MASTER

Improving R&D project portfolio management at a pre-development department

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Award date:
2014

Link to publication
Improving R&D project portfolio management at a pre-development department

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BSc Mechanical Engineering
identity number 0595798

in partial fulfilment of the requirements for the degree of

Master of Science
in Innovation Management

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TU/e, ITEM
Improving R&D project portfolio management at a pre-development department

TUE. Department Industrial Engineering and Innovation Sciences.
Series Master Theses Innovation Management

Subject headings:

Abstract

Firms innovate by developing new products through identifying and selecting Research and Development (R&D) projects. Often confronted with limited budget and risky choices with many stakeholders involved, they use project portfolio management to help make the right choices and manage these risks.

In this thesis, the author is looking to optimise an R&D department’s project portfolio management process by conducting a case study and compare the findings with best practices found in literature. Findings revealed that the portfolio management process was semi-formal and semi-systematic and few evidence-based criteria for selecting projects were used. Therefore, decision-making occurred rather intuitive and power-based instead of supported by objective data. Due to short-term objectives of the business while research explores and introduces new technologies, the pre-development department is prone to develop unique peak designs instead of product platforms. This is exacerbated by (i) the company’s culture, (ii) limited consideration of the company’s strategy, (iii) afterwards evaluation not good enough, and (iv) too few platform architecture competences present.

To improve the current project portfolio management process, the pre-development department should carefully outline and visualise the project portfolio selection process and apply more evidence-based decision-making. Furthermore, deploying a platform-thinking mind-set throughout the organisation and improving the department’s platform architecture competences is recommended. Finally, the department should improve the end-result overview, evaluation and future direction of the portfolio.
Executive summary

Research and Development (R&D) firms innovate by developing new products through identifying and selecting R&D projects. These projects are invested in to obtain new information about promising technologies to be implemented in new or current products (Carlsson, Fullér, Heikkilä, & Majlender, 2007). However, firms often have limited financial resources and choices are risky with many stakeholders involved (Ringuest, Graves, & Case, 1999). They use project portfolio management to help make the right choices and manage these risks.

To effectively manage the risks involved in R&D investments, a portfolio of projects has been developed and advocated by the company’s pre-development department. It involves the selection of R&D project proposals for projects that typically have a development time of three to five years. The department is responsible for technology and function creation to subsequently develop architectures for new product platforms for future generations of products coming from new emerging technologies. Research confirms that careful portfolio management can make R&D investment’s influence on firm performance more effective (Cooper, Edgett, & Kleinschmidt, 2004a). Knowledge as to which tools or mix of tools are most effective remains scant. A lack of understanding of the effectiveness of the current R&D portfolio practice in the pre-development department may result in suboptimal risk management and decision-making. In this regard, the research question is formulated as follows:

1. How effective is the project portfolio management process and related decision-making of the pre-development department, and
2. how can it be optimised regarding dealing with technological trends based on best practices found in the literature?

Methodology

First, the literature was studied before analysing the case study at the pre-development department. The department’s current project portfolio management process was investigated, decision-making was observed and the influence on business strategies noted.

The research design is based on the level of seniority, role of people, different departments and is split into four subsequent phases. First, a draft of the current project portfolio selection process was created. Second, the draft was extended to the real process and the role and responsibilities of the actors involved were identified. Third, evidence-, power-, and opinion-based decision-making processes were revealed. Finally, a more profound understanding of the decision process and its impact on strategic outcomes was developed. Stakeholders were mapped in pre-determined designs. Axes used were level of seniority, function, monetary influence, department, and product platform strategy attitude. Next, the findings were analysed and reflected with literature. Conclusions were drawn and recommendations put forward.

Findings

Since formal guidelines and decision support tools were not set in advance the process was rather informal and vaguely formulated. Also, not many criteria or methods for decision-making were defined. Research showed that well performing firms use multiple portfolio methods and in a more formal way. They rely on clear, well-defined portfolio procedures, consistently apply their portfolio method to all projects, with support of management (Cooper, Edgett, & Kleinschmidt, 1999). Although the literature indicated that decisions in R&D project portfolio management are best made through a combination of evidence-, power-, and opinion-based processes (Kester, Griffin, Hultink, & Lauche, 2011), many decisions were solely based on power and opinion processes. By some, the process was even viewed as a political game. Also, the link with strategy was rather unclear and implicit. Due to regular interaction between many
actors and the Head of Department pre-development, the process was perceived to be somewhat difficult and time-consuming.

After mapping the selection process the structure became more clear and revealed one pre-process phase (strategic review meeting) and three selection process phases (pre-screening, individual project analysis, screening & selection) with each having several in- and output documents. Archer and Ghasemzadeh (1999) suggested that using five clearly outlined process phases is key to an optimal portfolio selection process. In the department’s case, a final phase was not identified and two phases seemed to be combined.

Due to power- and opinion-based processes in the portfolio selection, limited exploitation of technologies in the business through long-term product platforms occurred. This happened mainly because the research department as well as a part of the business showed a rather negative attitude towards platform designs. Hence, long-term projects were exchanged for short-term projects. Also, the presence of platform architects could be improved. This counteracted the goals of the pre-development department in deploying a sustained platform development strategy. However, research suggested that firms should be ambidextrous; being innovative but also exploit the value of proprietary assets (Birkinshaw & Gibson, 2004).

**Recommendations to management**

Due to short-term objectives of the business while research explores and introduces new technologies, a gap exists. A platform strategy should bridge this gap. However, considering the current selection process, influences and diverging goals of the stakeholders, the pre-development department is prone to develop unique peak designs instead of product platforms. The most important recommendations for improvement are as follows:

1. Clearly outline and formalise the project portfolio management process.
2. Improve evidence-based decision-making through quantitative or qualitative methods.
3. Make the link with strategy transparent during the process.
4. Improve result overview, evaluation and future direction of the project portfolio.
5. Deploy a platform-thinking mind-set throughout the organisation.

For each recommendation several actions for implementation are listed in Table 1 below.

**Table 1 – Overview of actions to implement recommendations**

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Acknowledgements

First and foremost, I would very much like to thank my father and mother who’ve supported me through eight-and-a-bit years of studying. Particularly for the cheese, shampoo and washing detergents I received on a regular basis and of course the yearly negotiations with dad to secure myself of yet another year of cash flow to continue my career.

Also, I want to spend a word of gratitude towards my professor Ed Nijssen with his strong analytical capabilities and creative way of thinking. I’m honoured to have picked his brain from time to time which holds a plethora of knowledge. Not only in relation to my graduation project, but also on business efforts I undertook.

In addition I want to thank my second supervisor, Fred Langerak, for his useful contributions at end of my Master thesis. His fresh and critical view contributed to the quality of the report to give it just what it needed.

Furthermore, a big thank you goes out to [redacted]. Head of Department Pre-development. He enabled the playground for me in order to have this wonderful opportunity. Without his strong support I would not have been able to talk with so many people involved on such a variety of topics within the organisation. It needs some kind of gut for a manager to have his own process evaluated.

I will also not forget [redacted] and our regular midday walking’s to the Brood2Day corner. There, I spent hard-earned internship loan on bread with baked chicken and a piece of salad. Alas, I miss one stamp to receive a free sandwich. [redacted] was always prepared to make some time in his over occupied working-studying-girlfriend schedule for me. Furthermore, as a sparring partner about the innovation processes we came to creative solutions by sometimes agreeing to disagree. His working experience at [redacted] lowered the bar for me to gain access to a lot of people.

My girlfriend, Mariët, whom I met at this very same house I’m writing these final words for my thesis. She supported me in all my efforts, especially through these final harsh and stressful entrepreneurial and graduation times. She encouraged me to stay focused and prioritise (“Ga je het wel halen?”).

There is still some space left to thank my roommates at “Het Boschj Genootschap”, fraternity “Rhetoricadispuut Tau”, my former hockeyteam “Kanniballen”, my colleagues at the “Wervingsdagen”, and of course the close group of friends I’ve made along the way. Thank you Edo, Tom, Bram, Eggie, Giel a.k.a. “Bolognaboys”. Together with Edo, I’ve built the company mPossible, which is still operational in providing a media player that connects one’s entire media environment. Also with the help of Rick de Visser and Rico van Genugten, thank you guys. In particular I want to thank Ferdi Verboom for the great 3D printing business opportunity we are going to pursue these coming years. As far as my two best friends from high school Tommy and Jeroen: I think we did well.

All of the aforementioned have contributed to a wonderful time and great balance between relaxing and studying at the Eindhoven University of Technology. Without them, I would have not been able to feel so good about these eight years of my life. I shall not regret a moment of it.
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Chapter 1. Introduction

1.1 Background and problem recognition

Corporations seek to find sustainable competitive advantage through innovation. Innovation is the process of bringing new products and services to market (Hauser, Tellis, & Griffin, 2006). Part of innovation concerns new product development (NPD), which focuses on identifying new product ideas and developing them into value propositions for customers in the marketplace. Successful NPD has shown to benefit financial success and long-term business growth (Cooper et al., 2004a; Hauser et al., 2006). Furthermore, NPD helps firms to protect their current and future market share (Dooley, Subra, & Anderson, 2002; Nicholas, Ledwith, & Perks, 2011). An important aspect of NPD is proper Research and Development (R&D) management for developing (new) R&D projects (Cooper et al., 2004a).

To outpace competitors firms collect information about promising technologies and methods (Carlsson et al., 2007) and engage in R&D projects that they select. However, such decisions involve risk. Research shows that 40 percent of the projects fail to meet objectives in terms of profit, sales and market share (Cooper et al., 2004a). The question many companies face is: “How should corporations most effectively invest their R&D resources?”

For the past fifteen years, the most important management technique in the literature to facilitate managers make R&D investments is project portfolio management (PPM) (Cooper, Edgett, & Kleinschmidt, 2001b). So far, PPM literature has evolved from single project management tools (Baker & Freeland, 1975) concerned with quantitative models to assist with the single R&D project selection and resource allocation decision problem to holistic portfolio methods (Cooper et al., 2001b) – which concerns a collection of (R&D) projects that manifest a company’s business strategy. A broad understanding of the portfolio selection process has been developed, revised, and optimised (Archer & Ghasemzadeh, 2007; Archer & Ghasemzadeh, 1999). PPM leads to a decision process to “identify and develop the set of activities that seek to find and maintain the optimum current and future balance of R&D programs to support the company’s business strategy in terms of criteria such as risk and reward” (Jones, 2005).

Recent literature states that PPM decision-making is a complex process with “interrelated decision-making processes that aim to refine and implement the firm’s strategic goals by allocating the available resources” (Kester, Hultink, & Lauche, 2008) in which also subjectivity and power play important roles (Kester et al., 2011). Consistent with this, three main portfolio decision-making processes have been identified as well as their interrelatedness: evidence-, power-, and opinion-based (Kester et al., 2011; Kollbe, de Man, & Bossink, 2013). Evidence-based decision-making should help direct opinion based decision making and prevent power struggles from taking over. However, what the optimal mix is remains unclear to date.

While R&D project portfolios concern projects in pre-market stage, product portfolios typically refer to the post-market stage. Capon and Glazer (1987) proposed that the distinct portfolios are linked in such a way that “a single position in the technology portfolio gives rise to multiple entries in the product portfolio”. They used different criteria for each portfolio i.e. R&D stage x technological capability/strength, and growth stages of the product life cycle x market position. Another literature stream focuses on developing frameworks to illustrate and understand how to carry out integration of R&D project and product portfolios with the goal to develop a co-aligned technology-market portfolio (Ernst, Fabry, & Soll, 2004). Integration of market requirements and technological capabilities during new product development increases success (Kahn, 1996; Souder, 1986).
1.2 Research context and Research question

The pre-development department is part of the main company and is located in the Business Division X that is amongst others responsible for Product A. In 2012, the Business Category generated 52% of total sales for the main company. The main responsibilities of the department are to identify product areas for new emerging technologies developed by research, also called pre-development. Specifically, it involves technology and function creation to subsequently develop architectures for new product platforms for future generations of products coming from these technologies. Figure 1 shows the positioning of the department of research, pre-development, and the business, and states the goal and core characteristics of each department.

![Figure 1 – Relation between departments of research, pre-development and the business.](image)

Head of Department of pre-development wonders whether the department's current approach of allocating means is up-to-date or can be improved. As it becomes clear in Figure 1, pre-development is in-between two parties: research and the business. Therefore, it is a challenging task to optimise the department's Mid- and Long-Term (M&LT) program and satisfy all parties involved. That is why the department head, in his effort to compose a program, would like to compare the approach used to alternatives and developments in the literature and review the current process in order to be able to identify areas of improvement or redesign.

Decisions made in the current project portfolio selection process eventually affect products in the business. To what extent product platforms are considered is embedded in the decision-making process of the current project selection process of the pre-development department. Since one of the goals of the pre-development department is architecture and platform creation, they are the linking pin between research department and the business. First, projects are developed and considered in a project portfolio. Second, a program is made that should be aligned with or determine products from the product portfolio. The program can contain projects from multiple portfolios (e.g. short-, mid-, and long-term). Therefore, to what extent can a platform strategy be found in the current decision-making about the project portfolio, to eventually affect products in the product portfolio? Because of this link, mapping the current process is important to subsequently discuss the usage/consideration of a product platform strategy. Figure 1 briefly illustrates this link across departments.
Typically, the M&LT program consists of R&D projects that fall into the categories Function & Architecture creation (terms analogous to those in Figure 1). These projects have a scope between one and five years. The main goal of the M&LT program is to prepare and develop for long-term product platforms (and optimise product architectures); in accord with this goal the term “platform” is even part of the department’s name. Platforms offer the opportunity to generate a decrease in R&D expenditures over a longer period. Furthermore, they have implications beyond the current product mix and costs; they also affect the cost structure of follow-up products (such as development costs, product costs, service, and other after-sales costs) and determine the ease and speed with which such products can be brought to the market (Meyer & Dalal, 2002). Platforms are also used to indicate a deliberate strategy to optimise architecture decisions for a product family (Krishnan & Gupta, 2001; Ulrich, 1995). Since Product A’s technology is becoming mature, the department head thinks this strategy can be improved by further optimising the project selection and evaluation process (i.e. the project portfolio management process).

Based on the above, the problem and related research question are formulated as follows.

Business problem:

- A lack of understanding of the effectiveness of the current R&D portfolio practice within the pre-development department may result in suboptimal risk management and decision-making.

Research question:

(1) How effective is the project portfolio management process and related decision-making of the pre-development department, and

(2) how can it be optimised regarding dealing with technological trends based on best practices found in the literature?

In this context, optimisation refers to identifying areas of improvement such as linking to firm strategy, and enhancing or rejuvenating the firm’s business model but also to the effective and timely development of platforms for exploiting new technology developed by research downstream in the organisation.

First, in order to address the business problem and research question, literature is investigated to answer the following sub questions:

- What is (R&D) project portfolio management?
- How is the process of (R&D) project portfolio management described in literature?
- What kind of decision-making processes exist regarding (R&D) project portfolio management?

Building on the research from Kester et al. (2011), sub questions to investigate the business problem are as follows:

- How does the current project portfolio process look like?
  - Who are the stakeholders and what is their role?
  - Which (input) documents are used?
  - What kind of decision-making is used: evidence-, power-, and opinion-based processes?
- How do technological trends affect the current decision-making style in the choices regarding a platform development business strategy?
- How do these decisions influence the relations between research, pre-development, and the business?
1.3 Objectives

The main objective is to answer the research question by investigating and addressing the business problem. Thereto, this thesis uses literature to identify portfolio decision-making processes and answer corresponding sub questions in this regard. This also helps to create a thorough understanding of the portfolio management process currently applied. Next, stakeholders will be identified and their objectives registered. Their role and influence in the process will be studied and conclusions drawn. Therefore, deliverables for the department head include:

1. Develop a map of the current project selection process for setting up the R&D mid- and long-term program of the pre-development department.
2. Provide recommendations for improvement of the current project portfolio management process of the pre-development department with regard to product platform development.

The research serves as a basis for further investigation across different companies where similar topics are present.

1.4 Structure of the thesis

The remainder of this thesis consists of a literature review to give insight into the current research status regarding R&D project portfolio management found in Chapter 2. Next, Chapter 3 presents the case-study, data collection and analyses. This leads to Chapter 4 where the findings of the case study are presented. In Chapter 5, the findings are discussed and recommendations are provided for the current selection process with reflection of literature. It also posits recommendations regarding a product platform strategy for the pre-development department. Finally, implications for managers and science as well as limitations and further research are discussed. Table 2 below shows the delineation of the report.

Table 2 – Structure of the master thesis.

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<td>• Description of the case study</td>
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<td>Findings</td>
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<td>• Actions for implementation</td>
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<td>• Re-design of current project portfolio process</td>
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<tr>
<td></td>
<td>• Implications for practice &amp; science</td>
</tr>
<tr>
<td></td>
<td>• Limitations &amp; further research</td>
</tr>
</tbody>
</table>
Chapter 2. Literature review

Portfolio management and the prioritization of new R&D projects has become a critical management task during the 90s (Roussel, Saad, & Erickson, 1991). Its main concern is proper resource allocation of the firm. It involves the alignment between technology development in an industry or environment and a firm’s business strategy. Today’s products decide tomorrow’s product/market profile of the firm. Approximately 50% of a firm’s sales today stems from products introduced to the market five years ago (Barczak, Griffin, & Kahn, 2009, p. 15). Portfolio management is also about balance to achieve an optimal mix between risk versus return, maintenance versus growth, and short-term versus long-term R&D projects. Since the strong link with the product portfolio, these objectives should lead to maximizing the value of the total product portfolio and maintain the firm’s competitive and financial position in the market (Cooper et al., 2001b).

Project portfolio management includes identifying, prioritizing, authorizing, managing, and controlling projects, programs, and other related work, to achieve specific strategic business objectives (PMI, 2001). It is a challenging, complex and multifaceted process vital to new product success. Researchers have stressed the dynamic nature of the decisions making involved (Cooper et al., 1999, p. 335):

“R&D project portfolio management for new products is a dynamic decision process whereby a business’s list of active new products and R&D projects is constantly updated and revised. In this process, new projects are evaluated, selected and prioritized; existing projects may be accelerated, killed or de-prioritized; and resources are allocated and re-allocated to the active projects. The portfolio decision process is characterized by uncertain and changing information, dynamic opportunities, multiple goals and strategic considerations, interdependence among projects, and multiple decision-makers and locations.”

Different stakeholders have a different understanding of portfolio management (Cooper et al., 2001b). For instance, the strategist sees it as allocating resources across businesses or developing a strategically correct portfolio to support the corporation’s vision and mission; as a way to manage the risk involved in dealing with new emerging technologies. Whereas, finance sees it as efficiently dividing scarce resources in order to achieve maximum shareholder value. The technical staff such as R&D managers and engineers will try to pick the right projects to foster the right kind of innovation, and see it as interesting work or employment for the next few months or years. While, on the other hand, a marketing person would hope that portfolio management yields better prioritization of projects and products and faster times to market resulting in more satisfied customers and better return on marketing investments. Finally, a CEO interprets portfolio management as a tool to produce big winners with positive financial impacts, preferably on short term.
Although much is written about the project portfolio management process, many challenges are still not fully understood or unaddressed. Table 3 provides an overview of the (unresolved) difficulties in NPD portfolio management (Loch & Kavadias, 2008, p. 138).

Table 3 – Challenges in NPD project portfolio management

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Authors</th>
<th>Type</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability a project will be successful in its technical objectives is usually difficult to know</td>
<td>Rubenstein and Schröder (1977)</td>
<td>Empirical</td>
<td>R&amp;D projects</td>
</tr>
<tr>
<td>Programs and projects often do not evolve in the same manner</td>
<td>Pich, Loch, and De Meyer (2002)</td>
<td>Conceptual</td>
<td>Project</td>
</tr>
<tr>
<td>NPD projects are characterized by lack of precise knowledge regarding their outcomes</td>
<td>Kavadias and Chao (2008)</td>
<td>Conceptual</td>
<td>Project / Product</td>
</tr>
<tr>
<td>Scarce resources critically constrain the NPD portfolio problem</td>
<td>Kavadias and Chao (2008)</td>
<td>Conceptual</td>
<td>Project / Product</td>
</tr>
<tr>
<td>Projects are interdependent</td>
<td>Kavadias and Chao (2008)</td>
<td>Conceptual</td>
<td>Project / Product</td>
</tr>
<tr>
<td>Difficult to quantify the potential of promising ideas or precisely measure the risks involved.</td>
<td>Kavadias and Chao (2008)</td>
<td>Conceptual</td>
<td>Project / Product</td>
</tr>
</tbody>
</table>

2.1 General stages of project portfolio management process

2.1.1 Overall project portfolio selection framework

Due to the high complexity of the portfolio selection process, Archer and Ghasemzadeh (2007, pp. 245-251) developed an extensive project portfolio selection framework (see Figure 2) that can help decision makers to move logically toward an integrated consideration of projects. The framework can be divided into three stages: pre-process, portfolio selection process, post-process. Each stage consists of several phases as shown in Table 4. Each stage and associated phases are described sequentially and depicted in Figure 2. Integration with other literature (e.g. strategy, resource allocation, coupling Stage-Gate) is done by the author. Table 4 below shows an overview of the project portfolio selection framework stages, phases and activities (Archer & Ghasemzadeh, 1999, p. 213).

Table 4 – Overview of the project portfolio selection framework stages, phases and activities.

<table>
<thead>
<tr>
<th>Process stage</th>
<th>Phase</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-process</td>
<td>Strategy development,</td>
<td>Strategic mapping</td>
</tr>
<tr>
<td></td>
<td>Methodology selection, Resource</td>
<td>Portfolio matrices</td>
</tr>
<tr>
<td></td>
<td>constraints &amp; Guidelines</td>
<td>Cluster analysis</td>
</tr>
<tr>
<td>Portfolio selection process</td>
<td>Pre-screening</td>
<td>Rejection of projects which do not meet portfolio criteria</td>
</tr>
<tr>
<td></td>
<td>Individual project analysis</td>
<td>Calculation of common parameters for each project</td>
</tr>
<tr>
<td></td>
<td>Screening</td>
<td>Rejecting non-viable projects</td>
</tr>
<tr>
<td></td>
<td>Portfolio Selection</td>
<td>Integrated consideration of project attributes, resource constraints, interactions</td>
</tr>
<tr>
<td></td>
<td>Portfolio adjustment</td>
<td>User-directed adjustments</td>
</tr>
<tr>
<td>Post-process</td>
<td>Final portfolio</td>
<td>Project development</td>
</tr>
</tbody>
</table>
2.1.2 Pre-process stage

The pre-process stage involves strategy development and methodology selection before the actual selection process begins. This stage provides the basis for the whole selection process by defining strategic guidelines and determining upfront resource allocation. Strategic and new product development literature stressed the importance of resource allocation for effective NPD (Bower, 1986; Cooper, Edgett, & Kleinschmidt, 1998a; Kavadias & Loch, 2003; Roussel et al., 1991). Meskendahl (2010) suggested that strategic orientation moderates the relation between project portfolio structuring and project portfolio success. Furthermore, she posited that strategy orientation is positively related to successful project portfolio structuring. Thus, strategy development increases the likelihood of successful portfolio selection. A strong link between strategy and project and portfolio management can be found in other literature as well (Cooper et al., 1999; Jamieson & Morris, 2004; Klingebiel & Rammer, 2013).

Strategy development must occur before engaging in portfolio selection and enables a firm to deploy its focus through available projects (Figure 3). It includes an overall division of budget. Cooper et al. (2001b) Chapter 5 delineates a wide variety of complex strategic implications involving many factors, including marketplace and the company’s strengths and weaknesses.

Figure 2 – Project portfolio selection framework (Archer & Ghasemzadeh, 2007).

Figure 3 – Strategy development.
Methodology selection is about the tools and methods applied for selecting and evaluating the projects that enter the portfolio selection process (Figure 4 and section 2.2 “Project portfolio management methods”). Therefore, it is also a strategic process and should be determined a priori. Typically, selecting the right methods is a one-time event. Furthermore, the choice of methods is also strongly dependent on the decision makers’ understanding and willingness to learn new approaches. Lastly, it is critical that common measures (e.g., NPV, scoring attributes, valuation of risk, etc.) are chosen so they can be calculated separately for each project under consideration, allowing an equitable comparison of the projects (Archer & Ghasemzadeh, 1999).

2.1.3 Portfolio selection process stage

The portfolio selection process stage involves the “periodic activity involved in selecting a portfolio, from available project proposals and projects currently underway, that meets the organization’s stated objectives in a desirable manner without exceeding available resources or violating other constraints” (Archer & Ghasemzadeh, 1999, p. 208). It consists of five subsequent phases: pre-screening, individual project analysis, screening, optimal portfolio selection, and portfolio adjustment (see Figure 5). The phases are discussed accordingly.

Pre-screening is necessary to ensure that all projects entering the process are somehow classified and aligned with a particular strategic topic determined during the strategy development stage. However, there is possibility that some criteria override the strategic considerations such as sacred cows (by influence of key stakeholders), operating and competitive necessity. Furthermore, Chien (2002) suggested that in this phase, projects should also be classified as independent, interrelated, or synergistic.

During Individual project analysis, each project is individually assessed with the aim of having a common set of parameters in order to make an equivalent comparison between competing projects. Mostly, this assessment is based on feasibility studies and/or from a database of previously completed projects (Archer & Ghasemzadeh, 2007, p. 249). Both quantitative and qualitative data are required to form a complete set of parameter estimates. Individual project analysis is best practised with a formal Stage Gate process in place. Typically at this phase, the portfolio selection process could intertwine with the Stage Gate process (Cooper, 1990).

Next, the Screening phase follows where data from the previous phase is carefully examined to “eliminate any projects or interrelated families of projects that do not meet pre-set criteria such as estimated rate of return, except for those projects that are mandatory or required to support other projects still being considered” (Archer & Ghasemzadeh, 2007, p. 249). Furthermore, this phase may also be used to eliminate projects not matching strategic focus of the firm or do not yet have sufficient information upon which to base a logical decision. Additionally, Lieb (1998) posited that this is the phase to consider the optimal number of research projects to be developed for NPD portfolios. Research and development is viewed as a two-stage process, where the task of research is to reduce the uncertainty for eventual development. He concludes by saying that an optimum fraction of projects usually exists and that
optimum fraction is critically dependent on the relative average research project cost and effectiveness compared to development.

The **Optimal portfolio selection** phase is to optimise the preceding stages. Typically, interactions among the various projects are considered, including interdependencies, competition for resources, and timing, with the value of each project determined from a common set of parameters that were estimated for each project in the previous phase. In the first step, the relative total benefit is determined for each project involving comparison methods such as AHP, pairwise comparison and Q-sort (especially for smaller amounts of projects). In the second step, all project interactions, resource limitations, and other constraints should be included in an initial optimization of the overall portfolio.

Finally, this leads to the **Portfolio adjustment** phase where the optimal portfolio is being represented, using matrix-type displays, and re-evaluated to obtain a portfolio that meets the objectives of the organization optimally or near-optimally. Important here, is to reflect on and consider balance in the developed portfolio. Balance with regard to, for example, the scope, risk, and size of the projects. Furthermore, decision makers should be able to make changes at this phase, and if these changes are substantially different from the optimal portfolio developed in the previous phase, it may be necessary to recycle back to recalculate portfolio parameters such as project schedules and time-dependent resource requirements (Archer & Ghasemzadeh, 2007).

### 2.1.4 Post-process stage

For completeness, the post-process stage (see Figure 6) is included where the final developed portfolio of projects is ready to be executed. The **Project development** and **Project evaluation** can generate data from experience that are highly useful to learning and project evaluation. Furthermore, projects that have reached major milestones or gates can be re-evaluated at the same time as new projects being considered for selection. This allows a combined portfolio to be generated within available resource constraints (Archer & Ghasemzadeh, 2007).

![Figure 1 – Post-process stage.](image)

### 2.2 Project portfolio management methods

This part of the study provides insight into the current decision-making selection support methods and systems for uncertain R&D projects. Numerous methods are described in literature to carry out the project portfolio management process. Linton, Walsh, and Morabito (2002) concluded in their literature review that the project selection techniques can be divided into management science techniques (Amer, Fox, & Smith, 1994; Bard, 1990; Bard, Balachandra, & Kaufmann, 1988; Brenner, 1994; Cardús, Fuhrer, Martin, & Thrall, 1982; Czajkowski & Jones, 1986; Dias Júnior, 1986; Golabi, 1987; Liberatore, 1988; Lockett, Hetherington, Yallup, Stratford, & Cox, 1986; Moore & Baker, 1969a, 1969b; Ringuest & Graves, 1989, 1990) and graphic decision support systems (Cooper, Edgett, & Kleinschmidt, 1998b). First, an overview is provided of each method, tools and its pros and cons in Table 5. Next, a more detailed description is provided in the subsequent sections.
Table 5 – Overview of project portfolio management methods and tools.

<table>
<thead>
<tr>
<th>Type of method</th>
<th>Concrete tool</th>
<th>Pros and cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Net Present Value (NPV) combined with the Internal Rate of Return (IRR)</td>
<td>Tends to disfavour advanced technology projects due to the long-term payoffs and high likelihood of failure (-).</td>
</tr>
<tr>
<td></td>
<td>Bang-for-Buck Index (NPV of the project divided by the total resources remaining to be spent on the project)</td>
<td></td>
</tr>
<tr>
<td>Scoring</td>
<td>Criteria used:</td>
<td>Weighting and scores is a subjective process that depends as much on personal opinion as on hard numbers (+).</td>
</tr>
<tr>
<td></td>
<td>▪ strategic alignment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ product advantage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ market attractiveness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ ability to leverage core competences</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ technical feasibility</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ risk vs. reward</td>
<td>Appropriate with low degree of interdependence between projects.</td>
</tr>
<tr>
<td>Probabilistic</td>
<td>Excepted Commercial Value:</td>
<td>Useful in later stages of development (-).</td>
</tr>
<tr>
<td></td>
<td>▪ Recognising incremental process through options</td>
<td>Rely on single financial criterion and quantitative data (-).</td>
</tr>
<tr>
<td></td>
<td>▪ Constrained resources</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Maximize the value</td>
<td>Neglects the balance of the portfolio (-).</td>
</tr>
<tr>
<td>Behavioural</td>
<td>▪ Modified Delphi: a repeated open discussion and individual decision-making with visualisation of result.</td>
<td>Useful in early stages when no accurate quantitative data is available (+).</td>
</tr>
<tr>
<td></td>
<td>▪ Q-sort: a repeated open discussion with sorting a deck of cards (projects) from high to low or yes/no.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ AHP (paired comparison): paired ranking of both projects and criteria.</td>
<td></td>
</tr>
<tr>
<td>Mathematical</td>
<td>Linear, integer, dynamic programming. Using decision theory, game theory, or probability theory.</td>
<td>Inflexible nature and limited consideration of alternatives (-). Objectives must be quantifiable (-).</td>
</tr>
<tr>
<td>Decision support systems</td>
<td>PASS:</td>
<td>For managers doing largely analytical work in less structured non-routine situations with unclear criteria for success. Requires detailed analytical understanding and data input of the decision maker (-).</td>
</tr>
<tr>
<td></td>
<td>▪ Resource limitations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Timing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Balancing criteria</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Interconnectedness among projects</td>
<td></td>
</tr>
<tr>
<td>Mapping approaches</td>
<td>▪ Aid group decision-making with a display of the projects in relationship to factors that need to be balanced.</td>
<td>Positive correlation between the use of portfolio maps and portfolio objectives (+).</td>
</tr>
<tr>
<td></td>
<td>▪ Portfolio grids/Matrices/Bubble charts:</td>
<td>25-40% uses portfolio maps.</td>
</tr>
<tr>
<td></td>
<td>▪ Reward (NPV, IRR, benefits after years of launch; market value) vs. Risk (technical, commercial)</td>
<td>Used as a supporting tool, not decision-making tool.</td>
</tr>
<tr>
<td>Strategic</td>
<td>Divide the overall resource budget into smaller, focused budgets (buckets).</td>
<td>A strategic bucket is aligned with an innovation strategy; Top-down as well as bottom-up (+).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prevents completely different projects to compete for the same resources (+).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Frequently used by best practices (+).</td>
</tr>
</tbody>
</table>
2.2.1 Financial or Economic models
According to Cooper et al. (2001b), the most common and straightforward approach for ranking projects to see which one provides maximum value is the Net Present Value (NPV). It is mostly combined with the Internal Rate of Return (IRR) and compared to cut-off criteria for making Go/Kill decisions. However in portfolio reviews with many projects, the NPV is displayed along with its resource requirements. Eventually, to make an honest comparison the Bang-for-Buck Index is applied; NPV of the project divided by the total resources remaining to be spent on the project. Still, theoretically this looks promising. However, the NPV method ignores probabilities and risk; it assumes that financial projections are accurate; and it fails to deal with constrained resources. Finally, it assumes an all-or-nothing investment decision, whereas in new product projects, the decision process is an incremental one.

Another popular financial method is the Productivity Index (PI) (Cooper et al., 2001b, pp. 40-41) which is the probability-adjusted NPV divided by R&D costs remaining in the project (alternately, divided by the total costs remaining). Projects are rank ordered according to this index (Bard et al., 1988; Cooper et al., 1999; Matheson, Menke, & Derby, 1989).

In contrast to what might be expected is that organizations that solely rely on financial tools perform less. According to Cooper et al. (1999) these firms showed the worst performance results in terms of poor value projects in the portfolio, too many projects for the resources available, and projects not done on time; creating a gridlock in the portfolio. This is in accordance with other, more recent research (Killen, Hunt, & Kleinschmidt, 2008). Another drawback of financial methods is that the outcome can be unreliable since project data is often speculative until market launch; there is no accurate data (Linton et al., 2002). Financial methods also “tend to disfavour advanced technology projects due to the long-term payoffs and high likelihood of failure” (Chao & Kavadias, 2008).

2.2.2 Scoring Models and Checklists
Scoring models can be used for making Go/Kill decisions at gates but can also be applied for project prioritization in portfolio management. Typically, the following criteria are used in scoring models: strategic alignment, product advantage, market attractiveness, ability to leverage core competences, technical feasibility and risk vs. reward. Then, the criteria can be weighted in some type of algorithm (additive or multiplicative) to emphasize the importance of some criteria over others which results in a figure of merit for each proposal.

Generally, they require a well-informed management group to assess a project on a variety of characteristics. Determining the weighting and scores is a subjective process that depends as much on personal opinion as on hard numbers (Coldrick, Longhurst, Ivey, & Hannis, 2005). According to Henriksen and Traynor (1999) “scoring is appropriate when there is a low degree of interdependence between projects, that is, when the activities and results of one project do not depend on the activities and results of a different project”. Furthermore, an important advantage of scoring in comparison with other methods is that it is “quantitative enough to possess a certain degree of rigor, yet not so complex as to mystify and hence discourage potential users”.

Research by Cooper et al. (1998a) revealed that scoring models produce a strategically aligned portfolio and one that reflects the business’s spending priorities. Furthermore, they yield effective and efficient decisions, and result in a portfolio of high value projects.

2.2.3 Probabilistic Financial Models
The main reason for these probabilistic financial models is to modify the previously mentioned models to better handle the element of risk and uncertainty evident in most development projects. Two main approaches are Monte Carlo simulation (such as the add-on programs to various spread sheets, such as At
Risk and Crystal Ball) and decision trees (such as the expected commercial value (ECV) method). A theory that is gaining popularity is the Options Pricing Theory (OPT) (Cooper, Edgett, & Kleinschmidt, 2000; Cooper et al., 2001b).

The Expected Commercial Value (ECV) (see Appendix C.4) method seeks to maximize the expected value or expected commercial worth of the portfolio, subject to budget constraints, while taking into account risk and probabilities.

Options pricing (or real options) recognizes that investments in projects should be done incrementally instead of the all-or-nothing approach (Faulkner, 1996). The ability to buy options instead of making the full investment reduces the risk of the project. This risk-reducing nature of the incremental decision process has monetary value that is ignored in traditional NPV calculations. When the project is high-risk, the traditional discounted cash flow calculations considerably understate the true value of the project. Remarkably, though OPT is yet to be thoroughly assessed, many firms indicate to use real options approaches. Especially to evaluate higher risk, larger, longer-term, and platform projects (Cooper et al., 2001b).

Conclusively, both (probabilistic) financial and economical methods are generally more effective in later stages of the development process. This is mainly due to the absence of reliable financial and other quantitative data.

2.2.4 Behavioural Approaches

Behavioural approaches are designed to bring managers to consensus in terms of which projects to undertake. Commonly used methods are Delphi and Q-sort (Lilien & Kotler, 1983; Souder & Mandakovic, 1986).

Modified Delphi is a method of integrating the collective wisdom of a decision-making group. It facilitates a behavioural process where a group of decision makers engage in open discussion, followed by individual decision making. After one round the decisions or best guesses of each participant are displayed which leads to more discussion. Subsequently, more discussion occurs followed by individual decision-making. Several subsequent rounds of decision-making eventually lead to consensus.

Cooper et al. (2001b) mentioned that Q-sort is “the simplest and most effective method for rank-ordering a set of new product proposals”, especially in the early stages of a project. Furthermore, Q-sort is the most adaptable in achieving group consensus (Archer & Ghasemzadeh, 1999). Each participant is given a deck of cards wherein every card denotes a particular project to be ranked. An open discussion is held on all projects and each member sorts and resorts the deck into five categories (from “high” to “low”, or a simple “yes” or “no”). The results of all projects are then put in order and displayed. After several rounds of discussion the group usually moves to consensus on the ranking of projects.

Paired comparison models and Analytical Hierarchy Processes (AHP), such as Expert Choice, are decision tools based on paired comparisons of both projects and criteria. They allow a decision-making group to select a subset of projects from a larger list, or to rank a list of projects. AHP methods force choices between pairs of criteria in order to determine the relative importance of each criterion. Subsequently, it forces to choose between a number of pairs of projects on these criteria. Eventually, the “decisions are analysed by a sophisticated computer model which provides rank order of the projects and the strength of preferences” (Cooper et al., 2001b).

Behavioural methods are particularly useful in the early stages of a project when no accurate quantitative data is available, merely qualitative information. A major disadvantage of Q-sort, pairwise comparison and AHP is the large number of comparisons involved, which makes it difficult to use for comparing large
numbers of projects. Furthermore, the process must be repeated whenever a project is added or deleted from the list. This makes these methods a time-consuming, inflexible activity. Finally, AHP, pairwise comparison, and Q-sort become cumbersome and unwieldy for larger numbers of projects.

2.2.5 Mathematical Optimization Procedures
Mathematical optimization models are part of the original portfolio models and consist of mathematical routines that attempt to optimize some objective function (e.g. profit) which is subject to resource constraints (money, expert-personnel, person-days). They include techniques such as linear, integer, and dynamic programming but also decision theory, game theory, and probability theory (Curwin & Slater, 2008; Lapin, 1991). However, the main caveat of these models is the inflexible nature and limited consideration of alternatives. Additionally, the objectives must be quantifiable and specific leaving no room for factors such as judgment and experience (Cooper et al., 2001b).

2.2.6 Decision Support Systems
According to Turban (1990) a decision support system (DSS) is “an interactive, flexible, and adaptable computer-based information system that utilizes decision rules, models coupled with a comprehensive database and the decision maker’s own insights, leading to specific, implementable decisions in solving problems that would not be amenable to management science optimization”. Typically, these models are more flexible because of the inclusion of the decision maker as part of the system. DSSs are “intended to support managers who are doing largely analytical work in less structured, non-routine situations with unclear criteria for success” (Cooper et al., 2001b). A DSS relies on simulation, statistical methods, and optimization models to guide management through the decision-making process. A prominent example is the Project Analysis and Support System (PASS) developed by Ghasemzadeh and Archer (2000). It considers resource limitations, timing, balancing criteria, and interconnectedness among projects. Taken these into account, it then maximizes the total portfolio benefit. Other examples are the models of Chu, Hsu, and Fehling (1996), Graves, Ringuest, and Case (2000), Ringuest et al. (1999), Kocaoglu and Guven Iyigun (1994), and Lin and Hsieh (2004). Decision Support Systems often require detailed analytical understanding and data input on the part of the decision makers. Executives rather receive the end results instead of doing the analytical work themselves which might explain the limited use of these methods.

2.2.7 Mapping Approaches
One of the primary aims of portfolio maps is to aid group decision-making by providing a display of the projects in relationship to factors that need to be balanced. Mostly, they are provided as bubble charts and portfolio grids or matrices divided into four quadrants being Pearls, Bread and Butter, White Elephants, and Oysters. Essentially, these are extensions of the original Boston Consulting Group (BCG) portfolio models (stars, cash cows, dogs, wildcats) which were designed to allocate resources across the business units in a corporation. Basically, various parameters are plotted against each other in a bubble diagram format. Although they appear to be equal to the BCG models, the axes are quite different, and projects rather than business units are plotted (Day, 1977). Most common examples are plots containing Reward versus Probability-of-Success or Ease-of-Undertaking versus Project-Attractiveness. Other types of chart can be seen in Table 6.

Table 6 – Axes used in popular bubble diagram plots (Cooper, Edgett, & Kleinschmidt, 2001a).

<table>
<thead>
<tr>
<th>Rank</th>
<th>Type of chart</th>
<th>X-axis</th>
<th>Y-axis</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Risk vs. Reward</td>
<td>Reward: NPV, IRR, benefits</td>
<td>Probability of success (technical,</td>
<td>44.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>after years of launch; market</td>
<td>commercial</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Newness</td>
<td>Technical newness</td>
<td>Market newness</td>
<td>11.1</td>
</tr>
<tr>
<td>3</td>
<td>Ease vs. Attractiveness</td>
<td>Technical feasibility</td>
<td>Market attractiveness (growth potential,</td>
<td>11.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>consumer appeal, life cycle</td>
<td></td>
</tr>
</tbody>
</table>
2.2.8 Strategic methods

Strategic methods strive to divide the overall resource budget into smaller, more focused budgets resulting in a set of strategic buckets for managing the NPD portfolio. A strategic bucket is “a collection of NPD programs that are aligned with a particular innovation strategy. The NPD programs in a strategic bucket may involve process improvements and cost reductions, minor product modifications, radical next-generation technological research, or ground-breaking R&D initiatives”, said so by Chao and Kavadias (2008).

According to Cooper et al. (2001b), resource allocation in strategic buckets should be carried out top-down as well as bottom-up. Top-down implies that, from a strategic point of view, some areas merit more than the normal allocation, other areas merit less. Bottom-up involves an opportunistic approach in that it must consider the specific projects and opportunities that each business area has. An advantage of the strategic bucket method is that it prevents completely different projects to compete for the same resources by creating “non-permeable partitions between dissimilar NPD programs to ensure access to resources for projects that are seemingly unattractive to commonly used project valuation methods” (Chao & Kavadias, 2008). Evidence suggests that best practices with a well-defined, structured portfolio management process make more frequent use of strategic buckets than their less performing counterparts (Barczak et al., 2009).

2.2.9 What portfolio methods can be considered best practices?

Best practices are methods used by firms that excel in R&D management and enjoy a superior performance. Research shows that these firms employ similar methods as less well performing firms but use these methods more and in a more formal way. They explicitly manage their portfolio of projects: “they rely on clear, well-defined portfolio procedures, consistently apply their portfolio method to all projects, and management buys into the approach” (Cooper et al., 1999). The four applied performance indicators are summarised in Table 7 (Cooper et al., 2000). A firm’s focus can be on either one of them and influences the choice in portfolio methods.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Method</th>
<th>Performance Indicators</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Strengths vs. attractiveness</td>
<td>Competitive position (strengths) Attractiveness (market growth, technical maturity, year to implementation)</td>
<td>11.1</td>
</tr>
<tr>
<td>5</td>
<td>Cost vs. timing</td>
<td>Cost to implement Time to impact</td>
<td>9.7</td>
</tr>
<tr>
<td>6</td>
<td>Strategic vs. benefit</td>
<td>Strategic focus or fit Business intent, NPV, financial fit, attractiveness</td>
<td>8.9</td>
</tr>
<tr>
<td>7</td>
<td>Cost vs. benefit</td>
<td>Cumulative reward Cumulative development costs</td>
<td>5.6</td>
</tr>
</tbody>
</table>

*Rank ordered, in descending order of popularity; last column shows percentage breakdown of bubble diagram usage (as a per cent of businesses using bubble diagrams).*

Killen et al. (2008) found a strong positive correlation between the use of portfolio maps and four performance measures relating to balancing the portfolio, developing existing technologies and technological competencies, alignment with strategic objectives, and the portfolio containing high value projects. Among businesses known to be active in new product development practices, approximately 25 to 40% use portfolio maps (Cooper et al., 2001a; Killen et al., 2008).

Bubble diagrams are the most commonly used mapping approach and often strongly supported by senior management. However, bubble diagrams should not be used for making portfolio decisions but rather as a supporting tool (Cooper et al., 2001a). Evidently, bubble diagrams seem to be used as a discussion tool to display the current portfolio breakdown, the “what is” (Cooper et al., 2001b).
Table 7 – Project portfolio management objectives clarified (Cooper et al., 2000).

<table>
<thead>
<tr>
<th>Objective</th>
<th>Clarified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value maximization</td>
<td>Allocating scarce resources so as to maximize the sum of the values or commercial worths of all active projects in the pipeline. Denoted in terms of some business objective (such as long term profitability, EVA, return-on-investment, likelihood of success, or some other strategic objectives).</td>
</tr>
<tr>
<td>Seek balance in the portfolio</td>
<td>Achieve balance in terms of long-term projects versus short ones; high risk versus lower risk projects; and across various markets, technologies, product categories, and project types (e.g., new products, improvements, cost reductions, maintenance and fixes, and fundamental research).</td>
</tr>
<tr>
<td>Alignment with strategy</td>
<td>Regardless of all other considerations, make sure the final portfolio of projects truly reflects the business’s strategy.</td>
</tr>
<tr>
<td>Allocation of resources to the right projects</td>
<td>Ensure a balance between resources required for the “Go” projects and resources available, thereby preventing a pipeline gridlock (i.e. projects ending up in a queue or taking increased time to market).</td>
</tr>
</tbody>
</table>

In a benchmark study carried out by Cooper et al. (1999), 205 North American companies which were known to be active in new product development were investigated. Main industries that participated were amongst others chemicals and advanced materials, high technology and consumer goods. It was found that firms relying solely on financial methods perform worse. Precisely for this reason, best practices apply a combination of methods and techniques. On average, the NPD portfolio selection process utilizes 2.4 techniques in the typical firm (Cooper et al., 1999). According to Figure 7, financial methods are the most dominant portfolio methods employed, followed by business strategy methods.

Figure 7 – Dominant portfolio methods employed in best in class firms (Cooper et al., 1999).

Furthermore, an overview of what particular methods and techniques best in class firms use to achieve their success on each portfolio performance metric is provided in Table 8. It shows that financial methods combined with scoring models and checklists are best used for value maximization. Scoring models and checklists are particularly useful to seek balance in the portfolio. Bubble diagrams and strategic methods are applied to alignment with strategy and doing the right projects.

Table 8 – Combination of methods best suited for each portfolio objective (Cooper et al., 2001a).

<table>
<thead>
<tr>
<th>Performance Metric</th>
<th>Financial Methods</th>
<th>Strategic Methods</th>
<th>Scoring Model and Checklists</th>
<th>Bubble Diagrams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value maximization</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seek balance in the portfolio</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alignment with strategy</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allocation of resources to the right projects</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.3 Subjective side of R&D project portfolio management

Until recently, the actual decision-making process in project portfolio management remained a black box; little research had focused on it. Previous literature had focused on project portfolio selection processes.
Most of this work considered decision-making as a “rational, evidence-based rigorous comparison of numbers” (Kester et al., 2011). However, recent work takes a more nuanced view and is sensitive to power and subjective influence. It was inspired by research showing that companies that relied solely on quantitative, financial methods in project selection decision-making performed worst! (Cooper et al., 2004a; Cooper, Edgett, & Kleinschmidt, 2004b, 2004c).

A formal definition of the project portfolio decision process is given (Cooper et al., 2001a):

“It encompasses or overlaps a number of decision-making processes within the business, including periodic reviews of the total portfolio of all projects (looking at the entire set of projects, and comparing all projects against each other), making Go/Kill decisions on individual projects on an on-going basis (using gates or a Stage-Gate® process (Cooper, 1990)), and developing a new product strategy for the business, complete with strategic resource allocation decisions.”

Project portfolio decisions deal with uncertain information and require a long-term vision. Additionally, these decisions should not only be based on individual project characteristics but they should also be placed in the context of the whole portfolio and the achievement of strategic goals (Kester, Hultink, & Lauche, 2009). Next, a more in-depth approach of this literature stream is provided. First, portfolio decision-making genres are identified in accordance with Kester et al. (2009). Second, project portfolio decision-making processes and their implications on decision-making effectiveness are outlined.

2.3.1 Project portfolio decision-making genres

Kester et al. (2009) investigated what kinds of project portfolio decision-making genres are commonly applied. Through an in-depth interview study of 19 key informants in 11 multinational firms, three genres were identified: formalist-reactive, intuitive, and integrative. These genres are outlined and linked to a unique set of project portfolio management methods.

**Formalist-reactive** firms – their approach toward portfolio management is determined by responses to competitor actions and a focus on incremental new products.

**Intuitive** firms – portfolio decisions are guided by the managers’ insights and less by a strategic approach. Their attitude toward NPD depends on the risk profiles of decision makers.

**Integrative** firms – their portfolio decision-making is driven by a strategic vision and by a desire to obtain market leadership.

In their framework, the authors linked each genre to an innovation strategy and posited several challenges to consider. They showed that firms with a reactive strategy lose out on more radical innovation opportunities due to their number-driven approach they tended to align with low risk innovation profiles. Intuitive firms had difficulties to select “the best” overall set of projects and risk profiles depended on the individual risk profiles of the decision makers. Integrative firms emphasized strategic considerations and tended to take higher risks. However, they could be overenthusiastic in selecting the right number of projects which lead to an over-commitment of resources. Other authors promoted this latter approach (Cooper et al., 2001b).

Portfolio methods described in “Project portfolio management methods” on page 9 are linked to the different decision-making genres and shown in Table 9. It shows that formalist-reactive firms, characterised by responsive behaviour and focus on incremental innovation, rely on financial methods and mapping approaches. Intuitive firms, wherein portfolio decisions are guided by the managers’ insights, merely apply behavioural approaches. Integrative firms, which are driven by a strategic vision
and a desire to obtain market leadership, recognise that different degrees of innovativeness require different decision-making methods.

Table 9 – Project portfolio methods linked to different decision-making genres.

<table>
<thead>
<tr>
<th>Method</th>
<th>Formalist-reactive firms</th>
<th>Intuitive firms</th>
<th>Integrative firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial methods (Section 2.2.1)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real options (Section 2.2.1)</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Scoring models and Checklists (Section 2.2.2)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Probabilistic financial methods (Section 2.2.3)</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Behavioural approaches (Section 2.2.4)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytical Hierarchy Approach (Section 2.2.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dynamic programming models (Section 2.2.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mapping approaches (Section 2.2.7)</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Strategic methods (Section 2.2.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What can be learned from the research of Kester et al. (2009), is that when firms want to achieve both innovativeness (explore new opportunities) and market leadership (exploit current innovations) they should at least consider this in their project portfolio decision-making methods in order to be successful. Kester et al. (2009) revealed that there are different decision-making genres but the link with decision-making effectiveness is not addressed.

2.3.2 Project portfolio decision-making effectiveness

Kester et al. (2011) investigated decision-making effectiveness by introducing intuitive and power processes in addition to decision-making based on objective data. Since most preceding literature investigated portfolio management decisions as individually discrete decisions, this research provides insights into how some of those components may be combined for best interest of the firm’s portfolio. Their model is exhibited in Figure 8. Decision-making effectiveness is defined to which degree a firm has a portfolio mind-set, is agile and creates a focused effort. Thus, managers should make decisions based on a complete understanding of all the R&D projects in their portfolio aligned with the firm’s strategic goals. Agile decision-making prevents firms from lagging behind when new technologies are invented, and a focus prevents teams from chasing every possible innovation. In the model, the dimensions (mind-set, agility, and focus) are preceded by the decision-making processes: evidence-, power- and opinion-based.

Figure 8 – General model for project portfolio decision-making (Kester et al., 2011).
With evidence-based decision-making, the project’s technical, financial and market information is subjected to an in-depth discussion among decision-makers. Power-based decisions occur when goals of individuals, subgroups or even company goals are suppressed by other individuals or subgroups. This type of decision-making may not take the best interest of the firm into account. Furthermore, portfolio decisions can also be made on personal experiences and feelings. This process is called opinion-based decision-making. Since there is no argumentation about specific pieces of evidence, personal conflicts arise in all likelihood.

Findings of Kester et al. (2011) indicate that decision processes rarely depend purely on one process but rather occur in parallel as an integrated system of processes. Also, they state that the processes that are activated depend on cultural factors, such as trust and leadership style. Additionally, Kester et al. (2011) “indicate that opinion- and power-based processes – triggering intuition and politics – become more dominant in breakthrough product areas with a high uncertainty concerning the available information” (Kolbe et al., 2013). Lastly, they found that managers engaging in political behaviour but with the best interest for firm and stakeholders lead to successful NPD project portfolio decisions. Peculiarly, this contradicts other literature that stresses the negative effects of politics on decision outcomes (Dean & Sharfman, 1996; Eisenhardt & Bourgeois, 1988; Elbanna & Child, 2007).

In addition, Kolbe et al. (2013) found that rationality and intuition interact with each other in an on-going process throughout the decision. Furthermore, rational decision contexts facilitate more effective political processes and managers that make their intuitions explicit and respond to their co-workers decisions improve the effectiveness of the political decision making process. They proposed that a high level of alternation between intuitive and rational decision processes leads to a lower amount of political behaviour.

Decision-making literature has been enriched for the past decades. The author of this thesis tabulated the main findings with accompanied dimensions (if present) in Table 10 and shows the link with project portfolio management. Early research has investigated project portfolio management decisions as individually discrete decisions. However, project portfolio decision-making is better understood if considered as an integrated system of processes applying different decision styles simultaneously. Table 10 is discussed below.

Table 10 – Literature overview regarding decision-making and link with project portfolio management.

<table>
<thead>
<tr>
<th>Author</th>
<th>Topic</th>
<th>Methods</th>
<th>Findings</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kester et al. (2009)</td>
<td>Decision-making genres</td>
<td>Qualitative interview study in 11 multinational firms</td>
<td>Three genres of portfolio decision making: formalist-reactive, intuitive and integrative, each with a unique set of PPM practices.</td>
<td>Rationality, Intuition, Politics</td>
</tr>
<tr>
<td>Kester et al. (2011)</td>
<td>Decision-making processes</td>
<td>Qualitative multiple-case study, four companies in different industries</td>
<td>Managers use different types of portfolio decision making processes and need the right inputs for them. Decision making as a rational-, political- and intuitive-based process.</td>
<td>Rationality, Intuition, Politics</td>
</tr>
<tr>
<td>Kolbe et al. (2013)</td>
<td>Combining decision-making processes</td>
<td>Qualitative single-case study, 35 semi-structured interviews, 28 non-participant meetings</td>
<td>Rationality and intuition interact with each other in an on-going process, rational decision contexts facilitate more effective political processes, high level of alternation between intuitive and rational decision processes leads to a less political behaviour.</td>
<td>Rationality, Intuition, Politics</td>
</tr>
<tr>
<td>Christiansen and Varnes (2008)</td>
<td>Behaviour of decision makers in portfolio</td>
<td>Single case-study</td>
<td>Managers do not follow the rules agreed for PPM in their decision making, but they observe others,</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Method</td>
<td>Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Singh and Xin (2012)</td>
<td>Qualitative research with 5 semi structured interviews; coding</td>
<td>Strategy and vision (small &amp; big), Creativity and intuition (small), Evidence based (big), Cross functionality (big &amp; small)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Martinsuo and Lehtonen (2007)</td>
<td>Questionnaire survey with 279 respondents</td>
<td>Single project management, i.e., goal setting, information availability and systematic decision making, has a significant effect on PPM success</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dean and Sharfman (1996)</td>
<td>A longitudinal field study design of 52 decisions in 24 companies</td>
<td>Procedural rationality is positively related and political behaviour is negatively related to decision effectiveness, Rationality, Politics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dean and Sharfman (1993)</td>
<td>61 strategic decisions in 24 companies</td>
<td>Procedural rationality and political behaviour are independent dimensions of the strategic decision-making process, Rationality, Politics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atuahene-Gima and Li (2004)</td>
<td>Questionnaire and in-depth interviews with 373 Chinese new technology ventures</td>
<td>Decision comprehensiveness leads to better/worse product performance if technological/market uncertainty is high, Rationality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elbanna and Child (2007)</td>
<td>Stage 1: 128 questionnaires addressing 117 strategic decisions.</td>
<td>Rationality is positively related to decision effectiveness; Rationality, Intuition, Politics</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stage 2: Four hundred questionnaires in private Egyptian manufacturing companies (response rate 42%)</td>
<td>Intuition is weakly positively related to decision effectiveness; Politics is negatively related to decision effectiveness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cowlrick, Hedner, Wolf, Olausson, and Klofsten (2011)</td>
<td>Web-based questionnaire, 52 respondents made five sets of judgment</td>
<td>Substantial differences in individual judgment in drug discovery and development which may reflect judgment in the real world, Intuition</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Earlier research on strategic decision-making found no empirical evidence of the relationship between rationality and political behaviour, and ignored possible intuitive behaviour (Dean & Sharfman, 1993). However, in a subsequent study the authors did find a relation of each dimension with decision effectiveness (Dean & Sharfman, 1996).

Other research showed the importance of considering intuition based decision-making (Cowlrick et al., 2011). Other research, based solely on the rationality dimension, emphasizes to pay careful attention to the (uncertain) information requirements in an environment when deploying a comprehensive strategic decision-making process during NPD. They noted to keep an eye on both demand and technology conditions (Atuahene-Gima & Li, 2004). This is important when the link between product and project portfolios becomes apparent. Considering studies that combined all three dimensions (i.e. rationality, intuition, and politics), their outcomes showed that rationality and intuition are positively related to decision-making effectiveness, while politics have a negative effect (Elbanna & Child, 2007).

For the last six years, the human side of project portfolio decision-making processes is investigated. These studies also measure on different axes of decision-making with respect to project portfolio: i.e. behaviour of decision-makers (Christiansen & Varnes, 2008), company size (Singh & Xin, 2012), effect of project management (Martinsuo & Lehtonen, 2007), different practices (Kester et al., 2009). In conclusion, these recent studies show that the decision-process in R&D PPM should not be seen as a singular process but as a span of interrelated decision-making processes (Kester et al., 2011).
2.4 Conclusion of literature study

So far, project portfolio management literature has evolved from single project management tools (Baker & Freeland, 1975) to holistic portfolio methods (Cooper et al., 2001b). Consequently, portfolio selection models were highly mathematical and involved techniques such as linear, dynamic and integer programming. During the years, more qualitative models emerged such as mapping approaches, scoring models and checklists. It was found that well performing firms make more use of these tools and in a more formal way. They rely on clear, well-defined portfolio procedures and consistently apply their portfolio method to all projects. A complete understanding of the portfolio selection process has been developed, revised, and optimised (Archer & Ghasemzadeh, 2007; Archer & Ghasemzadeh, 1999). Also the subjective side of decision-making in R&D project portfolio management (Kester et al., 2011) has been investigated.

A separate stream of literature indicated that the integration of market requirements and technological capabilities during new product development increases success (Kahn, 1996; Souder, 1986). Other streams focus on developing frameworks to illustrate and understand how to carry out integration of R&D project and product portfolios with the goal to develop a co-aligned technology-market portfolio (Ernst et al., 2004). Although the impact of technological change was addressed to some extend by Capon and Glazer (1987), many of the aforementioned authors have not considered this in their research. They are mainly concerned with the process and evaluation methods. Also in R&D management literature, much attention has been paid to identifying and minimizing environmental and technological risks (Brown & Karagozoglu, 1989; Floricel & Ibanescu, 2008).

While the above literature has greatly contributed to our knowledge about R&D PPM, less attention has been paid to the specific influence and benefits of technological change on product portfolios and portfolio management. While of course new technologies are considered for adoption in the portfolio the strategic importance of the matter has been considered more in terms of risk rather than impact on business strategy and how to deal with this adequately. Research shows that firms struggle to adopt a new technology if they have not yet made some progress developing patents in a certain new (to the firm) domain (Cuervo-Cazurra & Annique Un, 2010). Other research shows, that with the emergence of a dominant technological regime, the nature of technical change shifts from product innovation to a relatively long period of process innovation. Generally, this goes alongside incremental refinements of the selected technology (Abernathy & Utterback, 1978; Ettlie & Reza, 1992; Utterback, 1994). Benner and Tushman (2003) proposed that as process management techniques focus on continuous improvement in routines and variation reduction (Anderson, Rungtusanatham, & Schroeder, 1994; Hackman & Wageman, 1995; Harry & Schroeder, 2006), their increased utilization in an organization affects the balance between exploratory and exploitative innovation (Benner & Tushman, 2002). In order to be successful, according to Birkinshaw and Gibson (2004), firms should be ambidextrous: being innovative and proactive while also exploiting the value of proprietary assets, rolling out existing business models quickly and taking the costs out of existing operations. It is the ability to be both capable at adaptability (move toward new opportunities) and alignment (create short term value by streamlined activities).

This literature review is used to optimise the current project portfolio selection process applied by the pre-development department. Furthermore, through a case study the author attempts to find empirical evidence about the link between the portfolio decision process and the effect on strategic outcomes.
Chapter 3. Methodology empirical case study

Project and product portfolio processes and decisions were studied at a pre-development department through a case study (Dul & Hak, 2008). First, a general outline of the department and the company is presented. Then, research design is described and data collection and analyses discussed.

3.1 Case study

The case study is done at the pre-development department which is located within the Business Division X of the main Company. The department has a supporting role the business category but also conducts R&D for the other business divisions within the main company. It does not generate external income, but generates income mostly from internal customers. Generally, their main internal customers are Business Category A and Business Category B which are both located in Business Division X. Since many pre-development projects are co-developed, another important stakeholder is the company’s research department. One of the main goals of the pre-development department is to identify product areas for new emerging technologies developed by the research department. Pre-development is responsible for technology and function creation to subsequently develop architectures for new product platforms for future generations of products coming from new emerging technologies. Eventually, this should positively affect the long-term cost structure of R&D when the projects are transferred and exploited by the development/business side. Since two years, due to a financially driven organisational change, the involvement of their internal customers has shifted. Now, the business pays a part of their revenues, via Division X, directly to the department of pre-development.

This thesis involves decision-making for R&D projects in the Mid- and Long-Term (M&LT) program. Typically, this program is approximately EUR 20 million in size which is about 40% of the total budget of the pre-development department. The department head wonders whether the department’s current approach of allocating means is up-to-date or can be improved. As it becomes clear in Figure 1 (Section 1.2), the pre-development department generated the M&LT program. Therefore, it is a challenging task to optimise the department’s M&LT program and satisfy all parties/stakeholders involved. That is why the department head, in his effort to compose a program, would like to compare the approach used to alternatives and developments in the literature and review the current process in order to be able to identify areas for improvement or redesign.

3.1.1 Company characteristics

<table>
<thead>
<tr>
<th>Category A</th>
<th>Category B</th>
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</thead>
<tbody>
<tr>
<td>Pre-development</td>
<td>Pre-development</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>R&amp;D</td>
</tr>
<tr>
<td>Projects</td>
<td>Projects</td>
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</tbody>
</table>

(Olaf) van Duren
Figure 9 exhibits the organisational structure of the Company. It shows the position of the pre-development department and the input regarding new technologies that come from the research department. In this regard, research can be seen as a partner in developing new technologies. Also noticeable are two main Business Categories A and B which serve as internal customers. Also, a brief structure of the pre-development department can be seen: Head of Department, Department Principal, Group Leaders, Project teams. Project teams, led by a Project Leader, consist of Function Owners, Specialists, Architects, and Engineers from different competences.
3.2 Research design

The research design is based on the level of seniority, role of people, different departments and is split into several phases: (1) orientation/sampling, (2) data collection (3) findings/analyses.

3.2.1 Orientation & sampling

In the orientation phase, a first draft of the current project portfolio selection process was created from preliminary conversations with the department head and Department Principal, and by studying company documents (e.g. e-mail to stakeholders, project proposal template, and project prioritisation sheet). There was no official process description; the current process was built from scratch.

The Head of Department offered information about which persons are involved in and might exert influence on the process of the Mid- and Long-Term project portfolio management. With that information, a list of persons to interview was created. Other potentially interesting functions were added to the list by the author (e.g. purchasing, business, others from research). Different technological background and level of seniority were taken into account. Also when interviews progressed, new insights surfaced and potentially interesting new persons to interview (e.g. system/platform architect) were identified and added to the list. In particular, one platform architect was added to the list because of his experience at another Business Division (e.g. Y); a department that has a well-developed platform development process. The list is shown in Table 11.
Table 11 – List of conducted interviews, ranked on seniority level.

<table>
<thead>
<tr>
<th>Seniority Level</th>
<th>Function</th>
<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Higher management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>R&amp;D Manager Business Division X</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>R&amp;D Manager Business Category A</td>
<td></td>
</tr>
<tr>
<td><strong>Semi-high management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Head of Pre-development department</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Department Principal of Pre-development</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Business Process Expert</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Business Process Expert</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Program Manager research department</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Innovation Area Manager</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Technology Program manager</td>
<td></td>
</tr>
<tr>
<td><strong>Lower management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Group Leader</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Group Leader / Function Owner</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Group Leader</td>
<td></td>
</tr>
<tr>
<td><strong>No management, but technological input</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Function Owner / Special Topic Coordinator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Function Owner</td>
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<td></td>
</tr>
<tr>
<td>Function Owner</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special Topic Coordinator / System Architect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special Topic Coordinator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purchasing support</td>
<td></td>
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</tr>
</tbody>
</table>

To check the list of functions included they were plotted against their level of seniority and department. This is shown in Figure 10. It would help to evaluate the completeness or coverage of the interviews over the organisation and process from up- to downstream; from research via pre-development to the business. In total, eighteen interviews were conducted: twelve persons from the pre-development department, two from research and the business department each, and one from purchasing. The latter had a support function and was positioned inside pre-development. Furthermore, the R&D Manager from Business Division X was interviewed since this function controls the cash flows to the pre-development department.

Most interviews were conducted within the department of pre-development, since information for new projects was gathered through a bottom-up approach. Persons from the business were interviewed since they are an internal customer and influence the selection of R&D projects. The Program Manager of the research department who is responsible for the program topic ‘Product A’ has significant influence on the M&LT program due to co-development activities between the research and pre-development departments.
3.2.2 Data collection
The data collection procedure was designed to deal with reliability and validity issues upfront. Process consistency was assured by formulating a research question, sub-questions and developing a formal interview guide. Internal validity (drawing credible and correct conclusions) was strengthened by triangulating methods and data sources and also through feedback sessions with the author’s company supervisors (Eisenhardt, 1989; Maxwell, 2012; Yin, 2003). External validity (transferability of results to similar situations) was enhanced by thoroughly describing the research context (see Section 1.2 “Research context and Research question”). Three distinct data collection methods were used to ensure triangulation of data: (1) company documents, (2) interviews, (3) (non-)participant observations.

First, company documents provided insight into the formal processes in place for project portfolio decision-making and produced familiarity with company specific jargon and culture, organisational structure, and strategic vision (e.g. project proposal templates, prioritisation sheet, technology roadmaps). Documents also exposed the evidence-based dimension of the decision-making process during meetings. In order to understand company documents, they were discussed with the author’s supervisors. Eventually, documents were analysed and kept in a separate archive for structural purposes or later use (shown in Appendix B).

Second, interviews were conducted with a list of pre-determined stakeholders as discussed in Section 3.2.1. By asking participants to substantiate their answers with examples or use-cases increased reliability. Interviewing senior managers from multiple disciplines (e.g., business, research, purchasing) produced multiple perspectives and reduced informant bias (Maxwell, 2012; Miles & Huberman, 1994). Although interviews are subject to reactivity bias (Maxwell, 2012), the author tried to minimise this by avoiding leading questions and using a formal interview guide that will be described in Section 3.2.2.1. During the interviews, notes were taken and summarised afterwards; quotes of participants were stated explicitly.
Third, non-participant observations were made to identify power and intuitive processes and to observe relations between participants. These also helped to observe what actually happened in the decision-making process as opposed to what informants said had happened. Non-participant observations are generally less subject to reactivity issues. Especially when they occur in their natural setting (Maxwell, 2012). Meetings also provided insight into evidence being used such as presentations, spreadsheets or other relevant documents. These are helpful to identify the evidence-based dimension of the framework from Kester et al. (2011). Meetings lasted between 30 minutes and 4 hours and varied between project proposal meetings, project portfolio meetings, and one-on-ones with the department head. Some meetings were formal, with PowerPoint presentations providing detailed information on project assumptions and progress. Other meetings were informal in nature with general discussions of only some aspects of a set of projects. Decisions were made about as few as two projects or as many as twenty projects in any one meeting. Notes were taken at each and were written down as descriptive as possible to avoid any premature interpretations. All these data were gathered into an archive separated from interpretations.

3.2.2.1 Interviews

A formal interview guide was developed and used for the semi-structured interviews (see Appendix D). In designing the guide the author had two aims: (1) to carefully cover all topics relevant for project portfolio management (e.g. content of decisions, methods used, political influence) and (2) being careful to avoid suggestive questions and preserve objectivity. Questions about the selection process were structured using the “Overall project portfolio selection framework” from Archer and Ghasemzadeh (1999). Topics used in the interview guide that reflect this are “project proposals” and “roadmaps”, “strategy”, and “tools”. Interviews regarding decision processes were structured based on Kester et al. (2011)’s framework. Topics used are “evidence”, “opinion”, and “power”. The interview guide is adapted to different management levels. For example, questions related to decision processes were asked to senior management (i.e. R&D Managers, Process Experts) while questions about evidence in- and output were asked to lower level participants such as Function Owners or Architects. Interviews ended with questions about policy recommendations & conclusions from the perspective of the interviewee. For example, questions to reflect on the current process: e.g. “what do you think is going well in the current process”, and “what can be improved from your point of view”. This was done with the aim to gather preliminary feedback on the project portfolio management process from people that are engaged with it on a daily basis. Furthermore, it was placed at the end to prevent from confounding reality with individual’s opinions. While the interviews progressed, questions were better formulated with the aim to be more relevant and to the point. The detailed interview guide can be found in Appendix D.

In this qualitative research several iterations took place. The first round (13 interviews) mainly concerned persons from the pre-development department. Questions were asked to identify the role and responsibilities of the actors, to extend the initial draft into the current project selection process and uncover potential bottlenecks or areas of interest. How a person dealt with technical or financial risks and how the company generally dealt with such risks was asked to address the company’s culture. Strategic considerations were also covered during the interviews. Since questions dealt with processes, participants were asked to underpin their answers with examples or use-cases. After round one, findings were interpreted in accord with the literature.

The second round (5 interviews) was used to (i) further enhance the current process and (ii) to create a more profound understanding of the portfolio decision process and influence on platform strategy usage. Thereto, the framework of Kester et al. (2011) was extended with strategic link and platform development. This second round was necessary because important topics emerged during the first round that needed follow-up. Mainly the role of platform strategies in relation to portfolio decision-making was
addressed. Questions asked were mainly focused on the development of product platform architectures and how pre-development and other departments currently addressed these topics. Typically Architects and R&D Managers are part of these interviews as well as Special Topic Coordinators. Architects make choices about platform architectures, R&D Managers are the ones that decide on the investments in the M&LT program. Special Topic Coordinators look into long-term interesting topics in relation to product platforms. In the analysis, this data was used to reveal to what extent the current portfolio decision-making process affects how pre-development and their internal customers and partners exploit current technologies and deal with new ones. Here too, participants were asked to underpin their answers with examples or use-cases with the aim to compare views across participants. During this round, documentation about platform development processes was received.

3.2.2.2 Non-participant observations

Two “one-on-one” meetings, one telephone conversation, one meeting with all stakeholders and one Function Owner review was observed. During the first one-on-one meeting, every project proposal was discussed between the Program Manager ‘Product A’ from research and the department head. The meeting lasted approximately four hours. Both actors had filled out a prioritisation sheet before the meeting commenced. Projects were ranked on a scale of 1-6 (1 = go, 5 = no-go, 6 = sent to another division) by preference of the department head. However, the reasoning behind this ranking was rather implicit – what does 2, 3 and 4 mean? It became clear that the stakeholder from Research used priority setting from 1-3 (1 = go, 3 = no-go, and 2 = maybe). After this meeting, the prioritisation sheet was received and added to the archive. Some preferences from other stakeholders were already filled out during earlier meetings. Eventually, annotations were made and quotes or actions were brought under each decision-making dimension (evidence, power, opinion).

In the second one-on-one meeting, the Program Manager from the business (Business Category A) and the department head were present. In this meeting, the Program Manager used a slideshow that showed the planning, forecasted resource allocation of projects, issues and open actions. It seemed that several iterations regarding the selection of projects for the R&D program already occurred.

The telephone conversation was initially a meeting between the Program Managers ‘Technology Strategy’ and topic ‘Product A’, and the Head of Department. However, the Program Manager Technology Strategy did not enter the conversation. Therefore, this became a meeting between the Program Manager ‘Product A’ from research and the department head pre-development. It occurred further in the selection process.

A meeting with every stakeholder in the room and one dial-in from abroad was observed. All decision makers were present: R&D Manager from Business Category A and Business Category A, Program Manager topic ‘Product A’ from research, Program Manager Business Category B, Department Principal and the department head of pre-development. Also present were the project proposers, (part of the) project teams, and several Group Leaders (e.g. Group Leader administration). During this meeting, only project proposals that were unclear were presented by the project champions, supported by a PowerPoint presentation. In total, eighteen project proposals were presented. The goal of the meeting was about collecting information for decision makers.

The author and his supervisors observed the Function Owner review. This was a meeting between the department head and a Function Owner. The Function Owner presented his technology roadmap that contained watched trends for his specific function over a five year timespan.

Also, two feedback sessions were held between all supervisors, one Business Process Expert and the author. The first session was to define the thesis deliverables; the second was to discuss preliminary
findings. The author also actively participated in several meetings. These were mostly with the direct company supervisors with the aim to clarify interviews, observed meetings and understand the opinion of the department head or to gather additional company documents.

3.2.3 Data analysis

First, documents were categorised and used to make a draft of the current portfolio selection process. For example, to look up budgets, determine the number of projects, and better understand formal processes. The portfolio selection framework from Archer and Ghasemzadeh (1999) was adopted to analyse the interviews. Summaries were divided into topics that reflected parts of the framework (e.g. input, output, strategy, and methods).

Next, the author applied a thematic analysis in line with the dimensions of the framework from Kester et al. (2011), which was adopted. This was done with the aim to identify the main topics that summarise all the views that were collected. It began with reading and annotating interview summaries. During the iterations between the two interview rounds, areas of interest were identified and the framework of Kester et al. (2011) was extended with product platform development and link with strategy. Afterwards, a coding scheme was developed, summaries were coded, and eventually cut and paste into piles of code. Use cases were separated in coding the data as a check across participants. Despite that it may take the data out of context, data across participants was now brought under the same topic to look for patterns across the data. To make sense of the data from the second round of interviews, a map was created to rank stakeholders from each department in the preferred area of peak designs or product platforms. This helped to understand the decision-making processes and explained political influences on the process. When statements became unclear during the analysis, the particular case was looked up and its context considered. Participants were asked to clarify their statements during the interview with follow-up questions, and sometimes by e-mail (e.g. questions about the roadmap or platform processes). The department head also helped to clarify and comment on interview findings (e.g. financial flows, criteria usage, use-cases, platform mind-set).

Power and intuitive processes noted in the framework of Kester et al. (2011) were analysed with the data from non-participant observations. The annotations that were made were divided in these decision-making dimensions. This helped with coding the data in order for quotes or actions to be brought under each dimension.
Chapter 4. Empirical findings of case study

This chapter contains the findings from the case study at the pre-development department. First, we elaborate on the role of actors that were interviewed in line with Table 11 of Section 3.2 as well as their influence during the project selection process. Then, the current project portfolio selection process is mapped based on data collected from company documents and the interview rounds. A general overview is provided after which each stage of the portfolio selection process is detailed and diverging views of stakeholders are presented. Since one of the main objectives is creating product platforms, findings about platform usage and interpretations of stakeholders are presented. Conclusions are drawn and recommendations put forward. In the following section, these are discussed.

4.1 Actors involved

Two R&D Managers (level 1) were interviewed: one department head of the internal customer and thus a decision-maker during the selection process, another is the department head of Business Division X. His responsibility is to have the right people (competences) in the right place (business division). He is mainly involved during strategy development.

Head of Department Pre-development (Level 2) reports directly to the R&D Manager Business Division X. He initiates the meetings necessary for the project portfolio selection process and considers the requirements of every stakeholder and his own department. Business Process Experts (level 2) facilitate process transparency between the pre-development department and its stakeholders. Their task is to make potential investments for the business transparent. Business Program Managers (Level 2) report directly to the R&D Manager from their business division and are responsible for defining and managing the pre-development program from a business perspective. Research Program Managers (Level 2) concerned with the topic ‘Product A’ are responsible for identifying and selecting projects that are going to be co-developed with the pre-development department.

Within the pre-development department, Group Leaders (level 3) are mainly people managers and report directly to the Head of Department. They are involved with the input for specific parts of the Mid- and Long-Term (M&LT) program and some are also project proposers. For example, the group “facilitates the project selection procedure with financial and administrative tools.

Besides general project development activities, Function Owners (no management level) gather necessary information regarding a specific technological function. They create and maintain a technology roadmap and develop a long-term vision (3-5 years) about a particular technological area. Specifically for the M&LT program, Special Topic Coordinators are used to investigate single difficult or worthwhile topics for long-term benefits. Examples are. Function Owners and Special Topic Coordinators deliver input and create transparent insights regarding technological trends for their specific function or topic.
4.2 Current project portfolio selection process

A first draft of the selection process was made based on an e-mail sent by the department head of the pre-development department to stakeholders. The e-mail contained the proposed structure of the M&LT program, which is divided into a Function Program and a Special Topic program. Furthermore, it showed a list of persons (Function Owners and Special Topic Coordinators) who gather input and give advice on project priorities. These actors were instructed to find their counterparts in the business for alignment purposes. It also provided a rough time schedule of the selection process. The author found no documents delineating (parts of) the process. Therefore, the draft was extended to the real process that took place as shown in Figure 11. The extensions were made based on results of (i) additional interviews with Group Leaders and Function Owners (ii) further desk research, and (iii) non-participant observations. For convenience, process labels used are similar to the project portfolio selection framework developed by Archer and Ghasemzadeh (1999) and shown in Section 2.1.

Figure 11 – Current project portfolio selection process of pre-development for the M&LT program.

Figure 11 includes a timeline at the bottom. This was added based on the same e-mail. It shows that the process spans four months in the year this thesis project began (2013) and is performed annually. The timeline indicates that the process kicked-off at the end of June. The official kick-off consisted of the e-mail described above. The entire process lasted until mid-October. Selected projects start execution from January in the consecutive year as can be seen by the Start-block in the bottom right, unless projects required starting later. The complete selection process consisted of a pre-process phase called Strategic review meeting and three main project selection process phases: Pre-screening, Individual project analysis, Screening & Selection (rectangles in the middle). It was initiated by the department head of the pre-development department. Each phase has specific input and output visualised in the figure by the bubbles that enter and exit each phase. Furthermore, every phase involved actors, data present and decision-making methods as indicated in the block beneath the process phases.
After the kick-off, all actors from Section 4.1 became involved. There was a lot of interaction between stakeholders and the department head of the pre-development department. This caused the process to be perceived as difficult and time-consuming. The fact that the process was not clearly delineated by the department head of the pre-development department emphasised this. Project proposal templates were distributed, and project proposers were given short deadlines to fill out these proposals. The Group Leader from the group “Project Office” said “budgets are allocated by estimation and experience”. The tool “Clarity” was used for employee, materials, and housing registration per project. These tools were used for administration rather than creating insight for decision-makers.

In general, the Department Principal of the pre-development department thought the bottom-up approach, interaction with the business, and feasibility of the projects went well due to top-down defined targets. He also found it positive that a “business check” is being done through the business’ Program Managers. He meant that when projects are useful for the business, they are easier adopted for further development. He also thought that “the program of the pre-development department is always a bit fragmented with respect to the type of projects and full-time equivalents (FTEs)”.

In the following sections, each phase is described in detail. These details could be filled in based on interviews with R&D Managers, Program Managers, Head of Department the pre-development department, and by further analysing company documents (see Table 23 in Appendix A).

4.2.1 Strategic review meeting

Before the selection process started, a Strategic review meeting (see Figure 12) was held to develop or re-evaluate important strategic themes that reflect the strategic objectives of the business, research and the pre-development department. It occurred once every two years, and provided steering to divide possible project proposals into categories. Key stakeholders present were R&D Managers from the Business Division X and Business Categories A and B were present. Also present were the Head of Strategy from Business Division X, Program Manager from the research department concerned with ‘Product A’, and Department Principal of the pre-development department. The meeting was initiated by the department head of the pre-development department. Since the strategic review meeting was not attended by the author, because it was held before the internship started, there are no observations of how discussions went and how stakeholders came to conclusions.

A slideshow (see Table 23 in Appendix A) that steered the meeting was outlined as follows: (i) technical challenges, (ii) competence development, (iii) strategic roadmap templates, (iv) new topics M&LT, and (v) feature-up topics. The slides looked well prepared, and elaborated in detail. The most important outcome of the meeting was agreement about strategic innovation themes. Every theme was detailed and activities outlined. As shown in Figure 11, strategic themes served as a reference framework for the subsequent phases.

According to what stakeholders said, it took a long time for people to agree on certain topics; probably because many stakeholders were involved during strategy development. Disagreement was observed about the formulation of the themes. Some found them “clear, just the right amount, should care for enough steering, and well-balanced”. While others thought they were a bit “unclear and vaguely formulated and decided upon behind closed doors”. The department head of the pre-development department mentioned that the strategic review was held every two years because themes “should not change that much, otherwise it would not be strategic”. People were also critical about the balance of
strategic themes: “we should not underspend a strategic theme; why else would you have it?” Furthermore, the Department Principal of the pre-development department mentioned several protected topics that are always considered for long-term. Examples are .

Thus, interviews revealed that strategic themes might be formulated more accurately to avoid unclear and vague topics with the aim to provide better guidance. In addition, the number of themes could be optimised because it relates to employees saying that the program turned out to be fragmented.

4.2.2 Kick-off and Pre-screening phase

The Kick-off (see Figure 13) was announced at the end of June through an informal e-mail (described above) from the Head of Department to Group Leaders, Function Owners and Special Topic Coordinators. Contrary to previous year, when this was done by organising a “Product Technology Day” where several stakeholders formally presented technology roadmaps and other interesting developments that they worked on. One interviewee thought that stakeholders would receive a process chart with important dates and milestones, instead of a briefly formulated listing of dates and actions. On the other hand, one said that “previous year’s kick-off was time-consuming”.

Technology roadmaps played a role in formulating strategic themes and were important for steering project proposals. They are created by every Function Owner, and consist of a timeline showing current and future trends in technology on a typical scope of 1-5 years. Every function has its own roadmap. Technology roadmaps were presented during a market: a two-day event where ideas and knowledge were informally presented to other employees, but also to the department head of the pre-development department.

According to a participant, “technology roadmaps are presented to internal clients to communicate the focus from the company and are used to tell suppliers to work on certain things, because we find them important”. He never compared roadmaps from previous years. He also stated that “projects are translated into roadmap topics” and concluded with: “a roadmap is the most important aspect for a Function Owner”. This contradicts another participant who said “strategic themes serve as input for the technology roadmap”. It shows that not everyone fully understands the purpose of a technology roadmap. Another Function Owner said that the technology roadmap “might help in defining strategic themes”. He thought his roadmap was not used explicitly, but the department head of the pre-development department saw the list of trends during the market. An R&D Manager stated that a technology roadmap is about “linking proposition to applications: quantified by preference in ”.

All Function Owners said that there is a trend that can be identified in terms of technical specifications such as . Another Function Owner translated these into qualitative terms such as . Although most participants acknowledged these trends, one roadmap showed them in a rather random order. It was concluded that the input and use of roadmaps can be optimised. Evidence for this was found by participants that said: “input and needs from the business are not clear and making this transparent would improve the quality and alignment with strategy of project proposals”.

Figure 3 – Pre-screening phase.
During the Pre-screening phase (see Figure 13), project proposals were gathered to generate the long list of R&D projects to be evaluated and considered for selection or rejection. A project proposal template was used that consisted of the project goal, relation to strategic theme(s), timing and resources, project description and aimed results (see Appendix B.1). Project proposals often showed no objective data, only in terms of funding needed. Observed from company documents (see Appendix A), proposals were mainly submitted by Function Owners and Special Topic Coordinators and used different functions and employees in the organisation. The average number of proposers was three and approximately seven project proposals were delivered per Function Owner or Special Topic Coordinator. Project proposers were given the task to indicate their own priorities with a budget-bandwidth. Although respondents recognized the value of a structured project proposal template, they were also critical noting its limitations. One participant said: “Tools to evaluate project proposals quantitatively are simply not in place. Sometimes it is too early for financial and technical numbers to be reliable or feasible”. They explained that their “hit-rate was rather low”. For example, half of the proposals were directly rejected due to resource constraints. Another part was rejected with the reason “that it should be paid by another division” and some proposals slightly changed in contents due to the fusion with similar proposals and therefore ended up in another technology group. One participant said that he “tried to deliver as many project proposals as possible, so always some will remain”. Head of Department: “previous year there were a lot of project proposals, probably too many”. This year he made a more subtle notification. In a bottom-up approach “you must consider all project proposals and everyone should be heard” because if you ask for ideas of your employees but ignore the input “they'll never submit another idea”. Although the ‘silent’ kick-off was meant to decrease the number of project proposals, the opposite had happened and a fairly large amount of project proposals were submitted

During this phase, discussions between the Head of Department and Department Principal of the pre-development department versus the Function Owners, Special Topic Coordinators and Group Leaders occurred. After this phase, the department head of the pre-development department gathered all the remaining project proposals and put them into a single slideshow (denoted as Long list) to be reviewed in the following steps. The department head classified the project proposals into three separate categories:

4.2.3 Individual project analysis
In the Individual project analysis, alignment with the internal customers and partner occurred. Preliminary project proposals were further developed if necessary. The long list developed in the previous phase served as input for this phase; the output was the short list. All decision-makers, project proposers, (part of the) project teams, and several Group Leaders were involved. Unclear project proposals were presented by the project champions with the aim to provide decision-makers with more information. Project teams were present to answer questions regarding different functions or technologies. The aim of this phase is to filter projects that are not worth the effort, infeasible, or not in line with strategy to come to a Short list of project proposals. The department head of the pre-development department categorised and ranked all projects in a “prioritisation sheet” (Appendix B.2) according to meetings and comments from stakeholders.

One meeting revealed that every project proposal was discussed and projects were ranked by the Program Manager from research and the department head of the pre-development department. It was observed
that they had a close relationship: “we’ve known each other for a long time now, and we more or less know what the other wants/thinks”. No quantitative and qualitative methods or decision support systems were used during the meeting; except the long list of project proposals. The project proposals showed an indication of labour and material costs. Therefore, much emphasis was on the detailed cost structure of a project. Many projects were fixed in the program (“they are bound to current roadmaps”) and therefore non-negotiable. However, the (technology) roadmaps were not present during the meeting. Each actor had a very broad technological understanding recognised by the fact that several discussions went into technical detail. It became obvious that they mainly used experience or intuition in their argumentation due to the absence of objective data or formal methods. For example: “I think that it is a large market / specific market”, “a project could fit in current product range”, “just do it, because it is not a large amount of money”, “we’ve already invested in this previous year, we aren’t going to invest in it this year”, “to learn from a technology is also profitable”.

Several decisions were driven by personal interests or motivations of groups and thus reflected power-based processes. For example, the Program Manager said: “I’d rather spent budget on other projects instead of ” without supporting his argument with facts. Also: “because Business Category B wanted it to be number one” or “we do not make this, perhaps why should we do this?” The Program Manager said: “I want one big project with ”. Furthermore, observed from comments in the prioritisation sheet, one project was not supported by the department of research because it was about “small business” and therefore not worth the effort. It did not mention why. The stakeholders considered strategy with statements such as “something has to be done about this strategic theme” and “only if it is better aligned”. Evidence to consider the complete portfolio was found when participants said that “may also be relevant for other projects such as ”. This meant that although they were looking at the individual projects, the interrelatedness of projects across the portfolio was considered.

A meeting with almost every stakeholder in the room revealed that decisions were made afterwards and “behind closed doors”. No quantitative or qualitative methods were used to structure the meeting or support the decision-making process. It was sometimes not directly visible what “number” should be so exciting about the project in order to fund it. Statements that supported this were, for example, “”. Regarding cost-down, stakeholders stated that “the cost-down structure should be clear at this stage and if we invest in it, it should eventually pay off”. This showed that stakeholders were asking for evidence in order to make a decision, but it remained absent. A discussion between research and the business occurred. Research said that “we should do projects closer to home”. However, the business said that “it’s a key area for us”. Research: “then what do you want to achieve with it?” Since objective data was not present to provide structure, it triggered political processes recognised by the interests of one particular group (the business). Another project proposal raised questions about the potential customer and competition: “you should do customer validation during the project” and “who do we want to beat?”. Questions that were asked by the business were “when will this project be applicable, from a commercial perspective” and “what exactly do you want to achieve with it?”. Again, these statements reflect the need for critical thinking to generate objective decision inputs together. It thus felt that this made it hard to come to decisions.

A participant experienced the decision-making about his project proposals as a “quick (political) bargaining between stakeholders”. A Business Process Expert mentioned that “tools are used to give structure to a conversation”. However, he did not have examples that reflected on R&D project selection tools. Some others mentioned NPV calculations, but these occurred only in a later stage of the projects during the business case development, when technical and market uncertainties are less. Technology
roadmaps were not considered during this phase and inclusion of a database with current projects was not found.
4.2.4 Screening & Optimal portfolio selection

Project proposals were further evaluated during the Screening & Optimal portfolio selection phase with the goal to make decisions about the Short list and come to the Final list of project proposals. It was experienced as an iterative process with meetings between the department head of the pre-development department and different stakeholders about project preferences and budget alignment. Moreover, the total budget for the M&LT program became more certain since sales numbers from the internal customers arrived. The phase ended when resource allocation corresponded to budget constraints, competences were divided and all stakeholders were satisfied.

During a one-on-one meeting with the Program Manager from the business, Head of Department pre-development mentioned that he had “trouble seeing the solution because there is a budget gap”. This meant that there were too many projects selected which can be improved with e.g. more focus. The stakeholders solved it: “we could split projects over time so that they can be done in series instead of parallel and free up budget”. Topics of the pre-development department projects and the business differed in name: while the department head divided the projects into three distinct categories while the Program Manager divided them into seven other topics. According to the Program Manager, the division of projects into categories was as follows: Category I while the other saw it differently. It showed that stakeholders watched the division of strategy on higher level. However, there was confusion as to how projects were categorised. A telephone conversation between the Program Manager topic ‘Product A’ from research and Head of Department pre-development concluded with “the program was still too fragmented”. He was advised to make bigger chunks of FTEs, and responded: “this is not the issue at hand, but rather a matter of presentation”.

Observations during these meetings showed that it was not completely clear how projects were divided among strategic themes. The department head said that he “constantly managed to keep an eye on the division of projects over strategic topics”. This answer was supported by looking at the prioritisation sheet that labelled every project into a category. Due to the absence of any methods to compare projects across the portfolio, discussions were based on intuition and experience.

New technologies popped up and were put into new project proposals during the final phase. There was no other possibility than to squeeze the proposals in through stakeholders. The department head said: “this behaviour really presses my buttons”. In line with this, a participant said: “we do not have a process in place to consider the ‘next best thing’ during project development; I like to call it ‘exception management’”. Therefore, it disturbed the process and actors since there was no possibility to consider new technologies in a later phase.

An R&D Manager of the business said that pre-development used to be centrally funded for the purpose of strategic alignment. The business categories had to pay a fixed amount called ‘tax’ to be spent on pre-development projects. Due to less involvement of the ‘tax-payers’, many radical and technological advanced projects were developed. Previous year, a change occurred and stakeholders directly paid resources as a percentage of their own sales which lead to more involvement. He said: “Percentage of sales shifts the balance of power and creates a higher level of involvement of the parties to better fix the
next platforms”. The participant was aware that this change might jeopardize the mid- and long-term program in exchange for more short-term projects.

4.2.5 Start project development

Findings revealed that the current selection process at pre-development consisted of the phases shown above: Pre-screening, Single project analysis, and Screening & Selection. After the M&LT program was finalised and resources were allocated, the project assignments were written and projects executed.

According to a participant the R&D project portfolio selection process or project portfolio was never evaluated. Some evaluation occurred but it was merely in the corridors. No formal evaluation process was found. In general, employees thought that pre-development executes too many projects in parallel. This is also the reason why people’s division of labour was very fragmented, as participants stated. Head of Department pre-development mentioned that the selection process was sometimes extended until after the 1st of January and projects would start late.

4.3 Observations referring to platform strategy usage

4.3.1 Observations

The second round of interviews was used to create a more profound understanding of the decision process and its impact on platform strategy usage in relation to new technologies. Further documentation about platform development processes known in the company was received. It showed a detailed overview of the platform development process (see Appendix B.4). Here, a product platform is a set of building blocks and standardized interfaces compliant with a defined reference architecture that forms a common structure from which a stream of derivative products can be efficiently developed and produced.

One building block consists of several R&D projects. A product platform approach is the key to successful mass customisation – the ability to produce products in high volume that are tailored to the needs of individual customers. It allows for quick and efficient development for a set of differentiated products at low (technical) risk. Furthermore, effective platform planning balances between the market value of product differentiation and the economies of scale achieved through commonality. According to an architect who was involved with product platforms in another Company subdivision, the main drivers for success were maturity of technology and the organisation. He said: “the most important aspects for platforms are to rely on technology trends (Function Owners), decoupling of functionalities, constantly think about consumer insights and make sure the interfaces between the components are standardised”. He always looked at the whole value chain. For a detailed overview of the platform development process known at the Main Company the reader is referred to Appendix B.4. The R&D Manager of Business Division X said:

“Pre-development should come with platforms for the business by creating a 1st, 2nd and 3rd generation platform which in turn should decrease the R&D costs on long term. On the other hand, pre-development should avoid creating peak designs. The role of the pre-development department is creating an inflow of new products with a healthy balance between long vs. short term, and connecting in a right way with research and the world outside.”

Although documentation is present and higher management know-how is present, Head of Department pre-development stated:

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“I feel like we can do a better job in developing product platforms. Possibly we pay too little attention to platforms. Probably, a reason is that we in fact only have one person who really understands architectures. Generally we choose for peak designs. Cost-wise this is feasible and generally offers the maximum performance. We once tried designing a platform Product X but this was rather quickly abandoned. In the end the product looked the same on the outside but the internal elements were all different.”

About this product X, an architect said “it is like putting an engine in a carriage”. Using an existing interface was understandable since the market was huge. However, specifications were not logical to take into account “it is a whole different story in relation to the traditional design of Product X”.

An example of a platform was at stake due to wrong cost calculations. At the last moment, they changed the design to make it cheaper. Therefore, the technology changed and the opposite had happened: costs were rising leaving the project unattractive. A Function Owner noticed this and commented:

“The current people are not the specialists anymore. There is no material knowledge in the Business Categories. Although they do have competence owners, it lacks material knowledge at, for example, Business Division Y. This knowledge is diminished because they want to achieve their goals and have lost insight in technology”.

These statements showed that architectural competences regarding product platforms in pre-development and their stakeholders can be improved.

R&D projects in the Mid- and Long-Term (M&LT) program of the pre-development department are partly meant to be integrated in product platforms (as shown in Section 1.2 Figure 1). Decision-makers for these projects are the R&D Managers and Program Managers from the business, and the Program Manager from the Department of Research concerned with the topic ‘Product A’. In this regard, an example was Product Y that was created and developed by pre-development. Product Y can be fully disassembled and re-assembled, therefore showing how well the buildings blocks of your platform are. He said:

“Product Y will not enter the market because Business Category A does not feel they’ve added enough value on their own for it to be manufactured. They do not want this. Therefore, this product did not land in the business. This is a political and career oriented game and managers have a bonus list. When the projects/products are not on that list it is unlikely they will be pushed to market. Apparently this is important, achieving your bonus list.”

This behaviour shows the political processes during portfolio decision-making.

Another Special Topic Coordinator said:

“Due to a lot of competition, people are in a hurry. This stimulates short term decision-making with the result of making invalid choices after half a year of development. Therefore, development efforts result in continued peak designs which are killing for the organisation.”

In accord with this, a Function Owner said that “short term focus from the Company Subdivision is mainly caused by the business due to a desire for fast payoffs and EBITs”. In defence, the R&D Manager of Business Division X stated that “the Business Categories are in favour of platform design thinking. However there are two forces at work: (1) pressure for generating products quickly, and (2) creating more business output per person.” He admitted that “well thought out platforms suffer from these forces, but it should be recognised that generation to generation platforms go faster than building from scratch”.
From this, it was found that the business has short-term goals that might jeopardise the development of long-term projects for product platforms.

A participant said: “Research is the front end of innovation and should keep looking for technology opportunities. However, they should always pass through pre-development and not go directly to the business and show off (Look what we can do!). Sometimes they evade pre-development, though perhaps unwittingly, and go directly to the business”. This was acknowledged by the department head of the pre-development department. The participant also said that you should not risk missing opportunities by giving the research department technology constraints. This means that research should be sprouting new technologies but in doing so, they should not ignore the role of the pre-development department. In this regard, platforms play a role by bridging the gap to exploit technologies on the business side.

According to a participant, “you should not only maintain a tunnel vision for your platform, but keep an open process to take care of new technologies that might be beneficial for the platform (no lock out).” Several Function Owners said to “create a better vision and focus from the marketers and gain more market insights.” Participants recognised that this is a difficult yet important task and marketers should be aware of fast developments by external competition. In response, the Program Manager said that the business was typically market pull and found pre-development really technology push driven. This was also recognized by the fact that he was really looking at who the real internal customer was, what projects this customer needs, and which product you make with it. He thinks this balance is right. In contrast, a Special Topic Coordinator stated that “the balance is currently more technology push”. The fact that Research sometimes skips pre-development, confirms this. From this, we draw that market insights can be further optimised and keeping an open process should help increase product platform development.

The R&D Manager of Business Division X and Special Topic Coordinators found most important to “involve other functions in order to increase the speed of platform design and achieve broad acceptance amongst different departments. That way, it is not solely a product from R&D. Involvement might also decrease the level of political processes since everyone delivers its value.”

### 4.3.2 Attitude of stakeholders towards product platforms

From the above, the findings are plotted in Figure 17. This helped to interpret how actors thought about product platforms, how this influenced the current process and the effect on a platform strategy. The bags of money show the amount of monetary influence.
Figure 17 – Person's preferred development strategy: peak designs or product platforms.

It shows that two stakeholders with significant influence on the program have a rather negative attitude towards platform-design. Interviews elicited that the department head of the pre-development department wants to make the transition to more platform-designs. However, he found that “the department of research acts as a disturbing factor and the business provides not enough guidance”. The right side of the figure shows that the attitude of persons from the business was mingled; one part leaned towards platform-thinking, the other part did not think in platforms at all. This was concluded from comments of the department head of the pre-development department (“In Business Category A, development in product platforms is not their mind-set”). On the left side, the Program Manager from Research said:

“I miss some topics that have to do with recognising trends. There should be more challenging projects present in the M&LT program and we have to look further than the business portfolio by looking at the building blocks of the future”.

This showed that he used peak designs as a way to explore new technologies instead of trying to create platforms with current or future technologies. Furthermore, he could not understand the use of platforms but rather thought it was from peak to peak design (he said: “what’s the use of platforms if peak to peak works?”). While this works for Business Division Y, he did not have any more cases.

Due to reorganisations, decision-makers from the business are more involved. How the level of influence relates to the amount of resources is difficult to say. However, it was assumed that more resource commitment leads to a higher influence on the program since money can be spent on more or bigger projects.

It can be concluded from Figure 17 that keeping a strategic balance between peak and platform design is difficult for the pre-development department. An influential stakeholder from the business mainly thinks in peak designs as well as the stakeholders from research. Positively experienced was the R&D Manager
in the top-right of Figure 17 who sees the benefit of platform-thinking (he said: “The higher level of involvement of the parties creates a way to better fix the next platforms”). The department head of the pre-development department seeks balance and is committed to developing product platforms.

4.3.3 Conclusion of platform strategy usage
Knowledge about platforms and platform-thinking can be further integrated throughout the organisation. Also, the presence of architectural competences can be improved. Therefore, pre-development and its stakeholders have a tendency to go for peak designs. While this is understandable as long as Product A’s technology was immature, now that it has matured it should change to allow for efficient exploitation in the business. Due to short-term objectives of the business while research explores and introduces new technologies, a gap exists. A platform strategy should bridge this gap. However, considering the influence and different goals of the stakeholders, pre-development is prone to develop unique peak designs instead of developing platforms for long-term benefits. This latter is recognised by the department head of the pre-development department and several R&D Managers. However, these differences generate serious struggles in R&D project portfolio decision-making. In Section 4.2, we found that the portfolio management process is less formalised with limited structure. Furthermore, decisions were made rather intuitive- and power-based instead of supported by evidence or formal methods. Due to the absence of objective data for decision-making, the process allowed for political and intuitive decision processes. As a result, stakeholder rather considered their own targets in disregard of a product platform strategy.
Chapter 5. Discussion of findings

5.1 Brief response to research question

Firms innovate by developing new products through identifying and selecting Research and Development (R&D) projects. Often confronted with limited budget and risky choices with many stakeholders involved, they use project portfolio management to help make the right choices and manage these risks. In the pre-development department of an R&D Company, there is a lack of understanding of the effectiveness of the current R&D portfolio practice. The main responsibility of their project portfolio is technology and function creation to subsequently develop architectures for new product platforms for future generations of products coming from these technologies. In this regard, the research question is formulated:

(1) How effective is the project portfolio management process and related decision-making of the pre-development department, and
(2) how can it be optimised regarding dealing with technological trends based on best practices found in the literature?

The answer to the first part of the research question is given by mapping the current R&D project portfolio selection process. Main findings revealed a semi-formal and semi-systematic process with limited use of formal tools and limited attention for platform strategies. In this Section 5.2 and 5.3, findings are discussed and recommendations put forward. Also, a re-design of the current portfolio process including an implementation plan is given in Section 5.4.

5.2 Current project portfolio selection process of pre-development

The case study helped to understand how R&D Company uses project portfolio management in the pre-development department. It proofed systematic process spanned a period of four months. However, as no clear directives exist the process emerges based on requests from the department head. As a result the process is semi-formal and semi-systematic. The structure that exists can be very much traced back to the excel sheet used and clear recognition of function owners. Consequently, experience and intuition are strong factors in the process. Due to less formal and less tool-wise supported processes it is prone to power and influence of individuals and sub departments. Another remarkable finding was limited attention for platforms and architecture. This can be explained by a limited set of stakeholders with platform knowledge and close relationship between pre-development and research. However, also day-to-day business focus of the business department does not help. Room for improvement is present. Finally the process was highly linear and links with business strategy of higher management were considered to a limited extent. Evidence for this conclusion came from observations during the meetings and the absence of formal evaluation afterwards. An improvement for the current selection process would be to create an evaluation moment afterwards that could reflect on the division of strategic themes in the developed portfolio. It should also provide feedback on the methodologies used in different phases and on the process itself. Another improvement could be to show project portfolio management progress of the last years, e.g. to show changes in strategic directions. Table 12 summarises the current project portfolio selection process applied in the pre-development department. Per phase, it lists the findings, conclusions and most important bottlenecks. Each stage is discussed separately for a more detailed understanding to provide recommendations.
Table 12 – Overview current project portfolio selection process of the pre-development department.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Findings</th>
<th>Conclusions</th>
<th>Bottlenecks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-process</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strategic review meeting</td>
<td>▪ Many stakeholders involved who needed a long time to reach agreement.</td>
<td>Possibility to improve the number of strategic themes and how they are formulated.</td>
<td>Allocate resources and selection of methods for ranking projects is difficult.</td>
</tr>
<tr>
<td></td>
<td>▪ Ten themes are well-balanced, but somewhat unclear and vaguely formulated.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Protected topics.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selection process</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-screening</td>
<td>▪ Proposal template used.</td>
<td>Room for improving project proposals by including more objective data for quantitative evaluation.</td>
<td>Amount and quality of project proposals.</td>
</tr>
<tr>
<td></td>
<td>▪ No tools found for estimations in proposal template.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Many proposals, but low hit rate.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Projects classified in strategic themes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual project analysis</td>
<td>▪ Decisions based on intuition and politics.</td>
<td>Room for improvement by applying formalised methods and tools for ranking projects.</td>
<td>Difficult to make informed decisions due to limited usage of decision support systems or project ranking methods.</td>
</tr>
<tr>
<td></td>
<td>▪ Prioritisation settings used dissimilar between stakeholders.</td>
<td>Possibility to improve decision by learning from current/running projects.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Unclear proposals explained with presentations.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ No inclusion of current / previous project database.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screening &amp; Selection</td>
<td>▪ Decisions based on intuition / experience.</td>
<td>Room for improvement by applying formalised methods and tools for ranking projects.</td>
<td>Difficult to identify the division of projects among strategic topics or categories.</td>
</tr>
<tr>
<td></td>
<td>▪ Department head implicitly keeps track of strategy.</td>
<td>Room for improving the consideration of strategy.</td>
<td>Fragmentation of the program makes resource allocation difficult.</td>
</tr>
<tr>
<td></td>
<td>▪ Classification of projects between the business and pre-development differed</td>
<td>Possibility to improve process flexibility for late entrants.</td>
<td>Time-consuming process due too many interactions.</td>
</tr>
<tr>
<td></td>
<td>▪ Proofed process inhibits late entrants with possible new technologies.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-process</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start</td>
<td>▪ No formal evaluation process present to evaluate the (i) process or (ii) final portfolio.</td>
<td>Room for implementing formal evaluation.</td>
<td>Difficult to see portfolio progress.</td>
</tr>
<tr>
<td></td>
<td>▪ Selection process extended after the 1st of January.</td>
<td>Room to improve the strategic overview.</td>
<td>Division of labour very scattered.</td>
</tr>
</tbody>
</table>

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5.2.1 Pre-process phase

In correspondence with Cooper et al. (1998b), the strategic direction of the firm was determined before individual projects were considered for a project portfolio. Strategic themes were formulated together with research, the business and higher level managers who did not partake in the selection process. This is in accord with Archer and Ghasemzadeh (1999), who state that determination of strategic focus may be carried out at higher managerial levels than the portfolio selection committee, because it very much involves the firm’s strategic direction. They also mention that only occasional adjustments will be needed for strategic guidelines developed at this point in the process. According to the findings, this is done by organising the strategic review meeting once every two years. In line with Cooper et al. (2001b), pre-development uses the bottom-up (project proposal generation by employees) as well as a top-down (protected topics) approach to consider strategy.

In the case study several pre-process steps were found to be unclear e.g. setting formal guidelines and methodology selection. Thus, there is room for improvement to provide more structure beforehand in order to enhance evidence-based decision-making during project selection meetings.

Findings showed that there are eight Function Owners creating a technology roadmap. Among them, there was confusion about the use of a technology roadmap. Although there was no direct evidence found that these roadmaps are incorporated in the strategic review meeting, it could improve the quality and selection of project proposals. Therefore, stakeholders should improve the usage of technology roadmaps during the process.

Table 13 – Strengths / weaknesses and recommendations for the current pre-process phase.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic direction determined beforehand.</td>
<td>No clear formal guidelines found.</td>
<td>Improve formal guidelines.</td>
</tr>
<tr>
<td>Included higher level managers.</td>
<td>No formal methods selected beforehand.</td>
<td>Select methods for project ranking and selection beforehand.</td>
</tr>
<tr>
<td>Bottom-up as well as top-down.</td>
<td></td>
<td>Increase usage or visibility of technology roadmaps.</td>
</tr>
</tbody>
</table>

5.2.2 Selection process phases

According to Archer and Ghasemzadeh (1999), the Pre-screening phase should use manually applied guidelines selected in the strategy development stage. The project proposal template found was in accordance with this. However, the contents were mainly qualitative. Essential requirements before the project passes this stage should also include a feasibility analysis and estimates of parameters needed to evaluate each project. For every project, there was a project champion that delivered the proposal and (if necessary) gave a project presentation. This echoes what Archer and Ghasemzadeh (1999) said about appointing a project champion who will be a source of further information. Furthermore, they stated that it is necessary to ensure that all projects entering the process are somehow classified and aligned with a particular strategic topic determined during the strategy development stage. The department head stipulated that projects be classified and linked to a strategic theme in the proposal template. The Long list also contained a link with strategic themes and type of project (Function versus Platform Creation). In line with Chien (2002), who suggested that in this stage projects should also be classified as independent, interrelated, or synergistic, findings showed that stakeholders considered the interrelatedness of projects across the portfolio. However, they did this based on experience and knowledge. Thus, recommendations for this phase are to create more elaborate parameter estimates and steer project proposals to include a feasibility analysis. Stakeholders should also consider the nature of projects more explicitly.
Table 14 – Strengths / weaknesses and recommendations for the current Pre-screening phase.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project proposal template as guideline.</td>
<td>Mainly qualitative requirements / forecasts.</td>
<td>Include a feasibility analysis and parameter estimates needed to evaluate each project.</td>
</tr>
<tr>
<td>Inclusion of project champion / proposer.</td>
<td>Interrelatedness of projects only on personal experience.</td>
<td>Consider the nature (independent, interrelated, synergistic) of projects based on evidence/data.</td>
</tr>
<tr>
<td>Projects entering aligned with a particular strategic topic.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consideration of the interrelatedness of projects.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the Individual Project Analysis phase, according to Archer and Ghasemzadeh (1999), each project is individually assessed with the aim of having a common set of parameters in order to make an equivalent comparison between competing projects. Mostly, this assessment is based on feasibility studies but they also state the usefulness of an additional link with the project management database at this stage. It should be a source of information for project attribute estimation and decision-making based on previous project results. Thus an improvement could be to include a database with current/running projects during this phase, since it was not found.

Both quantitative and qualitative data are required to form a complete set of parameter estimates. Techniques as discussed in Section 2.2 “Project portfolio management methods” can be applied in this phase to calculate for example, project risk, net present worth, return on investment, including estimated uncertainty in each of the parameter estimates. Scoring models, benefit contribution, risk analysis, market research, or checklists may also be used. We found no methodology selection during the strategy development phase. Therefore, no methods either quantitative or qualitative were used. An improvement would be to integrate decision support tools. Now, it seemed that many decisions were based on experience/intuition and power. Having objective data present should prevent actors from pursuing their own interests. Furthermore, it can also help to make decisions about the projects during the carousel meeting to improve decision-making quality and leave room for discussion since everyone is present at the time.

Table 15 – Strengths / weaknesses and recommendations for the current Individual project analysis.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>No quantitative or qualitative methods applied.</td>
<td>Improve the presence of objective data and tools.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Include link with project management database.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Integrate decision support tools.</td>
<td></td>
</tr>
</tbody>
</table>

Following the framework of Archer and Ghasemzadeh (1999), the remaining process phases are Screening, Optimal portfolio selection, and Portfolio adjustment. The first two phases were not distinct or clearly outlined. Some actions to take during the Screening and Optimal portfolio selection phase were mingled into a single phase the author labelled Screening & Selection. The final phase did not seem to be present. During the Screening phase, data from the Individual project analysis phase should be carefully examined to “eliminate any projects or interrelated families of projects that do not meet pre-set criteria such as estimated rate of return, except for those projects that are mandatory or required to support other projects still being considered” (Archer & Ghasemzadeh, 2007, p. 249). Furthermore, this phase may also be used to eliminate projects not matching strategic focus of the firm or do not yet have sufficient
information upon which to base a logical decision. In contrast with this, the findings did not show a clear consideration of strategy and that it was discussed among stakeholders. Although the department head did this implicitly, there was no direct evidence that illustrated the amount of projects divided among the strategic themes to support discussions. Furthermore, findings show no pre-set criteria for ranking projects, selection seemed to be going opinion or power-based. The author recommends making the final phases explicit, clearly outlined and considering objective methods for ranking projects.

Table 16 – Strengths / weaknesses and recommendations for the current Screening phase.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experience of the stakeholders.</td>
<td>Screening and Optimal portfolio selection were not clearly outlined or distinct phases.</td>
<td>Make distinction between Screening and Optimal portfolio selection phases.</td>
</tr>
<tr>
<td></td>
<td>A final Portfolio adjustment phase not present.</td>
<td>Include Portfolio adjustment phase to reflect on the total portfolio.</td>
</tr>
<tr>
<td></td>
<td>No clear consideration of strategy during Screening phase.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No evidence that illustrated projects vs. strategic themes.</td>
<td>Illustrate strategic division among projects to support discussions.</td>
</tr>
<tr>
<td></td>
<td>No pre-set criteria present for ranking projects.</td>
<td>Consider objective methods for ranking projects.</td>
</tr>
</tbody>
</table>

According to Archer and Ghasemzadeh (1999), *Optimal portfolio selection* is used to optimise the preceding phases. Typically, interactions among the various projects should be considered, including interdependencies, competition for resources, and timing, with the value of each project determined from a common set of parameters that were estimated for each project in the previous phase. Research suggests to first determine the relative total benefit and second to include all project interactions, resource limitations, and other constraints in an initial optimisation of the overall portfolio. Findings showed no application of methods to come to informed decisions about the projects. Therefore, many decisions were based on experience of the stakeholders. Furthermore, it was not found that projects were compared amongst each other.

Table 17 – Strengths / weaknesses and recommendations for the current Selection phase.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experience of stakeholders.</td>
<td>No explicit project evaluation methods applied.</td>
<td>Consider methods to come to informed decisions about the projects.</td>
</tr>
<tr>
<td>Interaction or comparison between projects considered to a limited extent.</td>
<td>Make comparison between projects: (1) determine relative total benefit, (2) include all project interactions.</td>
<td></td>
</tr>
</tbody>
</table>

According to Archer and Ghasemzadeh (1999), during *Portfolio adjustment* the optimal portfolio is being represented, using matrix-type displays, and re-evaluated to obtain a portfolio that meets the objectives of the organisation optimally or near-optimally. Important here, is to reflect on and consider balance in the developed portfolio. Balance with regard to, for example, the scope, risk, and size of the projects. Furthermore, decision makers should be able to make changes at this stage, and if these changes are substantially different from the optimal portfolio developed in the previous phase, it may be necessary to recycle back to recalculate portfolio parameters such as project schedules and time-dependent resource requirements (Archer & Ghasemzadeh, 2007). A recommendation here is to reflect on the optimal portfolio and visualise it with matrix-type displays.
Table 18 – Recommendations to implement Portfolio adjustment phase in the current process.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>-phase was not identified-</td>
<td></td>
<td>Use matrix-type displays to represent the optimal portfolio.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Consider balance in the developed portfolio.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reflect on the optimal portfolio.</td>
</tr>
</tbody>
</table>

In general, many decisions were based on experience and intuition. This is in line with the statement of the department head during a conversation: “we use too few fact-based methods”. Furthermore, it was viewed as a “political game” and stakeholders wanted to “achieve their targets”. In accord with the findings, the main reason for this was the absence of structured methods for ranking projects against predetermined criteria. It begs the question: to what extent do stakeholders trust their own decisions? Another reason could be that stakeholders are now more involved due to the financial driven change. This might jeopardize the program in exchange for more short-term projects.

5.2.3 Post-process phase
According to the framework of Archer and Ghasemzadeh (1999) Project Development and Project Evaluation should be incorporated in the project portfolio selection process because it can generate data from experience that are highly useful to learning and project evaluation. Furthermore, projects that have reached major milestones or gates can be re-evaluated at the same time as new projects being considered for selection. This allows a combined portfolio to be generated within available resource constraints (Archer & Ghasemzadeh, 2007). The findings showed no connection with these post-process phases. Therefore, a recommendation is to make the link with project evaluation explicit in order to generate a combined portfolio within available resource constraints. During this phase, developed portfolio and the selection process can be evaluated.

Table 19 – Strengths / weaknesses and recommendations for the current Post-process phase.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection process was not connected with post-process phases.</td>
<td></td>
<td>Make link with Project Development and Project Evaluation phases.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Implement evaluation moment afterwards.</td>
</tr>
</tbody>
</table>
5.3 Platform strategy usage

The link between the project portfolio process and the role of platforms is shown in Section 1.2. Table 20 below shows an overview of the findings regarding platform strategies in an R&D Company. Per department, it summarises the findings, cause and effect, and recommendations for improvement.

Table 20 – Overview of findings and recommendations regarding platform usage.

<table>
<thead>
<tr>
<th>Findings (current mind-set)</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research</td>
<td></td>
</tr>
<tr>
<td>▪ New technologies are explored and introduced with a large focus on peak designs.</td>
<td>▪ Exploring new technologies.</td>
</tr>
<tr>
<td>Pre-development</td>
<td></td>
</tr>
<tr>
<td>▪ Too much emphasis on peak design and less on product platforms.</td>
<td>▪ Develop new technologies and product platforms.</td>
</tr>
<tr>
<td>▪ Few architecture competences present.</td>
<td>▪ Improve platform architecture competences.</td>
</tr>
<tr>
<td>Business</td>
<td></td>
</tr>
<tr>
<td>▪ Too much focus on peak design due to short-term goals and fast payoffs.</td>
<td>▪ Exploiting technologies in product platforms.</td>
</tr>
<tr>
<td>▪ In-depth technical know-how is limited.</td>
<td></td>
</tr>
<tr>
<td>Cause</td>
<td></td>
</tr>
<tr>
<td>▪ Limited use of objective data or formal methods leading to a semi-formalised, semi-structured project portfolio management process allowing decisions to be made based on opinion and power processes.</td>
<td>▪ Platform thinking mind-set throughout the organisation supported by senior management.</td>
</tr>
<tr>
<td>Effect</td>
<td></td>
</tr>
<tr>
<td>▪ Large diversity of products.</td>
<td>▪ Connected products, product families, and systems.</td>
</tr>
</tbody>
</table>

Research showed that with the emergence of a dominant technological regime, the nature of technical change shifts from product innovation to process innovation. Since Product A’s technology is becoming mature, the pre-development department is currently in this transition. Benner and Tushman (2003) proposed that as process management techniques focus on continuous improvement in routines and variation reduction, their increased utilization in an organization affects the balance between exploratory and exploitative innovation. To remain successful, according to Birkinshaw and Gibson (2004), firms should be ambidextrous: being innovative and proactive while also exploiting the value of proprietary assets, rolling out existing business models quickly and taking the costs out of existing operations. In this regard, project portfolio management should spread risk. However, short-term objectives mainly because of attention to financial aspects means less attention is allocated to the balance between explore and exploiting innovation. Findings suggest that the role of platforms is not fully understood by all stakeholders. Platforms have implications beyond the current product mix and costs; they also affect the cost structure of follow-up products and determine the ease and speed with which such products can be brought to the market (Meyer & Dalal, 2002). Platforms help to integrate new technologies easier to generate new product families for further exploitation. To achieve this, a changing mind-set of the research department and the business is necessary.

Currently, the business’ focus is mainly on short-term goals which influenced the pre-development department to also engage in these goals. The research department is a rather disturbing factor in this process by sprouting new technologies and trying to push them towards the business, through pre-development. This results in a focus on a large diversity of products rather than product platforms. Better yet, pre-development should identify and integrate new technologies, coming from research, into current product platforms so that these can be further exploited through products in the business. Therefore, the most important recommendation is to deploy a platform-thinking mind-set throughout the organisation accomplished through the knowledge of sufficient platform architects.
5.4 Recommendations and implementation

In order to answer the second part of the research question an implementation plan for the most important recommendations is provided. With the aim to optimise the current project portfolio selection process regarding dealing with technological trends based on best practices found in the literature. The most important improvement for the current portfolio selection process is to decrease the intuition and political processes by improving formalisation and evidence-based decision-making. Although recommendations are broadly defined, the author made a list of three most important concrete actions which can be rather easily implemented, namely:

I. Improve evidence-based decision-making through quantitative/qualitative methods.
   - Develop and apply scoring models (Appendix C.1) or check lists to valuate R&D projects.
   - Develop bubble diagrams (Appendix C.2) to visualise balance in the portfolio.

II. Make the link with strategy transparent during and after the selection process.
   - Develop a Strategic Buckets Model (Appendix C.3) to visualise spending on strategy.

III. Deploy a platform-thinking mind-set throughout the organisation.
   - Improve platform architecture competences.
   - Make stakeholders aware of the implications of product platforms.

Appendix C.1, Appendix C.2, and Appendix C.3 show examples of portfolio tools that can be used.

Summarising Section 5.2, a set of general (Table 21) as well as specific (Table 22) recommendations and actions to improve the current project portfolio selection process of the pre-development department are given. Also, one recommendation regarding the usage of a platform strategy is provided.

Table 21 – Overview of general recommendations for the R&D project portfolio selection process.

<table>
<thead>
<tr>
<th>Recommendation and actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Clearly outline and formalise the project portfolio management process.</td>
</tr>
<tr>
<td>- Split the Screening &amp; Selection phase and clearly outline them.</td>
</tr>
<tr>
<td>- Include a final Portfolio adjustment phase.</td>
</tr>
<tr>
<td>- Include the current project database to generate a combined portfolio.</td>
</tr>
<tr>
<td>2. Improve evidence-based decision-making through quantitative/qualitative methods.</td>
</tr>
<tr>
<td>- Provide more structure and decision support systems in advance.</td>
</tr>
<tr>
<td>- Implement more decision criteria to avoid emphasis on power- and opinion-based processes.</td>
</tr>
<tr>
<td>- Include a database with current/running projects during individual project analysis to enable decisions based on previous project results.</td>
</tr>
<tr>
<td>- Create parameter estimates and steer project proposals to include a feasibility analysis for each project.</td>
</tr>
<tr>
<td>3. Make the link with strategy transparent during the process.</td>
</tr>
<tr>
<td>- Visualise the optimal portfolio with matrix-type displays.</td>
</tr>
<tr>
<td>4. Improve result overview, evaluation and future direction of the project portfolio.</td>
</tr>
<tr>
<td>- Implement Evaluation phase afterwards.</td>
</tr>
<tr>
<td>- Include portfolio progress of previous years to show developments in strategic direction.</td>
</tr>
<tr>
<td>5. Deploy a platform-thinking mind-set throughout the organisation.</td>
</tr>
<tr>
<td>- Increase platform architecture competences.</td>
</tr>
<tr>
<td>- Make stakeholders aware of the implications of product platforms.</td>
</tr>
<tr>
<td>- Increase early involvement of research and the business, but also across the value chain (e.g. operations).</td>
</tr>
<tr>
<td>- Exchange people between research, pre-development and development/business.</td>
</tr>
<tr>
<td>- Enhance long-term market insights.</td>
</tr>
</tbody>
</table>
Table 22 – Overview of recommendations for each phase of the project portfolio selection process.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Recommendation / action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategy development</td>
<td>- Improve formal guidelines.</td>
</tr>
<tr>
<td></td>
<td>- Select methods for project ranking and selection beforehand.</td>
</tr>
<tr>
<td></td>
<td>- Increase usage or visibility of technology roadmaps.</td>
</tr>
<tr>
<td>Pre-screening</td>
<td>- Analyse feasibility and estimate parameters to evaluate each project.</td>
</tr>
<tr>
<td></td>
<td>- Consider the nature (independent, interrelated, synergistic) of projects based on evidence/data.</td>
</tr>
<tr>
<td>Individual project analysis</td>
<td>- Improve the presence of objective data and tools.</td>
</tr>
<tr>
<td></td>
<td>- Include link with project management database.</td>
</tr>
<tr>
<td></td>
<td>- Integrate decision support tools.</td>
</tr>
<tr>
<td>Screening &amp; Selection</td>
<td>- Split Screening and Optimal portfolio selection phases.</td>
</tr>
<tr>
<td></td>
<td>- Illustrate strategic division among projects.</td>
</tr>
<tr>
<td></td>
<td>- Consider objective methods for ranking projects.</td>
</tr>
<tr>
<td></td>
<td>- Make comparison between projects: (1) determine relative total benefit, (2) include all project interactions.</td>
</tr>
<tr>
<td>Portfolio adjustment</td>
<td>- Use matrix-type displays to show balance of the optimal portfolio.</td>
</tr>
<tr>
<td>(include this phase)</td>
<td>- Reflect on the optimal portfolio.</td>
</tr>
<tr>
<td>Post-process</td>
<td>- Make link with Project Development and Project Evaluation.</td>
</tr>
<tr>
<td></td>
<td>- Implement Evaluation phase afterwards.</td>
</tr>
</tbody>
</table>

The above recommendations lead to the re-design of the current project portfolio selection process shown in Figure 18. The grey part is the “current” situation, while the coloured parts are recommended additions. The bubbles show implementation of several tools for each phase taken from best practices in literature. A final Portfolio adjustment phase has been added to consider the balance in the developed portfolio. Furthermore, the former Screening & Selection phase has been split into separate phases. The project management database has been included as well as an evaluation moment afterwards.

Figure 18 – Current (light-grey) and recommended (colour) project portfolio selection process of the pre-development department (see also Appendix E for a large image).
Next, each change from the current to the recommended design will be discussed more thoroughly in order of priority.

### 5.4.1 Implement formal evaluation phase

Since the project selection process has been completed recently, the easiest way is to start with evaluation of the portfolio process and the developed portfolio. First, the department head of pre-development should organise a formal meeting to provide an overview of the portfolio by using several Bubble diagrams (e.g. Appendix C.2: financial and nonfinancial types) and Strategic Buckets (Appendix C.3: e.g. incremental, new projects, platform projects).

Second, in this meeting stakeholders should be asked to comment on the process of last year. How did they experience the process (e.g. positive/negative/easy/difficult/transparent/time-consuming)? Does their department agree with the developed portfolio? How did they experience the meetings? Were they well informed about methods to rank projects? The results of this meeting can be used in combination of the thesis’ findings to further improve the current project portfolio management process for the pre-development department of an R&D Company.

### 5.4.2 Formal guidelines, methodology selection and resource allocation

Figure 18 can be used by the Head of Department Pre-development to improve formalisation of the project portfolio process. Instead of a less-formalised e-mail with dates and activities, the figure can be complemented with important milestones and meetings. It helps to improve process transparency and to show stakeholders move logically through the project selection steps. Moreover, the importance of formalisation of project portfolio management processes has been emphasised by numerous studies (e.g. Cooper et al. (1999), Cooper et al. (2001a), and Martinsuo and Lehtonen (2007)). Therefore, the department head should notify stakeholders about the importance of a formal portfolio process. For example, make them aware of the portfolio adjustment phase (build in flexibility), inform them about decision-making methods and tools, and agree on a planning.

A formalised portfolio process includes the selection of methodologies to incorporate suitable and accurate data, and explicit and objective criteria (Archer & Ghasemzadeh, 1999; Blichfeldt & Eskerod, 2008; Martinsuo & Lehtonen, 2007). During the strategic review meeting, all stakeholders should agree on the portfolio methods used for evaluating projects that enter the process, dependent on what portfolio objectives they want to achieve (See Table 8 Section 2.2.9). Methodologies recommended in this thesis can be used by the department head to inform other stakeholders. The methods include Scoring Models (Appendix C.1), Mapping Approaches (Appendix C.2) and Strategic Methods (Appendix C.3). Furthermore, technology roadmaps are important tools during strategy development to show the current and future technological trends. Gathered by the department head, they should be used explicitly by improving their visibility towards stakeholders (e.g. showing the most important trends in a slideshow).

To avoid that projects from different categories compete for the same (scarce) resources, high level decision must be made to allocate resources to impervious project categories. Important here is to decide on the categories before the portfolio selection process starts. The strategic method shown in Appendix C.3 helps the department head to inform stakeholders and make decisions regarding resources.

### 5.4.3 Feasibility analysis & parameter estimates

Technical and commercial feasibility studies for each project can be implemented by the proposers in the project proposal template and checked by the department head and other stakeholders. Due to unreliable or highly biased data in R&D projects (Kavadias, Loch, & Tapper, 2005) using parameter estimates in these studies can be difficult. However, qualitative variables such as policy, political measures or strategic fit can be applied and quantitative output could be each project’s expected net value, risk, and resource
requirements over the project's time frame. To determine these estimates, scoring methods (Appendix C.1), benefit contribution, cost analysis, risk analysis, or market research may be used. Asking employees to incorporate feasibility studies and parameter estimates improves the quality of project proposals and possibly limits proposals to a more manageable amount. It also helps to make informed decisions during the Pre-screening phase.

5.4.4 Implement Portfolio adjustment phase
First, the department head of pre-development should notify stakeholders that there is a possibility to reflect on and consider balance in the developed portfolio (e.g. the scope, risk, and size of the projects). Furthermore, decision makers should be able to make changes at this stage, and if these changes are substantially different from the optimal portfolio developed in the previous phase, it may be necessary to recycle back to recalculate parameters such as project schedules and time-dependent resource requirements. Figure 18 helps to make stakeholders aware of the portfolio adjustment phase. The department head should visualise the optimal portfolio with matrix-type displays (e.g. Appendix C.2).

Second, this phase should also give an opportunity for stakeholders to include new projects that were not considered from the beginning. Here, the department head can build in the flexibility that otherwise upsets stakeholders and the process itself (e.g. “the next best thing”-projects).

5.4.5 Improve Optimal portfolio selection phase
During this phase, stakeholders should be made aware to consider project interactions. These include interdependencies, competition for resources, and timing, with the value of each project determined from a common set of parameters that were estimated for each project during Individual project analysis. First, stakeholders should determine the relative total benefit of each project. A comparative approach such as Q-Sort (Appendix C.5), pairwise comparison, or AHP, may be used in this step allowing qualitative as well as quantitative measures. Second, they should include all project interactions, resource limitations, and other constraints in an initial optimisation of the overall portfolio.

5.4.6 Include project database
In addition to allocating resources during strategy development, it is most optimal that the formal portfolio process needs to be applied consistently to all current and new projects on a periodical basis (Archer & Ghasemzadeh, 1999; Cooper et al., 2001a). This means to also include a database of short-term projects and other currently running projects. It should be a source of information for project attribute estimation and decision-making based on previous project results because it can generate data from experience that are highly useful to learning and project evaluation. Furthermore, projects that have reached major milestones or gates can be re-evaluated at the same time as new projects being considered for selection. This allows a combined portfolio to be generated within available resource constraints.

5.5 Implications of the research
First, this thesis provides managers with an optimised framework for project portfolio management, derived from a case study and improved according to best practices found in literature (see Figure 18). The effect of decision-making processes in an R&D setting and how these influence business strategies (this case: product platform development) is studied. To decrease individually negative intuitive and political processes, it is advised to have a formal project portfolio management process in place, in line with findings in literature (e.g. Cooper et al. (2001a) and Martinsuo and Lehtonen (2007)).

Second, the research enumerates the most important tools to assist stakeholders in making portfolio decisions (see Appendix C.1, D, and E). In optimising the process, it is important that the department head of pre-development initiates implementing the changes by addressing the implications of the current portfolio process on business strategies. It also creates acceptance of stakeholders and higher
management. For a detailed overview of recommendations and actions for implementation the reader is referred to Section 5.4.

Third, results are likely to be transferable to other businesses because management scientists and practitioners were involved. The findings might contribute to a general theory of the phenomenon studied (e.g. the influence of portfolio decision-making processes on platform development strategies). Although this case study is particularly focused on the pre-development department of one R&D Company, similar departments in other organisations can use these insights to further optimise their R&D portfolio processes. The resource allocation problem is not new (Engwall & Jerbrant, 2003) and possibly more organisations struggle with similar problems in interdepartmental R&D portfolio management.

Fourth, this research extends the body of knowledge and investigates the link between decision-making processes in project portfolio management (Kester et al., 2011), platform development strategies (Meyer & Dalal, 2002), and explorative versus exploitative business strategies (Birkinshaw & Gibson, 2004). In literature, emphasis has been on risk management and understanding the process involved while less attention has been allocated to the specific influence and benefits of technological change on portfolios. We showed that while technology matures the business strategy should change (e.g. from peak to platform designs). Enabling such change is embedded in the portfolio decision process and relations between stakeholders.

Finally, it provides insight into a project portfolio management process in a firm’s high-tech R&D pre-development, research and business department. By viewing the project portfolio management process as a span of interrelated decision-making styles it shows the effect of power processes on platform development strategies. Therefore, it extends the current work of project portfolio management with product platform development (Kester et al., 2011).

5.6 Limitations & further research

Some obvious limitations include the use of a small sample size and a single case study. The pre-development department of one sector of a company was investigated. A multiple case study would help to test certain statements across participants and strengthen the reliability. However, due to the scope and time related matters, this was not considered feasible. Due to circumstances, the author did not interview an influential decision-maker from the business. Therefore, findings regarding this person’s view on platform strategies were interpreted with findings from other stakeholders. This might affect the internal validity of the research.

The author found an effect of different portfolio decision-making processes enabled by a semi-formalised and semi-structured project portfolio selection process. However, to what extent power and intuitive processes occur can be further investigated by extending the research of Kolbe et al. (2013).

Since difficulties in platform development strategies were uncovered after investigating the current project selection process, less time was spent to investigate the role of platforms. Also, several calls from literature to consider platform projects in the portfolio have been made (Cooper et al., 2000; Martinsuo & Lehtonen, 2007; Meskendahl, 2010). Therefore, the author recommends further investigating the role of platform strategies in portfolio management to understand the link between platform development strategies and explorative and exploitative business strategies (Birkinshaw & Gibson, 2004).

Whether difficulties found are case specific, further research could be to organise a round table to learn from other companies. It would help to increase the external validity of the research. So far, the
optimised model is not yet applied in the pre-development department. Research is needed to prove the usefulness and practicability of the recommendations.
References


Utterback, J. (1994). Mastering the dynamics of innovation: How companies can seize opportunities in the face of technological change.

Appendices

In this section, an overview of appendices is showed. Confidential documents for employees only or non-anonymous information is omitted by the author of this master thesis.

Appendix A. Data collected in case study

Table 23 shows an overview of all the data collected during the case study. For information regarding the interviews and the meetings that were conducted or attended the reader is referred to the accompanied Sections listed in the table below. The table also indicates the documentation that was actually used for analyses or writing the report.

Table 23 – Overview of data collected in the case study.
<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation &amp; sampling</td>
<td>Non-participant observations</td>
</tr>
</tbody>
</table>

Table: Methodology

- Orientation & sampling
- Non-participant observations
Appendix B. Company documents studied
Improving R&D project portfolio management at a pre-development department
Improving R&D project portfolio management at a pre-development department

2014

(Olaf) van Duren
Appendix C. Project portfolio tools

Appendix C.1 Scoring models and checklists

Research into project selection methods reveals that scoring models produce a strategically aligned portfolio and one that reflects the business’s spending priorities; and they yield effective and efficient decisions, and result in a portfolio of high value projects (Cooper, Edgett, & Kleinschmidt, 1997; Cooper et al., 1998a).

Table 25 – Example: scored list of projects; a rank ordered list (Cooper et al., 2000).

<table>
<thead>
<tr>
<th>Project</th>
<th>Leader</th>
<th>Strat Fit</th>
<th>Prod Advtg</th>
<th>Market Attract</th>
<th>Core Comp</th>
<th>Tech Feasib</th>
<th>Reward</th>
<th>Project Attract Score</th>
<th>People FTE</th>
<th>Cum FTE</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epsilon</td>
<td>Peters</td>
<td>9</td>
<td>9</td>
<td>10</td>
<td>10</td>
<td>9</td>
<td>9</td>
<td>93.3</td>
<td>20</td>
<td>20</td>
<td>Active</td>
</tr>
<tr>
<td>Gamma</td>
<td>Cooper</td>
<td>10</td>
<td>10</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>80.0</td>
<td>20</td>
<td>40</td>
<td>Active</td>
</tr>
<tr>
<td>Alpha</td>
<td>Smith</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>9</td>
<td>75.0</td>
<td>15</td>
<td>55</td>
<td>Active</td>
</tr>
<tr>
<td>Delta</td>
<td>Scott</td>
<td>7</td>
<td>7</td>
<td>9</td>
<td>8</td>
<td>8</td>
<td>5</td>
<td>74.0</td>
<td>12</td>
<td>67</td>
<td>Active</td>
</tr>
<tr>
<td>Beta</td>
<td>Jones</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>8</td>
<td>8</td>
<td>6</td>
<td>66.7</td>
<td>20</td>
<td>87</td>
<td>HOLD</td>
</tr>
<tr>
<td>Omicron</td>
<td>Bally</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>7</td>
<td>5</td>
<td>86.7</td>
<td>20</td>
<td>107</td>
<td>HOLD</td>
</tr>
</tbody>
</table>

(resource limit: 70 FTE)

The way to work with a scoring list is as follows (Cooper et al., 2000):

1. Set up a spreadsheet - list your Active, On hold & Proposed projects
2. Rank these projects according to some criterion (e.g., Project Attractiveness Score or NPV)
   - in this example, 6 screening criteria are used (Strategic Fit, Product Advantage, Market attractiveness, Ability to leverage core competencies, Technical feasibility, Reward vs. risk)
   - the Project Attractiveness Score – the average of these 6 criteria, but taken out of 100 – is used as the ranking criterion
   - all 6 projects are good ones, with scores over 65 points out of 100
3. Include projects until you are out of resources (here measured by FTEs)
   - here the first 4 projects are Active (note the resource limit of 70 FTEs); and the last 2 are put on Hold

Furthermore, the Table 26 below shows a typical Scoring Model for project selection (Cooper et al., 2001b).

Table 26 – Typical scoring model for project selection.

<table>
<thead>
<tr>
<th>Key factors</th>
<th>Scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factor 1 – Reward</strong></td>
<td></td>
</tr>
<tr>
<td>Absolute contribution to profitability</td>
<td>5 year cash flow: cumulative cash flows less all cash costs, before interest &amp; taxes</td>
</tr>
<tr>
<td>Technological payback</td>
<td>the number of years for the cumulative cash flow to equal all cash costs expended prior to the start-up date</td>
</tr>
<tr>
<td>Time to commercial start-up</td>
<td>in &quot;years&quot;</td>
</tr>
<tr>
<td><strong>Factor 2 – Business Strategy Fit</strong></td>
<td></td>
</tr>
<tr>
<td>Congruence (how well the program fits with the strategy)</td>
<td>from &quot;peripheral fit&quot; to &quot;strong fit&quot;</td>
</tr>
<tr>
<td>Impact (the financial and strategic impact of the program</td>
<td>scored from minimal &quot;to &quot;critical&quot;</td>
</tr>
<tr>
<td>on the product line, Business and/or Company)</td>
<td></td>
</tr>
</tbody>
</table>
Business and/or Company)

<table>
<thead>
<tr>
<th>Factor 3 – Strategic Leverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proprietary position</td>
</tr>
<tr>
<td>Platform for growth</td>
</tr>
<tr>
<td>Durability</td>
</tr>
<tr>
<td>Synergy with other operations within corporation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 4 – Probability of Commercial Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existence of a market need</td>
</tr>
<tr>
<td>Market maturity</td>
</tr>
<tr>
<td>Competitive intensity</td>
</tr>
<tr>
<td>Existence of commercial applications</td>
</tr>
<tr>
<td>development skills</td>
</tr>
<tr>
<td>Commercial assumptions</td>
</tr>
<tr>
<td>Regulatory/social/political impact</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 5 – Probability of Technical Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical gap</td>
</tr>
<tr>
<td>Program complexity</td>
</tr>
<tr>
<td>Existence of technological skill base</td>
</tr>
<tr>
<td>Availability of people &amp; facilities</td>
</tr>
</tbody>
</table>

Each criterion above is scored by management on 1-10 scales; scale-points 1, 4, 7 & 10 are “anchored”. The five Factors are calculated via weightings x ratings. These Factors are then added in a weighted fashion to yield a Project Attractiveness Score. This Score is compared to a cut-off (to make Go/Kill decisions) and is also used to rank order projects – from best to worst.

More elaborate information about scoring models and checklists can be found in Cooper et al. (2001b).
Appendix C.2 Bubble diagrams

New product portfolio bubble diagrams plot individual new product projects, future businesses or what might be. Figure 31 shows an example of a risk vs. return chart.

- **Pearls** (upper left quadrant) are projects with a high likelihood of success, and which are expected to yield a very high reward.
- **Oysters** (lower left) are projects with a high expected payoff, but with low likelihoods of technical success. Typically, these are projects with technical breakthroughs that will pave the way for solid payoffs.
- **Bread and Butter** (upper right) are small, simple projects with a high likelihood of success, but low reward. Mainly, these include many fixes, extensions, modifications, and up-dating projects of which most companies have too many.
- **White Elephants** (lower right) are the low probability and low reward projects. Every business has a few white elephants.

According to (Cooper et al., 2000):

“One feature of this bubble diagram model is that it forces senior management to deal with the resource issue. Given finite resources (e.g., a limited number of people or money), the sum of the areas of the circles must be a constant. That is, if you add one project to the diagram, you must subtract another; alternatively you can shrink the size of several circles. The elegance here is that the model forces management to consider the resource implications of adding one more project to the list – that some other projects must pay the price!”

![Figure 31 – Example of a Risk-Reward bubble diagram (Cooper et al., 2000).](image)

A variant of a risk-reward diagram is shown in Figure 32 and deals with uncertainties.
Sometimes strategic issues and the quest for significant projects must take precedence over strictly financial and short-term return. Therefore, another variant uses nonfinancial metrics (see Figure 33); a subjective estimate ranging from “modest” to “excellent” and depend not only on the financial prospects for the project, but on its strategic importance and impact on the company. The vertical axis shows both commercial and technical success.

Figure 32 – 3M’s Risk-Reward Bubble Diagram Showing Uncertainties (Cooper et al., 2000).

Figure 33 – Risk-Reward bubble diagram using nonfinancial axes (Cooper et al., 2001b).
Appendix C.3 Strategic buckets model

According to Cooper et al. (2001b), the Strategic Buckets Model is particularly suitable for handling platform projects. First, management meets to agree on goals and strategy. Then they translate their strategy into resource allocations across three categories of projects (e.g. Figure XX). Thus, management makes a strategic and deliberate decision to allocate a certain proportion of resources to these longer-term platform developments. The major strength of the Strategic Buckets Model is that it firmly links spending to the business’s strategy. It also recognises all development projects that compete for the same resources should be considered in the portfolio approach.

![Strategic Buckets Model Diagram](image)

Figure 34 – Strategic Buckets Methods of portfolio management (Cooper et al., 2000).

It shows that the business’ strategy dictates the split of resources into buckets; projects are rank ordered within buckets, but using different criteria in each bucket (method used by AlliedSignal-Honeywell).

More information about Strategic Buckets can be found in Chao and Kavadias (2008).
Appendix C.4 Expected Commercial Value (ECV) approach

Figure 35 exhibits the determination of Expected Commercial Value of Project.

\[
ECV = \left( \left( PV \times P_{TS} - C \right) \times P_{CS} \right) - D
\]

- $ECV$ = Expected Commercial Value of the project
- $P_n$ = Probability of Technical Success
- $P_{cs}$ = Probability of Commercial Success (given technical success)
- $SD$ = Development Costs remaining in the project
- $SC$ = Commercialization (Launch) Costs
- $SPV$ = Net Present Value of project’s future earnings (discounted to today)

**Figure 35 – Determination of Expected Commercial Value of Project (Cooper et al., 2001b).**

Main advantages of this model are (Cooper et al., 2000):

- It recognizes that the Go/Kill decision process is an incremental one (the notion of purchasing options)
- All monetary amounts are discounted to today (not just to launch date), thereby appropriately penalizing projects that are years away from launch
- It deals with the issue of constrained resources, and attempts to maximize the value of the portfolio in light of this constraint.

However, its main weakness is dependency on extensive financial and other quantitative data. Additionally, these data must be available for all projects’ future stream of earnings; commercialization (and capital) expenditures; for their development costs; and for probabilities of success. Problem is that these estimates are often unreliable or even not available in the early stages of a project. Furthermore, the model neglects the balance of the portfolio. Lastly, it solely relies on a single financial criterion for maximization (Cooper et al., 2000).

Appendix C.5 Q-sort method for pairwise comparison

In Q-sort, each participant is given a deck of cards wherein every card denotes a particular project to be ranked. An open discussion is held on all projects and each member sorts and resorts the deck into five categories (from “high” to “low”, or a simple “yes” or “no”). The results of all projects are then put in order and displayed. After several rounds of discussion the group usually moves to consensus on the ranking of projects.
Appendix D. Interview guide

First, shortly explain what is going to be investigated. Second, explain what to achieve with the interview and put the person at ease. Talking about their hobbies could be helpful by gaining trust and them opening up to me. Then inform the participant that the interview is written down and afterwards the minutes will be showed and asked whether it seems correct or not. Notify the participant about possible follow-up (e-mail or another conversation).

[Role and responsibilities]
- What is your role/function within the pre-development department or company?
- What are the main responsibilities regarding this function?

[Current process]
- What do you think of the current process that the Head of Pre-development is applying?
- How do you deliver input for the mid- and long-term program and with whom?
- What happens with your input?
- Did you deliver any project proposals? Was there anything difficult about it?
- Do you consider the strategic themes that were developed?
- What do you think of those?
- Are there any project not accepted? Why was that?

[General]
- Do you know what project portfolio management is?
  - Align with strategy / maximize value / create balance / allocate resources

[Organizational context and processes]
- Can you name a recent project in which you were involved?
- Can you describe a recent portfolio decision with regard to this project?
  - What was the decision about and how was it made? (Decision characteristics)
- Who was in charge during this portfolio decision? (actors)
- Who else was involved with this portfolio decision?
- In what way does the strategy affect the way portfolio decisions are being made?
- What are the most important strategic aspects that you have in mind when making portfolio decisions?
- What are for you the most important aspects to bear in mind when making a decision about a project proposal?
- When you are involved in a portfolio decision who do you talk to? What kind of information do you need to make portfolio decisions?
- Where or from whom do you obtain this information or data? [what sources]
  - Possibility to go in-depth

[Methods & tools]
- What kinds of methods are being used for making portfolio decisions?
- Could you give examples and categorise each method that you mentioned? (financial/strategic/quality/environment/market/technological)
- What are in your opinion the pros and cons of method A, B, C? (limitations)
- How does the organisation use these methods?
[What would you change?]
- What are the strengths of how portfolio decisions are being made?
- What do you think could be improved? Did you miss anyone during the decision meetings?

[Dealing with uncertainty, complexity and risk > cultural factors]
- What kind of uncertainties do you have to deal with?
- What is the general mind-set of how the company deals with risk?
  - Are they risk-averse, or do you get rewarded when you take risk?
- Can you describe a situation in which you were confronted with a difficult portfolio decision? (Why was this decision difficult? How did you handle it?)
- Do you think there are cultural differences in the decision-making?
  - Between China/NL for example?

[Individual decision making aspects]
- Do you think there is a difference between persons who are experienced or new to the process and methods?
- How do you think your experience and expertise helps you in making portfolio decisions?

[Evidence-based decision-making]
- Did you/your group collect relevant information to come to the decision? (Collect information)
- Did you use analytic tools or calculations to come to a decision? (Use of tools)
- Have you considered several options? Which one? (Generate alternatives)

[Opinion-based decision-making]
- Did you trust your personal judgment when making decisions? (Personal judgment)
- Did you rely on your gut feeling? (Gut feeling)
- How important do you think past experience was? (Past experience)

[Power-based decision-making]
- To what extent were people open to each other about their interests? (Interest/preferences/goals)
- Was the decision influenced by powerful individuals? (Power)
- Were there alliances between different people/groups? (Alliances)
- Did you share all important information with others? (Information (hold back))

[Closing questions]
- In short, how would you describe your company’s style in portfolio decision making?
- Do you agree with the current decision-making processes?
- What would you like to change about it?
Appendix E. Re-design of the current project portfolio process

Figure 36 – Re-design (colour) of the current (grey) project portfolio selection process of the R&D Company’s pre-development department.
Appendix F. Glossary

Analytic Hierarchy Process (AHP)
This technique decomposes the overall goal into hierarchically related criteria, and the importance of criteria is compared in order to arrive at the relative importance of the criterion at the next highest level. The overall value of a project is arrived at by pairwise comparisons of its value on each criterion with each other project.

Decision support system (DSS)
An interactive, flexible, and adaptable computer-based information system that utilizes decision rules, models coupled with a comprehensive database and the decision maker’s own insights, leading to specific, implementable decisions in solving problems that would not be amenable to management science optimization (Turban, 1990).

Effectiveness
The degree to which desired organizational objectives are met (Ostroff & Schmitt, 1993).

Function
A mode, action or activity that fulfils the needs for a particular stakeholder and use case.

Innovation
Innovation is the effort to create purposeful, focused change in an enterprise’s economic or social potential (Drucker, 1985).

M&LT program
Mid- and long-term project program.

Net Present Value (NPV)
Calculation of project value, given the predicted flow of expense and income over time to some future date, assuming a particular discount rate.

New product development (NPD)
Process of developing a new product or service for the market. This type of development is considered the preliminary step in product or service development and involves a number of steps that must be completed before the product can be introduced to the market. New product development may be done to develop an item to compete with a particular product/service or may be done to improve an already established product. New product development is essential to any business that must keep up with market trends and changes (BusinessDictionary.com).
Peak design: Design with a single-product focus is a failure to embrace commonality, compatibility, standardization, or modularization among different products and product lines. For a given company, the evidence for lack of commonality is found in the products themselves and their component parts (Meyer, 1997).

Portfolio: A collection of projects or programs and other work that are grouped together to facilitate effective management of that work to meet strategic business objectives. The projects or programs of the portfolio may not necessarily be interdependent or directly related (PMI, 2001).

Portfolio decision process: It encompasses or overlaps a number of decision-making processes within the business, including periodic reviews of the total portfolio of all projects (looking at the entire set of projects, and comparing all projects against each other), making Go/Kill decisions on individual projects on an on-going basis (using gates or a Stage-Gate® process (Cooper, 1990)), and developing a new product strategy for the business, complete with strategic resource allocation decisions.

Portfolio selection: The periodic activity involved in selecting a portfolio, from available project proposals and projects currently underway, that meets the organization’s stated objectives in a desirable manner without exceeding available resources or violating other constraints.

Product platform: A set of building blocks & standardized interfaces compliant with a defined reference architecture, that forms a common structure from which a stream of derivative products can be efficiently developed and produced (Meyer, 1997).

Project: According to Archibald (2003), a project is “a complex effort, usually less than three years in duration, made up of interrelated tasks, performed by various organizations, with a well-defined objective, schedule, and budget.”. Within a new product development context, a project can also be long-term oriented thus have a scope of three to five years.

Project portfolio: A project portfolio is a set of projects that share and compete for scarce resources and are carried out under the sponsorship and management of a particular organization (Archer & Ghasemzadeh, 1999).
Project portfolio management (PPM)

This technique tries to identify and develop the set of activities that seek to find and maintain the optimum current and future balance of Research and Development (R&D) programs to support the company’s business strategy in terms of criteria such as risk and reward (Jones, 2005).

Research and Development (R&D)

Systematic activity combining both basic and applied research, and aimed at discovering solutions to problems or creating new goods and knowledge. R&D may result in ownership of intellectual property such as patents. In accounting for R&D costs, the development costs may be carried forward but the basic and applied research costs are often written-off as incurred (Businessdictionary.com).

Research and Development (R&D) management

R&D management is the discipline of designing and leading R&D processes, managing R&D organizations, and ensuring smooth transfer of new know-how and technology to other groups or departments involved in innovation (Chiesa, 2001).

Stage-Gate®

A conceptual and operational map for moving new product projects from idea to launch and beyond—a blueprint for managing the new product development process to improve effectiveness and efficiency.

Strategic Mapping

This is one way of establishing the strategic direction of the firm. This technique creates an aggregate project plan by focusing on project categories, their resource consumption, and how they contribute to the company’s development plan. Mapping project types allows any gaps in the plan to be revealed. Projects to be added must conform to and support the development strategy.

Task

Generally at the lowest level a task is what eventually forms a project. A formal definition of a task is a short-term effort (a few weeks to a few months) performed by one organization, which may combine with other tasks to form a project (Roussel et al., 1991).