TELECOM’S INNOVATION MANAGEMENT

An Analysis of the R&D’s Key Success Factors to Thrive in a Tough Industry

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Halmstad University
Master’s Thesis
M.Sc. Technical Project and Business Management
School of Business and Engineering
Sweden 2011

http://www.hh.se/
ACKNOWLEDGEMENTS

We would like to take this opportunity to thank everyone that made possible the research process behind this Master’s thesis. We would like to thank Joakim Tell, who as our supervisor helped us a lot during the whole process by smartly pointing us into the right direction, his accurate feedback enabled us to improve the overall research process.

We would also like to thank Henrik Florén, Bernd Hofmaier and other TPA students who provided us with very good feedback and suggestions during the different seminars. We would like to thank as well Christer Norr, as his lectures influenced us in selecting a topic within innovation management science.

We would like to extend special thanks to Isabelle, Arnaud, Marius, Victor and Alejandro for helping us in getting the needed empirical data, without your help the content of the thesis would not have been that complete and interesting.

Our families and friends have been instrumental in giving us the moral support that enabled us embark on this very interesting research journey.

Halmstad, Sweden 2011

L. Rodrigo Trejo

Zhiyuan Gao
AGRADECIMIENTOS

Me gustaría agradecer a todas las personas que hicieron posible el proceso de investigación detrás de esta Tesis de Maestría. Primeramente a mi asesor Joakim Tell por guiarme durante el proceso de investigación, de igual manera a Henrik Florén, Bernd Hofmaier y demás alumnos de maestría al darme la retroalimentación necesaria para mejorar el contenido de la Tesis. No podrían faltarnos mis agradecimientos al profesor Christer Norr ya que a través de sus clases despertó mi interés en el tópico de administración de innovaciones de tecnología.

Isabelle, Arnaud, Marius, Víctor y Alejandro. Su ayuda fue fundamental en la obtención de los datos empíricos que dieron valor a esta investigación.

Me gustaría agradecer a mi familia, en especial a mis padres, a mi hermana, a mi prima Ana y a mi abuela Emma, sin los cuales no hubiera podido llegar a donde estoy hoy. Quisiera agradecer también a mi primo Víctor por inspirarme a tomar la carrera que tomé. Por supuesto quiero agradecer a Tania Olivé, por ser mi inspiración cada día y por apoyarme en todos mis sueños.

Finalmente quiero agradecer a Dios por darme la fuerza necesaria para completar este periodo tan importante en mi vida.

Halmstad, Suecia 2011

L. Rodrigo Trejo
鸣谢

希望借此机会来感谢每一位曾经在这篇硕士论文研究过程中帮助过我们的人。首先需要感谢我们的指导老师 Joakim Tell, 在这段日子他给我们提供了悉心的指导, 帮助我们开拓研究思路, 他的反馈意见对我们的进步有着建设性的意义。

同时我们也需要感谢 Henrik Florén, Bernd Hofmaier 以及其他 TPA 的同学们。在讨论中，他们向我们提出了很多宝贵的意见。在此，我们还需要感谢 Christer Norr, 他的相关课程对我们选择研究企业创新管理有着重大的影响。

此外，特别感谢 Isabelle, Arnaud, Marius, Victor 和 Alejandro 帮助我们收集相关的研究数据, 这篇硕士论文正是由于有了你们的帮助才变得完整与生动。

最后，我们还需感谢来自家人鼓励与支持。

哈姆斯塔德, 瑞典 2011

高志远
ABSTRACT

In the telecom manufacturing industry, the business environment is characterized by high competition and challenging tasks. To be able to thrive in this environment, companies have to work hard in order to develop innovations in the form of products, services and solutions to the marketplace. R&D departments, in collaboration with other functional departments and external agents, become the main engine for innovation development. R&D managers face the difficult challenge of effectively managing innovation projects, which are surrounded by high complexity, uncertainty and risk. To help address this issue, this thesis explores four successful innovation projects within four distinct international telecom technology suppliers, namely Nortel, Alvarion, ZTE and ST-Ericsson, to identify the factors that directly influenced the success behind each innovation. To do so, a comprehensive study of the telecom innovation system was conducted; this study enabled the researchers to devise a framework that describes the innovation process in the industry and that highlights the value of the marketing department, the importance of early customer involvement and that clearly demonstrates the self-sufficiency of today's telecom manufacturing department. Additionally, the study highlights the importance of the human factor and the substantial value of nurturing staff and fostering different roles within the innovation team, such as that of the gatekeeper, entrepreneur, technology specialist and senior manager.

R&D management literature lists over 250 different success factors; the framework included in this thesis presents only the 60 factors that are relevant to the industry. These factors are categorized in two ways: (1) As either order winners or order qualifiers and (2) as either being affected or unaffected by the innovation type. The first categorization serves to identify 25 factors that can become a source of competitive advantage if managed accordingly and 35 factors that are considered to be the status quo of the industry, and while very important are not a source of competitive advantage. The second categorization brings awareness to the R&D manager by identifying nine factors, namely: the source of the idea, access to information, the probability of commercial success, the comprehensiveness of the requirements, newness to firm, market strength, innovation receptiveness, degree of innovation and supportive environment. The research showed that these nine factors are directly affected by the innovation type (incremental, architectural or radical).

Keywords: Telecom, R&D, Success Factors and Innovation Management.
ACRONYMS AND ABBREVIATIONS

List of acronyms and abbreviations that are found in the thesis:

2G, 2.5G- Second Generation (Wireless communication system)
3G-Third-Generation Cell-Phone Technology
3GPP-Third Generation Partnership Program
4G-4th Generation (wireless/mobile communications)
ANSI- American National Standards Institute
ATP- Assurance Test Procedure
ATR- Alpha Test Results
B2B- Business to Business
B2C- Business to Consumer
BSS-Base Station Subsystem
BTS- Base Transceiver Station
CAPEX-Capital Expenditure
CCB - Change Control Board
CEPT - Comite European des Postes et Telecommunications (French: European Committee of the Stations and Telecommunications)
CPO- Customer Product Organization
CR- Customer Request
E1- 2.048Mbps data rate (European)
EDGE- Enhanced Data-rates for Global Evolution
ERP- Enterprise Resource Planning
ETSI- European Telecommunications Standards Institute
FPGA- Field-Programmable Gate Array
GPS- Global Positioning System
GSM- Global System for Mobile Communications
HQ- Headquarters
HR- Human Resources
HSPA- High Speed Packet Access
HW- Hardware
IEEE- Institute of Electrical and Electronics Engineers
ISO- International Organization for Standardization
ITU- International Telecommunications Union
LTE- Long Term Evolution
OPEX-Operational Expenditure
PCM-Pulse Code Modulation
PLM-Product Line Management
PM- Project Manager/Project Management
QoS- Quality of Service
R&D-Research and Development
RF- Radio Frequency
SE-System Engineer
SPE-Senior Product Expert
SW-Software
TD-CDMA- Time Division - Code Division Multiple Access
TD-LTE-Time Division-Long Term Evolution (wireless networking)
UMTS-Universal Mobile Telecommunications System
WA1K-WalkAir 1000
WA3K-WalkAir 3000
WCDMA- Wideband Code Division Multiple Access
WiMAX- Worldwide Interoperability for Microwave Access
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1 INTRODUCTION

The introduction chapter contains the background of the thesis, the problem statement, the research question and purpose, followed by the thesis’ unique contributions, limitations, a brief discussion on the methodology used and the report outline.

1.1 Background

‘Rapid technological development, innovation and diffusion have turned the telecom industry into a major economic growth generator’ (Lindmark, Andersson, Bohlin, & Johansson, 2006, p. 49)

Today, most, if not all, telecom manufacturers have to compete on an international arena; even Chinese traditional companies that used to be focused on local sales have been increasing their international penetration in the last two decades (Fan, 2006). Due to the changing requirements from telecom operators (which represent an important part of the business for telecom equipment manufacturers) competition between manufacturers has a growing emphasis on price, quality of service and marketing campaigns (Henten, Falch, & Tadayoni, 2004). This industry is characterized by having a high pace of technological development, which ‘may be explained by the links between the sector’s own R&D and the creation of numerous innovations’ (Godoe, 2000, p. 1033). Technology is one the most important resource of any nation and its management is a matter of global focus (Ahuja, 2011). In order to maintain a competitive advantage, telecom manufacturers have to innovate through the use of their R&D departments (Ojanen & Vuola, 2006), and such innovations have to take into account the market, technology and management (Popadiuka & Choob, 2006). Furthermore, companies’ R&D resources need to be used in a productive way to be able to introduce products ahead of competition with the highest quality while at the same time reducing cost (Karlsson, Trygg, & Elfström, 2004). Nevertheless, R&D functional departments have several different traits that set them apart from other functional areas of business. One of them being that it is particularly difficult to be effectively managed (Ojanen & Vuola, 2006). Due to the high degree of variability and ambiguity in inputs and outputs, the more radical the innovation is, the harder the managerial task becomes. In the past, R&D was thought as being nearly impossible to systematically manage and control, R&D managers were just expected to perform a best effort task to try to maximize the returns in the long run (ibid). However this paradigm has changed more recently and R&D managers are expected to have a strategy to deal with innovation development and to systematically manage the R&D effort (Bremser & Barsky, 2004). In order to do so, they need to have a holistic view on the business and to know how to interact with manufacturing and marketing while being aware of the external environment (ibid). To help in the understanding of innovation management, researchers have conducted many analyses of different industries to provide a list of success factors (Balachandra & Friar, 1997), however these factors are vast and it is difficult to sort those that have a direct usability for the telecom manufacturing industry. From this arises the need to provide a framework that managers could use to handle innovations within the R&D
department of telecom organizations. Such a framework requires a comprehensive set of success factors that managers could concentrate on and encourage their people to focus on.

1.2 Problem Statement
The telecom industry has been for many years one of the most dynamic and talked about industries of the global economy (Cornu, 1997). The pace of change is so fast that telecom technology manufacturers have to be in constant innovation development processes to satisfy the needs of their customers (ibid).

There is evidence in innovation literature that suggests the direct relationship between a product success and the effective innovative management practices and policies behind it (Adams, Bessant, & Phelps, 2006). There are indications that even the most sophisticated technological companies have had flaws when it comes to innovation management (Maidique & Hayes, 1984). For years, researchers have focused in finding strategies, policies, best practices and success factors that enable organizations reaching the goal of managerial excellence that will allow increasing the likelihood of developing a successful innovation. From all these practices and factors, there are many studies that label success or failure within innovation projects. Nevertheless, these factors are vast and it is difficult to get a pragmatic view on the issue at hand. Furthermore, the empirical evidence is vast and spans from many different industries such as the airplane (Ranftl, 1984), electronics (Brown & Svenson, 1998), information technology (Maidique & Hayes, 1984), oil (Schumann, Ransley, & Prestwood, 1995), etc. Only few studies present empirical evidence of the telecom industry. However Balachandra and Friar (1997), provided a good contribution to this problem by stating that hoping to obtain a list of universally accepted success factors is a naïve endeavor which is not worthy of pursuing, and that these factors are contextual depending on the nature of the innovation, technology, market and possibly on the nature of the industry (Balachandra & Friar, 1997). From this, the problem at hand is the lack of a framework that would help the project, product and middle manager to lead innovations in the telecom industry; as while many of the factors located in the literature might and actually are pertinent to the telecom industry many others are not, thus the need for an exploratory analysis on the industry’s success factors for innovation development.

1.3 Purpose and Research Question
The purpose of this thesis is to provide a framework for R&D managers in the telecom sector that deal with the innovation development process. This framework will be based on the key success factors that the R&D manager should focus and foster during the development process, from beginning to end, thus the research question (RQ) that will be developed, discussed, answered and that guided the researchers during the creation of this thesis is as follows:

“What are the key factors that enable managers to influence the success of innovation projects within telecom manufacturer companies?”

From the above RQ, the research has the following aims:

- Stress the relationships between these factors.
• Classify the factors as either order winners of order qualifiers\textsuperscript{1}.
• Identify the factors that are affected by the type of innovation.
• Devise a model for the usage of management that graphically describes the innovation management process inside the R&D organization of a telecom manufacturing company.

One of the researchers’ intentions at the beginning of the research was to be able to measure the impact of the factors, and by this strengthening the accuracy of the importance among them. However, due to limitations of getting quantitative information on the projects, it was not possible to measure this impact. Nevertheless, to compensate this limitation, a qualitative analysis of four successful innovations will take place to make sure that the selected factors contributed to the innovation’s success.

1.4 Unique Contributions

To Academia

The first contribution of this thesis is that it provides a new framework that shows the innovation system in the telecom manufacturing industry, which consists of the process of turning inputs into outputs and outcomes in the form of innovations.

This research provides a contribution to the innovation management literature by collecting, selecting and filtering from over 250 different success factors found in literature, the selection was narrowed down based on their applicability towards the telecom industry, resulting in 60 factors. From these factors, 25 among them were classified as order winners and the remaining 35 were considered order qualifiers, this classification was the result of the analysis of empirical data from four distinct successful innovation projects. Furthermore, nine out of the 60 factors were identified as being affected by the innovation type (incremental, radical or architectural). Such collection of factors classified in this manner was not available in the literature.

Business

This research provides a contribution to the telecom industry, as it collects success factors from Chinese, Israeli, Canadian and Swedish/Italian technology firms that are of different sizes and have a very different cultural background and geographical diversity. Even though the contribution from the headquarters was of utmost importance for the innovations’ development, a large portion of this work was done in other countries including Romania, France, Japan and Mexico. The outcomes of the projects benefited several customers from all over the world; thus a contribution to the success of the research is the diversity of the samples, as they allow enriching the selection of key success factors, hence making the degree of generalization among telecom manufacturers very high.

\textsuperscript{1} ‘Order qualifiers are those criteria a company must meet to be considered as supplier. Order winners are those criteria that win the order over the competition’ in Hill study (as cited in Prajogo et al., 2007, p. 53). Order winners might be used by organizations to differentiate their products or services from the competition thus becoming a potential source of competitive advantage.
A second contribution is to the R&D team within telecom firms, as it will provide a framework that can be used in the pursuit of managerial excellence of innovations. The contribution is mainly for the product and project manager leading the innovation directly, as these managers will be able to know which factors are order winners and order qualifiers in the industry, they will also be aware of the factors that are impacted by the innovation type so they know what to expect when it comes to these factors. To a lesser extent the contribution is as well for senior management as some organizational and cultural success factors may help them shape the R&D organization and devise strategies. Having empirical evidence from four distinct successful innovation projects strengthens the contributions.

1.5 Limitations

Starting with the degree of generalization, the actual scope of the thesis poses a limitation regarding this topic, as it seeks to show key success factors for innovations within the telecom industry and may not be applicable for other industries. However, as Balachandra and Friar (1997) have suggested, there is the possibility that the framework proposed will be relevant to other development projects of different industries if they share the same nature of: (1) Innovation (incremental, architectural or radical), (2) market (existing) and (3) technology (high tech) as the cases shown in this thesis. Furthermore, even though it can be generalized to future innovation projects of the telecom industry there is a chance that its applicability is diminished for a project with a very radical innovation nature, where for example the market does not exist at all. Thus, the success factors regarding customers, the marketing department and the external environment might not be suitable, as in a very radical innovation it would be nearly impossible to involve the customer or to get customer feedback, as the customers would be yet to be identified (Balachandra & Friar, 1997).

While we strived to be comprehensive in the factors presented in this thesis, we are aware that some other success factors might be missing. The reason for this is twofold: (1) they were not evident during the empirical analysis. (2) They were not noticeable during the theoretical review of relevant literature.

The available empirical data also pose some limitation to this study, such as the following:

- The researchers focused on success factors and on the positive stimulations that successful innovation projects received, it was not possible to get examples on failed or cancelled innovation projects, which might have helped to strengthen the contributions of this research, the reason for this is that people would be reluctant to comment on errors or bad decisions, not to mention that the selected companies would have had to remain anonymous.
- It was not possible to obtain financial data and quantitative information on the projects, as the companies would not disclose this information for being confidential. Therefore, when it comes to financial data, the information obtained was somewhat general, which made difficult to strengthen the relationships between success and finance.
- The researchers considered a criteria for project selection to be on finished projects, as information on outputs and outcomes was essential for this research, however some authors, such as Balachandra and Friar (1997) mention that analyzing post
mortem projects may be a weakness as the interviewees might tend to excessively glorify the outcomes of the successful projects, which would be an impairment for a good research. Therefore it was necessary to obtain information on outcomes from secondary data such as companies’ websites, and in the case of two projects, previous direct observation, as for the case of Nortel and Alvarion one of the researchers worked personally with such organizations.

- The availability of people that participated in the analysis is also a limitation, as only one person per project was interviewed. It was not possible to interview people from marketing, manufacturing, or even to have a customer input. Availability on these sources is a limitation of this research.
- A final limitation refers to the empirical data from ST-Ericsson, as their business is different than from the other three companies. ST-Ericsson main business is being a supplier for mobile handset manufacturers (ST-Ericsson, 2011), and while Alvarion, ZTE and Nortel also have/had such business area, their main business is being a supplier for network operators, Internet service providers and federal governments (Alvarion Ltd, 2005-2011; Nortel, 1999-2011; ZTE, 1998-2011). The three cases are for network operators and not for handset manufacturers. Nevertheless, all four companies in this research are technology suppliers for the telecom business and they all are B2B and not B2C, thus having many similarities.

1.6 Methodology
This thesis collects data from one successful innovation project within four international telecom manufacturer companies. A qualitative methodology is used.

1.7 Report Outline
Chapter 1 introduces the thesis and briefly discusses the background of the research, as well as the purpose with corresponding contributions and limitations. Chapter 2 describes in detail the theoretical frame of references presenting a review of existing literature suitable for the research purpose. Chapter 3 describes the methodology used to deal with the thesis. Chapter 4 shows the empirical evidence from the four analyzed projects from different telecom manufacturer companies. Chapter 5 contains the analysis of the empirical data to answer the research question and finally Chapter 6 contains the conclusions and suggested future research.
2 THEORETICAL FRAME OF REFERENCES

This chapter discusses the scientific foundation behind classification of innovations; it also discusses the innovation system, which is a process that consists of Inputs, Outputs, Organization, R&D department, marketing department, manufacturing department and external environment.

2.1 Innovations’ classification

‘Invention is the creation of a new idea. Innovation is the process of applying a new idea to create a new process or product’ (Galbraith, 1982, p. 6)

To understand the R&D department within a telecom manufacturer firm, innovation must be understood, as it is within this department that innovations are born.

As stated above it is important to make a distinction between an idea and an innovation, ‘if an idea has not been developed of transformed into a product, process or service, or it has not been commercialized, then it would not be classified as an innovation’ (Popadiuka & Choob, 2006, p. 303). Innovations can be considered as an essential input that allows organizations to distinguish themselves from their competitors in orders to gain a competitive advantage (Morden, 1989).

Many authors have provided models to further help in the classification among innovations (Abernathy & Clark, 1985; Henderson & Clark, 1990; Chandy & Tellis, 1988; Tushman, Anderson, & O’Reilly, 1997). In this literature, innovations are classified by estimating the innovation impact on technology, market, customer, components or architecture; however for the purpose of this thesis the model proposed by Henderson and Clark (1990) appears to be suitable:

![Figure 1 A model for classifying innovations (Henderson & Clark, 1990, p. 3)](image)

Henderson and Clark explained that an innovation requires two types of knowledge, namely, components and linkages between components (architecture).

‘The combination of component and architectural knowledge produces four kinds of innovation: (a) Incremental innovation, where both architectural and component
knowledge are enhanced simultaneously; (b) Radical innovation, where both types of knowledge are “destroyed”; (c) Architectural innovation, where component knowledge is enhanced but architectural knowledge is destroyed; (d) Modular innovation, where component knowledge is destroyed but architectural knowledge is enhanced” (Popadiuka & Choob, 2006, p. 304).

By using the word “destroyed” it is implied that previous knowledge has been dramatically changed.

2.2 Innovation System’s Framework

The above model was created from literature; the diagram shows the innovation system as a process. The framework is the researchers’ interpretation inspired by models such as the ones created by authors like Brown and Svenson (1998), Schumann, Ransley and Prestwood (1995) and Twiss (1992). The center of the model depicts the R&D system, which represents the interactions between the functional departments of R&D, marketing and manufacturing. The R&D System in combination with the innovation’s inputs, outputs, organization and external environment constitute the innovation system, a term that will be utilized many times in this thesis. Inside of each of the boxes lie the success factors, which are thoroughly explained and discussed in the following section.

2.3 Key Success Factors in the Innovation System

This chapter explores the success factors of innovation projects that are relevant to the telecom industry, as they are all supported by empirical evidence. The aim of the authors is to include micro factors that can be applied directly to an R&D project, however some macro factors that are of utmost relevance are also mentioned.

2.3.1 Inputs in the development process

‘Inputs are the raw materials or stimuli a system receives and processes’ (Brown & Svenson, 1998, p. 30).

In this section, key success inputs to the innovation development system are outlined.

Typically, these inputs are gathered and evaluated during the project-initiating phase; the project-initiating phase is the phase before the development project inside a company
officially starts, this process grants the approval of utilizing the organization’s resources to start working in the project (Heldman, 2009). In the case of innovation projects, the existence of an original and powerful idea is the starting point (Brown & Gobeli, 1992), without it, no matter how capable the organization is or how specialized the R&D engineers are, the innovation process cannot start (Twiss, 1992). Even in high tech industries such as in the telecom one, the source of ideas does not have to be always R&D, but also can be marketing, top management, manufacturing managers and sometimes this source comes from external parties such as customers, competitors and suppliers (Twiss, 1992). The organization should be sensitive to gathering, channeling and evaluating these ideas. The role of idea generation should be part of the organizational culture to produce innovation (Roberts & Fusfeld, 1981). The concept behind the idea itself has to be aligned to the organization’s corporate objectives (Twiss, 1992); the potential benefits of developing this idea have to ultimately benefit the effectiveness of the organization (Twiss, 1992). In the case of the high tech industries, one important input is the existence of technical documentation (Brown & Svenson, 1998), as new products, protocols or features are not created from scratch, but are rather a mix and improvement of existing knowledge. Therefore having access to this information is key before starting an innovation project (Brown & Svenson, 1998). This is particularly true in the telecom field.

Two particular roles are an important input to the innovation development: (1) the strategic participation of top management, as it provides the high level strategy behind the innovation development and monitors the external forces (Imai, Nonaka, & Takeuchi, 1984). (2) The existence of a project champion or intrapreneur that pushes and demonstrates the potential of the idea and looks for senior management approval (Roberts & Fusfeld, 1981).

The above-mentioned inputs have to be in place, either in the external environment or inside the organization, however there are also actions that organizations need to do in a very careful manner to make good use of these inputs. One is to assess the value that the innovation will bring to the organization (Heldman, 2009), and its probability of commercial success (Balachandra & Friar, 1997), as top management will require it when taking decisions regarding project approvals. Creating a list of specific, clear and holistic set of technical and marketing requirements for the innovation is essential for a good project’s initiating phase (Brown & Svenson, 1998).

To conclude this section of key inputs, it is important to talk about resources, even though most companies will always have a problem with resources, the following factors are critical to have in mind. The first factors deal with having a sufficient number of R&D staff to take on the new innovation and also to assess the training, skills and experience of the existing staff (Brown & Gobeli, 1992). Perhaps one of the most important factors is to identify people that are good at innovating. People that are good at innovating are not necessary good at operating, and management has to identify both types of personnel and create a strategy to involve them in a specific stage of the innovation development to take the best elements of both types of people (Galbraith, 1982). The final success factor corresponds to the financial resources assigned to the innovation. However, this does not mean that having unlimited financial resources is a success factor, as this is never the case. Nonetheless, a good analysis and prediction has to be done in this initial phase. Some metrics that can be generated are
the internal rate of return, net present value (Heldman, 2009), the expected R&D financial return on investment, and the estimation of the annual business opportunities derived directly and indirectly from the innovation (Bjorn & Souder, 1997).

2.3.2 The R&D functional Department

*The R&D department inside a firm has as an objective to create new ideas and new knowledge through innovation* (Svensson, 2007, p. 4).

The R&D department is the central focus of this thesis, as it is where the innovation development takes place, some key factors that should be present in this department are outlined in this section.

A factor that seems to be a foundation within the R&D organization is the employee commitment (Balachandra & Friar, 1997). As ‘Innovations do not happen, they are made to happen’ (Twiss, 1992, p. 19) by employees that carry out activities and possess “technical vitality”, which means understanding the market, committing to leadership, executing activities with excellence and never lose the customer perspective (Schumann, Ransley, & Prestwood, 1995). Among this type of people the figure of the so-called intrapreneur should be encouraged inside this department; successful high-tech firms promote these internal agents of change who play multiple roles and take immediate decisions (Maidique & Hayes, 1984). The entrepreneurial culture entails a degree of tolerance to failure (ibid) as learning is fundamental in the innovative organization, the focus should rather be on minimizing the learning time among employees (Schumann, Ransley, & Prestwood, 1995). Another factor is the “newness” of the innovation, as it can have an impact in the results of development, R&D departments should “stick to their knitting” or else at least to develop a technology that is closely related to what they have been doing (Maidique & Hayes, 1984).

A large part of the responsibility falls under R&D management. Management should pay attention to some key factors, starting off with the comprehensiveness of the R&D program (Bjorn & Souder, 1997). R&D managers are encouraged to find and follow an industry best practice methodology in the specific field of the innovation development. Managers can find this best practice through literature research, patent reviews, customer visits, etc. (Schumann, Ransley, & Prestwood, 1995), or as well looking at best practices from telecom industry standards institutes such as the ITU, ISO, etc. The need for effective project management seems evident. However the key factor is the strategic management style (Twiss, 1992). During early stages of research an informal management control style is recommended as it allows people to be creative under a somewhat free structure. Nevertheless, this informal style should be reinforced by two actions: (1) By combining specialized senior engineers with young engineers from various backgrounds, the senior people will help when the innovation is too radical and the young figures will help when the project has reached an impasse (Imai, Nonaka, & Takeuchi, 1984). (2) By establishing central values in the employees, which are shared by the whole R&D organization, so they have a sense on how they should behave and what they ought to be doing (ibid). However, once the project turns more to the development stage, the management style should change and become more “traditional”, as in later stages of development an informal management style will inevitably lead to delays and cost escalation (Twiss, 1992). The R&D organization should
assess if one manager will be able to change styles as needed (ibid). Another factor managers should focus on is effectiveness. The R&D manager should concentrate on obtaining effectiveness out of the innovation first, as this is what will drive later profits from the customers, after the R&D organization has successfully developed effectiveness the manager can turn his/her attentions to efficiency, when this happens the R&D department will be able to ‘do the right things rightly’ (Schumann, Ransley, & Prestwood, 1995, p. 46). Finally, managers should know the importance of the willingness of employees to respond to peak demands and emergencies (Brown & Gobeli, 1992).

To conclude this section metrics that R&D managers should track are included:

- Timeliness in development/compliance with planning (Bjorn & Souder, 1997)
- Percentage of technical specifications met (Brown & Gobeli, 1992)
- Percentage of activities that required rework (Schumann, Ransley, & Prestwood, 1995)
- Number of engineering change orders (Brown & Gobeli, 1992)
- Number of design changes before release/engineering change orders (Brown & Gobeli, 1992)
- Number of tests performed per week (Brown & Gobeli, 1992)
- Number of engineering hours versus budget (Brown & Svenson, 1998)
- Net present cash flow to development cost (Brown & Svenson, 1998)
- Reporting results of development (Brown & Svenson, 1998; Balachandra & Friar, 1997; Brown & Gobeli, 1992)

2.3.3 The Manufacturing Department

‘Whatever the merits of the technical innovation, it is of no value until is manufactured and emerges as a product offered to the market’ (Twiss, 1992, p. 20).

R&D and manufacturing are very different in terms of objectives, the telecom equipment manufacturer industry is very competitive and the price factor has become more important ever since Chinese and Korean telecom manufacturers began their international expansion. This has forced everybody in this industry to minimize manufacturing cost, ‘The value of an innovation emerges as a product that must be produced at the lowest possible cost and then is offered to the market’ (Twiss, 1992, p. 16).

A separation of R&D design and production could generate a communication insufficiency. Since the R&D department is working on the future, and the manufacturing is all about the current demands, these different timescales could be a source of problems.

The design, production and marketing of the product should progress in parallel. The close relationship between R&D and production is a necessary element in the innovation process. The communication gap between these departments could lead to a series of problems. According to Twiss (1992), the most common consequence of lacking communication between these two departments could lead to manufacture of a product that is extremely and unnecessarily expensive to produce (ibid). The anticipated sales volume also needs to be coordinated between the R&D and manufacturing departments, as a suitable design for a small-scale batch may not be adequate for a massive scale production (Twiss, 1992).
staff should also have a good understanding on manufacturing possibilities (Patterson M., 1989).

Furthermore, differences in performances between the prototype and real product need to be considered. The prototype product is usually produced by highly skilled and knowledgeable specialists, which often have their own unrecorded minor modifications (Twiss, 1992). This unrecorded information may not be transferred to the production and it could lead to a performance problem with the final product. Thus, R&D and manufacturing departments need to set a close relationship to make sure the performance of the product is the same as they designed.

Every manufacturing department should be focused on minimizing errors, cost (Balachandra & Friar, 1997) and in being highly efficient (Karlsson, Trygg, & Elfström, 2004).

2.3.4 The Marketing Department

*Many authors have suggested that the organization should receive a strong support form the marketing function for the new product* (Balachandra & Friar, 1997, p. 287).

A strong market support is very important for the success of a new product (Balachandra & Friar, 1997). According to Twiss (1992), one of the most serious barriers for a successful innovation is the linkage of R&D and marketing. A major source of failure is to not consider the market orientation when making decisions. Both Mansfield and Wagner (1975) and (Cooper, 1997) have emphasized the importance of market analysis. Mansfield and Wagner (1975) advise the market analysis should be done as early as possible.

Twiss (1992) claims that the idea for a new product usually comes from two sources, either a specified market need or the R&D department, and both sources of ideas should be encouraged. Twiss (1992) has argued that the prerequisite for an innovation is to establish a firm linkage with the market. People that have expertise in R&D should form a close relationship with people that have expertise in marketing; the technologists need to know the requirements of the customer (ibid). A good market analysis could help the product satisfy the customer needs (Gaynor, 1990). The technologist should get feedback from the customer in order to make a better product.

An early market entry could be considered as a success factor (Maidique & Zirger, 1984), on the other hand Porter (1979) points out that it depends on the firms’ strategy.

2.3.5 Organizational Success factors

*On top of successful telecom companies is a strong leadership; ‘a company without formidable traits of leadership cannot survive for long’* (Maidique & Hayes, 1984, p. 18).

The above statement is particularly true in today’s tough telecom industry. This section presents a set of organizational management practices that could aid to reinforce such leadership.

The fist organizational success factor refers to communication, ‘In high tech organizations, top management needs to know the effectiveness of the R&D communications with related business units’ (Brown & Gobeli, 1992, p. 325). Communication in the company is so
important that many researchers have emphasized it over time. The communication is one of the most important factors for a successful new product (Twiss, 1992). Twiss (1992) identified two main problems in this area, the first one refers to communication problems between technologists and marketing individuals, and the second one is the existence of an organizational structure that hinders communication.

To continue with organizational success factors, a set of practices that are traditionally dealt with by the human resource department (HR) are discussed. The first refers to employee motivation, which is particularly important to the innovative organization where employees must be committed to achieve organizational goals. It is safe to say that satisfied employees seem to be more willing to work for this than dissatisfied ones (Keller, Julian, & Kedia, 1996). Furthermore there seems to be international evidence that productivity can be a function of employee motivation and cooperation on a team (ibid), and satisfaction must not be confused with conformity. HR should also have a special reward system for the innovative organization; this system should contain three main characteristics. Firstly, it should be different than the reward system for operations, as innovation requires an extra effort (Galbraith, 1982). Second, it should have as an objective to attract the best professionals to the organization and with equal importance to maintain them inside of it; employee attrition affects any business but affects dramatically the innovative organization (ibid). Third, the reward should be given due to successful performance (ibid). Nonetheless, rewards do not necessarily mean higher compensation or financial bonuses. Depending on the employee particular role and personal needs, the organization should reward him/her with attributes that could further motivate him/her, for example with recognition, higher visibility, more autonomy, more significant roles, more resources, etc. (Roberts & Fusfeld, 1981). The last factor that HR should look at refers to learning. HR should promote learning at all hierarchical levels and functions of the organization (Imai, Nonaka, & Takeuchi, 1984).

There are other factors that might be out of the scope of HR and may fall on the organization’s top management, one of them regards business focus, which means selling equipment and solutions relevant to one main telecom technology, in larger telecom manufacturers it is more common however to have parallel development in several technologies. Nevertheless, these technologies should be somehow related (Maidique & Hayes, 1984), the organization should also have a strong commitment with R&D, it is common to see that successful companies invest higher portions of their revenues in R&D than less successful ones (ibid). Telecom companies should strive to be consistent with this investment even in recession times, if cutbacks are needed they should be on operational areas of fixed expenses but not in R&D, furthermore the organization priorities should be consistent over as longer periods of time as possible (Maidique & Hayes, 1984). Nonetheless this focus on priorities over time should never cause innovative stagnation (ibid). The firm ‘must balance this focus with the willingness to undertake major and rapid change when necessary’ (Maidique & Hayes, 1984, p. 20) and this factor may be called adaptability. Top management should foster an internal environment receptive to innovation. It is likely that some managers inside high-tech firms are resistant to innovation as this brings change (Twiss, 1992). The organization should pay attention to the management of organizational change, as it is very related to innovation. Empirical evidence shows that when the firm innovator person is part of top management, the organization’s receptiveness to innovation
is enhanced (ibid). The organization should carefully select the proper team structure. Out of all the different team structures; a “heavy weight team structure” (Wheelwright & Clark, 1992) might be appropriate. It consists in the assignment of a senior project manager to lead the innovation; this PM outranks the functional managers by experience and organizational clout (ibid). To finish this section a factor that has been mentioned earlier, and should be in the eye of top management, refers to the entrepreneurial culture (Keller, Julian, & Kedia, 1996; Roberts & Fusfeld, 1981; Maidique & Hayes, 1984).

2.3.6 Target outputs and outcomes of the innovation

‘Outputs are facts or principles that were unknown before the development of the innovation’; ‘outcomes are the accomplishments that have value for the organization’ (Brown & Svenson, 1998, p. 31).

Outputs and outcomes are the reason why companies put so much effort on developing innovations; in this section some outputs and outcomes that telecom equipment manufacturers could use as a benchmark for success are outlined.

The first set of key outputs that are discussed refer to product-related properties, such as quality of the hardware and software (Brown & Gobeli, 1992), cost, availability (Karlsson, Trygg, & Elfström, 2004), reliability and performance (Schumann, Ransley, & Prestwood, 1995). Without these properties, the innovation is likely to be a failure. Furthermore the competitive value, degree of innovation and numbers of designs produced ought to be tracked carefully (Brown & Svenson, 1998).

Moving to key outputs that could arise from the innovation, is the inception of new knowledge or processes (Brown & Svenson, 1998), as it is a potential source of core competency for the company. The degree of patentability should be assessed next to the number of patents awarded to the innovation (Bremser & Barsky, 2004). These patents could later be translated into licensing or intellectual property benefits for the company (Schumann, Ransley, & Prestwood, 1995). Finally an output that should be carefully accounted for, is the comprehensiveness of the documentation (Patterson M., 1989).

After the outputs have reached the intended customers they become outcomes, and some outcomes that telecom companies should aim at are briefly discussed. The first is related to product improvement, as even when the innovation reaches the marketplace it has to be in a state of constant improvement (Brown & Svenson, 1998). This improvement shall include cost reduction (Brown & Gobeli, 1992). The perceived value of the products in the eyes of the customer is also important to be assessed as it might partially determine the price they would be willing to pay (Brown & Svenson, 1998). An additional outcome to be carefully managed refers to the customer complaint and feedback (Schumann, Ransley, & Prestwood, 1995). To close this section four key financial metrics that R&D managers should track are included:

- Contribution to market share (Schumann, Ransley, & Prestwood, 1995; Brown & Gobeli, 1992)
- Return on Investment (Brown & Gobeli, 1992; Schumann, Ransley, & Prestwood, 1995; Bjorn & Souder, 1997)
• Commercial proposals won thanks to the innovation (Brown & Gobeli, 1992)
• Price impact on customers (Schumann, Ransley, & Prestwood, 1995)
• Break even time (Schumann, Ransley, & Prestwood, 1995)

2.3.7 The external environment

‘A product cannot succeed if the environment in which is introduced is not supportive’ (Balachandra & Friar, 1997, p. 278).

There seems to be evidence on the importance of the external environment before, during and after the development of an innovation. A brief review of the important factors related to the external environment follows.

In the input section of the theoretical background of this thesis, the external environment was highlighted as being an important source of ideas for the innovative organization, especially from the customers, suppliers and competitors (Twiss, 1992). The market place is related to the external environment of the firm, as it is where the company competes and makes business, the market factors are very important when the innovation is incremental, the market already exists and the technology developed is high (Balachandra & Friar, 1997). The image that the company and the R&D organization projects to the external environment also has an impact on the innovation development success (Brown & Gobeli, 1992). In Robert and Fusfeld’s article entitled “Staffing the Innovative Technology-Based Organization” a series of key roles are developed, one of them called “Gatekeeper” plays an important function as being very aware of the external environment by channeling and collecting the changes in the firm’s environment (Roberts & Fusfeld, 1981). To finalize this section, it is important to say that the telecom business is ever changing, and to stay competitive in this sort of environment the innovative organization has to be aware of the external factors like changes in customer demands and developments in the market (Karlsson, Trygg, & Elfström, 2004).

2.3.8 Key Success Factors Summary

To this point, several success factors have been drawn from existing theory; the following table summarizes these 60 factors:

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Success Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inputs</td>
<td>• Quality and Source of the Idea[1][2][3][4]</td>
</tr>
<tr>
<td></td>
<td>• Having access to key information such as technical of research information[5]</td>
</tr>
<tr>
<td></td>
<td>• Top management participation[6]</td>
</tr>
<tr>
<td></td>
<td>• Entrepreneur Figure[4]</td>
</tr>
<tr>
<td></td>
<td>• Comprehensiveness of the requirements[1][5]</td>
</tr>
<tr>
<td></td>
<td>• (M) Probability of commercial success[7][8]</td>
</tr>
<tr>
<td></td>
<td>• Sufficient number of R&amp;D personnel[2]</td>
</tr>
<tr>
<td></td>
<td>• Having the right people recruited for the project[9]</td>
</tr>
<tr>
<td></td>
<td>• (M) Financial Metrics[2][5][7][10][11]</td>
</tr>
</tbody>
</table>

2 These factors were selected by the following two criteria: (1) they are included in several articles in recent innovation management literature. (2) They are supported by the collected empirical data.
<table>
<thead>
<tr>
<th>R&amp;D Department</th>
<th>Manufacturing</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>• High employee commitment</td>
<td>• A production orientation, with sound understanding on manufacturing</td>
<td>• The importance of internal communication</td>
</tr>
<tr>
<td>• People key Roles</td>
<td>possibilities</td>
<td>• Employee motivation and capability</td>
</tr>
<tr>
<td>• Newness to firm</td>
<td>• Minimize errors</td>
<td>• Reward system</td>
</tr>
<tr>
<td>• Comprehensiveness of the R&amp;D program</td>
<td>• Minimize cost</td>
<td>• Learning strategies</td>
</tr>
<tr>
<td>• (M) Conformance to best practices</td>
<td>• (M) Efficiency and Performance</td>
<td>• Business focus</td>
</tr>
<tr>
<td>• Effective Project Management and Control</td>
<td>• (M) Net present cash flow to development cost</td>
<td>• Adaptability</td>
</tr>
<tr>
<td>• Effectiveness of development</td>
<td>• Reporting results of development</td>
<td>• Organization receptive to innovation</td>
</tr>
<tr>
<td>• (M) The ability to respond to peak demands and</td>
<td>• Manufacturing culture</td>
<td>• Team structure</td>
</tr>
<tr>
<td>emergencies</td>
<td>• Minimize errors</td>
<td>• Entrepreneurial culture</td>
</tr>
<tr>
<td>• (M) Timeliness in development/compliance with</td>
<td>• Minimize cost</td>
<td>• Outputs and Outcomes</td>
</tr>
<tr>
<td>planning</td>
<td>• (M) Efficiency and Performance</td>
<td>• Quality, Reliability, Availability, technological capability</td>
</tr>
<tr>
<td>• (M) Percentage of technical specifications met</td>
<td>• (M) Number of patents, degree of patentability, and licensing and</td>
<td>• Designs produced</td>
</tr>
<tr>
<td>• (M) Percentage of activities that required</td>
<td>intellectual property</td>
<td>• Competitive value of innovation and degree of innovation</td>
</tr>
<tr>
<td>rework</td>
<td>• Number of tests performed per week</td>
<td>• New knowledge, new processes</td>
</tr>
<tr>
<td>• (M) Number of engineering change orders</td>
<td>• Number of engineering hours versus budget</td>
<td>• (M) Number of Patents, degree of patentability, and licensing and</td>
</tr>
<tr>
<td>• (M) Number of design changes before release</td>
<td>• Timeliness in development/compliance with planning</td>
<td>intellectual property</td>
</tr>
<tr>
<td>/engineering change orders</td>
<td>• Percentage of activities that required rework</td>
<td>• Number of complaints, complaint expense and customer satisfaction</td>
</tr>
<tr>
<td>• (M) Net present cash flow to development cost</td>
<td>• Number of tests performed per week</td>
<td>• (M) Contribution to market share</td>
</tr>
<tr>
<td>• Reporting results of development</td>
<td>• Percentage of activities that required rework</td>
<td>• (M) Return on Investment</td>
</tr>
<tr>
<td>• A production orientation, with sound understanding on manufacturing possibilities</td>
<td>• Minimize errors</td>
<td>• (M) Commercial proposals won thanks to the innovation</td>
</tr>
<tr>
<td>• Minimize errors</td>
<td>• Minimize cost</td>
<td>• (M) Price impact on customers</td>
</tr>
<tr>
<td>• Minimize cost</td>
<td>• (M) Efficiency and Performance</td>
<td>• (M) Commercial proposals won thanks to the innovation</td>
</tr>
<tr>
<td>• (M) Efficiency and Performance</td>
<td>• (M) Net present cash flow to development cost</td>
<td>• (M) Price impact on customers</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outputs and Outcomes</th>
<th>Marketing</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Quality, Reliability, Availability, technological</td>
<td>• Support from marketing</td>
<td>• The importance of internal communication</td>
</tr>
<tr>
<td>capability</td>
<td>• Strength of market</td>
<td>• Employee motivation and capability</td>
</tr>
<tr>
<td>• Designs produced</td>
<td>• Market analysis</td>
<td>• Reward system</td>
</tr>
<tr>
<td>• Competitive value of innovation and degree of</td>
<td>• Ministry of Science</td>
<td>• Learning strategies</td>
</tr>
<tr>
<td>innovation</td>
<td>• Business focus</td>
<td>• Business focus</td>
</tr>
<tr>
<td>• New knowledge, new processes</td>
<td>• Adaptability</td>
<td>• Organization receptive to innovation</td>
</tr>
<tr>
<td>• (M) Number of Patents, degree of patentability,</td>
<td>• Team structure</td>
<td>• Team structure</td>
</tr>
<tr>
<td>and licensing and intellectual property</td>
<td>• Entrepreneurial culture</td>
<td>• Outputs and Outcomes</td>
</tr>
<tr>
<td>• Documentation, books written</td>
<td>• Quality, Reliability, Availability, technological capability</td>
<td>• Designs produced</td>
</tr>
<tr>
<td>• Publications, presentations</td>
<td>• Competitive value of innovation and degree of innovation</td>
<td>• Competitive value of innovation and degree of innovation</td>
</tr>
<tr>
<td>• Product improvement</td>
<td>• New knowledge, new processes</td>
<td>• (M) Number of Patents, degree of patentability, and licensing and</td>
</tr>
<tr>
<td>• Cost reduction</td>
<td>• (M) Number of complaints, complaint expense and customer satisfaction</td>
<td>intellectual property</td>
</tr>
<tr>
<td>• Perceived value of the product</td>
<td>• (M) Contribution to market share</td>
<td>• (M) Contribution to market share</td>
</tr>
<tr>
<td>• (M) Number of complaints, complaint expense and</td>
<td>• (M) Return on Investment</td>
<td>• (M) Commercial proposals won thanks to the innovation</td>
</tr>
<tr>
<td>customer satisfaction</td>
<td>• (M) Return on Investment</td>
<td>• (M) Commercial proposals won thanks to the innovation</td>
</tr>
<tr>
<td>• (M) Commercial proposals won thanks to the</td>
<td>• (M) Price impact on customers</td>
<td>• (M) Commercial proposals won thanks to the innovation</td>
</tr>
<tr>
<td>innovation</td>
<td>• (M) Price impact on customers</td>
<td>• (M) Commercial proposals won thanks to the innovation</td>
</tr>
<tr>
<td>External Environment</td>
<td>• Supportive environment ²</td>
<td>• The R &amp; D organization’s image in the eyes of the customer ²</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------</td>
<td>---------------------------------------------------------------</td>
</tr>
</tbody>
</table>

**Table 1 Success Factors Summary**

(M) – Factor should be tracked by management figures.

1. (Schumann, Ransley, & Prestwood, 1995); 2. (Brown & Gobeli, 1992); 3. (Twiss, 1992); 4. (Roberts & Fusfeld, 1981); 5. (Brown & Svenson, 1998); 6. (Imai, Nonaka, & Takeuchi, 1984); 7. (Bjorn & Souder, 1997); 8. (Balachandra & Friar, 1997); 9. (Galbraith, 1982); 10. (Karlsson, Trygg, & Elfström, 2004); 11. (Bremser & Barsky, 2004); 12. (Maidique & Hayes, 1984); 13. (Patterson M., 1989); 14. (Mansfield & Wagner, 1975); 15. (Cooper, 1997); 16. (Maidique & Zirger, 1984); 17. (Porter, 1979); 18. (Langrish, Gibbons, Evans, & Jevons, 1972); 19. (Keller, Julian, & Kedia, 1996); 20. (Wheelwright & Clark, 1992)
3 RESEARCH METHODOLOGY

The research methodology is explained in this chapter. It includes six sections, which are research approach, research design, sample selection, data collection, data analysis, and research criteria.

3.1 Research Approach

Two methodologies are usually used in scientific research: qualitative and quantitative research approaches. In this study, the intention is to find the factors that have a direct impact on the success of innovation projects. Many researchers have found several factors that influence innovation success. However, these factors are vast and it is difficult to structure them. Therefore, due to the fact that few studies focus on researching this area in the telecom manufacturing industry, our study aims to develop a new theory rather than to verify or test any previous theory. Thus, a qualitative approach will be considered as suitable in this study (Bryman & Bell, 2007).

The secondary aim is to classify these factors either as order winners or order qualifiers. Moreover, the factors will be analyzed according to different types of innovations. Many identified factors are related to human behaviors and actions, which are difficult to measure quantitatively. It is important to study these factors and understand the relationship between those factors in order to achieve the research purpose. Thus, a qualitative research approach is suitable here, because it offers flexibility in terms of obtaining the respondents’ perspectives, attitudes and perceptions (Bryman & Bell, 2007; Miles & Huberman, 1994).

3.2 Research Framing

According to Bryman and Bell (2007), research framing is a structure that helps generate empirical findings. It needs to suit research questions and purposes. In this study, the research framing consists of four qualitative interview studies instead of case study, because the data is collected mainly by qualitative interview (Bryman & Bell, 2007; Miles & Huberman, 1994). This framing includes the following steps:

1) We determine the research question based on the research purpose. Meanwhile, a qualitative research approach is selected as a suitable approach due to the research purpose.

2) In order to perform the research, a thorough review of existing literature is performed. According to the existing researches, we build a theoretical framework that includes 60 factors, which are selected from more than 250 different factors. The framework was built in an important part by the use of four different researchers’ analyses, which are Twiss (1992), Brown and Gobeli (1992), Brown and Svenson (1998), as well as Balachandra and Friar (1997). The factors that were selected correspond to the ones relevant to the telecom manufacturing industry and the repeat frequency from recent articles.

3) This step is about sample selection. Considering the delimitation of this study is the telecom communication industry in amongst the whole world rather than a certain country or region. Thus, the selected samples represent a geographical diversity, as the telecom firms are from different countries.
4) This step refers to data collection and analysis. In order to comply with the research purpose, we decide to use semi-structured interviews to collect data. Details about the data collecting process are presented in the subchapter of data collection.

By analyzing the data, we can understand the relationship between factors. And the framework would be modified. Furthermore, the factors will be classified by order winners and order qualifiers, as well as by identifying those that are affected by the innovation type.

5) Finally, a modified framework and the answer to the research question will be included and discussed throughout the analysis and the conclusions sections.

3.3 Data Sampling
Qualitative approach has received some known critiques by academics. Academics claim that qualitative approach is too subjective, difficult to replicate, and has problems with generalization and having lack of transparency (Bryman & Bell, 2007). In this chapter the sample selection criteria for this thesis is outlined with a strong effort to minimize the impact of the above-mentioned critiques, particularly on lack of transparency.

The number of samples to have on a qualitative interview poses a challenge to any researcher. The intention was to have enough interviews that enable the reaching of a theoretical saturation of success factors (Bryman & Bell, 2007; Miles & Huberman, 1994). Finally four interviews saturated the theory, which includes in the framework to a good extent. The four samples are selected by following criteria.

3.3.1 Company Criteria
To select the companies that are to be subject of this research, a purposive sampling technique is selected (Bryman & Bell, 2007). The purpose comes back to the research question. Our research purpose is try to identify the key factors that managers should focus on in order to increase the success of an innovation development process in telecommunication industry, therefore the criteria for company selection is the following:

- The company is a telecom equipment/solution manufacturer
- The company is innovative
- The company has an R&D in-house department
- The company operates in an multinational environment

* Nortel does not comply with the criteria in present tense, as the company has been disbanded, however it did comply in the past and in the selected project with this criteria.

Following those criteria, four firms are chosen as our samples, which are ZTE, Nortel, Alvarion and ST-Ericsson. All of the companies are telecom equipment and solutions manufacturers and operate in multinational environments.

ZTE is driven by innovation as it develops last generation wireless and optical technologies, (ZTE, 1998-2011). In addition it employs around 30,000 R&D employees and has 15 R&D centers internationally.
Nortel was a multinational telecom equipment manufacturer with a history of over 100 years in technology development. Nortel had 16 R&D centers in 2006 (Nortel, 1999-2011).

Alvarion focuses on the development of last generation wireless technologies and it has three R&D centers worldwide (Alvarion Ltd, 2005-2011).

ST-Ericsson focuses on the development of last generation mobile platforms for several different operating systems, and it has four R&D centers worldwide (ST-Ericsson, 2011).

### 3.3.2 Interviewee criteria

In this study, a purposive sampling technique is selected (Bryman & Bell, 2007) to try and interview people who are instrumental and key in the development of a successful innovation project. The interviewees are chosen before the projects. Then the interviewees are asked to choose one project that they have worked with that is particularly successful. In order to reduce the possibility that the interviewee is involved only in one project, the interviewees need to be selected using strict criteria, which is stated as the following:

- Interviewee has to have a minimum of five years working for the company
- Interviewee participated directly in more than 3 projects, preferentially as a Project Manager
- Worked inside or directly with the R&D department
- Interviewee interfaced directly with the marketing or/and the manufacturing department.
- Interviewee participated in at least 80% development time of the project which he or she is chosen as successful later

In this study, all of the interviewees are known as complete those criteria by one of the following two strategies: the first, by talking to managers in the company that helped pointed these people out to the researchers’ attention. Secondly, by previous observational experience by one of the researchers who worked personally in Nortel and Alvarion in the past.

Nevertheless there is the possibility that the interviewees select a project according to his/her participation in the project, instead of choosing a project that is successful by itself. However in a previous call with each of the interviewees we would explain to them that we need a project that fulfilled certain criteria, which are stated in the next section.

### 3.3.3 Project criteria

Once the companies and the interviewees are selected, according to our research purpose, we need to select a project that could provide the needed view of success factors on the development of a success innovation, therefore the criteria for the project selection is the following:

- The project selected is indeed a project and it is not part of on-going operations
- The project is not ongoing at the time of the interview and has been finished
- The project should be considered a success\(^3\) by the interviewee

\(^3\) A project is considered successful if it met the company’s objectives
• The project deals with innovation in its specific field
• The project output is a new product, process, service or solution for the company
• The project involved the direct participation of the R&D functional department

Following these criteria, one success innovation is selected out from each company. The detail about each project is stated in empirical findings.

3.4 Data collection

Different kinds of data are used to collect the essential information in this study, which include primary data and secondary data. Both types are used in the thesis as this strengthens the outcomes of the research (Bryman & Bell, 2007; Holme & Solvang, 1997).

In this study, the primary data is collected from four different companies in the telecom industry by using semi-structured interviews. After sampling, an interview guide is established based on our theoretical framework. Even though the interview guide included a list of questions on the specific topic, the respondents have the freedom to answer the question in his or her own words. The interview does not need to follow exactly the interview guide’s structure. Interviewees can speak openly about all the factors that in their experience they consider as being a contributor to the project success and deeply discuss their views and opinions around them. It is the researchers intention to discuss with the interviewees not only which were the success factors behind each innovation, but also why were they important. Semi-structured interviews leave room for unexpected answers and they are more flexible (Bryman & Bell, 2007).

All interviews took place as videoconferences by the Internet with the project manager. Each interview lasts from 50 to 90 minutes, and it is digitally recorded for future reference. As a limitation of the time and location, the interview is done by videoconference instead of face-to-face interview. Nonetheless the videoconference system allows having eye contact and enables active participation from both sides based on face reactions. Thus, the videoconference system provided similar benefits to face-to-face interviews in this point (Bryman & Bell, 2007).

Some information about the company and the project is taken as secondary data from the web sites.

3.5 Data analysis

In this study, the research purpose and question are specified. We then built a framework based on our research purpose and theoretical review. After the sampling, we follow the interview guide and use semi-structured interview to collect data. Then by coding, all of the factors and the dimensions are found out from the interview. Factors are classified into dimensions. Dimensions include inputs, R&D department, manufacturing, marketing, organization, outputs/outcomes, external environment, and the customer.

Furthermore, a cross-interview analysis technique is used to examine the empirical data. By finding out the same connections between each dimension in four interviews, our framework could be modified. At the same time, the relationship between factors could lead us to find out the order winners and order qualifiers. Through four interviews, the same
factors that could provide competitive advantages are found out as order winners. The others are considered as order qualifiers. Finally, the differences between these factors in four interviews help us find out why some factors have more influence on project success. It is because the factors have different influence in different innovation types. The analysis steps are simplified by the following figure:

![Diagram showing data analysis method]

**Figure 3 Data Analysis method**

### 3.6 Research criteria

In order to make the research trustworthy and valid, the qualitative research should fulfill different criteria, such as validity and reliability (Bryman & Bell, 2007). Validity could be divided in internal and external categories.

#### 3.6.1 Validity

Generally, the internal validity is about making sure the phenomenon that researchers intend to capture is indeed captured (Bryman & Bell, 2007). External validity is about the use of the findings, which are generalized across social settings. In this study, the sources of primary data are people who are involved in the innovation project from beginning to end. Therefore all of them have a good knowledge and are very close to the studied phenomenon. Choosing the source of the data close to the phenomenon is one of the ways to strengthen the validity (Bryman & Bell, 2007). Besides, because we have cleared all of the sample criteria, interviewee criteria and project criteria, the findings in this study could be generalized for similar samples that have similar conditions in the telecom manufacturing industry.

Furthermore, the managers are aware that their names could be unknown in the thesis. This fact also helped to strengthen the validity, as interviewees feel more comfortable and are able to speak frankly (Bryman & Bell, 2007).

After the interviews, we have the opportunity to ask further questions by email to the interviewees in case an important data is left out during the interview. According to Bryman and Bell (2007), this could also increase the validity of research.
3.6.2 Reliability

The reliability of research refers to the consistency over time of the research outcomes; additionally the same results should be able to be obtained by another research using the same methodology (Bryman & Bell, 2007). In this study, we use the semi-structured interviews to collect data. According to Bryman and Bell (2007) it is trustworthy and valid to analyze. Furthermore, we have designed an interview guide based on the theories, and use it during the semi-structured interviews, which increase research reliability (Bryman & Bell, 2007). The interview guide is included in Appendix A. In order not to affect reliability no leading questions or other types of influences are established during the interviews (Bryman & Bell, 2007; Miles & Huberman, 1994).

To increase reliability of the data collected, the interviewees are informed several days in advance on the intentions of the research so they could start thinking about a very successful project that they would like to share with the researchers (Bryman & Bell, 2007; Miles & Huberman, 1994).
This chapter presents the empirical evidence collected after gathering secondary data and after interviewing people that “lived” the projects, meaning that they were fully committed towards their success during a time. Each project is presented individually, first with an introduction on the company, followed by a high level description of the project, followed by the innovation system explained in the literature review. This consists of inputs, R&D department, the marketing department, the manufacturing department, organization, outputs, and the external environment. All projects were considered as highly successful by the interviewees.

4.1 Alvarion

4.1.1 Company Presentation
Alvarion is a telecommunication technology provider headquartered in Israel, it is focused on 4G technology and has strong exposure in the market with over two million user units deployed by carriers, Internet Service Providers and private network operators in 130 countries worldwide (Alvarion Ltd, 2005-2011).

Alvarion itself was born in 2001 with the merging of two broadband wireless access Israeli companies BreezeCOM and Floware. This merging enabled the company to get the human capital needed to pioneer the WiMAX technology (Alvarion Ltd, 2005-2011). In 2003 Alvarion acquired another company called Innowave, which was a company focused on carrier grade voice and data solutions.

Technological Innovation is essential to the success of the company and towards achieving wireless broadband networks that meet the needs of service providers in the present and future (Alvarion Ltd, 2005-2011). The company focuses on wireless technology and competes with some of top high tech telecommunication equipment manufacturers such as Motorola, Alcatel Lucent, Ericsson and Samsung (Seeking Alpha, 2007).

4.1.2 Project Presentation
Alvarion designed, developed and manufactured a wireless point to multipoint solution by the commercial name of WalkAir 3000. For a general technical description of the product refer to Appendix B.

The project was mainly developed in Romania with support from Israel and manufactured in both Israel and Japan. The team consisted in R&D engineers (System, HW, SW, Testing), R&D Project Manager (PM), Senior Product Expert (SPE), Marketing Product Line Manager (PLM) and the Director of the Carrier division.

4.1.3 Innovation System

Inputs:

Some initial factors contributed importantly in the development of WalkAir 3000, henceforth WA3K. The first, was the input from Product Line Management (PLM), (which is the title of the marketing figure in Alvarion) as through contact with important service
providers and telecom carriers obtained a broad idea of the initial technological challenges that needed to be surpassed, as well as on the required services that would give a competitive advantage to these service providers. The main idea for creating a new product came from the market. As customer needs of additional bandwidth and more services to satisfy their growing customer demand began increasing, the PLM gathered these requirements and directly discussed them with R&D senior management and with the SPE. From these discussions two documents emerged, namely, “Software Requirements Document” and “Marketing Requirement Document”, (the latter also included specification on HW features) in the opinion of the SPE these documents were ‘The bible of the product’ and they were the main guideline for the development team, as they knew they had to stick to such requirements in a very precise way.

The PLM was the one that performed an analysis of the probability of commercial success by showing to Alvarion’s top management the potential of creating a product that would satisfy the needs of key customers, based on looking at the potential benefit on increase of market share, they decided it to give it the green light. Top management was particularly interested in budgeting this project as the proposed solution would have low competition levels and would be pioneering in its kind. Most of the broadband wireless solutions back then were not working on the 3.5, 10.5, 26 and 38 GHz frequency bands, and the ones that were, were point-to-point solutions and not point-to-multipoint (as WA3K), thus making Alvarion a pioneer in the segment.

However being a pioneer also imposed some restrictions to the R&D team, including access to technical information, as even though there was some, the information was not very complete. Alvarion actually imposed some standards in this technological segment. One thing that helped from the start was the existence of an older brother product called WA1K. In the words of the SPE “The existence of WA1K was very helpful for development in the early stage of development, as it helped to take it as a baseline when conducting tests and to try to predict product behavior” however the ability of this product to help diminished as the project move forward due to the different technology used in the new product.

The top management of Alvarion was involved in the beginning of the project by assigning a budget and by selecting the staff that would be developing the solution, they also decided on the project team structure, which including having a “triad” to solve disagreements. This triad consisted on the PLM, SPE and PM, who were supposed to have an equal power to make decisions. The number of people that would be working for this project was selected, however many of these people were not fully dedicated to this project, as they were also shared in developing other solutions. In the opinion of the SPE this caused some to have a feeling of having a shortage of human resources working for the project at some times, however in his opinion “There’s always a need for more resources and more people, but in real life you always have to manage with whatever you have”.

In Alvarion there is always a very careful control of the financials, therefore in the beginning of the project, Senior Management defined the financial resources that were to be assigned to this project.

*R&D Department*
A factor that contributed in the R&D department were the people that worked in it, their commitment, human and technical skills were some critical factors for success in this department, especially three main figures:

- The Director of the Carrier R&D division, who had a high organizational influence, was instrumental in development as he had a very strong technical background as being himself an SPE in Alvarion for several years in the past. This allowed him to help the R&D PM and SPE to get approval on some additional equipment and resources or training, as he knew that sometimes these additional efforts were essential for the staff.
- The R&D System Engineer, SE, which was a very technically educated figure in various fields in radio, electronics and engineering. Even though he was shared among different projects, whenever he worked for the WA3K project his input and help was highly valued, as his vast knowledge helped the team move forward whenever it reached an impasse.
- The Senior Product Expert, SPE, which combined technical and system integration expertise, made sure that the laboratory test would reflect a real life situation and was in charge of managing the feedback from real life tests.

There was a strong cooperation and team synergy inside the R&D department. The R&D department experienced some challenges due to the degree of newness of the technology, some of the technical specifications were new for them. However it was not the first time they implemented a new protocol or modulation into a new hardware, therefore their previous knowledge was very important.

The R&D PM followed an R&D methodology from the ISO, in which the way that R&D should approach marketing was defined; two important frameworks for testing were defined in this methodology:

- Alpha Test Results (ATR): This document contained the procedures and the schedule of the Alpha tests, which were the very first tests of functionality and requirements that needed to be successfully addressed and solved in the laboratory.
- Assurance Test Procedures (ATP): This document contained the procedures and the list of requirements that the BETA product (A product that had passed all the Alpha tests) had to fulfill in a real test scenario, with a potential customer.

Other than this, the ISO methodology also defined the phases of development and defined a series of CCB meetings, which were internal meetings where the follow up of HW and SW and the ATR and ATP were discussed and agreed upon.

Even though the product was an innovation and the company was pioneering in this specific technology, the R&D department was tracked with several performance metrics. The tracking was done by R&D Project Management and Senior R&D Management by means of a Gant chart and aided from ERP software that worked based on time-bound tickets that were assigned to a person, who then became responsible for addressing the issue. The main things that were tracked included: tests performed, technical specifications met and compliance with planning. The budget was tracked by PM in terms of engineering hours.
needed to work on the mentioned tickets. The people that were tracked in this budget were the SW/HW engineers and test engineers, however management and SPE figures were not included in this budget and were treated as an additional effort. This department had a focus on effectiveness as it rewarded R&D team leaders that did not incur in rework efforts.

Manufacturing

When it comes to manufacturing, it is Alvarion’s policy to develop high quality products of good performance manufactured at the lowest possible cost. This has been especially true since Chinese and Korean telecom manufacturers like Huawei, ZTE, Samsung, etc. have entered the market. In the opinion of the SPE ‘In the last years, when Chinese vendors entered the market I have noticed a change of priorities among some of the carriers (customers), their main priority is price; quality and special features take a second priority when it comes the time to choose a telecom vendor, this is specially true in Africa, Asia and South America’.

Even though Alvarion has internal manufacturing facilities in Israel, it is not uncommon that the company decides to outsource the manufacturing of a given product towards a more cost competitive country like China. In the case of WA3K, a business case was developed to decide the manufacturing strategy. WA3K’s intention was to be a highly reliable product for carriers; therefore a very high quality was required. The decision was to produce the indoor parts (Base Station, Terminal Station and IF Multiplexors) in-house in the factory in Israel, and the outdoor parts (Radio Frequency Units and Antennas) were to be outsourced to a Japanese manufacturer. In the words of the SPE ‘Japan was chosen as the location to manufacture the RFUs, as they were very efficient in manufacturing such HW components, due to their efficiency, it even meant a cost reduction of around 10% than developing in-house and the product had a higher quality’.

The manufacturing department in Israel that developed the in-door units was highly focused on efficiency, performance, minimizing cost and errors. When developing the first set of BETA products, the team focused on product effectiveness, as they needed to make sure that the HW, electronic components and the material used were good enough to reach expectations. However after the first products were manufactured, the company ran cost reduction efforts for several years. In the words of the SPE ‘cost reduction means designing again a product in such a way you are going to reduce cost of components, of internal materials you are using to produce it and people, man power needed to do it; there is a challenge when doing these cost reductions efforts as you need to make sure that the cost reduced product will perform as well as the previous one’

Marketing

Marketing was instrumental in every phase of product development process, one important factor was the people involved in the marketing department, this team was very good to analyze competitors’ solutions to find a good market positioning of WA3K offerings. The marketing leader, (PLM) pushed and had a strong influence on the decision making of the features to be implemented in the final product. The PLM team was monitoring the market development constantly and paid visits to key customers to find out the new needs in
features and functionalities that they needed and decided next to senior management if the features were worthy of being developed.

As stated earlier the PLM also worked during development as being part of the triad that together with R&D PM and SPE took on development decisions.

**Organization**

Communication between the three departments was an important factor for the development of the product, however the communication link between R&D and Marketing was stronger than the link between R&D and manufacturing, as manufacturing was under a different organizational unit. PLM however kept a closer relation to marketing as he needed to make sure that manufacturing understood to a full extent the requirements and the expectations.

The employees within the organization were motivated due to the fact that they were developing next generation wireless technology, when the project was at an early stage. The telecom market was sound and that was reflected in being able to provide financial rewards to the employees that complied with planning and that did not incur in rework, however the harsh economic environment in the last years have hindered additional financial incentives to take place. The people working in this project learned a lot from the experience and in the case that Alvarion decides to develop the next generation product with a higher capacity and extended features, the lessons learned would certainly help.

Alvarion is focused on creating wireless technology, and from this technology they are focused on WiMAX and TD-LTE technologies, which are 4G technologies for mobile communications. The case of WA3K does not fit the main Alvarion focus, nevertheless when the system was developed the R&D team did not suffer from this, as PLM and the Director of the carrier division managed to preempt resources from other projects to obtain a successful development. This enabled the solution to compete with top companies on the fixed broadband wireless business. However some years after the development of the project was finished, and product enhancements were requested by customers, the lack of the company focus on this line of products has somewhat hindered the development of this product improvement effort. And in the view of the SPE, ‘the lack of focus in this technology may have delayed the development of the next generation WalkAir product, that will enable the company to keep their advantage in the future’.

Alvarion is a company that is very receptive of innovation, as it is their main business to produce next generation wireless solutions, they are adaptive, as in 2010 they decided to commit on the development of TD-LTE solutions, to keep up with the market trends. (Alvarion Ltd, 2005-2011)

Regarding the team structure, in the view of the SPE, ‘Working daily and for a couple of years with this structure you can always find some things to improve, but generally speaking I think is a good structure, it’s optimal at some point, is not something fundamentally wrong, is fundamentally the best approach’
There were some hints of internal entrepreneur behavior during the development of the product, on was the PLM, who was traveling visiting key customers and through social interaction got a firsthand view of the technological needs that these customers required, which gave Alvarion a competitive advantage when developing the product.

**Outputs and Outcomes**

The outputs of the project go beyond the product itself. This project was a contribution to wireless technology and set some standards, some algorithms and designs were patented and the company published some documents and articles. The product also helped the academia world, as the product was introduced in a University program in Western Europe. Through meticulous documentation, WA3K has provided a contribution to the internal knowledge of the company and has and will likely help in the development of future innovations. WA3K has helped to win proposals directly and indirectly. Directly, as it competes in cost and performance with top telecom equipment providers and indirectly, as it is offered in combination with other products and solutions offered by the company, thus offering additional value to their customers. The product was not only sold to service providers and telecommunication carriers, but to other equipment manufacturers that purchased the product as “white label” and then re-sold them as if they were their own. However after some years these companies developed their own similar products and stopped purchasing from Alvarion.

The product was a success and has given good reputation to the company in this particular segment of the market, the SPE mentions “It’s not only me or the people in the company that label it a success, I can give you feedback from many people including customers which are happy with it, despite the fact that they always want something new”. This is one of the reasons why the product is in constant improvement. The product also offers a very appealing option to customers because even though is not a cheap product its price is not much more expensive than the offerings of competitors. The company got an increase on market share on this particular segment, and got good gross margin out of it, however in the opinion of the SPE, the return on investment and break-even time was not obtained quickly, as in this type of projects a lot of money is invested and it takes a long time to get a return.

Measuring the outputs is also a usual activity for the company, such as monitoring of sales, gross margin, return on investment and price vs. performance. Customer complaints are managed and evaluated as they are considered as feedback for the product and for further implementation in next releases.

**External Environment**

The external environment was influent only to some extent, at the beginning of the development the company was not doing benchmarking with competitors, as only Ericsson was developing similar products, and thus Alvarion was a pioneer. The influence came later when more competitors started developing similar products and then the marketing department did some analysis on competitor’s features and services. However when developing this technology, it was very important for the company to comply with telecom international standards such as the ITU, ETSI and CEPT.
4.2 Nortel

4.2.1 Company Presentation

Nortel was a multinational telecom equipment manufacturer headquartered in Toronto, Canada, (Nortel, 1999-2011), it has a history of over 100 years in the innovation of telecom systems, and their business branches included optical, data, wireless networks as well as voice, multimedia and unified communications (Nortel, 1999-2011). The company however during 2009 announced a strategic restructing that consisted in total ceased operations and sell off its business units. At the printing time of this thesis Nortel has sold most of their business units to companies such as Ericsson, AVAYA, GENBAND, Kapsch and Ciena, amongst others (Nortel, 1999-2011).

Nortel was responsible for the development of many innovations since the late 1800’s with the first telephones, and was one of the most important manufacturers that helped the Internet revolution in the 90’s to take place. During their late years they developed state of the art wireless and optical technologies (Nortel, 1999-2011).

4.2.2 Project Presentation

The project analyzed in this thesis for Nortel corresponds to a feature for the Global System of Mobile Communications (GSM) technology, which is a mobile technology of worldwide penetration. The feature is Called Network Synchronization, and in general provides enhancements to the air capacity of the customer’s GSM networks. For a description of the technical details of the feature refer to Appendix C.

4.2.3 Innovation System

Inputs:

The idea of the innovation started from the Customer and was manifested to the engineering team through the Product Line Manager (PLM); the USA customer is one of the largest wireless carriers in North America and had a wide deployment of Nortel’s GSM equipment. Back in those days, the customer had a very busy network. Their capacity transmission over the air had reached a limit. It was not possible to purchase additional air bandwidth within the GSM frequency band in some states such as New York, as it was already saturated amongst the different wireless carriers. Due to this problem, the customer decided to request to Nortel a development that would solve their current issues, the customer was not very interested in the way Nortel would solve this and they only wanted to implement a solution that would be as transparent and easy to implement as possible.

Due to the broad requirements, it was up to the PM to gather a team of experienced GSM engineers from R&D and the advanced features department to start a research project to find out scenarios to solve the customer problem. It was in the review of features proposed by the 3GPP (a telecom organization of GSM and 3G) that the engineers proposed to develop the network synchronization feature, a feature that back on those days no other GSM equipment manufactured had implemented. Nortel decided to develop this new feature with the least amount of effort and resources as possible, therefore a senior manager in France decided to appoint a PM and a very experienced advance feature
engineer to work fully dedicated to this project. The PM was to preempt internal resources from R&D when the activities required it, a total of up to 6 persons would participate in the development of the project during peak times.

_R&D Department_

The R&D effort could be divided in two, the engineering advanced feature department, which consisted of the PM (that had strong engineering background) and a very specialized engineer. The other department was the GSM R&D team, which consisted of a team of many engineers lead by a functional manager, up to four of their resources were “borrowed” during some of the time to help with development. The cooperation was key for the project, as they needed to provide the technical implementation of the feature in Nortel’s GSM base stations. The R&D functional manager was very keen on minimizing the borrowing of his resources as he had other priorities.

The team was focused on the degree of effectiveness as resources were limited and high efficiency was fundamental to achieve the completion of the project. The team synergy was quite strong and there was no internal competition between the engineers, but rather a feeling of cooperation. The R&D staff was able to respond when emergencies and high peaks of work were needed, often working after hours. R&D was somehow familiar with the development of other advanced radio features, however this particular one posed a challenge due to its complexity.

The PM used several metrics during development time, such as tracking the objectives of the employees, tracking cost, number of tests performed, tracking the evolution of the integration of the innovation, cash flow to development cost, compliance with planning and development time. All Nortel managers were requested to use best practices project management methodologies and to keep a Gant chart of the project with the help of diverse information systems, this project was no exception, as senior management needed to be informed on the overall project performance.

_Manufacturing_

In this particular development the manufacturing department of Nortel was not involved as no new hardware was created, due to the limitation of resources, the team decided that the Customer requirements could be accomplished by using a software feature and the use of existing GPS external devices.

_Marketing_

Marketing cooperation was present at the very beginning, during the conception of the innovation, as it was the communication channel with the customer that helped in gathering the initial set of requirements (which were very broad). Marketing was also present towards the end of the project to convince the customer that the proposed solution suited their needs; the customer accepted this offering and accepted to test the feature in New York City. However, during the development phase marketing was somewhat disconnected from the R&D engineering team, and did not keep track on whether the customer requirements were indeed being met.
Marketing requested this development to keep a good relationship with this key customer, however, it was apparent to the marketing team that the development of this feature would not help other customers or other markets, as according to them there were few to none customers that had experience such saturation on their Air interface and decided that it was not worth it to push this feature to other customers. The marketing team believed that this feature came too early to the market.

**Organization**

Communication between the customer, marketing and R&D was key during development, two distinctive communication channels were vital to get things done. Firstly a channel to convince non technical people such as senior management to give resources for the development, the second channel was to convince different people in R&D to work in this project to perform simulations, software changes, etc. The communication channels were provided by the PM. A factor that helped was that the people were concentrated in the same building in France, with the exception of Nortel’s marketing in USA and the customer located in USA as well.

The company was not thinking of selling this innovation to other customers. Therefore, their organizational involvement was at some points limited. However, people working in the project were motivated due to the feeling of technical contribution they were incurring in, as they knew they were among the first engineers in the world to develop this feature. They felt identified with this project, in the words of the PM: ‘In my experience, it is not the rewarding that motivates people, if you believe in something, if you like to do that crazy type of project is going to be an internal motivation, more than external, people were motivated and the interaction among them brought them closer, they were “living” the project, and this was a motivation in itself’. The selection of the staff assigned to this project was also very important. There were some organizational appraisals from Senior Management to further boost motivation.

As stated earlier, the organization was not focused on placing efforts on this particular project, however the company felt obliged to comply with the demands of such an important customer. R&D department became somewhat flexible as it cooperated with the PM to perform simulations and to implement software changes. The team structure was good as it minimized costs, as only two people were fully dedicated to the project, the contribution from the other four were “free” as their time was borrowed and did not count to the project budget. To achieve this internal borrowing of resources was not easy and required a lot of push and social interaction from the PM towards the senior manager, the R&D functional manager and the R&D engineers.

**Outputs and Outcomes**

The project was completed and was successfully tested in the customer network in Brooklyn, New York. The outputs were a new innovation for the company, a feeling of success for the people that developed the feature, as they were pioneers, it also provided new knowledge to the telecom field, however the company did not sell this feature to other customers, as marketing considered that it was an innovation that came too early to sell it to other
customers which may not needed such feature at that time. The feature was not patented as Nortel did not consider it necessary; there were no other publications or presentations of this feature to other customers.

The team learned a lot from this experience in both technical and human skills, as after so much social interaction good synergies came along and they became a better team in terms of team effort. They also learned the process of how to research, develop, implement and test an advanced GSM feature, which was of course a good learning experience for the staff. It was Nortel’s policy to document carefully every feature in R&D documents to serve as a baseline to future engineers; the team itself performed this documentation.

An important outcome was as well to maintain a good relationship with this major customer, however it is interesting to mention that after some years the usability of the feature started diminishing as this customer gradually migrated their GSM network towards a next generation 3G network of UMTS, which was a new technology with much more capacity, Nortel was not a supplier of UMTS technology, as it sold this business to Alcatel Lucent in 2006 (Nortel, 1999-2011), around the year that this customer started their network migration activities.

External Environment

The external environment had an important impact on the development of the project as for example Nortel considered to be early for customers to use this new development, which had an impact on how they treated the project. Furthermore the standards institutes such as the 3GPP and the ITU influenced the development of this innovation. The competitors did not influence the development as none of them had developed that specific feature.

4.3 ST-Ericsson

4.3.1 Company Presentation

ST-Ericsson was born in 2009 by the strategic joint venture of Swedish company Ericsson and French-Italian firm STMicroelectronics mobile platform divisions; it is highly focused in R&D as the vast majority of the workforce belongs to such department (ST-Ericsson, 2011). It focuses on the development of wireless access platforms for a range of technologies such as GSM, EDGE, WCDMA, HSPA, TD-SCDMA and LTE, plus it participates in all the stages of product development (ibid).

The company is headquartered in Geneva, Switzerland with main R&D centers on China, France, Korea and Sweden, yet it has presence on more than 20 countries worldwide (ST-Ericsson, 2011). ST Ericsson is a supplier of four of the top five handset manufactures, as well as other industry leaders such as mobile operators and device manufacturers, it has reached these important customers as it has over 15 years of experience from both parent companies Ericsson and STMicroelectronics (ibid).

4.3.2 Project Presentation

The project analyzed in this thesis for ST-Ericsson corresponds to the development of a new mobile platform. For a brief technical description of the platform, refer to Appendix D.
Early in the project definition phase, the company was able to sign a confidentiality agreement with three big customers to test and if satisfied buy the mobile platform. With that, the project started being developed in terms of hardware and software in parallel. The company decided to develop the project in its vast majority in the facilities located in Lund, Sweden, with some cooperation of the Indian office dealing only with the codec part of development. The team that worked in this innovation was of several development engineers divided by functional departments such as hardware, software, audio, video, radio, etc. A functional manager lead each department and they were at the same time leaded by a Senior PM responsible on the overall project.

4.3.3 Innovation System

Inputs:

The idea for the innovation was born as a combination of two reasons. The first reason was due to a market need of having a new and more powerful platform for the growing market of Android phones. The second reason was as the company developed previously a powerful and successful platform for the Symbian phones (which is a major vendor specific operating system). The company decided that it could use this platform as a baseline to develop the new one for a different operating system to attract different customers, as the probability of market success was appealing to ST-Ericsson top management.

The management team decided to present a pilot platform (with only basic functionality) to some potential-customers to try and convince them to test it, these business negotiations resulted in the commitment of three major mobile handset manufacturers that were satisfied with the pilot device. This marked the beginning of the development of the new platform. PM therefore planned a set of milestones; each milestone consisted in delivering the potential-customer a new stable release with a percentage of new features for the customer to verify and provide feedback on. The planning included defining the functional teams, the number of people and financial resources to be assigned to the project.

The need for technical documentation to start the project was essential, however this documentation was somewhat hard to be obtained and the development team incurred in social interaction and workarounds to obtain the required technical information. The company provided some training to the staff to help them take on the new development

R&D Department

Commitment of people was an essential factor inside the development department, as people were willing to work afterhours and during the weekends; they were not forced to do so, but they decided to do it to comply with planning. People inside the department were also very proactive as they looked for workarounds to provide the desired functionality even when some hard technical restrictions existed.

The degree of newness of this innovation could be argued, as it was new to some extent, some things were new, including tools, operating system, method of system configuration, etc. However other things remain unchanged to a certain degree, for example handling the
audio drivers, the components, the audio playback, audio control effects, etc. The interviewee expressed: ‘The implementation has been changed, the core remains’.

PM was very keen to keep statistical measurement of the development of the project and it focused on percentage of technical specifications met, compliance with planning, issues solved, errors found and number of tests performed. The development team was reminded of the advances of their work by means of big screens located at the office, displaying the performance and pending issues of all the departments, so they were encouraged to solve them. The potential customers provided feedback through the generation of CRs (customer requests) that the development team had to address if they wanted to continue in business with the potential-customers. PM used best practices methodologies for the project and encouraged the team members to follow them to be able to be more efficient at work and to get the best out of teamwork synergies, these methodologies were taught to the staff via the use of workshops and training.

Every activity conducted by this development team operated under a budget which was devised between the functional managers and the Senior PM, PM kept tight control of this budget and if an additional effort such as traveling or new equipment was needed, a careful analysis to minimize the cost of such expense was undertaken.

Manufacturing

The case of ST-Ericsson is particular when it comes to the manufacturing, as it is a fabless company (ST-Ericsson, 2011), which means that while the company designs all the software and hardware, the manufacturing of the devices is done by a highly specialized semiconductor foundry (Hurtarte, Wolsheimer, & Tafoya, 2007). This foundry has very specialized manufacturing capacity and provides high quality, reliability and low cost due to its high efficiency and strategic location in a lower cost country (ibid). The case of this project is not an exception and the development team had little to none contact with this semiconductor foundry, the development team designed and tested the hardware by using an FPGA, which is an electronic device that emulates to a very precise degree the behavior of the final product; once it was thoroughly tested, the last deliverable of this team is to send the final hardware design to be mass produced by the foundry.

Marketing

The marketing department participated in the project by performing studies that enabled ST-Ericsson to find out the current needs of the market for the next mobile platforms. From an early stage the target market of this platform was identified to provide a specific list of requirements and challenges that needed to be surpassed. However, the department that interfaced between development and the three potential customers was not called marketing, but was called Customer Product Organization (CPO), and they were in charge of channeling and evaluating the customers’ requests. This department took an active and technical role in the development during the whole process and worked as a very active interface between the customer and R&D to be sure that key requirements and features were implemented in the proper way.
The strength of the mobile market was analyzed and the increase acceptance of android phones helped in making the decision to develop this new platform.

**Organization**

The organization structure was a functional structure lead by a Senior PM responsible for the project.

Three communication channels were needed for the successful development of the project. The first channel was enabled by PM and was between development departments. A second key communication channel was between CPO and development. The third key communication channel was between CPO and the three potential customers. As stated earlier, communication with the manufacturing facility was not needed.

People were motivated most of the time as they knew that their efforts were going to reach the market and would make an important contribution to technology and to the company. They were motivated by the work itself. Nevertheless, there were some periods of time where motivation waned due to high workload and due to the existence of many issues to be solved in parallel. However, the work conditions in Sweden allowed the company the possibility to reward employees by changing their additional hours worked for a payment or free time, the choice was up to the employees. Employees were not demanded to work extra hours but they decided to do so when necessary, additionally the company was flexible by letting top employees choose a working schedule that suited them as long as they performed as expected.

The company is highly focused on the development of mobile platforms and all their efforts go towards developing this kind of projects, this helped as virtually everyone from project management to engineers were fully dedicated in working in this project.

The company’s R&D department has adaptability as a policy, as they need to adapt to customer requirements (after evaluation of feasibility and possible benefits). The organization is receptive to innovation, and actually encourages it along different business units.

**Outputs and Outcomes**

An important outcome of this development was reputation, as when the resulting innovation was sold to three major handset manufacturers, smaller customers were attracted and purchased the product due to its good perceived value.

Whenever a design, or algorithm is suitable to be patented the company tries to do it.

Quality, reliability, performance, and other attributes of this kind were a necessity; the project would not have even started if the pilot platform would not have passed the potential customers’ test procedures.

Another output of the development was knowledge for the company, as the development team learned many new things and the lessons learned can and will be applied in future projects, in the opinion of the interviewee: ‘*When the time comes to develop another*
platform, we will continue working with embedded systems, something can be changed but we will still need to do a similar work, even it the system changes, we have learned a lot and we will use that knowledge to improve and to get better platforms’.

The company documents the development of the SW and HW, as this is an important input for further product improvements and for further platforms.

The company had financial metrics to measure the success of the product and used these calculations as a baseline for future projects to know what to expect in terms of earnings, how much to invest in the next innovation, and the amount of time to wait to obtain a return. Although the target of the final product was to be error free, it is normal in this business to have customer complaints; the company manages these complaints and provides product improvement by means of software fixes.

*External Environment*

The external environment was a strong influence throughout the development of the product, as the product’s offerings were to some extent based on the competitors’ offerings. The company needed to provide better or at least equal features than competitors; another big influence was the major customers, as when they select a particular technology, operating system or technology tendency, the company has to be highly adaptable to cope with future customers’ needs.

The company is highly adaptable and it is very aware of the market trends, as the interviewee comments “When major market changes occur, such as the case of Nokia joining Microsoft to develop a common platform in early 2011; this represent a big development for the mobile market and a company such as ST-Ericsson needs to build a strategy and react to such market trends”. This is only an example of the big impact that the market has on a company such as ST-Ericsson.

4.4 ZTE

4.4.1 Company Presentation

ZTE Corporation was founded in 1985 in Shenzhen, China. It is the largest listed telecom equipment company in China trading in the Stock Exchanges of Shenzhen and Hong Kong (ZTE, 1998-2011). It provides voice, data, multimedia and wireless telecommunication solutions in over 140 countries worldwide (ibid). It is a company driven by innovation, as it employs around 30,000 R&D employees who work with new product development within their 15 R&D centers located in China, Sweden, USA, France and India.

Traditionally their main income was local. However in 2010 for the first time, the majority of their revenues came from international operations with the highest portion coming from the American and European markets. The company is in constant international growth obtaining a revenue growth of 27.5% in 2010 (ZTE, 1998-2011), their mission is to provide value to customers by delivering innovative and technology advanced telecom systems (ibid).
4.4.2 Project Presentation

ZTE developed a 3G multiplexer by the name of S385, while it had several functionalities for different technology needs for telecom service providers, in the case presented in this thesis it acted as an optical multiplexor that interconnected with the customer’s Radio Access Network (RAN) for their wireless network of 2G, 2.5G and 3G. The project presented here does not refer to the development of the S385 itself, but of the development of series of hardware and software especial features.

As part of its global expansion ZTE was entering the Latin-American market and established a local branch in Mexico City in 2001, as this city hosted the HQ of big wireless telecom carriers that expand in several countries in central and south America. ZTE’s sales and presales teams in Mexico with direct support from China established contact with one of those big carriers to try and introduce the S385 within the customer’s network, being highly technically specialized. The customer was looking for a new supplier that could cover some particularly challenging requirements. For a brief technical description of such requirements refer to Appendix E.

These requirements marked the beginning of a new product development, as ZTE developed all the required changes in HW, including new standard, fully compatible modules and a new backplane for the chassis. ZTE also developed all the required software to provide the customer the new functionalities of E1 re-timing and smart mirroring of redundancy.

4.4.3 Innovation System

Inputs:

The idea for the development of the product was born as being a customer requirement, the customer in Mexico was very specialized and was very aware of the latest developments in technology as it interacts with many different telecom providers from all over the world, therefore it provided ZTE a comprehensive list of technical and financial requirements, they needed a product that could reduce OPEX and CAPEX and would help strengthen and improve their current multiplexer network. The S385 was already developed and had an excellent set of features covering almost every technical and operational requirement of the customer, however as mentioned in the project presentation part, the S385 did not comply in some HW and SW features, not because the S385 had a poor offering but because the customer was requesting next generation features (that had not been identified back then).

The gathering of technical requirements was not a straightforward or simple process, it required a lot of effort from the sales and presales team in Mexico, especially from the presales leader of Mexico, who through constant visits to the customer’s premises and through social interaction identified key people that enabled him to obtain the technical requirements that were needed. As it is not that the customer was actively looking for a new supplier, instead ZTE knocked on the customer’s door, so to speak, trying to sell them a product that would give them something that other suppliers could not deliver. It is important to mention that due to the nature of the negotiation process as not being “formal” not all the requirements were indentified in an early stage, the requirement that refers to
the “smart” redundancy to mirror the microwave radio systems was requested by the customer in the middle of the technical tests between ZTE and the customer.

Once the requirements were obtained, they were subject to a thorough analysis conducted between the engineering department in Mexico and the R&D department in China to consider if they were technologically achievable and if this development would strengthen the technical offerings of the S385. R&D Senior management was involved in this process. This analysis was also performed financially, with the involvement of senior management of Mexico and China. The presales leaders in Mexico (a Chinese person and a Mexican person) showed R&D the financial benefit of getting in business with this customer, as this customer had operations in many countries within Latin America and pushed for the development of the new features, they had to sell the project internally to R&D, so to speak. On the other side, R&D calculated the cost of development and the possible benefit of its success.

Once R&D top management gave the green light to the project they assigned the project to an R&D manager in China leading ten R&D engineers.

**R&D Department**

The R&D team that worked for this project was located in China and consisted of ten engineers, a functional manager and a senior manager that were involved in every stage of development. The team’s priority was to develop products to satisfy the needs of all the current customers in Latin America, so they were not fully dedicated to this particular project. However these employees showed commitment to the task and were able to respond when emergencies and unusually fast results were demanded. Once senior R&D was convinced of this development and the development started officially, the team was very motivated to achieve the goals. In the opinion of the presales leader: ‘The R&D team in China will do anything they need to do to establish a business relationship with a new customer, especially if it is a big carrier, in the case of this project, the attitude of the personnel was very powerful and allowed a very fast development’.

In general the requirements were considered with a degree of newness to the team, as even though most employees had several years of experience developing SW and HW features, the new requested features posed an interesting challenge, specially the re-timing functionally, which later would become a competitive advantage for ZTE’s optical solutions portfolio.

Beside from the engineers themselves, R&D management had a very important role in this project. The functional R&D manager (as any other manager within ZTE) tracked every activity against a pre-established budget from senior management. This budget was somewhat limited, which encouraged the team to minimize use of resources and be efficient, the tracking was focused on people performance, number of test performed, number of features developed, and typical man-hour metrics. Management had also to keep a very careful track of delivery times, as in order for the presales team in Mexico to make an interesting proposal to the customer, the features needed to be completed as soon as possible. Other telecom manufacturer companies were trying to push their own solutions to this customer, which made timing a key element to track. A factor that imposed a further
challenge to the R&D team was the fact that new requirements arrived from time to time, as the customer sometimes stated new requirements that were not even mentioned before. However, this did not stop the R&D manager, who showed amazing adaptability in managing minor, but constant engineering change orders. The only major change was the one referring to the "smart" mirroring redundancy functionality mentioned earlier.

As mentioned earlier, an R&D senior manager was involved, and other than enabling the internal funding for the project, his role was particularly helpful for the development of the "smart" redundancy-mirroring feature. With information from the presales team from Mexico, ZTE found out the name of the two main microwave access suppliers for the customer in Mexico, and then the R&D senior manager, through entrepreneurial action, managed to obtain microwave radio HW from these suppliers to be able to increase the probability of successfully complying with this particularly tough requirement.

Manufacturing

In the view of a ZTE’s presales leader ‘The manufacturing possibilities of ZTE are a competitive advantage for the firm, as they are highly focused on high performance and efficiency, delivered at some of the most competitive costs available in the industry’. The below statement is possible as ZTE’s manufacturing factories are located in low cost countries. In the case of this project the new hardware of the standard modules for the chassis, along with an all-new back plane was fully manufactured in China. When R&D finished the new HW design of the modules, they asked for a low scale production of a series of sample modules, as the business was not guaranteed, therefore some modules were produced with a certain degree of quality having in mind that they were going to be used only for tests and were not going to be pushed to their limits. Being a very production oriented company, the HW was produced and modules worked perfectly during the tests with the customer. Once the S385 with the new set of HW and SW was accepted and purchased by the customer in Mexico, ZTE manufactured this time several new modules with standard grade quality, by producing them on a large-scale setting.

Marketing

The teams that interfaced directly with the customer were the sales and presales teams in Mexico (with both Mexican and Chinese people). They delivered the role of marketing in this project. This team actively pushed the S385 to the customer by showing them their potential capabilities, excellent features and low CAPEX and OPEX possibilities, as previously they analyzed the customer needs and knew that they were facing challenges in OPEX, CAPEX and next generation features. This team performed a market analysis that helped in creating some sort of internal business case that was shown to the people from R&D China when requesting the new development, they made a forecast of the possible market penetration of the product within Latin America and showed the potential market share increase and financial gain that ZTE could have if the development would be executed as requested. Once the new product was developed and delivered to the sales and presales team in Mexico, the search for approval through intensive testing from the customer side began, this testing was everything but straightforward, as constant design, topology and scenario changes were requested. In addition the tests were performed in ZTE’s lab, the customer’s lab and in a real
network scenario. Each scenario had different interconnecting devices including microwave radio access equipment belonging to more than one telecom manufacturer (during these tests the new requirement of “smart” redundancy mirroring was requested by the customer). Due to the nature of the negotiations, the testing times were short and this team had to be very fast in implementing the requested scenarios. However this challenges did not stop the presales and sales department to obtain the test approval certificate from the customer.

**Organization**

In the view of the Mexican presales leader, ZTE is a traditional Chinese company, meaning that they were somewhat reluctant to completely rely on foreigners, even from the same organization. This does not mean that there was no trust, but means that back then a cultural barrier existed that sometimes made difficult getting some approvals that required big investments or changes, such was the case of this project. Therefore to enhance this communication channel between R&D China and Mexico operations, a Chinese presales leader was sent to work from start to end, hand by hand with the Mexican presales leader, the Chinese leader experienced directly the pressures from the market, the difficult needs from the customer and got the feeling that if the features were not developed to a full extent of the necessities of the customer, ZTE might as well forget to sell the S385 to the wireless carrier. Then he helped convincing R&D senior management to approve the development. A direct communication channel with the manufacturing department is a usual factor for ZTE; this project was not the exception, being both R&D and manufacturing located in China. The employees both in Mexico and China were motivated by the idea of selling the S385 to this customer, as top management made sure to let the employees know that entering in business with a carrier of such size would mean an important sales increase and the later possibility of selling other solutions to the customer, such as 3G equipment for their next generation wireless UMTS network that would be deployed all over Latin America.

After the successful completion of the project that lead to selling the S385 to several countries in Latin America, there were some rewards for some people, for instance the presales leader in Mexico, was appointed to a new challenging set of tasks that would enable him to gain internal exposure and to travel around Latin America to find out the most vital market needs. These are tasks that ZTE top management knew would help the manager achieve a next step in his professional development plan.

ZTE learned a lot from this project, both technically and in business acumen, as it enable ZTE to understand how business was done in Latin America, which differed from what the company was used to deal with. This learning was passed along other members of the management team. Regarding organizational focus, ZTE is a very large telecom manufacturer with many different telecom solutions, however the organization tries to keep its focus by having to a certain degree independent business units. The organization was highly adaptable as it placed the right structure to get the job done and the right people in the right place, such was the case of sending a Chinese presales leader to live in Mexico and the appointment of a presales leader in Mexico that could obtain the customer requirements through intense social interaction. ZTE is committed to innovation and, as
stated earlier, it will innovate to whatever extent needed to win a big account. ZTE leaders are expected to behave beyond their job description even by the use of unusual means to obtain project success, but at the same time always committed by the highest ethical and honorable professional behavior.

**Outputs and Outcomes**

The customer certificate approval was used to deploy the modified S385 in countries such as Honduras, Ecuador, Brazil, Venezuela and Colombia. ZTE took advantage of the availability of the new set of features to begin testing with other carriers in Canada and the Netherlands. The two features that provided the most benefit in strengthening the optical portfolio were the re-timing and the new standardized modules, this new knowledge enabled ZTE to replicate these features in some other product lines, as they were innovative features that were an advantage over competitors.

When ZTE managed to be in business with this customer, several other microwave equipment manufacturers approach ZTE and tried to make business with them, trying to convince ZTE to allow them to test the interoperability between their own radios and ZTE’s S385, as they too wanted to make business with the big wireless carrier.

As in every development of ZTE, R&D produces a careful documentation of the new SW and HW designs that were suitable to be patented. One of the most important outcomes was the introduction of the S385 in many Latin American countries, as it contributed to ZTE market share in the region, it allowed good financial returns in terms of investment and a fairly good break even time. The price was competitive for the customer and by the end of the development the customer had a good perception of the product. Even if the product was delivered with good performance, quality and technological capacity, it is usual for customer to ask for product improvement, or to issue a complaint. ZTE managed these complaints between the originating country and China and decided on the given course of action to take.

**External Environment**

The external environment acted as an important variable in this project, especially in terms of the customer. The customer forced ZTE to develop the innovations discussed and pushed to obtain a next generation set of features. Another external factor were competitors, as since an early stage of the project they posed an important threat, as not only ZTE was trying to sell them that solution, other international manufacturers were there and ZTE had to be able to manage those threats and deliver a better solution, in order to not be left aside. As ZTE was fairly new in Mexico at the beginning of the project there was a general feeling that the customer did not trust the capacity or performance of ZTE’s equipment as thinking that they maybe were developed with low quality standards. However the customer’s perception on ZTE was completely different at the end of the project, as the product had matched every single requirement they imposed.
5 ANALYSIS

From our empirical findings we have deduced that the innovation model included in the theoretical frame of references needs slight modification to reflect the reality in innovations from the telecom manufacturing industry. In this section the updated framework is displayed and discussed, followed by a discussion of the success factors classified as order winners or order qualifiers, the final part of the analysis describes the impact of the innovation type on different success factors.

5.1 A new Innovation System’s Framework

The above framework is an updated version of the innovation framework included in the theoretical frame of references.

The revised framework shows a separation of the R&D system, which consisted in the interworking of the R&D, marketing and manufacturing departments. Manufacturing is often outsourced to cost competitive economies and it is organizationally located in a different business unit, which means that communication between R&D and manufacturing does not occur during the whole process, furthermore the precision of manufacturing figure in this industry seems to be very high. The importance of the marketing department is showed in the updated framework; in this industry the marketing function is very specialized and participates from idea generation to product improvement.

In this revised framework the outputs are divided in two, the reason for this is that some outputs, namely knowledge, documentation and proposals won become a direct input for the next innovations. All four analyzed companies used previous knowledge and documentation as an input for development, additionally winning commercial proposals means that if the new customer is a lead user it can be used as an important source of input for future innovations.

The customer is depicted in the revised framework. As mentioned above, telecom manufacturing companies should strive to have among their customer at least one lead
user\textsuperscript{4}, as it could be very helpful for future innovations. Customer should be involved in the development process as early as possible (as indicated by the arrows). Customer complaints are also included in the revised version as they are an important source for product improvement (including cost reduction efforts). This product improvement is also a potential source of input for future innovations.

### 5.2 Success Factors classification

Within the boxes of the framework of chapter 5.1 lie the success factors, they will be categorized either as order winners or as order qualifiers, chapters 5.3 and 5.4 discuss this topic in detail. The table below lists and classifies the factors:

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Order Winner</th>
<th>Order qualifier</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inputs</strong></td>
<td>• Quality and Source of the Idea\textsuperscript{1,2,3,4}</td>
<td>• Probability of commercial success\textsuperscript{7,8}</td>
</tr>
<tr>
<td></td>
<td>• Having access to key information such technical of research information\textsuperscript{5}</td>
<td>• Sufficient number of R&amp;D personnel\textsuperscript{2}</td>
</tr>
<tr>
<td></td>
<td>• Top management participation\textsuperscript{6}</td>
<td>• Having the right people recruited for the project\textsuperscript{9}</td>
</tr>
<tr>
<td></td>
<td>• Entrepreneur Figure\textsuperscript{4}</td>
<td>• (M) Financial Metrics\textsuperscript{2,5,7,10,11}</td>
</tr>
<tr>
<td></td>
<td>• Comprehensiveness of the requirements\textsuperscript{1,5}</td>
<td></td>
</tr>
<tr>
<td><strong>R&amp;D Department</strong></td>
<td>• People key Roles\textsuperscript{4,6,12}</td>
<td>• High employee commitment\textsuperscript{1,7,8}</td>
</tr>
<tr>
<td></td>
<td>• Newness to firm\textsuperscript{8}</td>
<td>• Comprehensiveness of the R&amp;D program\textsuperscript{8}</td>
</tr>
<tr>
<td></td>
<td>• A production orientation\textsuperscript{3,5}</td>
<td>• (M) Conformance to best practices\textsuperscript{1}</td>
</tr>
<tr>
<td><strong>Manufacturing</strong></td>
<td>• Support from marketing\textsuperscript{9}</td>
<td>• Effective Project Management and Control\textsuperscript{3}</td>
</tr>
<tr>
<td></td>
<td>• Strength of market\textsuperscript{8}</td>
<td>• Effectiveness of development\textsuperscript{1,8}</td>
</tr>
<tr>
<td></td>
<td>• Participation in every stage of development\textsuperscript{21}</td>
<td>• (M) The ability to respond to peak demands and emergencies\textsuperscript{2,7}</td>
</tr>
<tr>
<td><strong>Marketing</strong></td>
<td>• Employee motivation and capability\textsuperscript{2,19}</td>
<td>• (M) Percentage of technical specifications met\textsuperscript{2}</td>
</tr>
<tr>
<td></td>
<td>• Learning strategies\textsuperscript{1,6}</td>
<td>• (M) Number of design changes before release/engineering change orders\textsuperscript{2}</td>
</tr>
<tr>
<td></td>
<td>• Business focus\textsuperscript{3,5,6}</td>
<td>• (M) Number of tests performed per week\textsuperscript{2}</td>
</tr>
<tr>
<td></td>
<td>• Adaptability\textsuperscript{12}</td>
<td>• (M) Number of engineering hours versus budget\textsuperscript{5}</td>
</tr>
<tr>
<td></td>
<td>• Team structure\textsuperscript{9,20}</td>
<td>• (M) Net present cash flow to development cost\textsuperscript{5}</td>
</tr>
<tr>
<td></td>
<td>• The importance of internal communication\textsuperscript{1,2,3,8,18}</td>
<td>• Reporting results of development\textsuperscript{2,5,8}</td>
</tr>
<tr>
<td></td>
<td>• Reward system\textsuperscript{2,6,9}</td>
<td>• Issues solved\textsuperscript{21}</td>
</tr>
<tr>
<td></td>
<td>• Organization receptive to innovation\textsuperscript{3}</td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{4} Eric Von Hippel defines lead users, as ‘those whose present strong needs will become general in a market place months or years in the future’ (Von Hippel, 1986, p. 791)
Table 2 Order Qualifiers and Order Winners

<table>
<thead>
<tr>
<th>External Environment</th>
<th>Customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The R &amp; D organization’s image in the eyes of the customer</td>
<td>• Strive to have one or several lead users</td>
</tr>
<tr>
<td>• Supportive environment</td>
<td></td>
</tr>
</tbody>
</table>

(M) – Factor should be tracked by management figures.

1. (Schumann, Ransley, & Prestwood, 1995); 2. (Brown & Gobeli, 1992); 3. (Twiss, 1992); 4. (Roberts & Fusfeld, 1981); 5. (Brown & Svenson, 1998); 6. (Imai, Nonaka, & Takeuchi, 1984); 7. (Bjorn & Souder, 1997); 8. (Balachandra & Friar, 1997); 9. (Galbraith, 1982); 10. (Karlsson, Trygg, & Elfström, 2004); 11. (Bremser & Larsky, 2004); 12. (Maidique & Hayes, 1984); 13. (Patterson M., 1989); 14. (Mansfield & Wagner, 1975); 15. (Cooper, 1997); 16. (Maidique & Zirger, 1984); 17. (Porter, 1979); 18. (Langrish, Gibbons, Evans, & Jevons, 1972); 19. (Keller, Julian, & Kedia, 1996); 20. (Wheelwright & Clark, 1992); 21. Come from interview data

5.3 Order Winners

In manufacturing terminology, ‘order winners are those criteria that win the order over the competition’ in Hill study (as cited in Prajogo et al., 2007, p. 53)

We would like to extrapolate the above concept to the success factors within the innovation system. These “order winners” are the factors that could provide companies with a competitive advantage, as the company could use them to differentiate their offerings from the competition. In this chapter a discussion on such factors follows.

Inputs

The source and quality of the idea is very important, in this industry it comes from two sources: (1) Major Customer needs, (2) Previous innovations. In all four cases, a combination of the two different sources took place; the organization should be encouraged to find lead users (Von Hippel, 1986) that will help them identify technical and functional requirements that will become popular among other customers in the future. The case of ZTE represents a good example of this, as the innovation helped ZTE improving their solutions’ portfolio. The empirical data suggests that R&D managers should be encouraged to take as a baseline existing products and try to think of new ways to define them or enhance them.

Having access to technical information was very helpful for the four companies; this technical information came from two sources. (1) Internal source: From technical documentation from previous developments of the company, including information from other business units. The project manager was responsible in knowing who to contact and
pass this information to his/her team. (2) External source: From standardization institutes of telecom, such as the IEEE, ISO, ITU, 3GPP, etc., companies should be active members of those organizations as they can benefit from their information. It is common for these organizations to possess information such as algorithms or protocols that have not been developed in a real life scenario but that were proposed by researchers of other organizations, In the case of Nortel, the development of the network synchronization feature was possible due to access to information from the 3GPP.

The involvement from senior management was beneficial for the innovation development effort, other than the common task of approving the budget for the project, as it was the case in the four companies, top management should choose the team structure to follow and handpick a PM who possesses the required mixed of social and technical skills, as it was the case of Nortel and ZTE. Furthermore, it seems helpful for the senior manager to have a technical background as it makes him/her more sensitive towards the needs of the R&D department, as the case of Alvarion showed. Senior management should maintain from the start a communication channel with the intrapreneur figure in the company, as it was the case in ZTE.

The so called intrapreneur, can be the difference between initiating a project or not, in both Nortel’s and ZTE’s cases, the intrapreneur figure was very important, as through intense internal and external social interaction built human relationships that enabled obtaining the requirements and resources needed. The intrapreneur was characterized by having social skills and having the will and resolve to make things go forward.

The comprehensiveness of the requirements is an essential factor that R&D managers should monitor carefully. As stated earlier, broad requirements usually come from the customer. It is up to the R&D team to translate these broad requirements into technically precise requirements. This process is gradual and companies should not expect to obtain 100% of the requirements at the project initiating phase, they should start with the main requirements and display flexibility and adaptability to include new requirements when they come along, ST-Ericsson, ZTE and Alvarion experienced this. A good strategy is to negotiate the involvement of a potential customer at the start, this is the common model used in ST-Ericsson and it brings good benefits, a customer could be convinced to participate in this by making sure that he understands the benefits of receiving an innovation that will solve his current or future needs.

When talking about having the right people, these companies already have very skilled people working at the technical level. However the important part here is in the selection of the PM and in the appointment of young or senior engineers accordingly to the situation, such was the case of Alvarion, Nortel and ZTE.

A final success factor that fits in this category is having active and adaptable sales people, in the case of ZTE, an innovation was born as the presales leader went and knocked on the customer door; traditionally, sales people sell already developed solutions, but this seems to be a new source for innovation development that could be exploited. For this factor to become a reality the sales people in the company should be technically savvy.
**R&D Department**

There are some key roles within an R&D department that make a difference, one is a highly skilled engineer, which in the case of Alvarion and Nortel help the team when things were not moving forward. The PM is a key role if he acts as an intrapreneur, as he/she goes beyond the job description and borrows resources or gets information from unexpected sources, such were the cases of Nortel and ZTE. For management roles, it seems to be important to have a technical background, as the four companies showed.

The R&D department should promote the usage of best practices, in both management and technical levels; the management team could be aided by usage of dedicated SW that could help in tracking and organizing. Employees should receive training on best practices from standardization organizations; all four companies analyzed utilized these tools, but only ST-Ericsson provided best practices training to their technical level employees.

**Manufacturing**

In this industry there seems to be an increasing trend of outsourcing the manufacturing towards lower cost countries. Chinese vendors such as ZTE have a competitive advantage as they can manufacture in-house at very competitive cost, other companies located in countries where labor is more expensive, should consider the possibilities of manufacturing abroad. Manufacturing however should be very focus on quality and efficiency in addition to cost. Both Alvarion and ST-Ericsson have actively looked to have their manufacturing outsourced.

**Marketing**

Marketing should be involved as early as possible, in this industry however the marketing function is generally called Product Line Management and sometimes is done by consulting figures or by presales/sales teams. In the case of ST-Ericsson, a department called CPO performs this functions and it is very specialized on being an active interface between the customer and the R&D teams. The marketing figure, whichever the name it goes by, should be very aware of the developments and trends of the market and look for competitors offerings (when the company is not pioneering) as the innovation’s features should be at least as good as the competitors’.

The innovation seems to benefit if the marketing figure actively participates in every stage of development, as it was the case in ST-Ericsson, Alvarion and ZTE. The case of Nortel shows that lack of involvement from the marketing figures affected the outcomes, as the feature was not actively promoted to other customers.

**Organization**

The organizations analyzed focused on three main key communication channels, (1) between functional departments, (2) between R&D and marketing, and (3) between Marketing and customer. The communication channel between R&D and manufacturing, while necessary, seems to be not particularly strong; furthermore it belongs to completely
different business units (ZTE, ST-Ericsson, Alvarion). It seems that the manufacturing
department in this industry has become very advanced, making it somewhat independent.

In all four companies interviewed, it appears that employees are motivated by the work
itself, they know that they are contributing to science and to the company; hence, they feel
proud about it. They are further motivated to see the innovation reaching the market place.
It is therefore important that the organization promotes awareness among the employees,
regarding the impact and benefits behind the development. The case of Nortel showed a
particular synergy among employees, as they were really identified with the project as they
were “living it”, this identification boosted employee commitment.

All four companies had learning strategies of their own, learning can be classified in two: (1)
Technical knowledge: Regarding concepts, components, algorithms and architecture. And (2)
social knowledge, which can be external, by learning about how to reach the customers such
as the case of ZTE and ST-Ericsson; or internal, by learning how to work and grow as a team
and how to create team synergy, such was the case of Nortel.

Business focus was present in two ways: (1) Technology, companies seem to benefit to be
focused on one technology, such as the case of ST-Ericsson. Large companies should have
independent business units for each of their main solutions’ portfolio (ZTE, Nortel). If the
solutions’ portfolios are not independent, the focus may be disturbed (Alvarion). (2)
Persistency, companies might be very focus during product development but start losing
attention some time after the product has successfully reached the market place; In
Alvarion’s case, the focus on the innovation waned after some years, as the company’s
attention turned to 4G mobile technologies. However, companies should realize that older
products are a source for next generation innovations (ST-Ericsson, ZTE).

All four companies displayed adaptability, which is necessary as customers are specialized
and set the trends for the future needs, the degree of adaptability seems to escalate as
bargaining power of customers increase, such was the case of ZTE.

After the gathering of data from the four companies there seems to be no obvious right
team structure, however a heavy weight structure seems to encourage internal problem
solving and entrepreneurial culture, In ST-Ericsson and Alvarion a heavy weight manager
often facilitated the work of lower level employees.

Outputs and Outcomes

New knowledge is a main output. All four companies used previous knowledge as an input
for the innovation development. This output relates directly with documentation, the four
companies placed a lot of effort into documenting the innovations. If companies manage the
new knowledge properly it becomes and input for the next innovation.

Complaint management is a usual task in this industry, as the case of ZTE, Alvarion and ST-
Ericsson showed; from these complaints a source of product improvement can arise, as from
this feedback the telecom manufacturers can realize present and if look carefully future
needs of the customer. As the case of Alvarion showed, product improvement aims in
decreasing cost and adding features, the first line of products is usually manufactured with
high quality components. The next batches of production go through a cost reducing effort (materials, people, etc.), companies however make sure that the cost reduced product performs as expected through regression tests.

The perceived value of the product is an important output that can attract new customers (ST-Ericsson). However, as these companies operate in an international arena, it is important to know that in some regions such as Africa, Asia and South America there is an increasing emphasis in selecting the most cost effective innovation even over another that is perceived as having more features or reliability, as the interview with Alvarion revealed.

Increase of market share is another key output in this industry, other than the direct financial gain, it is a factor that enable the company strengthening its relationship with customers and it is therefore an opportunity to sell other solutions of the portfolio to these customers, such as the cases of ZTE and Alvarion exemplify.

A commercial proposal won thanks to the new innovation is perhaps what all companies strived for; the benefits are greater if one of the proposals is with a specialized customer, as he could become an idea generator for the next innovation (i.e. a lead user). ZTE, Alvarion and ST-Ericsson made a good use of this output.

**External Environment**

The R&D organization at the eyes of the customer is something that needs to be taken into account, especially for public companies that trade in stock exchanges, as the case of the four companies presented in the thesis. Organizations should place special care on the image that is projected towards the external environment as it has a direct impact on the company, if internal issues arise they should not reach the public. This factor is also related with product reputation, which is very important as it strengthens relationships with existing customers. Reputation is a source of increasing sales, as other customers will be drawn to the solution. ST-Ericsson and Alvarion interviewees commented on the importance that reputation has in this industry.

**5.4 Order Qualifiers**

In manufacturing terminology, *order qualifiers are those criteria a company must meet to be considered a supplier*’ in Hill study (as cited in Prajogo et al., 2007, p. 53)

Factors classified in this section are factors that all four companies analyzed have or try to focus on, as they seem to be the status quo in the industry, a company that does not pay attention to these factors may not even be able to develop innovations that compete successfully in the market place. Nevertheless, as important as they are, it is unlikely that superior performance on these factors brings competitive advantage to the company, as all other competitors also display them.

**Inputs**

In the four companies, the probability of commercial success was assessed internally, and it is directly affected by existing relationships with customers.
When it comes to staff needed for innovation, in the four cases there seems to be a feeling of lack or resources, and often people needs to work extra hours or in the weekends, however as the Alvarion’s SPE put it ‘In real life you have to manage with whatever you have’.

To establish a budget and the required financial metrics is something that all the four companies needed to do.

**R&D Department**

High employee commitment was displayed in all four cases, and it is one of the main drivers for innovation.

The comprehensiveness of the R&D program is a must; each of the four companies had all the required technical departments including HW design, SW design, audio, video, etc.

Effective project management and control is another essential factor, in the four analyzed companies one manager was kept from start to end, and in general acted as a facilitator and mentor for his/her employees. Towards the end of development the degree of control increased, as deliverables needed to comply with the established deadlines.

Effectiveness in development was necessary for all four companies, products should be highly effective if they are to be purchased by customers, every innovation goes through a thoroughly acceptance procedure before being purchased by a customer and if the product is not effective enough, it will be rejected. R&D departments should be focus on effectively solving all the list of requirements.

Project managers in the four companies also tracked the following factors:

- The ability to respond to peak demands and emergencies
- Timeliness in development/compliance with planning
- Percentage of technical specifications met
- Number of design changes before release/engineering change orders
- Number of tests performed per week
- Number of engineering hours versus budget
- Net present cash flow to development cost
- Reporting results of development
- Issues Solved

**Manufacturing**

As stated earlier manufacturing is highly specialized in the telecom industry; all four companies had a good understanding on manufacturing possibilities, and all companies seem to focus on three main aspects: (1) minimizing errors, (2) minimizing cost, (3) maximizing efficiency and performance.

**Marketing**
Conducting a market analysis is a required task for companies; senior management often takes decisions on approving new developments based on the market analysis, the sales forecast and in the potential financial benefits for the company. ZTE, ST-Ericsson and Alvarion needed to conduct market analyses in different stages of the project.

**Organization**

The organization must be receptive to innovation, from the employee level to senior management; all four analyzed companies were receptive to innovation to a certain degree.

**Outputs and Outcomes**

A list with the outputs that all companies need to produce follows:

- Quality, Reliability, Availability and technological capability
- Designs produced
- Competitive value of innovation and degree of innovation
- Number of Patents, degree of patentability, and licensing and intellectual property
- Return on Investment
- Price impact on customers
- Break even time

**External Environment**

All four companies maintained an active participation with external standardization organizations such as the ITU, IEEE, 3GPP, ISO, etc. These organizations are a source of ideas and they set some ground rules that should not be ignored, being active members of these organizations also increases companies’ reputation in the eyes of the customers.

**5.5 Innovation type impact on Success Factors**

The type of innovation directly impacts some success factors, before discussing such factors the four innovations will be classified.

The following figure shows the classification of the four projects marked by a star, according to (Henderson & Clark, 1990) figure:
For a detailed argumentation of the reasons behind this classification refer to Appendix F.

For the arguments stated in Appendix F, the most radical innovation corresponds to the one developed by Alvarion, followed by ST-Ericsson’s, ZTE’s and Nortel’s. It is important to say that inside whichever quadrant there is room for substantial differences. For example Alvarion’s innovation is considered as radical, however the green star shows that it is very close to the Architectural quadrant, as even though it “destroys” architectural and component knowledge, it is not possible to say that this destruction is massive, as the technology is still based to a certain degree in some previous knowledge and rules. Another example is located within the Incremental innovation quadrant, as even though both ZTE’s and Nortel’s innovations are located there, ZTE’s is closer into being an architectural innovation than is Nortel’s.

**Success Factors impacted by the innovation’s degree**

Some factors seem to be directly impacted by the degree of innovation (incremental, architectural and radical), the following table lists such factors. A detailed discussion of each factor follows.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Success Factor</th>
<th>Incremental – Nortel, ZTE</th>
<th>Architectural – ST-Ericsson</th>
<th>Radical - Alvarion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inputs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality and Source of the Idea</td>
<td>Idea comes from the customer</td>
<td>Idea comes from previous innovation and market analysis</td>
<td>Ideas are internal with some guidance from the market</td>
<td></td>
</tr>
<tr>
<td>Having access to key information such as technical of research information</td>
<td>Very important, comes from competitors and standardization organizations.</td>
<td>Somewhat important, comes from previous innovations and internal efforts.</td>
<td>Not so important, too difficult to obtain, internal basic research seems better</td>
<td></td>
</tr>
<tr>
<td>Probability of commercial success</td>
<td>Calculated with high details</td>
<td>Calculated with medium details</td>
<td>Vary vague details, if any</td>
<td></td>
</tr>
<tr>
<td>Comprehensiveness of the requirements</td>
<td>Very high and very important</td>
<td>Medium – high and important</td>
<td>Low, gradually increases, not to expect</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5 Innovation’s Classification diagram from (Henderson & Clark, 1990, p. 3)
Standardization information can probably be acquired from external sources such as benchmarking or from standardization organizations. Thus, managers should be aware that finding the technical information may not be available and the company might have to focus on basic research, as the company will be probably the first in creating the needed concepts, such as algorithms or new architectural ideas. For incremental and architectural innovations some technical information can be acquired from external sources such as benchmarking or from standardization organizations.

**Table 3 Factors affected by the innovation type.**

<table>
<thead>
<tr>
<th>R&amp;D Department</th>
<th>Newness to firm</th>
<th>Medium - enhancements</th>
<th>Medium – high, in architecture</th>
<th>High, in concepts and architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marketing</td>
<td>Strength of market</td>
<td>Very strong and established</td>
<td>Strong and established</td>
<td>Not that strong, customers get involved in an intermediate phase</td>
</tr>
<tr>
<td>Organization</td>
<td>Organization receptive to innovation</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Outputs and Outcomes</td>
<td>Competitive value of innovation and degree of innovation</td>
<td>Very competitive, medium degree</td>
<td>Very competitive, medium - high degree</td>
<td>Very competitive, high – very high degree</td>
</tr>
<tr>
<td>External Environment</td>
<td>Supportive environment</td>
<td>Environment is tough, competition is high, and negotiations are key, standardization organizations help</td>
<td>Low to medium competition, negotiations with customers are key</td>
<td>Competition is low; standardization organizations do not help too much.</td>
</tr>
</tbody>
</table>

(M) – Factor should be tracked by management figures.


**Inputs**

Quality and Source of the Idea: For incremental innovations (i.e. ZTE, Nortel), the broad idea in form of a requirement came from the customer, and then a technical idea was developed within the firm. In the architectural innovation (i.e. ST- Ericsson) the idea came from previous innovations and was devised internally, the customer input however was more important as the development advanced. In the case of a radical innovation (i.e. Alvarion), the idea was again coming internally with very broad requirements from the customer. Even though the idea seems to come always from the customer, the customer, as a source of ideas is stronger in an incremental innovation.

Access to key technical information such as technical or research information: This factor seems to become more difficult to obtain when the innovation is close to be a radical one; in the case of Alvarion, access to the required information was difficult, the company was not conducting too much benchmarking with competitors as only one other was developing a similar technology. Thus, managers should be aware that finding the technical information may not be available and the company might have to focus on basic research, as the company will be probably the first in creating the needed concepts, such as algorithms or new architectural ideas. For incremental and architectural innovations some technical information can be acquired from external sources such as benchmarking or from standardization organizations.
Probability of commercial success: As stated earlier, it is important to have an idea of the probability the innovation has in reaching the marketplace and being accepted, however this assessment becomes more difficult in the case of a radical innovation. When selling the idea internally, the intrapreneur (assuming he is the one selling the idea) should let senior management know that it is very difficult to involve a potential customer in early stages due to the high degree of uncertainty and variability, but at the same time he/she should let them know of the potential benefits of becoming a pioneer in the segment. In radical innovations, senior management should not expect to receive a very detailed description regarding the probability of commercial success when deciding in accepting a project, however they should expect receiving a much more detailed assessment on an incremental or architectural innovation.

Comprehensiveness of the requirements: The degree of comprehensiveness from the requirements that come from marketing is higher when the innovation is incremental and lower when is radical.

R&D Department

Newness to firm: When the innovation is incremental the degree of newness is expected to be relatively low, this does not mean that it will be simple. Nortel and ZTE’s cases showed that an incremental innovation also has many challenges, however the previous knowledge is key in this type of innovation. For an architectural innovation, the newness is expected in the linkages between core concepts, as the case of ST-Ericsson shows ‘The core remained’ but the way components were linked together changed in an important way. When developing architectural innovation a group of experienced senior engineers can help when devising the new product architecture. The empirical evidence collected does not include a modular innovation. However it could be inferred that when developing a modular innovation, the newness is greater in core concepts and components and, young researchers could be of great help in this type of innovation. Finally for a radical innovation, the newness appear to be greater as both core concepts and architecture need to be re-defined, when developing a radical innovation a combination or senior engineers that could help creating the new architecture in combination with young researchers that could propose new concepts seem to be adequate (Galbraith, 1982).

Marketing

Strength of Market: This factor is closely related to assessing the probability of commercial success, the marketing department in this industry is very technically oriented, and they should know the type of innovation they are dealing with when assessing the strength of the market. Once again the challenges increase when going from incremental to radical innovations, with architectural innovations somewhere in between. In Nortel and ZTE’s case, the market is already very strong, established and the customers demand the innovations. For an architectural innovation, the telecom manufacturer needs to look for a potential customer and convince them to participate, the market exists as well and the strength of the market can be assessed. In the case of Alverion it was difficult to obtain a customer at an early stage, as the market was not well defined, the company had to take some risks when...
developing the solution, however in an intermediate stage when the “BETA” product was ready, a customer could be involved.

**Organization**

Organization receptive to innovation: This factor is essential for all four organizations. Companies that develop radical innovations are more receptive than companies that develop architectural or incremental innovations.

**Outputs and Outcomes**

Competitive value of innovation and degree of innovation: This output should actually be divided in two. The competitive value does not necessarily reflect to the degree of innovation. For example both Alvarion and ZTE’s innovations were competitive in the market and became a success for their companies, by selling the innovations worldwide, however the degree of innovation was quite different.

**External Environment**

Supportive environment: For an incremental innovation the external environment can be very tough, as competition is already established and customers’ expectations are high. The customers have a great bargaining power sometimes, such was the case of ZTE. In this type of innovation companies should have a gatekeeper role that is very aware of technical developments in competitors and in standardization organizations, as this a source of ideas for the development. Such was the case of Nortel, as the idea developed for the network synchronization feature came from the 3GPP. For the case of radical innovations, competition is not very high and the customer establishes very broad requirements, nothing too precise, as the technology is quite new. Customers only have in their minds the general requirements and it is up to the internal staff to transform those needs into technical specifications. As the case of Alvarion shows, benchmarking is very difficult and the gatekeeper possibilities of getting external ideas is diminished, companies should focus on internal idea development instead.
6 CONCLUSIONS AND FUTURE WORK

In this chapter the conclusions of the research are outlined and a set of recommendations for future research is included.

6.1 Conclusions

The telecom manufacturing industry has a peculiar set of characteristics that set it apart from other high tech industries. This thesis presented a collection of the factors that are relevant to this industry and that are truly important, especially for R&D managers as it allows them to know what factors they need put more attention to, to directly influence the success of an innovation. The analysis was done based on qualitative interviews of four distinct multinational telecom equipment manufacturers. Four different highly successful innovation development projects were analyzed; all of them were successful as they accomplished the companies’ purposes. All these factors were ordered and organized via the use of a framework, which depicted the innovation development effort as a continuous process that consists in the participation of different entities within firms, such as functional departments, organizational policies, inputs and outputs. The framework also considered the impact of the external environment that surrounds an innovation. This framework can become a tool for the R&D manager of an organization, as it can help him/her in creating management strategies and device key measurements.

The framework highlights the importance of the marketing department, as its involvement is key in every stage of the development process. Manufacturing does not appear as a interworking department with R&D and marketing, as the manufacturing function in the telecom industry appears to be highly advanced and with a high degree of independence from R&D. The customers should be involved in the development process as early and as much as the innovation allows, if one of these customers is a lead user the benefits are greater as they are an important source of future requirements for future innovations. All innovations have different outputs, however some of these outputs are a key source for the next generation innovation and they should be nurtured.

The innovation process in the telecom manufacturing industry does not finish when the product reaches the market. When the company sells a product a relationship between them and the customer is born, companies assume a responsibility of innovation support that can span for several years. During this time the telecom manufacturers incur in product enhancement projects and companies manage customer complaints, which as well can become an important input for the next generation innovation.

Furthermore, the so-called factors of success were divided in two categories, namely order winners and order qualifiers. Order winners refer to factors that could enable companies to gain a competitive advantage if managed properly. None of the projects analyzed possessed an excellent management of all these factors. However, companies should strive to focus on most of them in their path towards managerial excellence. The order qualifiers factors are portrayed as a necessity for companies, meaning that organizations should consider them in every single innovation development project if they are to create a successful innovation that reaches the marketplace. However as opposed to the order winners, superior
performance in order qualifiers is unlikely to give the company a competitive advantage. The research included a simple way on classifying innovations based on Henderson and Clark’s (1990) criteria which consists in innovation classification based on two dimensions, namely core concepts and linkages between concepts. The research showed that the type of innovation has a direct impact on some factors. These findings are a contribution to innovation management science and are particularly interesting for R&D managers, as they are now aware that depending on the type of innovation some factors are less or more important or should require more or less attention, this awareness will help them to be more prepared when managing the project towards a more successful outcome. Having this knowledge will allow managers to make better decisions in staff selection, as some innovations require more senior people than others, and some innovations require a combination of new ideas and senior expertise.

The research showed the importance of the human factor, as people are perhaps the most important component behind innovations. This includes some key roles such as the gatekeeper, intrapreneur, technology specialist and senior manager. Without the commitment, will and energy of the staff no innovation can take place. Organizations should put special interest motivating the staff, and in letting them know the importance of their contributions to the company, this is particularly important as in the four companies internal motivation was the most important reward for employees, not one of the four companies displayed a clear financial rewarding system, but all of them motivated them through other means such recognition, exposure, autonomy or by giving them more important roles within the company after achieving the companies’ goals.

6.2 Future Work
Possible future work that could enhance and broaden the current research follows:

- Include empirical data from modular innovations and from very radical innovations, or from innovations where the market does not exist at all.
- To have a macro view on R&D in the organization, by analyzing several R&D projects within one firm, this kind of analysis will fill some gaps in this research including the project evaluation methods and high-level factors.
- Have a research that presents innovation failures; a research of this sort would enable to strengthen the analysis, as it would allow identifying with a stronger degree of certainty the effect of lacking some factors.
- Present a research that includes quantitative data, as it will allow strengthening the importance of different success factors and the relationship between internal factors with different outputs.
- Include empirical evidence on measurement; measurement of the different factors would strengthen the value of the current research.
7 LIST OF REFERENCES


8 APPENDIX

8.1 Appendix A – The Interview Guide

General Information

Full Name:

Company:

Years working for the company:

Current position held:

Other Positions related with innovation (Software, Hardware, Processes) you have had in the past:

Explanation of the purpose of the Interview:

This interview is for the purpose of academia, as part of a master thesis, all the opinions expressed are strictly confidential and we would not include any personal names in the written thesis. We will record this interview for personal use only and will not share it with anyone else.

Interview Questions

Before starting the interview we would like you to picture in your mind one especially successful development project you participated in.

Could you very broadly explain what was the project about?

What was your role on the project?

Inputs:

Q1: Before the project started, what factors helped in a great extent to the development of the project

Q2: Did the development team have some metrics to measure performance or success in the inputs of the project, before it officially started?

Q3: As a closing commentary for this section, we would like to mention some of the traditional measures of success found in theory of inputs of R&D, and as you have mentioned some, you may not have mentioned others, we would like to know if you considered them relevant or not.

- Sufficient number of R&D personnel
- Quality and source of the idea
- Having access to key information such as technical of research information
- Planning
- **M** Probability of commercial success
• Investment in research resources such as training, equipment or other financial needs

R&D System:

Q4: In your view, what were the success factors found inside the R&D department, that greatly helped in the success of the project?

Q5: Did the R&D department have some metrics to measure performance or success during the project development phase?

Q6: As a closing commentary for this section, we would like to mention some of the traditional measures of success found in theory of R&D departments, and as you have mentioned some, you may not have mentioned others, we would like to know if you considered them relevant or not.

• Reporting results of development
• Effectiveness of development
• Internal Competition
• Newness to firm
• Comprehensiveness of the R&D program
• M Net present cash flow to development cost
• M Number of design changes before release
• M Number of tests performed (per week, month, etc.)
• M Number of engineering hours to improve performance by X%
• M The ability to respond to peak demands and emergencies
• M Number of engineering change orders
• M Re-work
• M Conformance to best practices
• M % Of tech specs met
• M Timeliness in product development, compliance with planning

Production/Manufacturing:

Q9: In your view what were the success factors found inside the production department, that greatly helped in the success of the project?

Q10: Did the production department have some metrics to measure performance or success during the project development phase?

Q11: As a closing commentary for this section, we would like to mention some of the traditional measures of success found in theory of production departments, and as you have mentioned some, you may not have mentioned others, we would like to know if you considered them relevant or not.

• Production Orientation
• Minimize cost
• Minimize errors
• Good understanding on manufacturing possibilities
• Good performance

**Marketing:**

Q12: **In your view what was the influence, or the responsibility of the marketing department that helped in the success of the project?**

(Would a market analysis will help this project better?)

**Especially Communication:**

Q15: **In your view, what was the effect of a good communication among the R&D department, marketing and manufacture department to this project?**

**Organization:**

Q13: **In your view what were the success factors found inside the organization, that greatly helped in the success of the project?**

Q14: **As a closing commentary for this section, we would like to mention some of the traditional measures of success found in theory of R&D departments, and as you have mentioned some, you may not have mentioned others, we would like to know if you considered them relevant or not.**

- Team structure
- Employee motivation and capability
- Learning cycle
- Business focus
- Reward system

**Outputs:**

Q16: **In your view were there any outputs to the project other than the product itself?**

Q17: **Were there any metrics to assess the outputs of the project?**

Q18: **As a closing commentary for this section, we would like to mention some of the traditional measures of success found in theory for project outputs and as you have mentioned some, you may not have mentioned others, we would like to know if you considered them relevant or not.**

- New knowledge, new processes
- Patents
- Publications, presentations
- Documentation, books written
- Product improvement
- Designs produced
- Awards won
Metrics for Outputs:

- Proposals won thanks to the new innovation
- Contribution to market share increase
- Number of complaint and complaint expense & customer satisfaction
- Return on Investment
- Cost reduction
- Competitive value of innovation and degree of innovation
- Quality, Reliability, Availability, technological capability
- Licensing and Intellectual property
- Price impact on customers
- Perceived value of the product
- Break-even time

External Environment:

Q19: In your view opinion, the external environment of the firm influences the success of a development project?

Q20: Do you know if the company measures in some way the impact of external forces?

Q21: As a closing commentary for this section, we would like to mention some of the traditional measures of success found in theory for project outputs and as you have mentioned some, you may not have mentioned others, we would like to know if you considered them relevant or not.

- Supportive environment but at the same time competitive
- The R & D organization’s image in the eyes of the customer

To close this interview would you like add something additional to what we’ve discussed? In your view there is more than what we discussed to product development?

Would you mind if we use the name of the company and the name of the project for our thesis? If you think it compromises the affairs of the company of course the information will be completely anonymous.

8.2 Appendix B – Alvarion’s Innovation Technical Description

WalkAir 3000 is aimed for telecom service providers as it operates in the licensed frequency bands of 3.5, 10.5, 26 and 28 GHz. The solution delivers fiber-equivalent services at upstream and downstream rates of up to 138 Mbps per sector (Alvarion Ltd, 2005-2011), in terms of hardware it consist in indoor units: Base Station, Terminal Station and IF Multiplexor; and outdoor units: Radio Frequency Unit and Antenna. In terms of software it consists of internal software and algorithms that control the system and an operations and maintenance user application software that allows commissioning and configuration of the system (Alvarion Ltd, 2005-2011).

The following figure shows the WA3k Base station and Terminal station along with their Radio Frequency Units:
8.3 Appendix C – Nortel’s Innovation Technical Description

The project analyzed in this thesis for Nortel corresponds to a feature for the Global System of Mobile Communications (GSM) technology, which is a mobile technology of worldwide penetration, the feature is Called Network Synchronization and allows wireless carriers to precisely synchronize all their Base Transceiver Stations (BTS) with the help of an external GPS receiver, the traditional way of synchronization was not provided in this way, but instead only the GSM cells belonging to the same Base Station could be synchronized by receiving the PCM time; with the new feature, every GSM cell in the network and not only on the same site would be perfectly synchronized. The benefits of this feature include noise reduction, interferences cancellation and a gain of quality and capacity over the air when combined with an enhanced RF engineering planning.

The following figure shows a very general view or Nortel’s GSM architecture:
The network synchronization feature had an impact in the BSS Subsystem, which is shown in the above figure inside the yellow box.

The project started as a requirement from a major service provider in USA and Nortel had to use internal resources to finance the project, the organization decided that two people were going to work fully in this project, a PM and a technically skilled engineer, the PM had to constantly act as an intrapreneur to get resources from R&D key staff. The project was fully developed in France where Nortel GSM R&D facilities were located. The project was an innovation as Nortel was one of the first if not the first telecom equipment manufacturer to implement in a real environment the Network synchronization feature.

The following picture shows the general case of GSM cells without the feature:
The following picture shows the difference when the feature is applied:

8.4 Appendix D – ST-Ericsson’s Innovation Technical Description

The project analyzed in this thesis for ST-Ericsson corresponds to a mobile platform for the Android operating system using a low level operating system based in Linux, this project gave a very interesting proposal to handset manufacturers, as it combined the multimedia graphical interface of android with a highly reliable Linux kernel, the purpose was to develop all the incumbent HW and SW to create a standard innovative platform that customers could buy and later on modify to adapt it to their specific needs of design and functionality.

8.5 Appendix E – ZTE’s Innovation Technical Description

The customer posed technical requirements to be surpassed, which are listed below:

- The customer required having a new and special form of synchronization for their E1 links, in order to boost their synchronous network performance. This special feature was called “tributary re-timing function for E1 interface”
- The customer needed a multiplexer shelf that hosted standard modules. It is common to have different types of modules for different interfaces within a multiplexer chassis, for example modules for E1, STM1, Ethernet, etc. however back in those days most multiplexer manufacturers (including ZTE) had different hardware for different modules. And this customer required full compatibility in
terms of hardware, meaning that any module could be inserted in any slot within the chassis.

- The previous requirement for standard modules within the chassis also meant that a new backplane was required.
- Every carrier grade solution requires full redundancy in case of a SW/HW failure, for instance if a module fails, an immediate switch over would occur to the back up module. However, the customer wanted to coordinate this redundancy scheme with both multiplexer and their third party (more than one brand) microwave radio systems, meaning that they were looking for a “smart” multiplexer that could mirror the redundancy scheme of the customer’s third party microwave access systems.

The following is a picture of ZTE’s S385

![Figure 10 – S385 (ZTE, 1998-2011)](image)

8.6 **Appendix F – Innovation’s Classification**

**Alvarion’s WalkAir 3000 – Radical Innovation**

As mentioned in the Empirical data chapter, WalkAir 3000 had a brother product called WalkAir 1000, which was the baseline for development at the very early stage and served as a baseline for expected behaviors during some tests, however several core design concepts were changed, these include: algorithms, supported protocols, air modulations and internal components of the base and terminal stations such as new modules including managing processing unit and an Ethernet module. These new components were needed in order to enhance spectral efficiency, increase robustness and provide support for new services such
as IP with QoS, etc. Some other components did not change radically, but were enhanced including the E1 modules, and the HW used for the RFUs.

The architecture of the system departs considerably from its predecessor, as it was aimed to provide new services, which demanded a new architecture and support for new protocols. The internal architecture of the Base and Terminal stations was changed, however some principles remained such as respecting the architectural guidelines for broadband wireless point to multipoint solutions.

Therefore both, components and linkages between components (Henderson & Clark, 1990) depart considerably from previous Alvarion knowledge.

**Nortel’s Network Synchronization Feature – Incremental Innovation**

As mentioned in the Empirical data chapter, the feature was developed to work with the existing Nortel’s GSM Access portfolio (BTS, BSC, etc.), to reach the objective to decrease overall noise in the air interface to allow carriers to augment their air traffic, a new design of the existing synchronization method was developed, this was an enhancement of the existing method.

The new feature disrupted some linkages between GSM components, as when the feature was introduced it had an impact on several other parameters of the network, these other parameters needed to be adapted and Nortel’s GSM engineering rules and guidelines required an update, however other than this no change on the GSM architecture was needed.

Therefore, ‘both architectural and component knowledge were enhanced simultaneously’ (Popadiuka & Choob, 2006).

**ST-Ericsson's new Linux platform for Android mobiles – Architectural Innovation**

As mentioned in the Empirical data chapter, the platform was born with the baseline of a previous one for Symbian (major vendor specific operating system) using as well a low level Linux operating system. The components were taken from the previous development, including: HW for audio; drivers; components to connect to the device; playback and synchronization; etc. in the words of the interviewee ‘The core remained’.

However, the platform had to be adapted for Android mobile phones, which meant working with new tools, manage a new operating system, new frameworks, and in a way a new architecture.

Therefore, the linkages between components changed dramatically while the core design concept remained intact (Henderson & Clark, 1990).

**ZTE’s S385 enhancements – Incremental Innovation**

As mentioned in the Empirical data chapter, the set of SW and HW features were developed to work with the existing S385 optical multiplexer in order to satisfy the customer requirements. The core design concepts of the S385 were enhanced to cope with the new
requirements for E1 tributary retiming, “smart” redundancy scheme, and new module and chassis standardized HW.

The linkages between these components were enhanced, as they needed to be transparent to all the other’s S385 functions, they were treated as additional features, thus the S385 architecture remained intact.

Therefore, ‘both architectural and component knowledge were enhanced simultaneously’ (Popadiuka & Choob, 2006).