular events and often, to explain the mechanics of transition between events and between more macro-level unit, such as phases"* (Van de Ven, 2007, p. 156). Accordingly the case study reports highlight the problems and challenges experienced by the established SMEs in the course of the innovation process.

SME	Interviews	Documents Not publicly available
Sonder Food Systems B.V.	One interviewee, being the initiator (and owner) of the innovation process. Two interviews conducted.	- Internal reports on the innovation process - Subsidy request forms - Print outs of e-mail correspondence - Marketing reports
Doorgeest Koeltechniek	One interviewee, being the initiator (and owner) of the innovation process. Two interviews conducted, one personal interview and one interview was conducted via the telephone.	No documents available
Scheepswerven Bodewes B.V.	One interviewee, being the project manager of the innovation process. Two interviews conducted.	No documents available
Ambriose	One interviewee, being the owner of the innovation process and feedback was received per mail from an employee active in the innovation process. Two interviews conducted.	No documents available.
Shemat	Two interviewees. One interviewee, being the initiator (and owner) of the innovation process. One interviewee from another established SME (Mechatron) cooperating with Shemat. Three interviews conducted.	- An initial business plan - Meeting Reports

Table 6 Overview of Collected Data

Stage 3

After completion of the case study reports, they were sent to the interviewees to give them the opportunity to provide additional comments or notes and check for validity. The case study reports were adjusted after the provision of additional comments by the interviewees. The data was complete at that point and within case analyses were performed. The within case analyses identify (from the case study reports) the problems and challenges experienced by the established SMEs and the mechanisms applied to address the problems and challenges. The within case analyses are structured according to the stages of the DILab model, thus search, select and implement.

Stage 4

Once the case study reports were finished and the within case analyses were included, a cross case analysis was performed to enhance generalizability. Cross case analysis also allows for a deeper understanding and explanation (Miles & Huberman, 1994). The fact that a process perspective is applied means that the analysis *"explicitly focuses on events rather than variables because of the inherent complexity of developmental processes"* (Van de Ven, 2007, p. 155).

The cross case analysis is focused on the differences and similarities between the established SMEs in terms of the experienced problems, challenges and applied mechanisms. The cross case analysis was incorporated into the discussion to allow for a discussion based on empirical findings and literature.

4 Results

This chapter presents the discontinuous innovation process as experienced by the established SMEs. The findings are presented in case study reports written in the chronological order of the discontinuous innovation process. At the end of each case study report a within case analysis is presented. The within case analysis describes the challenges, problems and mechanisms used in the innovation process according to the DILab model (figure 1, on page 9), namely by search, select and implement.

4.1 Case Report The Dynko – Ambroise

This case study report will describe the innovation process as experienced by Ambroise in their pursuit to develop the Dynko. The case study report is based on retrospective data retrieved from two interviews with the owner of Ambroise, named dr. Ir. Nils van Leerdam. No documents, other than technical specifications were kept.

Ambroise is specialized in developing and producing products (orthoses) for individuals with posture or movement problems. Examples of these products are orthoses for individuals with paralysed arms or legs. The products are made under the design philosophy of Prof ir. J. C. Cool, in that the products need to fulfil the three Cs, thus good cosmetics, maximum comfort and optimal control by the end-user. To fulfil the latter requirements the end-user is central in the development process.

Ambroise was established in 1994 by dr. Ir. Nils van Leerdam and currently owns a workforce of ten employees. Ambroise spends 10% of its budget on R&D and collaborates with the technical University of Delft and the University of Twente. Ambroise is located in close proximity to the University in Enschede.

The innovation process studied at Ambroise is the development of an orthosis for children with club-foot deformity, named the Dynko. An explanation of club foot deformity is provided in textbox 1**.** The Dynko will correct club-foot deformity for children without limiting their movement development compared to the current orthosis, which restricts movement. The Dynko allows children to crawl and sleep regularly with their feet next to each other. Nils van Leerdam and a developer at Ambroise, named Mark Besselink were involved in this process. The Dynko has been nominated for the Overijssel Innovation Award in 2008. Table 7 provides reasons for why Dynko is a discontinuous innovation.

Clubfoot deformity causes the feet of newborn babies to point down and inward. Clubfoot can cause long-term problems affecting the ability to walk. Clubfoot deformity can be cured when treated in early childhood. The treatment starts with an operation, in which an orthopaedic surgeon will manipulate the foot and cast on a regular basis. In the operation the achilles tendon will be loosened to allow for a better position of the foot. Once the cast is removed the child will have to wear an orthosis. The current orthosis used is the Dennis Browne brace, yet this brace restricts movement and accordingly negatively influences the development of the child.(Information in

Textbox 1 Explanation club-foot deformity
Information in textbox retrieved from interviews

Selection Criteria for Discontinuous Innovations by Rice et al. (2002)	Criteria Present in the Discontinuous Innovation of Ambroise
New to the world performance features (Fundamentally new product/service)	The fact that children can move with an orthosis for club-foot correction is new to the world, yet an orthosis for club-foot correction is not.
Five-to ten-fold (or greater) improvement in performance features.	The Dynko allows children with club-foot deformity to move and accordingly develop as required at a young age. The current product does not allow movement.
30% to 50% (or greater) reduction in costs.	Not applicable

Table 7 Discontinuous characteristics of the Dynko

Idea Emergence

The idea to develop a new orthosis for correcting club-foot did not originate from Ambroise, but from Ing L. van Bekkum from Deventer Orthopedie Techniek, an orthotist. The orthotist knew about an existing orthosis for correcting club-foot deformity and about the related number of disadvantage. As a result he contacted Nils van Leerdam at Ambroise, with the question whether the existing orthosis could be improved.

Nils van Leerdam listened to the question posed by the orthotist and soon discovered that the existing orthosis is at least hundred years old. The related disadvantages of this orthosis were understandable and Ambroise believed a better orthosis could be developed. Yet in order to develop a better orthosis Ambroise decided to go back to the core problem, thus children with club-foot deformity.

Ambroise knows from past experience that it takes five to ten years before the costs of developing an innovation will be earned back. This experience made Ambroise more careful in questioning the viability of innovations. The reason why Ambroise decided to develop the Dynko is related to the Dutch insurance system. Insurance firms pressure orthotists and orthotic workshops to deliver the cheapest appliances, yet these are not always the most appropriate. The innovations which Ambroise develops are seldom the cheapest and that is not the goal; the goal is to develop the most appropriate orthoses and prostheses. As a result most products are under pressure, although national differences can be found depending on the details of the financing system. Child orthopaedics is an exception to the above, thus hospitals and insurance firms do not only look for the cheapest instruments, but also at the most appropriate. One for the reasons for this exception is the fact that parents want the best for their children and do their best to achieve that.

> *"Mothers fight for their children as lions fight for their whelps. They want the best for their children, otherwise they will protest. As a result child orthopaedics is still fun when considering the future in terms of developing innovations. When the innovations are good enough, the mothers will support receiving insurance coverage."* (Nils van Leerdam, November 10, 2008)

From Idea to Commercialization

This section will explain how the discontinuous innovation process was experienced by Ambroise in chronological order. Figure 3 on page 38 presents a timeline of the innovation process and table 8 presents the third parties active in this innovation process. The activities performed during the discontinuous innovation process were divided into four stages by Ambroise and will be explained accordingly[7]. The related problems and challenges are intertwined in the explanation of the process.

Name Third Party	Activities
Deventer Orthopedie Techniek	Problem identifier and eventual retailer of the Dynko
Maatschap Orthopedie van het Ziekenhuis Deventer (Orthopaedic department hospital Deventer)	Performs patient testing and eventual prescription authority
Patients (hospital Deventer)	Product testing

Table 8 Third parties involved in the innovation process of the Dynko

Research and Preparation

Stage 1

In April 2007 Nils van Leerdam and Mark Besselink spent an afternoon brainstorming about the specific problems children with club-foot deformity experience and how the deformity can be corrected with the least negative side-effects. During this afternoon existing solutions (orthoses) were not taking into account, thus the main focus was on the core problem. The main question during this afternoon was '*how can the problem be solved?*', yet this process was still quite abstract. Nils van Leerdam refers to the latter process as thinking before-the-box, because solutions were not taken into account. The brainstorm process was started solely taking the problem into account.

The output of the first stage was a global structure of the design in abstract terms.

> *"When the abstract design is finished, it is a design in our perspective, but not according to many others. When having the abstract design there is still a lot of work to do, such as performing construction calculations. But we have the tendency to believe that the big steps of an innovative process occur in the first stage of the process. Thus, when you think about the problem, conduct a problem analyses and translate the findings into an abstract design description. That is the power of innovative design, not all those things that occur in the course of the process."* (Nils van Leerdam, November 10, 2008)

To develop the Dynko, Ambroise cooperated with the parties presented in table 8, but these parties were not active in the first stage when the initial designs were made.

> *"We do not want the third parties to be present in the design process. Our experience tells us that all the existing things have to be neglected to start fresh and look at a problem from a different angle, thus to be more creative. You have to consider what you want to do, without thinking about the products that are being sold already. In such a process a hospital will for*

[7] Not all the established SMEs divided the discontinuous innovation process in stages. This case study does refer to specific stages, whereas other case studies may not. Nevertheless, all the case studies are explained in chronological order.

> *example soon state that certain things are not allowed, or not possible or they don't want it. As result the hospital will only become active in the process when to prototypes have to be tested."* (Nils van Leerdam, November 10, 2008)

Stage 2

Ambroise was convinced that it could develop a better orthosis than the existing one and continued to work on the idea. Since no prior solutions were taking into account in the brainstorming session, literature had to be read to make sure no similar orthosis exists. The chance of finding well-founded articles is small according to Nils van Leerdam and searching literature is often lost time, yet it has to be done.

Once the literature research was performed, the first concept design was constructed. After each performed step, the findings were discussed by Mark Besselink and Nils van Leerdam. In June 2007 the second concept design was constructed and discussed. The construction of a concept design took approximately one day (per concept design). The results were discussed per design and took approximately half a day (per concept design).

The first stages ran quite smoothly and good results were achieved in a short amount of time, but the overall process could be structured better:

> *"The process went quite fast, but it could have been structured better and more time could have been saved. The process lacked a specific structure, because in a relatively small company such as Ambroise daily business plays a strong role."* (Nils van Leerdam, November 10, 2008)

One may state that managing daily business and innovating at the time same was one of the major challenges. Daily business demands a lot of time, in terms of technical and non-technical problems which have to be solved. Ambroise did not appoint an employee to the project on full-time basis. Mark Besselink for example, is not only a designer at Ambroise, but is also the it-system manager. And as Nils van Leerdam stated, there are always other things that go wrong and require immediate attention. The latter negatively influenced the innovation process in terms of time.

Ambroise solicited for a subsidy at SenterNovem named the WBSO, this subsidy compensates for a part of the hours spent on R&D. In order to be granted this subsidy Ambroise had to define the innovation, which they experienced as a disadvantage, since costs have been made at that point already. Nevertheless Ambroise is used to this procedure and was granted the subsidy. The WBSO is the only subsidy Ambroise solicited for, due to the restriction which many other subsidies pose (e.g. the requirement to cooperate with another European partner and great administrative burdens)

Construction and Development

Stage 3

The third stage in this innovation process was concerned with making a physical prototype. Opposed to the other stages, Mark Besselink was the sole employee working on this stage. The feasibility of the Dynko was tested by conducting the following test;

1. Can the prototype be made?

2. Which problems are there, concerning; making the prototype, assembling the prototype? And does the prototype supply sufficient force and does it pass the balance test?
3. Testing the prototype on patients.

The first prototype was constructed in November 2007. Making the prototype took approximately two days and in Januari 2008 production of the first prototype-batch started.

Testing the prototype was of vital nature and the result was unanticipated, especially when testing the prototypes on patients. Ambroise did brainstorm about the possible weak links in the prototype before patient testing, but in reality different parts broke or malfunctioned.

> *"We have been doing this work for 14 years and we think we are good at anticipating how products are used, but in practice it is always different."* (Nils van Leerdam, November 10, 2008)

Stage 4

The main goal of the fourth and last stage of the innovation process was the regular supply of the Dynko to the Hospital in Deventer. In order to do so, the 0-serie was produced in February 2008 and the first Dynkos were supplied in March 2008. To produce the 0-serie the employees of the work-place of Ambroise became involved.

Ambroise is capable of developing the first prototypes themselves, but does not have sufficient capabilities to produce all the parts of the 0-series for patients themselves. Accordingly Ambroise ordered parts from external suppliers and assembled the parts themselves. Ordering the parts from external suppliers required quite some patience. The Dutch economy was doing well and Nils van Leerdam had to pull several strings to receive the parts within eight weeks, instead of thirteen weeks or even more. The downside of having to wait so long according to Nils van Leerdam, is that you generally continue developing the innovation and learn new aspects, meaning that you change your mind about the previous order of parts. As a result new parts may have to be ordered, which again takes a long time. Before you know it months have passed.

Ambroise deliberately ordered its parts from Dutch suppliers. Ambroise knows that developing innovations requires frequent alterations for which new parts are needed. If these changes had to be communicated abroad in a different language, the supply may not only take longer, but the quality may be insufficient. As a result the cost-price of Ambroise's products may be slightly higher, but so will the quality of the product.

One of the major challenges during the innovation process and more specifically during this stage relates to the need to anticipate for how the prototype functions when worn by the patients, hence by children. Generally this is always a difficult task and even more so for children, since they make many unexpected movements. Whenever a prototype was broken Ambroise was challenged with detecting why and how it got damaged.

> *"During this process a few things broke in the prototypes, which were unanticipated and strange. We wondered how the children could break the prototype. This led to a few changes, not only in the material, but we also had to adjust the functionality to ensure it would not break again. An example of a case that helped us is related to a broken Dynko from which we*

could not analyze how it was broken, until the father mentioned he filmed his child, while his child broke the Dynko. In the film we saw that the child could walk with the Dynko, one of the things we did not anticipate at that point." (Nils van Leerdam, December 10, 2008)

Ambroise learned a lot during the patient testing period. In technical terms deficiencies of the prototype were altered, examples of which are adjusting for force, which is dependent on the child's age. One of the difficulties of this stage was to estimate how long patient testing would take until the deficiencies would be discovered and solved. Obviously this depends on the number of deficiencies that would arise and the cooperation with the hospital in Deventer. In fact, Nils van Leerdam states that this stage never really finishes, since unexpected deficiencies can arise any time.

The current stage of the innovation process

Ambroise is positive about the cooperation with the Hospital in Deventer, which was limited to a few discussion sessions about the Dynko with the orthopaedic surgeons. One of the positive results from this cooperation is that one of the orthopaedic surgeons in training decided to write his PhD about the Dynko. Ambroise is convinced that the research will positively influence the market launch and further development of the Dynko. The orthopaedic surgeons at Deventer will be more engaged with the Dynko and more orthopaedic surgeons at divergent hospitals will have to be approached for the purpose of the research (to which orthopaedic surgeons respond more positive, than when being approached for pure commercial reasons).

Ambroise is also positive about the cooperation with the orthotist, with which they have worked on various other projects as well. The orthotist has provided input, but left the final decisions to Ambroise.

The cooperation with third parties in general, influenced the progress of the innovation process. Milestones have been communicated with each other. Milestones, which otherwise might have been postponed, were now adhered to due to the communicated agreements.

Until now the Dynko has been supplied to Deventer and has proved to work well in Deventer. The previous deficiencies that have arisen in Deventer have been altered and the Dynko is ready to further enter the market. The objective is to extend the supply-canal to other hospitals and orthotists.

The healthcare system can be quite confusing at times and one may question how the provision of the Dynko occurs and who the actual customer of Ambroise is.
To ensure optimal treatment for club foot deformity, the orthopaedic surgeon and the orthotist discuss the possible treatment procedure together with the patient.
The orthopaedic surgeon treating the patient can prescribe an orthosis. In the prescription the orthopaedic surgeon is not allowed to state the name of the orthosis, but only provide a functional description of the orthosis. In the past this used to be different, and the orthopaedic surgeon could prescribe a specific orthosis by stating the brand name. Nevertheless, the description will lead to the preferred product, thus in this case the Dynko.
Following this process, the orthotist receives the prescription, which will be send to the patient's insurance firm for approval. Once approval is received, the orthotist will receive funding from the insurance firm and can order a Dynko from its supplier, in this case Ambroise.
To summarize, the orthopaedic surgeon writes the prescription, the orthotist handles the required administrative tasks and receives funding from the insurance firm, with which it can make a profit and order the Dynko from the supplier, hence Ambroise.

Textbox 2 Healthcare system and the provision of the Dynko
Information in textbox retrieved from interviews

The planned road to commercialization

Ambroise plans to slowly expand the supply of the Dynko beyond Deventer in January 2009. Ambroise deliberately opts for a slow market entry strategy. From experience Ambroise learned that when a product functions well at one location, new deficiencies may be discovered at another location. In order to launch a well functioning product and to establish brand equity a slow market entry is preferred by Ambroise.

The advantage of Ambroise, being an experienced firm is the gained customer knowledge, in terms of probable customer reactions. The idea is therefore to contact hospitals from which Ambroise expects a positive attitude towards a new product and the most feedback in terms of the functioning. One of the difficult facets about introducing a new product in the 'treatment' market is that orthopaedic surgeons are used to a particular treatment and the associated product. The orthopaedic surgeons need to be convinced of the new product, which is difficult in the initial stages and needs to be done by providing evidence. This term is currently quite popular in rehabilitation medicine, yet it is still in the premature stages of usage.

Ambroise does not solve problems, when there are existing and similar solutions (products) on the market. The orthopaedic world is small, specifically the western world and one can identify whether products exist. A similar product to the Dynko does not exist and one may state that the road to global commercialization looks bright. The notification of the latter and contact with an American distributor informing Nils van Leerdam about the number of patients in the United States still receiving the conventional method and looking forward to an improvement, certainly triggered the motivation of Ambroise to continue the innovation process. Nevertheless potential market estimations are difficult to make. The number of children suffering under club foot deformity can be estimated, but the choice of the orthopaedic surgeon to adhere to the new product is questionable. Positive however is that the orthopaedic surgeons in Deventer expect that 80% of their colleagues will opt for the Dynko, instead of the conventional product, the Dennis Browne.

As can be depicted from textbox 2 the market is relatively complicated.One may view the patient as the end-user, while the orthotist-maker is Ambroise's direct customer. To increase general awareness of the Dynko, Ambroise is contemplating to present the Dynko at the Dutch club foot association for parents.

The introduction of the Dynko at the hospitals will be done by Nils van Leerdam and the orthotist. The main reason is to ensure that the product is well understood by the orthopaedic surgeons and to allow the orthopaedic surgeons to give feedback. Nils van Leerdam will also be responsible if the Dynko requires further optimization.

In October 2008 Ambroise solicited for an international patent from the PCT (patent corporation treaty) and the acceptance procedure takes approximately a year. Ambroise has already been granted a Dutch patent for the Dynko. The main reason for also wanting a PCT is that the main competitors of Ambroise are located in Germany, England and the United States.

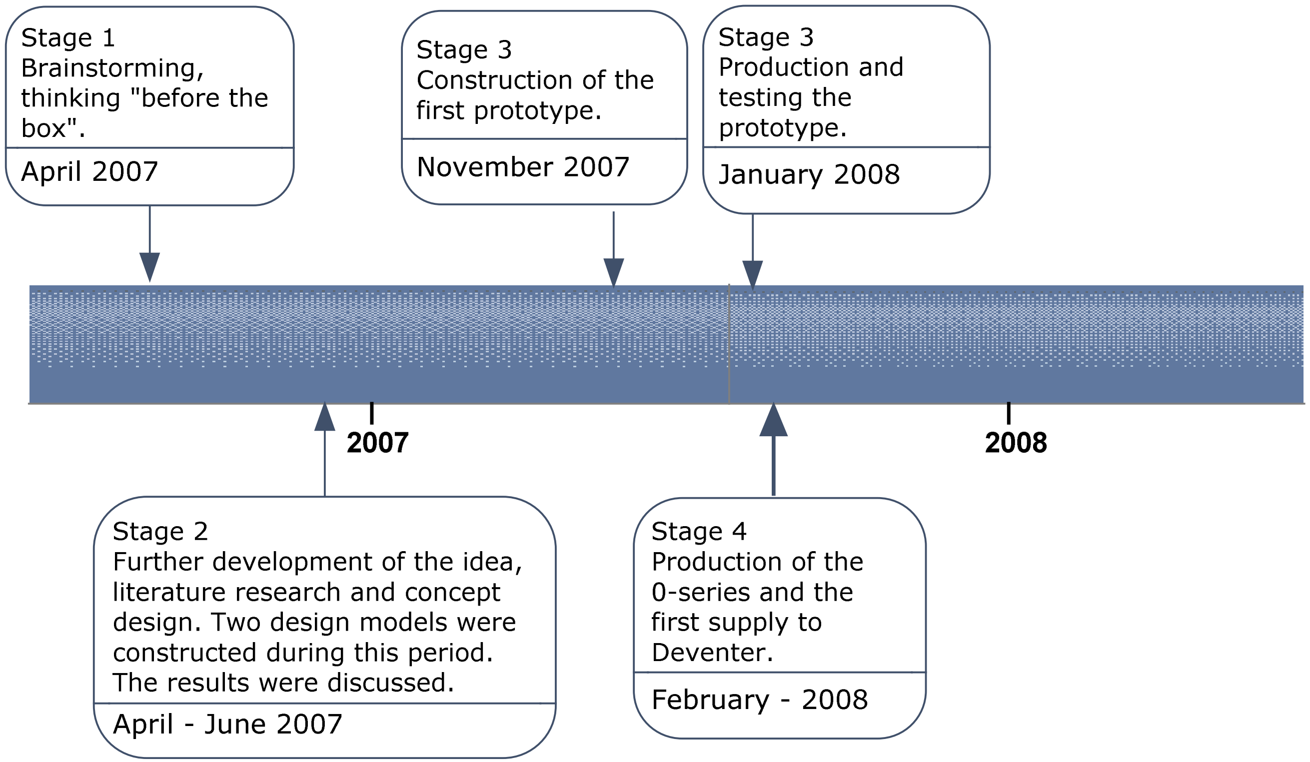

Figure 3 Timeline Discontinuous Innovation Process Ambroise

Anticipated Dates 2009	Activity
January	Expansion of the provision of the Dynko to other hospitals and orthotists

Table 9 Anticipated Dates 2009

4.1.1 Within Case Analysis - Ambroise

This section will reflect on the case study and highlight the problems, challenges and mechanisms used to develop the Dynko per stage of the discontinuous innovation process.

The Search Stage

Ambroise did not complete the search stage single-handedly, instead Ambroise was approached by an orthotist with the question to develop a better orthosis to correct club-foot deformity. One may state that Ambroise was steered in the right direction, but the established SME still developed the idea of the Dynko itself. In finding an appropriate idea, thus solution Ambroise emphasized the importance of what they call before-the-box thinking, this mechanism entails thinking about potential innovations without taking existing solutions (products) into account. Nils van Leerdam argued that not taking prior solutions into account, generates greater creativity and innovativeness.

The Select Stage

The owner of Ambroise decided to pursue the idea of the Dynko due to the fact that insurance firms are less cost oriented for children than for adults. The latter implies that there is still room to innovative and earn the investment back. Besides the latter reasons Nils van Leerdam was by his intuition and experience, thus his entrepreneurial skills.

The Implement Stage

The implement stage is the largest stage of the discontinuous innovation process, accordingly most challenges and problems were experienced in this stage.

Ambroise recognizes the importance of innovation, as the established SME spends 10% of its budget on R&D. Nevertheless the established SME also feels pressure to simultaneously manage daily business and innovative activities, which is quite challenging as daily business tends to take most attention, due to urgent matters, which are not necessarily important. An overview of the experienced challenges and problems is presented in textbox 3. An overview of the mechanisms applied during the implement stage is provided in table 10.

Challenges and problems experienced by Ambroise during the implement stage

- Simultaneously managing daily business and the innovation process.
- Reliant on suppliers for parts, requiring patience.
- Market launch requires care, no failures are allowed, this might harm the brand-name.
- No clear market estimations can be made, depends on the willingness of orthopeadics to accept the new orthosis.

Textbox 3 Challenges and problems experienced by Ambroise during the implement stage

Some of the mechanism used by Ambroise aided go/no go decisions, such as literature research to prove that no similar innovation exists or feasibility test, to test whether the Dynko can be made in practice. During the innovation process Ambroise was reliant on external suppliers for parts, which could not be made internally. The negative side effect of being reliant on suppliers, is that when ideas about the parts change, new parts have to be ordered, which again consumes large amounts of time.

In order to sustain the implement stage Ambroise opted for a subsidy named WBSO, which only compensates for the hours worked on the innovation, but does not impose many requirements. The established SME argued that subsidies may create a lot of administrative work (in terms of maintaining reports) and additional requirements (the need to find a European partner).

The implement stage	Mechanisms
Research and Preparation	- Literature research, to check whether no similar orthosis exists.
Development	- Subsidy (WBSO) - Prototyping and feasibility tests - Patient (consumer) testing in cooperation with Hospital (orthopaedics) and the orthotist-maker. - Purchase parts externally
Commercialization (market launch)	- PhD Research performed by future orthopaedic at hospital Deventer (aids market launch) - International Patent (PCT) - Slow market entry; allowing consumer feedback cycles

Table 10 Mechanisms applied during the implement stage

Even though Ambroise thoroughly tested the Dynko during patient testing, it still opts for slow market entry. The reason being that launching innovative products requires care, because if the innovation malfunctions it might harm the brand-name and trust might be lost. Accordingly Ambroise opts for slow market entry, by building in consumer feedback cycles. To safeguard the Dynko Ambroise solicited for an international patent from the PCT (patent corporation treaty) and already owns Dutch patent for the Dynko. The PCT will protect the Ambroise from the main competitors.

During the implement stage several challenges and problems were directly addressed, others were not. The challenges and problems experienced during the implement stage that were directly addressed are presented underneath in figure 4. Simultaneously managing daily business and the innovation was experienced as a challenge, yet this challenge was not directly addressed.

Figure 4 Overview of the problems and challenges, which were addressed with mechanisms during the implement stage by Ambroise

Within Case Conclusion

The discontinuous innovation process experienced by Ambroise took approximately one year and can be divided into four stages. In each stage a specific aspect was accomplished. For the search stage the established SME does have a specific mechanisms, namely before-the-box thinking, but the selection stage is based on the owner's entrepreneurial skills and market knowledge. In the implement stage most problems and challenges were experienced, accordingly most mechanisms were applied as can be depicted from figure 4.

The experience and entrepreneurial mindset of Nils van Leerdam certainly influenced the innovation process of the Dynko, which accordingly ran quite smoothly. No documents were kept concerning the process, nor was the process pre-structured, even though it can be divided into stages. One may conclude that tacit knowledge was applied to structure the process.

4.2 Case Report The EPC Pakket – Doorgeest Koeltechniek

This case study report will describe the innovation process as experienced by Doorgeest Koeltechniek in their quest to develop the EPC pakket. The case study report is based on retrospective data retrieved from two interviews with the owner and project initiator, named Jeroen Doorgeest. No documents, other than technical specifications were kept.

Doorgeest Koeltechniek was established in 1965 by Jaap Doorgeest and was taken over by his son, Jeroen Doorgeest in 1994. Doorgeest Koeltechniek currently employs fifteen employees and develops sustainable and innovative climate control systems. The firm is located in Heino, in one of the most energy sustainable buildings in the Netherlands.

The innovation process studied concerns the development of the EPC pakket, which is a heat pump able to cool and heat buildings using air. The pump functions on electricity and can be managed from a distance using a software application and the internet. The functioning of the EPC pakket is explained in textbox 4.

1. **The heat-pump (1,Figure 5) can distil energy from the air and turn it into heat or cold. The energy of the heat-pump is transferred to CV water, which flows to a buffer vessel (2, Figure 5).**
2. **The heat or coldness from the buffer vessel is offered to the transmission-system (3, Figure 5), for example floor-heating, or ventilator-convectors.**
3. **The second heat generator (4, Figure 5), e.g. the kettle, provides the house with tap-water and back-up delivery of space-heating to ensure the greatest energy yield.**
4. **The whole system, including the second heat-generator, is managed through the in-house developed EPC set-up.**

Textbox 4 Functioning of the EPC pakket

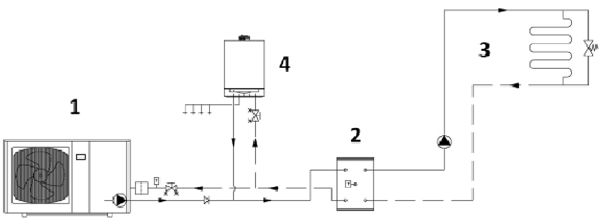

Figure 5 Representation functioning of the EPC Pakket

Selection Criteria for Discontinuous Innovations by Rice et al. (2002)	Criteria Present in the Discontinuous Innovation of Doorgeest Koeltechniek
New to the world performance features (Fundamentally new product/service)	The EPC pakket can provide houses and office buildings with 80 to 90% with heat and cold using open air.
Five-to ten-fold (or greater) improvement in performance features.	No CO2 emission, no gas consumption and radiators are required. The EPC pakket can be managed online.
30% to 50% (or greater) reduction in costs.	The EPC pakket will reduce energy costs by 40%.

Table 11 Discontinuous characteristics of the EPC Pakket

Idea Emergence

Jeroen Doorgeest has a business economics background, but has always been engaged in his father's business. At a young age he joined his father and spent time at the firm, where are learned a lot of technical aspects. Jeroen Doorgeest describes himself as an innovative individual, stimulated by his behaviour:

> *"I always have the feeling that something could have been made better, an idea is never great, I am always critical."* (Jeroen Doorgeest, October 25, 2008)

In the 1990s market developments were taking place concerning heating using aquafer systems. These systems heat buildings using ground water, stored in the earth, underneath the house. To heat the building, warm water is pumped from the earth to the house, when cooling is required, cool water is pumped to the house. As global warming takes place and the earth becomes warmer, one may expect thermic pollution to occur in the earth as more warm water will be send back into the earth. Jeroen Doorgeest was doubting this system and feared that the government would set taxes, due to the probable thermic pollution. Currently this system is popular, due to the increased environmental awareness and emerging regulations concerning CO2 releases. Nevertheless, taxes on using the ground as a storage room for water will be implemented soon.

A disadvantage of the energy market according to Jeroen Doorgeest is that many firms develop and produce parts of a heating system, e.g. boilers. Accordingly, not much is changed in the energy systems.

> "*It is like pimping up a car, you can put new headlights in, but the rest will stay the same."* (Jeroen Doorgeest, October 25, 2008)

Jeroen Doorgeest was doubting the aquafer system and believed that a new system could be develop by taking an integrative approach. The system should be environmental friendly, but not taxable by the government. Jeroen Doorgeest decided to merge his knowledge about cooling installations, air and process technology, to find a proper combination for a new system. As a result he decided to develop a system that enables both warming and cooling by using air.

From Idea to Commercialization

This section will explain how the discontinuous innovation process was experienced by Doorgeest Koeltechniek in chronological order. The related problems and challenges are intertwined in the explanation of the process. Doorgeest Koeltechniek did not apply specific stage during the develop of the discontinuous innovation, accordingly this section does not relate to specific stages as in the previous case study.

Research and Preparation

The idea of developing a system using air as a source for heating emerged in 2001, but due to time limitations the idea was only pursued in 2003. The time limitations are related to the function of Jeroen Doorgeest, who as the owner of Doorgeest Koeltechniek was also responsible for daily business. Jeroen Doorgeest had a good feeling about this idea, he believed in it and therefore decided to pursue it, although his environment did not share the same vision.

Jeroen Doorgeest decided not to opt for a subsidy, the main reason being the administrative burden and the need to document product specifications. Jeroen Doorgeest also had difficulty receiving a loan from the bank for his innovative work.

> *"There are not many banks, most think the same and allow little playground. Banks are authorities where you can pick up a bag of money, but not when you are pursuing radical ideas."* (Jeroen Doorgeest, October 25, 2008)

Jeroen Doorgeest decided to take the risk and pursue the development based on internally generated money, being aware that he will be responsible for the end result, thus whether the innovation will succeed or not.

Construction and Development

In 2003 the innovation process for the development of the EPC pakket was started. This process entailed working on the technology specifics of the heat pump and the development of a management system to allow for process management via the internet.

Developing an integrative system is a challenging task and was referred to by Jeroen Doorgeest as working on a puzzle:

> *"You start working on a puzzle piece and you need to search for all the right puzzle pieces in a puzzle consisting of over a thousand pieces."* (January 12, 2008)

Taking on such a challenge requires patience and commitment, but in this case double commitment, as Jeroen Doorgeest had to take care of the core business and the innovation process, requiring working days consisting of 16 hours. Simultaneously managing both is a very challenging task, requiring a great deal of commitment and trust in the idea to continue the innovation process. During the further development of the innovation, two more employees with technical backgrounds became involved in the process, yet only on part-time basis.

To ensure the functioning of the innovation, various tests had to be conducted, thus physics tests to prove the function of the innovation in extreme temperatures and sound tests to ensure the product would not be too noisy. These tests took place between 2003 and 2005, but the first abstract prototype was finished at the end of 2004, which proved that the idea was technically feasible.

Energy systems require labels stating that the system adheres to the market standards. Nevertheless, due to the discontinues nature of the innovation, there was not a measurement entity for the system developed by Doorgeest Koeltechniek. As a result the firm decided to consult TNO, a research institute, with the demand to develop a procedure with which the innovation can receive a similar statement and label. This process was started at the end of 2005, but took quite some time.

In 2006 the EPC pakket received a label and two days later a staggering event occurred. Jeroen Doorgeest was called by one of the largest energy market players in the Netherlands showing interest in the EPC pakket. This amazed Jeroen Doorgeest, as he had not communicated the development of the EPC pakket externally and he questioned the independence of TNO. This event influenced the innovation to such a large extent, that Jeroen Doorgeest decided not to solicit for a patent. He did not want to put the technical specifications in writing.

> *"Doorgeest Koeltechniek is a knowledge breeding nest, but the knowledge has not been made commercial."* (Jeroen Doorgeest, January 12, 2008)

In 2006 Doorgeest Koeltechniek started consumer testing, this involved placing the EPC pakket in newly built consumer houses and monitoring the functioning of the innovation under the given conditions. Consumer testing was started on small scale, enabling sufficient attention to the consumers. Consumer testing was continued until 2008 and the results were positive. Doorgeest Koeltechniek is also satisfied with the comments received during the testing period.

> *"During consumer testing you receive more focus and sharper knowledge about the product, how to present it in brochures and how to guide system installers."* (Jeroen Doorgeest, January 12, 2008)

In 2006 further developments on the EPC pakket involved architectonic research on how the EPC pakket functions in different buildings and how the EPC pakket should be located in the building. Research on this matter is still taking place.

In 2007 the first monitoring results were received and sent to SenterNovem. SenterNovem is a governmental organization stimulating innovative activities. Doorgeest Koeltechniek decided to cooperate with this organization, in order to increase brand awareness and become known as the specialist in environmental friendly climate control systems. SenterNovem is generally known for rewarding subsidies, but as mentioned Doorgeest Koeltechniek did want to solicit for a subsidy. Instead, SenterNovem will grant subsidies of 1.000,- Euros to consumers purchasing the EPC pakket.

Doorgeest Koeltechniek decided to set up a separate firm, named Wadus for the commercialization of the EPC pakket. Jeroen Doorgeest owns 51% of the shares of Wadus, the other 49% are owned by an external large firm. The external firm produces concrete and prefab concrete, allowing for joint-development in the future. A further advantage of the cooperation relates to the capital wealth of the external partner, due to which a larger market can be supplied. Wadus hired an employee to manage the marketing side of the firm and Jeroen Doorgeest is still responsible for the technical aspects of the firm. Jeroen Doorgeest emphasized the advantage of putting people with different backgrounds, thus knowledge together, to guard the firm against the market.

The current stage of the innovation process

The development of the EPC packet took five years, five uncertain years in which a lot of investments had to be made without any certainties. A problem experienced during these years relates to the investment costs, which were difficult to account for in the books. Another aspect is that banks require a solvability factor of 30%, which may be difficult to maintain when innovating. There were times during the development process that Jeroen Doorgeest experienced setbacks and feared bankruptcy. A great challenge during such times was not losing your temper and continuing.

Jeroen Doorgeest indicated that he was not the one to decide whether the product will be welcome on the market, these are the consumers. As a result, until now 60 houses have been tested and monitored. All the results were positive, the innovation even lasted the most extreme tests, as during the past winter period in which temperatures of below – 15 degrees celsius were experienced.

Until now the investment costs of the development process, starting up the new firm and financially securing the new firm required over one million Euros. Nevertheless, the technology applied in the innovation is two-years ahead of the general market.

The planned road to commercialization

In 2006 Jeroen Doorgeest was quite certain about the functioning of the EPC pakket and decided to arrange for production-lines abroad, in Italy and Hungary. The production lines can produce 100 heat-pumps in two days and 15.000 to 20.000 heat-pumps per year. When desired Jeroen Doorgeest can make arrangement to double the production numbers.

Jeroen Doorgeest argued that one should not want to develop and launch an innovation on the market at a fast pace. The innovation itself, thus the technology should prove itself first, otherwise the firm risks spoiling the technology and firm name. Jeroen Doorgeest strongly emphasized that the technical properties are the most important and should function properly. The advantage of Doorgeest Koeltechniek during the development process was the fact that the firm name was not well-known in the market yet. This allowed the firm to quietly start consumer-testing, thus if the technology would have failed, no large harm would have been done. Fortunately the technology proved to function well. Once the EPC pakket was introduced on the market, rumors about the well-functioning of the product moved fast and the brand name was spread on the market. To prove the well-functioning to consumers, a test model was made. Due to the discontinuous character of the innovation, Doorgeest was asked by several institutions to give lectures on the functioning of the EPC pakket. The latter increased awareness and eased market launch. Nonetheless Jeroen Doorgeest wants to enter the global market and is not satisfied with solely supplying on the Dutch market. In order to do so, he is planning to visit several retail organizations abroad and convince them of the new technology. Consequently he is hoping for the same enthusiastic responses abroad, which will semi-automatically create demand.

Jeroen Doorgeest is currently expecting a demand of 100.000 units in the Dutch market, resulting in a maximum turnover of 700 million Euros. The demand is positively influenced by the Dutch government, tightening regulations on the amount of CO2 emissions. The EPC pakket can also function in combination with gas and more wamth-pumps can be combined. This aspect allows the innovation to be implemented in city-heating systems, thus also contributing to demand. When being asked whether Wadus can supply according to the estimated demand figures, Jeroen Doorgeest simply answers that a way will be found.

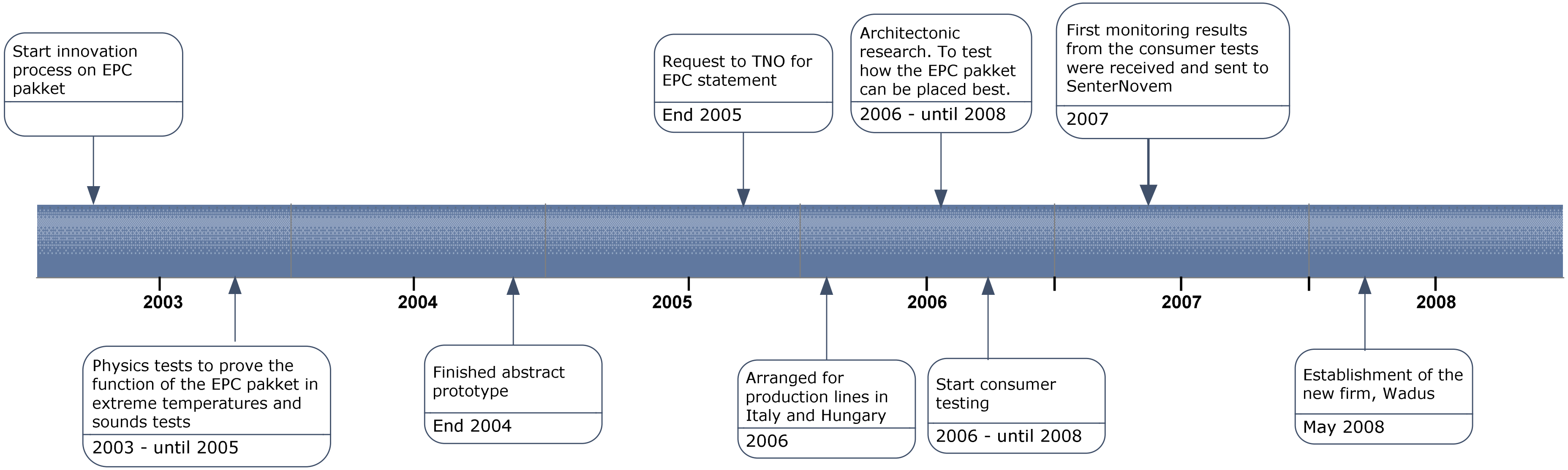

Figure 6 Timeline Discontinuous Innovation Process Doorgeest Koeltechniek

2001	**Idea Emerged**

Table 12 Prior Activities

4.2.1 Within Case Analysis – Doorgeest Koeltechniek

This section will reflect on the case study and highlight the problems, challenges and mechanisms used to develop the EPC Pakket per stage of the discontinuous innovation process.

The Search Stage

The owner of Doorgeest Koeltechniek created the idea of a heat-pump himself, due to the believe that the current developments would not be viable on the long term. An important trigger of the innovation was the believe that the CO2 emission legislation would be altered in the future. The idea of the EPC pakket emerged in 2001, but due to time limitations the idea was only pursued in 2003.

The Select Stage

The owner states that he recognized the viability of the idea due to his intuition and market knowledge. The fact that he assumed that the CO2 emission legislation would change, stimulated him to select the idea. Jeroen Doorgeest is the owner, inventor and project initiator of the EPC Pakket.

The Implement Stage

In the implement stage is the largest stage, accordingly most problems and challenges were experienced in this stage. The largest challenge according to Jeroen Doorgeest was to simultaneously manage daily business and the innovation process, which was an exhaustive task, requiring patience and commitment. Further challenges and problems experienced during the implement stage are summarized in textbox 5.

Challenges and problems experienced by as Doorgeest Koeltechniek in the implement stage

- Simultaneously managing daily business and the innovation process.
- Large investments without certainties. Banks require a solvability factor of 30%.
- When setbacks occur and fearing bankruptcy, not losing your temper and motivation.
- No existing measurement procedure for receiving a required standard energy label.
- Market launch, due to missing social legitimacy and financial resources to fulfil potential demand.

Textbox 5 Challenges and problems experienced by Doorgeest Koeltechniek during the implement stage

To successfully develop the innovation, several mechanisms were used in the implement stage as indicated in table 13. Some of the mechanisms overlap several sub-stages of the implement stage, as can be depicted from table 13, e.g. prototyping.

Implement Stage	Mechanisms	
Research and Preparation Mechanisms		- Prototyping and feasibility tests (physics, sound, infrastructural)
Development Mechanisms	- Research Institute (TNO) created a standard for a new label - Consumer testing - Real-time monitoring functioning apparatus at consumer houses - Cooperation SenterNovem by sending monitoring results.	
Commercialization (market launch)	- Production-lines abroad - Establishment new firm, named Wadus (51% owned by Doorgeest)	

Table 13 Mechanisms applied during the implement stage by Doorgeest Koeltechniek

Figure 7 provides an overview of the problems and challenges that were directly addressed during the implement stage. During the innovation process several challenges and problems were directly addressed, others were not. Simultaneously managing daily business and the innovation was experienced as a challenge, yet this challenge was not directly addressed. One of the reasons being that Doorgeest Koeltechniek did not have the manpower and financial resources to do so.

Jeroen Doogeest argued that banks and discontinuous innovations do not fit together. Banks dislike risk, thus dislike discontinuous innovation processes, due to the high number of uncertainties and required investments. Doorgeest Koeltechniek developed the EPC pakket without relying on subsidies, but once the innovation was developed the established SME ran into difficulty, namely how to finance the additional costs of producing and launching the innovation. As a result, the established SME set up a joint venture together with a large firm, but emphasized that care must be taken when selecting partners, due to wrong intentions. The established SME put great importance on internal knowledge and emphasized that it should not spilled outside the firm. Accordingly the established SME did not file for a patent.

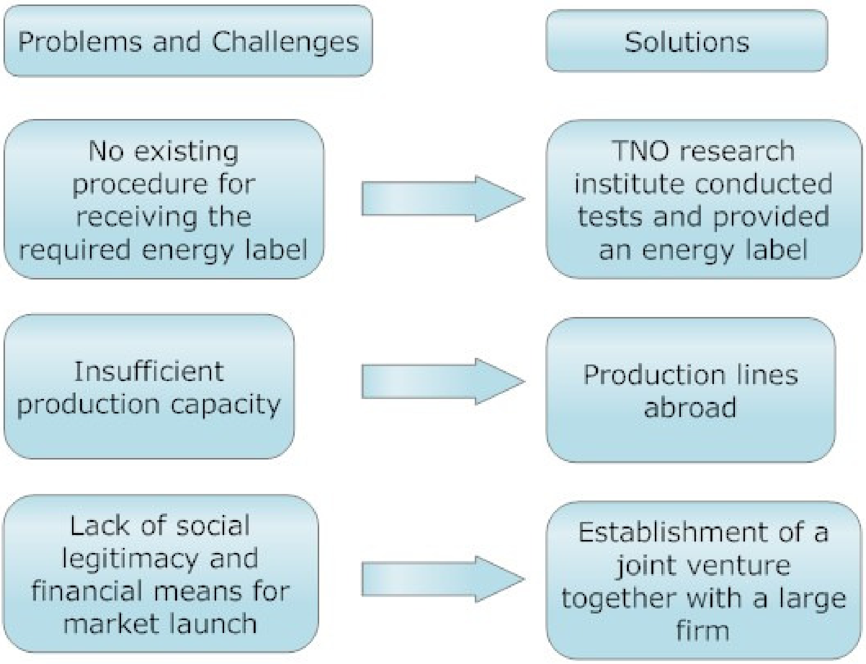

Figure 7 Overview of the problems and challenges, which were addressed with mechanisms during the implement stage by Doorgeest Koeltechniek

Within Case Conclusion Doorgeest Koeltechniek

The discontinuous innovation process to develop the EPC pakket took approximately seven years. The process was not structured into stages, instead the owner believed that innovation process cannot be directed and argues that it evolves. The search and select stage are mainly influenced by the owner's entrepreneurial skills and his market knowledge. Most problems and challenges were experienced during the implement stage and as can be depicted the established SME had to set up a joint venture to enable market launch.

4.3 Case Report The Fuel Cell Boat – Scheepswerven Bodewes

This case study report will describe the innovation process as experienced by Scheepswerven Bodewes in their quest to develop a fuel cell boat. The case study report is based on retrospective data retrieved from two interviews with the project manager of the innovation, named Jeroen Jousma. No documents other than technical specifications were kept.

Scheepswerven Bodewes is a shipyard located in Hasselt, a small rural village in the Netherlands. The shipyard performs a variety of disciplines, such as repairs, maintenance, extending ships, constructing new ships and placing engines in ships. Ships up to 82 meters can be placed at the shipyard, examples of which are tankers, dredging materials and passenger ships. Scheepswerven Bodewes employs between fifteen and twenty employees depending on the workload. Scheepswerven Bodewes was established in 1928 by Geert and Hermannes Bodewes, eighty years later the firm is still in family hands and owned by Thecla Bodewes.

The innovation process studied at Scheepswerven Bodewes is the development of a fuel cell boat. As the name states, the boat will function on fuel cells, which means that the boat will have no CO_2 emission. The fuel cell boat will be the first hydrogen boat of this size, built for commercial exploitation. Scheepswerven Bodewes has been nominated for the fuel cell boat for the Overijssel Innovation Award in 2008. Table 14 provides reasons for why the fuel cell boat is a discontinuous innovation.

Selection Criteria for Discontinuous Innovations by Rice et al. (2002)	Criteria Present in the Discontinuous Innovation of Scheepswerven Bodewes
New to the world performance features (Fundamentally new product/service)	The fuel cell boat will be the first zero emission cruise boat for cruising on the canal (of this size) and fuel cell technology has not been applied in boats before.
Five-to ten-fold (or greater) improvement in performance features.	One may refer to zero emission as being a performance feature
30% to 50% (or greater) reduction in costs.	The boat will be more expensive to purchase compared to regular boat, but the exploitation costs are estimated to decrease by 20 to 40%.

Table 14 Discontinuous characteristics of the Fuel Cell Boat

Idea Emergence

As mentioned this case study is concerned with how Scheepswerven Bodewes experienced the discontinuous innovation process. The idea of developing a fuel cell boat did not emerge from this established SME, rather from a consortium of five companies. To provide some background on this process, the following will be described in this section. A timeline of the innovation process can be found on page 59, figure 8.

Environmental concerns increase at a steady state all around the globe. Environmental awareness is an important issue at many public institutions, as it is in the city of Amsterdam. CO_2 emission is one of the major pollutants in cities such as Amsterdam. To anticipate for potential legislative alterations concerning CO_2 emissions the idea of the fuel cell boat emerged.

In the summer of 2005 Integral takes the initiative to discuss the topic of environmental awareness and how it may influence boat cruises in Amsterdam. The discussions lead to the emergence of the idea for a fuel cell boat. In December 2005 the idea was discussed for the first time in the presence of the following firms; Alewijnse, Integral, Linde, Lovers and Shell Amsterdam. Soon after the first meeting in December 2005 the firms; Alewijnse, Integral, Linde and Lovers met again on the 20th of January and decided to further explore the idea. In March 2006 a fifth firm decided to join the project, named Marine Service Noord (MSN hereafter). The consortium is complete, the five members are presented in table 15.

Fuel Cell Boat BV (FCB)	Type of firm	Role in the process
Alewijnse	Electric and multidisciplinary service provider	These 5 members came up with the idea to develop a fuel cell boat. They established a joint venture to do so, but outsources the actual construction of the boat to Fuel Cell Boat Construction BV (FCBC).
Integral	IT firm with focus on software	
Lindegas	Produces gas (focuses on the hydrogen station)	
Rederij Lovers	Organizer of canal cruises in Amsterdam (end consumer)	
MSN	Pipelines and engine installations among others	

Table 15 Fuel Cell Boat BV members and functions

In August 2006 the consortium established a project plan and near the end of September 2006 Allship received the task to work on the first basic designs of the fuel cell boat. It was only on the 6th of October that the five firms signed a cooperative agreement.

In November 2006 the consortium was able to obtain a subsidy from the Ministerie of Economische Zaken, Senter Novem (Ministry of economical affairs). The granted subsidy belongs to the subsidy arrangement named Energy Research Demonstration. A further subsidy was provided by Stadsdeel Amsterdam Noord (District Amsterdam North) and contributed to the start-up costs of the project. The subsidy was granted in terms of the climate policy 2004-2007 to improve the air quality in the city and to enhance the sustainable and innovative appearance of the district.

Once the subsidies were granted the joint venture Fuel Cell Boat BV was set up on the 4th December 2006. On the 17th of January Fuel Cell Boat BV publicly announced the establishment of the joint venture and the purpose, hence the development of a fuel cell boat. The specific functions of the member of Fuel Cell Boat BV are presented in table 15. From table 15 one can distil that Fuel Cell Boat BV was not able to construct a boat itself, it therefore approached Scheepswerven Bodewes. Rederij Lovers will be the end-consumer of the boat. The boat will be exploited for cruise purposes through the canals of Amsterdam and will transport employees to and from the Shell office Amsterdam. The concept of a fuel cell boat is new and will require a hydrogen station which is the prime task of Lindegas. To realize the actual development and construction of the boat FCB needed to find a shipyard with the competencies to accomplish such an innovative task. At that point Bodewes came into the picture. Thecla Bodewes, the owner of Scheepswerven Bodewes decided to take on the idea and develop a fuel cell boat. In order to do so, Bodewes needed the capabilities of MSN and Alewijnse, which resulted in the establishment of another separate joint venture, namely Fuel Cell Boat Construction BV (hereafter FCBC), which was set up in the beginning of 2008. Accordingly MSN and Alewijnse are members of both FCBC and FCB. The specific functions of the member of Fuel Cell Boat Construction BV are presented in table 16. The discontinuous innovation process will be described more in depth from this point onwards, since the focus of the case is on the innovation process, which except for emergence of the idea took place in FCBC.

Fuel Cell Boat Construction BV	Role in the process
Scheepswerf de Kaap (Scheepswerven Bodewes)	Construction of the boat and overall management of the development process of FCBC. T. Bodewes functions as the director of FCBC.
Alewijnse	Provides electricity on board
MSN	Arranges and develops the fuel cells for the boat in cooperation with Nedstack. Nedstack develops the fuel cells.

Table 16 Fuel Cell Boat Construction BV members and functions

From Idea to Commercialization

This section will explain how the discontinuous innovation process was experienced by Scheepswerven Bodewes in chronological order. The related problems and challenges are intertwined in the explanation of the process.

Research and Preparation

FCBC started the innovation process in 2008 and appointed Thecla Bodewes as the director of the joint venture. From that point onwards Thecla Bodewes was responsible for the communication to FCB and the meetings. FCBC had only been provided with the idea and an initial basic design and construction drawing, further development of the idea was now in their hands.

In the first quarter of 2008 (starting in January) Scheepswerven Bodewes was busy preparing for the construction stage. This entails that additional and more detailed design and construct drawings of the boat had to be arranged, engineering and calculations had to be organized and the required components had to be purchases.

Even in the first quarter challenges and problems started to arise quite quickly. The first problem and set back was concerned with the basic design and construction drawings provided by FCB. After studying the provided drawings, FCBC discovered that the fuel cells were larger than expected and would not fit in the boat given the provided drawings. This aspect has not been noticed in the previous stage by FCB, due to the time and costs that such an analysis demands. Time and costs, which FCB was not willing to spend at that time. Once the decision was made to continue with the project and once FCBC was established, this problem arose.

The main problem was that the boat was too small for all the components required to realize a hydrogen boat:

> *"This eventually turned out to be the biggest problem and it still is. At a certain time a design was made and we continued given the design, concessions were made about this, 'great we will build this'. And then it turned out that the fuel cells turned out to be larger, the bottles were large and the batteries were large etc, etc."* (Jeroen Jousma, November 25, 2008)

All the components turned out to be larger than expected, so a choice had to made, either to decrease the number of passengers the boat can transport or find another alternative. After conversations with Rederij Lovers it was clear that decreasing the number of passengers was not an option, due to the corresponding decrease in revenue that the end-consumer would have. This did not leave many options, therefore the choice was made to talk to Havenbedrijf Amsterdam en Binnen Wateren Amsterdam about expanding the boat. One must realize that cruise boats in the canals of are only allowed to be twenty meters long, yet the conversations made it possible to extend the boat by two meters, hence two more meter than allowed by regular legislation.

One of the reasons why FCBC was granted the additional two meters was related to an additional innovation in the boat, namely the bowthruster. This feature allows the boat to turn 360 degrees and be very movable in the narrow canals of Amsterdam. This is a new feature in the cruise boat industry, no cruise boat has this feature yet. To prove the adequacy of this feature an independent party had to write a report on the functioning. The results were positive and the report indicated the need for the extra two meters to install all the components.

Next to the size of the boat the design was modified. The initial boat design provided by FCB was quite classical and did not fit to such an innovative boat. Upon request by the end-consumer the design was altered. The university of Delft also contributed to the design, by developing glass windows, which could open side wards. Although the effort and the idea was good, the glass windows were rejected by the end-consumer, due to fear of breaking the windows in the narrow canals of Amsterdam.

A research group in Wageningen named Marin also conducted a few tests and calculations concerning the construction drawings provided by FCB. These tests had a positive influence, because it turned out that less components were required, which eventually saved money and time.

Construction and Development

In April 2008 Bodewes had made the required preparations and was ready to enter the construction stage. The development and construction of the fuel cell boat took place at the Shipyard Bodewes and started with the construction of a frame and gradually expanded by constructing the further components[8].

As explained FCBC does not solely consist of Bodewes, but MSN and Alewijnse are also members of this joint venture. Bodewes being a shipyard was used to plan and outsource activities to construct boats, Alewijnse and MSN on the other hand were not. The fact that they were not used to arranging several activities can be recognized, as they often searched for the best way to continue and experienced this as quite a burden. The latter and more reasons to be discussed in this section influenced the process negatively, accordingly the process took longer than anticipated by FCBC. As a result an overall project managers, named Jeroen Jousma was hired in August 2008 to guide the process and streamline the activities of the three firms in FCBC (Bodewes, Alewijnse and MSN). Jeroen Jousma had previously worked for larger firms and from his experience he states that:

> *"You see that smaller firms, do have less insight capacity, because they normally do less, which makes this project quite a burden."* (November 5, 2008)

[8] The fuel cells are not developed by FCBC, but are purchases from Nedstack, a tasks in the hands of MSN.

The project manager soon noticed that the communication between the three firms prior to his arrival had not been sufficient. He is not sure about the exact reasons, but an influential fact might have been the geographical locations of the firms, which may have complicated the communication slightly. Currently the communication deficit has been solved and communication among the three firms takes place on a daily basis.

The end-consumer (Rederij Lovers) is also considered an important party in the development process. The project manager therefore highlights the importance of frequent communication (a few times per week) to prevent additional work. The communication with Rederij Lovers is mainly concerned with the design and the costs of the boat.

In order for the fuel cell boat to be able to navigate through the canals of Amsterdam FCBC had to cooperate with a few authorities to receive the required licenses. One of those authorities is Germanischer Lloyd, a German organization providing licensing for the safety of applying fuel cell technology onboard. Germanischer Lloyd is the only organization with this service, which means that FCBC is quite dependent on this organization for the success of the innovation. Nevertheless difficulties were experienced concerning the communication between FCBC and Germanischer Loyd. Every alteration concerning the integration of the fuel cells onboard had to be communicated to Germanischer Lloyd. After approval the alterations can be made.

There are various reasons for the difficulties with Germanischer Lloyd, the first being that FCBC underestimated the process of receiving a license, which resulted in a lack of attention paid to the communication with Germanischer Lloyd. Another reason named by Jeroen Jousma is related to the fact that:

> *"Germanischer Lloyd is a large and German organization, everything has to be done according to their preferences, which makes it difficult to find the right entrances in the organization and to speak the right language, not Dutch or German, but the professional language."* (November 5, 2008)

Unfortunately FCBC was quite inexperienced with negotiating with such large authorities and dealing with discontinuities. The more often an organization deals with such situations, the better the organization 'speaks the required language' to come to an agreement. As a result the process of receiving approval did not take place as it should have, which means that more costs and time are incurred now.

When the project manager entered FCBC in August he realized that more attention had to be paid to the relationship with Germanischer Lloyd, in order to enhance the process of receiving a license. More specifically more attention had to be paid in terms of the cultural differences and respect as demanded by Germanischer Lloyd towards their substantial reputation. The project manager quickly implemented several changes to bring the innovation project on track again. One of the most important changes according to him was to improve the relationship with Germanische Lloyd. To do so, he personally visited the organization and increased the contact frequency, to prevent unnecessary work.

Even though the boat was permitted to be twenty-two meters (two meters longer than permitted by regular legislation), the challenge of fitting all the components in the given space was still a major challenge throughout the further development and construction of the boat. This aspect also influenced the ability of FCBC to adhere to the guidelines provided by Germanische Lloyd and required FCBC to spend extra time discussing possible deviations from the guidelines.

Fuel Cell technology has not been applied in boats before and one cannot find information on how to construct such a boat. In the navigation industry boats are usually developed by applying a structured process, starting with the idea, followed by engineering, preparation for construction, actual construction, test navigate and delivery. Generally the stages may interact a bit, but they tend to follow the path as described. This process however was far more messy and many of the stages described above occurred simultaneously. Many aspects of the boat were uncertain, both in terms how to construct the boat and what would be allowed. The disadvantage of such a messy process is that constructed components had to be removed again, because engineering found a better way to construct the components:

> *"Sometimes you can move three steps forward and then you have to move two steps backwards again, because new knowledge or insights have been gained. Sometimes you think something is a good idea, you move in that direction, the left direction, but then you change your mind, your idea was not so great and the whole team has to move to the opposite direction again, to the right."* (Jeroen Jousma, November 5, 2008)

The current stage of the innovation process

The initial plan of FCBC was to have to boat finished for exploitation by the end-consumer in January 2009. Unfortunately this target will not be achieved. FCBC is still active in the development and construction stage and the expected delay is three months. The new target data for the boat to be ready for exploitation by Rederij Lovers is 1st of april 2009.

The planned road to commercialization

The boat is still in the development and construction stage and FCBC is still in negotiation about the last aspects of the fuel cell boat. The objective is to put the boat in the water in February 2009, so that the Ministerie van Verkeer and Waterstaat (the ministry of traffic and water) can start the inspection, which may extent over the time period from February to March 2009. The inspection process includes; an analysis of the design drawings and a surveyor will test the functioning of the boat both before the boat is allowed in the water and once the boat is in the water. Once the license from the Ministerie van Verkeer and Waterstaat is given, the boat can be transported to Amsterdam. In Amsterdam Rederij Lovers will be able to obtain the additional licenses (due to the license received from the Ministerie van Verkeer and Waterstaat) for the exploitation of the fuel cell boat from Havenbedrijf Amsterdam (Harbour firm Amsterdam) and Dienst Binnenwaterbeheer Amsterdam (Service inland water management Amsterdam). Rederij Lovers will again exploit the boat to Shell Amsterdam, to transport employees to the office. An overview of the most important parties in the innovation process is provided in table 17.

Influential Parties	Translated	Activities concerning the Innovation
Brandweer Amsterdam	Fire Department Amsterdam	Influence concerning the security on board
Dienst Binnenwaterbeheer Amsterdam	Service inland water management Amsterdam	Influence concerning the exploitation of a fuel cell boat on the inland waters of Amsterdam
Germanischer Lloyd		Provides licensing concerning the safety aspects of the fuel cells on board
Havenbedrijf Amsterdam	Harbour firm Amsterdam	Influence concerning the navigation of the boat in the water
Scheepsvaart Inspectie van het Ministerie van Verkeer & Waterstaat	Shipping inspection of the ministry of traffic and water	Provides licensing concerning the actual authorization of the fuel cell boat
Lovers (Shell Amsterdam)		Future consumer, influences the process due to preferences

Table 17 Influential parties

Once this boat is finished it will function as the prototype. In the shipping industry prototypes are expensive and generally not made. FCBC is pleased about the boat until now, if all continues as planned the boat will reach the initial objective:

> *"So what has changed, not much the original idea will be realized. And that the necessary things are changed on the way, according to new technical insights, or whatever seems logical in such a process."* (Jeroen Jousma, November 25, 2008).

The end-consumer will receive a guarantee period of one year. According to the project manager, Jeroen Jousma:

> *"The after sales trajectory (guarantee period) for this boat will be a bit more than for a conventional boat with a diesel engine of which you know more. For this boat one has to anticipate whether everything will continue functioning as it should, but you do assume it will. But with a prototype you will never know for certain"* (November 25, 2008).

Until now no estimations are made about the potential demand for fuel cell boats. However Amsterdam is adjusting its policy and other cities are closely monitoring this process (e.g. Rotterdam, Paris, Venice). The future does seem bright, but until the policies are implemented the potential demand is uncertain. As mentioned the purchase price of the boat is higher and firms will not spend more money in case it is not necessary. More specifically Jeroen Jousma states that:

> *"Because the boat is so innovative, everybody is waiting to order a boat until the functioning has been proven. And everybody is waiting until the legislation is implemented"* (November 25, 2008). With everybody Jeroen Jousma refers to the potential consumers.

Another potential threat to the fuel cell boat is the development in Hamburg, where another firm is busy with a similar concept (for a fuel cell boat). Time will tell, which of the firms will survive and which prototype will be best. One may question why FCBC did not secure the innovation by applying for a patent. The reason for the latter is that, although the application of fuel cells in boats is a totally new, it is not sufficient to apply for a patent. The fuel cells are patented, but fuel cells in general have been applied in (hydrogen) cars and busses already and the application of fuel cells in boats is not innovative enough to apply for a patent.

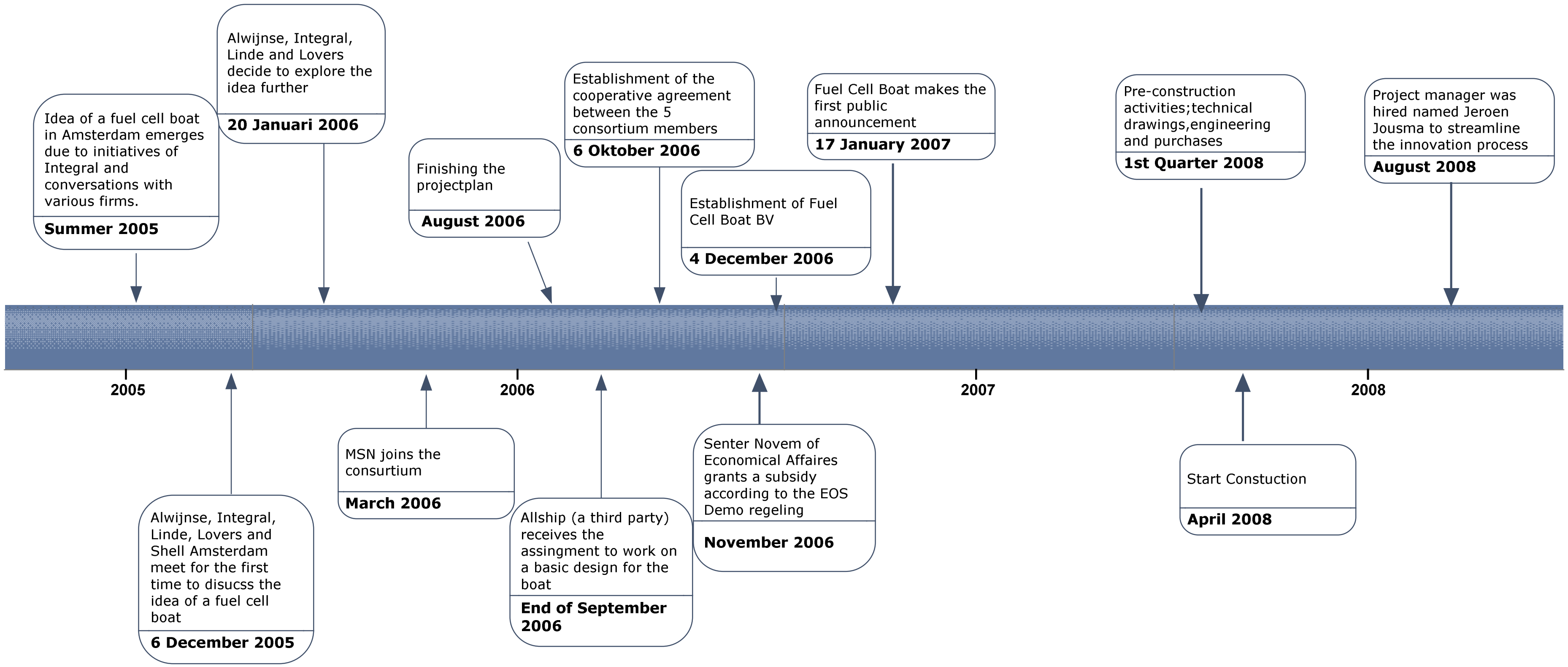

Figure 8 Timeline Discontinuous Innovation Process Bodewes

Anticipated Dates 2009	Activity
February – March	Start inspection Ministerie van Verkeer en Waterstaat. Boat in the water
April	Boat ready for exploitation. Delivery boat to Rederij Lovers

Table 18 Anticipated Dates 2009

4.3.1 Within Case Analysis – Scheepswerven Bodewes

This section will reflect on the case study and highlight the problems, challenges and mechanisms used to develop the Fuel Cell Boat per stage of the discontinuous innovation process.

The Search Stage

Scheepswerven Bodewes did not search for the innovative idea itself, instead the established SME was approached by FCB, a consortium not having the capabilities to develop the idea of a fuel cell boat itself.

The Select Stage

Scheepswerven Bodewes was excited by the idea imposed by FCB and decided to turn the idea into an innovation. The established SME was mainly convinced by the idea, due to future legislative changes concerning CO2 emissions. Another advantage, which made the decision to participate easier is that FCB was granted a subsidy already.

The Implement Stage

The implement stage is the largest stage and Scheepwerven Bodewes also experienced most of the problems and challenges in this stage. An overview of all the problems and challenges experienced is given in textbox 6.

Challenges and problems experienced by FCBC (Scheepswerven Bodewes) during the implement stage
- Fuel cells were larger than expected and would not fit into the boat provided the initial drawings. This required additional deliberations with authorities. - Not all parties of the consortium were used to arranging an innovative process and communication between the firms lacked. - FCBC was inexperienced in negotiating with large authorities. - The process was experienced as messy, several development aspects intertwined, requiring going back and forth. - No clear market estimations can be made, due to uncertainty about the exact date that the new legislation (CO2) will be implemented

Textbox 6 Challenges and problems experienced by FCBC during the implement stage

To battle the problems and challenges FCBC implemented several mechanisms, an overview of which is provided in table 19. Some of the mechanisms, such as outsourcing activities run over the various sub-stages of the implement stage.

Implement Stage	Mechanisms	
Research and Preparation Mechanisms	- A research group conducted tests and calculations to test feasibility of initial drawings - Subsidy provided by the consortium (FCB)	- Outsourcing activities (engineering) - FCBC was created, a joint venture consisting of three firms.
Development Mechanisms	- Project manager was hired to structure the process	
Commercialization (market launch)	- No specific mechanisms arranged yet	

Table 19 Mechanisms applied during the implement stage by FCBC

During the implement stage several challenges and problems were directly addressed, others were not. The challenges and problems that were directly addressed are presented in figure 9. One of the most influential decisions is the establishment of a joint venture named FCBC, due to the lack of capabilities of Scheepswerven Bodewes itself. The joint venture experienced quite some difficulties, such as communicating and deliberating with each other and authorities. From a more technological perspective FCBC was challenged with fitting the technology in the boat.

Figure 9 Overview of the problems and challenges, which were addressed during the implement stage by FCBC

Even though Scheepswerven Bodewes established a joint venture (FCBC), figure 9 indicates that it still had to rely on outsourcing, which was seen as a valuable mechanisms. To streamline the process, a project manager was hired, whose aim it was to improve and structure the process.

Within Case Conclusion Scheepswerven Bodewes

The discontinuous innovation process of the fuel cell boat took four years. Scheepswerven Bodewes received the innovative idea externally from FCB. The decision to select the innovative idea was influenced by the positive aspect that FCB arranged for a subsidy already. In the implement stage Scheepswerven Bodewes established a joint venture (FCBC), but also experienced most problems and challenges. FCBC did not implement stages or specific milestones for the discontinuous innovation process and was not used to managing such a project. As a result a project manager was hired to streamline the process, but this project manager emphasized it would have been better if FCBC had implemented a clear and structured process schedule with milestones and a decision maker to keep the project on track.

4.4 Case Report RF Production line – Machine Fabriek Sonder

This case study report will describe the innovation process as experienced by Machine Fabriek Sonder in the quest to develop a radiofrequency production line for sausages. The innovation process will be described in chronological order. The case study report is based on retrospective data retrieved from two interviews with Herbert Sonder, the owner and initiator of Machine Fabriek Sonder and Sonder Food Systems. As additional data documents were analysed, such as internal reports on the innovation process, subsidy request forms and printouts of e-mail correspondence.

Machine Fabriek Sonder is machine factory that develops, constructs and performs maintenance and extension work on production lines. The company is located in Hengelo and was established in 2000 by the owner Herbert Sonder.

The innovation process studied at Machine Fabriek Sonder is the development of a radiofrequency production line for sausages. The production line will enable quick homogenous heating of sausages (cooked sausages) by applying radiofrequency technology. The production line will enable homogenous sausage heating in only four to six minutes, compared to the current production process, which takes four to six hours. The current production process requires more resources, since the sausages have to be put in the skin of intestines, a procedure not required in the new production system. The innovation has been awarded the third place in the Bizz Innovation top 100. Table 20 provides an explanation for why the production line is a discontinuous innovation.

Selection Criteria for Discontinuous Innovations by Rice et al. (2002)	Criteria Present in the Discontinuous Innovation of Machine Fabriek Sonder
New to the world performance features (Fundamentally new product/service)	The production line is a fundamental new product. Radiofrequency has not been applied in production lines of this type before.
Five-to ten-fold (or greater) improvement in performance features.	The heating time will be reduced from 4 to 6 hours to 4 to 6 minutes.
30% to 50% (or greater) reduction in costs.	More sausages can be heated in less time. Less resources are needed, e.g. the skin of intestines.

Table 20 Discontinuous Characteristics of the sausages production line

Idea Emergence

In 2004 a fellow company of Machine Fabriek Sonder invited Herbert Sonder to join a meeting at Compaxo in order to provide technical support. Compaxo (fijne vleeswaren) is one of the largest meat producers in the Netherlands and is located in Gouda. During the visit Herbert Sonder talked to the director of Compaxo and realized that the production of sausages is a very extensive process. Herbert Sonder soon thought that the process could be improved, especially in terms of speed and he made a sketch of an altered production process.

> *"This is how the first step towards the innovation was made. I made a sketch on a piece of paper, which disappeared in the cupboard of the director at Compaxo. After half a year I was called and asked to visit Compaxo to talk about the sketch made on that piece of paper. This is how the process started to take off."* (Herbert Sonder, October 14, 2008)

Herbert Sonder mentioned that he always wanted to build his own machines, but the food sector is quite a side-step from what Machine Fabriek Sonder used to do and one may question how Herbert Sonder generated the idea of a production line for sausages. When being asked this question he answered;

> *"I think it has to with do the person. When walking somewhere I always tend to think about how things came into existence, how they were made and how they can be improved. It is a trait you ought to have."* (Herbert Sonder, October 14, 2008)

To receive feedback on the feasibility of the idea Herbert Sonder contacted a person at the University of Wageningen, whom he had spoken to about other projects in the past. This is how the process started to take off.

From Idea to Commercialization

This section will explain how the discontinuous innovation process was experienced by Machine Fabriek Sonder in chronological order. Figure 10 on page 68 presents the timeline of the innovation process. To structure the innovation process from idea to commercialization Machine Fabriek Sonder divided the innovation process into six stages. The University of Wageningen was of great influence on the structure of the innovation process, in that they suggested the framework. The discontinuous innovation process will be described by indicating the stages applied by Machine Fabriek Sonder. The related problems and challenges are intertwined in the explanation of the process.

Research and Preparation
Stage 1

In April 2005 the first stage of the discontinuous innovation process named proof of principle electromagnetic heating was started. As the name indicates this stage entailed the theoretical testing of radiofrequency technology. More specifically whether the application of radiofrequency technology in attainable in practice. Compaxo, the end-consumer has been involved from this point onwards, by providing feedback on the production of sausages and their preferences. The study was conducted by the University of Wageningen in assignment of Sonder. The results of the study were presented in a written report and the results were positive, thus the University of Wageningen concluded that RF technology will enable the heating of sausages. The positive results of the first stage and the enthusiastic responses from Compaxo provided the esteem to continue the innovation process. Consequently Sonder decided to solicit for a subsidy, but not in a ordinary fashion:

> *"I like short lines, being straightforward and I went to Den Haag myself. I went to the ministry with my plan and asked for a subsidy. My appearance did amaze them, but anyway, I did receive entrance due to my contacts at the University of Wageningen."* (Herbert Sonder, October 14, 2008)

At the time Sonder visited Den Haag SenterNovem was setting up a new subsidy policy, named Food and Nutrition Delta. The timing was right and Herbert Sonder was granted the subsidy.

The cooperation with the University of Wageningen was a central issue in this stage, yet it did not run untainted, which had to do with the contact person. The person had good technical knowledge, but lacked commercial and communication skills, which are essential in an innovation process as this (where multiple parties are active). In mutual agreement the person decided to depart from this specific project, the cooperation with the university of Wageningen remained, but now with another contact person.

Construction and Development

Stage 2

In the second stage theory was transformed into practice, by developing a small-scale pilot machine and by carrying out tests. This stage included the same actors, as in the previous stage, hence, Compaxo, the University of Wageningen and Machine Fabriek Sonder. This stage was successfully completed and the next step should have been the development of a large-scale pilot, but Herbert Sonder decided to skip this stage in order to save costs and time.

Stage 3

Stage three was concerned with the development and testing of a large-scale 0-serie production, instead of the originally planned large-scale pilot .The difference between a large-scale pilot and a large-scale 0-serie is that the latter is less abstract.

From this stage onwards the innovation process became more formalized both in terms of activities and organizational structure. Considering the activities a specification was made with all the ins and outs for the installation. The specification was used as a guideline throughout the innovation process.

To build a solid large scale 0-serie more diverse activities had to be performed for which third parties were included in the innovation process, as be depicted from table 21. Besides the input of Herbert Sonder himself, Machine Fabriek Sonder hired two employees with food knowledge to work on the innovation. The employees were put to work at a different location;

> *"The developments took place externally. We rented a building in Borne for a year, because I decided to keep the developments behind closed doors. So that not everybody would walk in and see what we were doing. Even the suppliers were not allowed in, until the innovation was protected."* (Herbert Sonder, October 14, 2008)

The activities really started to take off at this point in, accordingly Herbert Sonder decided to set up a new firm, named Sonder Food Systems. Herbert Sonder provided the following reason for setting up a separate firm:

> *"Sonder Food Systems is a small firm in which the innovation will be developed. The reason for setting up Sonder Food Systems is purely related to spreading the risk, in terms of this innovation. I had the feeling that the innovation would have large consequences in the future. If it will you will have to choose, either let the firm grow or let other parties exploit t."* (Herbert Sonder, October 14, 2008)

Third Parties	(Outsourced) Activities
Argotechnology and Food Innovations (A&F)	A&F is a departments of the institute for scientific research University Wageningen. A&F conducted research.
Top BV	Organization for technical development and engineering of pilots and 0-series in the food sector. Supported the named activities.
Sairem	Sonder Food Systems purchased the RF-generator and parts from Sairem.
GTI	Installation radiofrequency technology.
Stoomwezen	Mechanical testing of the steam parts.
Stevens IDE	Engineering development.
Compaxo	Is the end-consumer of the innovation, but was also actively involved in the innovation process, by providing feedback and meat for testing the production line.

Table 21 Third Parties Discontinuous Innovation Process Sonder Food Systems

The participating parties met once every two weeks to discuss the progress. The cooperation between GTI, Stevens IDE partners and the University of Wageningen went well, but the process was slowed down by Sairem, the supplier of RF components. Sairem did not deliver the components on time, which disturbed the planned development time. To decrease further supply delays, Herbert Sonder decided to visit Sairem in Lyon, Fance. He visited Siarem five times in four months and stated:

> *"In our eyes Sairem's priorities were wrong. The firm also develops other machine applications which demand a lot of work and provided them with 40% revenue growth in the year 2007. Accordingly other tasks were pushed aside for a while. And the good employees responsible for acquiring tasks from external firms left Sairem, thus everything turned out to be disorganized."* (Herbert Sonder, December 2, 2008)

The late delivery of components by Sairem resulted in a delay in the innovation process of half a year. When asked if Herbert Sonder ever experienced the urge to stop the innovation process, he immediately answered no, except for the time when there were problem with Sairem. Once the problems were overcome, due to the frequent visits, Herbert Sonder was motivated again to work on the innovation.

Stage 4

This stage is concerned with the further development and construction of the 0-serie. New knowledge about the innovation gained in the previous stage is incorporated in this stage, thus adjustments are made and new tests are done.

The current stage of the innovation process

Sonder Food Systems has almost completed stage four and is almost ready for transition to the next stage. To reach commercialization of the production line, two more stages have to be completed. Stage five, which is concerned with the production of the machine (production line) and stage six in which the machine will be (further produced and) sold. Herbert Sonder is already busy planning the transition to stage five and six, but he is concerned with the following:

> *"Currently the biggest problem is to launch the production line on the market, because the money provided by the subsidy has been used for the development of the innovation.We are now considering cooperating with external investors."* (Herbert Sonder, October 14, 2008)

Until now the innovation does not deviate a lot from the original idea, other than some technical specification. The largest development challenge was to develop the prototype according to the specification. More specifically to make sure that the sausages heat quickly and homogenously. There were some bottlenecks concerning homogenous heating of sausages with a large diameter, these took longer than anticipated, but were overcome.

To summarize one may argue that most changes were made concerning the technical development of the innovation.

> *"This technology has never been applied in a similar way. Everything is new, we started something, we calculated it, but in practice you need to redefine it, manage and adjust it."* (Herbert Sonder, December 2, 2008)

When Herbert Sonder was asked how he solved the problems, he gave a straightforward answer:

> *"Well, you have to solve the problems in a practical way, either by being creative or by gaining knowledge somewhere else."* (December 2, 2008)

The planned road to commercialization

As mentioned two more stages have to be completed to reach commercialization of the innovation. Stage five, which is concerned with the production of the machine (production line) and stage six in which the machine will be (further produced and) sold. Herbert Sonder estimates that the latter stages will take half a year, hence half a year before the innovation is present on the market. When launched on the market the innovation will be unique, an aspect appreciated by Herbert Sonder:

> *"The production line is unique on the market. You can obviously ask a different purchase price for this innovation compared to a pen, because there are various types of pens. And this is a unique product, one you treat very different compared to a multiple product."* (December 2, 2008)

All the IP rights of the innovation are owned by Sonder Food Systems, an aspect which Herbert Sonder arranged quite early in the process. At that time Herbert Sonder was confident that his idea would succeed, the others were not. He saw this as a great opportunity to reserve the rights and decided to become the owner and outsource activities which Machine Fabriek Sonder could not perform.

The innovation has been awarded the third place in the Bizz MKB Innovatie top 100. This achievement resulted in media attention from various sources, e.g. RTV Oost (a regional tv channel) and journals. The latter positively influenced Sonder Food Systems, as potential customers were triggered. A negative aspect however is that the process took longer than anticipated. During the interviews target dates were mentioned, which could not be achieved, due to among others, delayed supplies by Sairem.

The potential market in the Netherlands is 47 installation, in which Sonder Food Systems estimates to sell 5 machines, resulting in a revenue of 6 million. When considering the European Market, Sonder Food Systems estimates to sell 88 installations (which is approximately 9% of the total market), this would result in a revenue of 62 million. As can be distilled from the above figures, the market has great potential and has worldwide opportunities, e.g. China. One can also imagine that Sonder Food Systems, as an established SME may have difficulty investing the large amounts required to fulfill the potential demand. Therefore, as mentioned before, Herbert Sonder is considering cooperating with external investors, to enable commercialization abroad.

The market opportunities seem bright, but one should not neglect the potential threats specific for such an emergent market. The threats concerning the food market as mentioned by Herbert Sonder are:

- The food industry is quite conservative and maintains tight regulations. The regulations concerning new technologies are often unclear.
- The adjustments compared to the current technology may negatively influence the product image and results in retaining less consumers.
- We expect a higher product quality, but experience tells us that consumer have to get used to a different, yet better quality.
- There may be worries about the RF technology, in terms of health.

Sonder Food Systems will still have to be patient for the actual reactions of the consumers, but they emphasize that the introduction of the innovation on the market will be very important and will require care. This is certainly viewed as the next challenge. Failures are not allowed, it is really important that the consumers trust the technology applied in this machine. Most people still feel that applying RF technology for heating sausages is awkward, because the end-product is radiated food, an facet to which consumers look critically. To prepare for the market Sonder Food Systems outsourced market research to TDI, the last third party to join the discontinuous innovation process. Market research is currently in the last stages, but the main results are that Sonder Food Systems has to launch the innovation carefully and try to build trust.

In order to build trust Herbert Sonder made arrangements with Compaxo, where a prototype is located, which he is allowed to demonstrate the prototype to potential customers. Herbert Sonder is also planning to develop a small-scale prototype, which will fit in a kitchen. The aim of the above is to let the potential customers taste the sausages.

Even though the potential demand is large, the plan is to produce the machines at Sonder Food Systems (same location as Machine Fabriek Sonder). If demand increases quickly production will be outsourced and perhaps even partially outsourced abroad. The machine was intentionally constructed in such a way that components can be outsourced. Herbert Sonder has already established a ten year contract aboard for the delivery of components and a fifteen year contract with the end-consumer for the delivery of components.

Herbert Sonder is not planning to take on any new products in the coming years, rather his objective is to expand the application of RF technology to other food types. Which food types still remains a question, but research has been started.

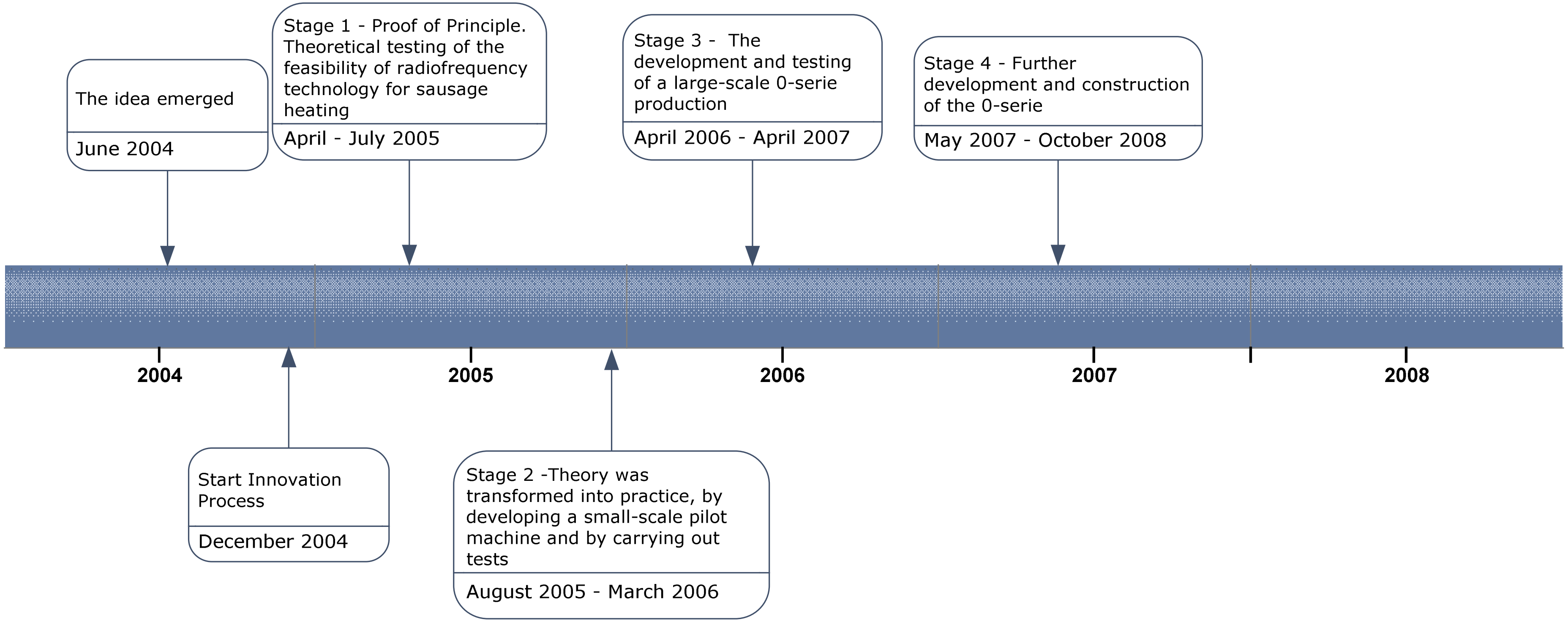

Figure 10 Timeline Discontinuous Innovation Process Sonder

Anticipated Dates 2009	Activity
June 2009	Stage 5 - Production of the innovation
June 2009	Stage 6 - Further production and market launch

Table 22 Anticipated Dates 2009

4.4.1 Within Case Analysis – Machine Fabriek Sonder

This section will reflect on the case study and highlight the problems, challenges and mechanisms used to develop the sausage production line per stage of the discontinuous innovation process.

The Search Stage

Herbert Sonder, the owner of Machine Fabriek Sonder, discovered the opportunity during a visit at a company in a different sector. The current process triggered his entrepreneurial instinct and he was convinced to improve it.

The Select Stage

Herbert Sonder made a sketch of his idea and sent this to the potential consumer. After waiting half a year he received positive feedback from the potential consumer, which stimulated his decision to develop the idea into an innovation.

The Implement Stage

Most of the problems and challenges occurred during the implement stage, which is the largest stage of the discontinuous innovation process. The problems and challenges experienced by Machine Fabriek Sonder during the implement stage are presented in textbox 7. The mechanisms applied during this stage are presented in table 23. As can be depicted from table 23 some of the mechanisms run over various sub-stages of the implement stage, such as the cooperation with the University of Wageningen and the end-consumer. The cooperation with the University of Wageningen greatly influenced the implement stage, in that the university applied a predefined structure for the development of the innovation, as a result the development of the innovation was divided into several stages with clear objectives and milestones.

Challenges and problems as experienced by Machine Fabriek Sonder during the implement stage

- Simultaneously managing daily business and the innovation process.
- Initial contact person from University left the innovation process, due to different views.
- Late delivery of components.
- Market launch requires care, no failures are allowed, this might harm the brand-name and new technology in general.
- Finding additional financial means to enable market launch.

Textbox 7 Challenges and problems as experienced by Machine Fabriek Sonder during the implement stage

<table>
<tr><th>Implement Stage</th><th colspan="2">Mechanisms</th></tr>
<tr><td>Research and Preparation Mechanisms</td><td>- Proof of principle; the feasibility of the idea was tested by consulting theory.</td><td rowspan="2">- Cooperation University of Wageningen and end-consumer.
- Prototyping and testing (consumer testing).
- Subsidy (Food and Nutrition Delta, SenterNovem)
- Outsourcing of activities, e.g. mechanical testing, engineering.</td></tr>
<tr><td>Development Mechanisms</td><td>- Development behind closed doors and at external location.
- Establishment new firm, named Sonder Food Systems.
- Frequent visits to supplier abroad.</td></tr>
<tr><td>Commercialization (market launch)</td><td>- Considering external investors to aid market launch.
- International Patent (PCT).
- Created the ability to outsource components of the innovation.</td><td></td></tr>
</table>

Table 23 Mechanisms applied during the implement stage

During the innovation process several challenges and problems were directly addressed, others were not. Simultaneously managing daily business and the innovation was experienced as a challenge, yet this challenge was not directly addressed, because Machine Fabriek Sonder did not have the manpower and financial resources to do so. The challenges and problems directly addressed are presented in figure 11 on page 71.

The discontinuous innovation process was enabled by a subsidy, yet this subsidy only covered the development of the innovation. For the market launch additional financial resources are needed, accordingly, the established SME is now considering external investors. The lack of capabilities was as can be depicted from figure 11 (on page 71) overcome by outsourcing activities. Machine Fabriek Sonder even went a step further in that it constructed a team from various parties it outsourced to, this team was multidisciplinary and met every two weeks.

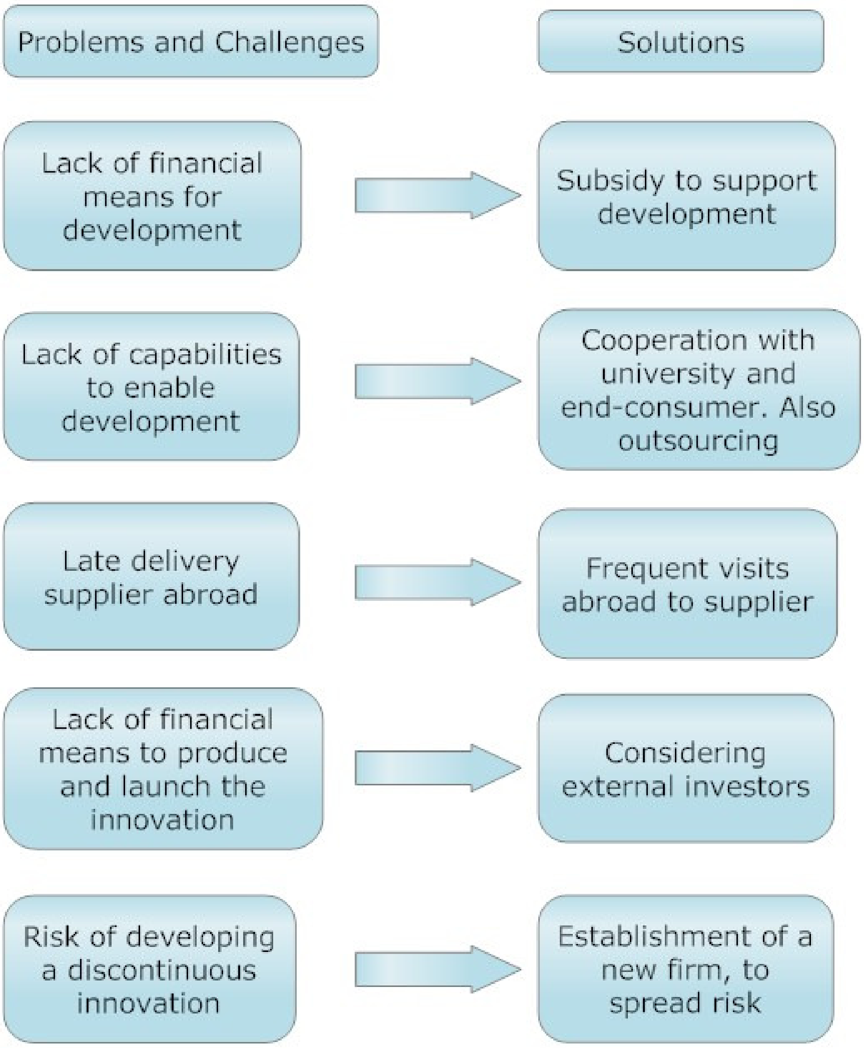

Figure 11 Overview of the challenges and problems which were addressed by Machine Fabriek Sonder during the implement stage

Within Case Conclusion Machine Fabriek Sonder

The discontinuous innovation process of Machine Fabriek Sonder took a total of five years, during which the established SME cooperated closely with the end-consumer and a university. The idea was generated by the owner's entrepreneurial skills and triggered by the current production process. The idea was only selected after positive feedback from the end-consumer, thus from that point onwards the end-consumer was involved in the process. The owner emphasized the importance of involving the end-consumer, as one can gain valuable knowledge about the desired end-product. The implement stage was is the longest stage and was structured into stages, due to the cooperation with the University of Wageningen. Machine Fabriek Sonder stated that the structure imposed by the university certainly had a positive influence on the process, because it created focus. Besides the university and the end-consumer the established SME also outsourced various other activities, but to achieve cooperation it constructed multidisciplinary team. By doing so, the owner recognized the importance of securing IP rights in the early start of the process, because the closer the team comes to solutions, the more interested the parties will become in the IP rights. Nevertheless, the largest challenge during the discontinuous innovation process remained managing innovative activities and daily business. More specifically the owner emphasized the difficulty of finding a balance to appropriately allocate the scarce resources (time, money, employees) between the two.

4.5 Case Report Hyperthermia Apparatus – Shemat and Mechatron

This case study report will describe the innovation process as experienced by Shemat and Mechatron[9] in their quest to develop an apparatus to fight breast cancer. The case study report is based on retrospective data retrieved from two interviews with the owner of Shemat, named Tom and one interview with the business unit manager of medical systems at Mechatron, named Ann. As additional, data documents were analysed, such as a business plan and meetings notes.

Shemat is specialized in sheet-metal work, machining and engineering. More specifically Shemat produces high quality modules, assemblies (machining parts) and finished products in small-series productions. Shemat is active in various market segments, such as aviation, aerospace, defence, medical systems and analysis systems among others. Shemat was established in 1978 and currently holds a workforce of 120 employees.

Shemat initiated the innovation process and Mechatron joined later as a partner. Mechatron is an engineering firm concentrated on the mechatronic market. Mechatron performs research and development to realize and produce mechatronic systems and products. Mechatron specifically generates high-end solutions for complex markets and supplies advanced systems upon request for leading OEMs (original equipment manufacturers). Mechatron exists over 25 years and currently employs 65 individuals.

The two firms investigated the opportunities of developing an apparatus to treat breast cancer by applying hyperthermia. Hyperthermia stands for excessively heating a human body, which under normal conditions is an undesired situation, e.g. a heat stroke. But, hyperthermia can also be applied to treat cancer. A part of the body can be (artificially) heated, which cause the cancer cells to shrivel.

The application of hyperthermia for cancer treatment purposes is still in the early stages of development. A few firms have tried to develop an appropriate apparatus to treat cancer, but the existing apparatuses have many negative side effects and are not fully accepted. The current treatment procedure requires a catheter to be implemented in the patient's body, in order to measure the heat inserted into the body. The apparatus itself is quite underdeveloped and requires the treatment rooms to be secured to prevent harmful radiation. Shemat and Mechatron were convinced to develop an apparatus, which would not have the above mentioned negative side effects and be more cost effective. The apparatus that the established SMEs had in mind would certainly be a discontinuous innovation, as can be depicted from table 24.

[9] For confidentiality reasons the names of the firms and individuals have been disguised.

Selection Criteria for Discontinuous Innovations by Rice et al. (2002)	Criteria Present in the Discontinuous Innovation of Shemat and Mechatron
New to the world performance features (Fundamentally new product/service)	There is no hyperthermia apparatus, which can be used without placing a catheter in the patient's body.
Five-to ten-fold (or greater) improvement in performance features.	As the above, the patient would not need an additional operation for the placement of a catheter.
30% to 50% (or greater) reduction in costs.	The current apparatus requires medical staff to be present during the treatment. The innovation would have apparatus that would communicate to a device, not requiring medical staff to be present during the entire treatment procedure. The innovation would make additional protection against radiation in the treatment-room abundant.

Table 24 Discontinuous characteristics of the Hyperthermia Apparatus.

Idea Emergence

In January 2006 Shemat was approached by Bill with the idea to develop a hyperthermia apparatus for the treatment of cancer. Bill had prior experience in the hyperthermia industry and knew that the existing apparatuses were of insufficient quality, resulting in the treatment not being generally accepted by e.g. insurance firms and several hospitals. Bill introduced the idea to improve an existing old-fashioned hyperthermia apparatus to treat deep tissue cancer tumours to the owner of Shemat.

Tom was initially not convinced by the idea of simply improving the existing apparatus, due to the great number of disadvantages and the fact that the functioning of the existing apparatus was not theoretically proven. Nevertheless Tom was attracted to the idea to develop an apparatus for this market and sent the general director abroad to investigate the potential opportunities.

By conducting market research Tom soon discovered that the Yellowstone clinic, which is closely allied to the Western University, is one of the leading clinics in oncology. Contact was established and it turned out that the Yellowstone clinic constructed a preliminary prototype in cooperation with the Western University. The prototype at the Yellowstone clinic is meant to treat cancer tumours just below the skin.

From Idea to Commercialization

This section will explain how the discontinuous innovation process was experienced by Shemat and Mechatron in chronological order. The related problems and challenges are intertwined in the explanation of the process. Shemat and Mechatron did not apply a stage framework. Figure 12 on page 77 represents a timeline of the discontinuous innovation process.

Research and Preparation

The prototype at the Yellowstone clinic proved its functioning, but it was in the infantile stages of development. The prototype was a construction of lose wires and stands placed throughout the treatment room. Nevertheless, due to the good reputation of the clinic and the responsible professor, Tom decided to further research the opportunities concerning this prototype in cooperation with the clinic. The idea brought forward by Bill was pushed aside by Tom, but Bill stayed at Shemat, due to his experience and knowledge about the market.

Shemat's aim was to develop a hyperthermia apparatus, which would not require a catheter to be implemented in the body (to measure the heat), instead software had to be developed. The new apparatus should not release radiation and be smaller, thus it should be designed as to fit on a pushcart. To reduce costs, the apparatus should electronically communicate to a device on which doctors can see the progress of the treatment. The latter would not require medical staff the be present during the entire treatment procedure. To develop such an innovative apparatus Shemat required additional capabilities. Shemat is specialized in sheet-metal work, machining and engineering, which is not sufficient to develop the desired apparatus.

Before Bill approached Shemat in 2006, he tried to convince Mechatron of his hypothermia idea. Mechatron did not accept the cooperative proposal and rejected the initial idea, due to similar reasons as mentioned by Shemat (e.g. the functioning of the apparatus was not theoretically proven, thus there was no proof of the effectiveness).

Mechatron is specialised in the more high-end mechatronic engineering and was regarded as a valuable partner in the development process. Shemat therefore approached Mechatron with the new idea in December 2007 and asked for cooperation. Mechatron accepted the proposal, due to the new idea, which seemed more viable. The cooperation with the Yellowstone clinic also influenced the decision to cooperate, since the clinic has an outstanding reputation. As a result the firms decided to continue the development process together. Mechatron sent an mechatronic-system engineer to the Yellowstone clinic to analyze the prototype.

With Mechatron onboard substantial subsidy knowledge was gained. The firms solicited for a subsidy which compensates for outsourcing market research. The subsidy was granted and a business case was written by an external consultant.

The business case was written, because both firms realized that this project would be quite a challenge, requiring large investments, time and market knowledge.

> *"It is a very large project, the technical aspects are feasible, but the project has a very high cost price. But questions concerning the market are also difficult, how should it be launched on the market? Each market has its own insurance system and that is very difficult to grasp. And one should not forget the required product certification procedures. Due to all the concerns, we wanted to wait for the results of the business case, before continuing and deciding go or no go."* (Ann, December 9, 2008)

Besides the granted subsidy, the firms wanted to solicit for an additional subsidy, which is a regional subsidy aiming to enhance the regional economy. Per year the subsidy has two calls, the last one was in November 2008 and was missed by the firms. When still interested, the firms can try to apply for the next call, but this would obviously extend the process.

The business case written by the consultant was presented in September 2008, but Shemat and Mechatron were not satisfied with the results. The business case was too abstract and theoretical, lacking concrete advice. A reason for the poor quality of the business case might be related to the consultant, who did not have specific medical knowledge. This knowledge is required to answer questions about the medical market, in terms of insurances systems, required certifications and product acceptation.

After the presentation of the business case Bill decided to leave the firms and not continue the development. Bill had been employed by Shemat, but felt he could not relate to the innovation anymore. All parties mutually decided it would be best that he left, due to colliding visions about the market and the apparatus.

Shemat and Mechatron were disappointed by the business case and lost time both due to the extended time taken by the consultant, but also due to their own busy agendas. As mentioned two individuals at Shemat were engaged in this process. At Mechatron, the owner was engaged and the business units manager for medical systems. As can be imagined the individuals had to simultaneously maintain their daily business, which was often prioritized and had to continue development on the innovation. Consequently the process took longer than anticipated, which according to the firms would not have occurred if they had assigned a full-time manager to the process.

When the results of the business case turned out to be negative, the firms were doubting whether to continue.

> "After the presentation we thought that our goal was unattainable. But we put so much time and energy in this project that it was worth continuing." (Tom, November 27, 2008)

Before making a definite decision, the firms decided to visit two firms as requested of the Yellowstone clinic. The two firms were said to be developing technology necessary for the development of the innovation.

Shemat and Mechatron visited the two foreign firms in November 2008. The first firm combines theoretical modelling and experimental testing in the field of radiation. The firm claimed that it developed software to measure the temperature of specific body part being treated with hyperthermia. Upon arrival Shemat and Mechatron made a disappointing discovery, the firm had not fully developed this technology yet. The technology was in the pre-mature stages of development, taking another two or three years before it can be applied.

During the visit the spokesperson of the firm stated that the current systems are low tech and old-fashioned. He stated that oncologists demand high-tech systems, but the acceptation process on the market would be a problem. However the spokesperson did seem interested in the market, but provided the large investment risk as one of the reasons why he would prefer cooperating with other firms. Shemat and Mechatron were understandably quite disappointed by the statements about the market.

The next day the firms visited the second firm, this firm developed an apparatus to aid physiotherapy (sports injuries) by applying (external) hyperthermia. Shemat and Mechatron were curious why the sole focus of the firm is on the physiotherapy market. If the firm would further develop the existing apparatus and wait for the software to be developed, they could enter also the oncology market.

The second firm stated that it does not want to enter the oncology market due to concerns about the difficulty of the market. The firm stated that regular hospitals are not ready to adjust to such a relative new technology. Furthermore many prior systems were underdeveloped and did not function properly, which damaged the treatment image. To conclude the firm stated that the market is too small for large OEMs, but too large for small SMEs, due to the long time to market and the high development costs. Since the firm itself was sure it did not want to enter the market, it would agree to supply (hardware) parts, e.g. generators.

The current stage of the innovation process

To summarize one may state that the visits were not stimulating Shemat and Mechatron to continue. Nevertheless, as Tom stated:

> *"We put a lot of time and money in this project. I think that we invested 100.000,- euro's, not to forget about the business and travelling time."* (Tom, November 27, 2008)

A very disappointing aspect was that the first visited firm gave the impression that they had the software ready for use, but in reality the software was only in the pre-mature stages of development. The time required to fully develop the software is still uncertain and this would further extend the innovation process and related financing. An expect not desired:

> *"The process already takes very long. We, as entrepreneurs want to reach our target faster. We want to build the apparatuses, sell them and make a profit. But this process takes longer, one of the reasons being that it involves more diverse parties."* (Tom, October 16, 2008)

The fact that more parties were involved in the process, was not solely regarded as a negative experience. The cooperation between the two established SMEs, Shemat and Mechatron was experienced as positive. The established SMEs were also reliant on the Western University and the Yellowstone clinic. The cooperation went well, but differences were experienced concerning the organizational structure and decision making power.

> *"The decision makers of Shemat and Mechatron were present during discussions. When necessary these persons could be asked for their decisions. Nevertheless, at the Western University the responsible individual was not allowed to make decision. He had to adhere to his management. Accordingly it was really difficult to discuss issues with each other and make decisions."* (Ann, December 9, 2008)

Shemat and Mechatron were at a point, where they needed to decide whether they wanted to continue or stop the innovation process. They gained more information, yet this did not positively influence the firms. Besides uncertainty about the development time, doubts have arisen about the market size and the acceptance process, since the apparatus would be of discontinuous nature. In December 2008, after the visit abroad the established SMEs exposed their negative feelings about continuing.

> *"I think we will stop, the idea grabbed us and we investigated the opportunities. We researched in all the possible areas to picture the market and the innovation, but we also have other concerns; Our core business, which demands a lot of attention."* (Tom, November 27, 2008)

The established SMEs decided to meet again in December to discuss the knowledge gained at the visit abroad. The conclusion of that meeting was that the established SMEs rather stop, there are too many uncertainties requiring too much investments, both in time and financial terms. The established SMEs rather focus on their core business again, which is less uncertain.

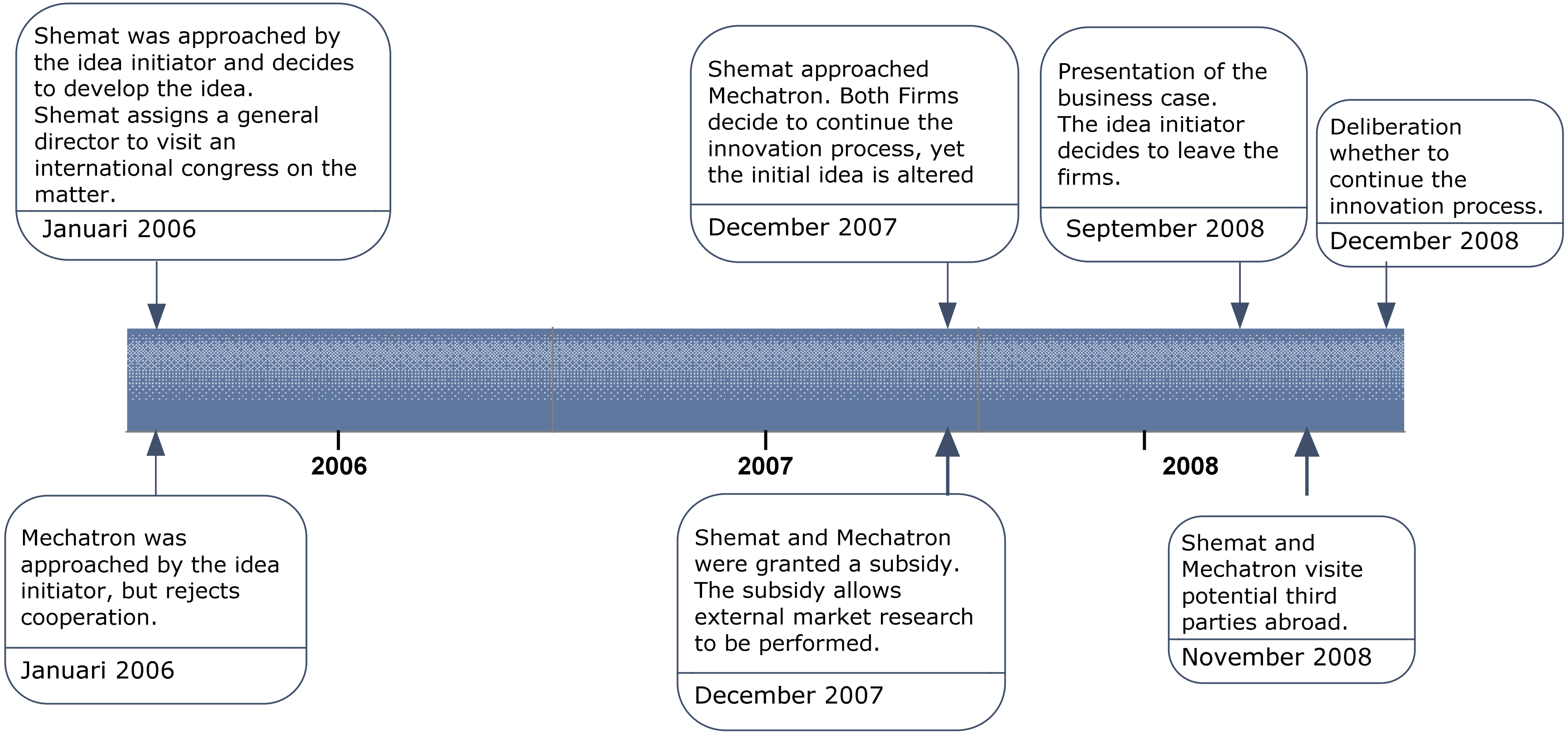

Figure 12 Timeline Discontinuous Innovation Process Shemat and Mechatron

4.5.1 Within Case Analysis – Shemat and Mechatron

This section will reflect on the case study and highlight the problems, challenges and mechanisms used to start to discontinuous innovation process on the hyperthermia apparatus.

The Search Stage

Shemat did not deliberately search for innovative ideas, but was approached by an individual, who had prior working experience in the healthcare market. This individual lacked both, the capabilities and financial resources to develop the idea himself.

The Select Stage

Shemat decided to select this idea, because the firm was attracted to the idea of improving the existing treatment procedure against cancer. Mechatron joined later and was convinced due to the cooperation with a well-known clinic and university.

The Implement Stage

Shemat and Mechtron did not reach actual development of the innovation, but both of the established SMEs experienced the research and preparation stage. Even though the established SMEs did not develop the innovation, several challenges and problems were experienced during the search and preparation period, as is indicated in textbox 8. One of the major challenges was simultaneously managing daily business and the innovation process, which made it difficult to set meetings. The market Shemat was interested in is a difficult market to understand and requires careful market entry.

Challenges and Problems experienced by Shemat (and Mechatron) during the implement stage

- Simultaneously managing daily business and the innovation process. Difficult to set meetings.
- Difference in decision making power at the own established SMEs compared to the Clinic (took longer, more bureaucracy).
- Idea initiator left the innovation process, due to different views.
- Difficult and specialised market. Technology name has been harmed, due to prior malfunctioning innovations.

Textbox 8 Challenges and problems experienced by Shemat (and Mechatron) during the implement stage

To receive more information on the market, several mechanisms were used, as indicated in table 25. Most of the mechanisms were viewed as go/no go decision tools, e.g. the business case and the visit abroad. With the knowledge gained at the visit abroad, the established SMEs met again decided not to continue the innovation process.

Implement stage	Mechanisms
Research and Preparation	- Cooperation with university and clinic. - Subsidy (to finance an external consultant for research purposes) - Business case written by an external consultant. - Visit potential partners abroad to investigate market and innovation potential

Table 25 Mechanisms applied during the implement stage by Shemat (and Mechatron)

During the innovation process several challenges and problems were directly addressed, others were not. The challenge of managing daily business and paying attention to the innovative idea was not addressed by implementing mechanisms. The challenges and problems that were directly addressed are presented underneath in figure 13.

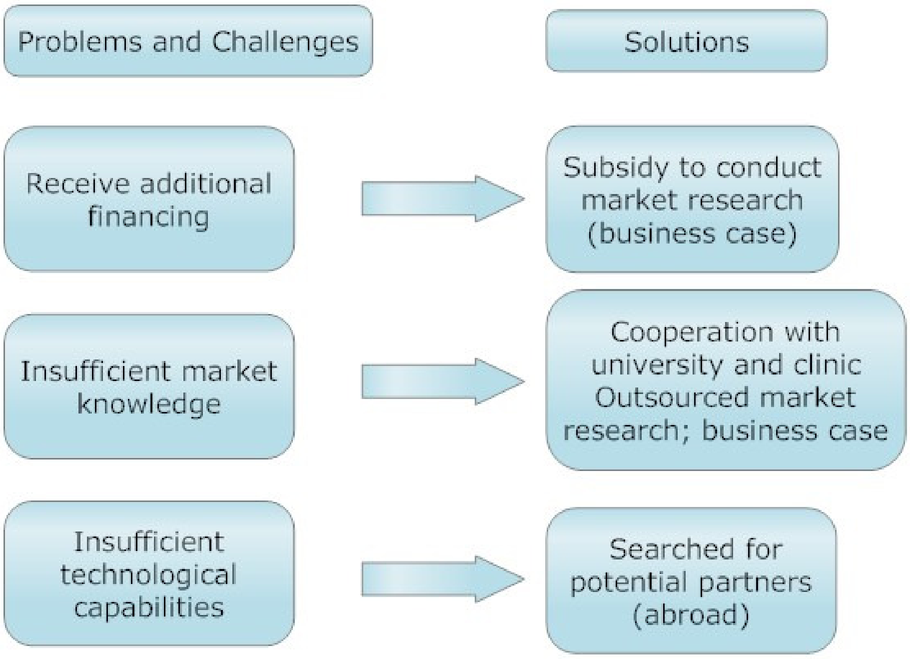

Figure 13 Overview of the problems and challenges which were address with mechanisms during the implement stage by Shemat (and Mechatron)

A fundamental challenge was receiving funding to start the implement stage. Although Shemat did not develop the innovation, it did receive a subsidy to outsource a business case. To gain further information about the market and the required technology, the established SMEs (Shemat and Mechtron) cooperated with a university and a clinic and tried to approach potential partners. The contact with potential partners and the great number of uncertainties influenced the decision of the established SMEs to discard the idea.

Within Case Conclusion - Shemat

Shemat spent almost three years investigating the opportunities to develop hyperthermia apparatus, but decided to discard the idea. Shemat was approached by an individual with an idea. The initial idea was altered a bit and selected, due to the perceived importance of developing an apparatus for cancer treatment. Mechatron joined the established SMEs, and they started to implement stage. During the implement stage the challenges and problems were viewed as to complex and the idea was discarded. The established SMEs emphasize the importance of performing sufficient market research in the early stages, an aspect not performed sufficiently by them. Furthermore they would hire a full-time manager to battle the challenge of simultaneously managing daily business and the innovative process, hence to increase the speed of the discontinuous innovation process. Besides the latter networking is viewed as important, as it may provide access to new bundles of knowledge.

5 Discussion

This chapter will discuss the theoretical and the empirical findings. The discussion on the problems, challenges and mechanisms will be structured in sections according to the discontinuous innovation process as structured by DILab, thus search, select and implement. The implement section will have subsections dedicated to frequently experienced problems and challenges by the established SMEs.

5.1 The Search Stage

The main objective of the search stage is to find an idea for a potential innovation, or even a set of potential innovations. The search stage will be discussed according to the search triggers and the mechanisms implemented by the established SMEs. Table 26 indicates the search triggers and the mechanisms used by the established SMEs during the search stage.

Search Stage	Ambroise	Doorgeest Koeltechniek	Machine Fabriek Sonder	Scheepswerven Bodewes	Shemat
Search Triggers	Value chain; problem owner	Potential legislative changes	Concern about current sausage production process	Idea externally supplied by a consortium of firms. Potential legislative changes	Idea externally supplied by an individual
Internal Mechanisms	Before-the-box thinking, Entre-preneuring, probe and learn	Entre-preneuring	Entre-preneuring	None, continued with the provided idea	Continued with the provided idea, but altered it a bit
External Mechanisms	None	None	None	None	Networking, to gain knowledge through which the initial idea was altered

Table 26 The search stage by the established SMEs

5.1.1 Search Triggers

Discontinuous innovations can be triggered by various sources, such as the emergence of new markets, new technology, new political rules, deregulation and a shift in regulatory regime(Bessant & Tidd, 2007). Table 26 illustrates the sources, which triggered the established SMEs. As can be depicted some of the established SMEs used external ideas, others generated their own ideas, which were triggered by the owners' market and technological knowledge. In comparison to established SMEs one should keep in mind that start-ups usually do not experience the search stage but come into existence due to an idea, hence they are founded based on the idea. Similarly, a firm may be started (spin off) as a means of technology transfer from a parent organization (Steffensen, 2000).

To find innovative ideas Bessant and Tidd (2007) argue that established firms need to search and scan their external and internal environment to pick up signals about potential innovations. In existing firms idea generators should be taken out of the standard routines to search for discontinuous ideas and connected to *"new pockets of knowledge"* (Leifer et al., 2000, p. 34). Organizational mechanisms can stimulate the latter. DILab performed research on the mechanisms applied to search for discontinuous ideas and found twelve search mechanisms, some of these mechanisms have an internal nature, in that they try to stimulate search activities using internal resources. The external mechanisms may rely on the internal resources, but simultaneously take the firm's external environment into account, hence external sources of knowledge. The mechanisms applied by the established SMEs will be discussed in the next two sections.

5.1.2 Internal Mechanisms

As stated, internal mechanisms try to stimulate search activities using internal resources. One of the internal mechanisms put forward by DILab is corporate entrepreneuring and intrapreneuring. This mechanism can be implemented or simulated by large firms to enhance search activities and creativity, instead entrepreneuring seems to be a given in the established SMEs. In all the established SMEs the owners either generated the innovative idea or initiated an externally provided idea. The results indicate that the triggers influenced the owners' entrepreneurial ability to make a link between the pool of invention and the market (Schumpeter in Debackere, 1997). Accordingly it seems that the owners have an entrepreneurial mindset and have the ability to 'think outside-the-box'. The owner of Machine Fabriek Sonder is certainly an out-of-the-box thinker, as he pursued a discontinuous idea not directly allied to his core business. Scheepswerven Bodewes is an exception, as the idea was provided externally and not adjusted. As entrepreneuring is a given for the established SMEs it resembles their advantage, compared to large established firms.

Probe and learn is a mechanism put forward by DILab. This mechanism refers to prototyping quickly rather than spending a lot of time on planning (Bessant & Stamm von, 2007). Ambroise is the only established SME that applied probe and learn in the search stage. The established SME applied this mechanism to develop extremely pre-mature prototypes. This mechanism has not been applied by the other established SMEs and the most logical reasoning relates to the degree of technical advancement of the other innovations and the related costs of developing prototypes. Probe and learn may therefore be a useful mechanism for established SMEs searching for less technologically advanced innovations.

The results indicate that only two of the internal mechanisms put forward by DILab were applied by the established SMEs, nevertheless the results depict a new mechanism named before-the-box thinking. Ambroise applied before-the-box thinking to find an innovative idea to solve the problem it was approached with. Ambroise refers to the brainstorming process as before-the-box-thinking, in which they do not take existing solutions into account. The owner argues that 'the box' entails the solutions and that knowing existing solutions may disturb the creativity level. The owner also stressed the importance of not including external partners in the brainstorming sessions, as they may impede the creative process. This mechanism has not been referred to in literature, but a closely allied mechanism, named out-of-the-box thinking is frequently discussed. The concept of out-of-the-box thinking was among others put forward by Leifer et al. (2000, p. 33), the concept refers to individuals with *"deep technical knowledge and who think outside the constraints of the firm's current business."* Before- and out-of-the-box thinking are two diverse concepts, because they take place at different dimensions. Before-the-box thinking entails not taking into account solutions, whereas out-of-the box refers to the ability to think beyond the firm's boundaries. One may argue that a combination of the latter two concepts allows for greater creativity levels, hence it increases the probability of finding truly discontinuous ideas.

5.1.3 External Mechanisms

External mechanisms may rely on internal resources, but simultaneously take the firm's external environment into account, hence external sources of knowledge. DILab proposed several external mechanisms, such as sending out scouts, networking, mobilising the mainstream and deep diving. Table 26 illustrates that only one established SME applied an external mechanisms, namely Shemat. Shemat was approached with a given idea, but decided to further investigate the viability of the idea and consulted the external market by networking. The reason for applying an external mechanism, relates to the lack of market and technological knowledge of the established SME to link the possible 'pool of inventions' to the market. One may argue that established SMEs wanting to innovate, but with insufficient specific knowledge, will be more likely to apply external mechanisms.

5.1.4 Conclusion Search Discussion

Large established firms frequently organize innovative activities and focus on their existing consumer base, which often results in incremental innovations. In comparison the search stage for established SMEs seems to be a natural and unplanned process. It seems as if the established SMEs did not intentionally scan their environment for discontinuous ideas, hence they did not specifically create momentum for search, but ran into the ideas or were approached with the ideas. The search triggers influenced the owners entrepreneurial ability and allowed them to make a link between the pool of invention and the market. The entrepreneurial mindset of the established SMEs seems to be one of most the important mechanisms enabling established SMEs to create truly discontinuous ideas and above all it seems to be a give not requiring additional implementation nor financial funds.

Some of the innovative ideas emerged out of market pull, such as the ideas of Ambroise and Scheepswerven Bodewes. Others have a technology push nature, such as the ideas of Doorgeest Koeltechniek and Machine Fabriek Sonder. Ideas emerging out of market pull are generally said to be less discontinuous, as they stem from the demand of the consumers. Nevertheless, the established SMEs were still able to develop truly discontinuous ideas, but did apply specific mechanisms to enable a creative process. Ambroise, for example did not include other parties in the search process and applied before-the-box thinking, which entailed brainstorming and without taking existing solutions into account to enhance the creativity level. This allowed the established SME, although experiencing market pull to develop a discontinuous innovation. Innovations with a technology push character will generally be more difficult to launch on the market, or at least take more effort, this stage will be discussed further later in this chapter.

5.2 The Selection Stage

Firms cannot develop every idea that they have, they are bound to resource restrictions and the challenge lies in selecting ideas that offer the most potential and the best competitive edge (Bessant & Tidd, 2007). In the DILab model selection occurs specifically after the search for ideas, but the results indicate that the established SMEs do not have one selection point in their innovation process, instead they implement several selection mechanisms during the course of the process.

The findings show that selection takes place throughout the innovation process, hence the established SMEs continuously invest money to search for answers about the technical feasibility, market potential and financial viability of the innovation. More specifically, the established SMEs applied mechanisms throughout the innovation process to receive answers on the viability of the innovation, these answers may either influence the SMEs' decision to continue or discard the idea. This phenomenon strongly relates to what Veryzer (1998) refers to as the fuzzy nature of discontinuous innovations, which creates an emergent selection environment. As a result one may conclude that the selection stage as depicted in the DILab model can be referred to as an initial selection stage, even if an idea survives this stage, it does not mean that the idea will be fully developed.

Table 27 presents the selection mechanisms applied by the established SMEs and as can be depicted a distinct difference is made between initial and further selection mechanisms. The initial selection mechanisms by the established SMEs do not require any capital investments, besides the entrepreneurs' own time. The so-named further selection mechanisms are those applied by the established SMEs in the course of the discontinuous innovation process to receive more feedback on the viability of the idea. These mechanisms generally do require more capital investments, because the established SMEs outsource several activities, such as feasibility tests. The initial and further selection mechanisms will be discussed further in the next two sections.

	Ambroise	Doorgeest Koeltechniek	Machine Fabriek Sonder	Scheepswerven Bodewes	Shemat
Initial Selection Mechanisms	Subjective judgment	Subjective judgment	Positive feedback from potential end-consumer, subjective judgment	FCB had accepted and subsidy was arranged	Subjective judgment
Further Selection Mechanisms (during the implementa-tion stage)	Literature research	Feasibility tests	Proof of principle (theoretical feasibility)	Research group conducted feasibility of drawings	Business case and visits abroad to potential partners

Table 27 Selection Mechanisms

5.2.1 Initial Selection Mechanisms

During the initial selection the established SMEs perform initial screening to decide whether resources will be allocated to the idea. The established SMEs in this study, generally based the initial selection decision on their entrepreneurial skills and their intuition.

Cooper et al. (2001) provide selection mechanisms, which can be of financial (NPV or ROI calculations) or non-financial nature (scoring models, business case, intuition experience). The non-financial mechanisms are mostly based on subjective judgments. The results revealed that none of the established SMEs used financial mechanisms, instead all the established SMEs applied mechanisms based on subjective judgements for the initial selection of the idea. The choice of selection mechanisms is obviously influenced by the owners of the established SMEs, who managed the discontinuous innovation process. One of the most influential characteristics emphasized by the owners is their experience and intuition on which many decisions are based, thus the owners' entrepreneurial skills. There are no clear reasons why the established SMEs did not apply financial mechanisms, such as financial calculations (NPV, ROI, payback period), nor why some of the non-financial mechanisms were not applied, such as checklists or scoring models were not used. The most evident rationale seems to be that the owners did not recognize the importance of applying financial mechanisms when being able to rely on their own subjective judgement. A further reason may relate to the difficulty of applying financial mechanisms given the numerous uncertainties and the time frame.

The fact that the established SMEs did not use financial mechanisms may indicate their strength. If they would have applied these mechanisms, they might not have opted for developing a discontinuous innovation. This is along the lines of Roussel et al. (1991), who argue that using financial mechanisms is meaningless and possibly harmful when applied to innovation processes reaching beyond a year or two. Similarly, Cooper et al. (2001) found that financial mechanisms are often the most popular, but they yield the worst results, accordingly top performing firms generally rely on non-financial mechanisms. The owners of the established SMEs relied on their intuition, market and technical knowledge to judge the viability of the idea. The entrepreneurial behaviour can therefore be recognized as a powerful tool in discontinuous innovation process, as it entails the courage and motivation required to make uncertain decisions and select discontinuous innovations. Courage and motivation are certainly vital facets, even more so when keeping in mind that discontinuous innovation often do not make sense during the first investment years, as argued by Christensen (1997).

5.2.2 Further Selection Mechanisms

The further selection mechanisms were implemented to receive further information on the feasibility of the planned discontinuous innovation, either in terms of the technology or business viability. Generally firms may fail to recognize value, due to a lack of capabilities to act upon innovative ideas, such as a lack of strategic insight. O'Reilly and Tushman (2008) argue that firms may in such a case acknowledge the opportunity, but are not able to act upon the opportunity in a timely matter. Some of the established SMEs did not have sufficient internal knowledge to judge e.g. the technical feasibility or the business viability of the planned discontinuous innovation. The established SMEs could wait to see how the technology evolves on the market, but would in such a case risk losing the competitive advantage and opportunity. The established SMEs on the other hand, acknowledged the need to outsource the further selection mechanisms to retrieve more information on the feasibility of the discontinuous innovation. The selection mechanisms were not specifically focused on financial aspects, but more on the make-ability and technological feasibility of the planned discontinuous innovation.

The reasons provided by Shemat (and Mechatron) to discard the idea resemble the general barriers to discontinuous innovations. The barriers provided relate to high technological uncertainty, long development time, the difficulty of the healthcare market, in terms of legislations and market launch. The large number of barriers require the established SMEs to take risk, place multiple parallel bets and have tolerance for failure, as explained by Veryzer (1998). Shemat did not want to take these risks and stated that it did not have the patience to deal with the technological uncertainty and the long development time. Instead Shemat preferred to capitalize on investments already made in the core business. This relates to the factors found by Charitou and Markides (2003) concerning how established firms respond to discontinuous innovation. In their findings the most influential factor is that firms prefer to remain focused on their core business and the second refers to the fact that firms prefer to capitalize on investment made in their existing business. These factors by Charitou and Markides (2003) only apply to Shemat, the other established SMEs all dared to take the journey of developing a discontinuous innovation given the accompanied risks. An interesting difference between Shemat and the other established SMEs is that Shemat employs 120 individuals, whereas the other established SMEs employ less than 30 individuals. This may have influenced Shemat's decision to stop the discontinuous innovation process, but to specify to what extent size influenced the decision would require additional research.

5.2.3 Conclusion Selection Discussion

In the established SMEs, the decision-maker is the owner himself, therefore not every decision needs to be backed up by careful research and analysis, which provides the established SMEs with a greater ability to embrace and initiate the discontinuous idea than large firms (Christensen & Overdorf, 2000). The influence of size and organizational structure on the selection of discontinuous innovations can be recognized, in that large organizations are generally bound by decision making procedures and more hampered by organizational inertia and hierarchy (Lefebvre & Lefebvre, 1992). In comparison, start-ups are argued to be more responsive to discontinuous innovations, because their values embrace small markets and their managers proceed intuitively, meaning that not every decision needs to be backed up by research and analysis (Christensen & Overdorf, 2000). Nevertheless, one must keep in mind that start-ups, specifically spin-offs usually emerge from an organized effort by the parent organization or by employees leaving the parent organization (Steffensen, 2000), meaning that these entities emerge from an idea that is in fact selected prior to the establishment of the firm. Instead, established SMEs exist already and need to decide whether to continue with the discontinuous idea or not. The results have indicated that the established SMEs proceed intuitively and that they structure their own decision making procedure. Established SMEs decide how to continue further upon receipt of new information, this process seems to resemble an informal stage gate process. The established SMEs seem to have experienced, as argued by Veryzer (1998) that the development of discontinuous innovations does not proceed in a conventional, stage-gate-like manner and it does not seem amenable to be managed according to such processes. The results indicate as argued by Debackere (1997) that the number of stages in the process may be arbitrary, but each stage should involve the search for answers to different managerial imperatives and require clear decision points and stage-reviews. The informal stage gate process experienced by the established SMEs, is informal, because the established SMEs did not plan all the stages beforehand and one can refer to the process as stage gate, because the process entails various go and no go decision points. The level of uncertainty seems to create the need of the owners to implement various selection mechanisms during the course of the innovation process, thus to provide answers and decrease the uncertainty. Veryzer (1998) has previously argued that the discontinuous innovation process does not proceed in a manner that can be described by stage-gate systems, hence his argument is in line with the findings of this study. Not all the established SMEs[10] were particularly experienced with such a large innovation process or did not experience the need to implement a stage gate system due to the limited number of people involved in the process, this may have influenced the fact that the established SMEs did not apply a pre-defined stage-gate system. The statement of Tienne and Koberg (2002, p. 361) *"making it up as you go along"* is indeed to some extent applicable to the process as experienced by the established SMEs. The informal stage gate process experienced by the established SMEs is positively influenced the discontinuous innovation process and was enabled by the courage and enthusiasm of the owner himself, hence the entrepreneurial mindset of the established SMEs. The fact that the established SMEs did not apply a long procedural selection process, but an informal stage gate process enabled them to continue the discontinuous innovation process. The subjective, thus entrepreneurial nature on which the discontinuous ideas are selected is a certainly an advantage of the established SMEs. Nevertheless, the owners of the established SMEs should not be risk-adverse.

5.3 The Implement Stage

The implement stage is the largest stage of the discontinuous innovation process. To discuss this stage in a coherent manner each sub-section will discuss a set of problems and challenges and the related mechanisms applied by the established SMEs to address the problems and challenges. Each subsection will include a table to provide an overview the problems and challenges and the mechanisms applied by the established SMEs. When reading this section, one must keep in mind that the discontinuous innovation process of the established SMEs varies, due to the difference in technological advancement of the innovations and the time spent on the development of the innovation. To give an example one may refer to the innovation process of Ambroise, which took only one year, whereas the longest innovation process was experienced by Doorgeest Koeltechniek, which took seven years. Shemat (and Mechatron) did not finish the innovation process, but spent two years, just reaching the initial stage of implementation, where it approached potential partners.

5.3.1 Development Funding

One of the first challenges or problems that the established SMEs run into when starting the implementation process is finding sufficient financial funding to cover the development of the discontinuous innovation. Table 28 indicates that all the established SMEs experienced a lack of financial means for the development of the discontinuous innovation. Table 28 also indicates that the problem was overcome by the majority of the established SMEs, as they were granted a subsidy.

[10] Machine Fabriek Sonder did apply a specific framework, due to the influence of the university, the others did not.

Challenges and problems vs. Mechanisms ✓ = present in the established SME		Ambroise	Doorgeest Koeltechniek	Machine Fabriek Sonder	Scheepswerven Bodewes (FCBC)	Shemat (and Mechatron)[11]
Challenges & problems	Lack of financial means for development	✓	✓	✓	✓	✓
Mechanisms	Subsidy	✓		✓	✓	✓

Table 28 Lack of financial means

The lack of financial funds is a barrier discussed by various scholars, such as Kleinknecht (1989) and Kaufmann and Tödtling (2002) who argue that the lack of financial funds is the highest barrier constraining SMEs to engage in innovative, high risk projects. Instead, as can be depicted from table 28 most SMEs were granted a subsidy to overcome this problem. The established SMEs all solicited for different subsidies, which seems obvious given that the planned innovations differ. Subsidies generally entail quite a few restrictions (the requirement to partner with a prescribed university or firm) and administrative tasks (keeping track of developments). Leifer et al. (2000) argue that external funding hardly ever leads to satisfactory outcomes and state that firms should outweigh the benefits and the downsides of acquiring external funding. Doorgeest Koeltechniek outweighed the advantages and disadvantages and decided not to opt for a subsidy, due to the administrative burden. Ambroise provided similar reasons and stated that subsidies generally impose too many restrictions, except for the WBSO subsidy. This subsidy compensates for a part of the hours spent on R&D. The other established SMEs seemed satisfied with the subsidies they were granted. As the opinions about subsidies are so diverse, no distinct pattern can be recognized, but it is apparent that established SMEs generally do require additional funding for the development of discontinuous innovations.

The established SMEs seemed to be aware of the subsidy options and how to obtain them, which contradicts the statement by Kleinknecht (1989) that SMEs are generally less informed about the existence of subsidies. A possible cause for this contradiction may be that Kleinknecht (1989) refers to SMEs in general, whereas this study investigates how established SMEs manage the discontinuous innovation process. A further cause may be that the argument of Kleinkecht (1989) has become outdated, as communication about subsidies may have improved over the years. The fact that the studied established SMEs have existed for some time and therefore have an existing network and gained experience may have positively influenced their ability to find suitable subsidies. Nevertheless, the project manager of the innovation process of FCBC (Scheepswerven Bodewes) did

[11] Shemat and Mechatron are included in this overview, but the innovation process was quit after some initial preparations for development.

emphasize that the subsidy world is a jungle, thus finding the right directions may be difficult at times.

5.3.2 Closing the Competency Gap

The challenges, problems and related mechanisms that will be discussed in this subsection are presented in table 29. The implement stage requires firms to acquire resources and knowledge to start the development of the discontinuous innovation. For large firms this is said to be easier, because they often have more resources available and more means to invest in R&D. Start-ups and SMEs generally have less resources available and as argued by Leifer et al. (2000) they often lack one or more competencies to successfully pursuit opportunities. As a result established SMEs may experience a competency gap, which refers to a situation in which a firm lacks one or more competencies to develop the innovation (Leifer et al., 2000). The findings indicate that most of the established SMEs did not have the capabilities in-house to singlehandedly develop the innovations, accordingly the established SMEs experienced a competency gap, but some more than others. To close the competency gap outsourcing is the most frequent applied mechanism by the established SMEs. Scheepswerven Bodewes even decided to establish a joint venture (FCBC) together with other established SMEs to bundle core capabilities and resources required to develop the innovation, but the joint venture FCBC still relied on outsourcing for additional competencies.

Challenges and problems vs. Mechanisms ✓ = present in the established SME		Ambroise	Doorgeest Koeltechniek	Machine Fabriek Sonder	Scheepswer-ven Bodewes (FCBC)	Shemat (and Mechatron)
Challenges & problems	Close the competency gap	✓	✓	✓	✓	✓
Mechanisms	Establish a joint venture to bundle capabilities and resources				✓	
	Outsourcing	✓	✓	✓	✓	Not applicable
	Cooperation university or knowledge institute		✓	✓	✓	✓
	Cooperating other external parties, e.g. firms, hospitals etc.	✓				✓
	Cooperation and extra attention to authorities and research institutes to receive labels (no standard procedures existed)		✓		✓	

Table 29 Closing the competency gap

Tidd et al. (2005b, p. 93) emphasized that the innovation "*process is about weaving together different knowledge sets coming from groups and individuals with widely different functional and disciplinary backgrounds."* Weaving together different knowledge sets required the established SMEs to cooperate with diverse parties. This was experienced as quite a challenge by the majority of the established SMEs. Leifer et al. (2000) argues that there may be a need to apply a system approach of dealing with teams and to successfully weave together the different knowledge sets. However Song et al. (1998) state that building consensus among groups, with different perspective and goals may be time-consuming and requires tremendous finesse from the project managers. The most challenging aspect of closing the competency gap mentioned by the established SMEs is attaining resources from external parties and arranging for tasks to be performed by external parties. To battle the challenge, the established SMEs all applied different structures or mechanisms. To release the pressure of the owner of Scheepswerven Bodewes (hereafter in the discussion referred to as FCBC) and the other joint venture (FCBC) members, they decided to hire a project manager to streamline the process. Machine Fabriek Sonder applied a different, but interesting structure to cope with the challenging task of weaving together different knowledge sets. The established SME created a multidisciplinary team of the parties to which it outsourced activities, these parties, hence this multidisciplinary team met every two weeks to discuss the advancements of the innovation. The owner of Machine Fabriek Sonder acknowledged the importance of multidisciplinary teams, more specifically of weaving together knowledge sets to enhance innovative solutions. The advantage of applying this structure is that Machine Fabriek Sonder remained the sole owner of the IP rights. Overall large established firms tend to structure multidisciplinary teams, as they have a larger and more diverse workforce, accordingly the solution implemented by Machine Fabriek Sonder seems to be a good alternative for established SMEs wanting to benefit from the solving ability and creativity level multidisciplinary teams own.

It seems that Ambroise and Doorgeest Koeltechniek experienced the competency gap to a lesser extent compared to the others, as they relied less on outsourcing. Yet, one should take the difference in development time into account, e.g. Ambroise spent one year developing its innovation, whereas the innovation process of Doorgeest Koeltechniek took seven years. One may assume that Doorgeest Koeltechniek could have increased the clock-speed of the process, if it had outsourced some activities, but this remains questionable[12] as the innovation seems more technically advanced.

The established SMEs highlighted the importance of networking to close the competency gap. Through networking one can extract the viable capabilities from the network not present internally. Accordingly the *"rise of networking, the emergence of small firm clusters, the growing use of 'open innovation' principles .."* as indicated by Tidd et al. (2005b, p. 411) also applies to the established SMEs[13] and their values. The results indicate that the established SMEs specifically cooperate with universities or research institutes in the initial stage of implementation, where technological facets had to be analysed, e.g. whether RF technology can be applied to heat sausages as in the case of Machine Fabriek Sonder. Massa and Testa (2008) have previously mentioned that SMEs often

[12] One should keep in mind that the innovation of Doorgeest Koeltechniek seems more technologically advanced than that of Ambroise, the statement is therefore only an assumption.
[13] Doorgeest Koeltechniek prefers to keep knowledge inside the established SME and performed most of the activities internally. One may state that Doorgeest Koeltechniek prefers a more closed innovation model compared to the other established SMEs studied.

consider the cooperation with universities as important, but only in the beginning of R&D. Similar arguments were provided by the established SMEs during the data collection, as some established SMEs argued that contact persons at universities are less commercial, yet very valuable for in-depth knowledge. The advantage of cooperating with universities in the initial stages of the innovation process is that established SMEs feel safer compared to cooperating with large external commercial partners, as the ideas are generally not legally secured in the initial stage.

All the established SMEs cooperated in some way with external parties and interestingly all the established SMEs viewed this as quite a challenge. Leifer et al. (2000) indicate that firms are generally faced with the challenge of identifying partners and accordingly with controlling the IP. The established SMEs did emphasize that care is required when selecting potential partners and Machine Fabriek Sonder emphasized the importance of securing the IP rights in the early stages of the development process. The owner argued that external parties will become more interested over time, as the innovation will prove itself. The challenges by Leifer et al. (2000) will probably also apply start-ups, but to a lesser extent to large established firms, as they generally own more control. The advantage of established SMEs in this matter, is that they have an existing network from which they can extract valuable competencies. Furthermore they have more social legitimacy than start-ups, which may make it slightly easier to find appropriate partners to cooperate with.

In order to be able to launch the discontinuous innovation on the market, most of the established SMEs were required to cooperate with authorities to receive labels. Doorgeest Koeltechniek and FCBC experienced the process of frequently communicating and making arrangements with such institutions as quite challenging. FCBC was not used to communicating with such a large institutions, an aspect which large established firms may be used to. As a result one may conclude that receiving labels for legal requirements may be more challenging and difficult for established SMEs than for large established firms that deal more frequently with such situations.

Challenges and problems vs. Mechanisms ✓ = present in the established SME		Ambroise	Doorgeest Koeltechniek	Machine Fabriek Sonder	Scheepswer-ven Bodewes (FCBC)	Shemat (and Mechatron)
Challenges & problems	Technology pitfalls, misleading promises and late supplies or long delivery times of outsourced activities	✓		✓	✓	✓
Mechanisms	(Frequent) Visits to or contact with suppliers or potential partners (abroad)			✓		✓

Table 30 Problems and Challenges related to closing the competency gap

To close the competency gap all the established SMEs decided to outsource some activities, nevertheless this option also implied challenges and problems as can be depicted in table 30. Rice et al. (2002) studied the uncertainties experienced by firms when faced with discontinuous innovations, one of these uncertainties is technological uncertainty. This uncertainty was experienced by the majority of the established SMEs as many experienced technological pitfalls, hence it took longer to develop the technology or to improve the technology than anticipated. A further uncertainty studied by Rice et al. (2002) in respect to discontinuous innovations is resource uncertainties, more specifically the difficulty to anticipate the exact resources required. This uncertainty was experienced by the majority, as during development more was learned about the innovation and different resources were required. This aspect influenced the outsourcing decision of Ambroise, which preferred outsourcing to Dutch firms, as communication is easier and delivery times are shorter. Others outsourced activities abroad, such as Machine Fabriek Sonder, who experienced long delays. To solve these problems the established SMEs decided to visit the suppliers, even though long distances had to be travelled. Ambroise and Doorgeest Koeltechniek, outsourced the least. Ambroise, because it owns most of the capabilities to develop the innovation, but does not have the capacity to produce all the required components. Doorgeest Koeltechniek, because the established SME is anxious to release too much valuable information about the innovation. Nurala (2004) retrieved similar findings, namely that *"SMEs tend to use non-internal means with a great deal of care, in some cases bordering on paranoia."* In this case the latter statement only applies to Doorgeest Koeltechniek[14], as the other established SMEs recognized to importance of using external capabilities.

5.3.3 Managing the Core Business and the Discontinuous Innovation Process

The owners of the established SMEs are the driving force behind the discontinuous innovation process, they do not only manage their core business, but also manage the discontinuous innovation process. The latter task was experienced as quite a challenge by the owner, as can be depicted from table 31, this will be further discussed in this subsection.

Challenges and problems vs. Mechanisms ✓ = present in the established SME		Ambroise	Doorgeest Koeltechniek	Machine Fabriek Sonder	Scheepswerven Bodewes (FCBC)	Shemat (and Mechatron)[15]
Challenges & problems	Simultaneously managing daily business and the innovation process	✓	✓	✓		✓
Mechanism	Hiring a project manager				✓	

Table 31 Simultaneously managing daily business and the innovation process

Birkinshaw and Gibson (2004, p. 49) introduced the concept of ambidextrous individuals, which relates to the ability of individuals *"to make choices between alignment-oriented and adaptation-*

[14] As described in footnote 13 Doorgeest Koeltechniek applied a more closed innovation model. The owner is afraid to expose too much valuable information and is anxious that the innovation will be replicated. As a result, the established SME does not opt for legal protection.

[15] Shemat and Mechatron are included in this overview, but the innovation process was not completed.

oriented activities in the context of their day-to-day work." Ambidextrous individuals take initiative, are alert to opportunities beyond their direct tasks, are looking to build internal linkages and are multi-taskers (Birkinshaw & Gibson, 2004). When faced with ambidextrous situations, large established firms often appoint project managers to manage innovation processes. Start-ups on the other hand do not have to deal with simultaneously managing existing activities. The owners of the established SMEs managed both the discontinuous innovation process and daily business, they were faced with various and diverse tasks and decisions, thus they may be described as truly ambidextrous individuals. The only established SMEs that applied a mechanisms to ease the tasks of simultaneously managing both process is FCBC, because the joint venture hired a project manager to streamline the innovation process. The other established SMEs may have had insufficient resources (financial and manpower) to apply this mechanism.

Kaufmann and Tödtling (2002) argue that the lack of manpower is the second more frequent barrier in SMEs (the first barrier is the lack of financial means). However, one should take into account that it can be influenced by the lack of financial means, hence if there are sufficient financial means, additional manpower could be attracted (if present in the labour market). From the results one may state that FCBC did have the financial means to hire a project manager. The other established SMEs indicated that they experienced a lack of manpower, but did not experience this as a barrier, compared to the argument of Kaufmann and Tödtling (2002). Instead, they viewed it as a challenge for which the owners worked longer hours to enable the development of the innovation. These findings, relate to those of Bourgrain and Haudeville (2002, p. 744), as they argue that SMEs "*carry out their R&D activities, without a formal R&D department or a formal budget and often even outside regular hours."* The established SMEs did not have a formal R&D department, mainly because they are too small. Another reason is that the owner himself is the driving force behind the innovation, his dedication stimulates him to work outside regular hours to enable the development of a discontinuous innovation. As result the findings of Lefebvre and Lefebvre (1992, p. 298) comply to the case studies, in that the innovative activities are "*often based on the creative talents of a few individuals including the owner/chief executive officer (CEO) himself".* More specifically, although the established SMEs experienced a lack of financial means and manpower, they compensated the latter by working longer hours and truly acting as a ambidextrous individual, even if it may be challenging.

5.3.5 Product Development Challenges

This sub-section will discuss challenges and problems related more to the actual product development of the discontinuous innovation. Table 32 provides an overview of the problems and challenges experienced and the mechanisms applied to address those problems and challenges.

Challenges and problems vs. Mechanisms ✓ = present in the established SME		Ambroise	Doorgeest Koeltechniek	Machine Fabriek Sonder	Scheepswer-ven Bodewes (FCBC)	Shemat (and Mechatron)
Challenges & problems	Product development challenges	✓	✓	✓	✓	Not Applicable
Mechanisms	Consumer testing	✓	✓	✓		
	Prototyping	✓	✓	✓		
	Development at different location and behind closed doors			✓		

Table 32 Further product development problems, challenges and mechanisms

One of the most frequent mechanisms applied during the development of the discontinuous innovations is probe and learn, this mechanisms entails taking a step into the market with an early version of the innovation to gain experience about the innovation and the market so that the innovation can be modified when needed (Lynn et al., 1996, p. 30). This mechanisms can aid to decrease the uncertainty about the innovation, but is not specified in table 32. The mechanism entails a combination of consumer testing and prototyping, hence those established SMEs performing those apply probe and learn. The aim of the established SMEs was to receive feedback on their innovation, in order to improve it before commercially launching it on the market. The established SMEs put great importance on the functioning of the innovation and consumer reactions, as they realize the difficulty of launching discontinuous innovation on the market. FCBC could not apply probe and learn, as the first fuel cell boat will be the prototype. Prior to consumer testing most of the innovations were tested, either externally by research institutes or internally. Even though FCBC could not apply probe and learn, it did learn to accumulate knowledge over time, which at times required going back and forth in the development causing to process to be experienced messy. The messiness described by the established SMEs is a known characteristic of the discontinuous innovation process.

The discontinuous innovation of Machine Fabriek Sonder was developed behind closed doors at a different location. Once the innovation was secured by IP rights the innovation was disclosed within the Machine Fabriek Sonder itself. The fact that Machine Fabriek Sonder decided to develop the innovation at a different location seems to resemble the concept of a radical innovation hub, as introduced by Leifer at al. (2001). Radical innovation hubs are generally established by large firms to nurture discontinuous innovations, hence to allow for more creativity and less bureaucracy. In this case the hub was established for different reasons, namely to keep the innovation disclosed, hence to secure the developments until the innovation was protected. The owner of Machine Fabriek Sonder therefore applied structural ambidexterity, next to contextual ambidexterity that was applied by all the established SMEs. The general goal of structural ambidexterity is to eventually reintegration the innovation into the core firm (Birkinshaw & Gibson, 2004). In this case the activities were moved into the core firm after the IP rights were received, but Machine Fabriek Sonder did set up a separate firm, named Sonder Food Systems. The objective of the new firm is to spread risk, as the development of discontinuous innovations is uncertain and risky.

5.3.6 Commercialization

This sub-section will discuss how the established SMEs managed to exploit or will try to exploit the discontinuous innovation. Table 33 provides an overview of the problems, challenges and specific mechanisms applied by the established SMEs for the commercialization of the discontinuous innovation, which entails production and market launch.

Challenges and problems vs. Mechanisms ✓ = present in the established SME		Ambroise	Doorgeest Koeltechniek	Machine Fabriek Sonder	Scheepswerven Bodewes (FCBC)	Shemat (and Mechatron)[16]
Challenges & problems	Difficult to make market estimations and, or to launch the innovation on the market	✓	✓	✓	✓	✓
Mechanisms	Slow market entry; allowing consumer feedback cycles	✓				Not applicable
	Establishment joint venture with large established firm		✓	✓ Considering external investors		Not applicable
	International Patent (PCT)	✓		✓	Not possible[17]	Not applicable
	PhD Research (aids market launch)	✓				Not applicable

Table 33 Challenges, problems and mechanisms for commercialization

[16] Shemat and Mechatron are included in this overview, but the innovation process was quit after some initial preparations for development. The established SMEs did experienced the difficulty of making market estimations.

[17] FCBC (Scheepswerven Bodewes) is an exception, because it could not file for a patent. The individual components of the boat are not new, even though the combination of fuel cells in a boat is new.

According to Narula (2004, p. 159) *"SMEs tend to concentrate their production and sales in their home country, much more so than large firms and do not have the resources necessary to engage in home-base augmenting activity."* This statement is not true for the established SMEs in this study, as all the established SMEs had greater aspirations and indicated to be interested in expanding their sales abroad, even globally. In order to attain sales beyond the home country the established SMEs (Machine Fabriek Sonder, Doorgeest Koeltechniek) indeed needed additional resources, such as additional production lines and distribution channels. In relation to this, Narula (2004) argues that SMEs tend to prefer outsourcing rather than alliances, due to the higher risk and costs of managing partnerships. The findings are consistent with this statement, but to be able to produce and launch the discontinuous innovation on the market the majority of the established SMEs were required to start an alliance, due to the lack sufficient financial means, production facilities, distribution channels and social legitimacy to launch discontinuous innovations on the desired scale. An easy solution to this challenge would have been to sell the IP rights (Machine Fabriek Sonder) or the product details (Doorgeest Koeltechniek), but the owners of the established SMEs wanted to retain an interest in the innovation, which is in line with the reasoning of Smith (2006). Consequently the owners of the established SMEs did not opt for selling the IP rights, which left no other option, but to start an alliance, hence search for external investors. Scheepswerven Bodewes is the only established SME in this study that started a joined venture at the start of the implement stage. This joint venture exists of other established SMEs and is therefore an ought one out. The advantage of this joint venture is that it did not experience financial difficulty for commercialization, however, as mentioned the constructed boat is the prototype and additional boats will be constructed upon request, which is different from producing multiple units.

When it comes down to the search for partners, Narula (2004, p. 157) argues that *"larger firms are in a better position to establish partnerships, because they have more to offer. SMEs have fewer technological assets with which to barter."* This statement is partially true, as indeed established SMEs have less to offer in financial terms, however in this case the established SMEs have succeeded in developing a discontinuous innovation, which is interesting to large firms. Consequently the established SMEs were fully capable of finding large firms interested in an alliance.

As can be depicted from table 33 all the established SMEs recognized the difficulty of launching discontinuous innovations and making market estimations. The case studies indicate that the challenges by McDermott and O'Conner (2002) were experienced by the established SMEs, hence the need to ensure the delivery of a perceptible benefit and the need to overcome market resistance to the innovation. To face these challenges the established SMEs all applied different mechanisms, which are presented in table 33. The threat of cannibalization put forward by McDermott and O'Conner (2002) was not mentioned as a threat by the established SMEs.

5.3.7 Conclusion Implement Discussion

The implement stage is the largest stage and the established SMEs experience most problems and challenges and apply most mechanisms in this stage. The implement stage starts with finding financial funding to enable the development of the discontinuous innovation and the results indicate that almost all established SMEs were granted subsidies. Next to the lack of financial means, the established SMEs experienced a competency gap, which was mainly solved by outsourcing. Given the lack of internal competencies, networking and extracting valuable competencies from the network is an important tool for established SMEs. Due to outsourcing the established SMEs were faced with the task to weave together different knowledge sets and activities from different firms (Tidd et al., 2005b). To structure this process Machine Fabriek Sonder established multidisciplinary teams from the firms it outsourced to and divided the process in stages, a facet influenced by the cooperation of the university. The latter activities seem to be beneficial for remaining focused and successfully combining different knowledge sets during the discontinuous innovation process.

The established SMEs have to deal with daily business and simultaneously manage the discontinuous innovation process. Large established firms usually have the resources to assign project managers and start-ups experience ambidextrous tendencies less, as these firms are not faced with an existing business. The latter implicates the importance of the ambidextrous and entrepreneurial ability of the owners of the established SMEs. The entrepreneurial ability of the owners provide them with the courage and conviction required in the implement stage. The ambidextrous ability provides the owners with cooperative skills and the capability to multitask (Birkinshaw & Gibson, 2004) and close the competency gap.

During the discontinuous innovation process the established SMEs experienced various technological pitfalls and were required to go back and forth in the development process as new aspects were learned. Given these uncertainties probe and learn was the most favoured and valuable mechanism applied during product development, as it continuously provides new insights. Once the discontinuos innovation were developed the owners faced the challenge of commercialization. The majority of the established SMEs lacked the financial means to launch the discontinuous innovation and were required to consider external investors. Established SMEs should therefore anticipate technology pitfalls and the need for additional resources when favouring global commercialization.

Overall established SMEs seem to use a variety of internal and external mechanisms. The importance of combining both has been emphasized by Bougrain and Haudeville (2002), as they state that *"innovation capabilities depends on the ability to exploit external knowledge and in-house R&D efforts"* (Bougrain & Haudeville, 2002, p. 743). This statement is specifically true for the established SMEs in this study, as they frequently have insufficient internal capabilities and have to be good at organizing resources and activities externally, if they are not, they will have great difficulty to develop discontinuous innovations.

6 Conclusion

The previous chapter discussed the case study findings and the related theoretical implications. This chapter will conclude the thesis and answer the research questions; how do established SMEs manage the discontinuous innovation process, in terms of search, select and implement. The first section will provide answers to the challenges and problems experienced per stage of the discontinuous innovation process and indicate the mechanisms applied by the established SMEs. The second section provides managerial advice based on the problems and challenges experienced by the established SMEs during the discontinuous innovation process. The last section will discuss the limitations of this thesis and provide suggestions for further research.

6.1 The Discontinuous Innovation Process by Stage

This section will provide answers to the research question, by focusing on the three stages of the discontinuous innovation process, namely search, select and implement.

The discontinuous innovation process starts with the search stage, which was not structured by the established SMEs. Instead ideas were triggered by potential legislative changes, dissatisfaction about existing systems or by problems of others. Those established SMEs that were approached with innovative ideas, may have benefited from social legitimacy in the region or industry through which inventors or problem owners approached them. The entrepreneurial mindset of the established SMEs, also largely contributes to the ability of established SMEs to generate innovative ideas, thus link inventions to the market.

Once ideas have been generated the established SMEs move to the selection stage. This is where established SMEs differ from start-ups. Start-ups are generally founded on an idea that emerged from a university or a parent organization. Accordingly start-ups are not faced with the selection decision, whereas established SMEs need to select an innovative idea by taking its core business into account. Opposed to the DILab model, selection in the established SMEs does not solely take place after the search stage, instead the unpredictable nature of discontinuous innovations creates an emergent selection environment. None of the established SMEs applied financial selection mechanisms, instead established SMEs seem to prefer mechanisms based on subjective judgement, thus entrepreneurial instinct.

After an initial selection the established SMEs start the implement stage, which has the largest scope of the discontinuous innovation process. The main problems and challenges experienced during this stage are the lack of capabilities and resources (among others, financial and manpower) resulting in a competency gap to develop the discontinuous innovation. The established SMEs generally solve this problem by outsourcing the tasks it cannot perform itself. Preferences in cooperation or outsourcing for knowledge in the initial stage of implementation goes out to universities, as these are great knowledge domains and less threatening to the established SMEs compared to large established firms. Nevertheless, the challenge of simultaneously managing core business and the discontinuous innovation process remains difficult for most of the established SMEs, as the majority lack the resources to implement mechanisms to ease this challenge.

Near the end of the implement stage, when the established SMEs have to start commercialization, insufficient financial resources are left to adhere to the aspirations of most of the established SMEs, which is global market launch. Accordingly these established SMEs set up joint ventures, usually with large firms to successfully launch the innovation and create social legitimacy. The majority of the established SMEs filed for patents and IP rights and all retained an interest in their discontinuous innovation.

The owners of the established SMEs can be depicted as ambidextrous and entrepreneurial individuals, thus multi-taskers. The owners should have the ability to make choices between daily business and the innovative activities, be alert to opportunities beyond their direct tasks and able to build internal and external linkages (Birkinshaw & Gibson, 2004). The entrepreneurial skills that are important are the ability to recognize a means-end framework for the recognition of opportunities, the courage to enter the discontinuous innovation process, the networking skills to close the competency gap and the conviction to complete the discontinuous innovation process.

Firm Type	Advantages	Disadvantages
Established SMEs	✓ More flexible and adaptive to environment and receptive to change compared to large established firms, due to; ✓ Short communication and decision lines ✓ Stronger commitment, entrepreneurial mindset, shorter decision making lines, due to ownership stake ✓ Established network and some social legitimacy, due to existence	✓ Fewer resources (e.g. financial, manpower) and greater chance of competency gap ✓ Social legitimacy present, but may be insufficient for global launch of a discontinuous innovation ✓ Owner responsibility (If risk averse it has a negative influence on the ability to innovate) ✓ Existing business, consumes time and may negatively influenceinnovation decisions

Table 34 Advantages and disadvantages of established SMEs

To conclude one may state that established SMEs are capable of developing discontinuous innovations, even though they have to rely heavily on the external environment. Their entrepreneurial mindset, flexibility, ability to find funding and to close the competency gap by networking and cooperating indicates that established SMEs although vulnerable do have the ability to successfully develop discontinuous innovation. Table 34 provides an overview of the advantages and disadvantages of the established SMEs regarding their ability to develop discontinuous innovations. One of the main strengths of the established SMEs seems to be the entrepreneurial mindset, which can be recognized by courage, patience, persistence and creativity. However, not all established SMEs can succeed in following their aspirations to globally launch the discontinuous innovation, unless they rely on external investors or establish a joint venture with large established firms.

6.2 Managerial Advice for established SMEs

This section will provide managerial advice for established SMEs based on the experience of the established SMEs studied, thus the problems and challenges experienced and mechanisms applied to address the problems and challenges during the discontinuous innovation process. Table 35 provides advice for established SMEs wanting to develop discontinuous innovations per stage of the discontinuous innovation process. The advice provided in table 35 will be elaborated in this section. Some of the advice provided in table 35 strongly relates to the specific nature of discontinuous innovations in general, such as organizing for additional financial means, other advice is specific for established SMEs wanting to develop discontinuous innovation, such as finding a balance between daily business and the innovation process.

Managerial advice for established SMEs concerning the discontinuous innovation process	
Advice for throughout the process	➢ Network and engage on innovation platforms throughout the discontinuous innovation process, as valuable competencies or information can be extracted.
Advice on the individual characteristics required throughout the process	➢ Entrepreneurial mindset is a must, which includes courage, conviction and the ability to recognize a means-end framework. ➢ Be patient, allow for uncertainty and take the long development times into account. ➢ Find a balance between daily business and the innovation process, which requires ambidextrous ability.
Search Advice	➢ Combine out-of-the-box thinking and before-the-box thinking to allow for truly discontinuous ideas.
Selection Advice	➢ Allow for an informal selection stage gate process, which will decrease uncertainty throughout the discontinuous innovation process.
Implement Advice	➢ Organize additional financial means, as bank do not prefer to support discontinuous projects. Accordingly subsidies may be required, but they also entail a lot of administrative work which should be taken into account. ➢ Implement a clear and structured process- and meeting- schedule (framework) to allow for clear milestones and discussion on various facets of the process. If possible assign a project manager. ➢ Apply outsourcing to close the competency gap and organize outsourced work by establishing a multidisciplinary team. Partnering may be required, but carefully select partners, consider the intentions. Universities can be a valuable and secure source of in-depth knowledge. ➢ Depending on the innovation, involvement of the end-consumers in the innovation process can be very valuable in terms of product experience, preferences and consumer reactions. ➢ Organize IP-rights (and patents) in the early stages of the process, but only solicit for patents when the innovation can be legally substantiated. ➢ When wanting to pursue global commercialization anticipate that additional (financial) resources, social legitimacy and capabilities may be required.

Table 35 Managerial advice for established SMEs

6.2.1 Managerial advice on the search stage

The established SMEs did not structure the search for discontinuous ideas, instead the process seemed to evolve naturally. This natural process is largely influenced by the entrepreneurial mindset of the established SMEs, more specifically of the owners. Established SMEs wanting to pursue discontinuous innovations should have an entrepreneurial mindset, which entails having courage, conviction and the ability to recognize a means-end framework. The majority of the established SMEs studied did not implement search mechanisms, except for Ambroise. Ambroise was approached with a problem for which it applied before-the-box thinking, which entails brainstorming without taking existing solutions into account to generate higher levels of creativity and to generate discontinuous ideas. The success of the mechanism applied by Ambroise, thus before-the-box thinking can be well combined with the existing concept of out-of-the box thinking, which entails thinking outside the constraints of the firm's current business (Leifer et al., 2000). The latter would provide established SMEs with greater levels of creativity without incurring too many costs.

6.2.2 Managerial advice on the select stage

Selection in established SMEs does not take place at one point in the discontinuous innovation process, instead established SMEs experienced an emergent selection environment. The discontinuous innovation process is uncertain and to reduce the uncertainty established SMEs should be eager to obtain further information on the feasibility of the idea. In the quest to receive further information on the feasibility of the discontinuous idea established SMEs are required to continuously invest in the search for answers. Initial selection is usually based on the non-financial mechanisms, thus subjective judgement and the entrepreneurial instinct of the owners. Financial mechanisms are applied the least, due to the difficulty to capture the feasibility of discontinuous idea in financial terms. To receive more information established SMEs can apply further selection mechanisms, thus tools to provide them with further answers on the feasibility of the discontinuous idea. The type of selection mechanisms to be applied depends on the type of discontinuous innovation, for example is the discontinuous innovation very technical and does it require technological feasibility tests, or is it less advanced and can prototypes be tested quickly on consumer. In case the established SMEs have insufficient in-house knowledge to base selection decisions on they can consult universities or innovation platforms, as these entities have experience, know about the latest trends and may have additional information required to select the discontinuous idea.

6.2.3 Managerial advice on the implement stage

The implement stage is the largest stage experienced by established SMEs and entails the development and commercialization of the discontinuous innovation. In this stage established SMEs continuously learn new facets about the innovation, which requires going back and forth in the development process. A useful mechanisms during this process is probe and learn, which entails taking steps into the market to gain experience in order to improve the innovation (Lynn et al., 1996). Established SMEs wanting to apply this tool for their discontinuous innovation should carefully take a step into the market, as the innovation may be harmed if it malfunctions. Instead, established SMEs can approach specific end-consumers and set-up non-disclosure agreements, reducing the change of harming the brand name or technology of the innovation, yet allowing the established SME to learn from feedback.

The majority of the established SMEs did experienced the implement stage as messy, due to the continuous emergence of new information and the need to go back and forth in the development process. Given these findings, one can refer back to the question posed by O'Connor (1998, p. 153); *"are there systematic processes in place, or is market learning carried out on an ad hoc basis, along the lines of 'improvisation' and 'probe and learn' as the more recent literature reflects?"* The latter seems to be true, yet the established SMEs studied seem to be aware of the need to implement a more systematic process, but emphasized that creating a framework is very time-consuming. Doorgeest Koeltechniek and Ambroise referred to the use of tacit knowledge by a few core employees working on the innovation, making a framework obsolete, but they admit that specific milestones would be helpful. In comparison, Machine Fabriek Sonder did apply a framework including stages of development, the application of which was influenced by the cooperating with the university. Given these diverse findings the remark of Christensen (1997, p. 147) seems to be applicable, namely *"strategies and plans that managers formulate for confronting disruptive technological change.. should be plans for learning and discovery rather than plans for execution."* But these plans should include as stated by Perel (2002, p. 16) "*both 'light bulbs (ideas) and ' flow-charts' (processes)."* Established SMEs facing the implement stage should therefore include stages with objectives to better structure the process.

The discontinuous innovation processes studied were managed by the owners, thus the owners were in charge of managing both the discontinuous innovation process and daily business. Unfortunately daily business distracted the owners too much to create the required focus on the discontinuous innovation process. Given the latter challenges established SMEs should try to implement milestones to allow for more prioritization and a better focus during the discontinuous innovation process. If the owner of the established SME feels too much pressure and is incapable of prioritizing and sufficient resources (financial and/or manpower) are present established SMEs should assign a project manager. A (full-time) project manager can create more focus, even though one cannot anticipate for the potential delays, problems and discontinuous character of the process. Close cooperation with universities may have a positive influence on the structure of innovation processes of established SMEs, as these institutions may have more experience in managing such processes compared to established SMEs.

All the established SMEs studied experienced a competency gap in their quest to develop the discontinuous innovation. Established SMEs in the implement stage should therefore analyze what activities should be outsourced and how to organize the outsourcing activities to allow for the development of the discontinuous innovation. The advantage of established SMEs in this matter, is that they have an existing network from which they can extract valuable competencies and knowledge. Furthermore they have more social legitimacy than start-ups, which may make it slightly easier to find appropriate partners to cooperate with. Established SMEs outsourcing several activities are advised to form multidisciplinary teams of the parties to which it is outsourcing activities, this allows for a convergence of different knowledge sets, which may stimulate and enhance the development process. Machine Fabriek Sonder implemented a similar structure and emphasized the benefit of greater creativity level and problem solving capacity when combining the different knowledge sets. A further aspect, which should be taken into account by established SMEs when taking the decision to outsource is the frequent need to adapt components, due to the discontinuous nature of the innovation process in which new facets are learned continuously. The latter influenced the decision of Ambroise to outsource to the Netherlands, thus enabling better communication and less shipping time. Many other established SMEs experienced delays and were required to travel long distances to solve the problems.

When outsourcing established SMEs should keep in mind the intentions of other firms. It may be wise to arrange for IP rights early on in the process. Machine Fabriek Sonder argued that in the initial stages of development many people may not be convinced of the idea, but as developments continue more people may become convinced and want to receive rights themselves. As a result when IP rights or patents can be legally substantiated established SMEs are advised to do so.

Once the discontinuous innovation is fully developed it is ready for commercialization, a stage often undermined as development takes up a lot of time and energy. The majority of the established SMEs studied had to consider external investors to realize their ambitions of launching the discontinuous innovation globally. As a result established SMEs with similar ambitions should anticipate that additional financial resources and social legitimacy may be required to successfully commercialize the discontinuous innovation.

6.3 Limitations and Suggestions for Further Research

This section will discuss the limitations and provide suggestions for further research based on the findings of this thesis. The research performed for this thesis is of inductive nature aiming to explore the discontinuous innovation process at established SMEs, a topic prior uncharted. The discontinuous innovation process itself is currently being researched by DILab, a beginning has been made as predecessors have investigated the search stage of the discontinuous innovation model as proposed by DILab. Accordingly one must understand that this topic offers enough research potential, which could not all be explored given the time span and scope of this thesis. As a results, this section will discuss the limitations of the thesis and provides a number of suggestions for further research. Some of the suggestions for further research emerged from the restricted scope of the thesis and others emerged from interesting findings.

Due to contributions of DILab and discontinuous innovation scholars the search stage of the discontinuous innovation process is quite lucid. Nevertheless during the search for literature on the discontinuous innovation process it has become apparent that there is sufficient room for further research regarding the select and implement stage. Not only concerning the problems and challenges experienced, but also concerning the applicable mechanisms. The results of this thesis have indicated that the selection of discontinuous innovations is of an emergent nature, but selection remains ambiguous as it is mainly based on subjective judgement in the established SMEs. Charitou and Markidez (2003) claim that the ability of established firms to respond to discontinuous innovations, among others depends on the nature and size of the conflict between the new and traditional business. The findings of this thesis are not directly in line with the statement of Charitou and Markidez (2003), in that one of the established SMEs decided to pursue an innovation not in line with traditional business and another established SME discarded the idea, but gave several reasons for this decision, most of which were related to the general barriers of discontinuous innovations. Further research is required to provide a statement on whether established SMEs are indeed influenced by the nature and size of the conflict between the new and traditional business.

The implement stage of the discontinuous innovation process entails among others the commercialization of the discontinuous innovation. In line with the results of this thesis Smith (2006) argues that firms often want to retain an interest in the innovation they developed. Nonetheless the results have indicated that the majority of the established SMEs are not able to pursue their aspirations of a global market launch by themselves, as a result they have to rely on external investors for financial support and social legitimacy. Further research in this field, concerning alternative options to commercialization for established SMEs would be interesting and may aid the sustainability of discontinuous innovations generated by established SMEs.

There was only one established SME (Shemat) that did not pursue the innovative idea. One of the main differences between this established SME and the others is that it employs a workforce of 120 individuals, whereas the other established SMEs employ less than 30 individuals. Perhaps the size unconsciously influenced the innovative behaviour of the established SME. Accordingly further research on the discontinuous innovative behaviour of established SMEs of various sizes may be interesting, perhaps there is limit to which the entrepreneurial mindset and informal stage gate processes found this thesis apply. A further firm type which should be studied are gazelles, these are rapidly expanding nimble firms that are adaptive to environmental changes and important drivers of employment. The majority of research on gazelles is focused on job creation, but as recognized by Hölzl (2008) there is a lack on the R&D behaviour of these firms. Given the characteristics of gazelles, such as their adaptive nature and agility, which are generally favourable for the development of discontinuous innovations it may be an interesting topic to study in regard to the discontinuous innovation process.

This thesis could not anticipate for differences between the industries and markets on which the established SMEs are active in, more specifically, it is extremely difficult to find several established SMEs that have developed a discontinuous innovations within a relative range and active on in the same industry or market. However this limitation does provide opportunities for further research, as one could study the differences in how established SMEs experience the discontinuous innovation process per e.g. industry or in a given market. Similarly, this study includes a diversity of discontinuous innovations, these obviously differ in technological advancements, which in turn may influence how the established SMEs structure the discontinuous innovation process.

The discontinuous innovation process was managed differently by all the established SMEs studied. The majority of the established SMEs applied a model similar to the open innovation of Chesbrough (2004). Chesbrough (2004, p. 23) describes open innovation as a situation in which *" firms can and should use external as well as internal ideas, and internal and external paths to market, as they look to advance their technology. Open Innovation assumes that internal ideas can also be taken to market through external channels, outside a firm's current businesses, to generate additional value."* In the open innovation paradigm, IP is not only viewed as a defensive mechanism, but it provides additional value as it can facilitate exchange on the market, by allowing IP to flow out and in of the firm (Chesbrough, 2006).

The majority of the established SMEs were aware of the value of external ideas and the interaction with the external environment in terms of outsourcing. Some of the established SMEs applied IP rights to serve as a defensive mechanism, but none of the established SMEs had the intention to sell the IP rights. All the owners wanted to retain interest in the discontinuous innovation. Besides the discontinuous innovation process studied all the established SMEs indicated that they had more innovative ideas, yet not the resources (financial, manpower, time etc) to pursue them. As a result the established SMEs are left with spill-overs created by their external environment and the entrepreneurial mindset within the established SME. This concept provides room for research, as the reasons and options for established SMEs to spin-off or sell ideas may be investigated, for example "*can established SMEs reduce spill-overs and generate greater profitability by finding additional ways to commercialize ideas? "* Besides the commercialization aspect, further research can be conducted concerning the applicability of a semi-open innovation model to established SMEs, given that the characteristics such as resource shortages, the lack of social legitimacy and the entrepreneurial mindset hinder the established SMEs to make a complete shift to the open innovation paradigm.

References

N. Ahmad and E. Gonnard. (2007) High Growth Enterprises and Gazelles *The International Consortium on Entrepreneurship (ICE)*. Copenhagen, Denmark: Statistics Directorate, OECD.

S. H. Alvarez and J. B. Barney. (2001) How entrepreneurial firms can benefit from alliances with large partners. *Academy of Management Executives*, **15**.

S. D. Anthony, M. W. Johnson, J. V. Sinfield and E. J. Altman. (2008) *The Innovator's Guide to Growth. Putting disruptive innovation to work*. Boston: Harvard Business Press.

E. Babbie. (2004) *The practice of social research*. Belmont, USA: Thomson Wadsworth.

L. Barton, D. . (1992) Core Capabilities and Core Rigidites: A Paradox in Managing New Product Development. *Strategic management journal*, **13**, 111-125.

J. Bessant, J. Birkinshaw and R. Delbridge. (2004) Innovation as Unusual. *Business strategy review*, **15**, 32.

J. Bessant and B. Stamm von. (2007) Beyond the lamp-post: Innovation search strategies for discontinuous conditions: Dilab.

J. Bessant and J. Tidd. (2007) *Innovation and entrepreneurship*
West Sussex: John Wiley & Sons, Ltd.

J. Birkinshaw, J. Bessant and R. Delbridge. (2007) Finding, Forming and Performing: Creating Networks for Discontinuous Innovation. *California management review*, **49**.

J. Birkinshaw and C. Gibson. (2004) Building ambidexterity into an organization. *MIT Sloan management review*.

F. Bougrain and B. Haudeville. (2002) Innovation, collaboration and SMEs internal research capacities. *Research Policy*, **31**, 735.

C. D. Charitou and C. C. Markides. (2003) Responses to disruptive strategic innovation. *MIT Sloan management review*, **44**, 55-63.

H. Chesbrough. (2004) Managing Open Innovation. *Industrial Research Institute*.

H. Chesbrough. (2006) Open Innovation: A New Paradigm for Understanding Industrial Innovation *Open Innovation: Researching a New Paradigm*. Berkeley: Oxford University Press.

C. M. Christensen. (1997) *The Innovator's Dilemma. When new technologies cause great firms to fail.* . Boston: Harvard Business School Press.

C. M. Christensen and M. Overdorf. (2000) Meeting the Challenge of Disruptive Change. *Harvard business review*, **78**, 66.

T. C. o. t. E. Communities. (2003) Commission Recommendation concerning the definition of micro, small and medium-sized enterprises. In: T. C. o. t. E. Communities, ed. *2003/361/EC*. Official Journal of the European Union.

R. Cooper, S. Edgett and E. Kleinschmidt. (2001) Portfolio management for new product development: Results of an industry practices study. *R & D management*, **31**, 361.

R. G. Cooper. (1990) Stage-Gate Systems: A New Tool for Managing New Products. *Business horizons*, **33**, 44.

R. G. Cooper. (1999) The Invisible Success Factors in Product Innovation. *The journal of product innovation management*, **16**, 115.

M. Corso and L. Pellegrini. (2007) Continuous and Discontinuous Innovation: Overcoming the Innovator Dilemma. *Journal compilation Blackwell Publishing*, **16**.

E. Danneels. (2004) Disruptive Technology Reconsidered. *The journal of product innovation management*, **21**, 246.

K. Debackere. (1997) Topics in the Management of Technology and Innovation: A Synopsis of Major Findings *Bedrijfseconomische Verhandeling*. Leuven: Department of Applied Economics, K.U. Leuven.

D. R. DeTienne and C. S. Koberg. (2002) The Impact of Environmental and Organizational Factors on Discontinuous Innovation Within High-Technology Industries. *IEEE transactions on engineering management*, **49**.

K. M. Eisenhardt. (1989) Building Theories from Case Study Research. *The Academy of Management review*, **14**, 532.

D. Faems. (2006) *Collaboration for Innovation: processes of governance and learning in R&D alliances.* Leuven Katholieke Universiteit Leuven.

W. Hölzl. (2008) Is the R&D behaviour of fast growing SMEs different? Evidence form CIS III data for 16 countries *Drivers and Impacts of Corporate R&D* Seville: Austrian Economic Research Institute.

S. K. Kassicieh and S. T. Walsh. (2002) Factors differentiating the commercialization of disruptive and sustaining technologies. . *IEEE transactions on engineering management*, **49**.

A. Kaufmann and F. Tödtling. (2002) How effective is innovation support for SMEs? An analysis of the region of Upper Austria. *Technovation*, **2**, 147-159.

I. M. Kirzner. (1999) Creativity and/or Alertness: A reconsideration of the Schumpeterian entrepreneur. *Review of Austrian Economics*, **11**.

A. Kleinknecht. (1989) Firm size and innovation. *Small Business Economics*, **1**, 215.

L. A. Lefebvre and E. Lefebvre. (1992) Competitive Positioning and Innovative Efforts in SMEs. *Small Business Economics*, **5**, 297-305.

R. Leifer, C. M. McDermott, G. C. O'Connor, L. S. Peters, M. P. Rice and R. W. Veryzer. (2000) *Radical Innovation. How mature companies can outsmart upstarts.* Boston, Massachusetts: Harvard Business School Press.

R. Leifer, G. C. O'Connor and M. P. Rice. (2001) Implementing radical innovation in mature firms: The role of hubs. *Academy of Management Executives*, **15**.

G. S. Lynn, J. G. Morone and A. S. Paulson. (1996) Marketing and discontinuous innovation: The probe and learn process. *Operations research/management science*, **36**, 365.

R. Mascitelli. (2000) From Experience: Harnessing Tacit Knowledge to Achieve Breakthrough Innovation. *Product Innovation Management*, **17**, 179-193.

S. Massa and S. Testa. (2008) Innovation and SMEs. *Technovation*, **28**, 393.

C. M. McDermott and G. C. O'Connor. (2002) Managing radical innovation: an overview of emergent strategy issues. *The journal of product innovation management*, **19**, 424.

M. B. Miles and A. M. Huberman. (1994) *An Expanded Sourcebook. Qualitative Data Analysis*: Sage Publications.

mkbservicedesk. (2009) Informatie over MKB in Nederland. Cijfers en organisaties bij het midden- en kleinbedrijf: www.mkbservicedesk.nl.

R. Narula. (2004) R&D collaboration by SMEs: new opportunities and limitations in the face of globalization. *Technovation*, **24**, 153-161.

G. C. O'Connor. (1998) Market Learning and Radical Innovation: A Cross Case Comparison of Eight Radical Innovation Projects. *The journal of product innovation management*, **15**, 151.

G. C. O'Connor and J. R. W. Veryzer. (2001) The nature of market visioning for technology-based radical innovation. *Journal of Product Innovation Management*, **18**, 231-246.

C. A. O'Reilly and M. L. Tushman. (2008) Ambidexterity as a dynamic capability: Resolving the innovator's dilemma. *Research in Organizational Behavior.*, 185-206.

M. Perel. (2002) Corporate courage: breaking the barrier to innovation. *IEEE engineering management review*, **30**, 14.

M. P. Rice, R. Leifer and G. C. O'Connor. (2002) Commercializing discontinuous innovations: bridging the gap from discontinuous innovation project to operations. *IEEE transactions on engineering management*, **49**, 330.

P. A. Roussel, K. N. Saad and T. J. Erickson. (1991) *Third Generation R&D - Managing the link to corporate strategy.*: Arthur D. Little, Inc. .

D. Smith. (2006) *Exploring Innovation*. Berkshire: McGraw - Hill Education (UK).

X. M. Song, J. Thieme and J. Xie. (1998) The Impact of Cross-Functional Joint Involvement Across Product Development Stages: An Exploratory Study. *The journal of product innovation management*, **15**, 289.

J. B. Sorensen and T. E. Stuart. (2000) Aging, Obsolescence and Organizational Innovation. *Administrative Science Quarterly*, **45**, 81-112.

M. Steffensen. (2000) Spin-offs from research centers at a research university. *Journal of business venturing*, **15**, 93.

S. L. C. Tan and K. X. Smyrnios. (2005) Business Orientation, Marketing Capabilities and Firm Performance. Fast 100 Versus Top 500 Companies.

J. Tidd, J. Bessant and K. Pavitt. (2005a) *Managing innovation. Integrating technological, market and organizational change*. West Sussex: John Wiley & Sons, Ltd.

J. Tidd, J. Bessant and K. Pavitt. (2005b) *Managing innovation. Integrating technological, market and organizational change.*. West Sussex: John Wiley & Sons, Ltd. .

J. Tidd and K. Bodley. (2002) The influence of project novelty on the new product development process. *R & D management*, **32**, 127.

M. L. Tushman and P. Anderson. (1986) Technological Discontinuities and Organizational Environments. *Administrative Science Quarterly*, **31**.

A. H. Van de Ven. (2007) *Engaged Scholarship. A guide for organizational and social research.* Oxford: Oxford University Press.

R. W. Veryzer. (1998) Discontinuous Innovation and the New Product Development Process. *The journal of product innovation management*, **15**, 304.

B. Von Stamm and J. J. Bessant. (2007) Beyond the lamp-post: Innovation search strategies for discontinuous conditions.

R. K. Yin. (2003) *Case Study Research. Design and Methods*. Thousand Oaks: Sage Publications, Inc. .

Appendix

General Interview Protocol

Inleiding

1. Kan u kort iets meer vertellen over het bedrijf (hoe is het ontstaan, missie van het bedrijf, belangrijkste bedrijfsactiviteiten)
2. Kunt u wat meer vertellen over uw functie binnen het bedrijf.
3. De bedoeling van dit interview, is om meer te weten te komen over de geschiedenis van innovatie [naam innovatie]. Zou u eens kunnen toelichten wat deze innovatie juist inhoudt?
4. Wat is vandaag de dag de stand van zaken wat betreft het innovatieproject (zijn er al producten op de markt, is er al een datum waarop het eerste product gelanceerd wordt op de markt?)

Research fase van het innovatietraject

5. Wie is op het idee voor de innovatie gekomen?
6. Is het idee tot stand gekomen uit marktbehoeften of uit technologische ontwikkelingen?
7. Zag u vanaf het begin potentieel in het idee? En waarom?
8. Was iedereen binnen de organisatie onmiddellijk enthousiast over het idee? Waarom wel/niet?
9. Was er sprake van een specifiek team dat zich bezighield met de ontwikkeling van deze innovatie? Hield dit team zich full-time hiermee bezig of was dit eerder een 'vrijdagmiddag' project?
10. Kreeg dit project een aparte plaats binnen de organisatie (zowel fysiek als organisatorisch) of werd het project volledig geïntegreerd binnen de bestaande activiteiten?
11. Heeft u de innovatie zelf ontwikkeld, of samen met andere bedrijven? Kan u eens concreet beschrijven hoe de samenwerking met de andere bedrijven verliep?
12. Hoe lang heeft het geduurd vooraleer er een eerste prototype van het product was?
13. Wat waren de belangrijkste problemen/uitdagingen bij het uitwerken van het originele idee?
14. Hoe bent u met deze problemen/uitdagingen omgegaan.
15. Is het originele idee onveranderd gebleven of hebt u toch aanpassingen moeten doorvoeren? Waarom ? Kan u een concreet voorbeeld geven?
16. Zijn er tijdens deze eerste fase belangrijke gebeurtenissen geweest (binnen of buiten de organisatie) die een grote impact hebben gehad op het innovatieproject
17. Hoe werd de uitwerking van het originele idee gefinancierd (enkel interne financiële middelen, overheidssteun, andere partners?)
18. Zijn er bij het begin van het project momenten geweest waar men overwogen heeft op het project te stoppen? Kan u hier iets meer over zeggen?

Development fase van het innovatietraject

19. Hoe heeft men getracht interesse te krijgen van potentiële klanten voor het nieuwe product?
20. Wat waren de belangrijkste vragen/opmerkingen van klanten?
21. Was het gemakkelijk om eerste klanten te vinden of verliep dit proces vrij moeizaam?
22. Werden klanten expliciet betrokken bij het ontwikkelingsproces?

23. Nadat de eerste prototypes zijn vervaardigd moet er dikwijls veel tijd gestoken worden in het verder optimaliseren en verbeteren van het product zodat het daadwerkelijk op de markt gebracht kan worden. Kan u eens beschrijven hoe dit optimalisatie proces binnen het bedrijf verliep?
24. Nadat eerste prototypes van het product klaar waren, werden er op dat moment andere mensen bij het project betrokken? Wie?
25. Werden er op dat moment externe partijen betrokken in het ontwikkelingsproces? Hoe verliep de samenwerking met deze externe partijen?
26. Zijn er tijdens het verdere ontwikkelingsproces nog belangrijke aanpassingen aan het product aangebracht?
27. Wat waren de belangrijkste problemen/uitdagingen tijdens dit optimalisatieproces?
28. Hoe bent u met deze problemen/uitdagingen omgegaan.
29. Zijn er tijdens deze fase belangrijke gebeurtenissen geweest (binnen of buiten de organisatie) die een grote impact hebben gehad op het innovatieproject

Manufacturing fase van het innovatietraject

30. Wat is vandaag de dag ongeveer de omzet die gehaald wordt uit dit nieuwe product?
31. Hoe wordt dit product geproduceerd (een geautomatiseerd productieproces versus stukproductie met veel handmatige handelingen)
32. Verliep de evolutie naar het produceren van deze producten vlot of zijn er specifieke problemen opgedoken (verklaar u nader)
33. Hoe bent u met deze problemen omgegaan?
34. Wordt er nog steeds getracht het innovatieve product verder te optimaliseren?
35. Zijn er al plannen voor nieuwe generaties van het product?
36. Wie is er verantwoordelijk voor de verdere optimalisatie? (Zijn dit nog steeds dezelfde mensen als bij de start van het innovatieproject?)
37. Worden hierbij externe partijen betrokken? Hoe verloopt de samenwerking met deze partijen?
38. Als u de huidige situatie vergelijkt met het prille begin van dit innovatieproject; wat zijn dan de belangrijkste verschillen?
39. Komt het uiteindelijke product dat nu op de markt zit overeen met het originele idee, of zijn er toch duidelijke verschillen (hoe zijn deze verschillen te verklaren?)
40. Zijn er tijdens deze fase belangrijke gebeurtenissen geweest (binnen of buiten de organisatie) die een grote impact hebben gehad op het innovatieproject

Vragen om interview af te sluiten

41. Wat heb u geleerd uit dit innovatietraject?
42. Algemeen gezien, wat zijn volgens u de belangrijkste uitdagingen waarmee MKBs geconfronteerd worden wanneer ze willen innoveren.
43. Wat zijn volgens u essentiële acties die managers van MKBs moeten ondernemen wanneer ze succesvol willen innoveren?