Master's Thesis
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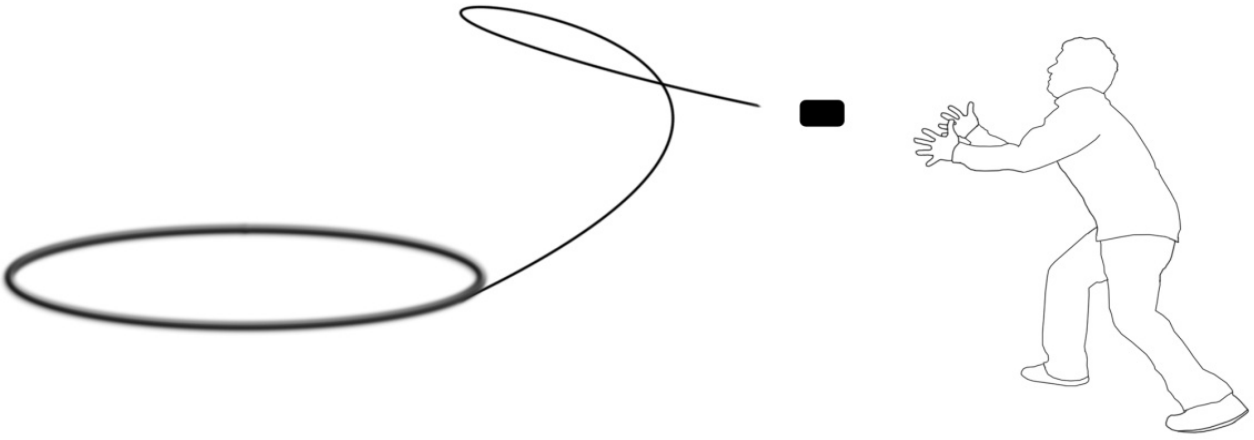
# Dissemination of CERN Technologies Through External Entrepreneurs

December 2008, Geneva



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CERN
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# Preface

This paper represents the Master thesis conducted by the undersigned author in collaboration with the Norwegian University of Science and Technology (NTNU) at the Department of Industrial Economics and Technology Management (IØT) and the European Organization for Nuclear Research (CERN) in Switzerland at the Technology Transfer Group (TT Group).

The topic investigated in this thesis has crystallized itself from the academic background achieved through specialization in Business Administration at IØT, the mandate of the TT Group and finally but most important the author's interest and curiosity in making a contribution within this field of study.

This work where conducted in the period 14th April - 12th December 2008. It is sought best purposes with this research, if there are any errors or omissions in this report they are in sole responsibility of the undersigned author.

I would like to show my gratitude for the efforts my supervisor Dr. Arild Aspelund and Henning Huuse have contributed my thesis. I would also like to thank Dr. Jean-Marie Le Goff and my colleagues for their dedicated time for feedback and discussion.

Geneva, 12th December 2008,

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# Abstract

This study focuses on dissemination of innovations through external entrepreneurs. The innovations studied are developed at the European Organization for Nuclear Research (CERN) and commercialized by entrepreneurs establishing spin-off companies on the outside of the Organization.

The objective of this study is to provide knowledge to facilitate future external entrepreneurs to increase dissemination of CERN technologies. The research questions looks at the timeline from preparations for creating the spin-off company, until having a product for commercialization in the market.

A qualitative cross case investigation was conducted to assess the experiences of four spin-off companies. A framework was created to structure the discussion by finding and categorizing impeding- and success factors seen from the entrepreneurs point of view. The findings where structured in three phases respectively, the time before starting the company, the beginning of the company and the final development before selling products.

The findings in phase one points at clarifying the ownership of the technology, finding an application, evaluating the role of patents and suggest establishing an external commercial contact network. In phase two it is found great value of CERNs name and it is suggested to create a framework for identifying shared technical objectives for future R&D partnerships. In phase three it is suggested to distribute the financial recuperation of the technology's value, accordingly to the financial strength of the company, it is also suggested to arrange a public event to create a stronger link between the research- and business world.

This study identifies economical impact of technologies from fundamental research on society. Fundamental research is an important source of innovations and spin-off companies have shown to be an effective vehicle for technology dissemination. For future literature it is recommended to expand the research to involve inventors, investors and national institutes and legislations for acquiring a more holistic picture on facilitating external entrepreneurs.

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# 1 Introduction

### 1.1.1 Entrepreneurs in economic theory

At the time of Aristotle, about 300 years BC, the entrepreneurs were considered to earn money at the cost of others, a player of a zero-sum game in the economy [Praag, 1999] and considered to be an actor in distribution of a fixed amount of resources in society.

In more recent times, their role in economy was changed by the pens of Jean-Baptiste (1767-1832) and Marshall (1842-1924) where entrepreneurs became coordinators of production, distribution, consumption and risk takers. Schumpeter (1883-1950) later on identified the entrepreneur as an innovator and leader, providing economic growth.

Today, entrepreneurs are considered to be key players in the economy [Walter et al., 2006], claimed to be an engine of innovation [Schumpeter, 1947, Hindle and Yencken, 2003]. They bring new products to the markets and bridge gaps between research and business worlds [Abramson et al., 1997, O'Shea et al., 2005].

### 1.1.2 Spin-off companies as vehicle for transferring innovations

A majority of the rise in material standards of living has since the industrial revolution in 18$^{th}$ century its causes from innovations, and they have been the engine of economic growth [Edquist, 2005, Cotis, 2006]. Innovations also play a central role in the evolution [Audretsch, 1995] of industry and market leadership [Freeman et al., 1997] and recently a more open approach to exploit innovations from public research has surfaced.

The open innovation paradigm was first introduced by Chesbrough [2003] and is partially characterized by using external paths to the market as the technology originator looks to advance the state of their technology [Chesbrough et al., 2006]. This open approach to commercialize innovations, provides diversity and growth to industry [Andersen, 2006, Praag

and Versloot, 2007], and it brings an increased utilization of the technology originator's base of innovations [Chesbrough et al., 2006].

One of the strategies to carry out open innovation is by using entrepreneurs creating companies. They discover market opportunities, shaped by disequilibrium in the market [Shane and Venkataraman, 2000], and sees the opportunity of capturing profits [Schumpeter, 1934, Casson, 1982] when transferring innovations [Kirzner, 1997] by creating spin-off companies.

### 1.1.3 Research object and questions

The literature on entrepreneurs commercializing innovations from research is today rapidly expanding in Europe and United States. The theme of creating spin-off companies in the commercialization process is a vibrant area providing a promising research avenue for further study [Rothaermel et al., 2007]. A lot of universities are therefore looking for strategies to deal with the vestiges [Wright et al, 2003] of entrepreneurship at universities [O'Shea et al., 2005] to guide practice [Powers and McDougall, 2005].

There has been found little attention in literature on how to transfer technologies spawned from fundamental research to industry by means spin-off companies [Le Goff, 2008]. The purpose is therefore to study how to facilitate entrepreneurs with the strategy of open innovation, by exploring existing experiences of disseminating technologies through spin-off companies.

It is chosen to use the European Organization for Nuclear Research (CERN) as object and representative for public organizations conducting fundamental research, and as technology originator providing external entrepreneurs with technologies. This will provide knowledge about the dissemination process to be capable of facilitating external entrepreneurs in their efforts.

CERN has provided society with innovations having a major impact on society. The most important is the World Wide Web, invented by Sir Tim Berners-Lee. CERN has also enabled

Positron Emission Tomography (PET) through contributing with essential development of reconstruction methods to establish pictures used for cancer treatment. Today, the PET is used in combination with CT scanning at hospitals worldwide. This is a very exciting provider of innovations to entrepreneurs!

To study dissemination of innovations, it has been decided to investigate how to facilitate external entrepreneurs bringing innovations to the market. This will be achieved by studying existing experiences among external entrepreneurs commercializing CERN technologies. The following questions have been subject of investigation:

- What were the impeding- and success factors influencing the creation of spin-off companies for transferring technologies?
- How can spin-off companies be facilitated in the process of commercializing basic technology in the market?

The empirical data was gathered from four case firms which already have commercialized CERN technologies. They have a history of collaborating with CERN and have been studied by using a qualitative positivistic approach.

### 1.1.4 Structure of this paper

This paper is structured to follow six main chapters. The introduction is the starting point for the study representing its context and focus. The literature review provides current research contributions related to transfer of technologies and research questions. The method chapter shows the procedures around collecting data. In the empirical data, CERN as research object, the firms and findings are presented, and the discussion debates the findings according to the research questions. Finally, the conclusion summarizes the findings.

# 2 Literature review

## 2.1 From political incentives to academic interest in Technology Transfer

### 2.1.1 Political incentives increases Technology Transfer activities

Technology Transfer (TT) could be defined as follows: *"Technology Transfer is an active and intentional process (licensing, foreign investments, buying) to disseminate or acquire knowledge, experience and the related artifacts"* [Hawthorne, 1978, The Management of Technology, page 65].

TT has its origin from industry when scientists saw the opportunity to go outside the company to realize their technology breakthroughs outside the main agenda of the mother company [Chesbrough et al., 2006]. For industry, open innovation enables tapping into innovation resources outside their own company and additional sources of technologies [Chesbrough, 2006].

This change caused increased attention towards intellectual property (IP) at universities. Their utilization of IP have initiated policymakers and academics with interest for publicly funded research [Mustar, 1997] as a way to generate wealth in society [HM Treasury and DTI, 1998, Rogers, 2003, Wright et al., 2004] through adopting the open innovation approach used by industry.

This interest was formalized when acts in the 1980s engaged universities in the US to formally start TT. The Bayh-Dole Act (1980), the Stevenson-Wydler Act (1980) and the Federal Technology Transfer Act (1985) implied a fundamental change in the commercial exploitation of scientific discoveries and Federal laboratories in USA [Molnar et al., 1997, Markman et al., 2005], because the acts gave the universities and laboratories control and interest in their IP.

Since the acts, universities in the US involved in TT activities have increased by eightfold [Markman et al., 2005] and the number of patents fourfold [Mowery and Shane, 2002]. As technology originators, this increased the utilization of their base of innovations [Chesbrough et al., 2006]. In addition to the US, it is a growing interest for TT in Europe among academics,

especially the UK, Germany, Italy and Sweden [Rothaermel et al., 2007], and universities have adopted an open innovation approach to utilize external sources for advancing their technology.

The TT activities have generated interest among academic researchers and policy makers in literature. A journal is dedicated to this topic and in the last decades, hundreds of books and articles have this term in its titles [Bozeman, 2000]. Changes in the legal, economic and political environments have accelerated the translation of academic research to commercial products and this interest has made universities today even more active towards TT [Feldman et al., 2001].

### 2.1.2 Spin-off companies emerging as TT strategy

Along with the increased attention towards TT, several strategies have arisen for commercializing innovations. Bozemann [2000] identifies several; open literature, patents and copyright, license, workshops, personnel exchange and sharing facilities. The different alternatives have initiated motivation to find the most efficient solution, and recently there have been changes in the way TT is conducted.

Disadvantages such as not being able to capture the full value of IP and difficulties with patenting and contracting, has made the universities look for more routes to commercialization [Lockett et al., 2003]. In parallel, there has been a change in culture towards a more positive attitude at universities to entrepreneurship [Wright et al. 2004], and now universities have extended from traditional licensing towards use of spin-off companies [Siegel et al., 2003].

The relation between TT and spin-off companies is shown through the forming of a company which is usually formed on the basis of the university's technology [Carayannis et al., 1998, Shane, 2006]. Chesbrough [2002] complements this view by adding that spin-off companies commercialize research discoveries outside the main agenda of the research organization, as a way of advancing technologies through open innovation. The spin-off companies is therefore

typically based on research and created to establish an independent organization with the purpose of commercializing the technology.

Spin-off companies have proven to be very efficient as TT strategy [Carayannis et al., 1998, Rogers et al., 2000] and enables a wider range than licensing of equity ownership to the technology, drawn from both the inside and outside of the research organization [Lockett et al., 2003]. Also, research shows that taking equity in spin-off companies usually creates larger returns than the average license [Bray and Lee, 2000].

There has been a rapid rise in Europe where spin-off companies serve as a strategy for commercialization, and where science parks, incubators and other property-based organizations have arisen to launch and nurture these companies [Lockett et al., 2005]. Today, research based spin-off companies have established themselves as an important TT strategy [Di Gregorio and Shane, 2003], and the literature have focused on both the creation of companies and how to best manage their process of evolvement.

## 2.2 Past research on spin-off companies

### 2.2.1 Overview on existing streams of research

To position this thesis it has been chosen to use Rothaermel et al., [2007] review of published articles investigating spin-off companies based on public research between 1981 and 2005. They identify four streams of research that encompass the different pieces in the fragmented field of literature on creating spin-off companies at universities.

The first stream is the entrepreneurial university, which emphasize organizational designs that could increase the commercialization of university innovations and the advancement of these. Examples of the investigated items are the incentive system, policy of the university and culture.

The second stream looks at the productivity of the technology transfer offices. These investigations emphasize the technology transfer office at the university as the formal gateway

between the research organization and industry. Measures of their productivity have been factors such as number of patents, received royalties and number of shared clients.

The third stream of research focuses on new firm creation, where it is mainly focused on entrepreneurial activity. Three elements have been found measured in the literature; the quantity of new firms, their performance and their attributes. It has also been studied both internal and external conditions influencing the creation of companies.

The fourth stream is looking at the environmental context and networks of innovation. It is here claimed that university entrepreneurship is a result of being embedded in networks conducting innovation. The researchers have looked at factors such as innovation networks, science parks, incubators and geographic location.

The first research question mentioned in the introduction is most relevant to the stream of entrepreneurial university. However, while the current literature is focusing on how to facilitate entrepreneurs seen from the universities point of view, it is here chosen to look at the subject seen from the entrepreneurs point of view.

The second research question is more related to the stream of new firm creation as the performance of the companies is found in the development of the company, rather than the initial event of creating the company. It is therefore chosen to further locate the current findings after the company has been established to collect a more holistic picture of the subject of facilitating spin-off companies.

### 2.2.2 Influences on creation spin-off companies

Franklin et al. [2001] identifies favorable conditions and barriers for creating spin-off companies among successful universities. In particular there has been found that the academics understanding of the potential applications and technologies to be important. There was also found to exist barriers if the university perceives the academics to become less active in their research if pursuing a company and if the lack of seed funding were present. They also suggest

using both internal and external entrepreneurs in the approach to develop successful spin-off companies, as it gives possibilities of combining the advantages of both strategies.

O'Shea et al. [2005] takes a resource-based perspective to identify practices for success. They recommend research organizations to invest in implementing educational, research and resource program to enable a culture of entrepreneurship and encourage academics to participate in the entrepreneurial process. It is also found that the faculty's quality, with regard to university spin-off activity, has proven to be important to success by hiring and keeping top ranked scientists and engineers to maintain knowledge to create novel innovations. Their final finding shows a positive effect of closer collaboration with industry.

The entrepreneurial team has been investigated by Clarysse and Moray [2004]. They have investigated the process from idea of starting a company to post startup phase through a prospective approach. They suggest teaching internal people at the university with a very high understanding of the technology, and teaching them the capability to develop the business when establishing companies. This is because they find achieving acceptance of outsiders in commercializing the technology extremely difficult, if the technical people behind the technology also are interested in commercialization. Therefore they recommend coaching of technical persons instead of finding external entrepreneurs. Important consequences of such a solution would however lead to a loss of intellectual capabilities with the best people leaving research organizations, and demand substantial experience and resources to coach the team. It would also be reasonable to expect the university's policy to influence the capability of the commercial activities.

In a retrospective longitudinal study, Shane and Stuart [2002] study the relationships between the spin-off companies and investors, both indirect and direct. They find the social capital of the entrepreneurs to endow the establishment of funding for the spin-off companies and to be the single most important determinant for establishing the first equity ownerships in the company. To obtain external funding, it has been found to be a critical element of success prior to establishing the company. The findings do not provide any information about this being an enabler the entrepreneurs are aware of before deciding to commercialize the technology.

Johansson et al., [2005] illuminate the relations between research organizations and spin-off companies through an instrumental case study approach with a wide perspective. They investigate the ties between the parties, and the strength of them. In fundamental research, they find the relations to be very important as they are difficult to substitute, implying that the spin-off company is dependent on continued support. The ties are found to be based on trust and informality. These results implicate the relevance of personal relations to the technology originator as very important for transfer of necessary knowledge and the vulnerability for the company is obvious. This might imply changes in the universities policy at higher levels.

Powers and McDougall [2005] use multisource data in a resource-based approach to investigate the effects of resources on number of companies started from universities. They compliment the other findings by investigating external conditions. It is found that R&D investment by industry is key element in successful TT programs. This opinion is built upon the universities change in role as they have become an engine of economic development, and that this could imply a greater collaboration with industry. They see external venture funding in geographical vicinity of the university as valuable, but advertise for more investigation on the relationship between creation of spin-off companies and venture capital before concluding because of earlier inconsistent findings.

They find that the role of the university in economical development has been strengthened because of an increase of knowledge in national and regional innovation systems of economical growth. Universities started therefore research as a core function and an increasing activity towards entrepreneurship. It is not commented that students, educated in the university system transferred to industry and further research, is the main contributor to TT. This is possible if granting education the status as an active intentional process of TT as mentioned in the definition in 2.1.1, and should be taken into account when evaluating the role of universities, and whether the change is significant or not with regard to economical development.

### 2.2.3 Findings on managing the process of the spin-off companies

The research stream on spin-off companies has also gradually shed light on how to manage the process of new spin-off companies based on two approaches [Lockett and Wright, 2005, Rothaermel et al., 2007]: First, it is useful to look at impeding factors to the process of commercialization and secondly it is valuable to look at success factors.

Impeding factors has been identified; informational gaps and uncertainty [Lerner, 2005], unrealistic expectations, lack of competence in founding teams, resource scarcity and cultural problems [Rappert et al., 1999, Rothaermel et al., 2007], little experience in managing the TT process related to spin-off companies [Collins and Wakoh, 2000], IP rights disagreements [Steffensen et al., 2000], crash of cultures between scientific and business environments [Samson and Gurdon, 1993] and the absence of holistic approach [Kinsella and McBrierty, 1997, Chiesa and Piccaluga, 2000].

Success factors have been investigated; a clear strategy towards spin-off companies and use of external entrepreneurs, offering expertise, external networking activities and with a widely distributed ownership equity in the spin-off [Grandi and Grimaldi, 2003, Lockett et al., 2003, Lockett and Wright, 2005] show external IP protection contributes to success of spin-off companies, and networking activities of university spin-offs, resources and university involvement have shown to have a positive influence [Rothaermel et al., 2007] and finally a contribution is found in TT offices support of development, channeling resources and giving credibility [Leitch and Harrison, 2005].

The current findings are mostly based on a qualitative cased based approach, but the past research is strongly dependent the availability of appropriate data. The found data is mostly based on survey designs and still there is potential for enhancing the external validity [Rothaermel et al., 2007] through investigating larger contexts than a single university. The literature could also benefit from better distinguishing the problems related to an early phase of the initiative of using spin-off companies, and long term consequences of using entrepreneurs at a university.

## 2.3 Further research: The gap between fundamental and applied technology

As presented in the introduction, there has been found a gap in the literature on science based spin-offs as intermediary between fundamental research and applied technologies, these companies were identified as mediators by Autio [1997], enabling their customers to compete on the technological forefront, but there has been found less research on how spin-off companies commercialize fundamental research technologies in the market and suggestions for routines on how the relation between the university or research center and spin-off company should be [Markman et al., 2005].

Fundamental research has no immediate practical payoff, but contributes to the long run research capabilities and is less targeted to the needs of companies [Cohen and Levintal, 1989]. Applied research, on the other hand develops targeted marketable products with a more immediate return for the companies on their technology [Cockburn et al., 1999].

This means that technology originating from fundamental research is rarely mature enough for a company to realize its commercial value immediately [Le Goff, 2008]. Fundamental research is driven by the curiosity of researchers and not for answering questions or problems based on commercial applications in the market [Smith, 2008], and it is not obvious whether or not the technologies have commercial value; furthermore they could be abandoned or further developed based on commercial potential.

The reasons for commercializing fundamental research are many. Several values of fundamental research have been identified by David [2003]. First, government funded universities are today subsidizing the R&D performed by the private business sector through providing high quality researchers for employment, as adequately equipped research universities serves as the choice for the most competent scientists and engineers. Secondly, the fundamental research provides industry with knowledge for applied research in the private sector, for example in the form of guidance to reach technical objectives as the latest techniques for science and engineering are provided by research. Third, it lowers the risk of the technical development because fundamental issues in the technology are solved. Aymar [2008]

compliments these findings by stating that the value of fundamental research in the market is visible because it provides the science to apply in industry.

Most of the technologies need further development before they could be used for commercial applications, and therefore the company commercializing it needs both time and resources to do so. It could be said that there exists a gap between the developed technology from fundamental research and to the point of applied research the result is the technology being applicable in the market [Le Goff, 2008].

## 2.4 Expected empirical findings

The past literature has been investigated to understand the background of TT and to find the existing findings. It is expected that this investigation will reinforce the existing findings as well as finding new ones when answering the research questions. The following findings would be expected:

*Research question 1: What were the impeding- and success factors influencing the creation of spin-off companies for transferring technologies?*

As mentioned in 2.2.2, it is expected that the creation of spin-off companies is influenced by the university system, the faculty's quality, the entrepreneurial founder teams, the relationships to investors, the social capital of the entrepreneurs and by the external conditions in industry.

It is also expected that the technology- and the market potential to be important before the entrepreneurs decide to commercialize the technology [Shane and Venkataraman, 2000] and as the necessary resources to bridge the gap between fundamental to applied technology, is likely to be substantial.

Finally, the university's policy would most likely influence the capabilities of the commercial capabilities of the research organization. There has been found less attention to this subject in literature, however the character of fundamental research is so different from applied research

that the effect of the difference between research and commercial activities is expected to have an impact.

*Research question 2: How can spin-off companies be facilitated in the process of commercializing basic technology in the market?*

The current findings in the literature are expected to have influence on what the entrepreneurs emphasize as impeding- and success factors to develop their company. A summary of the findings have been listed in table 1.

| **Impeding factors:** | **Success factors:** |
|---|---|
| Informational gaps and uncertainty | Clear strategy for spin-off company as TT strategy |
| Unrealistic expectations and lack of competency in the founding team | Use of external entrepreneurs |
| Resource scarcity | Offering expertise and external network |
| Little experience in managing the TT process | Widely distributed equity in the company |
| IP rights disagreements | External IP protecting |
| Crash between scientific and business culture | University involvement and resources |
| Absence of holistic approach to spin-off | TT office support of contacts, resources and credibility |

*Table 1: Expected impeding and success factors to develop spin-off companies based on the literature review.*

The companies are expected to have spent a significant amount of resources to bridge the gap between fundamental and applied research through investing resources and time to find a potential application for their technology and to adjust the technology for commercial use.

Also, the technology brought to the market by the spin-off company is expected to have an important influence on the private sector and that the significance of its innovative properties is novel compared to existing products.

# 3 Methodology

## 3.1 Choice of methods

### 3.1.1 A qualitative approach

The chosen method in this thesis is based on the knowledge sought through the chosen research questions [Silverman, 2000, Fowler, 2002, Dale and Murray, 2008, Helseth, 2008]. From studying the literature with regard to the research questions, there has been found some relevant knowledge, but the context of fundamental research is partially different, which implies an exploratory approach to find comparable and new knowledge in this investigation.

The sought knowledge will be investigated and presented in words, and it is rather complex. It is chosen to try to establish a meaningful, holistic picture of the situation to these companies, rather than a factorial analysis. To achieve this, it is more efficient with an interactive approach, and these considerations are characteristics of the qualitative research method [Lofland, 1971, Lilledahl et al., 2007, Tufte, 2007, Tjora, 2007]. It was therefore decided to use a qualitative research method to conduct this investigation.

### 3.1.2 Determining factors and chosen methods of collecting data

Within the qualitative approach, there are several methods of collecting data. Four methods are presented by Silverman [2000]: Observation, archival study, interviews and transcripts. To select between these methods, depends on internal as well as external considerations.

Internal considerations stand for the research questions and how it is investigated. The nature of the research questions and time frame, observation is not a good option, but selecting only one of the methods would also be inadequate. Therefore it was chosen to choose at least one method for collecting data to increase reliability of the research.

The external considerations are discussed by Yin [2003]. He emphasizes three aspects; the type of the research question posed, the extent of control the investigator has over actual

behavioral events and third the degree of focus on contemporary as opposed to historical events. The first two determining aspects correspond with the section above. The last point however, shows the importance of distinguishing the past and presence in research.

Benefits of the archival study are the easiness of interpretation, the availability of the sources when needed, and the low cost of resources spent to collect the material. In addition this source is stable and can be reviewed, unobtrusive, not created as result of the case study and they are exact and have a broad coverage in time, events and settings [Yin, 2003].

The interview is a well established research tool in studies with a social approach [Britten, 1995]. A benefit of the interview is that it takes into consideration the difficulties by conducting an exploratory investigation; the preconception of a subject characterized by distortion and shallowness [Holme and Solvang, 2004], the difficulty of explaining and rendering the coherent flux of reality [Lofland, 1971] and finding the thoughts, experiences and perceptions of the respondents world [Patton, 2002]. The interviews flexibility with regard to structure provides a handy tool to deal with these difficulties [Mason, 2002].

The transcription of interview data has among researchers been judged to be an important component of the analysis process of the found data [Lapadat and Lindsay, 1999]. It is not only the benefits of generating written material for facilitating the analysis, but the process also is valuable. The close attention given to the data and the interpretive process is needed to make sense of the data, and it is a theory-laden component of the qualitative analysis [Lapadat and Lindsay, 1999].

In accordance with the determining factors, it was therefore chosen to look further into archival study, interviews and transcripts. Due to the limited time of investigating the research questions and lack of control on the behavioral events, observation is less suited as methods in this investigation.

## 3.2 The role of the research methods

The archival study in this dissertation was used to collect the obvious and more formal information which is not valuable enough to spend time on during the interviews, and which did not need a profound interpretation. It was also sought to widen the approach by using it as a complementary source to the data gathered in the interviews, because of the easy availability of the sources. The archival study's role was also chosen to prepare the interviews in a way that facilitates the conversation with the respondents, because the background knowledge which increases the ability to memorize the conversational subjects and therefore increase the understanding during the interviews.

The interviews enable the collection of information in the exploratory study, and to meet the important challenges in the qualitative research as mentioned above. To achieve this, the role of the interview is to serve as a semi-structured approach, to reveal the respondents thoughts and experiences and overcome the preconceptions related to the research questions. The interview was also serving as an important part of the discussion as the transition between data collection and analysis is gradual [Holme and Solvang, 2004] and iterations are common [Lilledahl et al., 2007].

The role of the transcripts in this investigation is to extend the interview and interpretation of the interview, by transforming the recorded oral data into written material. The purpose of this was to relax the necessity for taking notes during the interviews, facilitate the interpretation of the data and to be able to check the emotional state of respondent after wise, for assuring accuracy and honesty of the given information.

## 3.3 Sample

### 3.3.1 Cases as research objects

To understand how to facilitate the spin-off companies, it is important to understand the dynamic environment where they are created. At present, studying cases are well fit implement this strategy [Huberman and Miles, 2002] and widely (64%) used within corresponding

literature [Rothaermel et al., 2007]. Cases are also well fitted to a combination of methods [Miles and Huberman, 2002], and they are typically used for synergies between interviews and archives [Eisenhardt, 1989]. Cases are also particularly suited for organizational and management subjects [Yin, 2003].

Firstly, the selection criteria's for the chosen cases were knowledge about which companies to contact. They were found in the database of companies commercializing research technology from a research organization conducting fundamental research. Secondly, they were evaluated according to focus the effort on relevant cases based on the theory studied, and to extend theory by filling the conceptual categories [Eisenhardt, 1989]. Third, it was chosen to learn from the experiences of Carayannis et al. [1998] and to look at the spin-off companies including both cases were inventor did or did not follow the company formed on the outside of the research organization.

### 3.3.2 Sample size

How to choose sample size is a debate in the academic literature. Eisenhardt [1989] claims there aren't ideal number of cases to investigate, but that fewer than four strikes the credibility of case research and generate difficulties to create complex theories. In this paper it is not the goal to create a complex theory, but to investigate practices on how to be able to successfully create and develop spin-off companies in the future. Gibb and Wilkins [1991] contradicts this view, and claims that one case is enough, because if more than one case is studied it is neglected less obvious insights and therefore the result is constructing a distorted picture of the underlying dynamics in the case. It is clear that both strategies have disadvantages.

Instead of defining a concrete number of cases, it was chosen to investigate a pre-assessed number which could give a representative picture of the company's situation according to the research questions. This means that after each case, the findings was summarized and compared to the findings in the next case. Consequently, the investigation was stopped after

four cases, where the findings reached a mature level when a significant amount of new results were rare.

## 3.4 Frameworks for collecting data

### 3.4.1 Creating the appropriate frameworks

Based on the choice of a qualitative approach (3.1), the role of the research methods (3.2) and sample (3.3), it was chosen to establish a framework for collecting data.

The main purpose of these frameworks is to provide answers to the research questions. Considering the learning's from the literature review, the data collection shall provide both findings for comparison, and new findings in the context of fundamental research. The framework also needs to take into account the interactive approach which is a key element in exploratory qualitative research and the investigation needs to collect a holistic picture.

This implies a challenge, but to solve these issues it is chosen to create a conceptual framework that both allow freedom and structure during the interview; a semi-structured approach [Kvale, 1996]. Considering the role of the archival study collect information, it is sought to answer basic questions to provide a background for understanding the companies during the interview. The role of the interview is more complex than the needs of the archival study, and is influenced by the researchers increasing understanding of the research questions during the interview and between the interviews, and therefore it is chosen to form a framework with categories and with as little content as possible, to ensure an achieved growth consequently arising from the pre-analysis [Strauss, 1987].

Finally, the framework for the interview is based on the practices used by Ndonzuau et al. [2002]; to split the commercialization process of the company into phases according to its main business activities, it was chosen to use the classical approach [Locket and Wright, 2003, Lockett et al., 2005] by looking at the influence of impeding- and success factors [Sine et al., 2003, Vohora et al., 2004] and the number of companies was the final factor that determined the design of the framework.

### 3.4.2 The resulting frameworks

The following information was collected from each company: Company name, the year it was founded, the technology it commercialized and the support it had from the research organization. The framework can be seen in table 2.

| **Company** | **Founded** | **Technology** | **Support from research org.** |
|---|---|---|---|
| Company 1 | Year | Commercialized technology | Facilitating factors |
| Company n | - | - | - |

*Table 2: The framework for collecting data from in archival study*

In the second framework for collecting data, the first part (phase 1) is intended to answer the first research question which specifically addresses the influencing factors that happens before the company is created. A broad approach is chosen where the respondent is encouraged to present his picture of what he did before he started the company. The second part (phase 2 and 3) is intended to investigate the process where the entrepreneur transfers the technology from the research organization to the point of having a market ready product. The second research questions looks at this process by exploring impeding- and success factors.

These factors were divided into four categories; “critical to success”, “less critical to success”, “impeding” and “less impeding”. Each of these four vertically divides each main phase of the company. The process of the development of companies was divided by main business activities. It is in this study presented three phases; phase 1: “The idea of a company”, phase 2: “Initiation of the company”, and phase 3: “Critical technology development phase”.

This framework was presented to the respondent, and if he were reluctant or less confident to speak freely, the questions listed in Appendix A were used to support them in helping them to provide information about their experiences. The framework can be seen in table 3.

| | | Creating the company | Process of commercializing technology | |
|---|---|---|---|---|
| *Company* | *Influence* | *Phase 1* | *Phase 2* | *Phase 3* |
| | Phase/Classification | The idea of the company | Initiation of the company | Critical technology development phase |
| | Characteristics: | Finding commercial potential. | Establishing the spin-off company. First phase of development. | Developing the technology for the market. Last phase of development before commercialization. |
| | Activities: | Technical/commercial feasibility study, team-building, creating business plan, sponsors. | Formal registering, organization structure, finding investors. | Solving technical problems, preparation for selling products, entering the market |
| | Critical to success | | | |
| | Less critical | | | |
| | Impeding factors | | | |
| | Less impeding factors | | | |

*Table 3: The framework for collecting data during the interviews*

## 3.5 Evaluation of the research design

The research design is supposed to represent a logical set of statements; therefore the quality of the design could be tested by logical tests [Yin, 2003].

It wasn't chosen to use a combination of qualitative and quantitative data, which is often used in research within social science. However, this study is not purely qualitative, since the data collection is categorized and put in order according to importance and since categorizing the data in this way also is a quantitative methodology [Tufte, 2007]. It could further be developed and used in a quantitative study. At this stage, it is more reasonable to conduct a qualitative study thoroughly, than stressing using both methods in parallel, due to resource constraints.

The interview is a many sided arena for exchanging information. Influencing elements distort an objective interpretation and the limits of cognitive capabilities are influencing the result. To reduce misinterpretations, misunderstandings and needs being stated which were not relevant in the communication process, it was sought to be aware of differences in non-verbal language, attitudes, clothing, cultural differences, educational background and other influential factors in the social positioning process and interpretations.

The framework and questions established, creates a semi-structured approach to the research questions. The preconception of the subject or problems is based on literature study, experiences and imagination and is not expected to represent the interpretation of the problem as seen from the respondents. It was therefore chosen not to interpret the framework too rigidly, and to keep an open approach by leaving most of the content from which it was created.

## 3.6 Data collection

To gain a better understanding of the context of fundamental research, it was chosen to investigate CERN as representative for a public organization conducting fundamental research and to study the background of the TT process and technologies that have been commercialized. The TT process and role of CERN was explored to understand the background of the entrepreneurs view on what they experienced when creating a company based on CERN technologies.

Before the interviews, basic information about the companies was gathered on the internet and archived possessed by the TT Group. The rest of the data were collected upon initiating contact by email describing the project, and then it was carried out by interviews both face-to-face and by telephone connection.

The interviews were conducted in the period October-November 2008 with representatives from each company. These persons were the CEO/CTO and founder of the companies being in

the company from their start up until November 2008. The interviews ranged between one to two hours, and were recorded on tape. They were conducted in the offices of the persons.

# 4 Empirical results

## 4.1 CERN

To investigate spin-off companies spinning out from fundamental research it was, as mentioned in the introduction, chosen to study CERN who represents more than 50% of the entire fundamental research activity worldwide [Le Goff, 2008].

CERN was founded in 1954 from the visionary scientist's imagination of a European atomic physics laboratory. The Organization has fostered three Nobel Prize Laureates in physics [CERN, 2007], 4500 Member States[1] scientists and 1700 non-Member States scientists are currently working here and about 50 000 articles have been published in various journals. This has made CERN one of the most respected centers for research worldwide [CERN, 2007]. CERN has the following Convention:

*"The Organization shall provide for collaboration among European States in nuclear research of a pure scientific and fundamental character (...). The Organization shall have no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available".* [CERN, 2007, CERN's mission]

The research agenda at CERN today is to reveal the conundrum of how mass were created. In the 1970s, Peter Higgs proposed that mass are created through coupling of the boson field, called Higgs, with the particles without matter. The interaction between the particles and the Higgs field gives mass to the particles, and those particles that don't interact do not acquire mass. The amount of interaction gave us the elements we have organized in the Periodic Table.

To prove this theory, the researchers need to go back to the very beginning of our Universe, when the Big Bang occurred 13,7 billion years ago. To be able to do this, it has been necessary to construct the world's largest and most complex scientific instrument; the Large Hadron Collider (LHC).

[1] CERN is funded and governed by the member countries of the Organization, referred to as the Member States, and currently the list consists of 20 countries in Europe.

The gigantic LHC is located in Geneva beyond the border between Switzerland and France. It is a circular tunnel constructed to house circular pipe shaped magnets which governs proton particles in its motion. Close to the speed of light, the particles will pass the same point in the 27 km long tunnel about 11 000 times per second, and at the maximum speed, particles with the exact opposite direction will collide and release extreme amounts of energy [CERN, 2008].

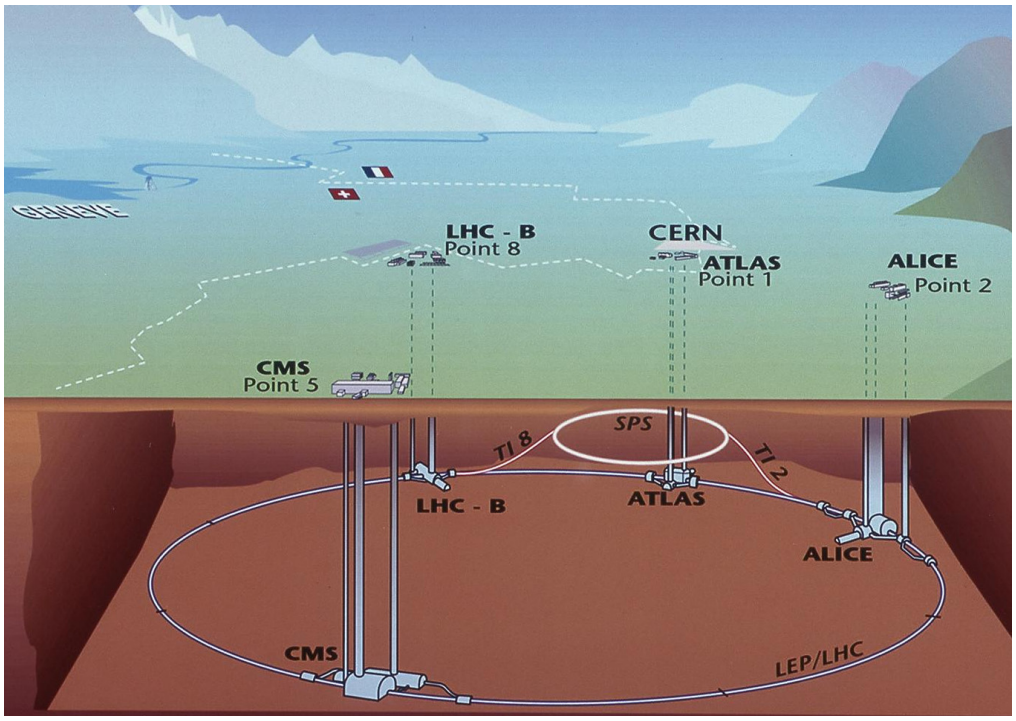


*Figure 1: The overview of CERN research facilities. The CERN office facilities are located close to ATLAS and the Large Hadron Collider (LHC) is located 100 meters underground.*

The collision between the particles will hopefully break our smallest known building blocks into smaller pieces revealing the Higgs Boson and four massive detectors, called Alice, CMS, ATLAS and LHCb, are used to photograph the collision and give information about the revealed particles.

The High Energy Physics (HEP) research needs very sophisticated instruments in their experiments to conduct this projects, and this often exceed the available industrial knowhow [CERN, 2007]. The technical complexity of LHC and its detectors, the extreme amounts of generated data (10 000 encyclopedias per second) have spawned impressive innovative results which potentially could be used as technologies in the industrial or consumer market.

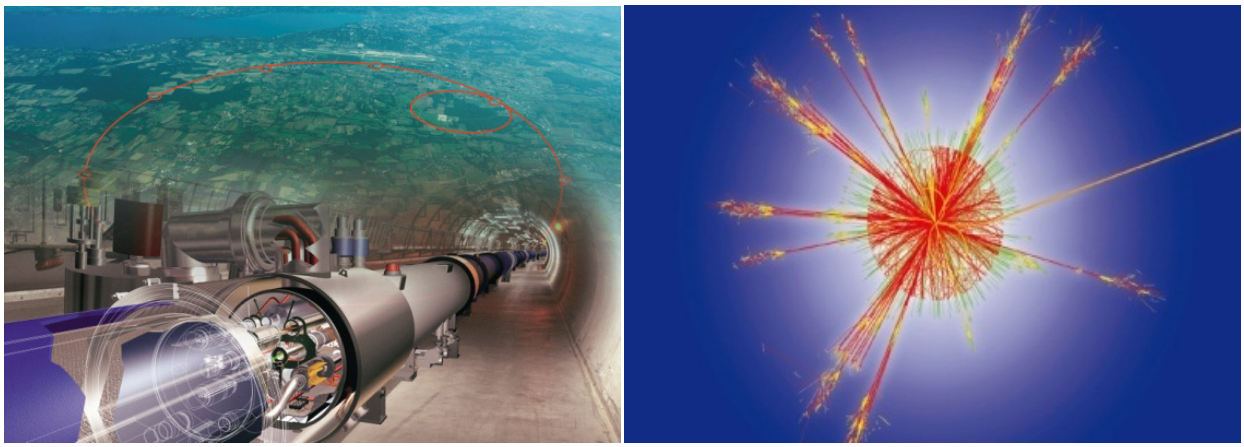

*Figure 2: A picture of the Large Hadron Collider to the left and its location in Geneva, and to the right is a simulation of the proton collision.*

## 4.2 TT at CERN

### 4.2.1 The mandate and recipients of technologies

The definition presented in the literature review, section 2.1.1, is also relevant to describe the activities of TT at CERN. The objective of TT is to actively increase technology dissemination, but the specific recipients of the technologies are industry in the Member States. The active and intentional technology transfers are carried out by the TT Group and their mandate is as follows:

*"CERN Technology Transfer activities are aimed at maximizing the impact of technology and expertise resulting from its fundamental research programme to Member States industry for the benefit of society."* [CERN TT, 2008, Our activities]

The technologies coming from CERN are evaluated in a process to find potential applications for use of the technologies in several domains. This process seeks to find a match between technology and product needs, cost effectiveness of manufacturing technology and the offered value of the technology. The domains of industry that CERN transfers technologies to are several; communications and information technology, medicine, energy, environment and scientific and technological knowledge [Le Goff, 2008].

### 4.2.2 The TT strategies at CERN

Normally, the TT Group offers four different schemes for conducting TT between CERN and industry. These strategies are made to maximize the technological and knowledge return to Member States' industry without interfering with the research which should be of fundamental character [Le Goff, 2008].

The first scheme CERN offer to its potential industrial and academic partners is collaborations. The purpose of this collaboration is to validate the pertinence of the technology in the foreseen application domains. The participants in this process are HEP institutes and CERN, and the research is performed at the locations of both of the parties.

The second scheme is R&D partnerships with industrial partners. The aim of this collaboration is to mature the technology until a level required for pre-industrialization. In concrete this often results in prototypes, made by CERN experts based on external funding.

The third scheme is license agreements. This is mostly used for mature technologies [Le Goff, 2008] in commercialization or to transfer technology to companies wanting further development. The license includes fees to cover CERN expenses determined by negotiations,

such as patent and technical assistance costs and to serve as an indicator of commercial exploitation of the technologies.

The last scheme at CERN is service- and consultancy agreements. This serves the need accessing CERN facilities partners otherwise are unable to access. Agreements like this gives limited transfer impact, so CERN favors R&D partnerships to enhance opportunities for dissemination.

### 4.2.3 CERNs role in the creation of spin-off companies

The extent of CERNs involvement in spin-off companies is limited by the policy that the Organization shall be conducting research of fundamental and not applied character. The innovations are results from developing tools to be able to fulfill the objective of the LHC and the technologies should not have any other considerations that benefit this purpose the most.

Another consideration is the importance of the responsibility of serving the Member States as they all are equally entitled to access each technology spinning out from CERN. The TT mandate is to maximize the technology and knowledge return and not to maximize profit for the Organization. This implies a challenge of choosing the degree of dissemination versus the income from transferring the technology.

Finally, CERN cannot provide technologies for use in military applications. It is specifically stated in the Convention of CERN that the Organization shall have no concern with work for military requirements as parts of the purpose of founding CERN was to sustain peace in Europe after World War II.

## 4.3 The four investigated spin-off companies

The identified companies are presented to briefly to give an overview in table 2, before they in the next sections of this chapter are presented in a more profound way. All of the companies have commercialized CERN technologies the experiences of the companies is further presented.

| Company | Founded | Technology | Support from the TT Group |
|---|---|---|---|
| M1i | 2003 | Software for controlling business/logistical processes. | Facilities at CERN. License and training of personnel. |
| Interon AS | 2002 | Electronic chip for use in medical imaging and material research. | Facilities at CERN. Partnership and license. |
| SpinX Technologies | 2003 | Laser based assay system for biological experiments. | - |
| Advanced Accelerator Applications S.A. | 2002 | Radiopharmaceuticals for Positron Emission Therapy. | Facilities at CERN. Partnership and license. |

*Table 4: Introduction of the four case companies*

## 4.4 M1i

### 4.4.1 The company

M1i is a spin-off company founded by four associates in 2003. The founder's established new software based on CERN technology, which could enable defining and implementing business processes in multiple company domains such as ordering, stock and purchasing. Their software is called Agile BPM/BAM, and is based on Cristal technology which conducts data- and process management.

The firm emphasizes the most important aspect of their technology to be the identification of an application and they spent at least two years before having something "user friendly". The company experienced a setback in phase 3 when the CEO left because of unrelated issues and

this was the most difficult part for the firm as he was the major investor and manager of all commercial activities, leaving just technical people left in the company. They also struggled with the technology state as ahead of the needs in the market.

It was spent most resources on the adaption of the technology for use on servers and on establishing web functions to avoid local installation on end users computers. Their offered values are several; graphic business process configuration, possible configuration during execution, capable of handling exceptions in the data management and seamless integration to existing IT systems.

M1i has received training of personnel at CERN, and they received the code of the Cristal software and exclusive rights to commercialize the technology. The company has successfully implemented its software in several companies and is mainly active in France so far, but is preparing to become international through partnerships and OEM opportunities. The firm has today started selling products, but has not yet reached breakeven. They are now focusing their efforts on marketing, after recently releasing a version of their software.

The firm consists of four founders, seven employees conducting R&D, support and sales. The competencies of their associates is a mix of people with the following academical backgrounds; one with production and information systems and industrial automation, one is a computer science engineer, one with industrial information systems engineer and the last with background from Business School. M1i is located in Seynod in France and is moving to larger facilities in 2009 at approximately the same geographical location.

### 4.4.2 Findings

Of the critical success factors, two was presented which were important in the first phase; help with contracts to assess IP for commercialization as they did not know how to do it, and having an exclusive license to stop others from spinning out the same technology. In the second phase use of the CERN brand was important in relation to the investors and to find collaborating companies to push their product to the market. In the third phase the customization of the

product and the identification of end user needs were important, and finally funding to push the product to the market.

Less critical success factors in the first phase were the acquired internal network of persons at CERN and the technical experience with the product. In the second phase CERNs use of the software gave credibility when attracting investors and it was more efficient if people hired in the company had a mixed background of business and technical experts so they didn't have to change roles compared to their background. The third phase it was presented as helpful that CERN offered complementary technologies which could be found at potential seminars at CERN also giving knowledge to CERN about the company, and finally technical support from the TT Group.

Impeding factors were in the first phase a rigid founder in negotiations with related actors, no commercial contacts and lack of business experience in the crew. In phase two it was a problem that the technology was too far ahead of the market and that the technology was adapted for research purposes and not industrial needs. In phase three a long time to enter the market was problematic as it demanded a lot of resources, and conflicts arose because of multiple ownerships to the technology.

Less impeding elements was in the first phase language problems in collaboration with CERN. In the second phase no formal R&D collaboration of the development of the technology with CERN, and phase three the change in R&D pace and adjustment for the technical experts coming from CERN of developing the technology.

## 4.5 Interon AS

### 4.5.1 The company

Interon AS was founded in 2002 when they identified an opportunity to use technology from CERN in their own electronic system, based on their former experience from working at the research Organization. The technology is a high performance chip for use in medical photon

imaging like X-ray and life science applications which offers significant advances in domains such as photon sciences and electron spectroscopy.

The most challenging part for this firm was the amount of resources necessary to develop and integrate the technology in collaboration with CERN; they regret not spending more time on clarifying issues before entering the partnership. The foreseen time of development was underestimated and it took five years before the company could focus all efforts on commercial activities instead of the needs of the LHC.

The added value of their technology are; decomposition of tissue through scanning of different X-ray energies, reduced radiation for the patients, low power consumption and fast readout electronics and a high counting rate functional in a computed tomography detector module.

A collaboration was formed and a R&D partnership was established where Interon paid for having employees and facilities at CERN to develop the technology. The company possesses exclusive license for use in the application domain of tomography and sells products to the company General Electric, but still needs more time to generate a self sufficient positive cash flow by selling products with their technology.

Interon AS has a team of six members with backgrounds from electronics, physics research, electronic hardware and one person doing the administrative tasks. They are in a partnership with DxRay which is a developer of digital X-ray systems. The company is today located in Hvalstad in Norway and have an annual income in 2007 of about 670 000 Euros.

### 4.5.2 Findings

Critical success factors mentioned were in the first phase the value of the CERN technology and the technology assessment linking the technology to an application conducted by the founder. In the second phase it was critical to assess what CERN could offer the company and use of the partnership to attract investors. In phase three the former business experience of the founders was central.

Less critical success factor in the first phase was experience from working at CERN, both internal network people at CERN and technical background. In the second phase it was the R&D partnership with CERN as it was used to gain credibility among investors.

Impeding factors were in phase one a difficult transfer process in terms of a complex relationship agreement making it hard to understand, lack of commercial competencies in the TT Group and problems in partnership with CERN. In phase two the R&D partnership became very costly and of less value to the company because of diverging goals between the parties. In phase three it was a problem that the technology was developed for research being costly, instable and unsafe and not for industrial use and this made the time to market longer.

Less impeding elements mentioned in phase three were troubling issues because of the internal competition at CERN, representing diverging objectives that occurred in the facilitation process compared to the company's interests, and unfavorable policy as CERN claims license fees.

## 4.6 SpinX Technologies

### 4.6.1 The company

SpinX is a spin-off company founded by two researchers from CERN in 2003 as they coincidentally met an investor at IKEA. The founder allied himself with a partner from CERN and they started treating micro fluidics in industry. They offer technology where the user can choose the exact dilution, mixing and incubation conditions in real time, which has been a problem in industry which has used conventional technology for a long time. Their product is used in a variety of applications and consumer diagnostics and drug discovery are examples of these.

In this case it was spent a large portion of efforts on finding and application for the technology and assessing the ownership of the technology before establishing the company. The founder of the company also spent a fairly large amount of resources on teaching himself to aspects related to start a company. They struggled also a bit with trying to get facilities at CERN, but as they perceived it as to complex and difficult, they chose to pursue alternative opportunities.

The firm has spent significant amounts of resources on creating a product which have the necessary prices, reliability and performance. It is offered added value through providing technology that provides flexibility and simultaneous assembly of many subtle assay conditions. It offers a cost-effective use of compound and reagent by interfacing directly to microliter-scale well technologies.

SpinX is the only company with no support from the TT Group or from CERN, except for the knowhow they achieved through working in the Organization, and they have only a paper stating the ownership of their invention. Currently they are testing their prototypes with big pharmaceutical and biotechnical companies and have built and operated 8 instruments for assays in drug discovery [Business Services Industry, 2007]. They are not yet selling any products and they are seeing the overall financial situation as the essential ingredient for success.

SpinX is managed by the founders from CERN. They have an academical background from physics, but the CEO is currently taking education in business. They have eight additional Board of Directors and seven members of their Advisory Board. In total the company has about 32 employees. The company is today located in Meyrin in Switzerland and have raised more than 10 million Euros since establishing the company.

### 4.6.2 Findings

The critical success factors in the first phase were the market- and technology assessments they conducted to identify an application with help from external contacts, establishing IP rights in line with CERN's comprehensive ownership and to learn how to draft a patent, and meeting with investors. In phase two it was use of CERNs reputation for gaining credibility of their technology, and external IP support. In phase three it was exposing the technology to industry, access to CERN knowhow and adjusting the technology for releasing it on the market.

The less critical success factors were in phase one finding a business partner, use of external business contacts and to keep the relation to CERN simple with regard to necessary efforts to

make the technology available for them. In phase two it was external access to patent help and the CERN Pension Fund investment. In phase three it was to understand customers and their needs.

The critical impeding factors in phase one were the technology as it was originally developed based on research knowhow and no IP background among the founders of the company. In the second phase it was a disloyal IP lawyer to the company's interests, therefore external IP contacts were used. In phase three it was the vulnerability to each customer as all of them represent large market shares and an unclear IP situation hindering investors.

The less critical impeding factors were in the first phase the restrictions from CERN in terms of taxations, having visitors, purchasing and access to library and use of facilities at CERN.

## 4.7 Advanced Accelerator Applications S.A.

### 4.7.1 The company

AAA was founded in March 2002 by a former researcher at CERN. The company was based on a patent developed at CERN, protecting technology that allows high efficient radioisotope production. The company is a large provider of Positron Emission Tomography (PET) radiopharmaceuticals for use in the nuclear medicine field and they are currently working with production of PET tracers for pre-clinical and clinical research, new brachytherapy technique for solid cancers, radio metabolic therapy and PET molecular imaging for drug discovery.

The special story of this company is the fact that they started the company based on an alternative product to finance the development of the patent technology from CERN and surviving financially. The patent has not provided any income for the company even today, because the technology is not finished, and the rest of their product portfolio is their source of income.

The technology offers efficient production of neutron rich elements using a particle accelerator, it enables the patients to go through repeated treatments for higher therapeutic efficiency, and

since they are magnetic the nanospheres are migrating into the irradiated tissue and form micro conglomerates which does not enter the main bloodstream of the patient.

AAA had a partnership with CERN for 3-4 years to develop the technology at the facilities at CERN they paid for. The company achieved an exclusive license for using neutron driven transmitter technology for medical applications. AAA is today selling products and establishing new research facilities in Switzerland and Italy. They have several products in the pipeline, and could be described to have surpassed the point of being breakeven.

The management team of the company consists of 8 members with competences within the field of physics, engineering, chemistry and pharmacy. Their company has expanded and today they are using mostly people able to conduct research on radiopharmaceutical products. The company's headquarters is today in Saint Genis-Pouilly in France and AAA has raised more than 12 million Euros since they started.

### 4.7.2 Findings

The critical success factor mentioned in the first phase was having an alternative product to finance the development of the main technology. In the second phase it were private investors and external venture funding. In the third phase it were the ability to handle the growth and successfully administer the company.

The less critical factors were in phase one use of CERN facilities, offices, phones and patent support, as this saved time and money for the company. In phase three it was the amount of money to fund the long time of development necessary, as this could be difficult.

Impeding factors in phase one were no business experience in the TT Group, and no access to CERN knowhow. In the second phase it were difficult to attain funding because of long time to market and small chances of success, and lack of contact with Member States industry.

The less impeding factors were in the first phase the fees and royalties paid for the patent and the problems of planning the research until having a market ready product. In the second phase it was no TT follow up of the company in commercial aspects such as creating business plans.

## 4.8 Summary of the collected impeding- and success factors

In phase one, the companies mention various critical success factors. The elements they present are related to intellectual property, establishing an application for the technology through technology- and market assessments, and funding to cope with the long time to market. They differentiate in their wish to involve CERN in the commercialization process related to both technical- and commercial aspects.

When it comes to impeding factors it is reported problems with commercial issues; no network, experience or support from the TT Group. Two companies also miss the access to technical experts at CERN and one company the costly partnership they were involved in. Of less important factors the possible use of CERN as a host for the company varies, as they differentiate in their view of the benefit of being located at the Organization. The restrictive regulations around tax and access to resources lead to one company establishing itself outside, while the three others found the facilities useful.

In phase two, the companies coincide in the great value of the CERN brand when attracting investors, partners and credibility in the market. The report private investors as main financial contributors, but also venture funding was used by one company. Of less critical factors it was emphasized technical collaboration with CERN, mix in commercializing team and utilizing a network on the outside to master the commercialization process.

The results of the impeding factors show a tendency to favor both causes and consequences related to the technology. The considerations for developing the technology at CERN are reported to have a mismatch to characteristics of market technologies, and the consequence of this is difficulties to attain funding and comprehensive development before having a market ready product. In the relation to the TT Group, the companies mention lack of contact with

Member States' industry, lack of relevance of support and conflicting goals of the intellectual property.

In phase three, the companies still focus on both technical- and commercial elements. They mention choosing the right customers for adjusting the technology, and would like support from CERN to achieve this. The commercial factors are related to achieve necessary funding to finish the product, business experience and handling the growth of the company to be important. Of less important factors, one company benefited from support from the TT Group for technical development and supply of complementary technologies, while others gives attention to the former experience they achieved at the Organization.

The most important impeding factors mentioned are the inhibiting elements of multi party ownership of the commercialized technology, generating difficulties for the companies in the relation to CERN and the long time needed for adjusting the technology. It is also troubling in one case where the customers represent large market shares which make the company vulnerable in the market. Of less important elements the internal competition for the technology is interfering in one case and adapting to the pace of delivering products in the market. For an overview over all the factors see table 3.

| | | *Creating the company* | *Process of commercializing basic technology* | |
|---|---|---|---|---|
| **Company** | **Influence** | **Phase 1** | **Phase 2** | **Phase 3** |
| M1i | | | | |
| | *Critical to success* | Help with IP contracts | Investor network | Funding to push market |
| | | Exclusive license | Use of CERN brand | Defining end user needs |
| | | | Collaborating companies | Technical adjustment |
| | *Less critical* | Internal network at CERN | CERN using the software | New CERN technologies |
| | | Product experience | Mix in team background | TT Group support |
| | *Impeding factors* | Rigid founder | Technology ahead of market | Long time to market |
| | | No commercial contacts | Technology for research | Multi party ownership |
| | | No business experience | | |
| | *Less impeding* | Language problem | No CERN R&D cooperation | Change in R&D pace |
| Interon | | | | |
| | *Critical to success* | CERN technology | Establish what CERN offers | Business experience |
| | | Technology assessment | CERN partnership | |
| | *Less critical* | CERN experience | R&D collaboration | |
| | *Impeding factors* | Difficult transfer process | Expensive R&D agreement | Technology for research |
| | | Complicated cooperation | | Long time to market |
| | | No TT business support | | |
| | *Less impeding* | | | Internal CERN competition |
| | | | | Unfavorable CERN policy |
| SpinX | | | | |
| | *Critical to success* | Market assessment | Use of CERNs reputation | Show technology to industry |
| | | Technology assessment | External IP contacts | Access to CERN knowhow |
| | | Acquiring investor | | Adjusting technology |
| | | Establish IP agreement | | |
| | *Less critical* | Business partner | External patent help | Understand customers |
| | | External business contacts | CERN pension fund funding | CERN experience |
| | | Simple CERN relation | | |
| | *Impeding factors* | CERNs closed innovation | Lack of TT support | Vulnerable to customers |
| | | No IP background founders | Disloyal IP lawyer | Long time to market |
| | | | | Unclear IP |
| | *Less impeding* | CERN restrictions | | |
| AAA | | | | |
| | *Critical to success* | Alternative product | Private investors | Ability to handle growth |
| | | | External venture funding | Administrative success |
| | *Less critical* | CERN facilities | | Lot of money |
| | | CERN patent support | | |
| | *Impeding factors* | No TT business experience | Difficult to attain funding | |
| | | No CERN knowhow access | Little contact with industry | |
| | *Less impeding* | Fees and royalties | No TT follow up | |
| | | Difficult to plan research | | |

*Table 5: The findings of impeding- and success factors, from before starting the company until having a market ready product.*

# 5 Discussion

The objective of this investigation was to study the experiences among the spin-off companies transferring technology from fundamental research to industry. The purpose was to bring knowledge about the process from before creating the company until having a market ready technology in order to better facilitate this process in future spin-off companies.

A qualitative insight has been offered into case firms already commercializing technologies from an organization as a representative for fundamental research. In doing so, it has been offered a broad knowledge of the aspects related to their experiences. Several important elements have been found that contributes to success or impedes have been identified, and the rationale behind the considerations has been presented. The findings show the entrepreneurs view of their experiences on how it was to create a company based on CERN technology and their situation during their commercialization process.

## 5.1 Phase 1: Creating the company

*Research question 1: What were the impeding- and success factors influencing the creation of spin-off companies for transferring technologies?*

### 5.1.1 The IP issues

Two of the companies mention IP issues as critical to success when it comes to commercialization; M1i because of important help with setting up the contract since they had no IP knowledge and SpinX as troubling because of CERNs comprehensive IP ownership to "everything" made by employees of the Organization, "even music or paintings made on your own spare time" as the respondent expressed it.

It is important to understand the different background of the companies when evaluating their responses. SpinX wanted to be taught how to draft a patent, instead of acquiring a patent. "I do

not know how to draft a patent. It was not possible for us to ask how should draft a patent, CERN should help us". In M1i's case they have a different approach, as they were satisfied with the IP: "The model is ok. We got a contract of exclusive right. Very important so we could be sure of no competitors on the same technology."

The responses show a difference in the expectations to what the company could achieve if commercializing CERN technologies. SpinX clearly sees a threat because of CERNs extent of potential claim of IP ownership and investigated this with external IP help in the patent process. M1i sees CERN as the owner, and appreciate the extent of the commercial arrangement. The key issue is the difference in perception of ownership of the technology, and this is where the background of the founders is relevant. M1i built a new software "on top" of CERN software and received a license, but SpinX used only their knowhow to build a product for a chosen application and has no license agreement with CERN.

The cases illuminate differences in perception of IP rights among the commercializing actors and reinforce the findings by Steffensen et al. [2000]. It would be valuable to identify the subjective ownership the commercializing entrepreneurs have to the technology. The expectation of having help from CERN to draft patents, and interpretation of IP claim could be subject of misunderstandings.

How much the founders were involved before they made the decision to commercialize would be a key influencing factor. Expectations of the entrepreneurs influences the IP negotiation and the facilitation of the spin-off company in a way that both parties reach an agreement they perceive as fair to avoid future problems in the collaboration with the company.

### 5.1.2 Identifying an application for the technology

Interon and SpinX report the technology- and market assessment to be essential as this connects the technology to one application in the market. In Interon's case they found the technology at CERN themselves by contacting persons they knew from working at CERN before. "I knew the organization very well, and when I quit, I was not interested in reinventing the

wheel, so I contacted CERN to find what they had to offer." SpinX discovered applications after being initiated by an external investor they coincidentally met. "I was at IKEA and we went for meat balls, and because of a lot of people I got in front of an unknown guy while eating, and we started chatting. He said that he was an investor. And I thought, what is an investor? He asked me: If you know all this things at CERN, high-end very specific, why haven't you thought to apply what you know in other fields?" SpinX conducted their study all by themselves with help from external people they knew.

The companies proved to have a different approach to commercializing technology. While Interon already had decided to start a company and was looking for a technology they could use for a planned application, SpinX was convinced of starting a company after being initiated by and investor to look for the potential application of the technology the founders knew. In both cases the relevance of working at CERN proved to be essential for creating a company. The interesting finding is that despite their lack of entrepreneurial experience, both companies conducted an assessment of their technology to find a market application, and they both see this process as very important. These actions confirm the findings by Franklin et al. [2001], that the understanding of the technology and application is important, but also shows a lack of judgment in essential elements of the commercialization process.

To compensate for their lack of knowledge, SpinX chose to get help from external business contacts. This network of commercial actors have proven to be important as suggested by Johansson et al. [2005], but not as facilitator for technical development, instead it was used for commercial issues as recommended by Clarysse and Moray [2004].

It would be interesting to see if CERN as technology originator could provide useful information by both discovering technologies and finding potential applications for these for the purpose of creating a company. The research Organization could administer this process if involving external contacts, or they could conduct it in line with existing practices. A challenge is the variety of technologies and enormous amounts of potential applications. Some people might see this as too ambitious considering the restricted resources of the TT Group. M1i states: "It is very difficult, can you imagine the skill of knowledge the people should have? It is a question of

constraints of resources. They cannot have one person for each technology.", while AAA sees not having this as an important impeding factor: "The people from technology transfer are too much former researchers. Their experience is too far away from reality to use in this phase because in this phase you have to be a business man with somebody who knows how to start a company."

The companies diverge clearly in their expectation of what kind of support they should receive form the TT Group, but their answers could clearly be biased as a consequence of mismatch between expectations and received support, or because M1i still have frequent contact with the TT Group. The role of TT should be clearly communicated to avoid problems, and the role of TT needs to be clarified. An assessment of what TT could provide the companies of information and especially important what they could provide which could increase the number of companies that commercialize CERN technologies. A further study which could map the interests of the inventors supplying technologies would be an interesting finding in this matter.

It is clearly valuable to the companies to have a technology- and market assessment, but most of all the commercializing team [Clarysse and Moray, 2004] and its background influence the role TT could have in increasing the number of spin-off companies. It is essential that it is understood that the technical and market aspects of creating a company are both very important, but as the TT Group is located inside CERN, the technical assessment is much easier to conduct than assessing the market. Either the TT Group has to increase the total number of people with commercial knowledge and experience, or external resources for support should be mapped so the future companies are facilitated to an extent which creates a match between the needs of the company and the capabilities of the TT Group.

### 5.1.3 Patents role in commercializing technology from fundamental research

AAA reports having an alternative product as critical, as the time to market is very long for the CERN patent they planned to commercialize, they needed a "cash cow" product to be able to make the company capable of surviving financially. "Because it is difficult to get venture money

in very early phase of development. The patents usefulness is not so good in the medical field. You cannot expect less than 10 years developing. In medical field the lifetime of the product is 20-30 years and just to go to market is 10 years for pharmaceutical products treating patients. In average if you have an idea in pre-clinical phase you have a probability of 1/10 to a product. The rationale was to use and existing accelerator and use it as a cash cow for the business of research and development of the patent."

The use of patents must be understood by the stage of technical development the technology is in. Corresponding to the findings in literature, the company commercialize a technology that needs both time and resources to conduct this process [Le Goff, 2008], and this is well recognized by the entrepreneur in AAA as they mention the costs of patents as an impeding factor to create the company, and lack of usefulness in the beginning of the company.

M1i specifies the license protection they need: "We got a contract of exclusive right. Very important. We are going to take this R&D project and the put it on the market, you need to be sure that you will not see any others with the same product. If CERN license the same technology for other companies then we are losing parts of the advantage."

It should be carefully evaluated if research organizations should patent the technology as this process represents potential large costs in drafting, filing and maintaining the patent, and as it is dependent on the state of the technology [Le Goff, 2008]. The company has to pay for this cost to get a license from CERN, and the protection they seem to recognize is the protection from comparable companies starting with the same technology for the same application, and not the potential- and market actors. Maybe the technical sophistication along with the first mover advantage is enough protection, and the bureaucracy and monetary costs of this is zero. In the end, a patent for a product which will exists in 10 years and with a lifetime of 20 years, might contradict the superior goal of disseminating technology in trade off for short term profits and this might stop the company from commercializing technology. The protection this investigation shows could also be acquired through internally protecting the technology from being commercialized by other interested parties at CERN, and the possibilities for this should

be investigated before acquiring patents on the technologies as a system for giving the companies competitive advantage in the market.

### 5.1.4 The importance of having a commercial network

The lack of commercial network is emphasized as important by M1i and they lacked commercial contacts when they needed partners for development and financing for their technology, confirming the findings by Johansson et al. [2005]. SpinX mentions the network as one of the success factors, as they used people on the outside of the Organization for selecting applications, funding and for IP support.

In relation to the impeding factors, SpinX mentions CERN as conducting "closed" innovation as the technologies don't even go to the market, but remains within the research organization. "You can really find a lot of examples at CERN, where such ideas used at CERN for which the utility was not recognized. People don't see this because at CERN people are the user of themselves. You invent things for yourself." Such a network could also be used to provide support from people with business experience and for venture funding as wanted by AAA and Interon as support from CERN.

Many of the countries in Europe offer institutions and legislations to nurture entrepreneurship. It would be useful to have contacts or partners comprising a network on the outside of the Organization, both to utilize the research Organization [Chesbrough et al., 2006] and the incentives for entrepreneurship. All of the case companies mention commercial aspects in their process of creating a company, and it would be in the interests for the research Organization and the entrepreneur to facilitate collaboration between these parties. As an alternative to trying to establish a TT Group that could cover all the needs of spin-off companies, it would be more rational to have contacts which could be used when necessary. It would also be connected less risk to such a practice than starting to hire people on contract basis as employees for the research organization. It would be recommendable to establish such a

strategy to facilitate the companies in their efforts to start a company, and to be able to maintain the role of the Organization.

## 5.2 Phase 2: Commercializing basic technology

*Research question 2: How can spin-off companies be facilitated in the process of commercializing basic technology in the market?*

### 5.2.1 The CERN name

A new finding which has not been identified in the literature is the use of the reputation of the research organization as originator of the commercialized technology. After establishing the company, three of the case firms found use of CERN's name as useful to have credibility among external contacts in the market.

M1i and SpinX mentioned it as help in gaining credibility about their product among different contacts: "Regarding the challenges to push the product on the market we were helped by the global image of CERN. This is very important. Lots of people are aware of what CERN is, it is help in discussion about the product, with investors, analysts and customers." and SpinX: "I think CERN is extremely important branding. It is known everywhere, It is clear that many technologies that are used there, they are also aware that at CERN you don't develop technologies from scratch. It is very important the difference."

Interon focuses more on the credibility of the company for finding investors: "CERN has an advantage of being big, and it is an advantage with a known name which you could use in your own marketing for making investors invest in your company. Two people seem a bit fragile, but a partnership with CERN have a positive effect. It is only positive."

First of all, the use of the CERN brand, or any research organizations brand, is a low cost way of facilitating the companies efficiently. Funding and external contacts have been mentioned by M1i, AAA and Interon and if the brand could help the companies to acquire funding, this would

be a resource efficient alternative to choose. It is not likely that this could do any harm to the reputation of the Organization if the use of the brand is well specified to avoid this through specifying it as “based” on CERN research and not as an official extension of the research Organization. There is clearly a potential where it could provide the research organizations and spin-off companies with mutual benefits. It is recommended that the use of the brand is well defined and extended to facilitate the future companies. Research organizations spends significant amounts of resources on marketing, and it could contribute in communicating its value to society.

### 5.2.2 Partnership for developing the technology

An issue with commercialized technologies is the state the technology is in, when they are transferred. M1i described it: “Agilium was an early bird, that needed huge investment and the market was not really there before we launched product on the market after 6 years. Now the market is here. Things coming from huge research is earlier than real markets, the market was not there and it is not a product, it is not finished.”

Interon presents different considerations for technologies developed at CERN: “At CERN there are totally different targets, in a system at CERN (which the technology is used) there is only focus on performance. It is good enough, exciting, but it lacks stability and does not consider safety issues. There are also far too high production costs. For industry this thinking is very distant.” Because Interon is in the health sectors, this opinion must be understood in its context, as the demands for safety differentiate for research and the health sector [Le Goff, 2008].

The main reason for Interon is the difference between industry and CERN, and the technologies they receive. They show a pessimistic view on the technology: “The rule is that the technology will not work (in industry).” M1i is more nuanced as they consider both the state of the technology, costs of changing it and the market for the technology when they judge the value.

The remaining question is how to facilitate the companies in handling the technology and its related aspects to make it commercially applicable. First, the company needs resources to finance the adaption of the technology. This could be solved as suggested by Leitch and Harrison [2005], by channeling resources, helping with the development through technical experts and giving credibility. To achieve this there has to be present actors with resources which believe in both the technology originator and company. The development is a problem and complex problems arise about the role of the research Organization. CERN will not conduct any R&D which is not corresponding to its research program.

For the technical development, CERN and the spin-off company could establish a R&D partnership, but CERN can't do applied research, and the company won't do fundamental research. The diverging goals of each party, creates problems. Interon experienced this in the following: "During the execution of the partnership, we tend to commercial aspects, and in this way we deviated from research and development (gets angry) and we were not aware of the commitment we did. When CERN could not follow our commercial development the partnership became of no use and expensive." Inexperienced of a potential R&D agreement, but in contradiction, M1i states that not having a partnership with CERN was an impeding factor to their company.

The emphasis must be in the partnership to find common technical objectives that are wanted for the research organizations and the needs of the companies. If they can find a common ground, they can share costs and competencies. As mentioned by AAA, it would also be of interest to support to write a business plan because the lack competence [Rappert et al., 1999, Rothaermel et al., 2007], and to provide contact with industry, which is in the interest of both parties as they seek to disseminate the technology. If no commonalities are found, the partnership is likely to end in troubles for both parties. To monitor this relationship and maintain the necessary flexibility to end it in time, is an advantage since the planned research is hard to predict both in content and time.

It would be recommendable to explore this form of collaboration since the potential benefits are large, and some of the risk of diverging interests could be removed for the spin-off company

in this phase. Interon emphasize this adequately: “We would have spent more time on the agreement, so you avoid misinterpretations and see to that the spending of resources correspond to what you get.” Such collaboration might also solve issues related to IP as SpinX experienced and some of the restrictions that M1i felt complicated their relationship to CERN.

## 5.3 Phase 3: Commercializing basic technology

*How can spin-off companies be facilitated in the process of commercializing basic technology in the market?*

### 5.3.1 The importance of funding

In this phase the companies addressed money issues as very relevant and important. M1i, AAA, Interon and SpinX shed light on the problem about the long time needed for developing the product and it is tightly related to funding. M1i states: “The biggest problem is the amount of work we have done around CERN technology that something that is usable for us. So I think it is only today, 5 years after we have something good to present (to customers)”, and AAA illuminate more strongly the issue of money: “Because the medical environment the time to develop a new product is about 10 years. A very long time to do, and very difficult to get money. So from being at CERN for 5 years, 3-7 years before seeing a product.”

To be able to facilitate this issue of acquiring funding for the large effort of developing the technology for use in a product, it is necessary to have an understanding of why it is difficult to attain funding. Interon sees the problem related to costs and the policy of CERN: “The fact is that CERN is not interested in royalties. They have a conflict when it comes to, we don’t know if they want it or not, because the day they start earning money the incomes from the Member States will reduce their contributions of stable income for CERN, and in this way you meet yourself in the door.” SpinX sees the causes of the problem related to IP issues and the quality of the idea; “We was already, actually, going to a quite advanced stage, but essentially realized

that if the IP was not clear, everything was useless, because an investor will never put money into something that is, for an investor, is not clear."

Their view on how to solve these problems are split among emphasizing how to avoid costs and achieve funding. AAA: "We borrowed just offices. No money for renting offices, but for variable costs. I think this has helped a lot because to build this lab took two years. This has been a big help, using the procedure of paying through CERN accounts, if you have to find people for these things, it is really an effort and maybe a higher cost, maybe. For sure a lot of time lost and so on." Interon mentioned the CERN brand as useful to achieve funding, and M1i avoided this problem by spending their own private money.

First, Interon states clearly that CERN should not receive any royalties from license. In phase 1 of the company, AAA states also that this is an impeding factor; "In which we pay 2 per cent of royalties of the final product. And we pay initial fees of 45 000 CHF, to get the license. By default, this is the strategy of TT to recoup costs of TT [Le Goff, 2008]. Since money is such an important issue, and it is even suggested to oppose the interest of the research Organization by Interon, an interesting question would be if CERN should charge money or not, when licensing their technologies, or at least how much.

CERN is funded my Member States, and Member States can decide to stop providing money after political pressure. This would stop CERN from conducting their research. Resources are an essential factor. CERN established the TT Group to maximize the impact on society through industry, after it was proposed by the Member States. So why should CERN charge industry, in this case spin-off companies, for disseminating the technology? The state of the technology makes it worthless in the market without the companies effort to bridge the gap between technologies from fundamental and applied research. An exclusive license makes the spin-off company capable of legally protecting their efforts when developing and selling it in the market. However, to pursue this legal right could be advocated to be a rather ambitious project, considering the resource scarcity [Rappert et al, 1999, Rothaermel et al., 2007] the spin-off companies experience. So what is the value of the license for the company?

The amount of money and the state of the technology are important aspects related to pricing the technology the spin-off tries to commercialize. The research Organization could claim fees for giving back value to its Member State for the purpose of increasing research. However, the funding from the Member States could be reduced as a consequence of significant income from TT, and CERN is not as vulnerable as the spin-off companies. The company would benefit from being more flexibly distributed.

After the company has a stronger financial situation, CERN could charge more at this stage, rather than in the critical beginning of their lifetime and during their costly process of technical development. In the end, this would also make them capable of channeling resources and more efficiently develop the product, instead of spending unnecessary resources at the worst financial timing and therefore impeding the technology dissemination. This complex issue is not fully debatable in this thesis, as the extent of the questions and decisions that are made is dependent on other strategies of TT and deeply into the policy and purpose of patens, which goes beyond this thesis.

SpinX emphasize the importance of distinguishing good and bad ideas to further enhance the probability of achieving funding. It should be further investigated what the investors requirements are for investing in a company commercializing technology from fundamental research, and CERN could continue to facilitate through offering facilities [Leitch and Harrison, 2005] as in most of the cases to avoid large cost for housing and reduce the risk of starting a new company. This could also prove to generate more credibility to entrepreneurs in the organization, as the culture could be influenced [Samson and Gurdon, 1993] and reduce the dependency on external contacts. If contracts allowing technical experts to return to CERN after committing to work for the spin-off company could also prove to contribute to the company and CERN because of the training the specialists get conducting applied research. The TT Group could also achieve greater commercial knowledge and experience through closer collaboration with the companies when they try to solve their challenges.

### 5.3.2 Public events

M1i reports four important factors which could be facilitated through a public event where industry could meet inventors and technologies at CERN. Funding to push for market would be positively influenced by providing knowledge about the research Organization to society and investors, knowledge about industry would be shared through such an event which facilitates the technical adjustment, and new complementary technologies could be identified as information are exchanged.

SpinX reports the interest of showing their technology to industry through such an event: “In fact we were the first one who used the Globe, just after our seed financing we were able to host one of the most important conferences in biochemistry in US and Europe. It was here in Geneva, there were 5000 people, top scientists from CERN, so we did organize at visit to CERN facilities. We really paid for buses and so on, you should know the Danish attention was enormous. So they were top motivated. Still a lot of people remember it!”

M1i thinks such events could be a place where the two worlds of research and business could meet: You need to create some events where the two worlds where they can meet. Existing companies or people wanting to start companies or that you sell something. It’s really important because I got some people from CERN they don’t understand commercial aspect and sales process.”

It is particular important to understand that inside the large environment in a research organization, the employees have little experience with the dependency between funding and research. Stable public income from Member States, and very long term and large scale projects is a completely opposite setting than for spin-off companies. The incomes are unstable and mostly coming from private investments, the projects are small and length is not comparable to projects in high energy physics, it takes years, but not decades. The environment is also very influenced by politics in a large research organization with very specialized roles. In the companies there are requirements for a broader range of competencies and few political restrictions.

It would not be unreasonable to credit the differences in the environments as a key challenge to open CERN as a research organization to the business world. A public event would benefit the companies as the informational gap and uncertainty Lerner [2005] are reduced and such an event could bring the different world's closer. Unrealistic expectations and lack of competences [Rappert et al., 1999, Rothaermel et al., 2007] could be counteracted through events consisting of entrepreneurs, inventors, investors and politicians and it would be highly recommended for the future.

## 5.4 The a gap between fundamental and applied research

In SpinX's case, the company proved to be capable of solving problems the industry had been struggling with for a long time, and according to them they did this by introducing new working methods different from the conventional approach used by industry: "I realized the existing technologic solutions pretty much worked in the way as early computing. Big solutions, reproducing humans, accelerating solutions by conventional solutions. I tried to find out if a biologist could use a computer in the same way as physicists, with a high degree of automation. Many companies trying to do it, but not really in the market." In M1is case they used the source code of the technology to build and extended version of the software engine and Interon used a chip from basic research as starting point for integrating their component in a larger system and bridged the gap in the way identified by Autio [1997]. AAA has experienced a period of 10 years of development and still their technology is not in a market ready state.

In three of the cases the value of basic technology has proven to be important for the private companies and impact the industry doing applied research by taking a large step within research. The subsidizing of private R&D sectors as identified by David [2003] has been identified as both giving experience to further develop the technology and to increase the return on investment by the novelty of the technology.

The presence of a gap has proven to exist both in time and state of the technology, not being mature enough for commercial use as identified by AAA, SpinX and Interon. The technical

properties of the invention, costs and time that is necessary for developing the technology is representing a gap in all cases [Le Goff, 2008], and the awareness and relevance of this gap is a very important element to consider when investigating future spin-off companies spawned from fundamental research. It is important to consider the benefits of society of covering this gap, if the spin-off strategy should be justified as a practice of the research Organization.

## 5.5 Spin-off companies impact on society

The innovations from the case companies have proven to have impact on society. AAAs invention of the PET scanning equipment for tumor diagnosis and therapy has proven to be important [Landry et al., 2004], the company is already a key player in the economy being the European largest provider of PET tracers [AAA, 2008] and the company is currently bridging the gap between basic research and industry by using CERN technology and/or knowhow and collaborating with public research as suggested by [Abramson et al. 1997, O'Shea et al., 2005].

The case firms has proven to be engines of innovation as they have taken basic research technology and turned in to products providing strong innovative results. Interon provide novel technology for use in X-ray detectors [Interon, 2008], SpinX has developed a new benchmark for technology for pharmaceutical industry [Next Generation Pharmaceutical, 2008], M1i is offering a unique software that can handle exceptions in business processes in an easy way [Agilium, 2008] and AAA is a provider of PET tracers which have become very important at hospitals worldwide [Le Goff, 2008].

The findings in this study have shown innovative results from the efforts of the spin-off companies. They have utilized technologies coming from a major actor in fundamental research, and could be said to have increased the material welfare in society since they deliver strong support for the industry in the medical sector and software for improving business processes in companies. Not only through introducing new technology, but through improving the existing working processes within applied research. Since research organizations possess

many of people with high education today, it would be unwise not to utilize these resources in the future.

As a part of the open innovation paradigm, the use of spin-off companies as external paths to the market [Chesbrough, 2003] has proven to have a strong influence as both channel for technology dissemination and impact of their activities. Several jobs has been created [Legge and Hindle, 1997, Andersen, 2006, Praag and Versloot, 2007], strong growth, AAA and SpinX have raised more than 10 million Euros in five years, has occurred and it has shown to increase the utilization of the technology originator's base of innovations as suggested by Chesbrough et al. [2006].

It is relevant to establish practices for increasing the number of started companies based on technology from commercial research, as the investigation has shown several examples of companies having a good start and as they have proven to survive for many years without any funding from the mother organization. The spin-off companies have proven to influence industry and the local societies through novel technologies and creating jobs, and it is an important TT strategy for justifying the value of fundamental research to society.

The low awareness of where the web and PET technologies were created is two examples of the necessity of increasing the strength of the relation between technology originator and technology, in the market for the purpose of justification of fundamental research [Le Goff, 2008], as it is a fact that CERN is where the web was born.

## 5.6 Recommendations for facilitating future spin-off companies

### 5.6.1 Phase 1: Facilitating the creation

In the first phase of the company it is recommended that research organizations spends resources on addressing the IP issues and clarify them as they have proven to be very important by the companies, and as it influence the negotiations and disagreements in the collaboration between the parties.

The second issue in the first phase is the valuable information of finding and exploring the application for the presented technology. The TT Groups would benefit from offering knowledge about the technology in relation to the foreseen applications in the market. However, because of the complexity of commercial aspects, it is recommended that technology assessments are prioritized supplied by the TT Groups and that external contacts are used to complement the commercial assessment in the process of commercialization.

Third, the role of patents has to be further explained and the use of license fees should be adapted to suit the needs of the companies. It is recommended that the use of patents is more strongly considered with regard to the technology and its foreseen application, as well as the relevance of patenting in the targeted market. There could be other strategies to provide the entrepreneurs the protection they need and this is suggested further explored.

Fourth, it should be emphasized greater attention to building up a contact network on the outside of the research organization. It would not be recommendable to establish these resources in a TT Groups at research organizations. The commercial aspects are important and complex, and utilization of existing resources in institutions and legislations to facilitate entrepreneurs are essential to be resource efficient.

### 5.6.2 Phase 2: Facilitating the start

The first important finding is the value of the brand of the research organization. Co-branding the research organization reputation and spin-off companies in marketing is an easy way of facilitating the companies when they try to acquire funding and establish partnerships. This is clearly an unused potential which are strongly recommended to further utilize. Such an action could also benefit both parties in disseminating technologies in the future.

For future R&D partnerships it is important that it is spent resources on finding the common goals of the research on the technology and to collaborate on reaching these goals. Next, it should be sought help from external institutions in commercial elements such as writing business plans and establishing contact with industry.

### 5.6.3 Phase 3: Facilitating the development

Funding is a very central issue in the last phase of the development of companies. It would be recommendable to further investigate how costs could be saved, by removing or modifying the initial lump sum and royalties of the license, and to implement practices which could make it easier for the company to attract funding and reduce insecurity such as facilities and leave of absence for employees.

An important facilitating factor would be to create public events to open up CERN to society and industry, to create a meeting place for the research- and business world, and where the informational gap that exists between the external entrepreneurs, inventors, investors and politicians could be narrowed or removed. However, it would be a challenge to find a low cost solution to achieve the wanted effects, which demands a greater attention to TT.

## 5.7 Implications for literature

The research was conducted to complement existing technology transfer literature by offering a qualitative approach to investigate spin-off companies coming from research. It was chosen to study research at a fundamental level.

An interesting finding is that in all of the cases the entrepreneurs have initiated themselves, bringing a technology to the market. In contrast to literature who could be said to identify practices on how to facilitate the entrepreneurs, the findings raises an important question which is unexplored in literature; the background for choosing to start a company. This is an interesting topic to further within academic entrepreneurship, which could contribute with more knowledge on how to increase the number of created spin-off companies.

The established framework has offered a new approach to look at impeding- and success factors by combining the findings for facilitating companies with the level of influence they have on the company, seen from the entrepreneurs point of view. It is important that literature in the future emphasize a more mature approach to facilitate companies. The attention should shift from identifying influencing elements and the causes of them, to a more quantitative

approach, that determines their importance and level of relevance for the increasing amounts of spin-off companies coming from research environments.

Among existing literature, the research in environments of pure fundamental research gives attention to interesting challenges on how the research organization should facilitate the spin-off companies. The distinction between fundamental and applied research raises an interesting confusion reflected in the findings of the different views on the research organizations role in their commercialization process. It is believed that further research could contribute to clarifying this role. Future research could benefit from taking a step back and look closer to what role the research organization should play, and the consequences on the collaboration between the parties caused by the commitment of conducting fundamental research.

## 5.8 Limitations and reliability of the data

This evaluation is based on recommended questions presented by Løyning [2008]. First of all, the respondents have ownership in their company and the consequence of this could be distortion and exaggeration of the information provided related to the success of the company. This is a limitation of the study as only the entrepreneurs are investigated.

This investigation has not explored the benefits of using existing networks and sources for facilitating and spawning entrepreneurs. There are important key players in the market that could potentially represent an important source of help for facilitating entrepreneurs.

A critical player in the TT process is the inventor which possesses the knowledge about their innovation. This study has not investigated the factors that could make the inventors at the research organization submit their ideas and technologies for TT. To raise a portfolio for external entrepreneurs to commercialize offers a greater set of opportunities for commercialization.

The correspondence of the emotional state of the respondent and the information given was noted in the interview and after based on the voice recordings. It was also taken note of the attitude to the topic when questioning and listening to the respondent, whether the overall

impression of the respondent was positive, neutral or negative to check for non corresponding behavior according to the information that was given.

All of the interviews were conducted in similar environment where the respondent felt comfortable and secure, in their own office with no other persons present. Also it was not provided other information than the topic of the conversations to less likely have biased answers and to force impulsive reactions and audible thoughts on the topic.

Finally, it could increase the reliability of the data if the available samples where more heterogeneous with regard to year they were founded, technology, location and companies that did not succeed in creating companies based on CERN technologies.

## 5.9 Suggestions for future research

For more reliable information about how to facilitate external entrepreneurs, the subject should further be investigated from the perspectives all of the involved parties. The study should collect more data from entrepreneurs, inventors, investors and the research organizations point of view. This is useful to build a more holistic picture on the situation of spin-off companies.

A study would be very helpful for TT offices if current opportunities for influencing factors such as external funding, facilities, IP and patenting legislations and local support would have been mapped. Many governments encourage entrepreneurship and utilizing the resources locally could help the interest of the external entrepreneurs.

For future research it would be interesting to map the inventor's relationships to commercialize technologies through creating companies. To assess what they could contribute with, how they would prefer to be involved and what could make them increase their efforts for sharing their knowledge for utilization in society by other means than publishing.

# 6 Conclusion

## 6.1 Summary of results

This study has investigated how to facilitate entrepreneurs in commercializing technologies from fundamental research. It has been given attention to both creation and process of developing the spin-off companies until the entrepreneurs had a finished product to sell in the market.

When creating the companies, it is recommended to investigate precisely the subjective ownership the involved parties have to the technology, to create a solution which facilitates the IP negotiation. Secondly, it would be valuable to provide the entrepreneurs with a technology- and market assessment to introduce its potential applications. Third, the default process of patenting all technologies should be investigated as they represent significant costs for a spin-off company. Finally, it is suggested to build a contact network with the commercial actors and assess the legislations in the sought markets for the commercialized technologies.

In the beginning of the companies in is recommendable to increase the attention for using the CERN brand when bringing technologies to the market through spin-off companies. Secondly, in future partnerships for developing technologies for commercialization it is very important to assess the common interests of the company and research organization.

In the later stages of developing the companies, it is suggested that the earnings from giving out license to spin-off companies is distributed accordingly to the financial strength of the company. It is also suggested to provide facilitation by housing the companies at the research organization. Secondly, it is suggested to expose the companies to industry through public events for establishing a stronger link between the research- and business worlds.

## 6.2 Epilogue

To write a master thesis abroad at CERN has offered challenging tasks. Being at an international organization, the myriad of geographic and academic backgrounds, different languages, cultures and policy have influenced the research with great uncertainty. It has been an interesting experience to complete this work in such a complex and foreign environment as the learning's have provided a wide perspective on many sides of the research as well as giving opportunities for self-development.

I would again like to thank my colleagues and supervisors for coping with a sometimes impatient search for answers from my side, and for support at this final stage of my education. The discussions have been very valuable, and the joy of understanding complex tasks and environment is my essential motivation for continuous growth in knowledge and as a person. I am grateful to have been able to accomplish a demanding education and look forward to continue my journey of learning.

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## Appendix A

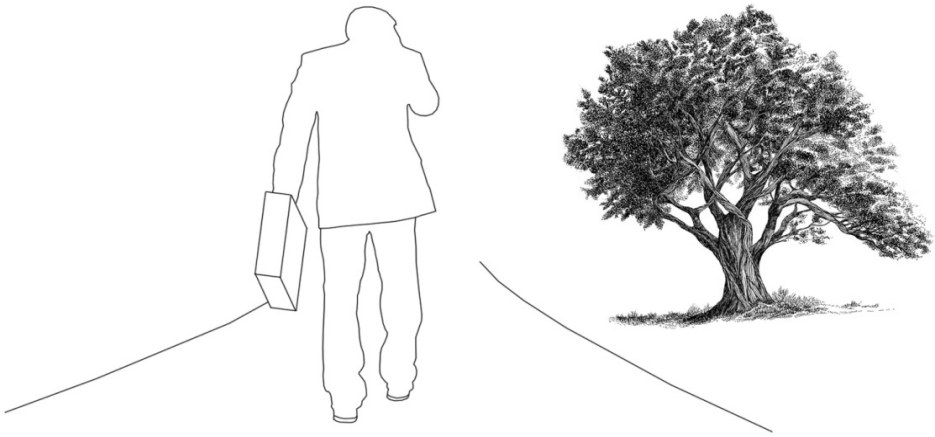
Support questions formulated to be used during the interviews, depending on the development of the interview this is to be considered only as a starting point.

*What were the barriers and success factors influencing the spin-off companies from the idea of starting a company until having a commercial product?*

1. Could you start with telling why you decided to start a company based on CERN technology?
2. Could you tell me about the most important events of your company?
3. What were the problems you experienced during the three phases I showed you?
4. What were the success factors you experienced during the three phases I showed you?
5. What do you consider to be more important of the factors you mentioned? (follow up question for question 2 and 3)
6. How do you see CERN could be more open towards external entrepreneurs to increase the numbers of spin-off companies?

*How can CERN facilitate spin-off companies in the process of commercializing basic technology in the market?*

1. How do you see that CERN could help the companies in becoming successful?
2. What do you think is special about CERN technologies when using them as a commercial product, what distinguish them from market technologies?
3. How many years have you spent on developing your technology before being able to sell it in the market?
4. What could CERN offer of services to facilitate the future spin-off companies?
5. What external sources could compliment the capabilities of the CERN TT Group?
6. Could you shed some light on the special experiences from using CERN as a technology originator?



“The direction in which education starts a man will determine his future in life.”

- Plato