LAPPEENRANTA UNIVERSITY OF TECHNOLOGY
Department of Industrial Engineering and Management

MASTER'S THESIS

MANAGING TECHNOLOGIES IN RESEARCH ORGANIZATION: FRAMEWORK FOR RESEARCH SURPLUS PORTFOLIO

The subject of the thesis has been approved by the council of the Department of Industrial Engineering and Management in the meeting of 4 October 2006 in Lappeenranta University of Technology.

Supervisor: Professor Marko Torkkeli
Instructor: M. Sc (Econ.) Pekka Salmi

Kouvola, October 13, 2006

Sari Viskari
Torikatu 2 A 20
45100 Kouvola
Tel. +358 40 7317673

ACKNOWLEDGEMENTS

I would like to thank my supervisor Professor Marko Torkkeli and instructor Pekka Salmi from the Kouvola unit of Lappeenranta University of Technology. Many discussions with you and your constructive comments have been very helpful during the thesis work.

I would also like to thank Nokia, Nokia Research Center and TEKES (Finnish Funding Agency for Technology and Innovation) about Onions-project and enabling the thesis. I thank project members for collaboration, especially Project Manager Matti Karlsson and Jukka P. Saarinen, Head of Multimedia Laboratory in NRC.

Also, I thank my family and friends for the support. Special thanks to my friend, Jutta Jäntti, who have helped me to improve my English.

Finally, my greatest thanks go to my best friend, Pasi, who have supported me not only during the thesis work but also during the whole master's studies. I would not be here without you.

Kouvola, October 13, 2006

Sari Viskari

ABSTRACT

Author: Sari Viskari **Title: Managing Technologies in Research Organization:** **Framework for Research Surplus Portfolio**
Department: Industrial Engineering and Management
Year: 2006 **Place:** Kouvola
Master's Thesis. Lappeenranta University of Technology. 76 pages, 22 figures, 6 tables and 2 appendices. Supervisor: Professor Marko Torkkeli
Keywords: Research Surplus Portfolio, portfolio management, non-core technologies, open innovation **Hakusanat:** tutkimusylijäämäportfolio, portfoliojohtaminen, avoin innovaatio
Open innovation approach and the effective use of innovations are becoming the essential parts of companies' R&D processes. The purpose of the thesis is to create a framework for managing non-core technologies in more efficient way in the research organization. In the thesis, the constructive concept of Research Surplus Portfolio (RSP) is constructed based on the literature review of intellectual capital management and portfolio management. In addition, tools and techniques for the evaluation of surplus technologies are identified. The new portfolio for non-core technologies can be utilized as a searching engine, an idea bank, a communication tool or a market place for technologies. The important phases of the management process of RSP are documentation of the data of non-core technologies, the evaluation of them and maintaining and updating the system.

TIIVISTELMÄ

Tekijä: Sari Viskari

Työn nimi: Teknologioiden johtaminen tutkimusorganisaatiossa: Viitekehys tutkimusylijäämäportfoliolle

Osasto: Tuotantotalous

Vuosi: 2006 **Paikka:** Kouvola

Diplomityö. Lappeenrannan teknillinen yliopisto
76 sivua, 22 kuvaa, 6 taulukkoa ja 2 liitettä
Tarkastaja: professori Marko Torkkeli

Hakusanat: tutkimusylijäämäportfolio, portfoliojohtaminen, avoin innovaatio
Keywords: Research Surplus Portfolio, portfolio management, non-core technologies, open innovation

Avoimesta innovaatiosta ja innovaatioiden tehokkaasta hyödyntämisestä on tulossa tärkeitä osia yritysten T&K-prosesseihin. Diplomityön tarkoituksena on luoda viitekehys teknologioiden, jotka eivät kuulu yrityksen ydinliiketoimintaan, tehokkaampaan hallinnointiin tutkimusorganisaatiossa.

Konstruktiivinen viitekehys on rakennettu pohjautuen aineettomien pääomien johtamisen ja portfolion hallinnoinnin teorioihin. Lisäksi työssä määritellään työkaluja ja tekniikoita ylijäämäteknologioiden arviointiin.

Uutta ylijäämäteknologioiden portfoliota voidaan hyödyntää hakukoneena, ideapankkina, kommunikaatiotyökaluna tai teknologioiden markkinapaikkana. Sen johtaminen koostuu tietojen dokumentoinnista järjestelmään, teknologioiden arvioinnista ja portfolion päivityksestä ja ylläpidosta.

TABLE OF CONTENTS

APPENDICIES:

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

DCF	Discounted cash flow
EBRC	Emergent Business Research Coalition
ECV	Expected commercial value
IA	Intellectual assets
IAMS	Intellectual assets management system
IC	Intellectual capital
IP	Intellectual property
ITU	International Telecommunication Union
IPMS	Intellectual property management system
LUT	Lappeenranta University of Technology
MIT	Massachusetts Institute of Technology
MMT	Multimedia technologies
NIH	Not invented here
NRC	Nokia Research Center
NPV	Net present value
NSH	Not sold here
PPM	Project portfolio management
R&D	Research and development
ROI	Return of investment
RSP	Research Surplus Portfolio
TOL	Technology out-licensing

1 INTRODUCTION

1.1 Overview

The thesis is a part of the Innovation Practices for New Business Creation in NRC –project named as Onions, which is a business project in the program called “Uudistuva liiketoiminta ja johtaminen” organized by Tekes. The objectives of the Onions are to find innovation practices for new business creation in Nokia Research Center (NRC) and enhance innovation climate there. Apart from NRC and Lappeenranta University of Technology (LUT) other parties in the project are Tampere University of Technology, Emergent Business Research Coalition (EBRC), the University of Tampere, Technology Centre Hermia and consulting companies Ledi Oy and Professia Oy. (Liito, 2006)

We live in a knowledge era where information floods from everywhere and knowledge is spread and becomes more detailed. In the business world it means the shorter life cycles for products and technologies and tighter competition. Innovation, “the process of transforming an invention into something that is commercially useful and valuable” (Miller & Morris, 1999, 2), and intellectual capital have become essential. The research and development (R&D) activities of companies have to follow that change and become more and more efficient. Miller & Morris (1999, 3) state in their book that R&D needs to find new approaches to innovation processes. The fourth-generation innovation models have the following characteristic (Berkhout et al., 2006, 393):

- Innovation is embedded in partnerships
- Early interplay between science and business is important
- Knowledge of emerging technologies is complemented by knowledge of emerging markets (combination of hard and soft knowledge)

- The need for skills and new concepts for managing networks with partners such as specialized suppliers and early users
- Entrepreneurship is vital

A company can not survive alone anymore and even the innovation processes should go beyond the boundaries of the firm. Henry Chesbrough (2003a) launched a term “open innovation” to describe a new way to manage innovation and the R&D process. This new open innovation paradigm is discussed in the first part of the thesis.

NRC produces a lot of ideas, technologies and inventions that can not be used for some reason or another in the corporation’s core business. Most of those are not licensed, either, because of incompleteness or the fear of knowledge flowing to the wrong hands. In the spirit of the open innovation NRC is looking for opportunities to create new businesses from the research surplus and that is also the ultimate goal of the Onions-project. One of the very first problems in the new business creation is that NRC does not have a suitable storage for its “research waste”. This study concentrates on the problem and aims to create a framework for a portfolio where research surplus can be stored and classified.

Figure 1 illustrates the position of Research Surplus Portfolio (RSP) in the new business creation framework in the general environment. Research Surplus Portfolio is a new term and has not been used in literature before, but intellectual capital in general, technology portfolio and portfolio management have been written about, so theory context comes from that literature.

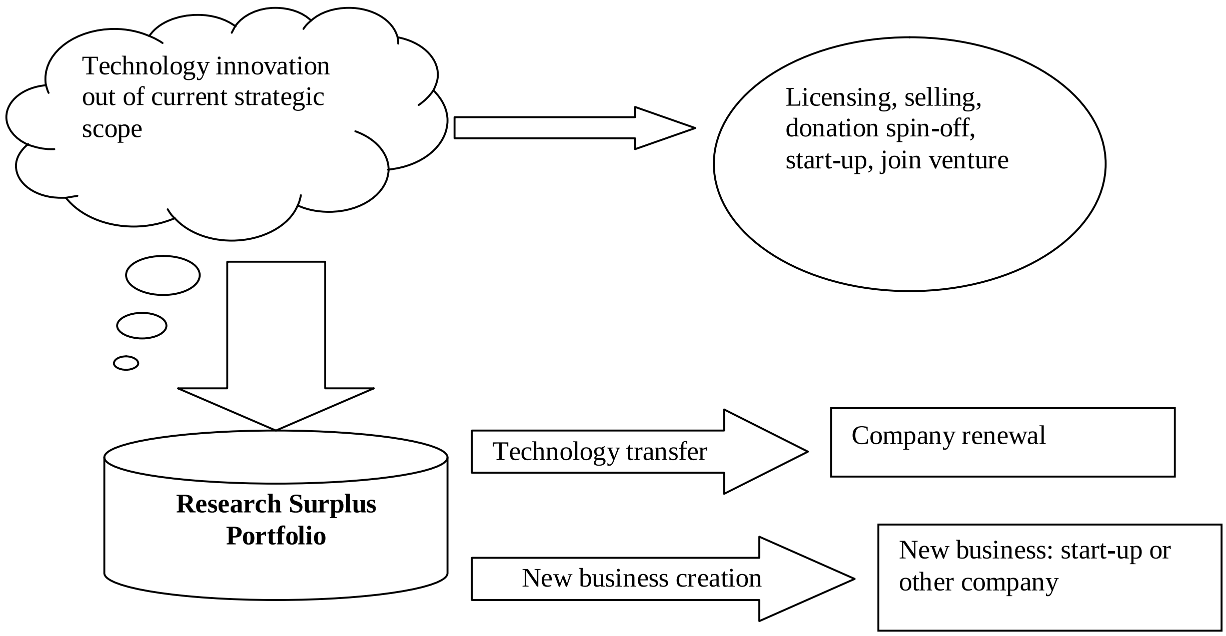


Figure 1. Starting point for Research Surplus Portfolio

1.2 Objectives, Restrictions and Research Method

The purpose of the thesis is to develop a framework for Research Surplus Portfolio. The main research problem is to define the whole new concept, RSP. How RSP could be utilized in NRC and how it could be managed? It is good to keep in mind that RSP is created for the new business creation from the research waste and it will not just be a graveyard of innovations, which are not currently useful. Another objective for the thesis is to find tools and methods for managing RSP. As mentioned before the concept of Research Surplus Portfolio is new, but the portfolio management literature offers many tools for managing technologies and some of them could be applied in the RSP management as well. The main research questions of the thesis are:

1. What elements does Research Surplus Portfolio consists of?
2. What tools and techniques could be applied to the RSP management?

Research Surplus Portfolio does not mean an idea portfolio where new ideas are stored, or a technology portfolio where currently used technologies are sorted. It is important to notice that the technologies placed in RSP are already verified to be “waste”. The thesis is restricted to examine only the surplus portfolio. It does not concern other technology portfolio management issues and practices or other parts of innovation chain in NRC.

The goal of the thesis is to create the concept description of Research Surplus Portfolio. It does not discuss about a single technology that might be placed in RSP. The Implementation of RSP with the physical entity and the computer system design is left out and only general recommendations are given.

The theory of the thesis is a literature review of the open innovation, the intellectual asset management and the portfolio management. To create the framework for RSP, the constructive approach is used. It has been used as a research methodology since 1990s. The constructive research aims to build an innovative, new solution for a real-world managerial problem with both practical and theoretical contribution. The approach emphasizes close co-operation between the researcher and the practitioners, linkages to previous theoretical knowledge, testing the practical applicability of the new construction and the reflection of the findings to prior literature. The elements of the constructive approach in the thesis are visualized in Figure 2. (Lukka, 2000, 114) To create the constructive framework, information about NRC is collected from interviews with Project manager, Matti Karlsson and Jukka Saarinen, head of Multimedia Laboratory, from NRC (Kalrsson, 2006a, 2006b; Saarinen 2006). In addition, Nokia’s websites are used to collect the general data about NRC.

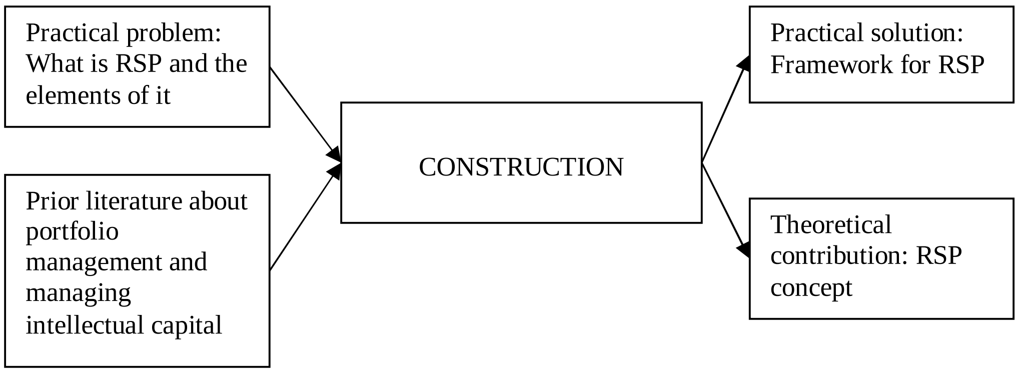


Figure 2. The elements of the constructive approach in the thesis (adapted from Kasanen et al., 1993, 246)

1.3 Structure

The thesis starts with the literature review about the open innovation paradigm. It is justified to get acquainted with this new innovation phenomenon, because the inspiration of the Onions-project and the thesis comes from the open innovation. The second theory chapter deals with intellectual capital and its management. The technology portfolio management handled in the chapter four is a part of the intellectual asset management and especially important with the open innovation paradigm. In the chapter five the Research Surplus Portfolio framework is introduced and the best suitable portfolio management methods from the previous theory chapters are discussed. Finally, research conclusions are made. The structure of the thesis is visualized with an input-output scheme in Figure 3.

Input		Output
Onions-project overview and background for the thesis.	**Chapter 1: Introduction** Clearing research perspective, goals, methods and structure.	Objectives, restrictions and structure for the thesis.
Introduction of the closed and open innovation paradigms. Drivers for chancing innovation process.	**Chapter 2: Open Innovation Paradigm** Literature review from open innovation literature.	The understanding of new needs and challenges of innovation management.
Literature review to intellectual capital terminology and management.	**Chapter 3: Intellectual Capital Management** Managing intellectual capital and extracting value with it.	Concept of intellectual capital. The importance of managing intellectual assets in the open innovation world.
Portfolio management as a part of the intellectual capital management. Methods from literature. Managing stored technologies.	**Chapter 4: Technology Portfolio Management** Technology portfolio management, tools for technology evaluation.	The meaning of the portfolio management. Tools and methods used to managing technology portfolio.
Tools and methods for RSP from the previous chapter. Information from NRC	**Chapter 5: Framework for Research Surplus Portfolio** Design of the RSP concept	RSP framework for NRC. Recommendations for the implementation of the portfolio
RSP framework and other results of the thesis	**Chapter 6. Conclusions** Assessment of the thesis and usability of RSP	The result of the thesis.

Figure 3. The structure of the thesis

2 OPEN INNOVATION PARADIGM

2.1 Closed, Traditional Innovation Model

The innovation models have been changing during the past decades. The first simple "Technology push" and "need pull" models were used in the 1960s. After that "Coupling models" emerged in the 1980s followed by "Integrated systems" in the 1990s. Already then the business world understood the importance of flexibility and intercompany networking in the innovation process and the "Strategic Integration and Networking" model was discussed. (Rothwell, 1992, 221) But still companies' R&D processes were very closed from outside the company. Tidd et al. (2001, 254-255) use the expression "the development funnel" to describe the transformation of an idea to a product or a service. Innovations move through different stages from the idea creation to the launch phase. Later the funnel approach was connected to Cooper's State-Gate System (Cooper, 1990, 46).

Even if teamwork and cross-functional co-operation in the R&D process was found and widely used, Chesbrough (2003a, 21) calls the traditional innovation model as a closed innovation paradigm, because the whole innovation process from the basic research to the product implementation was classified information and it was protected from the business world outside a firm's boundaries. The closed innovation approach worked well in the environment of the twentieth century and it led many companies to success. But changes in the knowledge landscape that are discussed in the next chapter forces the industrial R&D to develop new models for the innovation process. But before that part, the closer look to the closed innovation model is made.

Figure 4 pictures the closed innovation model. Research projects move through the development funnel. Some of them are terminated and some end up to the market as new products or services. R&D projects can only enter in and exit one way. (Chesbrough, 2006,

4) Companies believe that they have to do everything internally and “Not Invented Here” (NIH) syndrome dominates the industrial R&D thinking. If a company had not developed the technology itself, how it could be sure that the technology is qualitative, operative and useful for it. (Chesbrough, 2003a, 29-30) In the other side of the pipeline, people think that if the developed technology is not sold by us, why we should let anyone else sell it, either. This phenomenon is known as “Not Sold Here” (NSH) virus. (Chesbrough, 2003b, 4)

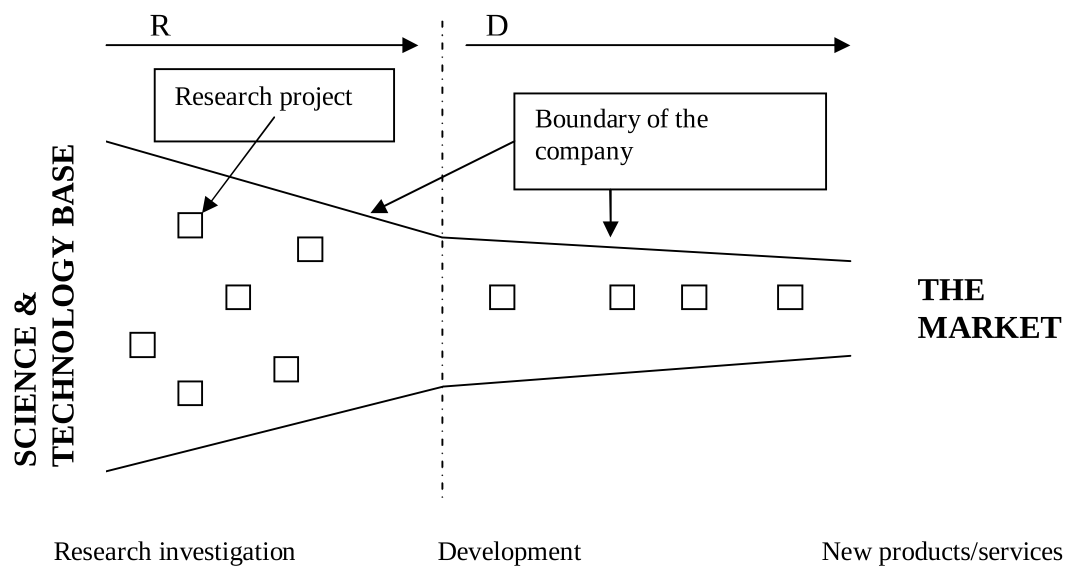


Figure 4. The closed innovation model (Chesbrough, 2006, 4)

2.2 Changing Environment and Challenges for R&D

Centralized, internally focused approach to innovation fitted well in the industrial R&D management in the early twentieth century and it still fits in some industries, but for many industries it has become outdated. In this chapter reasons for that are introduced.

It is clear that management has become more complex, because market expansion, access to information and opportunity to choose from many alternatives has given the power to customers. Today, the management of knowledge and intangible assets is the essential element of success. Challenges for our generation R&D are for instance the multiple sources of knowledge, combining explicit and tacit knowledge, need for a new organizational model and an innovation process, new approaches to finance, decision making and accounting, and tools and processes for integrating all these elements. (Miller & Morris, 1999, 24)

Chesbrough (2003a, 34-41) names four erosion factors that have caused problems to the closed innovation model. The first factor is the increasing availability and mobility of skilled workers. The number of high educated and trained people has grown significantly after the Second World War, and increased labor market gives well-trained workers an opportunity to shift from one company to another. If a talented employee does not change the employer, she or he might start a company of her or his own with the help of a venture capitalist. The raise of the venture capital market is the second erosion factor. These two factors mentioned lead to the third, external options for ideas sitting on the shelf. The customers and the competitors will not wait for establishing of those ideas. If a company does not launch the technology, someone else will. The last erosion factor identified is the increasing capability of external suppliers. A successful company can trust its suppliers instead of doing everything on its own. Figure 5 collects the erosion factors.

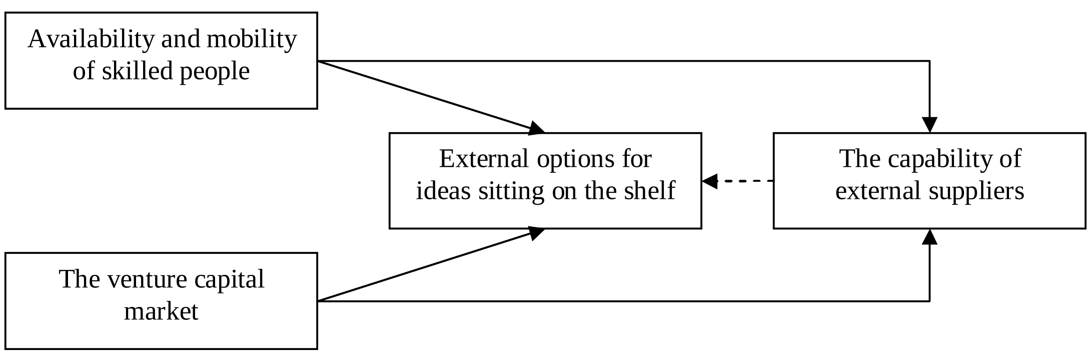


Figure 5. Erosion factors

The use of the closed innovation model makes innovations more incremental. The innovation process concentrates on the current businesses and does not create new ones. The return of a R&D investment has been dissatisfaction in many corporations. It is also noticed that a big part of technologies developed by the company's research labs lie actually unused in some kind of shelf. Only a small percentage is in use in the current business. The next chapter offers an answer for these problems – the open innovation. (Allio, 2005, 19)

2.3 Open Innovation Model

The open innovation paradigm (Figure 6) suggests that ideas for innovations can also emerge or go to market from outside the company as well as inside. The new model assumes that knowledge is spread widely and even the successful innovators with big R&D resources have to look for the external sources of innovation. (Chesbrough, 2006, 2-3) The open innovation leverages the role of R&D. Researchers' job is now, not only to create knowledge, but also to capture it from outside the company. Once a new innovation has taken place a company can use several business models to bring it to the market. If a technology is not suitable for the current business model, it can be licensed or donated to other companies or a new spin-off can be created. (Chesbrough, 2003a, 52, 187-188) But even if openness in the innovation process is highly encouraged there will always be need for some closeness, too (Christensen et al., 2005, 1535).

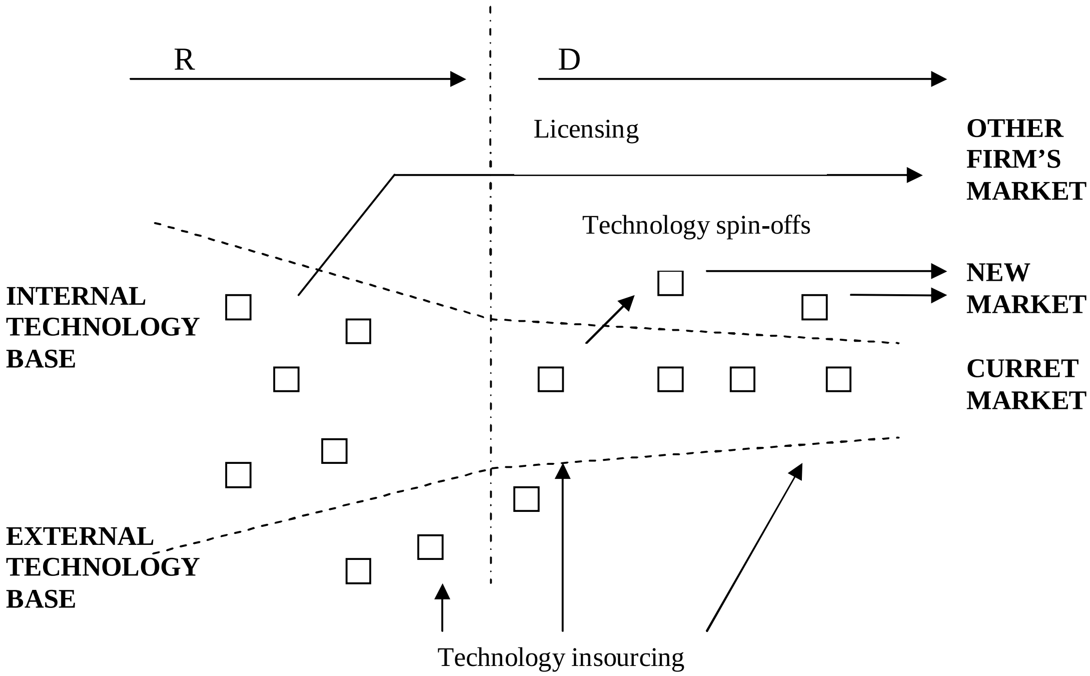


Figure 6. The open innovation model (Chesbrough, 2006, 4)

Although the open innovation is a new term, the sub-areas of it have been written before Chesbrough. A decade ago von Hippel (1994) suggested that companies should use external sources, customers, suppliers, universities and other companies, in their R&D activities. At the same time, Cohen & Levinthal (1990, 149) proved with they empirical studies that firms have to learn from the environment. For doing that, R&D resources need to be allocated to the absorptive capacity, too. The importance of alliances and networks has been studied also in the 90s by for instance Gulati (1998).

Still, the open innovation model offers new perspectives to the innovation management. The open innovation paradigm keeps external knowledge as important as internal knowledge. The basic assumption of the model is that the knowledge landscape has changed. Useful knowledge can come from multiple external sources, from universities and government laboratories to start-up companies, and from individual inventors to graduate students. The business model has a central position in the open innovation. Besides a clear current business model a company can use a variety of other business models to commercialize new innovations. The current businesses compete for new technologies with the external channels to the market. The approach to the intellectual property management has been defensive in the traditional innovation models. Now the open innovation gives a proactive role to the intellectual property (IP). There are plenty of options how to benefit from IP. Companies can sell, license, donate, release or buy it. These alternatives are discussed in the chapter 3.3.3. New intermediate markets have been created to offer information about and access to external IP. With the new open innovation model, new measures of the performance of R&D have been developed. Measures like percentage of innovations originate outside our company and investments in outside firms will expand the assessing of R&D activities. When assessing the potential of a new innovation, measurement errors (false positives and false negatives) are paid attention in the open innovation model. Those are discussed more deeply in chapter 3.1. Especially the measurement of the false negatives has not been studied before. Table 1 summarizes the principles of the open innovation and compares them with the principles of the closed innovation. (Chesbrough, 2006, 11-16)

Table 1. The comparison of the principles of the open and the closed innovation (Chesbrough, 2003c, 38)

Open Innovation	**Closed Innovation**
Not all the smart people work for us. We need to work with smart people inside and outside our company.	The smart people in our field work for us.
External R&D can create significant value; internal R&D is needed to claim some portion of that value.	To profit from R&D, we must discover it, develop it and ship it ourselves.
We do not have to originate the research to profit from it.	If we discover it ourselves, we will get it to market first.
Building a better business model is better than getting market first.	The company that gets an innovation to market first will win
If we make the best use of internal and external ideas, we will win.	If we create the most and the best ideas in the industry, we will win.
We should profit from other's IP whenever it advances our own business model.	We should control our IP, so that our competitors do not profit from our ideas.

3 INTELLECTUAL CAPITAL MANAGEMENT

3.1 Intellectual Capital and the Open Innovation

How companies manage their intellectual capital depends on how open they are. It is widely admitted that most patents are worth little, technology itself does not bring value to companies and commercialization requires the suitable business model to success. The open innovation suggests that corporations should more actively sell and buy their intellectual property. If a company's own business models are not proper for a new technology, it can be sold, licensed or even donated to someone else. Of course, there are still some cases when it is better to protect the technology, instead of outsourcing it. (Chesbrough, 2003c, 39-40)

In the era of the closed innovation, patents were used mostly as barriers to the entry of the industry. Now companies start to realize the revenue-generating opportunity and other alternatives to use IP. Chesbrough (2004, 24-25) refers to the false negatives, which are projects that companies abandon, because they seem to be unpromising and unsuitable to the firm's business model. To manage these measurement errors in conditions of high technology and market uncertainty, he proposes that companies adopt a new way to manage innovation – play poker instead of chess.

The open innovation paradigm emphasizes the importance of the intellectual assets management. Already a big part of the assets in a knowledge firm are intellectual, and entire industries will emerge and grow up based on the exploitation and licensing of the intellectual property of other companies and institutions. (Hogan, 2005, 30-31). In this chapter general issues about managing intellectual capital are discussed.

3.2 Concept of Intellectual Capital

A term “intellectual capital” (IC) was first used in the middle of the twentieth century (Stewart, 2001, 192), but the interest towards its management start to grow dramatically in the last decade, and in the beginning of the twenty-first century intellectual capital has become an essential part of the business, especially to the technology-intensive companies. (Goldheim et al., 2005, 43)

There are many definitions of intellectual capital. Edvinsson & Sullivan (1996, 363) define it as “knowledge that can be converted to value”. Intellectual capital is an umbrella term that is divided into smaller components (Figure 7). Human capital includes employees’ skills, know-how, the memory of important things to the company and collective experience. The value of human capital is connected to the persons and can not be written down. The other component of IC is intellectual assets (IA). It could be classified into three groups: commercializable assets, customer-related assets and structure-related assets. Intellectual assets are the source of innovations that will be commercialized. Usually intellectual assets are used internally, but if an asset is protected, it becomes intellectual property (IP). Typically, IP refers to patents, but the other protection forms are for instance copyrights, trade secrets, trade marks and semiconductor marks.

Companies also have structural capital, which supports the translation of human capital to intellectual assets. It stands for the whole infrastructure of the firm. Structure-related and customer-related assets can be seen as the intangible element of structural capital. The final term introduced here is complementary business assets. Those are a part of structural capital and are needed to deliver the products and the services to the customers. Without them intellectual assets are worth very little. Complementary assets can also be tangible or intangible. In the thesis, only intangible are noted. (Edvinsson & Sullivan, 1996, 358-361) Stewart (1994, 4) has named earlier another form of capital, customer capital, which means intellectual capital from the customer relationships. It could be included in complementary business assets. There are also several other divisions, but those are not discussed in the thesis.

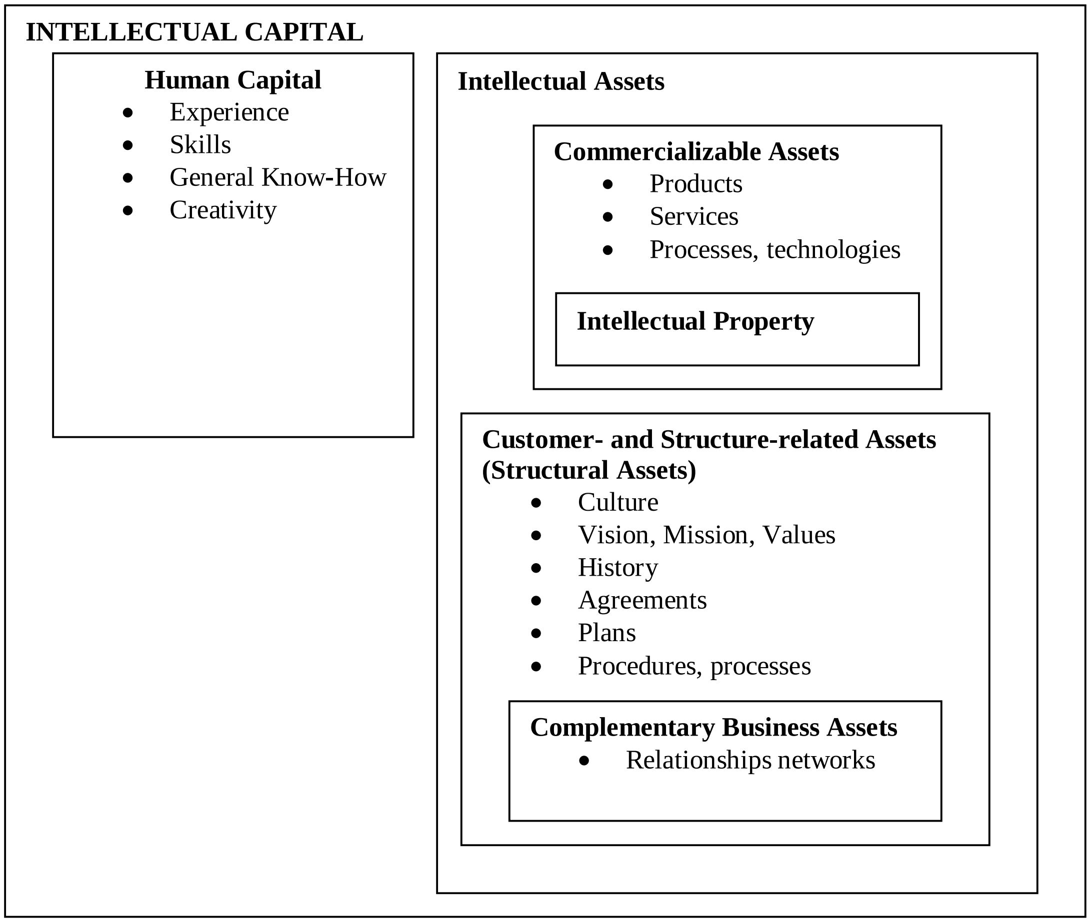


Figure 7. Components of intellectual capital (adapted from Edvinsson & Sullivan, 1996)

The role of intellectual capital depends on the company. It can be defensive or offensive. IC could be used as a protection of the product or the service or as an avoidance of litigation. More offensive roles are: revenue generation, standard creation, access to other's technology, basis for new alliance and creation of barriers to the entry of new competitors. (Harrison & Sullivan, 2000, 142)

Since there are several roles for IC, there are also several ways to manage it. It makes the management of intellectual capital a complex and difficult task. The IC management consists of two basic functions: value creation and value extraction. Value creation deals with the new knowledge creation through learning and acquisitions. It concerns mostly human capital and it is left out of the thesis. Value extraction, on the other hand, focuses more on a company's intellectual assets and aims to extract more value from existing intellectual capital. (Sullivan, 1998, 10)

3.3 Extracting Value from Intellectual Capital

3.3.1 Managing Intellectual Property

A well-constructed intellectual property management system helps firms to extract value from IP. It also provides a good basis for creating an intellectual asset and intellectual capital managing systems. Intellectual property represents the current pieces of IC that are creating value to a company at the moment and most companies have already portfolios for intellectual property. (Sullivan, 2000, 127, 130)

There are two different ways to manage IP. The portfolio of intellectual property (the IP portfolio) can be used as a protection, but another portfolio-as-corporate-business-asset-view has received more and more attention. With this view, IP has very offensive roles (view chapter 3.2). (Sullivan, 2000, 131-135)

The value extraction of the IP portfolio could be carried out by reducing the portfolio expenses or by increasing the portfolio income. A big part of the expenses of the IP portfolio comes from the maintaining fees of the patents, and taxes. It is estimated that approximately 70-90 percent of a company's patents are useless to it and by eliminating, licensing or donating them the cost reduction could be made (Tao et al., 2005, 54). The IP portfolio income could be increased by improving royalty incomes from out-licensing.

These actions are meant for short-term value extraction. If a corporation wants to extract value during the longer period, it has to focus on increasing the quality of the portfolio and the use of it in the business negotiations and, expanding licensing, joint venture and strategic alliance activities. (Sullivan, 2000, 131-135)

The IP management system (IPMS) is illustrated in Figure 8. It is a series of action that links the innovation process, the patent portfolio and the business strategy together. It can be divided into five different responsibility areas: generation of candidate intellectual property, portfolio management, IP valuation, competitive assessment and strategic decision making. (Sullivan, 2000, 144)

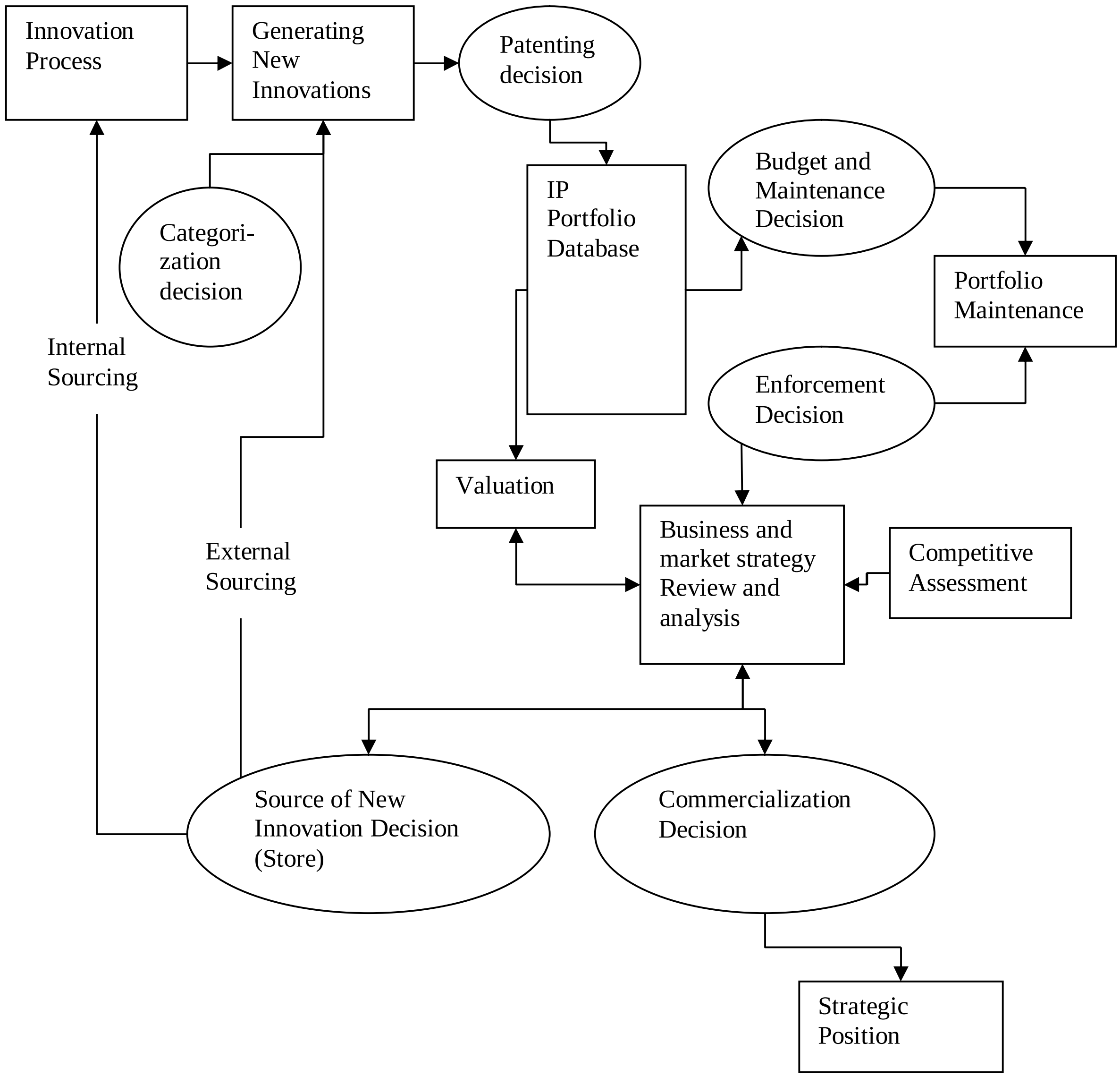


Figure 8. The intellectual property management system (Sullivan, 1998, 113)

The generation of candidate intellectual property includes three different tasks. The first is the overseeing of the innovation process. Usually, firms have the specific descriptions of their innovation process, where stages: research, development and product creation, are identified. It is needed for continue/discontinue – decisions, investment decisions and resource allocation. The second task is about generating new patents. This is a crucial part and it determines the future of the firm. That is why the technology and business analyses of patentable innovations must be carried out carefully. Next, the patents are categorized and coarse valuation is made. (Sullivan, 2000, 144-147)

The IP portfolio is screened routinely. Patents that no longer bring value to a company can be moved for cost reduction. Portfolio managers make budget and maintenance fee decisions. The other element of the portfolio management is patent enforcement decisions that have to be done when infringement of a company's patent is noticed. (Sullivan, 2000, 147-148)

Valuing intellectual property is difficult, but quite often there is a need to valuate a firm's own technologies, patented or not. Chesbrough (2003c, 55) highlights the meaning of the business model. Even if a technology has a potential commercial opportunity, the value of it depends on the business model. Goldheim et al. (2005, 44-45) list three types of IP valuation methods. Market reference is a one measure. The value of a patent or a technology is a price someone is willing to pay for it, and it can be defined by comparing firm's own asset to a similar one in the market. Second, buyer can value a patent (or another piece of IP) at the cost of producing the patent itself. The third method, net present value (NPV), calculates the expected cash flows from the future and discounts them to the present. All of these methods have pitfalls and are not very suitable for valuation IP. Some tools for technology evaluation are introduced in the chapter 4.

Competitive assessment function scans the environment and the competition. It includes activities like gathering, conjoining and communicating the information from the competitors. The assessment function helps the strategic decision-making process (the fifth area of responsibility). The decision is made, whether commercialize intellectual properties or pace them into a store to wait better opportunities, perhaps until another developing technology makes it more profitable to commercialize them. (Sullivan, 2000, 149-150) The open innovation gives also other opportunities for non-core technologies. Those are considered later in the thesis.

3.3.2 Managing Intellectual Assets

Intellectual assets are directed more to the future than intellectual property. When discussing about the value extracting, strategies rather than tactics needs to be considered. An intellectual asset management system (IAMS) is very similar to the IPMS. Those two have the same elements and there are only two notable differences. The first difference is the portfolio. In the IPMS, it is a collection of each kind of IP and logically, in the IAMS, it is a collection of the portfolios of different kind of intellectual assets. Also competitive assessment function is wider and more complex in the IAMS, because the perspective is now broader and a company has to seek much more information. If in the IPMS, competitive assessment focuses only on competitors' patent portfolios, in the IAMS, assessment pays attention to things such as competitors' licenses, business practices, and internal systems and methods. (Sullivan, 2000, 134, 163-164)

There are many methods how the value of intellectual assets can be extracted. But first, it is good to remember that the value of every individual asset is different and most of the assets are of very little value. (Tao et al., 2005, 53) In Figure 9, there are methods for extracting value from IA. Those are separated out of two sections: external and internal methods. There are also value creation dimension and cost dimension in the picture.

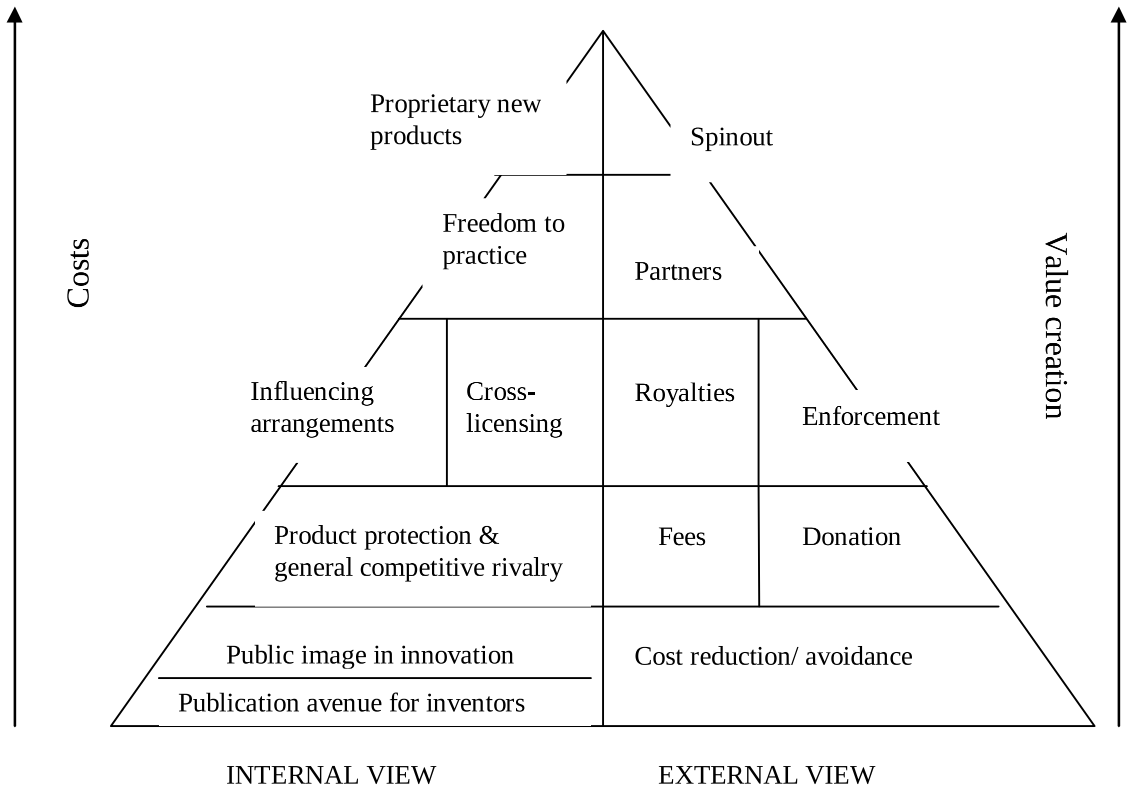


Figure 9. The methods for extracting value from company's intellectual assets (adapted from Tao et al., 2005, 55)

The most high-valued intellectual assets can be used internally into the new products or services, or they can be applied to start-up, spin-offs or partnership companies. The middle range IA can be licensed or cross-licensed outside the company. Internally, value extraction occurs with "freedom to practice", right to make and sell. IA could also be very profitable in negotiations about arrangements or partnerships by providing or denying access to technologies (or other IA). Naturally, protected intellectual assets (IP) give protection to a firm's products. Low value IA, which usually just makes portfolios bigger and more costly, could be donated (if licensing is not possible). But even criticized, low value IA can have some benefits, too. Many companies publish their total number of active patents for boosting their reputation as an active innovator. Large IA portfolios and encouragement to patent could also motivate researchers. (Tao et al., 2005, 54-56)

3.3.3 Managing Non-Core, Technology-Based Assets

Non-core technologies are those that a firm can not use in its core businesses. Not only technologies protected by patents are able to be non-core technologies but also ideas from idea databases, and more mature projects and business units, which could become non-core due to the company's strategic changes. A firm should regularly review the whole technology portfolio because there might be technologies with great potential outside the parent company. (Parhankangas et al., 2003, 6-7) Some of the modes managing non-core technologies (intellectual assets) are already introduced, but some alternatives to manage and gain value with non-core assets are discussed in more detailed here.

The types of managing non-core technologies are classified into three groups (Figure 10) based on the involvement of external parties. With the external methods technology-based assets are transferred outside the parent company. The hybrid modes illustrate situations where a technology is commercialized with an external partner. With the internal modes, technologies are kept in-house and developed further, put on the shelf or terminated. (Parhankangas et al., 2003, 9)

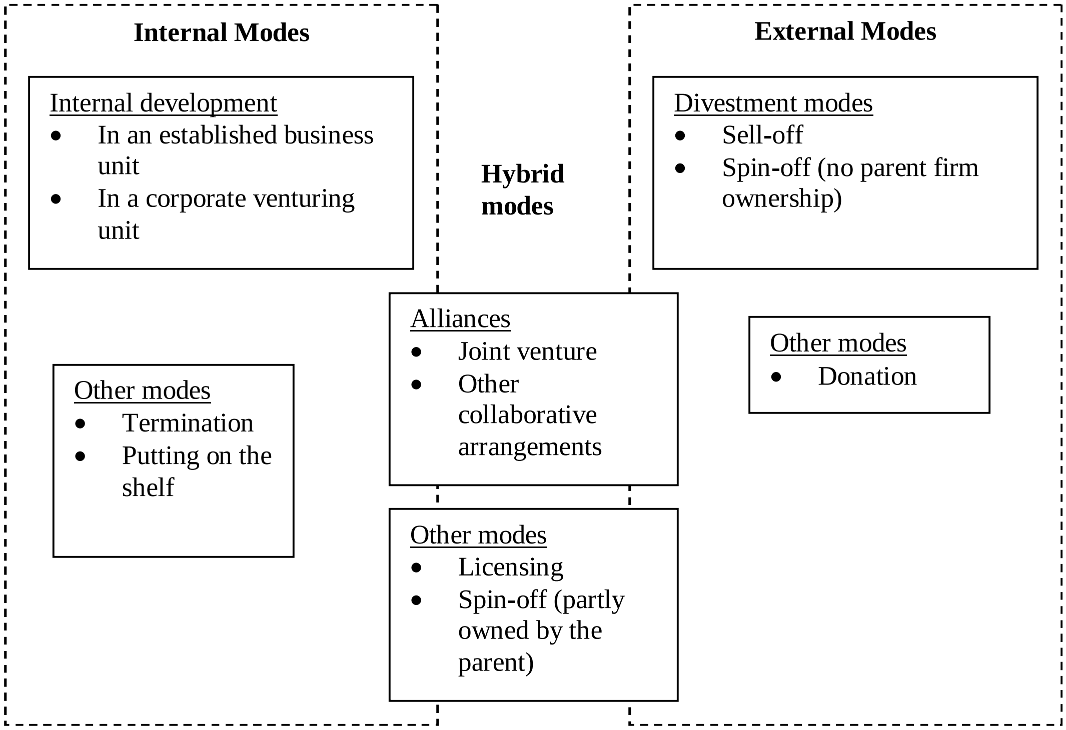


Figure 10. The modes for managing non-core, technology-based assets (Parhankangas, 2003, 9)

Selling a non-core asset is probably the quickest way to gain money from the non-core technology, but after selling it the parent does not have any rights to it. Sell-off has some big challenges with pricing, motivating employees, the timing of the sale and finding a buyer. Spinning off is another alternative to give up a technology-based asset. Now the technology is moved to a new firm organized around it. The parent and the new company can be competitors, partners or customers to each other or the spin-off can be independent. If the parent owns a portion from the spin-off the case is hybrid. Typically, this approach is applied when the technology is disruptive or the hurdle rate is below the company’s threshold for profit contribution (Goldheim et al., 2005, 45). If a company wants to get tax benefits, make contacts to universities or other research units, or it does not find a buyer, an option is to donate the asset. (Parhankangas et al., 2003, 9-12)

Use of the hybrid model reduces cost and risk to launch a new technology, but profits have to be shared with a partner, too. There are many arrangements for collaboration, but co-operation could be divided into two main categories: strategic alliances with cross-ownership (such as joint ventures) and alliances with just exchange of knowledge, resources and services. Besides other companies, firms collaborate with universities and other non-profit organizations. Licensing is a good and already largely used method for extracting value from non-core assets. Similarly to the collaboration, there are many types of license arrangements. Licensing suits better for managing mature technologies than emergent ones. (Parhankangas et al., 2003, 12-14)

Internal development allows a company to have full control of a technology and future profits. Although technology is non-core, sometimes it is developed internally, for instance completed for licensing or selling. Many corporations in these days have their own corporate venturing units. Typically, radically new and high risky activities are carried through the venturing unit. The venturing unit is a temporary arrangement, because when a venture matures it is moved to a business unit or outside the company. (Parhankangas et al., 2003, 14-15)

Some non-core technologies end up on a shelf. This was a one of the pitfalls of the closed innovation and a question, why non-core assets should be kept in a company, arises. Even if technology is classified as non-core, the future is unpredictable. It may be wise to keep some of the unpromising technologies for future development and new business opportunity identification. In the next chapter that concerns transformative capacity, this subject is discussed more deeply. (Parhankangas et al., 2003, 14)

3.3.4 Transformative Capacity

In contrast to absorptive capacity, ability to look opportunities outside a company (see chapter 2.3), Garud & Nayyar (1994) argue that transformative capacity, ability to exploit the storehouse of the company's own technologies, is even more important. To create new business opportunities, existing resources could be combined, and knowledge transfer across time could be the basis for a new business. That is why knowledge or technologies needs to be codified and stored.

The thesis focuses strongly on this area. Research Surplus Portfolio will be the shelf described above, where NRC can place their non-core technologies that are no longer in the research focus. In addition, the Onions-project aims to create new opportunities from the surplus technologies, in other words, increase NRC’s transformative capacity.

Garud & Nayyar (1994, 381) give some practical advices for the management of the transformative capacity. Because those are closely related to the management of the surplus technologies and the portfolio, they are discussed in this thesis, too, and gathered in table 2.

Table 2. Practical implications of transformative capacity (Garud & Nayyar,1994, 381)

Choice
Gather information.
Choose difficult-to-create to maintain.
Adopt rich media when making choice decisions concerning tacit knowledge.
Coordinate efforts across business and research laboratories to identify technologies for shelving.
Develop criteria for evaluating technological options.
Brainstorm on which technological paths to follow and which ones to abandon.
Consider the impact on other businesses and technologies when making technology maintenance decisions.
Maintenance
Catalog shelved technologies.
Periodically review the catalog of shelved technologies.
Develop avenues for researchers to share information.
Permit "underground" research and development activity.
Conduct internal scanning for shelved technologies.
Provide incentives for maintaining currently unwanted technologies.
Retain key personnel who posses tacit knowledge.
Maintain a minimum threshold of knowledge.
In fast-moving environments, retain more knowledge.
Retain entire teams when knowledge is systemic.
Reactivation and synthesis
Encourage scientists and engineers to move around among product groups and research laboratories.
Coordinate the work of business and research laboratories through sharing information.
Organize symposia and expositions to share information.
Install lateral information processing mechanisms to encourage co-operation among researchers and business.
Internally publicize topics being researched.
Formalize the task of recognizing demand and supply triggers.
Minimize any negatives associated with the not-invented-here-and-now syndromes.
Reward reactivation.
Allow enough time for successful reactivation and synthesis.
Assess reliability and validity of retrieved knowledge.
Encourage the development of interface standards to allow synthesis later.

To store non-core technologies and use them later (the transformative capacity) a company needs to manage three tasks: The choice of technologies, the maintenance of technologies and, the reactivation of technologies and synthesis. First, a company must choose, which technologies it will maintain. The catalog of shelved technologies should be scanned periodically. The third task, reactivation, includes for example the business opportunity recognition and coupling the reactivated technologies with the current ones. (Garud & Nayyar, 1994, 378-383)

3.4 Managing Intellectual Capital

The management of intellectual capital is easiest to begin from IP and IA management. After that it can be moved to managing the whole intellectual capital by adding human capital management. (Sullivan, 1998, 261) Saint-Onge (1996, 10) has examined intellectual capital from the human capital perspective. He argues that the most of a company's IC is tacit and should be managed with the knowledge-based models. He groups IC into three categories (table 3).

Table 3. Saint-Onge's categories of intellectual capital (adapted from Saint-Onge, 1996, 10)

IC category	Description
Human Capital	The capabilities of employees to meet customers need
Customer Capital	External relationships with customers. It includes the depth, width, attachment and profitability of customers.
Structural Capital	Organization's capability to provide solutions to customers

Measuring intellectual capital means actually predicting the future of the company. Managing (and measuring) IC has to be tightened to the business strategy and the objectives. Measures must also be something that can be managed against. There are some measure examples in Figure 11. Measures can be either qualitative or quantitative. Qualitative measures are divided further into value-based and vector-based measures and quantitative into financial and non-financial measures. Several measurement schemes have been developed, such as the Skandia Navigator, the Balanced Scorecard, the Sveiby Model and the OECD Measures, but in the thesis, those are not introduced further. (Sullivan, 1998, 267-271)

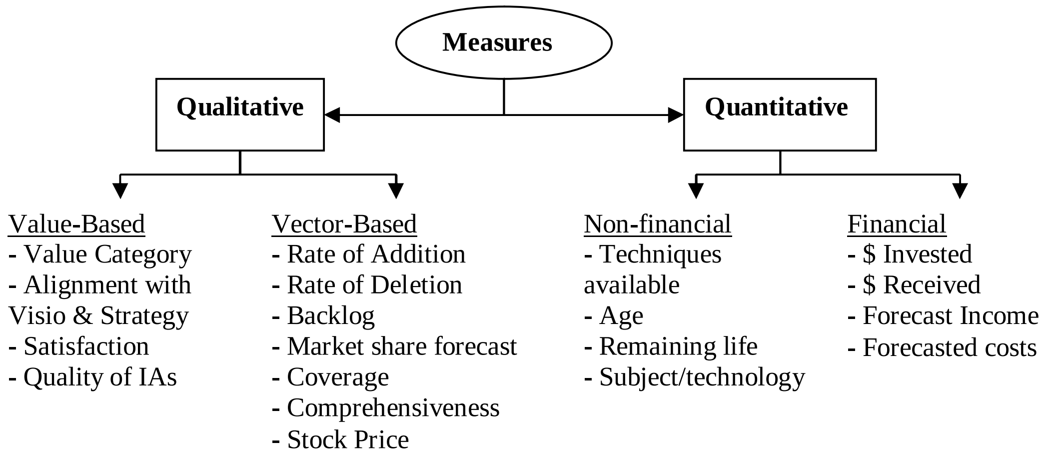


Figure 11. Sample measures (Sullivan, 1998, 269)

There are quite a few factors that affect the way companies manage their IC, and different ways to manage it. Some take value creation perspective and focus on human resources and knowledge creation or ability to convert knowledge into intellectual assets. Other companies, with large amount of unused patents, pay attention to patent portfolio. Knowledge companies, whose strategy requires focusing on intellectual capital, manage both value creation and value extraction. (Edvinsson & Sullivan, 1996, 362-363)

4 PORTFOLIO MANAGEMENT

4.1 Importance of the Portfolio Management

The technology portfolio management is a part of the IC management. The portfolio thinking comes from the finance. The restrictions of the term "portfolio management" are different, but in the thesis the portfolio management refers to the technology, project or R&D portfolio. Cooper et al. (1999, 335) defines the portfolio management as "a dynamic decision process, where by a business's list of active new products and (R&D) projects are constantly updated and revised. In this process, new projects are evaluated, selected and prioritized; and resources are allocated and reallocated to the active projects." The other definition tells that the portfolio management is the science of meeting needs and expectations of the organization's investment strategy with a set of knowledge, skills, tools and techniques (Dye & Pennypacker, 1999, xii). In the knowledge intensive environment and with growing interest in the intellectual capital management, the importance of the technology portfolio management is growing, too.

The portfolio management has three main goals: maximizing the value of the portfolio, balancing the portfolio and linking the projects to a company's strategy (Cooper et al. 2000, 27-28). Other objectives related to value maximization are to maintain the competitive position and effective resource allocation. Financial reasons for the portfolio management are according to Cooper (2001, 364-366) the most important ones to companies. Besides these goals, improved communication and better project selection were mentioned in Cooper's et al. survey. The following part will introduce a few frameworks for the portfolio management and some portfolio management methods for reaching the objectives.

4.2 Portfolio Management Process

A portfolio management process could be seen as a part of the company's intellectual capital management process that was already considered in the last section (see for instance Figure 8. IP management system). However, the portfolio management process is a meager approach to the intellectual capital management. It handles (R&D) projects and leaves other IC out.

In the portfolio management process, the main goals of the portfolio management: value maximization, balance of the portfolio and strategic fit, should be kept in mind. Systematic framework for the portfolio management decreases the impact of personal opinion in decision making, guarantees that projects are evaluated equally, and helps managing situations where personnel changes. (Poskela et al., 2001, 85) The portfolio management process includes two phases. First of all, projects must be selected to the portfolio, and effective evaluation is needed, but the portfolio has to be reviewed continuously, too. With these tasks a company can be sure that projects in the portfolio aim for its strategic objectives. (Dooley et al., 2005, 469)

In the literature, several portfolio selection frameworks have been introduced. Cooper et al. (1997a, 44, 46) introduce two models: strategic bucket model that is discussed in the next section (methods for portfolio management) and StratPlan strategic check model that is pretty similar to the bucket model, but moves bottom up while the bucket model has top-down approach. Strategic table is another way to select R&D projects to the portfolio. All projects are opportunities to a company and resources are allocated among these opportunities. It can be divided into a five-step process (Figure 12) (Spradlin & Kutoloski, 1999, 26-27)

Figure 12. Strategy table model (Aalto, 2001, 31)

The third framework for the portfolio selection discussed is Archer & Ghasemzadeh's (1999, 211) model. The actual selection process is divided into five stages: Pre-screening, individual project analysis, screening, optimal portfolio selection and portfolio adjustment. Framework also takes into account the pre-process strategy development and methodology selection as well as the post-process stages: project development, phase evaluation and the successful completion of a project. Archer & Ghasemzadeh (1999, 213-214) also discuss about a possibility to integrate this selection process to the computer based decision support systems (DSS) and the group decision support systems (GDSS).

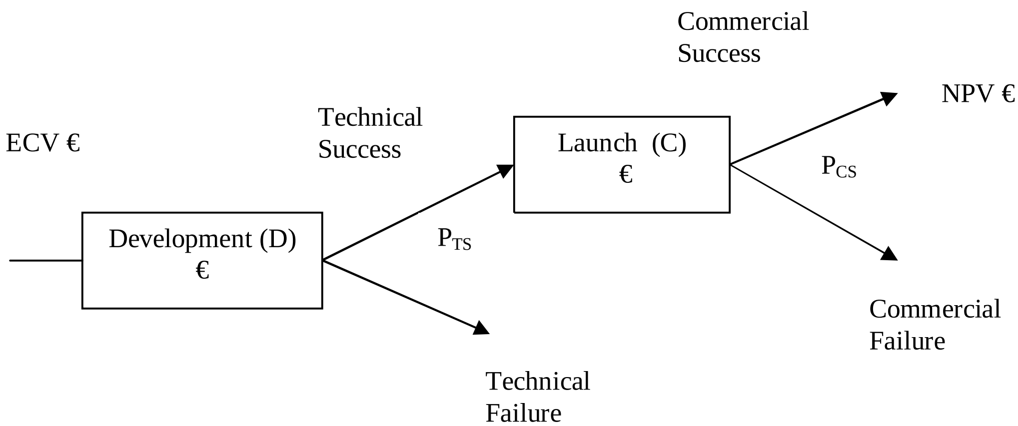
Regular portfolio reviewing meetings are essential (considered already in chapter 3.3.1) There decisions whether to continue a project or not are made. It is important to have courage to make a canceling decision as early as possible if needed. (Poskela et al. 2001, 86) In addition, with this reviewing process one of the big challenges of the portfolio management, control and communication between project teams, is met (Dooley et al., 2005, 470-471).

While the typical frameworks suggest that the portfolio should implement a company's strategy and projects should be selected based on strategic fit, Martinsuo (2001, 73-74) considers the portfolio management process from a different point of view. A portfolio is managed like in the fashion world: a portfolio is a curriculum vitae or a sales documentation that is offered to customers. The customers' impact on the contents of a portfolio and the portfolio management process actually modify the strategic direction. The RSP management is more about offering technologies to the customers (notice that the customers can be inter-organizational, too) and modifying strategy than normal portfolio management.

4.3 Methods for the Portfolio Management

4.3.1 Financial Methods

The most popular portfolio management methods are financial, such as NPV, return on investment (ROI) and payback period (Cooper et al., 2001, 366). Those are widely well-known, but Figure 13 visualizes the Expected Commercial Value (ECV), a variant of NPV, which is a little less familiar method. It is based on the decision tree and the option pricing theory, and it takes into account constraining resources (Cooper et al., 2000, 27). It could be used when prioritizing projects, but the pitfall is that it does not consider portfolio balance. (Aalto, 2001, 36)



$$ECV = \left[\left(NPV \cdot P_{CS} \cdot SI - C\right) \cdot P_{TS} - D\right]$$

ECV = Expected commercial value of the project
SI = Strategic importance of the project
P_{TS} = Probability of technical success
P_{CS} = Probability of commercial success
D = Development Costs
C = Commercialization (launch & capital) costs
NVP = Net present value of project's future earnings

Figure 13. Expected commercial value decision tree (Aalto, 2001, 36)

There are some problems associated with the traditional financial methods. First, the methods require accurate financial data for calculating the results right. Usually, input data comes from rough market and cost analyses that are easy to manipulate. Second, the decision whether to carry on a project or not must be done in the early state of the project, and financial data is therefore impossible to get. (Cooper et al., 2001, 378)

4.3.2 Strategy Related Methods

The use of the business strategy for allocating money to projects is the second used method for portfolio management. It starts with business's goals, vision and strategy. Projects are divided into strategic buckets and every bucket has a certain budget. Then projects are ranked within the buckets and projects under the spending limit are realized. This method is called Strategic Bucket approach and is illustrated in Figure 14. (Cooper et al., 2001, 366-368)

New Products: Product Line A Target Spend: $8.7M	**New Products: Product Line B Target Spend: $18.7M**	**Maintenance of Business Product Lines A & B Target Spend: $10.8M**	**Cost Reduction All Products Target Spend: $7.8M**
Project A 4.1	Project B 2.2	Project E 1.2	Project I 1.9
Project C 2.1	Project D 4.5	Project G 0.8	Project M 2.4
Project F 1.7	Project K 2.3	Project H 0.7	Project N 0.7
Project L 0.5	Project T 3.7	Project J 1.5	Project P 1.4
Project X 1.7	**Gap = 5.8**	Project Q 4.8	Project S 1.6
Project Y 2.9		Project R 1.5	Project U 1.0
Project Z 4.5		Project V 2.5	Project AA 1.2
Project BB 2.6		Project W 2.1	

Figure 14. Strategic Bucket Method (Cooper et al., 2001, 368)

R&D spending can be split into the buckets several ways, for instance type of market, type of development (maintenance, exploratory or frontier research), product line, project magnitude or technology area. For prioritizing projects within a bucket, formal methods or just strategic approaches are used. The strategy is in a great concern when the go/kill decisions are made, and the strategy approach is therefore encouraged to use. (Cooper et al., 2001, 371)

4.3.3 Bubble Diagrams and Portfolio Maps

Bubble diagrams and portfolio maps are used mostly as a supporting method, because with them the balance of the portfolio is visualized. An idea is that projects are drawn into an X-Y coordinates by using bubbles. The size of a bubble will be the third dimension of the matrix. In addition, colors and different color brightness could be used to enrich the analysis (Aalto, 2001, 57). Maybe the best known example of the diagram analysis is Boston Consulting Group’s matrix – stars, cows, dogs and wildcats (Henderson, 1970).

The parameters or the criteria on the axes can vary. Companies could use the parameters such as fit with business and strategy, strategic importance, durability of competitive advantage, reward (based on financial expectations), probabilities of success, cost of completion, time to completion, business maturity, market potential, market size, technical familiarity and market attractiveness. (Aalto, 2001, 39-40) Figure 15 introduces a model used in the industry. The model links technology novelty and market novelty. (Stevens, 1997, 44)

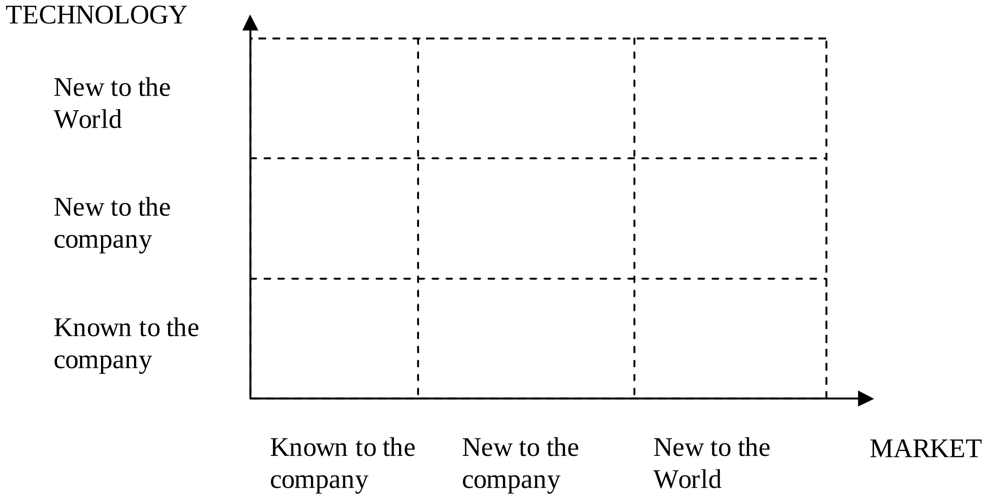


Figure 15. Technology/Market matrix (Stevens, 1997, 44)

4.3.4 Portfolio of Real Options

The R&D portfolio can be visualized also as a portfolio of options. MacMillan & McGrath (2002, 50-56) introduce a bubble diagram, which employs three types of real options in Figure 16. Projects are placed in a technical/market uncertainty matrix. Positioning options are opportunities to compete with uncertain technology arena. Those are appropriate in situations where there are several technologies that could satisfy the market need and it is not clear, which one will be the winner, or the trajectory of development of the technology is unclear. Scouting options are investments to learn from the market. They are used when the technology is not a problem, but the company is not sure, which combination of attributes is the most attractive. Stepping-stone options are opportunities that include both high uncertainty of the technology and the market. Some projects do not meet so much uncertainty and options are not necessary. In the matrix, those projects are divided into enhancement launches, which improve existing products and services, and platform launches, which require bigger investments and are more uncertain.

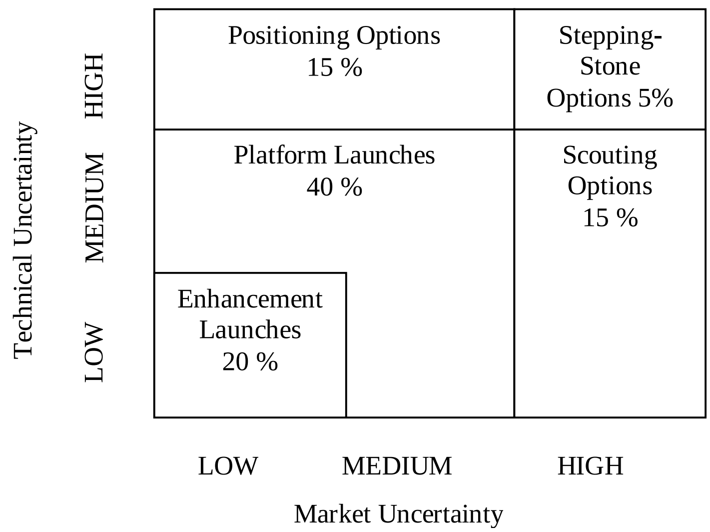


Figure 16.The R&D portfolio based on the real options (MacMillan & McGrath, 2002, 55)

The portfolio has to fit with the company’s strategy and it has to suit to the business environment, too. That is why every company has to make its own decisions, on which parts of the portfolio are the most essential ones, and weight resources based on that decision. In Figure 16, percentages represent the amount of allocated resources. However, those percentages are just a general guide for the allocation and can not be applied as such. After the mix of projects is determined, the projects are evaluated and prioritized only in their own category. For example the positioning projects compete for resources only with the other positioning projects.

4.3.5 Scoring Models and Check Lists

Scoring models are considered as an effective portfolio management tool. Projects are scored based on selected questions or criteria. The implementation of the scoring method varies. The criteria can be either simple or weighted, a project can be scaled for instance with low-medium-high, 0-5 or 0-10 scales. The model can be used to prioritizing projects against each other, or scores can be compared to some cut-off criteria (to make kill/go decisions). The selection criteria include for instance strategic fit, financial reward, risk, probability of success and own technological and business capabilities (Cooper et al., 2001, 368, 371)

A check list approach is pretty similar to the scoring model. Projects are evaluated with yes or no questions. The criterion to carry on the project could be a certain number of yes answers or every answer has to be yes. The check lists are not as popular as the scoring models and they are usually used in go/kill decisions, unlike the scoring models that are most popular as a ranking method. (Cooper et al., 2001, 368, 372)

4.3.6 Methods in Use

The best companies managing their technology portfolio in practice use explicit and formal methods. In those companies, rules and procedures for the portfolio management are well-defined and the tools are applied to all projects. None of the methods mentioned provides a universal answer. Typically, a company uses two or three methods. It is recommended to use a combination of the financial methods, the strategic approaches, the scoring tools and the bubble diagrams. (Cooper et al., 1999, 350)

With the portfolio methods, strategic alignment and the selection of high value projects can be ensured, but there are some problems in the portfolio management that the methods fail to solve. In many cases, projects interact with each others and compete for scarce resources (Archer & Ghasemzadeh, 1999, 210). The methods mentioned above are weak to select the right number of R&D projects, encourage the timely completion of projects and balancing the portfolio. Because of the pitfalls main challenges for the portfolio management are: resource balancing, prioritizing projects against one another, making go/kill decisions in the absence of solid information and too many minor projects in the portfolio. The portfolio management should be integrated with the State-Gate processes to improve the quality of the information of projects, and with the resource capacity analysis, to balance between the demand and availability of resources. These methods connected to the right tools make the portfolio management more efficient. (Cooper et al., 2000, 19, 24-27)

Even if the efficient, well-defined models are used right, the decision-making is still done by people. The technology portfolios are complex and there are many liaisons between the projects, so a situation is impossible to visualize exactly with any of the models. Therefore, individuals in an organization must be tightly integrated into the decision-making process between projects. (Aalto, 2001, 49)

4.4 Technology Evaluation

4.4.1 Technology Assessment Process

The previous chapter gave examples how to manage the entire portfolio, but this chapter deals with the evaluation of an individual technology. Of course some of the portfolio management tools, such as the financial methods and the scoring models, can also be applied to assess a single technology in the portfolio, but more examples of methods are discussed here. A big part of the value of technologies, especially new ones, is related to real options. The approach is discussed in chapter 4.4.3. Technology assessment is a wider process than just an evaluating task. The process is shortly gone through before the methods.

To choose the right technologies for the further development is essential for a company. Technology assessment plays a vital role when R&D spending is increasing, competitive advantages are narrowing and life cycles are getting shorter. Doering & Parayre (2000, 77-96) illustrate four steps of a dynamic technology assessment process:

§ Scoping: A firm has to decide boundaries for technology assessment. Limits are established based on the firm's capabilities, strategic intent, potential new markets and technologies.

§ Searching: A company can look for new technologies and opportunities from inside the firm, from the public licensor of technology and from the literature. This step includes sensing strong and weak signals from the environment and developing a "group mind" by capturing knowledge and information and gathering it.

§ Evaluating: Managers use different methods for evaluating and ranking promising technologies and possible development projects. Some tools for that task are introduced in the thesis, too. A firm's strategic position, the environment and the different types of risks must be considered.

§ Committing: When decision to pursue a new technology is made, a firm has to decide how to do it, and it makes a strategic commitment.

4.4.2 Methods for Evaluating Technologies

Opportunity identification methods try to define different market or technology arenas, which a company may be interested in. Tools for assessing the uncertain future are roadmapping, technology trend analysis and forecasting, competitive intelligence analysis, customer trend analysis, market research and scenario planning. The methods could be used in the opportunity analysis, too. When in the idea identification, the tools were used to identify the opportunity, in the opportunity analysis, the same tools provide more detailed information about the selected technology and help to allocate resources. (Koen et al., 2002, 15-18)

Roadmapping has been used since the beginning of the 1990s. It can be compared with the linkage-based structure of World Wide Web. Every element of the map is linked to more than one individual or data source. A well constructed map tells, for instance, where the information comes from, its timelines and responsibilities. (Foreier, 2002, 52) The value of the roadmap is actually the mapping process, a forum for sharing wisdom about projects' resources and teams' capabilities. (Koen et al., 2002, 16)

Scenario planning goes a step further from the mapping. It gathers information available to number of possible stages, and images possible futures of a company. It shows how different elements might interact under certain conditions. Scenarios should be made relevant, internally consistent, and they should describe generally different futures, not be the variations of a one. The scenario planning tries to illustrate changes that decision makers otherwise would ignore, organize the data of emerged possibilities into easier form and challenge the prevailing mind-set. The power of the scenario planning is that it deals with uncertainty and complexity the way the other planning and strategy tools do not. (Schoemaker, 1995, 25-26, 30; Shoemaker & Mavaddat, 2000, 211-214)

Competitive intelligence analysis, in other words, the gathering of information about the competitors, is largely used in the business world. The analysis refers to the practice of collecting, analyzing and communicating data about competitive environment trends. It should not be just the information gathering but also finding workable data. (Koen et al., 2002, 16)

The decision trees can be also used to estimate the value of a R&D project. The methodology provides an opportunity to eye projects' value when it is possible to terminate a project at the each point of the development process. In the decision tree approach, weights are assigned to different scenarios and then weighted NPV is calculated. But only a small number of diverse scenarios can be made. If a manager wants to assign probabilities for many variables at the same time, Monte Carlo analysis can be applied. (Boer, 1999, 291-297)

4.4.3 Managing Real Options

The traditional financial tools, like Discounted Cash Flow (DCF) methods, ignore some opportunities, such as the option to terminate, the options of making follow-on investment and the acceleration option, when estimating R&D projects. A new approach to assess technologies, which has gained a lot of detention in the literature, is real options. The traditional DCF model is compared to the real option approach in table 4. Although, real options were discussed earlier in the context of the portfolio management methods, those are used as a tool for valuating a single technology, too. Real options are analogue to financial options. Like financial options, if a company makes a strategic investment, is has the right, but not the duty to exploit opportunities among the investment in the future. (Boer, 1999, 290, 300; Boer, 2000, 26)

Table 4. Traditional DCF versus Real option perspective

Traditional DCF Perspective	Real Option Perspective
Views uncertainty as a risk that reduces investment value	Views uncertainty as an opportunity that increases value
Assigns limited value to future information	Values future information highly
Recognizes only tangible revenues and costs	Recognizes value of flexibility and other intangibles
Assumes clearly defined decision path	Recognizes path determined by future information and managerial discretion

Real options are difficult to evaluate. They arise in the most technology investments, but they take many forms, and could be hard to recognize and implement. Some of them emerge naturally, but they could also be created. The valuation of real options might be difficult as well. A real option management process includes four phases: adopting an options perspective, creating and structuring options, valuing options and implementing the real option approach. (Hamilton, 2000, 274-277)

Before real options can be valuated, they have to be identified. Some of them could be created by the systematic decision process. Real options create value by generating financial return from future commercialization, by strategic positioning, providing new opportunities and by creating new knowledge. To value these benefits is not an easy task. Financial models are the most popular method to valuate real options. The decision analyses (decision tree was discussed earlier) can also be used in the valuation. The third tool is threshold assessment, which is not trying to solve the absolute value of the options, but concentrates on a question whether the value of the option is enough to justify the investment, instead. It is crucial to keep in mind that the value of an option is not static and it depends on how and when the option is applied. (Hamilton, 2000, 277-286)

5 FRAMEWORK FOR RESEARCH SURPLUS PORTFOLIO

5.1 Nokia Research Center

Nokia invest strongly to research and development activities. R&D expenses were approximately 11 % of Nokia's net sales in 2005. R&D resources are divided between Nokia's principal business groups, Technology Platforms and Nokia Research Center. (Nokia, 2006a)

Nokia Research Center was founded in 1986. The mission of NRC is to renew Nokia through the strategic and long-term research. NRC supports Nokia's strategy by developing technologies and concepts for existing Nokia businesses, but it also challenges the strategy by exploring and researching potential technologies for the future. Figure 17 visualizes the organization structure of NRC at the moment. (Nokia, 2006b)

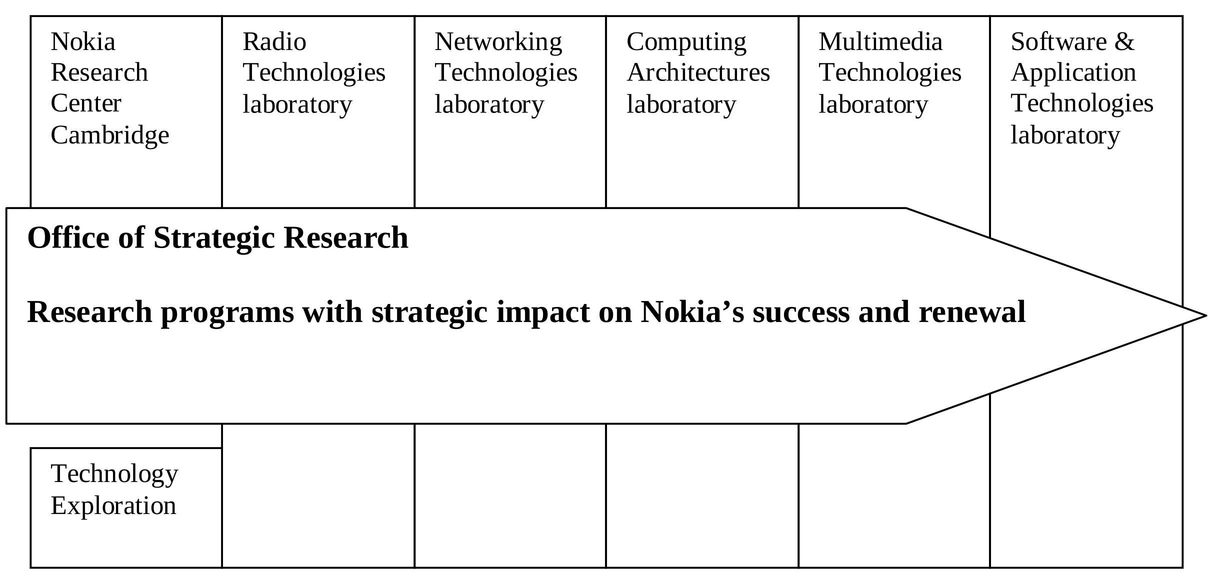


Figure 17. Nokia Research Center innovation network (Nokia, 2006b)

NRC operates in six countries. Research centers are located in Tampere, Helsinki, Bochum, Budapest, Cambridge (USA), Mountain View (Palo Alto), Beijing and Tokyo. In 2005, there were 1097 employees in NRC, which is 5 % of Nokia's R&D personnel. Half of Nokia's essential patents originate from NRC. In 2005, it generated 311 patents. (Nokia, 2006b)

5.2 Open Innovation in NRC

Open innovation is becoming more and more important to Nokia, and also NRC implements many aspects of it. The most important element of the open innovation to NRC is external research collaboration that searches for new opportunities for Nokia. (Karlsson, 2006a) Nokia is a part of many consensus creating consortia, such as International Telecommunication Union (ITU). To NRC, bilateral cooperation with universities is also important. For example Nokia Research Center Cambridge joins Nokia and Massachusetts Institute of Technology (MIT). NRC has a powerful, global research network with universities, research institutes, international organizations, large corporations and venture capitalist companies, and R&D project cooperation in Europe, North America, China, Japan and India. (Nokia, 2006b)

In addition, Nokia supports the open source development. NRC participates in several open source projects as a host, contributor and/or sponsor. (Nokia, 2006c) But even if the external opportunity seeking and the research collaboration have functioned well for a long time, the other direction of the open innovation, new business models outside the parent company and core business, has not been applied much. The Onions-project concentrates on that area of the open innovation. In the future, the creation of new businesses from NRC's technologies and funding activities by selling or out-licensing old technologies are interesting targets for the development. (Karlsson, 2006a)

5.3 Surplus and Its Storage Now in NRC

All activities and laboratories in NRC produce research surplus. It can also be in every possible form, such as A4-paper, code, research report, patent or demo. Naturally, it means that surplus items are in the different stages of development, too.

At this moment, there is no a research waste treatment system in NRC. All projects are stored in a single database. It means that NRC's core and non-core technologies are in the same place. All documents, codes and other material from the research projects are in that system. The level of the documentation style and quality is good, but only basic information from the projects is available. (Saarinen, 2006) NRC does not have any kind of explicit principles for managing their research surplus and there is no portfolio for surplus technologies, either. Different laboratories do not know each other's storage methods for surplus, if there even are such methods. (Karlsson, 2006a)

In Multimedia technologies (MMT) laboratory the descriptions of surplus material are written on a paper and collected to a folder, but this paper version of "surplus portfolio" is not connected to the other data systems and portfolios. Only the surplus patents are in the patent database. MMT-laboratory has used the following list of questions in storing their research surplus:

1. For how long the research/development has been done?
2. Current status/ stage of the technology?
3. How many people are currently employed? Names?
4. The way of technology transfer? Receiver?
5. Connection to Strategic Focus Areas?
6. Plans for the future?
7. Financiers?
8. Is this project in the core field of NRC?
9. Other information?

But the paper portfolio with these questions is not exactly Research Surplus Portfolio, though. It is done on an ac-hoc basis, and the purpose has not been to list surplus technologies for later utilization. So there is no reason why just these elements from the surplus should be collected. (Karlsson, 2006b)

Cancelled projects and the results of those projects have really not interested anyone, because the focus is towards the future; looking back at the old research projects has been considered being a waste of time. The surplus research has been only a part of the learning process. NRC has been strictly closed from outsiders, so there have not even been reasons for the waste research documentation. But now, when the open innovation is becoming common in many industries, like the telecommunication business, and openness will be more and more important, NRC will also follow the evolution. (Karlsson, 2006a)

5.4 Goals and Requirement for RSP

Research Surplus Portfolio is not like company's ordinary technology portfolio and should therefore be managed differently than other intellectual assets. The biggest difference is that technologies in the RSP are already classified as non-core. In other words those are not used in the current businesses.

The ultimate goal of the creation of RSP is the new business creation from the research surplus. Another goal that should be considered is to generate profits and benefits from surplus technologies by selling, licensing or donating them. The RSP system should be build to serve these goals. The purpose is to get information from researchers' heads into a computer database. The information should be easy to find, understand and analyze.

For making surplus technologies useful, the external technology environment should be scanned. It is more likely to find opportunities for waste technologies from outside the company or from the new business areas. However, the technology transfer to maintain the current businesses is also an opportunity. In chapter 3.3.4 Garud & Nayyar (1994) gave guidelines especially for that. Because input to the portfolio is something that has been left over, the balance of the portfolio and its strategic fit are not important. Evaluation should be concentrated on the future opportunities.

In the portfolio literature, the management of a technology/project portfolio should be efficient and effective. It is easy to build a massive system with various complex tools, but that does not help a new product development process. The concept of RSP should be even lighter than a normal technology portfolio. The research surplus attributes must be easily stored, searched and updated. Because technologies are already classified as wastes, some phases of the portfolio management process can be dropped out. Typically, the portfolio managing process includes seven phases (see chapter 4.2): selection (storage), evaluation, prioritizing, resource allocation, balancing the portfolio and strategic fit consideration, decision making (go/kill decisions) and maintaining. The RSP managing process must have only a data storage phase, some kind of evaluation system and a maintaining process.

It is important that the new portfolio does not require much extra work. Selected tools should be light and easy to use and understand, but still efficient. A management team that is responsible for RSP is needed. To make sure that the portfolio is properly managed and maintained, the members of the team should be involved in the task for a long period.

Because the material that needs to be stored in RSP is in various forms (reports, codes, demos...), it is difficult to find a method for saving the useful information. The purpose of the whole portfolio has to be kept in mind. RSP aims to serve the creation of new businesses. That is why a one of the main questions in the RSP concept creation is how surplus should be collected and stored so that it would be useful. Other arising questions are for instance: What kind of storage RSP would be? How is it utilized? Which elements of the surplus technologies and cancelled projects should be stored in RSP? How the surplus is evaluated? As well as to all business activities, the cost/benefit consideration is valid to RSP and its development, too.

5.5 RSP Concept

Figure 18 illustrates the position of the new portfolio in Nokia's innovation system. As mentioned before, all activities in NRC produce the surplus from their research. On the other hand, every activity in the new technology development process has access to and can benefit from RSP. In this part of the thesis a constructive concept for RSP is created and a framework for its utilization, management and implementation is considered.

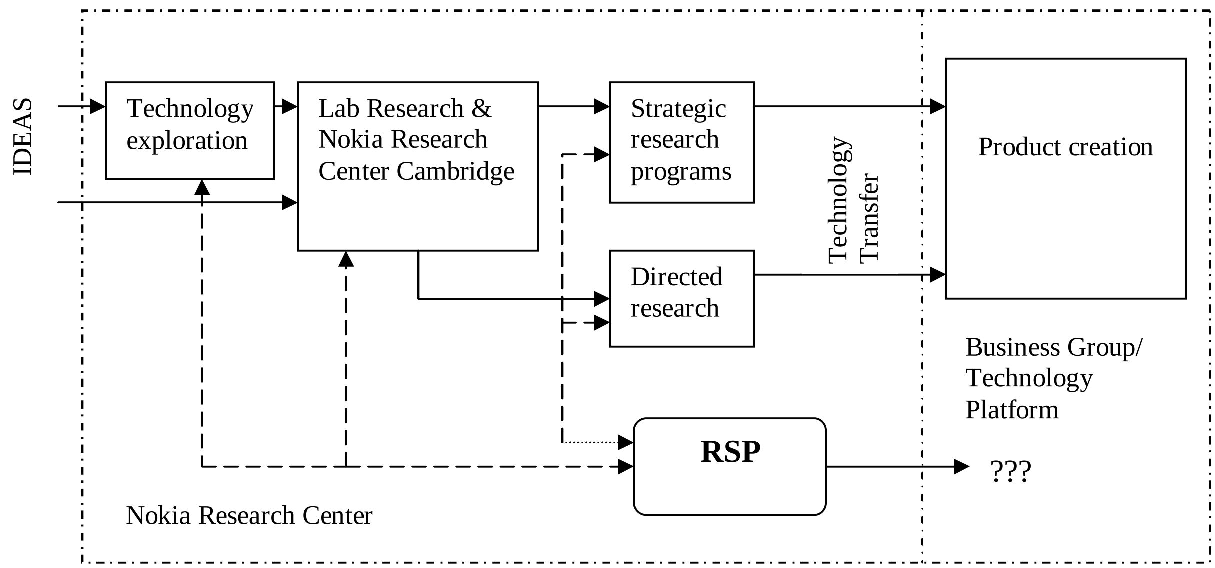


Figure 18. The position of RSP in NRC's new technology development process

Research Surplus Portfolio is an inventory for the non-core technologies from the projects that have been cancelled and the technologies that have not been transferred to Nokia's businesses. To create RSP, a single database system for projects is split in two portfolios – to core technologies and non-core technologies. The latter will be new RSP. At this point, it is reasonable to view, what kind of surplus could there be in RSP. The surplus items placed in RSP could be technologies outside the current business, project results without value, ideas, parked technologies that are shelved for later use, possible out-licensing and selling cases, spin-off and venture opportunities and open source technologies (Saarinen, 2006). So RSP could be seen as a solution that separates non-core technologies mentioned in Figure 19 from core technologies. Technologies could be divided into different classes, too. The classification is essential for the efficiency of the portfolio. Managers and researchers are able to find what they are looking for more easily. Figure 19 illustrates the division of the project portfolio

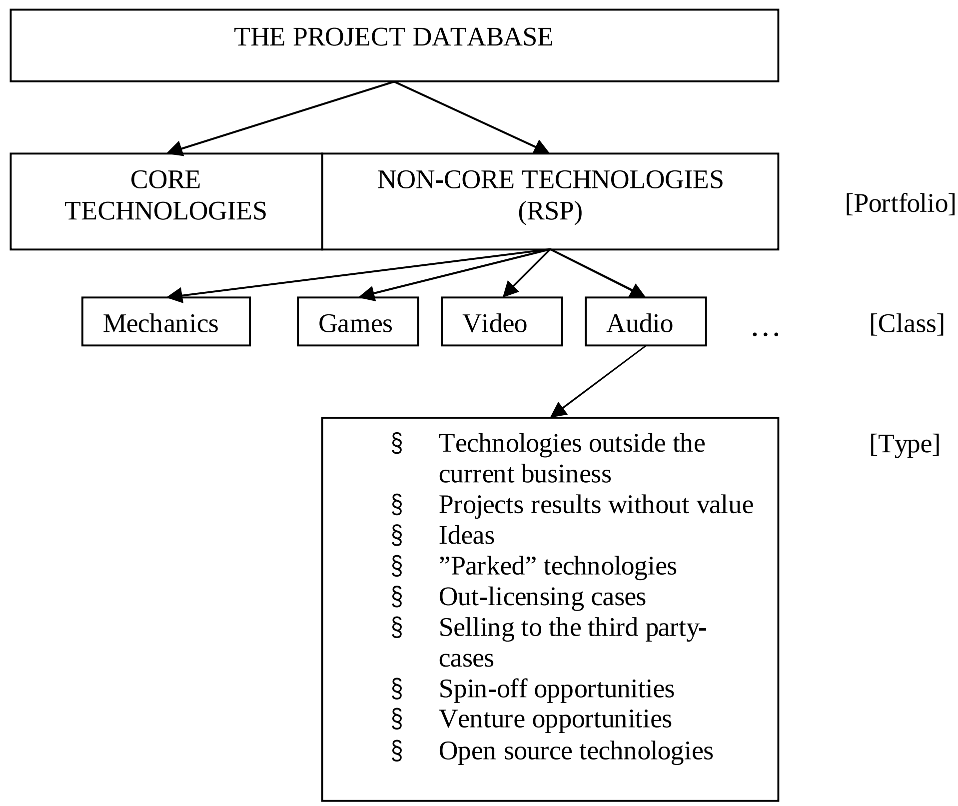


Figure 19. The division of the project database (adapted from Saarinen, 2006)

Research Surplus Portfolio consists of two parts: the management of data in RSP and its utilization (Figure 20). Both are continuous processes that do not depend on each other, which means that data can be stored and searched anytime. At the storage stage, the research surplus is documented to a database and its future potential is evaluated. The third managerial task is the maintaining of the portfolio. The utilization possibilities of RSP are several. It could function as a search engine, a communication tool, an idea bank or a marketplace for surplus technologies. The following chapters will introduce the phases of the both sides of RSP. First, the four utilization possibilities mentioned above are discussed and after that the management of RSP is considered. Last, some database and implementation issues are highlighted.

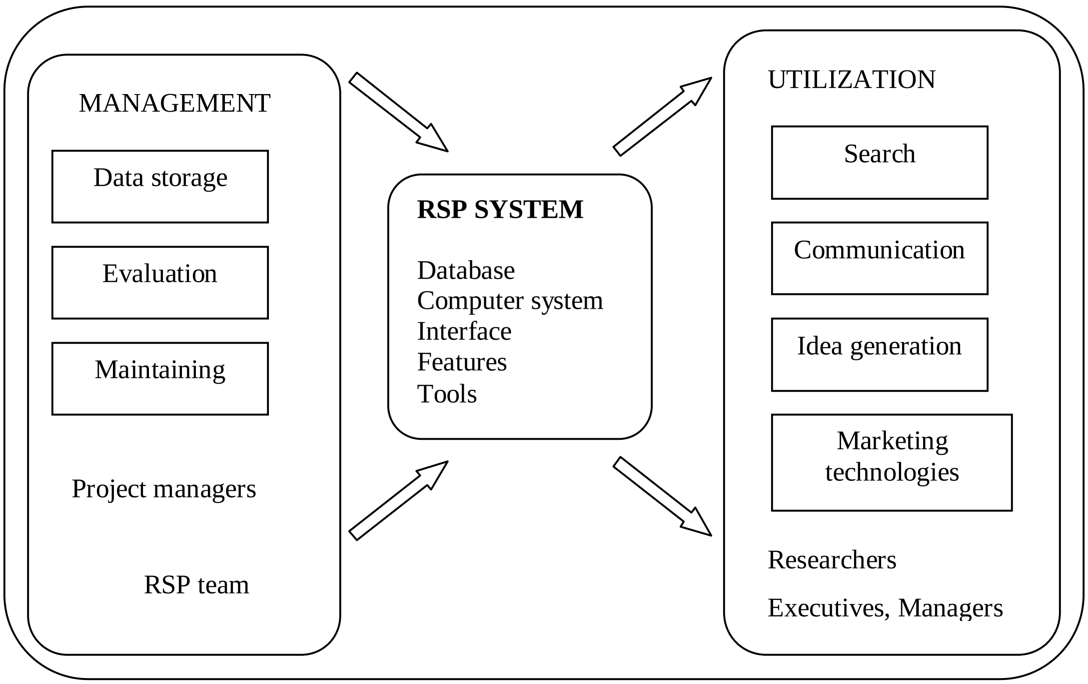


Figure 20. The concept of RSP

5.6 Utilization of RSP

5.6.1 RSP as a Search Engine

The searching facility is a very important aspect of RSP from the new business creation point of view and it has to be designed carefully. No matter what the final concept of RSP is, there must be an effective search tool included in RSP. On the other hand, the whole concept of RSP could be based just on searching technologies from other databases. This kind of Internet search engine would search data from all NRC's data systems and portfolios. RSP used in this kind of concept would be beneficial in the basic research work, too, when researchers could be able to search more efficiently the earlier research projects.

This approach demands no extra work from employees at the storage phase and not much managerial effort, either, but how beneficial the system would be, if the new business creation is considered. Is just a search tool able to identify the promising surplus technologies, if those are not documented properly? One big problem in utilization of the research surplus is that surplus technologies are usually very difficult to understand without special technical knowledge, and if there is not any summary of a particular surplus technology, it is hard for an outsider to recognize the opportunities that a technology may include.

5.6.2 RSP as an Idea Bank

When technological possibilities and market needs match, an idea occurs. New ideas are essential for the new products development and the success of the whole business, especially in the high-technology industries. A company has to have a system for the idea generation. Ideas can appear from several sources. One of the main sources is the company itself and its personnel. (Cooper, 1997b, 121-123,128)

RSP is the in-house source of new ideas. Researchers may find synergies between their own projects and the surplus, figure new possibilities to use surplus or invent an original idea based on the surplus. Like Cooper (1997b, 132) suggest, new ideas can be delivered by e-mail to researchers. Also, in the case of RSP, the information about some promising surplus technologies could be displayed on e-mail. It does not mean that information should be sent to every researcher in NRC. When a piece of the research surplus is documented to RSP, the documenter can pick a few persons to send the publication of the surplus material to. Mail could be sent for example to certain “RSP contact persons”, to one researcher from every laboratory or to out-licensing personnel.

5.6.3 RSP as a Communication Tool

Chien (2002, 367) emphasizes that portfolio selection approaches will serve communication between project teams and encourage discussion. Also, Bordley (1998, 407) brings up the project selection models as a method to ask questions from the entire organization. RSP can be an avenue for researchers to share information. It can be used for collecting information, sharing options, asking questions and contribute inter-organizational discussion.

In NRC, separated laboratories do not know details about each other's projects and this is not just NRC's problem. In companies, it is very common that only a few persons on the top can piece together the big picture. From RSP, different research groups, project teams and laboratories in NRC are able to observe, what kind of research has been made in house. Somebody's waste might be useful in some different contexts. Communication with technology out-licensing (TOL) will be more effective with RSP, too. With more open attitude to alternative paths to markets, such as using of out-licensing, continuous discussion between laboratories and TOL experts will become more important in the future.

5.6.4 RSP as a Technology Market Place

Chapter 3.3.3 gave alternatives to how non-core technologies and assets could be employed. For the external and the hybrid modes, a technology marketplace is needed. One potential use for RSP is to use it as a marketplace for technologies. It requires that at least some parts of the database are open outside NRC. Other companies are able to search technical solutions useful for them, which will advance out-licensing and sell-off activities, when possible buyers could contact to NRC instead of NRC searching for them. Many large corporations, such as IBM, Philips and DuPont that have gained remarkable revenue through licensing have their own web pages for marketing their technologies.

On the Internet, there are already service providers, such as Yet2.com (Yet2.com, 2006), whose business is based on providing others' technologies for selling and licensing and helping companies to contact with each other. Those vendors are one possibility to market the surplus technologies, if the database of the surplus technologies is chosen not to be open only for internal personnel.

5.7 Management of RSP

5.7.1 Packaging of the Surplus

When the development of some new technology ends and a project is cancelled for example due to changes in the environment or the strategy, or developed technology is not used in Nokia's businesses, research results and other material are non-core material to NRC. At that point, a project (or a technology) will be packaged to RSP. In other words, it is stored into a database. A project manager fills in a questionnaire, where all information that is wanted to store will be asked. The questionnaire could be for example like a project proposal template, but of course if the purpose is to store technologies, it is not reasonable to use the project proposal templates. In some cases, the research surplus may be at a stage where proposal has not even been made, but if there is a proposal it could be employed in the data storage phase. Usually, the project proposals contain for instance evaluation of costs, value and risks.

You cannot manage what you do not know. Information that is gathered from surplus has to be enough descriptive to allow the surplus to be analyzed and new opportunities to be identified. Following mind map (Figure 21) gives some suggestions about attributes that could be stored, but the final decision about data, collection methods and place will be made by a RSP implementation team. The key is to choose the attributes that will yield information useful to researchers. In appendix 1, there is a more detailed list of the key characteristics of projects, which could be stored to the database.

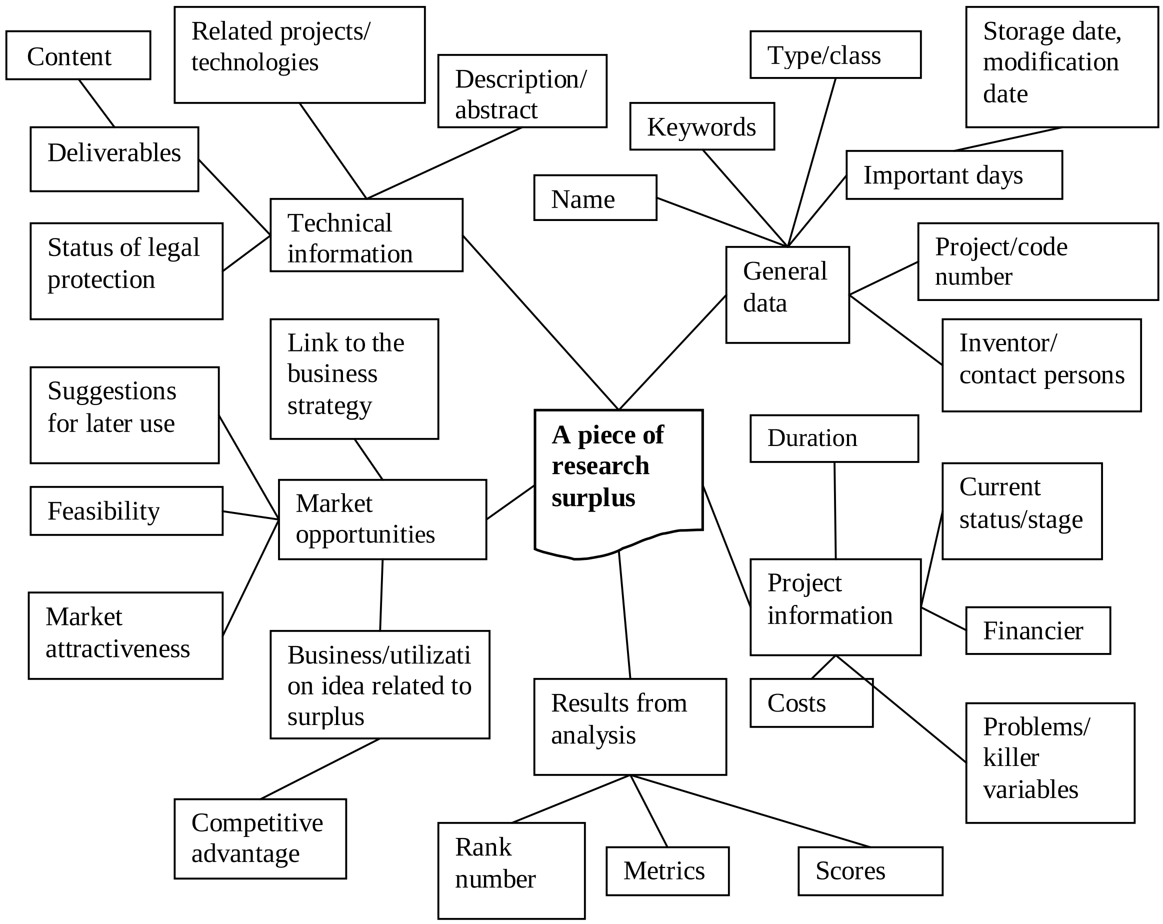


Figure 21. Attributes of research surplus

Collectable attributes are divided into the five categories: general data, project information, technical data, market opportunities and results from analyses. Because the amount of the research surplus from the whole NRC will be huge, the identification of a single project or a technology is essential. General data is for that purpose. Project information gives basic background information, too. Technical information is needed so that researchers can observe the features of the surplus technologies. Some technology evaluating methods can be integrated into the RSP system. Results from those evaluations are one part of the saved information. Information about the potential market is very important. A market research can also be an evaluation tool, but the description of the business idea and the planned market for a surplus technology helps to determine the future use of a technology. If information about the future opportunities is not available at the moment of documentation, the information could be added later and it does not necessarily have to be the project manager who identifies the market opportunities. There could also be a possibility to suggest ideas about the future use of the non-core technology.

Proper management of RSP and especially data storage phase is critical for the later opportunities of the research surplus. When it is done delicately, there are better changes that a surplus technology is founded from RSP and it can be utilized in the new business creation in NRC or licensed out of the company. To make sure that data is documented carefully, there could be some kind of bonuses or rewards for a team or a laboratory, whose surplus is the most utilized in the new business creation or whose surplus has created most value to the company.

5.7.2 Toolkit for the Evaluation of the Surplus

Tools for the research surplus management and evaluation are hard to find. This is a common problem for the portfolio management and the whole innovation process. Cooper (1997b, 169) argues that the evaluation methods must be user-friendly, but still realistic. Many tools are too complex to use or they contain too many simplifying consumptions. The relations between technologies, changing conditions, measurement of critical success factors and uncertainty increase the difficulty of evaluation.

Evaluation of technologies in RSP is done from different basis than in the project portfolio management (PPM) process. Project portfolios contain a firm’s current projects and technology portfolios current technologies. The normal PPM process aims to allocate scarce resources for the most beneficial projects and balance the portfolio of projects to fit the firm’s strategy. RSP does not have a role like that. Evaluation tools and techniques applied to RSP have to help to understand portfolio content, find new market opportunities and identify technologies that can be licensed out.

Chapters 4.2 and 4.3 introduced a collection of tools for managing portfolios and assessing technologies. In this chapter, tools, which are considered to be the most appropriate for the evaluation of the surplus, are discussed. The methods are evaluated based on how well they fit in the RSP concept, so the general benefits and pitfalls of the methods are not considered in the thesis. Table 5 summarizes the discussion.

Probably the most suitable method for the RSP concept is the scoring model. It is a simple, easy and effective tool. It allows a subjective analysis, which is useful feature for RSP, but the danger is that the analysis becomes too subjective. Another pitfall is that it is very hard to identify criteria that measure right issues, and weight those criteria right. Therefore, the criteria and their weights must be selected carefully. With scoring model every kind of surplus can be evaluated. It is an essential feature for the evaluation tool, because as mentioned before the surplus can be in every form from the patent to the code. Cooper et al. (2001, 369) categorize criteria used in scoring models into five sections: reward, business strategy, strategy leverage, probability of commercial success and probability of technology success. The categories are almost the same than the attribute suggestions in the previous chapter (Figure 21). Below, there is a list of criteria suggestion in every section that could be applied for the surplus:

- Reward: NPV, payback time and other financial measures
- Business strategy fit: how far a technology is from the strategy, the financial and strategic impact of technology
- Strategic leverage: proprietary position, growth opportunities, durability, synergies with other technologies/programs
- Probability of commercial success: market opportunities, competitive advantage, market maturity, commercial/later use assumption
- Probability of technology success: stage of development, technology complexity, technical skill base

It is very likely that the research surplus contains real options that have not been wanted to be used or have not been founded yet. In the latter case, identification of those options should be done. The future options identification is basically the purpose of the whole RSP. The problem is that options are hard to define and value. Even if the real options approach is reasonable and useful in theory, there are not many workable applications in practice.

A major reason why new product development fails is the lack of market knowledge: inadequate market research and not understanding customers needs and wants (Cooper, 1997b, 43). In this context, market research does not necessarily mean an ordinary market research that normally is made with the final customers of the new product. Market opportunity identification helps to find new market for the surplus technologies and new businesses based on the research surplus. The importance of strong market orientation can not be emphasized enough, but off course, it is not the only thing that matters. Other analyses are needed, too. In the thesis, the form of market research application is not considered in more detail, but it is essential to integrate it into RSP.

The broadly applied SWOT analysis about strengths, weaknesses, opportunities and threads could be applied in the surplus technologies evaluation, too. The traditional method offers a framework for the documentation and evaluation of the different aspects of the surplus. Technologies are evaluated internally (strengths and weaknesses) and externally (opportunity and threats) and, on the other hand, positive aspects (strengths and opportunities) and negative aspects (weaknesses and threats) are eyed. But the execution of a thorough analysis requires time and usually more than a one person. The subjective analysis is suitable for RSP, but if the analysis just lists strengths, weaknesses, opportunities and threats of a technology, the view might be too subjective.

PPM-solutions providers highlight the importance of a bird-eye view from all projects in the portfolio. Usually, bubble diagrams, different tables and maps are used. Even if those tools are meant primarily for strategic fit and balance check, which are not important in RSP, the bird-eye view can be applied to RSP, too. The front page of the RSP solution can provide general information, such as how many technologies are there in RSP, how many from different laboratories and recently stored technologies. In addition, a diagram tool could be helpful in the technology search, if the tool would draw technologies to a coordinates with selected dimensions. It is possible that with some metrics, RSP could be divided into clusters.

The financial methods are the most popular tools for evaluating projects and technologies, but those are not very appropriate for the technologies in RSP. The financial tools are well known and can assist discussion and decisions about the new technology development, but if the results are wanted to be reliable, plenty of accrual financial information, such as cash flows from several becoming years, is needed. In many cases, information is impossible to get. If the financial information is available or some kind of financial analysis has already been done for example in project proposal, it can be included into RSP.

Table 5. Methods for evaluating the future potential of research surplus

Method	Suitable for RSP	Not suitable for RSP
Scoring model/Scorecard	+ Effective, simple and easy to use + Subjective assessment can be made + Qualitative and quantitative aspects are considered +Lists questions for discussion + Suitable for evaluation of every kind of surplus	- Requires well defined criteria/weights for criteria - Too subjective approach
Real options	+ Are included in almost all new technologies +Strongly related towards future opportunities	- Not a simple method for implementation - Options are difficult to define - Valuation of the benefits of options is hard
Market Research/ Market opportunity identification	+ Identifies new business opportunities + usually used too little in companies	- Only market aspect
SWOT	+Several aspects + Basic framework	- Time consuming - Too subjective approach - Hard to evaluate immature technology
Bubble diagrams/maps	+ A bird-eye view + An assistant tool in technology search	- used mostly to visualize balance of portfolio
Financial models	+ Well-known + Assist discussion	- Requires accrual financial data, which can be impossible to get - Probably negative outcome from the analysis

The methods introduced above do not rule each other out. There could and should be more than a one method integrated to RSP. The methods can be combined in several ways. For example the combination of scoring model and bubble diagram applications gives wider results from the evaluation and do not require extra work.

In the thesis, metrics and criteria for the methods are not discussed. To identify tools and metrics best suitable for the research surplus evaluation, workshop approach, like Delphi method, could be used. Delphi method is based on an expert group, whose size is recommended to be 10-18 persons, answering anonymously a questionnaire designed to solve a problem. (Okoli & Pawlowsky, 2004, 19) The group could include for instance NRC's researchers, managers, academic researchers and consultants.

5.7.3 Managing RSP

It is vital for communication and functionality that the RSP management team is a cross-functional group with researches that present the technical aspect, marketing/business personnel with the knowledge of market opportunities and legal counselors for understanding protection and enforcement issues. The team consists of members from as many laboratories as possible. In addition, there has to be a so called "knowledge broker" in a management team, who works as a link between project managers and RSP. The team does not have to be large; few persons could take the responsibility of RSP and searching new technologies from it.

The RSP management team is responsible for maintaining the portfolio. Even if data can be stored whenever projects become surplus and technologies can be searched and observed anytime, a seasonal reviewing is useful to do, at least when the strategic focus areas change or when big environmental changes occur. The portfolio could be gone through systematically with experts one to three times a year. The reviewing sessions could also be symposia for sharing information about the recently ended projects. Table 2 (chapter 3.3.4) gives some advice to management team how to reactivate the surplus technologies.

The portfolio can be open to everybody in NRC. Every researcher is free to observe non-core technologies, but the system is hierarchical. It means that only certain employees, such as project managers, are able to update the system. The thesis does not consider the data security and protection issues, because Nokia and NRC have their own methods and systems for managing those issues.

5.8 RSP Database

In this chapter, a short view to the database of RSP is given. The clearest alternative is to separate core technology and non-core database from each other. This is essential, if RSP is used as a market place for non-core technologies and some part of it will be opened outside NRC. If the database stays the way it is now, all projects are in the same database, the surplus has to be easy to recognize and distinguish from the core. However, a strong linkage between core technologies and surplus has to be kept no matter what kind of storage solution is chosen (Figure 22).

Core technologies can become non-core and should be moved into RSP. It might happen for example to old technologies that have been used to Nokia's products but are now considered to license out. At the same time, non-core technologies can become core. The example of this could be open source technologies that might become core in some circumstances.

At the moment, projects and patents are documented into different databases, which are not linked with each other. While developing RSP, the linkage between patents, RSP and core technologies should be created (Figure 22). The utilization of RSP can benefit from the linkage, because from the database of the patents a person who is observing the surplus is able to estimate the commercial value of a non-core technology better. (Saarinen, 2006)

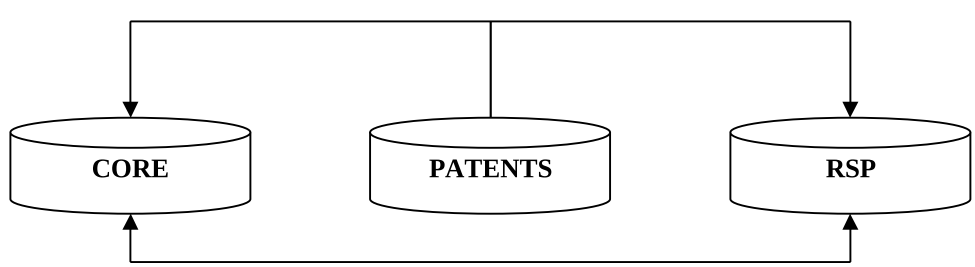


Figure 22. The connections between the databases of core technologies, patents and RSP

5.9 Implementation

RSP will be some kind of a computer system. The thesis does not include deeply consideration of the implementation of RSP, but some topics are discussed in this chapter and the appendix 2 gives the simplified example of the RSP system in practice. Following ideas for RSP are common suggestions and arguments that have been captured from the literature and different solution providers on the Internet.

There are three main issues that have to be considered when implementing the RSP system: functionality, technology and costs. If the software for the system is decided to be developed in-house, operating systems, databases, and programming languages have to be considered. Even if there are plenty of project portfolio management solution vendors, normal PPM-solutions are not suitable for research surplus management. So in this case, in-house solution may be the best alternative. The integrations of RSP into NRC’s other data systems must be considered, too.

Implementation requires a task force that consists from five to nine persons. Cooper (1997, 268) argues that it is the most appropriate size for the development team in implementing new innovation process. Two to three persons do not provide enough perspective and on the other hand, with over ten persons, it is hard to schedule meetings. Before actual implementation phase, it is essential to do proper detailed design. In addition, it is important to discuss with other personnel about the concept of RSP. They might give good suggestions and ideas related to RSP.

In any organizational change, the resistance of change is usually tough, especially in situations where workload or control of the work will increase. RSP does the both; workload will increase because the surplus has to be stored in the system and maintained, and from RSP, executives and other laboratories can observe how much surplus a laboratory or even a particular person has produced. The implementation of RSP does not succeed without the dedicated implementation team.

Commitment to use RSP is gained with communication and training. The development team must convince the organization that RSP is needed. Like in every reform, commitment of top management is important, too. User-friendly manual and a few training sessions ensure that the purpose of RSP is understood and it will be employed properly. In many cases, if the organization is big, like NRC, the pilot version of a new system is used. MMT laboratory is a good place to test RSP before it is extended into the whole organization.

After RSP is implemented, generated surplus can be documented into it anytime, but how the current research surplus material that already exists is moved to the new portfolio has to be considered during the implementation. There have to be general instructions about how old research material is still relevant enough for RSP, who can be responsible for the information transfer and when the surplus should be filed.

6 CONCLUSIONS

Changing business environment with shorter lifecycles, globalization and more intensive competition force companies to be more innovative, and look for new business models. The open innovation that emphasizes more open attitude in a company's innovation process, collaboration and alternative paths to market, is adopted as an innovation philosophy in many industries. The development requires new pursuit patterns from R&D divisions. The goal of this thesis was to create the constructive concept to one of those new patterns in NRC - Research Surplus Portfolio. The purpose of the concept is to move human capital into intellectual assets that can be managed. The main research question was: what kind of system is suitable and effective for managing the research surplus (non-core technologies) in NRC. The second purpose of the thesis was to identify tools and techniques for RSP.

In the thesis, the framework for RSP is constructed. The thesis designs the concept of the portfolio and gives suggestions to how to utilize and manage it in NRC. The framework gives guidelines for the research organization to implement the portfolio for their non-core technologies better and advance the new business creation from the surplus. From the constructive approach point of view, the thesis introduces the term "Research Surplus Portfolio", which is new to the portfolio management literature, and creates the framework for it. Even if models and tools are pretty similar to the ordinary project portfolio management, the essence of RSP is so different from the project portfolio that new management processes and procedures have to be considered. Table 6 collects the main differences between PPM and RSP management issues.

Table 6. The comparison of the project portfolio management and RSP management

	PPM Management	RSP Management
Organizational approach	Top-down or bottom-up approach	Bottom-up approach
Goals	Value maximization, balance, strategic fit	Effective use of innovations, finding opportunities, new business creation
Management process	Selection, evaluation, prioritization, resource allocation, balancing the portfolio and strategic fit consideration, decision making (go/kill decisions), maintaining	Storage, evaluation, maintaining, technology search
Time perspective	Present projects	Future opportunities
Project selection	Projects are not placed into the portfolio automatically. Selection is based on the evaluation of value, strategic fit and balance	All surplus projects will be placed to the portfolio
Projects prioritizing	Projects are prioritized for resource allocation	No need for prioritization or resource allocation
Evaluation methods	Combination of financial method, strategic approach, scoring model and bubble diagram	Combinations of scoring model, bubble diagram and market research

The approach to the project management could be either bottom-up or top-down, but in RSP management, the approach needs to be bottom-up, because project managers and researchers know their needs and what they have done the best. There are three goals for the ordinary project portfolio management: value maximization, balance and strategic fit, and the portfolio management processes are designed to meet these goals. The RSP management has different objectives: the increased utilization of research resources, increased innovativeness and new business creation. But even if the goals of the RSP management differ from the goals of the project portfolio management, some PPM tools and techniques are suitable for RSP management, too. For example, the technology evaluation methods in both systems are similar. Overall, RSP management process is much lighter than PPM process. It concentrates on the future opportunities and deals with the more complex and uncertain environment.

NRC produces a lot of research material from numerous projects. Typically, the information documentation and sharing is a challenge for research organizations. That is why RSP concept fits to NRC well. It is clear that it would ease the management of non-core technologies, but in addition, it could help the new business creation, as well. RSP could offer several benefits for the research organization:

- New business opportunities
- Applications for out-licensing
- Advancement of venture and spin-off activities
- Visibility and transparency
- Increased managerial efficiency
- Increased utilization of resources and technologies
- Learning
- Increased innovativeness
- Moving towards open innovation paradigm

RSP could be used in several ways. The thesis gives four examples on how to use the portfolio: It could function as the technology search engine, the idea bank, the communication tool and the market place for technologies. Its utilization depends on whether the system is internal or external. If it was created just for the internally use, an efficient search engine application might be enough. Then RSP would function as a researchers' extra memory, from where earlier projects could be reviewed. However, if the purpose of RSP is to create new businesses from the research surplus or market the waste technologies outside the company, RSP must be developed further.

To make the system functional, RSP solution must be simple and it has to have the approval of the executives and other employees. When assessing the usability of the RSP, the most important elements are the documentation of the surplus to the portfolio and searching it from that. Documentation is done by project managers. It is essential that it becomes a part of their basic work and a routine task during a research project. The attributes stored from the surplus need to be categorized and evaluated effectively. The organization has to name a few persons, who review the database regularly and are responsible for RSP. Advanced searching facility must be applied to RSP. It should be able to accept several different search words and search types.

One problem in the utilization of RSP is that the reviewing of the research waste is certainly not the core activity in NRC. Even if an effective application for RSP is found, decision making has still strong human aspect that should not be forgotten. How much Research Surplus Portfolio will be exploited and new opportunities from the waste be found, depends on the organization and the people behind RSP. The danger is that it becomes an unused data system. It is clear that RSP demands at least little extra work, and looking back may seem to be worthless, but benefits from exploring old research results could be significant, if new business could be created from already wasted research.

In the thesis, the first step towards the implementation of Research Surplus Portfolio is taken. The next step will be a more detailed design of the portfolio system and its testing, first in paper and then in practice. Further research is needed for instance to select the evaluation tools, construct the suitable applications with metrics to RSP and design the physical entity in more detail. Hargaron & Sutton (1997) discuss the innovation process with technology brokering. The results of the thesis could also be concerned from their survey's point of view and examine possibilities to combine their survey and the results of the thesis.

The contraction of RSP framework has been made with close cooperation with different persons in NRC. That is why it can be argue that the result is reliable. If the usefulness of the framework constructed in the Thesis is validated with the weak market test (Kasanen et al.1993), it is justified to state that it is gained. Responsible manager has expressed the usefulness of the RSP framework for the further development of the management system of the research surplus. On the other hand, developed framework is constructed in general level and it is easy to generalize to other research organizations as well.

REFERENCES

Aalto, T. 2001. Strategies and Methods for Project Portfolio Management. In Artto, K., Martinsuo, M., & Aalto, T. (eds) Project Portfolio Management: *Strategic Management through Projects*. Project Management Association Finland, Helsinki. 176 p.
ISBN: 951-22-5594-4

Allio R. 2005. Interview with Henry Chesrough: Innovating Innovation. *Strategy & Leadership*, Chicago, vol.33, iss.1, pp. 19-25

Archer, NP. & Ghasemzadeh, F. 1999. An Integrated Framework for Project Portfolio Selection. *International Journal of Project Management*, Kidlington, vol. 17, iss. 4, pp. 207-216

Berkhout, A.J., Hartmann, D., Van der Duin, P. & Ortt, R. 2006. Innovating the Innovation Process. *International Journal of Technology Management*, Geneva, vol. 34, iss ¾, pp. 390-404

Boer, F.P. 1999. *The Valuation of Technology: Business and Financial Issues in R&D*. John Wiley & Sons, Inc, USA. 403 p. ISBN: 0-471-31638-5

Boer, F.P. 2000. Valuation of Technology Using “Real Options”. *Research Technology Management*, Washington, vol. 43, iss. 4, pp. 26-30

Bordley, R. 1998. R&D Project Selection versus R&D Project Generation. *IEEE Transactions and Engineering Management*, New York, vol. 45, iss. 4, pp. 407-413

Chesbrough, H. 2003a. *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Harvard Business Press, Boston, Massachusetts. 227 p.
ISBN 1-57851-837-7

Chesbrough, H. 2003b. The New Rules of R&D.*Harvard Management Update*, Boston, vol. 8, iss. 5, pp. 3-4

Chesbrough, H. 2003c. The Logic of Open Innovation: Managing Intellectual Property. *California Management Review*, California, vol. 45, iss. 3, pp. 33-58

Chesbrough, H. 2004. Managing Open Innovation. *Research Technology Management*, Washington, vol. 47, iss. 1, pp. 23-26

Chesbrough, H. 2006. Open Innovation: A New Paradigm for Understanding Industrial Innovation. In Chesbrough, H., Vanhaverbeke, W. & West, J. (eds). *Open Innovation: Researching a New Paradigm*. Oxford University Press, Oxford. 400 p. ISBN 0-19-929072-5

Chien, C. 2002. A Portfolio-evaluation Framework for Selecting R&D Projects. *R&D Management*, Oxford, vol. 32, iss. 4, pp. 359-368

Christensen, J., Olesen, M. & Kjaer, J. 2005. The Industrial Dynamics of Open Innovation – Evidence from the Transformation of Consumer Electronics. *Research Policy*, Amsterdam, vol. 34, iss. 10, pp. 1533-1549

Cohen, W. & Levinthal, A. 1990. Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly*, Ithaca, vol. 35, iss. 1, pp. 128-153

Cooper, R. 1990. State-Gate System: A New Tool for Managing New Products. *Business Horizons*, Greenwich, vol. 33, iss. 3, pp. 44-55.

Cooper, R., Edgett, S. & Kleinschmidt, E. 1997a. Portfolio Management in New Product Develompent: Lessons from the Leaders II. *Research Technology Management*, Washington, vol. 40, iss. 6, pp. 43-52

Cooper, R. 1997b. *Winning at New Products: Accelerating the Process from Idea to Launch*. Second Edition. Addison-Wesley Publishing Company, Inc., USA. 358 p.
ISBN: 0-201-56381-9

Cooper, R., Edgett, S. & Kleinschmidt, E. 1999. New Product Portfolio Management: Practices and Performance. *The Journal of Product Innovation Management*, New York. vol. 16, iss. 4, pp. 333-351

Cooper, R., Edgett, S. & Kleinschmidt, E. 2000. New Problems, New Solutions: Making Portfolio Management More Effective. *Research Technology Management*, Washington, vol. 43, iss. 2, pp. 18-33

Cooper, R., Edgett, S. & Kleinschmidt, E. 2001. Portfolio Management for New Product Development: Results of an Industry Practices Study. *R&D Management*, Oxford, vol. 31, iss. 4, pp. 361-380

Doering, D.S. & Parayre, R. 2000. Identification and Assessment of Emerging Technologies. In Day, G & Shoemaker, P. (eds). *Wharton on Managing Emerging Technologies*. John Wiley & Sons, Inc., USA. 460 p. ISBN: 0-471-36121-6

Dooley, L., Lupton, G. & O'Sullivan, D. 2005. Multiple Project Management: A Modern Competitive Necessity. *Journal of Manufacturing Technology Management*, Bradford, vol. 16, iss. 5/6. pp. 466-482

Dye L. & Pennypacker, J. (eds). 1999. *Project Portfolio Management: Selecting and Prioritising Projects for Competitive Advantage*. Center for Business Practices, West Chester. 421 p. ISBN: 1-929576-00-5

Edvinsson, L & Sullivan, P. 1996. Developing a Model for Managing Intellectual Capital. *European Management Journal*, London, vol. 14, iss. 4, pp. 356-364

Foreier, B. 2002. Roadmapping: Critical Thinking for Interconnect Products and Technologies. *CircuiTree*, Troy, vol. 15, iss. 9, pp. 50-61

Garud, R. & Nayyar, P. 1994. Transformative Capacity: Continual Structuring by Intertemporal Technology Transfer. *Strategic Management Journal*, Chichester, vol. 15, iss. 5, pp. 365-385

Goldheim, D., Slowinski, G., Daniele, J., Hummel, E. & Tao, J. 2005. Exracting Value from Intellectual Assets. *Research Technology Management*, Washington, vol. 48, iss. 2, pp. 43-48

Gulati, R. 1998. Strategic Alliances and Networks. *Strategic Management Journal*, Chichester, vol. 19, iss. 4, pp. 293-317

Hamilton, W. 2000. Managing Real Options. In Day, G & Shoemaker, P. (eds.) *Wharton on Managing Emerging Technologies*. John Wiley & Sons, Inc., USA. 460 p.
ISBN: 0-471-36121-6

Hargadon, A.B. & Sutton, R.I. 1997. Technology Brokering and Innovation in Product Development Firm. *Administrative Science Quarterly*, Ithaca, vol 42, iss. 4, pp. 716-749

Harrison, S. & Sullivan, P. 2000. Profiting from Intellectual Capital: Learning from Leading Companies. *Industrial and Commercial Training*, Guilsborough, vol. 32, iss. 4, pp. 139-148

Henderson, B. 1970. Growth-Share Matrix. The Boston Consulting Group. 2006. [Internet document][Accessed:October12th]Available:
http://www.bcg.com/this_is_bcg/mission/growth_share_matrix.html

Hogan, J. 2005. Open Innovation or Open House: How to Protect Your Most Valuable Assets. *Medical Device Technology*, Chester, vol. 16, iss. 3, pp. 30-31

Kasanen, E., Lukka, K. & Siitonen, E. 1993. The Constructive Approach in Management Accounting Research. *Journal of Management Accounting Research*, Sarasota, vol. 5. pp. 343-264

Koen, P., Greg, A., Boyce, S., Clamen, A., Fisher, E., Fountoulakis, S., Johnson, A., Puri, P. & Seibert, R. 2002. Fussy Front End: Effective Methods, Tools and Techniques. In Belliveau, P., Griffin, A. & Somermayer, S. *The PDMA Toolbook for New Product Development*. John Wiley & Sons, Inc., USA. 480 p. ISBN: 0-471-20611-3

Liito. 2006. Liito – Uudistuva liiketoiminta ja johtaminen. [Internet document] [Accessed: June 27th 2006] available: http://www.tekes.fi/liito/.

Lukka, K. 2000. The Key Issues of Applying the Constructive Approach to Field Research. In Reponen, T. (ed.). 2000. *Management Expertise for the New Millenium*. In Commemoration of the 50th Anniversary of the Turku School of Economics and Business Administration. Publications of the Turku School of Economics and Business Administration, A-1:2000

MacMillan, I. & McGrath, R. 2002. Crafting R&D Projects Portfolios. *Research Technology Management*, Washington, vol. 45, iss. 5, pp. 48-59

Martinsuo, M. 2001. Project Portfolio Management: Contingencies, Implementation and Strategic Renewal. In In Artto, K., Martinsuo, M. & Aalto, T. (eds). *Project Portfolio Management: Strategic Management through Projects*. Project Management Association Finland, Helsinki. 176 p. ISBN: 951-22-5594-4

Miller, W. L & Morris, L. 1999. *Fourth Generation R&D: Managing Knowledge, Technology, and Innovation*. John Wiley & Sons, Inc., USA. 347 p. ISBN 0-471-24093-1

Nokia, 2006a. Nokia-Research. [Internet document] [Accessed: August 7th 2006] available: http://www.nokia.com/link?cid=EDITORIAL_4070.

Nokia. 2006b. NRC General Presentation/February 2006. Power-point presentation slides.

Nokia. 2006c. Nokia and Open Source. [Internet document] [Accessed: August 7th 2006] available: http://opensource.nokia.com/contributions.html

Okoli, C & Pawlowsky, S. 2004. The Delphi Method as a Research Tool: An Example, Design Considerations and Applications. *Information & Management*, Amsterdam., vol 42, iss. 1, pp. 15-29

Parhankangas, A., Holmlund, P. & Kuusisto, T. 2003. *Managing Non-Core Technologies: Experiences from Finnish, Swedish and US Corporations*. Technology Review 149/2003. Tekes, Helsinki. 77 p. ISBN 952-457-142-0

Poskela, J., Korpi-Filppula, M. & Mattila, V. 2001. Project Portfolio Management Practices of a Global Telecommunications Operator. In Artto, K., Martinsuo, M. & Aalto, T. (eds). *Project Portfolio Management: Strategic Management through Projects.* Project Management Association Finland, Helsinki. 176 p. ISBN: 951-22-5594-4

Rothwell, R. 1992. Successful Industrial Innovation: Critical Factors for the 1990s. *R&D Management*, Oxford, vol. 22, iss. 3, pp. 221-240.

Saint-Onge, H. 1996. Tacit Knowledge: The Key to the Strategic alignment of Intellectual Capital. *Strategy & Leadership*, Chicago, vol. 24, iss. 2, pp. 10-14

Schoemaker, P. 1995. Scenario Planning: A Tool for Strategic Thinking. *Sloan Management Journal*, Massachusetts, vol.36, iss. 2, pp. 25-40

Shoemaker, P. & Mavaddat, V. 2000. Scenario Planning for Disruptive Technologies. In Day, G & Shoemaker, P. (eds). *Wharton on Managing Emerging Technologies*. John Wiley & Sons, Inc., USA. 460 p. ISBN: 0-471-36121-6

Spradlin, T. & Kutoloski, D. 1999. Action-Oriented Portfolio Management. *Research Technology Management*, Washington. vol. 42, iss. 2, pp. 26-32

Stevens, T. 1997. Balancing Act. *Industry Week*, Cleveland, vol. 246, iss. 6, pp. 40-44

Stewart, T. 1994. Your Company's Most Valuable Asset: Intellectual Capital. *Fortune*, New York, vol. 130, iss. 7, pp. 68-73

Stewart, T. 2001. Ten Years Later, How Far We've Come. *Fortune*, New York, vol. 143., iss. 11, pp. 192-194

Sullivan, P. 1998. *Profiting from Intellectual Capital: Extracting Value from Innovation*. John Wiley & Sons, Inc., USA. 366 p. ISBN: 0-471-19302-X

Sullivan, P. 2000. *Value-Driven Intellectual Capital: How to Convert Intangible Corporate Assets into Market Value*. John Wiley & Sons, Inc., USA. 276 p. ISBN: 0-471-35104-0

Tao, J., Daniele, J., Hummel, E., Goldheim, D. & Slowinski, G. 2005. Developing an Effective Strategy for Managing Intellectual Assets. *Research Technology Management*, Washington, vol. 48, iss. 1, pp. 50-58

Tidd, J., Bessant, J. & Pavitt, K. 2001. *Managing Innovation: Integrating Technological, Market and Organizational Change*. Second Edition. John Wiley & Sons, Inc., England, 388 p. ISBN 0-471-49615-4

von Hippel, E. 1994. *The Sources of Innovation*. Oxford University Press, USA. 232 p. ISBN: 978-0-19-509422-0

Yet2.com. 2006. Company’s homepage [Internet document] [Accessed: September 28th 2006] available: http://www.yet2.com/app/about/home

Interviews

Saarinen, J. 2006. Head of Multimedia technology laboratory in NRC. Tampere 7.9.2006

Karlsson, M. 2006a. Project Manager in NRC. E-mail 3.8.2006

Karlsson, M. 2006b. Project Manager in NRC. E-mail 8.8.2006

APPENDIX 1: List of Key Characteristics of Surplus

General data:

- Project name
- Code number
- Laboratory
- Class (audio, video, games…)
- Type (licensing case, parked technology, idea…)
- Status (defensive, offensive, breakthrough)
- Documentation day
- Modification day
- Contacts (inventor, project manager..)
- Competitors
- Key words

Project information:

- Duration
- Start date
- Financier(s)
- Problems/ Kill variables
- Costs
- Stage of the development
- Size of the project (resources, personnel)

Technical information:

- Description/abstract
- Related projects/technologies
- Status of the legal protection
- Related patents/invention publications
- Deliverables (results, materials)
- Source of idea

Market opportunities:

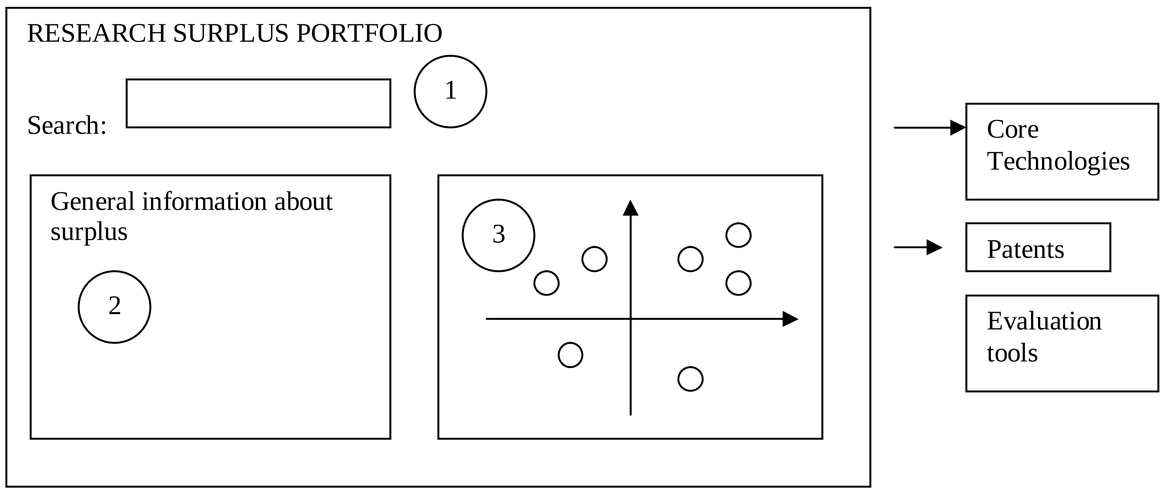
- Suggestions for later use
- Feasibility
- Market attractiveness
- Business/utilization idea
- Competitive advantage
- Link to the business strategy
- Market segment
- Competitive impact of technology
- Market position

Evaluation results and probabilities:

- Rating (0-10) on key criteria
- Ranking (1-N) based on some ranking criteria
- Attractiveness scores
- Related financial analyses: NPV, ECV, IRR, Payoff…
- Probability of technical success
- Probability of commercial success
- Market research (for example opportunity analysis based on Delphi method)
- Risk analysis (scenario planning, sensitive analysis, Monte Carlo simulation)
- SWOT
- Real options (definition, valuation)
- Bubble diagrams/maps (could be drawn from other information gathered)
- Other methods and analyses (Business case analysis, investment opportunity analysis, trend analysis)

APPENDIX 2: Example of the RSP system in practice

This simplified example gives an overview about RSP system in practice. Note that, the example illustrates only a one possible search event.



1. The most important element of RSP is the searching function. It should be very sophisticated and efficient. It should allow very different searches and search words, such as certain time period, key words, certain stored attribute or searches based on evaluation. The search facility is related to the other databases, too; the system also allows searching core technologies and patents.

2. The front page of the interface of the portfolio could contain general information. It could summarize how much surplus is there in the database, latest documentations, latest results from the utilization and other current news.

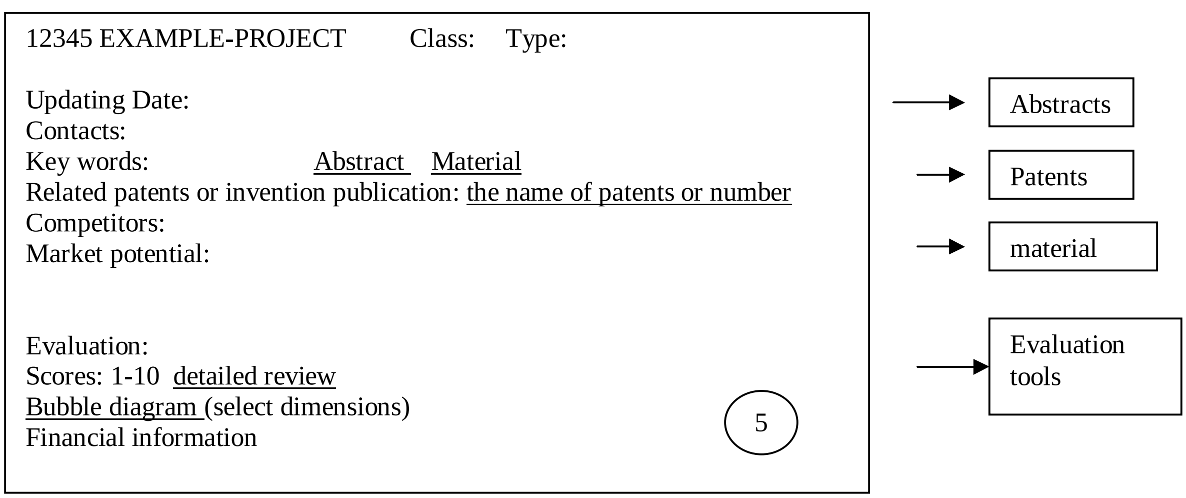
3. Some kind of graphics to support the general information would increase the usability and intelligibility. It could be useful to add a function, which allows changing the dimensions of the diagram.

RESEARCH SURPLUS DURING THE LAST 5 YEARS

Code	Name	Class	Type	Lab	Date

4

4. In this case, non-core technologies that are produced over the last five years are searched. The system shows a list of those surplus items and basic information about them.



5. A searcher can review a single technology in more detail and get more information about it. The goal is that this page would contain all the information that is needed to identify the future opportunities. From this page, the managers and researchers have access to review technical information, related material and, patents and invention publications related to the particular technology.