Portfolio management process

a case study after the performance of portfolio manangement

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Portfolio Management Process
A case study after the performance of portfolio management

by
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Portfolio Management Process

A case study after the performance of portfolio management

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The organization in which the research has taken place considers that publication of the research would harm its interests. Therefore the name of the company has been changed as well as other clear links to the company.

Abstract

This Master thesis is a case study after the Portfolio Management Process at CS1. One of the two objectives of the study is to understand the current situation of the process and identify opportunities for improvement. The second objective is to understand the consequences for both the portfolio management process as well as for the company when developing different product innovations.

Management Summary

Introduction

Changes in the market environment leave organizations with the need of a continuous flow of new innovations and only with the creation of new innovations, organizations are able to defeat competitors by successfully bringing (new) products to (new) markets in less time then their competitors.

There are two things, which are important to be successful in new product development. First is doing projects right. This refers to the chosen methodology for the new product development process and deals with the efficiency of NPD. On the other hand it is important to be doing the right projects. This refers to the portfolio management process, which makes a company capable to select those projects, with the best prospect to develop successful product innovations with a constraint of having limited available resources. Doing the right projects by executing portfolio management is about the effectiveness of NPD. The company sub 1 (CS1) had made a start with introducing portfolio management into their organization around 2005. However, the feeling existed that the process had to be further developed. The expectation of this research is to understand how the current portfolio management process could be improved.

Theoretical background

Two main topics are described. The first topic is the portfolio management process. The portfolio management process is defined as a dynamic decision-making process, for evaluating and selecting NPD projects. The portfolio management process is important for new product development in a way that the process is used to evaluate and select the best development projects, which are in line with business strategy and together form a balanced portfolio of development projects for the companies, by taken into account the limited available resources. In order to have a successful portfolio management process, it is important to take care of the three mentioned goals, value maximization, balancing the portfolio and creating alignment with business strategy. Although the portfolio management process can create lots of benefits for a companies' new product development, implementation of the process is not easy and there are many traps identified like the lack of commitment from top management and the use of weak input data.

The second topic discusses the need to have different approaches when developing different product innovations. The linear approach, as most traditional new product development processes are, is discussed to be not applicable to use when a company wants to develop radical innovations. Chaotic approaches, having a spiral approach instead of linear, are said to be more capable to develop radical innovations. Therefore, if a company wants to create innovations, it has to step away from the traditional approach known in innovation management. However, the transition to become an innovative firm cannot be done before the levels of efficiency, quality and flexibility are in place.

Based upon the insights from literature, it can be expected that implementing a solid portfolio management process will be a timely and difficult undertaking and that it is important to gain full support throughout the organization. Furthermore, the more innovative a firm becomes, PMP can expected to become more important since the decision making for selecting the most valuable development projects for the company will become more complex and difficult.

Methodology

Three research questions are stated for the research:

1. How has the portfolio management process been introduced at CS1?
2. How is the portfolio management process performing at CS1?
3. How should portfolio management be used when developing different types of innovations?

The three research questions will contribute to answer how the portfolio management process at CS1 could be further developed and what the consequences for the PMP and CS1 are when different type of innovations will be developed.

For the part of diagnosis, a case study will be executed whereby key members are interviewed and documentation analyzed. Based on the results of the case study, a stream analysis as discussed by Porras (1987) will be used to identify core problems of the current situation of portfolio management at CS1.

For the design phase, a new insight will be explained and dialogued during a workshop with key members of CS1 and experts in the field of innovation management, providing new insights for the redesign.

Results

As a result of the cause-effect diagram it can be concluded that the maturity levels of the portfolio management process is low. Core problems have been identified which were lack of time to develop the process, lack of commitment for the development of the process and missing a clear process owner.

Next to the identified problems, a new insight provided direction for the future of product development at CS1. Two possibilities arise for CS1 to choose from. On the one hand, it can be chosen to stay closely in line with the corporate way of developing products. This means that CS1 chooses to follow the NPDP process and accepts the fact that, although improving the efficiency and quality of the production and products, real novelties won't be developed and therefore it can be expected that the limits of growth will be reached within several years. On the other hand, CS1 can choose to make the transition into the flexibility level. Although this will be difficult and lot of changes are needed, it will be the only way in order to create a situation in which CS1 can become an innovative firm and create real novelties.

Redesign

Several specifications have been stated for the redesign. Comparing the situation at CS1 with the findings in literature, it has been concluded that:

- There was no implementation team created for the development of the PMP.
- For the development of the PMP, no clear agreement was created between the developers of the process and sponsor about the requirements for the process.
- No implementation plan was developed

From the dialogues about the insights of Chaordic System Thinking, it has been concluded that:

- CS1 needed to better adopt the concept of discontinuous growth. This concept leads the way towards a more dynamic kind of project management.

Given the specific situation of CS1, it has been concluded that:

- The redesign should only focus on the situation of CS1.
- The 6 Sigma methodology should not be used to develop a PMP.

Sketching the entire product development of CS1, four elements have been identified as part of product development. These are opportunity recognition, project proposal selection, new product development process and the business unit of CS1.

Based upon the specifications, an action plan has been proposed with 6 action items to improve the portfolio management process as project selection method. These action items are:

1. Create a project team.
2. Present the objectives of the team to senior management.
3. Gain insights in the topic of portfolio management.
4. Understand the current situation at CS1.
5. Develop a detailed work plan.
6. Give a presentation of the findings so far, find buy-in from the entire organization and continue with the development.

Next to proposing action items to improve the portfolio management process, action items are proposed with which the opportunity recognition capabilities of employees could be tried to enhance. The action items are:

1. Support willingness to express ideas by individuals.
2. Provide access to external information and insights.

For the new product development process at CS1, it has been recommended that the discussion is open concerning the right structure of the new product development process for different types of innovation projects and that it should be understood by the management that there is not one right approach or process for developing products.

For the business unit CS1, it has been recommended that there are different elements within new product development which, next to the specific situation of CS1, have to be taken into account when the desire to develop radical innovations is pursued.

Preface

This report describes the result of my Master Thesis research, as final part of the program Innovation Management at the department of Technology Management from the Eindhoven University of Technology.

The research focused upon the portfolio management process, which can be seen as a process by which the right decisions can be made for selecting product development projects. My personal interest in the topic of new product development is to understand how companies are able to create new products with which they can create a competitive advantage. During the research, the aim was to understand how the portfolio management process was working at CS1 and how it could help to make the right decisions for project development selection.

First of all, I would like to thank my supervisor ####### for his support and input during my research. Furthermore I would like to thank ####### for providing me the opportunity to conduct my Master Thesis at CS1 and all the employees at CS1 who have helped me with my research one way or the other.

A special thank to my supervisors from the Technical University of Eindhoven, Jimme Keizer and Frans van Eijnatten for their critical remarks and input during my entire Master Thesis.

Finally, I would like to thank my parents for all their support during my study and my fellow students and friends for the pleasant time in Eindhoven.

Pieter Pennings
's-Hertogenbosch, March 2008

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Chapter 1

Introduction

1.1 Introduction

Economies around the world have changed over the past decades. Where national economies used to be independent entities, they have become part of an integrated global network of trade and labor since the 1960s (Dunn et al., 2000). The environment, in which companies operate, has become more global, intense and dynamic due to changes in competition, customer demands and technologies (Clark and Wheelwright, 1993). All these changes leave organizations with the need of a continuous flow of new innovations. Only with the creation of new innovations, organizations are able to defeat competitors by successfully bringing (new) products to (new) markets in less time (Muthusamy et al., 2005; Pohlmann, 2005).

1.2 Literature review

Most companies in Europe, America and Japan declared that new product development is their number one strategic manufacturing priority (Ettlie, 2006). Therefore it is an increasingly discussed topic in scientific literature. A literature review was conducted on the topic of new product development, which gave insights in the topic and identified gaps in the existing literature.

1.2.1. Definitions

The topic of new product development (NPD) has received a lot of attention by researchers and businesses throughout the last decade. Much has been written on this topic, resulting in a lot of (various) definitions for NPD. The first step in the literature review was to define the topic of new product development and the way it was interpreted.

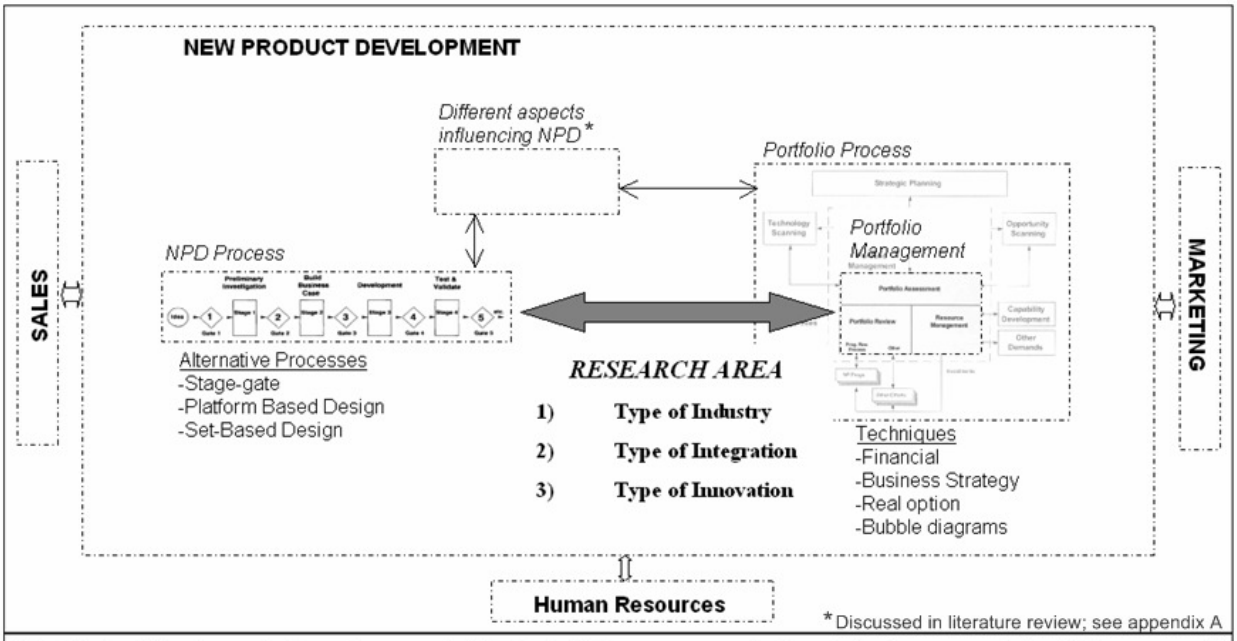
New product development has been defined as a system - as part of the total efforts a company undertakes - to develop new products, with the purpose of improving overall performance. In this context, NPD is seen as one of the systems undertaken in an organization, next to and interrelated with 'systems' like sales, human resources and marketing, which are all in place with the purpose to let an organization perform in the best possible way.

Each system consists of different elements. Within the system of NPD, several factors were identified as having impact on the performance. The literature review focused on two of these factors; the new product development process (NPDP) and portfolio management process (PMP).

The new product development process has been defined as a sequence of steps or activities companies utilize with the purpose of developing one or more new products, by transforming a perception of market opportunities into the commercialization of new products. The portfolio management process has been defined as a dynamic decision-making process, for evaluating and selecting NPD projects, with the goals of 1) maximizing the value of the portfolio, 2) creating a balanced portfolio and 3) building strategy into the portfolio, taking into account the limited available resources. Portfolio in this context means the collection of all development projects. All definitions in the literature review presented here were based upon definitions cited in scientific literature.

1.2.2. Literature review and identified gaps

There are two things, which are important to be successful in new product development. First is doing projects right. This refers to the chosen methodology for the new product development process and deals with the efficiency of NPD. On the other hand it is important to be doing the right projects. This refers to the portfolio management process, which makes a company capable to select those projects, with the best prospect to develop successful product innovations with a constraint of having limited available resources. Doing the right projects by executing portfolio management is about the effectiveness of NPD.
By conducting a literature review, three gaps in literature where identified. Figure 1.1 summarizes the definitions and gaps in literature.



New Product Development: *The system, as part of the total efforts a company undertakes, to develop new products with the purpose of improving overall performance*

New Product Development Process: *A sequence of steps or activities companies utilize, with the purpose of developing one of more new products, by transforming a perception of market opportunities into the commercialization of new products.*

Portfolio Management: *A dynamic decision-making process, for evaluating and selecting NPD projects, with the goals of 1) maximizing the value of the portfolio, 2) creating a balanced portfolio and 3) building strategy into the portfolio, taking into account the limited available resources.*

Figure 1.1 Definitions and gaps in literature for the topic of New Product Development (own source)

The gaps are classified as:

1. Type of Industry. There is gap in the understanding of the influence of the type of industry in the management of both NPDP and NPD. In literature conclusions are that there is no best way to conduct NPDP and PMP. The question remains what the influence of type of industry is for choosing the best way to conduct both processes.
2. Type of Integration. A second gap is the linkage between the NPDP and PMP. In literature different approaches for linking NPDP and PMP are discussed. There is not yet a clear agreement on which approach or combination of approaches should be used; literature shows no consensus about how NPDP and PMP should be linked with each other.

3. Type of Innovation. There is a growing stream of literature, identifying different theories about the NPDP, for developing different kind of product innovations. Literature shows the need to have a different NPDP in place for developing incremental innovations compared with developing radical innovations. However, the question remains how this affects the linkage between the NPDP and the PMP. If literature shows a need for a different NPDP for developing different product innovations, the question is how portfolio management should differ for decision making for the different product innovations.

1.2.3. Initial research question

After finishing the literature review, Company Sub 1 (CS1) was approached. During this first contact, the topic of new product development and the literature review were discussed and formed the basis for the start of this research. Like most large manufacturing companies, the feeling exists at CS1 that there is a need to focus upon the development of innovations in order to keep ahead of competition. Therefore, after a discussion about the literature review, an initial research question was stated:

"Should portfolio management be included as an integral facet of the total stage-gate process or should it be seen as a stand-alone process?"

CS1 had made a start with introducing portfolio management into their organization around 2005. However, the feeling existed that the process had to be further developed. The expectation of the outcome of this research was to understand how the portfolio management process at CS1 should be further developed and to create a better understanding of the linkage with the new product development process. As expressed by the new product development manager at CS1, the expectation, and therefore the primary objective, for CS1 was to understand how to bring the maturity level of the portfolio management process to the next level.

1.3 Content of the report

Company Sub 1, the company where the research took place, will be discussed more in detail in chapter 2. Chapter 3 provides a theoretical background on the topic of portfolio management process as well as the insights from literature, discussing the consequences for product development for different types of innovation. In chapter 4 the research questions and learning objectives, which are based upon the initial research question, will be described as well as the methodology for the research. In chapter 5 the results of the diagnosis are described. The redesign will be discussed in the last chapter.

Chapter 2

Company description

2.1 Introduction

The research was conducted at Company Sub 1 located in the Netherlands. This chapter includes a description of Company Incorporate as well as a description of Company Sub 1.

2.2 Company description

Company Incorporate is a manufacturer of equipment and has three principal lines of business: Business line A, Business line B and Business line C. Some 15 years ago, the company did not design, develop and manufacture specific equipment. The special equipments that were sold by the company before they acquired other equipment manufacturers were purchased from external suppliers and a small number of standard special equipment were made internally. From a strategic point of view, the company started to acquire special equipment manufacturers.

As a result, the company merged two manufacturers and started one joint venture. This resulted in three business units, which together have the design control of today's Company Incorporate special equipment offering. Design control means that the facilities are responsible for the design of the equipment including the development of new special equipement. The result of the two merges is the business units of CS1 and CS2. CS3 is the joint venture.

In 2005, the two single business units CS1 and CS2 were combined into one group, keeping the two facilities physically separate but being managed as one. This means that product control of the diverse special equipments is divided over the three business units, but that for the business units of CS1 and CS2, one total budget is available and therefore resources must be shared between the two facilities. The Company Sub division is part of the business line C (figure 2.1). Throughout the rest of this report, Company Sub will be referred to as CS

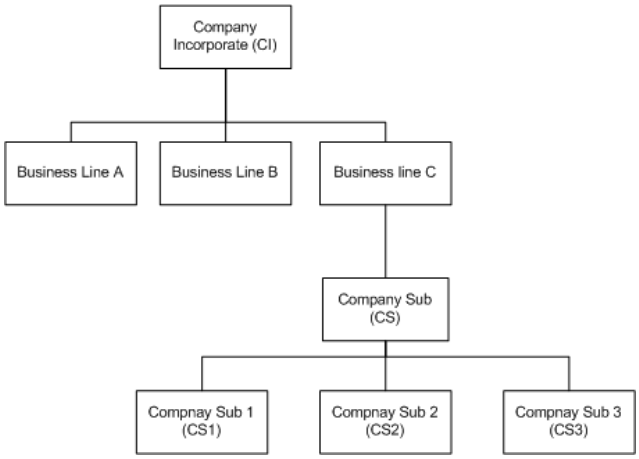


Figure 2.1 High-level organization chart of Company Incorporate with Company Sub as part of the business line C (internal source Company Sub 1)

2.3 Company and portfolio management

A combination of the organizational change within CS and the sense of urgency for proper NPD project prioritization within CS created the situation for focusing on portfolio management. There was a need for proper portfolio management when the two business units (CS1 and CS2) that used to work separately in terms of product development where combined, since for the first time scarce resources for product development had to be divided over the two business units. The urgency for the need to have portfolio management already existed at CS2. Next to doing the project right, which was covered by the implementation of the corporate product development process (CPDP), the question was which projects had to be done in order to do the right projects. There were already many CPDP projects in the development pipeline, however clear coordination for these projects was missing. With the introduction of PMP, an attempt has been made to make better decisions in selecting the most value development projects, since PMP can be seen as a guide for development direction. Around 2005, a first attempt has been made to develop a PMP. Three years after the start of implementing PMP, the feeling exists that project prioritization was still not working as it should be and as a result, it is expected that the PMP can be further improved at CS1.

Chapter 3

Theoretical Background

3.1 Introduction

In the theoretical background, the portfolio management process as been described in scientific literature will be discussed (3.2). The portfolio management process is an increasingly discussed topic in the field of innovation management and is seen as important process for the management of product developing efforts, undertaken by (manufacturing) companies. As literature discusses the need to become innovative in order to cope with the increasing competition, the criteria for becoming an innovative firm will be described in section 3.3.

3.2 Portfolio management process

This section will describe the topic of portfolio management. The reason why portfolio management is believed to be important in companies nowadays will be discussed, including the objective of portfolio management. Furthermore, portfolio practices and approaches to the linkage with the new product development process are illustrated. Finally, insights for the implementation of the portfolio management process are described.

3.2.1 The importance of portfolio management

The first concept of portfolio management, building business portfolios, emerged in the late 1950s. This initial concept generated highly mathematical models, but early applications of portfolio management made an allocation of resources over the business units possible. The business portfolio planning evolved over the 1970s and 1980s, and in the 1980s and 1990s, the use of portfolio management extended for new product selection and the allocation of resources in R&D. Over the next decades, the tool of portfolio management is expected to become a powerful management tool (Dickinson et al., 2001; Cooper et al., 1999). It is important for new product development to do the right projects. But why is there so much focus on doing the right projects nowadays?

Portfolio management is seen as vital for an organization, because it evaluates the possible 'investments' in the organization's new product development process (Kahn, 2005; Cooper et al., 1999; 1997). Furthermore, companies need to evaluate the possible project portfolios in order to improve and maximize new product development efforts, resulting in better performances of the company (Munson and Spivey, 2006; Mikkola, 2001; Cooper et al., 2001b; Crawford and Di Benedetto, 2000; Spradlin and Kutoloski, 1999).

Portfolio managers compare a NPD project as an investment. The use of portfolio management is used to pick the right 'investments' in order to select the high value projects (Cooper et al., 2002). Another benefit of portfolio management is the creation of a better balanced portfolio of projects; a right mix between long and short term, and low and high risk projects. Furthermore, implementation of portfolio management solves the resource crunch. Cooper and Edgett (2003) argue that a lack of effectively allocating the resources to the highest valued projects resulted in low performance for product development. The need for portfolio management seems logical where time to market is important and

where money only can be made if new products and technologies are brought as (one of the) first to the market. So it is very important how your businesses spend its scarce time and resources on NPD projects (Cooper et al., 2001b).
Despite of the understanding of the need to select the highest value projects for the limited available resources, business still let too many projects enter the development pipeline. A reason for this are projects which are seen as 'must do' projects in order to retain customers. Other projects look too good to be true and are therefore entered in the development pipeline regardless the resources available. Projects also won't be killed; once a project is started it will go through the entire development process, since go/kill decisions are not (effectively) made due to lack of quality criteria and lack of engagement by senior management (Cooper et al., 2004; Cooper and Edgett, 2003). As Cooper et al. (2001b) identified, one of the reason of low NPD performance is the lack of focus and effective portfolio management, causing too many and low value projects in the pipeline.
Cooper et al. (1999) have done a benchmarking study after the portfolio management practices of the best performing NPD businesses. It can be concluded that the best performers differ from worse performers in a way that they had a balanced project portfolio of high value NPD projects, with the right balance of project duration and risk. Furthermore was the portfolio of projects aligned with the business' strategy. Finally, the best practice performers had a formal and systematic portfolio management process in place and were skilled in ranking and the prioritization of NPD projects (Cooper et al., 2001b; 1999).
Cooper et al. (2001a) identified three goals of portfolio management. These three goals are:

Goal 1: Maximizing the value of the portfolio.

The first goal is to maximize the sum of a set of objectives. An objective can be financially based, strategically based, based on level of risk etc. So the goal is to choose one or more objectives and to maximize the value of the objective(s). A variety of techniques can be used for achieving this goal. One of the most common techniques is the objective of maximizing the Net Present Value (NPV) of the portfolio. All available projects are scored on NPV and ranked in such a way that the project with the highest NPV is on top of the list. Alternatives for NPV are Expected Commercial Value (ECV), the productivity index (PI) and options pricing theory (OPT). A short explanation of these alternatives can be found in appendix B

Goal 2: A balanced portfolio

The second goal is to achieve a portfolio that is balanced in terms of risk, project duration, types of product innovation, types of markets or technologies etc. A portfolio should be balanced because a portfolio in which there is no balance in terms of low and high risk, won't bring optimal NPD performance to a company; e.g. a company only developing low level risk projects, will make profits in short term, but will encounter problems in the future, since over a longer period of times, low level risk projects will not generate profits. Furthermore it is important to balance the portfolio in terms of risk. It makes sense not to bet on one type of product or market, but to spread the risk among several products and markets.

Goal 3: Building strategy into the portfolio

"The goal to maximize the value of the portfolio is meaningless unless value is measured in terms of a company goal and that goal is articulated as part of your strategy" (Cooper et al., 2001a). Similar, the goal of balancing the portfolio is useless without a clear strategy. The ideal balance of portfolio can only be accomplished if management clearly knows what they want to achieve. Identifying a strategy does that. As result of identifying a strategy, resources can be allocated to projects. This must be done in such a way that active projects are chosen in line with the strategy and resources are allocated in such a manner that the strategy is clearly identifiable in the (number of) active projects. Cooper et al. (2001a) describe three broad objectives in the desire to create strategic alignment in the portfolio management process. The first objective is strategic fit. Strategic fit requires all the projects to be in line with the strategy. The second objective is strategic contribution, which is more complex compared with the objective of strategic fit. It deals with the question what must be done in order to achieve strategic goals and to realize the business strategy. The last objective is strategic priorities. Strategic priority is needed to make sure that the spending of resources is in line with the actual strategy. For instance, if the business strategy is to grow, most of the resources should be devoted to growth projects.

Two general approaches to create strategic alignment are used by companies. These two approaches are (Cooper et al., 2001a):

- Top-down approach. "Top-down approaches begin with the business's vision, goals, and strategy, and from this, new product initiatives and/or resource allocations are decided" (Cooper et al., 2001a). So the business strategy is the starting point and based on the strategy, the right set of projects are identified.
- Bottom-up approach. The bottom-up approach focuses on opportunities in the form of project proposals. The project proposals are screened and the best projects are selected in line with the business's strategy and goal. In this approach, it is important to have a solid tool for reviewing projects and making the right project selection.

Both approaches have benefits as well as disadvantages. The strength of the top-down approach is the strong linking with the business's strategy and all projects (which are competing for the same resources) are evaluated together. On the other hand the top-down approach is time-consuming, especially for senior management. (Cooper et al., 1997). Along the three goals of portfolio management is the constraint of resources. Therefore, when performing portfolio management, the goals must be pursued while taking into account the constraint of scarce resources (Cooper and Edgett, 2003).

3.2.2 Portfolio management methods

Figure 3.1 gives an overview of the study by Cooper et al. (2001a) after the most used portfolio methods. Figure 3.2 shows the most dominant used portfolio management methods. A remarkable finding of the study is that the financial methods are the most popular methods (77.3% of the business uses financial methods and 40.4% of the business uses financial methods as the most dominate one), but the strategic approach is most used by the best performing businesses. Looking at the portfolio methods used by the best performers can provide insight in how to perform portfolio management, although methods successfully used at one company do not have to bring success for another company (Cooper et al., 2001b).

What can be concluded is that there is not a dominant approach towards portfolio management. Also the best performers rely on more than one tool (Cooper et al., 1997), not only because there is not one best

way to perform portfolio management, but also to deal with the unreliability of the methods. By triangulation, the use of more than one method can solve the problem of unreliability of a single method (Cooper and Edgett, 2007). The most common combination of portfolio techniques by best performers are 1) a combination of strategic and financial methods, 2) a strategic approach with bubble diagrams and 3) a combination of a financial method, strategic method and a scoring model (Cooper et al., 1999). Whatever technique or model is chosen, "each company needs to design its own portfolio planning process to fit the nature of its business" (Kahn, 2005)

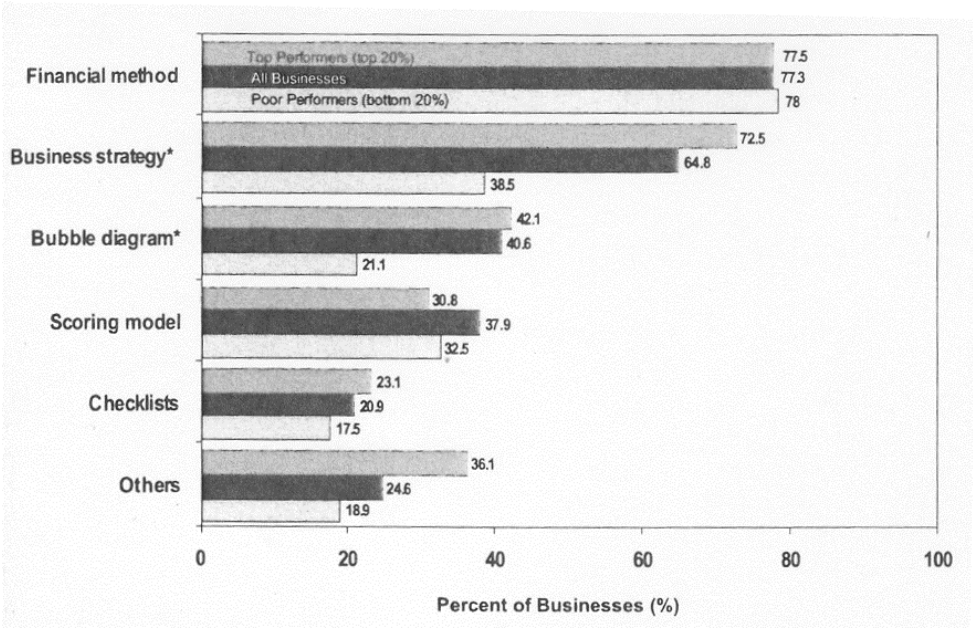


Figure 3.1 most used portfolio practices in businesses (adapted from Cooper et al., 2001a)

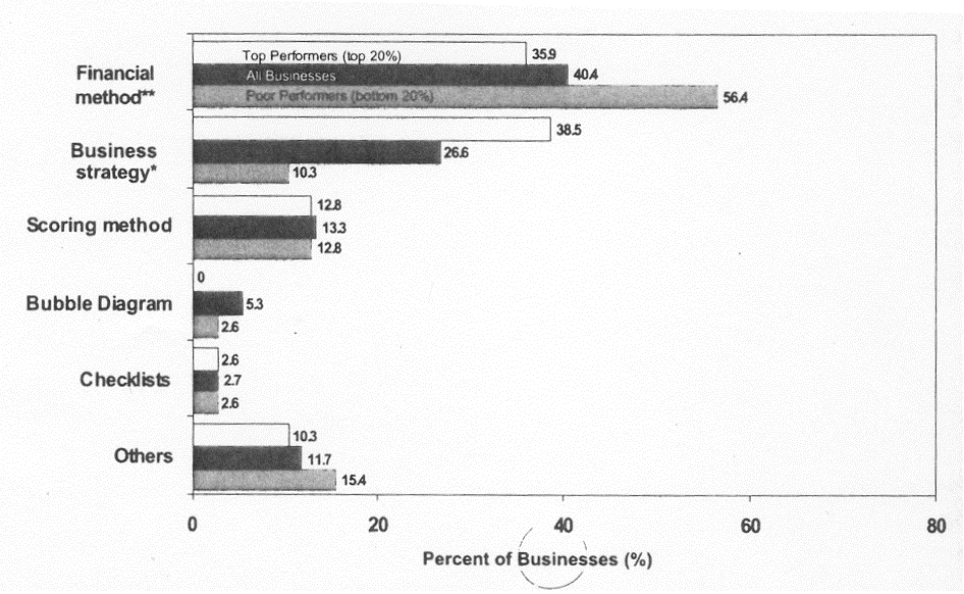


Figure 3.2 most dominant portfolio practices in businesses (adapted from Cooper et al., 2001a)

Next to the mentioned methods in figure 3.1 and figure 3.2, numerous other portfolio management methods have been discussed in literature. Examples of other methods are probabilistic financial models (like Monte Carlo simulation and decision trees), analytical hierarchy approaches (based on paired comparisons of both projects and criteria), behavioral approaches (approach which bring managers to a consensus about the selection of projects by using techniques like the Delphi technique) and the real options theory (Cooper et al., 1999). The (real) option theory implies that firms should make an investment (as allocating resources to a project) if the value of the investment exceeds a certain critical value. The critical value reflects the total required investment and the value of waiting to allocate the resources (Lint and Pennings, 2001). The real option approach is more applicable than the conventional valuation and budgeting techniques if there is a high level of uncertainty included in the decision of the investments (Lint and Pennings, 2001; McGrath, 1997). By creating options, the real option approach creates managerial flexibility because "information continues to be gathered about project technical performance and market outcome potential" (Ettlie, 2006). Ettlie (2006) discusses that the real option theory comes back in the set-based design approach for new product development in which technology depended key decisions are delayed to get the best trade-off between speed and decision quality.

3.2.3 Integration of portfolio management process and new product development process

Cooper et al. (2001a) discuss the integration of the portfolio management process and the stage-gate process (which is as a type of new product development process). There are two fundamentally different approaches to integrate the PMP in the stage-gate process, but in both situations the same portfolio management methods (like the mentioned financial methods and scoring models) can be used, although in different ways (Cooper et al., 2001a). The two different approaches are the gates dominate approach (figure 3.3) and the portfolio reviews dominate approach (figure 3.4).

In the gates dominate approach, the decision-making takes place at the gates of the new product development process. At the gate, two types of decisions are made. The first decision is whether the project meets certain standards (pass/kill criteria) and secondly whether the project is the best decision compared to the other projects (prioritization). During the gate review, projects are evaluated thoroughly and resources will be allocated to the good projects, where the poor projects will be taken out of the process. Besides the decisions at the gates, once or twice a year a portfolio review checks the overall portfolio in terms of the right balance and will check whether the gate reviews are working well. So at the gate-dominate approach, the decision-making process will largely be conducted at the gates (Cooper et al., 2001a).

Hart et al. (2003) performed research on the criteria in NPDP gates and found that companies use different criteria in different in along the new product development process. Where criteria like probability of technical success and potential of the market are criteria used in the early gates of the NPD process, criteria like product performance and staying within development budget come back at later gates (Hart et al., 2003).

The other approach is the portfolio review dominate approach. This approach combines the gate 2 and portfolio review in one, in a way that three or four times a year all projects at or beyond gate 2 are evaluated at once (figure 3.4). During this evaluation, the projects are identified which will be performed and the total portfolio will be checked for balance and strategic alignment and resources are allocated to projects. Compared with the gate dominate approach, gates are more used as check points whether projects are on time and budget and still worth doing (Cooper et al., 2001a).

Looking at the two proposed approaches, it can be said that the 'gate dominate' approach is a more decentralized decision making process and the 'portfolio review dominate' approach, a more centralized decision making process (Cooper et al., 2001).

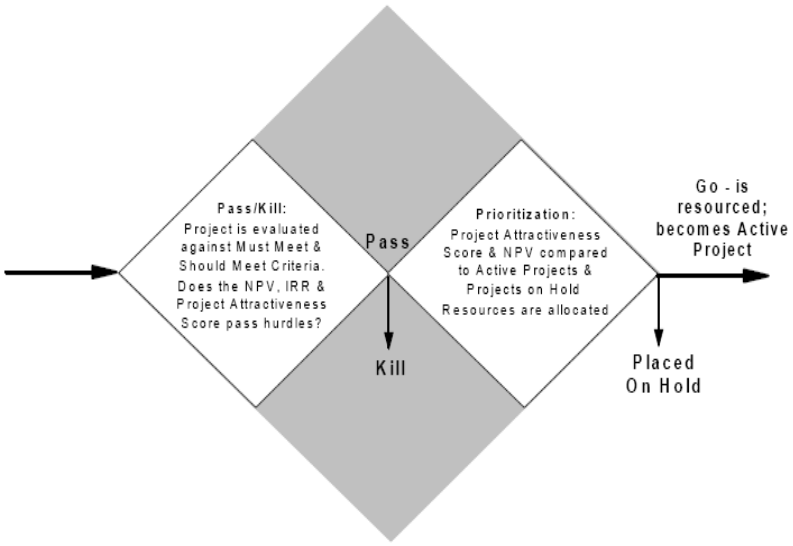


Figure 3.3 The two-part decision process at gates (adapted from Cooper et al., 2001a)

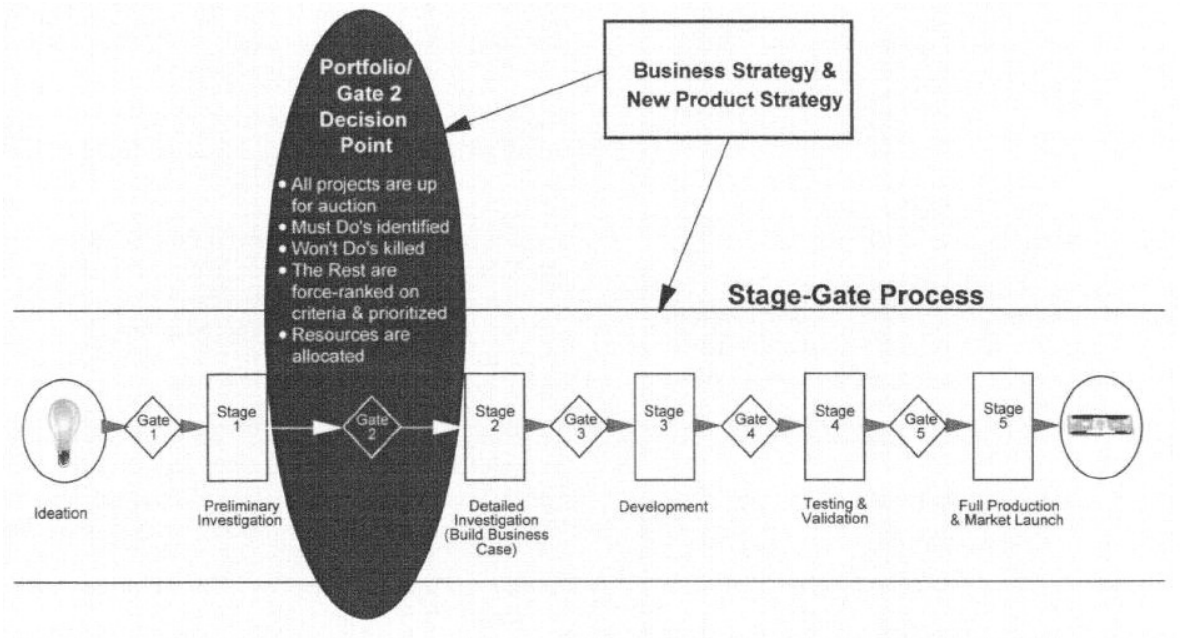


Figure 3.4 Portfolio review dominate approach of portfolio management intersecting with stage-gate process (adapted from Cooper et al., 2001a)

3.2.4 Implementation of the Portfolio Management Process

In order to let any process work, not only the design should be good as well as the implementation strategy. Without implementation strategy, even the best designed process may fail to succeed. For the process of portfolio management, several design and implementation plans have been described in literature. Cooper et al. (2001a), as one of the most prominent researchers in the field of new product development process and the portfolio management process, came up with a four-stage method for the design and implementation of the portfolio management process (Figure 3.5).

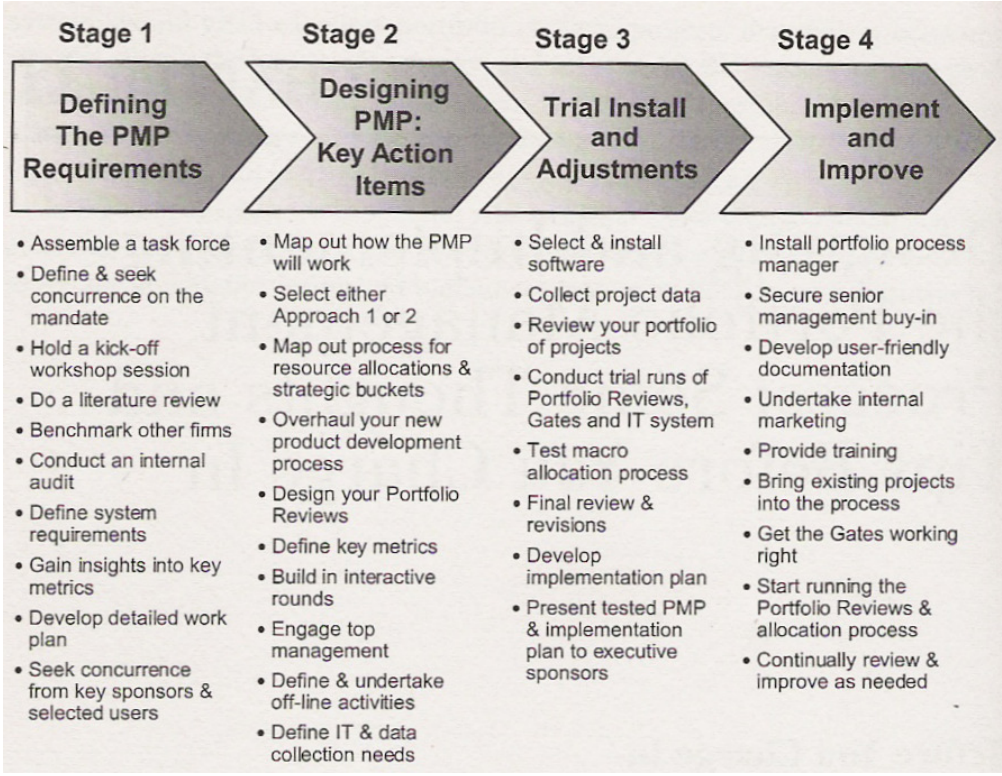


Figure 3.5 Four-stage approach for designing and implementing PMP (adapted from Cooper et al., 2001a)

The first stage is defining the requirements. The purpose of this stage is to identify the reason for having a portfolio management process. It should be understood which problems regarding portfolio management and project selection exist and need to be fixed within the firm. Secondly, the specifications and requirements have to be set about what has to be accomplished with the PMP and in which manner. The second stage is about designing the actual portfolio management process. One of the designing elements is how the portfolio management process should be linked with the new product development process and how the new product development process should be refined. At this stage, a start has to be made for creating buy-in from top management. In the third stage, the process will be tried. This 'trial installation and adjustment' stage has the purpose to try out the portfolio management process as it has been designed in the second stage. During the trial installation, errors in the process will come up and can be solved before the process is actually implemented. During this stage, data are collected on projects and trial runs for the portfolio reviews are held. Besides testing the designed process, an implementation plan has to be written. The result of the test as well as the implementation plan has to be presented to top management.

In the last stage, the implementation and improvement stage, the portfolio management process will actually be implemented (Cooper et al., 2001a).

One of the important steps to take is to install a portfolio process manager. After designing the portfolio management process, it is important to implement it according to the implementation plan. In order to let the designed portfolio management process work, a process keeper should be installed to make sure that the process actually is implemented. The missing of a clear implementation plan and implementation team or owner will, despite the quality of the design of the portfolio process, often lead to failure of implementation of the process (Cooper et al., 2001a).

Another important aspect is to secure senior management buy-in. It is important to have support from top management. Without this support, the portfolio management process will struggle to become a success. Buy-in from top management is important to let the process work, especially at the reviews where decision should be made based on facts instead of decisions made on the believes of top management. At the end, it is important to continually review and improve the portfolio management process, since minor problems will occur over time. This point again declared the importance of process manager to make sure the portfolio management process is implemented and sustained over time (Cooper et al., 2001a).

O'Connor (2004) discusses another implementation plan for the portfolio management process. According to O'Connor (2004), implementing portfolio management process is difficult for even the most advanced company. Many factors hinder the implementation of the portfolio management process, which cause lower benefits experienced from portfolio management process. Examples of such factors are lack of a clear new product development strategy, lack of high quality data or lack of management involvement. Next to these hindering factors, there are other challenges expressed by top managers when implementing the portfolio management process. Examples of such challenges are the difficulty of getting buy-in from the entire organization, the lack of consistent metrics for measuring key characteristics and overcoming the culture of wanting to do all projects. In order to implement portfolio management process in the right way, it is important to understand and address these hindering factors and challenges (O'Connor, 2004). Appendix D shows the entire list of hindering factors and managers' statements about the implementation of portfolio management process mentioned by O'Connor (2004).

O'Connor (2004) discusses the need for a spiral implementation of the portfolio management process. For the situation of software development, research showed that the output of the system (quality of software) was "dependent upon the maturity of the capabilities a group has in developing software" (O'Connor, 2004). O'Connor (2004) suggests that in order to develop the portfolio management process, a certain maturity level should be achieved for all critical components of the process. Only when all components have reached a certain level they should continue to grow to the next maturity level. This so called spiral up implementation approach addresses one maturity level at a time, with the advantage that the implementation will go more easily, benefits of portfolio management process are gained quicker and that the portfolio management process will be steadily implemented. During the implementation, it is important to understand and improve the tools that are used (for instance the way data are stored), to learn and understand the meaning of each component and to finally create consistency in the way the organization uses each component (O'Connor, 2004).

3.3 Becoming an innovative firm

In the introduction of this report, it was stated that due to a changing environment, companies have to create innovations in order to survive and grow. Due the changes in the environment, the focus now lies on the development of innovations, but this hasn't always been the case.

This section will start with defining innovation, since it is an important term but often used in different perspectives (Garcia and Calantone, 2002). Thereupon, literature will be described that shows the need to have different approaches for new product development process for developing different innovations. This section will finish with an evaluation of the changed performance criteria for manufacturing companies over the years. By discussing the evolution towards the criteria of innovativeness, insights are given for the growing importance of creating innovations for companies nowadays.

3.3.1 Defining innovation

In literature, the topic of New Product Development gains a lot of attention, because the creation of innovations is important to the survival and growth of a company. Therefore, there has been much written on the topic of innovation. Roberts (2007) and Dewar and Dutton (1986) conclude that innovation can be seen as a composition of two parts: (1) the generation of an idea or invention and (2) the conversion of that invention into a business or other useful application. The *invention* part of the innovation process deals with all efforts of creating new ideas and the *exploitation* part with all effort of developing the idea into a commercial useful application (Roberts, 2007).

There are a lot of distinctions made in literature for innovation. Probably the best known is the distinction between radical versus incremental innovation. Dewar and Dutton (1986) define radical innovation as "fundamental changes that represent revolutionary changes in technology", whereas incremental innovation is defined as "minor improvements or simple adjustments in current technology" (Dewar and Dutton, 1986). So, the difference between the two is the extent of technological change, which is used in the innovation, and therefore also the level of new knowledge embodied in the innovation. In this way, radical and incremental innovations are distinguished on a knowledge based perception. Other researchers make the distinction based on the level of risk (radical innovation comes with higher risks) or on the level of experienced newness of the innovation (radical innovations come with a higher level of perceived newness) (Roberts, 2007; Dewar and Dutton, 1986; Ettlie and Subramaniam, 2004).

As described in the introduction, nowadays business would not be able to operate without innovations. The problem is that a business cannot survive on incremental innovations only, nor can a business survive by spending time and money in finding radical innovations. When relying on incremental innovations, a company can make money in the short term, but will never be able to have a market share in future markets were the need for better and newer products inevitably would come. This is because they have not spent time and money in developing new products and are therefore defeated by their competitors. Only spending money and time in radical innovation also is not an option, because by only focusing on radical innovations, an organization will not be able to make money in short term and therefore will not even make it to future markets. Burgelman and Doz (2001) stated that the key issue for strategy is to find the right balance between exploitation of existing technologies (the incremental innovations) and the exploration of new technologies (the radical innovations).

3.3.2 Product development for different type of innovations

A growing amount of literature shows that there is a need to make a distinction between different types of innovations in regard to the execution of the new product development process. Wheelwright and Clark (1992) make a distinction between four different types of development projects. Barczak et al. (2006) conclude that the formal NPD process, as used by most product firms, has to be adaptable and scalable to different types of projects; e.g. incremental versus radical. Miller (2006) states that effective innovation management requires two different types of processes: a process for radical innovation and a process for incremental innovation.

This first generation NPD process was based on a technology push. The results of the process were the development of ideas from the R&D department that were pushed into the marketplace. The assumption in the first generation processes was that innovation started with basic science. This view changed in the mid 1960s. The creation of a new product was based upon a market demand. These market pull models were also simple linear processes in a way that the creation of innovation was treated as a sequential process. However, at the second-generation models, the demand from the market was the starting point of product development (Miller, 2006; Hobday, 2005). In the 1970s, a third generation model replaced the market pull dominated models. Empirical studies showed that innovation was interaction between science and technology (Hobday, 2005). The third generation innovation models "added strategic coordination with new concepts and practices including scenario planning, technology lifecycles, and product platforms" (Miller, 2006).

However, the first, second and third generation innovation models (all sequential in nature) are believed to be incapable of developing radical innovations. Therefore a fourth model was proposed to overcome the weaknesses of the third generation innovation model (Hobday, 2005; Miller, 2006). The fourth generation innovation model included a spiral process (instead of linear) for managing radical innovation (Miller, 2006) and created significant overlap between department's and / or activities (Hobday, 2005). The model created a high degree of cross-functional integration within firms, as well as external integration with activities in other companies including suppliers, customers and sometimes universities (Hobday, 2005). Hobday (2005) proposed a fifth generation model. It can be seen as a development of the 4^{th} generation model in which information technology is used to speed up and computerize the process of innovation.

Literature shows that there must be a clear difference between the processes used for developing incremental or radical innovations. Incremental innovations are mostly product development of existing products in existing markets (Miller, 2006) and use a sequential approach for the development process, like the stage-gate process. Breakthrough innovations on the other hand are more likely managed by using a dynamic development model (Ettlie and Elsenbach, 2007).

When looking at the total new product development framework, three different types of NPD frameworks were identified by McCarthy et al. (2006): linear, recursive and chaotic.

The new product development has been seen as linear system with sequential and discrete stages. The stage-gate model introduced by Cooper in the 1990's is an example of the linear approach for a new product development framework and is a result of a traditional project management method, with the aim of delivering projects in time and on budget. Although the linear view can expose how an inappropriate organization and management structure can influence new product development performance, it tends to neglect those factors that govern the innovative capacity of a new product development process (McCarthy et al., 2006)

The linear approach seems not sufficient; the assumption of the new product development process as being an ordered and sequential process, as well as the explanation of the possibility to develop radical innovations with the linear framework, was questioned in literature. Therefore two other frameworks were proposed; the recursive and the chaotic framework for NPD (McCarthy et al., 2006)

The recursive framework differs from the linear framework in a way that it undermines the idea of innovation going through a set of stages and gates. It challenges the idea of a new product development process as being an ordered process of sequential steps, because innovation is a dynamic and nonlinear process (McCarthy et al., 2006; Canner and Mass, 2005).

The chaotic framework is in line with the recursive framework in that it assumes a new product development process is not sequential. Highly innovative NPD processes are more likely to be random-like and disorderly. Therefore, the process is unpredictable, especially because small changes might influence the direction of the entire process. This is also referred to as sensitivity to initial conditions (McCarthy et al., 2006).

3.3.3 Evolution of market requirements and performance criteria

Kumpe and Bolwijn (1994) made an analysis of the changing character of the competitive environment. Over the years, performance criteria of R&D management changed from efficiency to quality, from quality to flexibility and from flexibility to innovativeness.

In the mid 1960s, the most successful firms were the efficient firms. Therefore, firms where mainly internal orientated, resulting in standard procedures and routine tasks asking for a high level of control in order to create efficiency. The manufactured products have life cycles that last for a couple of years and product innovations are generally incremental in nature, where the focus lies on bringing down the cost of producing the products (Kumpe and Bolwijn, 1994). Efficiency can be described as the relation between input and output. Increasing the output or decreasing the input or a combination of both could improve the efficiency ratio (Kling, 2006). It is not remarkable that the focus in an efficient firm is therefore on the input and output of the processes. At the manufacturing department, focus lies on growth and efficiency by focusing on the output of the manufacturing process. By being efficient, companies were able to offer their products at the lowest prices and therefore had a competitive advantage. The barriers for international trade and the fact that demand was always higher than supply strengthened the competitive advantage (Kumpe and Bolwijn, 1994).

Around the 1970s, the trade barriers started to fade, resulting in a growth of international competition. Due to the change from markets being locally orientated into international markets, competition intensified (Dunn et al., 2000). By the intensification of competition, the strategy to provide the lowest prices was not sufficient anymore to have a competitive advantage. Production moved to low wages countries and another strategy had to be chosen in order to provide an answer to the intensified competition. The new strategy for competitive advantage was quality and by providing quality, companies differentiated themselves form the companies who where still focusing on price as most important market requirement (Kumpe and Bolwijn, 1994). Kaynak and Hartley (2005) concluded that quality management could create competitive advantage for high tech firms.

In the 1970s, the quality firms were the successful ones. Kumpe and Bolwijn (1994) state that although the focus shifted towards quality, the focus on efficiency did not diminish. Instead companies had to focus on efficiency and quality in the same time, since quality is not achievable without efficiency and, in return, quality supports the efficiency within the firms.

The serviceability and producibility got more attention at the design process at the development of products. This was due the fact that the focus laid on quality and that the delivered quality from manufacturing could never exceed the quality of the designed product. Another aspect was the need for closer cooperation between the different departments like R&D and marketing due to the changed market pull situation, where it became more important to understand and listen to the customers' desires (Kumpe and Bolwijn, 1994).

At the end of the 1970s another change took place in the market environment. Due to a growing offering of diverse products, consumers started to become fashion-conscious and firms could not count on customers being loyal to a certain brand anymore. Therefore, the ability to offer a wide range of up-to-date products became the important factor determining success for companies (Kumpe and Bolwijn, 1994). This change in the market environment meant that the elements of efficiency and quality were not enough to survive in the competitive environment and that companies had to become flexible in a way that they could react quickly to changes in the environment (Dhar, 1989).

For the development of products, it became important to be able to deliver products faster to the market compared with competition, combined with the aspects of price and quality. Due to this change, time became an important factor in product development, where cost always had been the success factor of product development (Kumpe and Bolwijn, 1994). Due to the increase of speed to the market and complexity in products, companies were seeking for greater flexibility (Moguilnaia et al., 2005).

The companies started to create an external focus and cooperation between different departments became even closer due to shorter communication lines and a decrease of the number of hierarchical levels in the organization (Kumpe and Bolwijn, 1994).

In summary, since the 1960s requirements in the market shifted from offering the lowest prices towards offering the lowest prices for the highest quality towards low prices and high quality for an extensive line of products. Kumpe and Bolwijn (1994) state that there are indications that a new change in the market requirements is growing. In order to stay ahead of competition again, companies have to find another way to distinguish themselves from competition. This new performance criteria is expected to be innovativeness, which means that firms are not making the same product for a lower price or better quality, but that they are making a totally different kind of product in order to cope with competition. Companies have to bring in more innovativeness to their products in order to answer the new market requirement of uniqueness. Figure 3.6 shows the change of market requirement and performance criteria over the years.

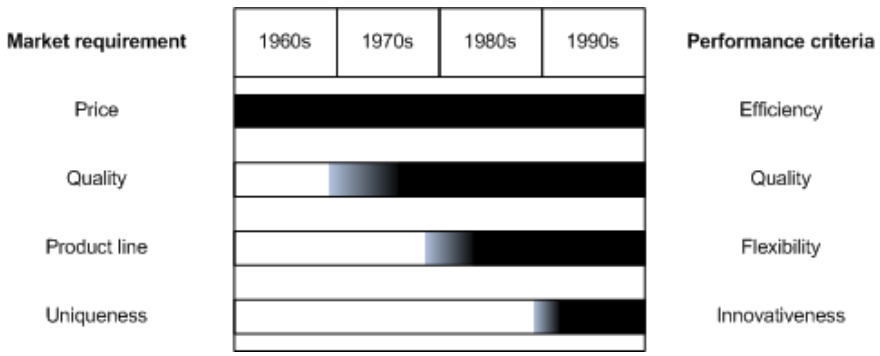


Figure 3.6 Evolution of market requirements and performance criteria for large manufacturing industries (adapted from Kumpe and Bolwijn, 1994)

Although market requirements and performance criteria changed over time, a firm had to meet the performance criteria of the previous market requirements. A company that tries to become flexible will have to accomplish the efficiency and quality 'stage' before being able to become flexible. Due to competition, it is important to change rapidly. In order to be able to change in a short time, a company has to be flexible. In order to attain the innovativeness criteria, it is important that the firm first goes through the efficiency, quality and flexibility stage in order to be able to answer the performance criteria of innovativeness. Innovativeness always comes with renewal and renewal means change. Therefore, it could be stated that innovativeness cannot exist without flexibility within an organization. Moreover, in order to become flexible, the quality and efficiency of the production process has to be under control. Without a quality and efficient production process, a firm is not able to become flexible, because in order to become flexible, a wide product range has to be offered with high delivery demands. This cannot be done for a reasonable price, if the processes for quality and efficiency are not in control (Kumpe and Bolwijn, 1994). Therefore, it can be concluded that in order to become an innovative firm, the first steps are to establish an efficient, quality and flexible organization (Figure 3.7).
As expressed by Kumpe and Bolwijn (1994), in the efficient and quality firm, product innovations are often of incremental character since the focus lies on minor product improvements in order to cut down production costs and improve quality aspects of a product. However, when the company moves towards the flexible and innovative firm, innovations will not be only incremental of nature, but have to be radical as well.

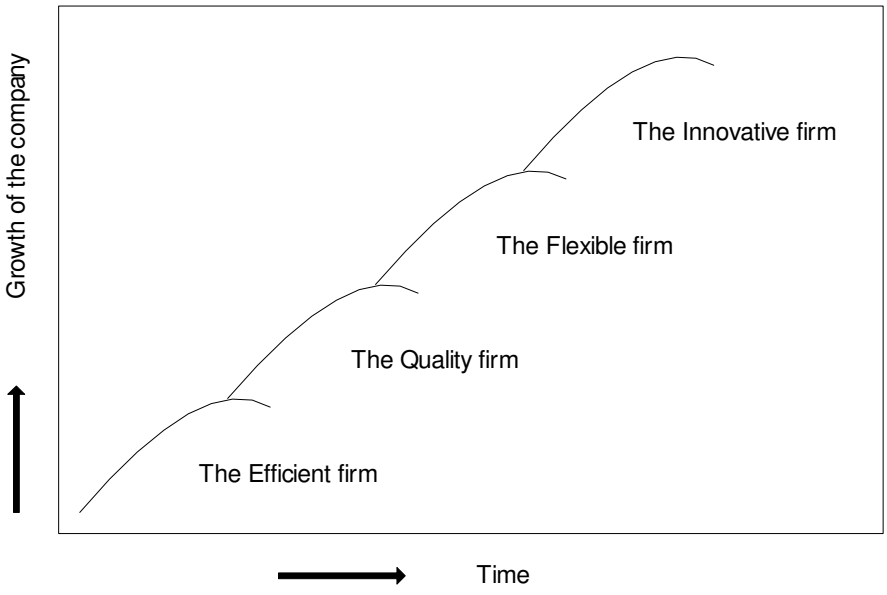


Figure 3.7 The industrial evolution where skipping a stage is impossible since each stage has to be acquired in order to growth into the new stage (Adapted from Kumpe and Bolwijn, 1994)

3.4 Interpretation of insights from literature

Portfolio management has been defined as a dynamic decision-making process, for evaluating and selecting NPD projects. It can therefore be seen as input for the new product development process and as an instrument to guide the efforts for product development. As discussed in literature, it is not enough to do development projects right, but as well as to do the right projects.

The insights in literature clearly show that there is not one single best way in which a portfolio management process could be designed or in which tools could be selected. Taking into account the specific situation of the company for which the process is designed, it therefore important. It should be understood by developers of the process that due to several possibilities, different tools should be tried to fit the situation of the company. Regarding the implementation of the process, it is expressed in literature that implementing a portfolio management process will not be easy and that even the best performing companies find it difficult to successfully implement PMP. According literature, implementing PMP will be a time-consuming undertaking, in need of full support by the company in order to be successfully implemented.

If PMP is positioned in the industrial evolution diagram of Kumpe and Bolwijn, it could be discussed that PMP becomes increasingly important if a firm evolves towards becoming an innovative firm. Development projects in efficient and quality firms have been discussed to mainly focusing on product improvements. It can be discussed that experienced managers, with knowledge of their products, will be able to make a right selection of the most value improvements projects even without a portfolio management process for decision making. Based on their experience, these managers can be expected to understand which products provide the most rewards when improved.

However, if the firm starts to grow and tries to make the transition to become a flexible and thereafter an innovative firm, the decisions which development projects to choose can be expected to become more complex and difficult. Decisions are not simple anymore and relying on the experience of the manager or ranking tools purely based on financials won't be sufficient to select the most valuable development projects, due to the complexity of the type of development projects and the uncertainty of the outcome of the projects.

Chapter 4

Research methodology

4.1 Introduction

The segment manager at CS1 stated the following initial research question: "Should portfolio management be included as an integral facet of the total stage-gate process or should it be seen as a stand-alone process?" The objective of the question was to understand how the portfolio management process at CS1 should be further developed and to create a better understanding of the linkage with the new product development process. Based upon the initial research question, research questions and learning objectives will be discussed below (4.2). As part of the methodology of the research, the manner in which the data are collected and analyzed for the diagnosis (4.3) as well as for the design phase (4.4) will be discussed below as well.

4.2 Research questions and learning objectives

When this research started, a portfolio management process (PMP) already existed at CS1. The first research question will focus on the current portfolio management process by aiming at the specific situation of CS1 and its PMP. Based upon the initial research question, three research questions for this research will be discussed below. For each research question, one or more learning objectives will be stated, with the purpose to find answers for the three research questions.
The first research question deals with understanding of why and how the portfolio management has been introduced in today's development efforts of CS1:

1. How has the portfolio management process been introduced at CS1?

The objective of this research question is to understand the existing process at CS1 in order to create a basis of insight of the process. Understanding why the PMP has been developed and how the design of the process has been done are the learning objectives of the first research question as well as the implementation of the PMP.
After understanding the background situation at CS1, a close look will be taken at the performance of the process. The question is whether or not the PMP is actually doing what it is intended to do. So, the second research question can be stated as followed:

2. How is the portfolio management process performing at CS1?

Three learning objectives will focus on the development over time of the portfolio management process and the current situation of the process.
During the literature study, it became clear that there is a discussion in literature about the need to have different NPD processes for developing different types of product innovations. Automatically, if there is a need to differentiate on product innovation types in terms of chosen NPD process, the question arises what the influence will be for the portfolio management process. Also, CS1 identified the need to develop

different product innovations in the nearby future. The third research question that will be addressed in this research is:

3. How should portfolio management be used when developing different types of innovations?

The objective of the third research questions is reach a conclusion about how portfolio management should be further developed if CS1 starts to develop different types of innovation. A first learning objective will be looking at the criteria for being an innovative firm. Also, the implication for the portfolio management approaches for the situation of developing different product innovations will be looked at. Table 4.1 summarizes the research questions and the learning objectives.

Table 4.1 Summary of research questions and learning objectives

Research Question	Learning Objective
How has the portfolio management process been introduced at CS1?	Why is the portfolio management process developed?
	How has the portfolio management process been developed?
	How has the portfolio management process been implemented?
How is the portfolio management process performing at CS1?	How has the portfolio management process been evolved over the years?
	How does the portfolio management process function in the current situation?
	What is the maturity of the portfolio management process?
How should portfolio management be used when developing different types of innovations?	What is the implication for the portfolio management approach and the development of innovations?
	What are the implications for CS1 in general in order to develop innovations?

The three research questions will contribute in answering how the portfolio management process at CS1 should be further developed and will create a better understanding of the linkage to the new product development process, especially if CS1 expresses the desire to develop different types of innovations. The first two research questions will focus on the PMP and the results of the research questions will provide insights for the current situation of the process. Based on the current situation, improvements for the process can be given. The third research question will focus on the influence of different types of product innovations. Combined with the results from the first two research questions, recommendations can be given about how the PMP should be further developed and about the possible consequences for developing different product innovations for the portfolio management process at CS1.

4.3 Diagnosis

This section discusses the means by which data were collected and analyzed for the diagnostic part of the research. First the research strategy will be discussed. Next, the method of data collection and analysis will be described.

4.3.1 Research strategy

Several research strategies are possible, all with their own (dis) advantages. Yin (2003) identified three conditions that can help to determine which type of strategy is the best to use. An overview of the strategies and the three conditions can be seen in table 4.2.

Table 4.2 Relevant situations for different research strategies (Yin, 2003)

Strategy	Form of Research Question	Requires Control of Behavioral Events?	Focuses on Contemporary Events?
Experiment	how, why?	Yes	Yes
Survey	who, what, where, how many, how much?	No	Yes
Archival analysis	who, what, where, how many, how much?	No	Yes/No
History	how, why?	No	No
Case study	how, why?	No	Yes

The first condition is about the form of the research question, which is basically a differentiation of questions of the "who", "what", "where", "how" and "why" form (Yin, 2003). Given the research questions as discussed in the previous section, all three research question are in the form of a "how" question. According to Yin (2003), it is therefore that the strategies of experiment, case studies and histories should be the chosen research strategy.

The second and third conditions focus on the requirement of control over behavioural events and the focus on contemporary events. A distinction can be made between the three types of research; Experiment, Case study and History. History is the right strategy if there is no access or control, for instance in the situation of dealing with the "dead past" (Yin, 2003). This is certainly not the case in the situation of CS1, where the persons involved with the portfolio management process are still available for the research. A Case study can be used for examining contemporary events (third condition), when relevant behaviours cannot be manipulated. Compared to the History approach, a case study adds two sources of evidence; the direct observation of the events being studies and interviews with the committed persons (Yin, 2003). An Experiment can be done when behaviour can be manipulated in a direct, precise and systematic way (Yin, 2003). Given the research question, it is not desirable to create a situation in which behaviour can be manipulated; a case study approach seems the best strategy.

There are different types of case studies possible. Yin (1993) describes that a case study can be based on single or multiple case studies. In the situation of a single case study, the focus is on a single case. A multiple case study includes two or more cases. In the situation of this research, there will be a single case. As case, the portfolio management process within CS1 was selected.

Furthermore, a case study can be exploratory, descriptive or explanatory. An exploratory case study tries to find support for certain questions or hypotheses, or determines the viability of certain research procedures. A descriptive case study focuses on describing a certain phenomenon in its own context. The explanatory case study focuses on the collection data for understanding cause-effect relationships. It tries to understand which effects are the results of which causes (Yin, 1993).

In this research, the case study was explanatory, since the objective of the study was to understand the current situation and the cause-effect relationships of that situation in order to further develop and improve the portfolio management process at CS1.

4.3.2 Data collection

There are various ways to collect data when conducting a case study, like the analysis of documents, taking interviews and making observations (Yin, 2003).In this research, interviews were held and available documentation was analyzed. Making observations was not a relevant option in this research, although it might have been interesting to observe the actual discussion held at the annual portfolio review. Due to the location of this meeting (at a facility of Company Incorporate), observation was not a part of the methods for data collection.

According to Ten Have (2004), interviews are probably the most popular method for collecting data in qualitative research. With the method of interview, the researcher can ask questions about certain subjects to a specific target audience. The questions can be open ended, for which the interviewee can talk about a certain subject, or the question can be more specific. The crucial part of the interview is to let the interviewees express their thoughts and experiences. Due to that advantage, interviews make it possible to collect a large amount of data from a specific (on-target) audience, making this method one of the most used methods by researchers in qualitative research (Ten Have, 2004).

The questions during interviews are mostly open ended, so that the respondent can express his experience and ideas. Next to the prepared questions, other questions will come up during the interview as result of the answers by the interviewees. The interviews will be recorded, enabling this researcher to analyze them later on. The interviewed person will once more evaluate the information of the interviews to identify possible misinterpretation by the researcher.

The interviews were held among employees within CS1, that are involved in both the corporate product development process (CPDP) Process and the portfolio management process. Figure 4.1 shows the organization chart of CS1 and the persons involved in the processes.

The interviews can be divided into two parts. One part focused on the background of both the portfolio management process as well as the new product development process. For this part, interviews were held with the former CPDP developer (who is currently a improvement project leader), since that person was involved and partly responsible for the implementation of the new product development process (the CPDP process) at CS1. Furthermore, all the development project leaders (1-3) were interviewed since they all are involved in the CPDP process. The segment manager was interviewed since he was the supervisor for the development of the portfolio management process.

For the second part of interviews, about the portfolio management process, both the development project leader (1) and the segment manager were interviewed since they were the portfolio management experts at CS1 and were closest involved with the process. As described in the chapter about CS1, the other facility of the Company Sub department is CS2. Although there are also persons involved with the portfolio management process form the CS2 facility that might provide insights, it was decided to focus upon the facility of CS1. The reason for this was that the portfolio management process was originally developed by CS1 and that communication with the persons would be costly given the limited time of this research.

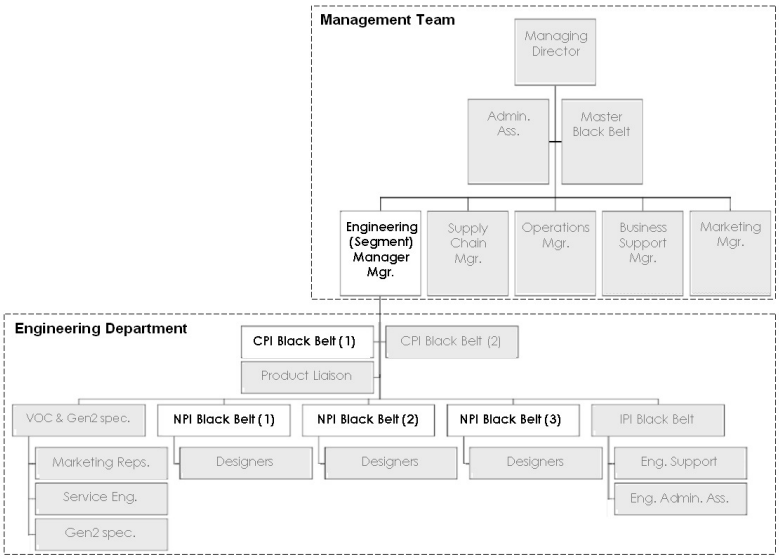


Figure 4.1 Organization Chart CS1 and interviewees

Next to the interviews, documentation was used to collect data. Documentation can be available in several formats like records in text, figures, sound records or a combination (Ten Have, 2004). In this research, two sources of documented texts and figures were used. Documentation from the CI global CPDP website was used for the understanding of the background of the new product development efforts at CS1. Secondly, the documentation of the project that was used to develop the portfolio management process was consulted for information about the design and implementation of the portfolio management process.

4.3.3 Data analysis

Every firm encounters problems with the many processes existing within the organization, e.g. every process gives room for redesign or change in order to improve the process to the current situation. The same thing was true for the portfolio management process at CS1. The first part of the interviews (in line with the first two research questions) focused on the evolution of the portfolio management process and the current situation of the portfolio management process. Thereafter, the interviews focused on the functioning of the current portfolio process to understand which problems exist today and what is causing these problems. Based on the collected data from the interviews and documentation, an analysis will be made to understand the current problems with the portfolio management process.

The analysis was made according the concept of stream analysis as discussed by Porras (1987). As Porras (1987) states, due to the complexity of the processes existing within firms, it is often difficult to understand the cause of the problems in these processes when certain desired targets, like a certain sales volume or achieved quality level, are not met. The problems of not meeting the targets are just the end of a set of problems, a tip of the iceberg where below the surface root causes are the starting point of the final problems of not meeting the targets (Porras, 1987).

In order to create improvements to such a process, it is not sufficient to understand which high level problems exist, like not meeting the desired targets, but to understand the root causes, which are the fundamental lower level problems and starting point of the higher level problems. Again, due the often existing complexity in such processes, several ‘layers’ lie between the higher level problems and the root causes, making it more difficult to identify the fundamental root causes. Therefore some kind of tool in

tracking down the root causes should be used. Stream Analysis is such a tool, providing the methods to track down the root causes of higher level problems within a complex process. The Stream Analysis tools consist of three components in order to effectively change organizational process. The three components are problem diagnosis, planning and intervention. (Porras, 1987).
In this report, the problem diagnosis element of stream analysis was used for identifying root causes for the complex process of portfolio management. Based on the description by Porras (1987), this was done as followed. A chart was made, which graphically represented the problems. The researcher could decide to divide the graph into several columns or streams for each organizational dimension that was considered. After identifying all the problems, a discussion with the segment manager was held in order to discuss the identified problems. After this the last step was to identify the connection between all categorized problems. This was done as well in a discussion with the segment manager. By following these steps, root causes could be identified and used in the redesign and recommendations for the portfolio management process at CS1.

4.4 Design

Based on the analysis of the current situation of the portfolio management process, root causes could be identified which hinders the development of the portfolio management process. Based on the identified problems, guided action could be proposed in order to cope with these issues. However, the need to bring the portfolio management process at CS1 to a higher level is also the result of a desire to become more innovative.
As has been discussed, firms have to be innovative in order to survive in today's competitive market environments to be able to grow and survive. The question is what could be done in order to let a company create innovations? Insights from the field of chaos and complexity theory about Chaordic Systems Thinking (CST) were applied to develop recommendations for CS1 to learn to deal with consequences of developing radical innovations.

Chapter 5

Results

5.1 Introduction

In this chapter the results of the diagnosis will be discussed. The first part of this chapter will discuss the findings concerning the design and implementation of the existing portfolio management process and the findings concerning the functioning of the process (5.2). Based upon the findings, a cause and effect diagram for the current situation of the PMP at CS1 will be constructed and analyzed (5.3). As part of the design, Chaordic Systems Thinking as new insight in becoming an innovative firm and the consequences for CS1 will be discussed (5.4).

5.2 The portfolio management process at CS1

In this section, the collected data for the diagnosis concerning the design and implementation of the portfolio management process will be described as well as the execution of the process.

5.2.1 The initial development of the portfolio management process

When two separate business units of CI, CS1 and CS2, started to report to one global product manager (or product development manager), a need for proper portfolio management increasingly existed. Moreover, the urgency of the need to have portfolio management already existed at CS1, because next to doing the project rights (which was covered by the implementation of the CPDP process) the question was which projects had to be done in order to do the right projects. A limited amount of available resources supported the need for a prioritization tool and the allocation of resources is one of the objectives of portfolio management. Thereby, CS1 was already unsatisfied with the way projects were prioritized, mainly based on financial criteria (NPV), missing value maximization and inputs like risk management. Prioritization of development projects was based on very simplistic financial data. In summary, a combination of organizational change within CS (Company Sub) and the sense of urgency for proper NPD project prioritization created the situation for focussing on portfolio management.

The development of the portfolio process took place around 2005 and was conducted within a 6 sigma project called ‘portfolio management process’. The 6 Sigma methodology is an embedded approach at the company for the development or improvement of processes. The advantage of using 6 Sigma within the company is the existing commitment to the process and therefore commitment for the outcome of the process.

For each 6 sigma project, a project charter is written in which the business case (the reason for the start of the project and the link with strategy), opportunity statement (what goes wrong at the moment and what are the current problems), goals (what is the objective and which variables will be used to improve or achieve the objective) and scope (what will be the focus of the project) are defined. Figure 5.1 shows the original project charter for the 6 Sigma project.

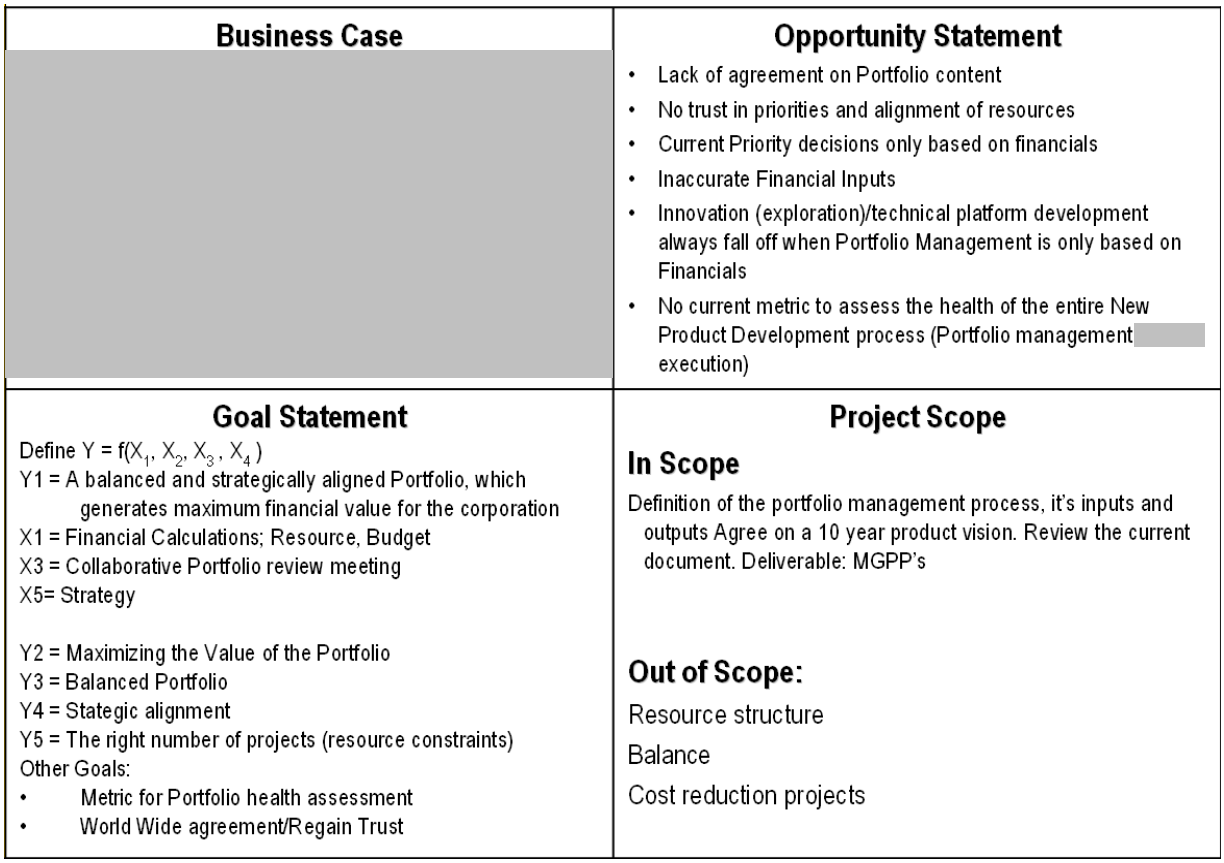


Figure 5.1 Original project charter of 6Sigma project "Portfolio Management Process" (source CS1)

The business case of the portfolio management process was the creation of a Global special equipement development group and therefore a need to improve CPDP project prioritization since there was no prioritization tool or at most a prioritization just based on simple financial data. Also, portfolio management could help improve the prioritization of the CPDP projects and create a stronger product portfolio for CS. In the opportunity statement current problems have been stated, like the quality of the used metrics, which were merely based on financials, and the prioritization based on emotions instead of objective metrics. The goal of the 6 Sigma project was to set up the beginning of a portfolio management process, which solved the prioritization problem of the project proposals. As can be seen, out of scope is the resource structure and the balancing factor. The original objective of the 6 Sigma 'portfolio management process' has never been to completely design an entire portfolio management, but to make a start and especially focus on the improvement of the ranking method by using more than just financial methods.

The project started in July 2005 and had to be finished in September 2005, since the ranking tool would be used at the CS strategy session in September. For that reason, there was a short period of time in which the process (or better said the ranking tool) had to be developed. The initiator of the project was the segment manager of CS1. The segment manager was searching for an answer to the problem for the ranking of the CPDP projects in the strategy session. As a result, the theory by Cooper provided a tool to overcome the problems of project prioritization. Due to a combination of the time pressure and a preliminary investigation by the segment manager of CS1, the theory of Cooper was used as basis for the

development of the ranking tool. Other approaches were not evaluated and the focus was therefore on the findings by Cooper. This can be clearly seen if the practices in the ranking tool are analyzed, which shows much resemblance to the theory by Cooper. Based on an extensive benchmarking study among top performing companies, Cooper identified the most used and most popular portfolio practices among top performers. This information was used as the basis for developing the ranking tool. In the ranking tool, two methods are used to create a ranking of project proposals. Next to the financial method, scorecards were used in order to create strategic alignment.

Part of the ranking of projects was based on the Expected Commercial Value (ECV) calculation. Compared with NPV and bang-for-buck method, the ECV takes risk into account. Using the Net Present Value of a project as basis, the probabilities of technical and commercial success are taken into account. The development and launch cost are also taken into account. The other part of the ranking of projects is based on two scorecards. The first scorecard contains scoring factors for strategic leverage. Four factors (Proprietary position, Platform for growth, Durability and Synergy) are giving a score of 1, 3, 7 and 10. The average score of the factors determines the overall scoring factor for strategic leverage. The second scorecard contains scoring factors for business strategy fit. Two factors (Congruence and Impact on business) are giving a score of 1, 3, 7 and 10. The average score of the factors determines the overall scoring factor for business strategy fit. Both scorecards were copied from the theory by Cooper and changes had been made in order to align the scorecards with the situation of CS1. A description of the ranking tool can be found in appendix C.

The CPDP process was a globally initiated and supported process in all facilities of the company like the 6 Sigma methodology and as a result received buy-in from the (top) management. The portfolio management process is not a global initiated and supported process, but initiated by a single business unit within The company. The difficulty was to get buy-in from top management, which is one of the important elements discussed in the portfolio management literature to make the process work. Moreover, there is not a global portfolio management approach. The global CPDP team, which was responsible for the development and support of the CPDP process, declared that the decision about which projects to develop and enter into the CPDP process is a decision, which had to be made by the individual business units of The company. Therefore, the individual business units were responsible for the portfolio of product development projects. Since buy-in management from top management was lacking, it is less likely that other business units would make efforts to develop or spent time and resources to develop a portfolio management process.

During the development of the portfolio management process, an implementation plan had not been written. The identification of the next steps to take in the process of creating a complete portfolio management process had not been in the scope of the project. However, documentation of the 6 Sigma project showed that the maturity levels of portfolio management had been mentioned and were known by individuals who were involved in the project. After finishing the project and the first strategy session, there was no plan for further implementation made. Only the ranking tool had been seen as burning platform. The burning platform for the entire portfolio management process did not exist.

What has been discussed is the question about how many times the ranking tool should be used. After the first session, it was discussed with the involved persons to use the ranking tool four times a year (twice in a face-to-face meeting and twice in a telephone conference). During these sessions, new product ideas could come up and quickly be identified, improving the decisions made at CPDP project execution.

However, these decisions have been changed afterwards. Due to the lack of time by the involved persons and the fact that CPDP projects will last for months, the decision has been made to do the recheck of the list once a year.

Another issue was the assignment of a clear process owner for the ranking tool after the 6 Sigma project ended. In theory, the Black Belt of a 6 Sigma project (the project leader) will hand over the project to the process owner, who becomes responsible for the process. During the 6 Sigma project, a clear process owner had not been assigned. The segment manager, who was the initiator of the 6 Sigma project and came up with the idea to create a portfolio management process, became more or less the process owner.

A reason for this problem can be found in the 6 Sigma process itself. Around the same period, a problem with declining benefits of 6 sigma projects in general was identified at the company. After investigating this problem, it seemed that process ownership was not executed in the right way after finishing a 6 Sigma project. In the old situation, the Black Belt was not only responsible for the execution of the 6 Sigma process but also often threaten as process owner of the process after finishing a 6 Sigma project. However, according the 6 Sigma methodology, a process should be handed over to a process owner when a 6 Sigma project had been completed making the Black Belt not responsible for process ownership. This problem now has been identified and in the current 6 Sigma projects, process ownership gets much more attention.

Next to the lack of proper process ownership in the 6 Sigma process, a misunderstanding by the segment manager of CS1 created the situation in which there was no process ownership at all. According the belief of the segment manager, the black belt would become an internal expert of the portfolio management process. At that time, a program called 'internal expert' was set up at CS1. The program had the objective of using the knowledge of the employees at CS1 about certain topics. For instance, if somebody had a high interest in the topic of strategy, the individual could get time to read and understand the topic after which the knowledge of the individual could be used in several projects. The segment manager believed that the black belt would become an internal expert on the topic of portfolio management, but this eventually did not happen. Due to miscommunication, there had not been a clear responsible person to further develop the process and therefore the development came to a stop. A formal owner of development of the portfolio management process was and is still missing today.

The above discussion shows several issues during the design and implementation of the portfolio management process. Summarizing the issues:

A. The 6 Sigma methodology had been used to develop a new portfolio management process. After investigating the problem with declining benefits, it seemed that process ownership was not executed in the right way after finishing a 6 Sigma project.
B. The original objective of the 6 Sigma 'portfolio management process' had never been to completely design an entire portfolio management, but to make a start and especially focus on the improvement of the ranking method by using more than just financial methods.
C. The total duration of the 6 Sigma project was three months, which is a short development time for developing a solid ranking tool as part of the PMP.
D. The theory of Cooper was believed to be the right approach and used as basis for the development of the ranking tool, without evaluating other literature concerning PMP.

E. The PMP is not a globally initiated process. A global initiated process like the CPDP process receives buy-in from management in all the business units of the company. Business units have to implement these globally initiated processes, which has not been the case for PMP.
F. Lack of commitment for further development of a PMP at CS.
G. No implementation plan has been written
H. Decision changed to have a recalibration session once a year, instead of 4 times a year.
I. Only the ranking tool has been seen as burning platform. There was no burning platform for an entire portfolio management process by all segment managers at CS.
J. During the 6 Sigma project, a clear process owner had not been assigned.
K. The segment manager, who was the initiator of the 6 Sigma project, became more or less the process owner.
L. A miscommunication between the segment manager of CS1 and the project leader of the 6 Sigma project created the situation in which there was no process owner assigned.

5.2.2 The execution of the portfolio management process

During the portfolio review (as part of the strategy session at CS), the ranking tool as developed in the 6 sigma project was used. At this session, product managers, segment managers and marketing managers of the different business unit are present. The product managers are responsible for the growth of the products within their business units. Segment managers are responsible for the input of project proposals plus data and would get projects assigned. Marketing managers would verify whether the growth values as assumed by the project proposals are in line and realistic compared to the growth targets.

The special equipement group consists of several segment groups over which the design control of all products in the portfolio of CS is divided. For each segment, the segment managers will provide project proposals and the data for each proposal, which is used for the ranking of the projects. The data consist of financial figures and scorecards regarding the probability of technical and commercial success. There is not a standard way in which these data are collected and each segment manager is responsible to deliver the data. This means there are no standards or definitions made for the input data. All project proposals for the different segments are collected by the segment manager of CS1, who is also the host of the portfolio management session, and combined into one list of project proposals. Figure 5.2 shows the process flow of the portfolio review.

After all project proposals have been collected, the segment manager will scan through all the proposals and if there are data that are disputable according to him, the data are discussed during the strategy session. For instance if forecasted sales are unreliable or probabilities for technical/ commercial success are unrealistic, the disputable data are discussed until there is consensus among all the persons in the strategy sessions. Based upon this data, a score for each project proposal can be calculated. Based on this ranking, a list of projects is made. After the list is calculated, each segment manager will provide an overview of the selected projects in his segment and will make a proposal about which resources and budget he needs to accomplish the projects. At the strategy session, all proposed portfolio of development projects are presented and consensus is achieved between the attendants for the plans. This results in the list of projects, which will be executed. Each segment manager takes his responsibility for executing the list of projects. The segment manager of CS1 expressed his doubts about the input data and the manner in which other business units are actually following the list of prioritized projects. However, the manner in

which other business units were selecting their development projects was not part of this research and will therefore not be further evaluated.

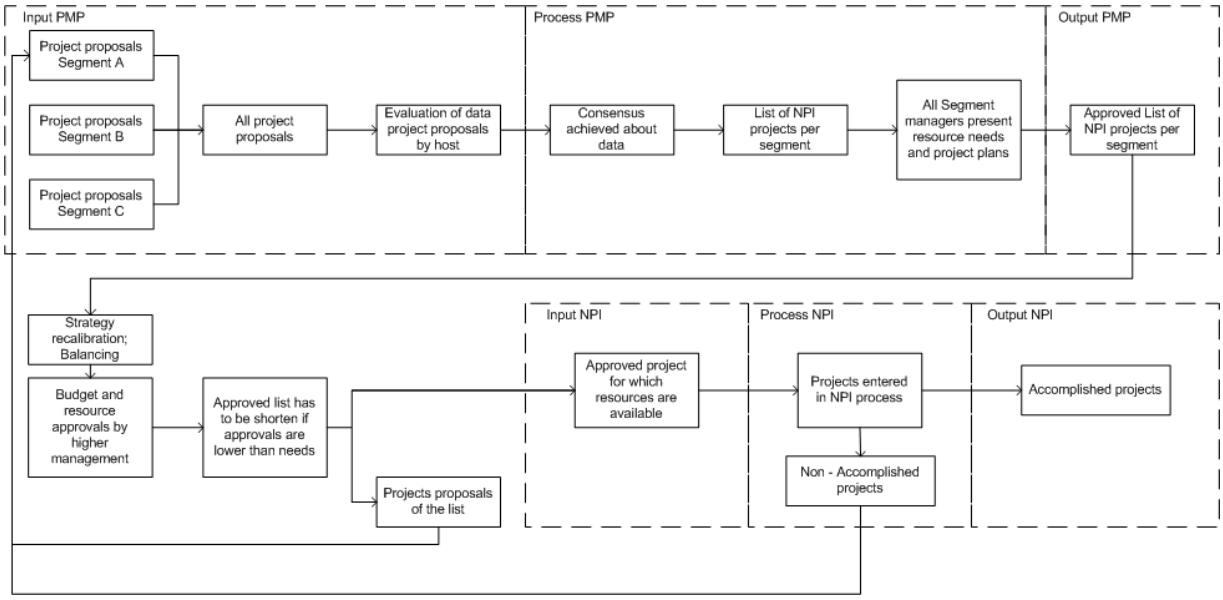


Figure 5.2 Portfolio review (own source)

The segment manager at CS1 will take the approved list into the local strategy calibration session. During this session, the list of projects will be evaluated and compared with the strategy of CS1. If there are projects not in line with the overall strategy of CS1, the list will be adjusted and even the projects on the list could be reshuffled. During this session, the segment manager uses the developed balancing aspect of the portfolio management process in order to align it with the strategy (appendix C).
After the local strategy calibration session, the list will be proposed to top management and approval will be given for (a part of) the needed resources and money. After this approval, projects might be taken of the list, since top management might not give the needed budget or resources. These projects are evaluated the next time in the global strategy session. The other projects on the list will be entered into the CPDP process. At this point, the mapping element will help to clearly state the objective of the CPDP project. Until the next strategy session at CS a year later, the CPDP projects are executed. The projects that are not finished within that year are again taken into account in the ranking tool during the global strategy session. A problem is that resources and budget is often not given to CS1, resulting in a shortening of the executing CPDP projects. As a result of the followed strategy and the not given resources, there has not been a single CPDP project completed at CS1.
After the 6 Sigma project, the portfolio management process had to be further developed e.g. only one of the elements of portfolio management had been developed and used in the strategy session. However, there were problems and ambiguity about the responsibility for further development of the process.
By missing a clear process owner for further development of the process, the segment manager continued to further develop the process at CS1, resulting in two different versions of the portfolio management process. Next to his daily job, the segment manager developed the portfolio management process and

experimented with elements for balancing and strategic alignment as described by the theory of Cooper. These elements are used at CS1. However, the process as used in the global strategy session has not been radically changed over the years and is basically the same ranking tool as developed in 2005.
The performance could be analyzed by evaluating the input into the NPDP as output of the PMP. In this way, the process can judged as low performing, not only since the elements of balancing and mapping are most likely not used by the segment managers outside CS1 and the tools for balancing and mapping as used at CS1 were identified as low matured. If the list of project proposals is evaluated, the conclusion can be that the strong control by steering the direction of product development, which should be the result of PMP, is missing due to the low maturity of the process. It has helped to make a first step at the strategy session by having a ranking tool for project selection. However, there a still several opportunities with which the selection of the right development projects at CS1 can be strengthen.
Again, the above discussion shows several issues during the design and implementation of the portfolio management process. Summarizing the issues:

M. Segment managers deliver the data for the project proposals but there is no standard way of gaining the data resulting in weak input data.
N. There is no uniform way for using the outcome of the PMP.
O. Differences between business units in dealing with PMP.
P. There were no initiatives from CS for further development of a PMP.
Q. Lack of time for segment manager to further develop process next to daily duties.
R. Even though efforts were taken to further develop the PMP at CS1, PMP is still an immature process.

5.3 Root cause analysis

Based on the information obtained form the interviews and documentation, issues have been identified and will be discussed below. After identifying the issues, a root-cause diagram was made, which will be analyzed below as well.

5.3.1 Cause-effect diagram

Based upon the identified problems, connections were identified between the different problems. The researcher discussed the connections with the segment manager and used the follow four questions, as proposed by Porras (1987):

- Does one problem seem to be driving or causing the other?
- Is one problem simply related to another with no evident causal relationship?
- Is one problem seeming to cause as well as be caused by another?
- Is there no clear and reasonably significant relationship between one problem and any other?

When determining the connections, it is important to establish a direction of the causality of the relationship. Therefore it should be avoided to determining connections as result of the second and third question (Porras, 1987). In the situation of the second question, direction of causality cannot be given, since it is unclear what the cause-effect relationship is. In the situation of the third question, it is needlessly complicated to analyse problems that are caused by, as well as causing another problem. Therefore, a direction in causality should be forced in discussing the interconnections. The fourth question has the purpose to leave unimportant connections out of the diagram, since there will be a lot of problems signalized in the beginning of this analysis. Problems with no clear significant relationship

should be left out (Porras, 1987). Based on the identified problems, a cause-effect diagram was made as a result of discussion between the segment manager and the researcher (figure 5.4).
When analyzing the problems, three types of problems can be identified. The first type of problem is the symptom. This is a problem which is on the top of a large number of other problems and which is clearly visible by members in the organization. Symptoms can be identified in the cause-effect diagram by issues having only arrows direction towards them. If the symptom would be solved, the deeper causes of the symptom will not be taken care of and therefore, the symptom will return sooner or later. The second type of problem is the core problem, which is a problem with only arrows directed out of the problem e.g. the problem is only causing other problems but is not caused by other problems. These core problems should therefore be taken care of when trying to solve the situation. The last type of problems is the fundamental problem, which could be identified as the problem having no connection with other problems in the diagram and driving the problem itself. Solving fundamental core problems will bring even more leverage than solving core problems (Porras, 1987)
In the diagram (figure 5.3) the core problems are identified with red and the symptoms are identified with green. There were no fundamental core problems identified.

5.3.2 Analysis of the cause-effect diagram

Porras (1987) discusses that identifying story problems can be used for the analysis of the cause-effect diagram. The identified stories are

- **Story 1: Path R-P-G-B-C**. The low maturity level of the process can be identified as a symptom in the diagram. Analyzing the cause-effect diagram can identify a core problem of this symptom. It can be concluded that due to a short development time of the initial 6 Sigma project, there was never enough time to fully deploy a PMP. Due to this short development time, the further development of the PMP has not been taken into account. As a result, no implementation plan or strategy has been written. With the lack of clear implementation plan, no follow up initiatives for the PMP have been discussed, resulting in a low matured PMP. Another symptom of the core problem of lack of development time is the use of the theory by Cooper to develop a ranking tool and not evaluating other available approaches in literature (issue D). However, in order not to make the cause-effect to complex, this symptom has not been taken into the diagram.
- **Story 2: Path R-P-I-F.** The low maturity of the PMP is not only caused by a lack of time but as well as a lack of commitment. Due to a lack of commitment, the creation of an entire PMP has not been understood or identified as opportunity at CWGT. Only the ranking tool, as part of a PMP, has been seen as a burning platform. Therefore, no follow up initiatives were undertaken after finishing the development of a ranking tool.

  A possible cause for the lack of commitment might be the fact that PMP was not a globally and corporate initiated process (issue E). A symptom of the lack of commitment could be the fact that after the first session, it was decided that instead of 4 times a year, the session would take place once a year (issue H), due to a lack of time. It has to be understood that PMP takes time and efforts and that the managers should be committed to making efforts for the PMP. However, both issues (E and H) cannot be clearly stated based upon the collected data and therefore these issues have not been taken into the cause-effect diagram.

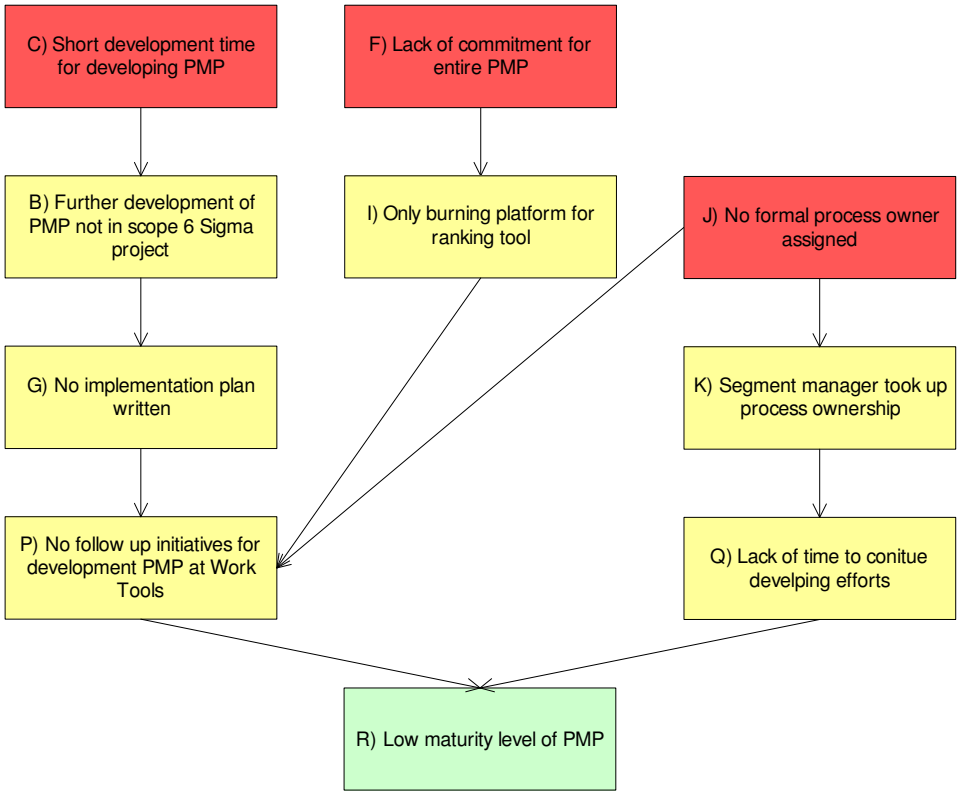


Figure 5.3 the interrelationships between conclusions drawn upon current situation

- **Story 3: Path R-P-J.** Next to the lack of time and commitment, the missing of a process owner resulted in the lack of follow up initiatives. Having a clear process owner, a call for action could have been given. If an individual would have been responsible to develop a PMP, it could have been expected that the individual would have taken different efforts to continue with development of PMP. However, this was not the case, and therefore contributing to the low maturity of the PMP.
- **Story 4: Path R-Q-K-J.** A difference could be seen between the PMP at CS and CS1 (issue O), where the segment manager at CS1 had further explored and developed tools to create balance and mapping elements into the (local) PMP. Without a clear process owner, the segment manager at CS1 undertook efforts to further develop PMP at CS1. However, developing an entire and solid PMP is a difficult, if not impossible task to be performed by a single manager. It can therefore be concluded that, although the segment manager undertook efforts to create elements of balancing and mapping, the current PMP at CS1 was also a low matured process.
  There have been possible reasons discussed for not assigning a formal process owner. The problem with process ownership after finishing a 6 Sigma project (issue A) resulted in not assigned a clear process owner. However, this issue has been solved and process ownership receives more attention in the current 6 Sigma projects. Another issue was the miscommunication between the black belt (project leader of the 6 Sigma project) and the segment manager about process ownership (issue L). However, this has been understood and taken as a lesson to learn.

Therefore, both issues have not been identified as the core problems for the current situation of the PMP.

In the beginning of this report, it was discussed that due to a change in the organization, the need for a proper PMP became clear. Looking at the original project charter of the 6 Sigma project, it can be said that there were clear opportunities for developing a PMP. However, three years after the initial attempts to create a PMP, the process is still immature. Analyzing the stories, it could be concluded that the core problems were lack of development time for the process, lack of commitment for the developing the process and the absence of a clear process owner. These core problems will have to be taken into account when developing a proposal for the redesign focusing on further development of the PMP.

5.4 Presentation of a new insight

In this section, a new insight about the approach towards the development of innovations will be discussed. As has been described in the theoretical background, literature is implicating the need to have a different approach for the development of different innovations. A workshop has been held in which the new insights were discussed with members of CS1. The results of the workshop will be discussed before discussing the consequences of the new insights for product development at CS1.

5.4.1 Chaordic Systems Thinking

The chaotic framework has previously been mentioned in chapter 3. It has been recognized that the linear framework will not be applicable for the development of radical innovations. McCarthy et al (2006) proposed two different frameworks, the recursive and chaotic framework that are believed to be more applicable for developing radical innovations. The professor (HPM)[1] discussed the concepts of the Chaordic Systems Thinking. The five basic concepts, of which each will be discussed in detail, are Discontinuous growth, (Time of) Bifurcation, Instability, Unpredictability and Emergence.

Discontinuous growth

Time is the most important variable of complexity. Whatever is done, there will always be another situation since you can never step into the same situation twice. Therefore, there will always be change. The other important aspect is complexity and coherence, which means that it is about complicatedness and the interaction between things.

Assume a certain complexity level x. At a certain time, a system is 'born' (expressed with the yellow sun in figure 5.5a) and starts to grow. At the beginning it takes energy to grow (as expressed in the line below the complexity level x) until it starts to grow further in a linear way. However, there are limits to growth, so the system will grow linearly until the system reaches it limits and if nothing is done, the system will fall apart, just like every organization. There are several equilibriums like Equilibrium (E), Near to Equilibrium (NTE), Far from Equilibrium (FFE), Fatal Chaos (FC) and the bifurcation point (as indicated with the yellow sun). When looking at the graph, a next level of complexity, x+1, can be seen. Before the limits of growth of the current level of complexity are reached, an alternative cycle with a higher level of complexity might be started. That system starts to grow again and hits again the limit of growth before an alternative cycle of a higher level is born etc. This is known as discontinuous growth or the Sigmoid Curve. Looking at the graph, two situations of linear growth at different complexity levels can be seen.

[1] During the workshop at CS1, the professor (HPM) as expert in the subject of chaos and complexity theory explained the Chaordic Systems Thinking.

During this linear phase, the traditional management techniques can be used. Looking at the non-linear phase of the graph, the system is not behaving according to traditional rules and models. It cannot be controlled since there are at least two or three more possibilities competing with each other. So whatever you try to control, the system is not obeying your rules.

(Time of) Bifurcation

When is the best time to change and to move from a system with complexity level x to a system with complexity level x+1? Figure 5.5b shows three alternatives A, B, C for the birth of a new cycle or the time of bifurcation. Alternative C is too late. At the time that the former system is reaching the limits of growth, the new system has not enough time to become mature enough to take over the old system. Both alternative A and B are on time, in a way that they had time to become mature and are ready to take over the former system. However, system A has had more time to become mature and has already entered the linear growth path and is therefore stronger in comparison with alternative B. System A creates much more opportunities to be stronger in comparison with competition, because the system is mature in an earlier stage. So to the question when does the system need to change, the answer is given that it is preferably to change it before it is time to do so.

Instability

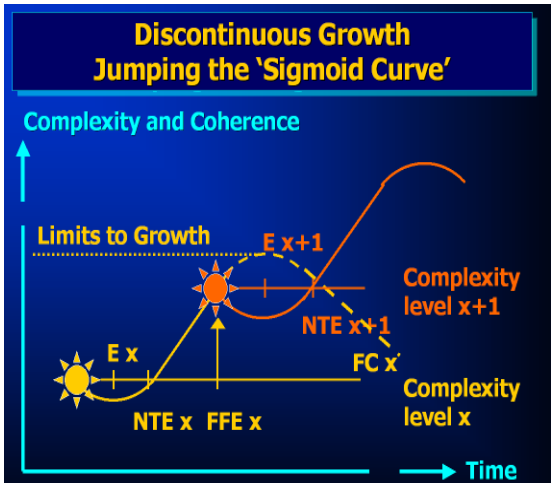
What can be done in a turbulent situation? Taking a look at the cross in chaos (figure 5.5c), two signals can be seen, the dominant thinking which is the strong signal of the current system at complexity level x and the dreaming of a new thinking which is the weak signal of the system with complexity level x+1. There are four situations identified. “Old thinking, Old doing” refers to the situation in which you, although you hit the limit of growth, are keeping to think and do in the old way. On the other side is “New thinking, New doing” where you already start to act differently and think in the new way. The two other situations (“Old thinking, New doing” and “New Thinking, Old doing”) can be seen as transition phases in-between. The professor (HPM) explained that a future strong signal cannot be predicted, but that it can be seen as a weak signal in the present. So in complex systems, so many things happen that you cannot rely on planning to predict future, but you can look at the present weak signals. To the question what we can do in turbulent situations, the answer is to listen to the weak signals, because they might be forerunners of a new future.

Unpredictability

Taken a look at the traditional linear approach of planning, it is assumed that the past leads to the present leads to the future. So based on the knowledge about the past and present, the future can be predicted by a statistical process of extrapolation or linear planning. However, there is often a difference between what is realized and what is planned (figure 5.5d). After a period of time, the planning has to be adjusted since it cannot be realized. One of the reasons is that the environment is so complex, that there are all processes playing part and influencing the outcome.

Due to the complexity of the nonlinear dynamical system, a small variation in the initial condition can result in large variations over time in the behavior of the system. This sensitivity dependence on initial conditions is also known as the butterfly effect, which may occur when positive feedback loops in a complex system[2] (figure 5.5e)

[2] http://en.wikipedia.org/wiki/Butterfly_effect (Accessed on 09/01/2008)



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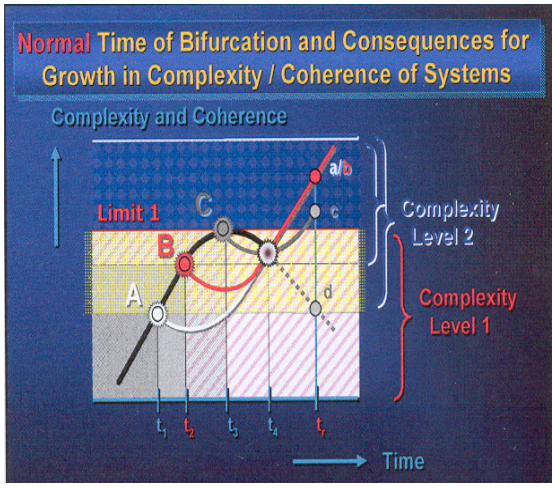

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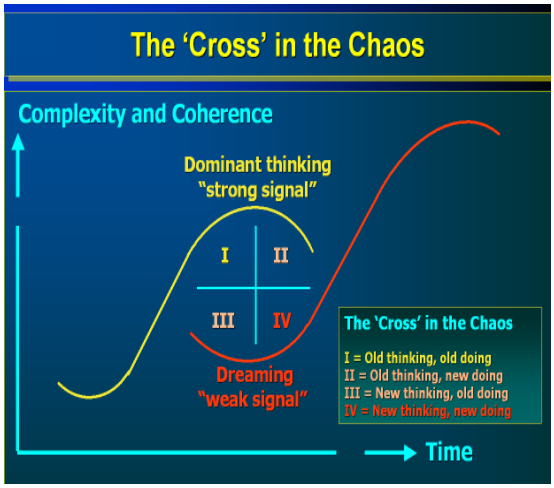

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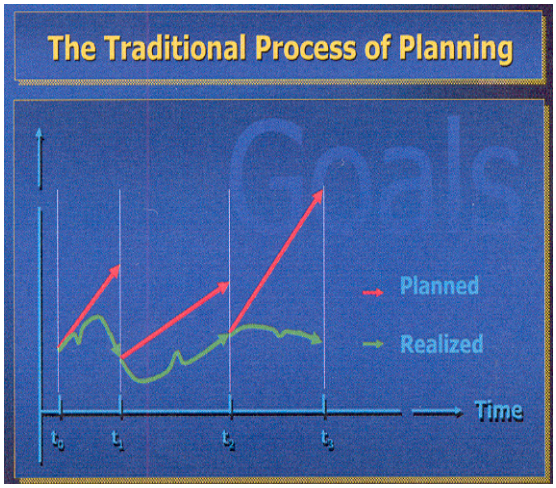

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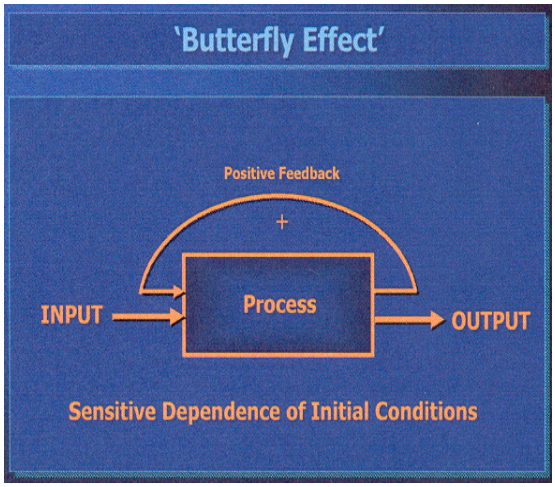

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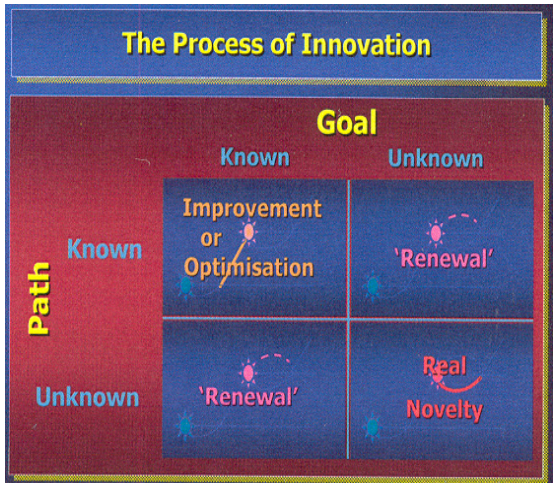

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Figure 5.5 Slides as presented during the workshop by the professor (HPM).

So the chaordic (combination of chaos and order) approach of planning is that there is only the moment of now. Past is represented as a memory and future is represented as a vision, but there is only the moment of now which moves over time. Therefore it can be concluded that the future is principally unknowable in advance. Therefore, planning can be better used for the purpose of priority setting. Planning is used for priority setting and not as planning. So to the question what are you going to do: planning or discovering the future, the answer is to develop desirable future scenarios with all your stakeholders.

Emergence

Figure 5.5e shows 3 situations in the process of innovation. Real novelty is the process of innovation where the goal and the path are unknown and therefore comes with a high risk. If the goal and path are known, the process of innovation can be seen as improvement or optimization. If the sigmoid curve is placed in the four quadrants, it can be seen that the linear path fits the known-known part, hitting the limit to growth can be placed as unknown goal-known path or known goal-unknown path and that real novelty is the start of the weak signal. Therefore, to the question how are you going to organize for real novelty?, the answer is by letting people interact as much as possible and let go of control.

5.4.2 Implications for organizational change

Based upon the theory of Kumpe and Bolwijn, CS1 can be identified as a company currently being in the efficiency and quality level. The company identified the need to grow to the next complexity level of flexibility. Although the understanding exists to grow to the level of flexibility, the organizational structure has to be taken into account in order to be successful. Not only the structure of CS1 itself, but as well the structure of CS and the way CS1 is part of that structure should therefore be understood.

Several challenges have been discussed in order to make the transition work. Catching weak signals is, although extremely difficult, important to start in time with investing time and money to mature the cycle in such a way that the transition can be made. Another important issue is the style of management, which will have to be changed in order to give employees the change and ability to work out weak signals.

CS1 will have to understand what the position is within CS and it seems that two possibilities arise to choose from. On the one hand, it can be chosen to stay closely in line with the corporate way of developing products. This means that CS1 chooses to follow the CPDP process and accepts the fact that, although improving the efficiency and quality of the production and products, real novelties will not be developed. Therefore it can be expected that the limits of growth will be reached within several years. Moreover, CS1 will be depended on the creation of real novelties on corporate level in order to develop new products in the future. On the other hand, CS1 can choose to make the transition into the flexibility level. Although this will be difficult and there will be a lot of changes needed, it will be the only way in order to create a situation in which CS1 can become an innovative firm and create real novelties.

Chapter 6

Redesign

6.1 Introduction

In the last chapter of this report, a redesign for the portfolio management process at CS1 will be described. Based upon the outcome of the analysis of the current situation of PMP at CS1 and the insights gained by discussing Chaordic System Thinking, improvement proposals will be discussed.

6.2 Foundation for redesign

The first part of this section will evaluate the specifications for the redesign. Thereafter, product development at CS1 will be described before continuing with discussing the redesign.

6.2.1 Specifications for redesign

The specifications can be divided into three parts; specifications based on literature, specifications based on the outcome of the workshop and specifications based on the specific situation of CS1. If a comparison is made between on the one hand the results from the root-cause analysis and on the other hand the insights from literature by Cooper et al. (2001a) and O'Connor (2004), the following specifications can be stated:

- Create an implementation team and process owner. There was no implementation team created for the development of the PMP. Although a 6 Sigma project including important team members took place, the continuing of the development at CS1 took place by one or two persons. The missing of a clear process owner has resulted in declining efforts to further develop the process. Cooper et al. (2001a) and O'Connor (2004) describe the importance of having a process owner to overcome this kind of problem.
- Create a mandate between developers and process owners for PMP. For the development of the PMP, no clear agreement was created between the developers and sponsor about the requirements for the process. Within a 6 Sigma project, a team has been described and a sponsor assigned. However, at the end of the project there was no process owner assigned and there was no team with important stakeholders left, for further development of the PMP. A kickoff meeting has been held, however only with the project team. According Cooper et al. (2001a), having one or more presentations about PMP and making clear agreements might have increased the commitment for development of the PMP.
- Create an implementation plan. No implementation plan was developed and no clear objectives or needs communicated within a development team or within the business with senior management. Without a clear strategy to continue developing PMP, the process stayed immature. The need to have an implementation plan has been discussed by both Cooper et al. (2001a) and O'Connor (2004).

Discussing the insights of CST during the workshop, remarks have been made by the attendants from CS1 for the situation of the company. The remarks will be taken into account when developing a redesign for the situation of CS1. In conclusion, the following remark should be taken into account as specification for the redesign:

- CS1 should understand the concept of discontinues growth. From dialogues on complexity it became clear that CS1 needed to better adopt the concept of discontinuous growth. This concept leads the way towards a more dynamic kind of project management.

Next to the insights from literature and the workshop, the specific situation of CS1 has to be taken into account for the redesign. Given the specific situation of the organization, the following remarks can be defined as specifications:

- The redesign should only focus on the situation of CS1. To overcome the problem of lack of commitment for the development of the process, the focus should be on implementing PMP at CS1. It has been seen that it is hard to get commitment for PMP outside the business unit of CS1. Instead of making lots of efforts in gaining commitment, it is easier to develop PMP at CS1 and if successfully, present other business units the results in order to get their commitment. In the beginning of the development of the process, the focus should be on creating a solid base by attaining commitment from management of CS1, before continuing developing the actual tools and metrics of the PMP.
- The 6 Sigma methodology should not be used to develop a PMP. In the first attempt, the 6 Sigma methodology was used to develop the new portfolio management process. Although 6 Sigma can be used to design new processes, a clear difference exists between for instance a new process for order delivery and PMP. A process for order delivery can be expected to be less complex and much easier to be developed. Due to the complexity of PMP, the development of the process should be approached as a unique process. The 6 Sigma methodology is a standard method for developing current processes and therefore less applicable to develop a complex process as the portfolio management process.

6.2.2 Sketch of product development at CS1

Portfolio management has been defined as a dynamic decision making process, with the purpose of making the right decisions in the selection of development projects. A list of selected projects, which are entered in the new product development process, can be seen as output of the process. Project proposals can be seen as one of the inputs for the process.

Within the current PMP of CS1, project proposals are created and used as input of the portfolio review session, taking place once a year. Each segment manager of CS provides project proposals for the products in their segment. The segment manager at CS1 creates project proposals, based upon several sources of information like strategy and generation plans for the different products in the segment. The manner in which other segment managers create project proposals remains unclear, since the focus was on CS1 in this research.

According the theory by Cooper et al. (2001a), there are three goals pursued with portfolio management; value maximization, balancing and strategy alignment. The selected projects should deliver the company as much reward as possible and the product development strategy should be in line with corporate strategy. In order to create a healthy balance of development projects, low risk, short term and low

rewards projects as well as the high risk, long term and high reward projects should be in the portfolio. Cooper et al. (2001a) classified four different kinds of development projects. On the left side of figure 6.1, a diagram typifies four different kinds of development projects. In this diagram, the development projects in the quadrants "Pearls" and "Oysters" represent the project proposals with an expected high financial reward and respectively with a high and a low probability of technical success. The development projects in the quadrants "Bread and Butter" and "White elephants" represent the projects with an expected low financial reward and respectively with a high and a low probability of technical success. After projects have been selected, they are the input for the new product development process (NPDP). The output of the NPDP is a new product added to the current product portfolio. Figure 6.1 illustrates this process.

Looking at the project proposals of the portfolio review sessions that have been held in the past years, most of the proposals focused on the improvement of a current product or extending the line of types for a single product. These types of project are identified as 'Bread and Butter' and 'White elephants'. And expected to result in short term, low risk and low reward outcome (Cooper et al., 2001a). In the current product development process of CS1, there are too many of this type of projects and a clear lack of the long term, high reward and high risk projects; the 'pearls' and 'oysters' projects (as expressed in figure 6.1). In the situation of a lack of the 'pearls' and 'oysters' projects, the product portfolio will only exist of products that have been modified over the last years, resulting in low margins and a product portfolio that is not balanced enough to secure profits in the future. In the current situation, there are too many development projects with a low expected financial reward and too few projects focusing on long term result, with a high risk but high financial reward in prospect in the development pipeline at CS1. Not changing this situation will eventually lead to a product portfolio in which high margin product are missing, and low margin products will have to provide enough profits.

In the current product portfolio of CS1, no products can be classified as 'Oysters'. The 'Pearls' are the products that have been in place for a while and therefore will slowly move towards the 'Bread and Butter' quadrant, because margins will (and are already starting) to erode over time. In order to create a healthy balance, it is important to bring more 'pearls' and 'oysters' products into the product portfolio. In order to do so, a start should be made by creating project proposals for these kinds of products. It is therefore interesting to understand how 'Oysters' and 'Pearls' project proposals could be created and therefore experiments will be proposed with which members form CS1 can learn how to recognize opportunities for these kind of projects.

During the workshop held at CS1, Chaordic System Thinking (CST) has been discussed. According the theory of CST, an existing system will hit the limits of growth at some point in time and if nothing is undertaken, the system will fall apart after a while. This could be the case of CS1 if the product portfolio only contains low margin products and no attempts are undertaken to 'fill' the portfolio with high margin projects. If the current situation is identified as a system with a certain complexity level hitting the limit of growth, an alternative cycle might be started with a higher level of complexity at some point of time (time of bifurcation), which again starts to grow and will hit the limits of growth after a while. It can be discussed that in order to keeping growing, a transition should be made from one system to another. In the turbulent time of transition, two signals can be seen; a strong signal that represents the current system and its complexity level, and a weak signal that represents the system with the next complexity level. When the focus is on the strong signal, it can be expected that 'Bread and Butter' and 'White elephants' will be

generated. It has been discussed that in the linear phase of the dominant thinking, incremental innovations for which the path and goal are known take place. Focusing on the weak signal will more likely lead to 'Oysters' and 'Pearls' project proposals. Radical innovations are expected to take place at the beginning of a new system, where development paths and goals are unknown. In order to understand the development of radical innovations and especially the creation of project proposals or radical innovations, the focus has to be on the start of a new system. It should therefore be understood how to catch weak signals and to transform them into 'Oysters' and 'Pearls' project proposals.
To complete the sketch, CS1 as business unit has to be taken into account. The workshop resulted in a dialogue about the situation of CS1. Based upon the theory by Kumpe and Bolwijn, consensus about positioning CS1 as efficiency/quality firm was created. The consequences are that in order to make CS1 an innovative firm, a first step for the company will be to become a flexible firm.
Looking at the sketch of product development for CS1, different elements could be recognized (figure 6.3). Opportunity recognition for creating different project proposals is the first element and serves as input of the second element that is the project selection. In the situation of CS1, a portfolio management process has been taken as tool to make a selection of the development projects. The output of the second element serves again as input in the third element, the product development process. In the situation of CS1, the CPDP process is used for structuring the development efforts from project proposal till the introduction of a new product. The fourth and last element is the company itself.

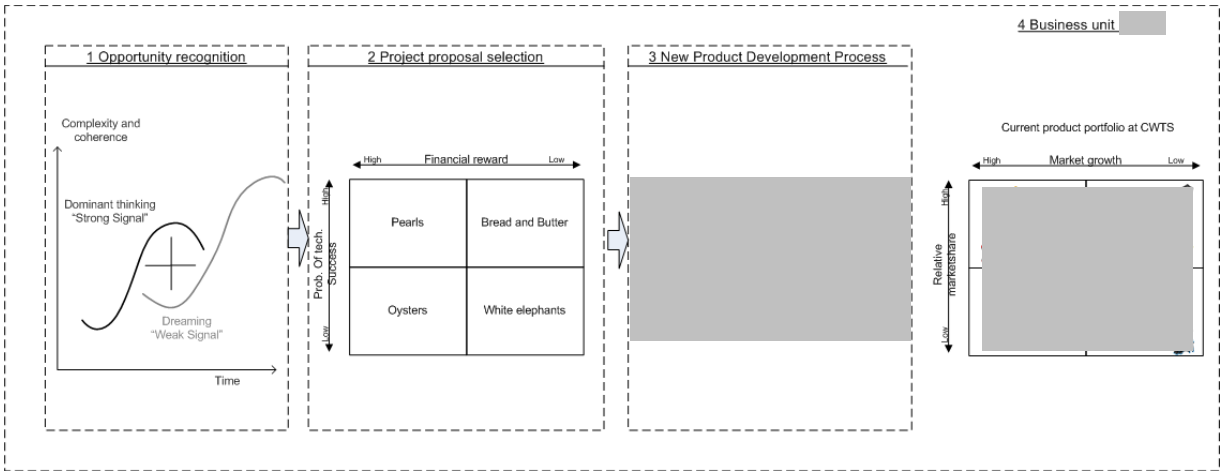

Figure 6.1 Sketch of product development at CS1 (source: presented slide during workshop by professor (HPM) and Cooper et al. (2001a))

It can be said that in order to become innovative, all the different elements should work as one. It is therefore important to understand that only improving one of the elements is not enough in order to create radical innovations. Being able to really create radical innovations means not only to improve the opportunity recognition part as well as the selection, development and the overall firm in which the innovation is developed should fit and change focus upon innovation creation.
However, as a result of the specifications, the first element (opportunity recognition) and second (improve the current PMP) will be taken into account for the redesign e.g. a redesign will be proposed for these elements. For the third and fourth element, recommendations for further research will be discussed.

6.3 Improve the current situation

Given these remarks and the conclusion that the current PMP is an immature process, the best way to continue with the portfolio management process is, according this researcher, starting from the beginning using the lessons learned during the first attempt to implement PMP.

Based upon the insights by Cooper et al. (2001a) and O'Connor (2004), an action plan for further development of the PMP at CS1 will be proposed. Several aspects of the first stage in the implementation approach by Cooper et al. (2001a) were not part of the approach by CS1. Although the approach by Cooper is not the only available approach, the findings are clearly worked out and therefore useful to take into account when developing an implementation plan. Thereby, the findings of Cooper et al. (2001a) are supported by the theory of O'Connor (2004). O'Connor discusses 7 component groups of which 5 groups were defined as supportive tasks for the main process. One of the supportive tasks was the involvement of top management. Other supportive tasks, like the use of proper metrics and the need to have an implementation team can also be found as action items in the approach by Cooper et al. (2001a). An action plan for further development of the PMP at CS1 is described below and consists of the following 6 items:

Item 1 Create a project team and assign a process owner. A first step is to create a project team including an executive sponsor in order to create a platform and buy-in from within the organization for the PMP. The segment manager could function as executive sponsor since he has been the initiator of PMP the first time and has experience with the process. By this he can support the team in terms of knowledge and buy-in. A process owner should be assigned, who is held responsible for the development of the process. Furthermore, the team should consist of individuals with different backgrounds and functions within the organization in order to gain different perspectives during the development of PMP.

Item 2 Present the objectives of the team to senior management. This step can be seen as a combination of the second and third step as discussed by Cooper et al. (2001a). First the team will have to clearly state what their objectives will be and what they want to accomplish. Learning from the first attempt to implement PMP, a clearer and broader project charter should be written in which the tasks and objectives are clearly stated. Having a detailed project charter, a presentation for the management team should be given to inform the efforts undertaken by the team and to discuss the stated objectives. With this presentation, buy-in from senior management will be more likely created since they are involved in an early stage.

Item 3 Gain insights in the topic of portfolio management. Now the awareness has been created at management level and the team can continue with their efforts, the team should gain insight in the topic of portfolio management. Not only the insight by Cooper et al. (2001a), but also other insights by other researchers can be useful during the development of the process. The insights are needed to understand the purpose of the process and to learn from experiences and insights by other researchers and companies.

Item 4 Understand the current situation at CS1. The team should perform a study after the current project selection, prioritization and resource allocation practices and deficiencies. This report has made a start in describing part of the background of product development activities at CS1. Understanding the

current situation, the efforts which have been made so far during implementation of PMP can be evaluated and lessons learned can be used during the develop of the process.
For understanding the (current) situation of the PMP, it can be helpful to create a Capability Maturity Model like O'Connor (2004). A CMM can help to identify the most important points to undertake and can be used as a measurement tool for the efforts during the development. The advantage of developing such a tool is that it could contain the elements that the development team thinks are most important to track down (and which might differ from the items as O'Connor uses). Especially in an organization like The company where it is important to show results, a CMM could help to easily present the progress of the implementation. An attempt has been made to use the maturity model by O'Connor (2004) to identify the current maturity of the portfolio management process. The model by O'Connor has been discussed with both the CPDP Black Belt and the segment manager, however some of the descriptions of the maturity levels are unclear and it was therefore difficult to identify a score for the maturity level for all the 25 components. Therefore, the CCM model, as described by O'Connor, is not entirely applicable in the situation of CS1 and therefore could not be used to identify the maturity level. However, for those components with clear and understandable descriptions, the score was between a maturity level of 0, 1 and 2. The model of O'Connor can be found in appendix E.

Item 5 Develop a detailed work plan. After understanding the current situation and understanding the topic of the PMP, the team can develop a detailed work plan for the designing the various elements in their PMP. The team can set goals and requirements for the PMP and an adjusted Capability Maturity Model could provide support in monitoring the progress. Insight in the topic of PMP and especially about implementation of a PMP could help to create a solid work plan.

Item 6 Give a presentation of the findings so far, find buy-in from the entire organization and continue with the development. By now, the team has made a detailed work plan, set requirements and gained insights in the current situation as well as in the topic of portfolio management. Having this solid base, the team could present the findings again to the senior management and other knowledgeable persons in the organization, who can provide comments about the plan. A presentation could be given during the all-employee meeting. In this meeting, all employees of CS1 are invited for a meeting in which presentations of different subjects concerning the company are given (for example, subjects like the financial figures, the chosen strategy as well as the safety precautions which have been taken in the last months and presentations of process improvements in the factory). The advantage of this meeting is that in a short presentation, the awareness of portfolio management can be created for all employees.

6.4 Portfolio management process regarding the selection of R&D projects

The second specification for the redesign was to show insights in how to deal with radical innovations, especially in regard to the portfolio management process. In the current situation of CS1, too many incremental project proposals are entered into the PMP, creating a lack of radical innovation projects in the new product development process. In this section, the manner in which radical project proposals could be created will be evaluated. Action items will be proposed for experimenting with the creation of radical project proposals.

6.4.1 Creation of project proposals for radical innovations

In literature, it is discussed that in order to create radical innovations, it is important for a company to enhance the ability to recognize the opportunities for this kind of innovation. Cooper et al. (2001a) expressed the importance of the creation of radical innovations for having a balanced portfolio of development projects. Kumpe and Bolwijn (1994) discussed that in order to grow and stay ahead of competition, a firm should try to become innovative in that it can create unique products compared to competition. Therefore the creation of radical innovations is seen as important for a company and opportunity recognition is a facet of the creation of radical innovations. Opportunity recognition connects the breakthrough ideas with the selection process for development projects in the new product development process (O'Connor and Rice, 2001). The question is how opportunities could be recognized and how radical innovations ideas could be generated serving as input of the portfolio management process? During a workshop, insights have been presented about Chaordic System Thinking (CST). To the question what should be done in turbulent situations, the answer is to listen to the weak signals since these signals might indicate a new cycle. To the question how this should be organized, the answer is by letting people interact as much as possible and let go of control.

Opportunity creation is a creative act and not an organizational process. Creativity lies within the individual. Thereby, the amount of creativity differs from person to person. However, to rely on the creative capacity of a single individual is not efficient for a firm. Managerial actions can enhance the probability of developing the creative side of an individual (O'Connor and Rice, 2001). A managerial action could be to bring individuals together and motivate interaction between the individuals in order to increase creativity. Such meetings could also be directed in a way that management initiates such meetings and creates points for discussion between the individuals.

Koen and Kohli (1998) stated, "Interaction between the customer and the engineer/ scientist is the most important source of radical innovations". So not only interaction between individuals within the company can be important but also interaction with individuals outside the organization like customers, competitors or even outsiders like professors from Universities. This is in line with the comments by O'Connor and Rice (2001), who discuss that a firm, which desires to create radical innovations should be externally focused e.g. it should filter information from outside the company in order to create ideas for radical innovations. It is also in line with the theory by Kumpe and Bolwijn (1994) in a way that a flexible and innovative firm, compared to the efficiency and quality firm, are much more externally focused.

O'Connor and Rice (2001) propose some methods for improving the opportunity recognition of a company. These methods are;

1. **Articulating a call to action.** Senior management can communicate a need for radical innovations to individuals within the organization. This can be done by organizing a meeting with a group of individuals from the organization and explicitly ask for development ideas. Another option is to create a group of individuals that get the task to think 'outside-the-box'. The purpose of both actions is gaining new directions for growth.
2. **Investing in organizational enablers for opportunity recognition.** Besides a direct communication for the need to create ideas, management could also undertake actions like providing individuals with different sources of information. By providing and giving access to a variety of data, individuals could be encouraged to create and recognize opportunities for the firm. Including the use of several data in an individual's job can also enhance the opportunity recognition capabilities of the individual. Other enablers mentioned are technology forecasting

exercises and meetings with scholars and researchers in a particular field of expertise. Exposing individuals to a variety of sources of information could support their capabilities to recognize opportunities.

3. **Sustaining attention: the need for a project oversight board.** The strategic priorities of a company will change over time. Due to a change in priorities and employees, radical innovation projects that are often long term and high uncertain projects, may be experienced as a threat since such projects need a lot of investments over a long period of time and will need resources which might have been used for the existing product lines. In order to keep the attention on the project, an oversight board for the project could be formed with the purpose to go on with articulating the opportunity of the project for the firm. Individuals with a long-term view on technology breakthroughs and the ability to make a long-term commitment should be in the board
4. **Promoting and nurturing informal networks.** Opportunities are often created within the individual who has a broad-based understanding and sensitivity to the business issues. A managerial action to enhance opportunity recognition is therefore to create informal networks in which individuals could gain a broader understanding of and becoming more sensitive to the business issues. As discussed in literature, interaction with other individuals plays an important role in opportunity recognition.
5. **Developing organizational structure mechanisms that support breakthrough innovation.** The individual who has recognized an opportunity will not always be motivated to actively expose his ideas. A managerial action could therefore be to create a mechanism in the organization for which will make it easier for an opportunity recognizer to come forward. It is thereby important to focus on the type of opportunity recognizer how to create the mechanism.

Some other methods mentioned by Brown (1998) for increasing opportunity recognition are:

1. **Organize a meeting between managers and knowledgeable individuals outside the company.** One of the examples mentioned by Brown (1998) is a Business Models Workshop where Xerox technical staffs meet once or twice a year at a faculty from the Harvard Business School. This workshop provides insights to research managers like fundamental concepts of strategy, business models and finance.
2. **Listen to your customers.** Another issue mentioned by Brown (1998) is to learn how to listen to customers. The use of Internet as source to listen to the customers can provide a link to your customers. Gaining information by communicating with your customers and understand the perceptions during the usage of your products can help to recognize new opportunities.

6.4.2. Action items for creation of radical project proposals

Several aspects have been mentioned in literature about opportunity recognition, although two points are mentioned in several sources in literature. First is the point of interaction. It has been discussed that in order to create the ideas for radical innovation, interaction between the individuals within the company is important. A second point is the external focus. In order to recognize opportunities, information from outside the firm should be taken into account. As an experiment for recognizing opportunities and given the situation of CS1, two action items are proposed that could be conducted including both interaction and external focus. While conducting experiments, lessons could be learned about what actions are effective at CS1 to recognize opportunities.

Based upon the situation of CS1 some action items are proposed with which the opportunity recognition capabilities of employees could be tried to enhance. The action items are:

- **Support willingness to express ideas by individuals.** Let individuals within the organization think about a future concept or product and have a clear call from the segment manager or any senior manager to come with ideas for product development. This is a cheap and relative easy way to make use of the existing creativity within CS1, but there are more advantages. It creates an opportunity for individuals to express their ideas and to get involved with product development. The question to come up with ideas for product development could create interaction between individuals, since they will start talking about the ideas they have with other individuals in the organization. Another benefit is that individuals who like to express their ideas not only get a change to do so, but could also be identified as potential opportunity recognizers.
- **Provide access to external information and insights.** Provide individuals with information from outside the cooperation. This could be done by providing literature like scientific magazines as well as by letting individuals visit tradeshows or symposia's.
  During the workshop, possibilities for cooperation between the University and CS1 have been discussed. Again this can be done in a rather simple way by providing time and effort to help students performing some assignments at CS1 and in return gain insights by interacting with the students. A longer-term relationship could be made by providing commitment to a PhD student which in return could do research for the specific situation of CS1.
  Other possibilities discussed have been interaction between engineers and customers. Having a meeting between the 5 or 10 most important customers of CS1 and engineers could provide many insights, not only in current problems, but as well in future needs.

Although there may be more methods discussed in literature, which are of importance for improving the opportunity recognition abilities of a company, the above experiments will provide insights from which senior managers at CS1 could learn what can be expected to work and what. If the desire of creating radical innovations is pursued, these experiments could be seen as a starting point. However, it has to be understood, that these experiments will not be enough to create radical innovations. As discussed earlier in this chapter, opportunity recognition can be seen as part of the total development process. For the elements that were not included in the redesign, opportunities for further research will be discussed.

6.5 Opportunities for further research

Action items have been discussed for the first and second element identified in figure 6.1. However, more insights have been collected during the research. Based on this collected information, recommendations will be given for further research opportunities for the new product development process (element 3 in figure 6.1) and the CS1 as business unit (element 4 in figure 6.1). Only focusing on the opportunity recognition and project selection process will not be sufficient to improve the overall situation. The idea behind this section is to show insights that could be taken into account by managers at CS1 when creating innovations in the future.

6.5.1. New product development process at CS1

In the current situation of product development, incremental or product improvements are the outcomes of the new product development efforts at CS1. At the basis of this situation is the CPDP process. The

CPDP process can be identified as a linear framework for the development of products, since the process exists of sequential steps in which standardized actions are taken to come to a product improvement. Furthermore, it shows many similarities with the proposed stage-gate process as discussed by Cooper, where after each stage, a gate review is held in order to continue to the next stage. Some researchers discuss that using a process, which can be seen as a linear framework, incremental innovations can be expected to be the outcome of the process (McCarthy et al., 2006; Canner and Mass, 2005; O'Connor and Rice, 2001). Thereby, radical innovations will probably not be developed, since it has been discussed that, due to the complexity, it will be not likely to develop radical innovations based on a linear framework. In line with the theory of Chaordic System Thinking, these researchers state that for the creation of radical innovation, managers should be less controlling and give product developers the freedom to explore and try-out ideas as part of product development.
On the other hand, Cooper et al. (2001a) discuss the need to have extra stages and gates added to the product development process when developing radical innovations. The goal for CS1 is therefore to understand whether there should be changes made to the current standard development process (CPDP process) and what the consequences are for these changes. How should a different process be structured and how should management deal with these processes. Brown (1998) expressed another approach that will be interesting for CS1. He discusses that it is perfectly possible to have a radical transformation for one element of a product and therefore create a total new product. In the case of CS1, the radical transformation of using electricity instead of hydraulics for powering the tools could be such an example. Brown (1998) refers to this as radical incrementalism. In conclusion, the discussion is open concerning the right structure of the new product development process for different types of innovation projects. Management at CS1 should understand that there is not one right approach or process for developing products.

6.5.2. The business unit CS1

As described in the theoretical background of this report, Kumpe and Bolwijn suggest that a company will have to go through the phases of efficiency, quality and flexibility in order to become an innovative firm. Based upon the strategic objectives of CS1 and comments by the product development manager, it can be assumed that the need exists to become an innovative firm. Assuming that the company can be identified as a quality firm, a next step is the transition towards a flexible firm. It can be expected that changing a certain situation will always be difficult and making the transition from a quality towards a flexible firm will not be easy. A new situation will always lead to some kind of resistance and it is therefore important to understand the need and the consequences for making the transition in order to successfully make the organizational change. If the decision is made at CS1 to focus on efficiency and quality, it can be expected that the limits of growth will be reached within a short period of time. There is an indication that CS1 is close to hitting the limit of growth, where the gap with competition becomes smaller and margins on sales erode. CS1 will also be dependent on the decisions made at corporate level. On the other hand, if the decision is made to try to become a flexible organization, the situation can be created in which truly new products will be developed at CS1, making further growth possible.
Directions for further research can be the understanding of the consequences for becoming a flexible organization. Elements like self-management teams have been discussed at the workshop, but how should this team be formed and how does the role of management changes within a flexible firm?

Other points for discussion could be whether or not CS1 needs radical innovations. At first, this question seems unnecessary since every company is in need of truly new products over time in order to make profit and create market share, as expressed in literature. However, when looking at the market in the situation of CS1, it can be concluded that the market is rather traditional and that truly new products have not been entered in the past years. Also, it has been expressed in the workshop that The company is not truly an innovator, but more a follower who keeps a close look at the marketplace and will follow as soon as new innovations are entered and start to be successful. Although this should be further investigated, the arguments why CS1 should develop radical innovations are also visible. Not only does literature show the need to create radical innovations and the need to become innovative in a way of gaining competitive advantage, but also the marketing manager at CS1 mentioned that margins are starting to erode and CS1 premiums are not justified anymore compared with competition. As dialogued during the workshop, if CS1 is not changing their products and create real novelties, the limits of growth will probably be reached in a short period of time.

Another discussion point could be whether CS1 should be the business unit to develop radical innovations. Since CS1 is part of the company, the question could be whether CS1 should try to develop radical innovations or whether radical innovations should be developed at the company corporate level and that CS1 should only focus on product improvements. What will happen if CS1 will not make the transition and becomes innovative? It will become entirely depended on the outcome of the corporate company when it comes to new technologies. Since in the past this has not been the case, it can be expected that this will not happen in the (nearby) future either. If CS1 is not becoming innovative, it will loose the value for the corporate organization. It can be expected that a production company in the Netherlands, which is not creating new knowledge, will be replaced within a short period of time by a facility in a cheaper production country. On the other hand, is CS1 capable of making the transition towards an innovative company? The current position shows that the next level will be the flexibility level, which will not be easy to achieve. Moreover, it will need time and resources in order to make the transition, but at the same time CS1 has to deliver output in order to achieve the goals of the corporate organization. It will also be extra difficult to make the transition, since CS1 is still part of the corporate organization and will have to follow the process what corporate desires. There are different elements within product development that, next to the specific situation of CS1, have to be taken into account when the desire to develop radical innovations is pursued at CS1.

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Appendices

Appendix A

Different aspects influencing NPD

As part of the preparation for the Master Thesis, a literature study has been conducted. This appendix shows a section of the literature study in which different aspects are discussed that, next to the PMP and NPDP, are expected to influence the outcome of new product development.

"…This paper started with the discussion of New Product Development being vital for a company. New Product Development is defined as a part of all efforts of a company to increase overall performance by developing new products, next to other efforts like sales, marketing and human resources. Within New Product Development, several different aspects influence the performance of New Product Development (Wycoff, 2003[3]). Two aspects have been discussed; the New Product Development Process and Portfolio Management…"

"…Wycoff (2003) discusses the InnovationDNA (figure A.1) showing that next to culture, also the *context* in which development takes place, influences New Product Development….As Wycoff (2003) indicates with the innovationDNA model, the context or ''the interactions between organization and the world around it'' influences the outcome of New Product Development…."

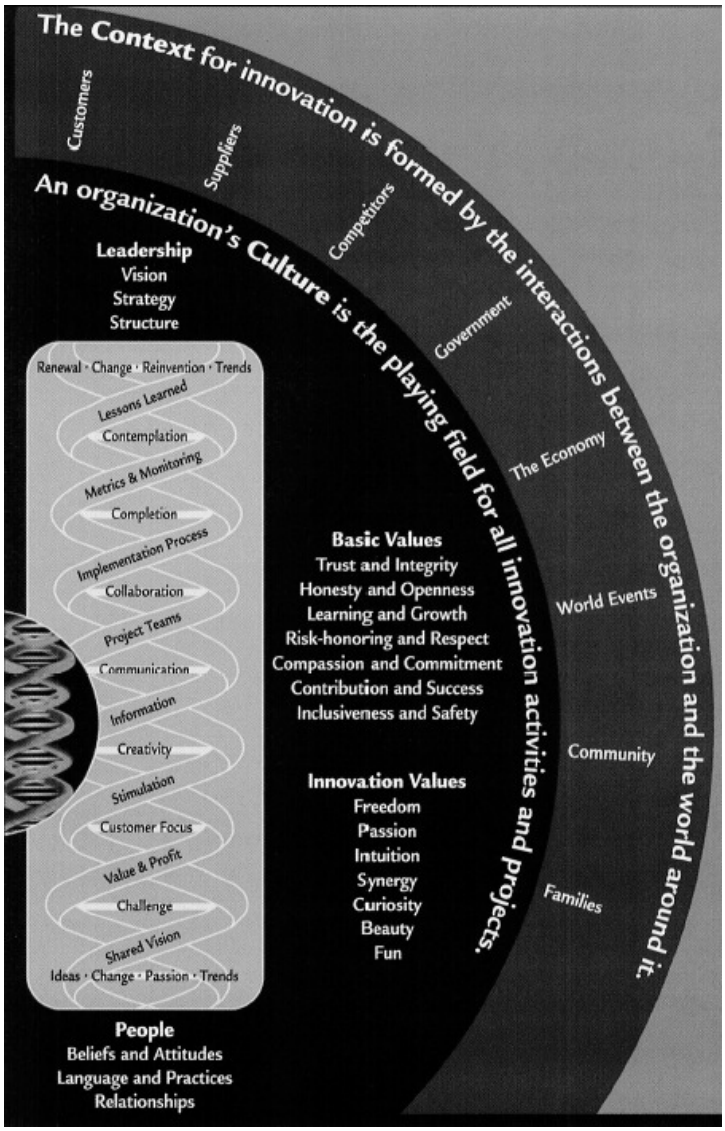


Figure A.1 The innovationDNA™ (adapted from Wycoff, 2003)

[3] Wycoff J. "The 'big 10' innovation killers: how to keep your innovation system alive and well", *the journal for quality and participation*, 2003; 26; p. 17-21

Appendix B

Alternative techniques for value maximization[4]

A variety of techniques can be used for maximizing the sum for a set of objectives. The most common is the objective of maximize the Net Present Value (NPV). Alternatives for NPV are Expected Commercial Value (ECV), the productivity index (PI) and options pricing theory (OPT), which will briefly be discussed.

Expected Commercial value (NPV)

The reward to company is based on the Expected Commercial Value (ECV) calculation as identified by Cooper. The formula for the ECV calculation is

$$ECV = \left[(PV \times P_{cs} - C) \times P_{ts} - D\right]$$

With ECV = Expected commercial value
PV = Present value of future earnings (discounted to today) revenue growth (stream) over time
P_{cs} = Probability of commercial success
C = Commercialization cost (Launch)
P_{ts} = Probability of technical success
D = Remaining development cost

Productivity Index (PI)

The Productivity Index (PI) is based upon the ECV and takes the probability of technical success and the remaining R&D costs. The ECV is different compared with the ECV as discussed above. The ECV in this context is the NPV adjusted for commercial risk. The formula for the PI calculation is

$$PI = \left[(ECV \times P_{ts} - R\,\&\,D)/\,R\,\&\,D\right]$$

With PI = Productivity Index
ECV = Expected commercial value adjusted for commercial risk = NPV* P_{cs}
P_{ts} = the probability of technical success
R&D = the remaining R&D costs for the training

Options pricing theory (OPT)

Techniques like NPV are taking risk into the equation in a manner that higher risk projects are penalized in the wrong way. With the NPV, investment decisions are approached as single and irreversible decisions, resulting in low scores for high risk projects. The options approach takes into account the risk in such a way that along the gates in the NPDP, management can make the decision whether or not to continue with the project based upon newly received information. Like options on the stock market, the options theory creates 'options' for projects for which can be decided to continue with or not by the management at the gates in NPDP.

[4] Adapted from Cooper RG, Edgett SJ, Kleinschmidt EJ. *Portfolio management for new products*. Basic Books: United States of America; 2001a

Appendix C

Portfolio Management Process

This appendix will discuss two topics, the situation before the introduction of a portfolio management process and the current portfolio management process.

Portfolio Management Process

The first Portfolio Management process (PMP) was a result of the 6 sigma project "New Product Portfolio Management" in 2005. Three major steps within the developed process can be identified. The three steps in the PMP are:

1. Ranking of the projects
2. Balancing the products in the portfolio
3. Mapping of the products in the portfolio

Ranking of the projects

In the current PMP, all NPD project initiatives of CS1 and CS2 are evaluated and ranked together since these projects 'compete' for the same resources. The information, which is collected for ranking the projects, consists of the following three figures: *Reward to the company*, *Business Strategic Fit* and *Strategic Leverage*. This is in line with the findings of Cooper and the three goals Cooper identified for the Portfolio Management Process Based on this information, all projects are given a (normalized) score. Based on this score, a project ranking can be made.

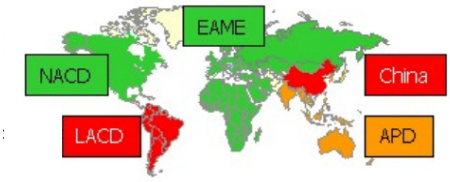
Reward to the company

The reward to company is based on the Expected Commercial Value (ECV) calculation as identified by Cooper. The formula for the ECV calculation is

$$ECV = \left[(PV \times P_{cs} - C) \times P_{ts} - D \right]$$

With
- ECV = Expected commercial value
- PV = Present value of future earnings (discounted to today) revenue growth (stream) over time
- P_{cs} = Probability of commercial success
- C = Commercialization cost (Launch)
- P_{ts} = Probability of technical success
- D = Remaining development cost

The present value of future earnings (are additional earnings; The difference between doing nothing and the earnings from the new product if a project is finished) is made for the period of the next five years for all existing markets (figure G.1). However, most of the current NPD projects have only market expectations in NACD and EAME.



EAME: Europe, Africa, Middle East
NACD: North America Commercial Division
LACD: Latin America Commercial Division
APD: Asia Pacific Division

Figure G.1 Marketing areas of Company (internal source CS1)

The sum of all the net current value for the forecasts of future earnings is presenting a present value (PV). The numbers of forecasts are gained from the local marketing employees) The Commercialization and Development cost are derived by the project leaders based on information gained from different departments in the organization. P_{ts} and P_{cs} are gained by filling out a scorecard. The scorecard is based on the scorecards as developed by Cooper where adjustments were made to better fit the situation of Caterpillar (figure G.2). Figure G.3 is an example of a scorecard.

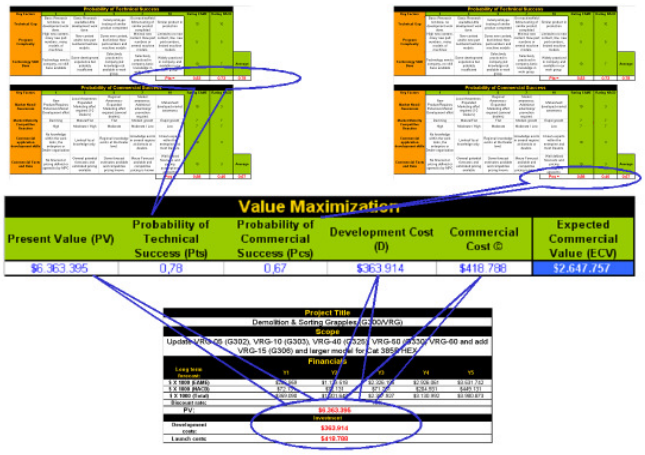
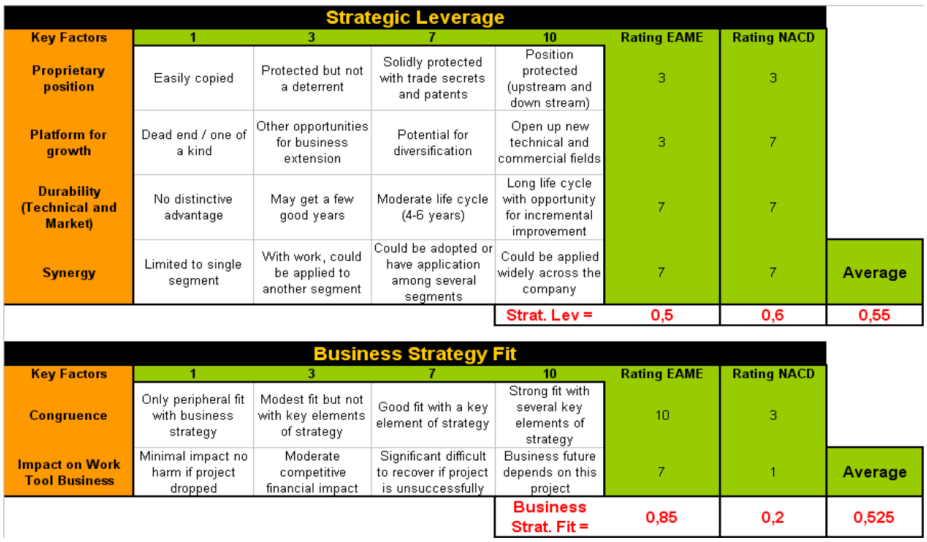


Figure G.2 Calculation of Expected Commercial Value (internal source CS1)

Business Strategic Fit & Strategic Leverage

The scores for the Business strategic fit and strategic leverage are gained by filling out a scorecard for the specific project. The scores are given for each involved market area (and thus most of the times for EAME and/or NACD). First the scores for each market is filled in by the two separate business units. So the market responsible for the EAME area is giving scores and the same thing does the NACD marketing responsible). The next step is to discuss the scores in a (telephone) conferences. Based on an average score, the total score is gained and used for the ranking calculation (figure G.3).



Strategic Leverage

Key Factors	1	3	7	10	Rating EAME	Rating NACD	
Proprietary position	Easily copied	Protected but not a deterrent	Solidly protected with trade secrets and patents	Position protected (upstream and down stream)	3	3	
Platform for growth	Dead end / one of a kind	Other opportunities for business extension	Potential for diversification	Open up new technical and commercial fields	3	7	
Durability (Technical and Market)	No distinctive advantage	May get a few good years	Moderate life cycle (4-6 years)	Long life cycle with opportunity for incremental improvement	7	7	
Synergy	Limited to single segment	With work, could be applied to another segment	Could be adopted or have application among several segments	Could be applied widely across the company	7	7	Average
				Strat. Lev =	0,5	0,6	0,55

Business Strategy Fit

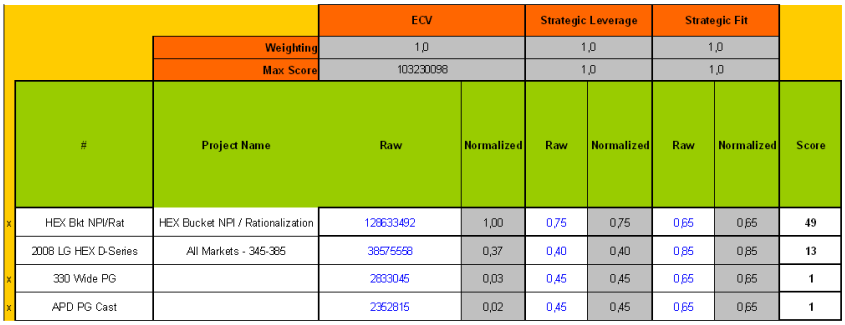
Key Factors	1	3	7	10	Rating EAME	Rating NACD	
Congruence	Only peripheral fit with business strategy	Modest fit but not with key elements of strategy	Good fit with a key element of strategy	Strong fit with several key elements of strategy	10	3	
Impact on Work Tool Business	Minimal impact no harm if project dropped	Moderate competitive financial impact	Significant difficult to recover if project is unsuccessfully	Business future depends on this project	7	1	Average
				Business Strat. Fit =	0,85	0,2	0,525

Figure G.3 scorecards for strategic leverage and business strategic fit (internal source CS1)

At this point there are three figures available for the ranking:

- ECV
- Score for strategic leverage
- Score for business strategy fit.

Based on the maximum score for each of the three figures, all other projects get a normalized score (= score of project/ maximum score). The sum of the normalized score x100 gives a final projects score (figure G.4).



			ECV		Strategic Leverage		Strategic Fit		
		Weighting	1,0		1,0		1,0		
		Max Score	103230098		1,0		1,0		
	#	Project Name	Raw	Normalized	Raw	Normalized	Raw	Normalized	Score
x	HEX Bkt NPI/Rat	HEX Bucket NPI / Rationalization	128633492	1,00	0,75	0,75	0,65	0,65	49
	2008 LG HEX D-Series	All Markets - 345-385	38575558	0,37	0,40	0,40	0,85	0,85	13
x	330 Wide PG		2833045	0,03	0,45	0,45	0,65	0,65	1
x	APD PG Cast		2352815	0,02	0,45	0,45	0,65	0,65	1

Figure G.4 Prioritization calculation overview (internal source CS1)

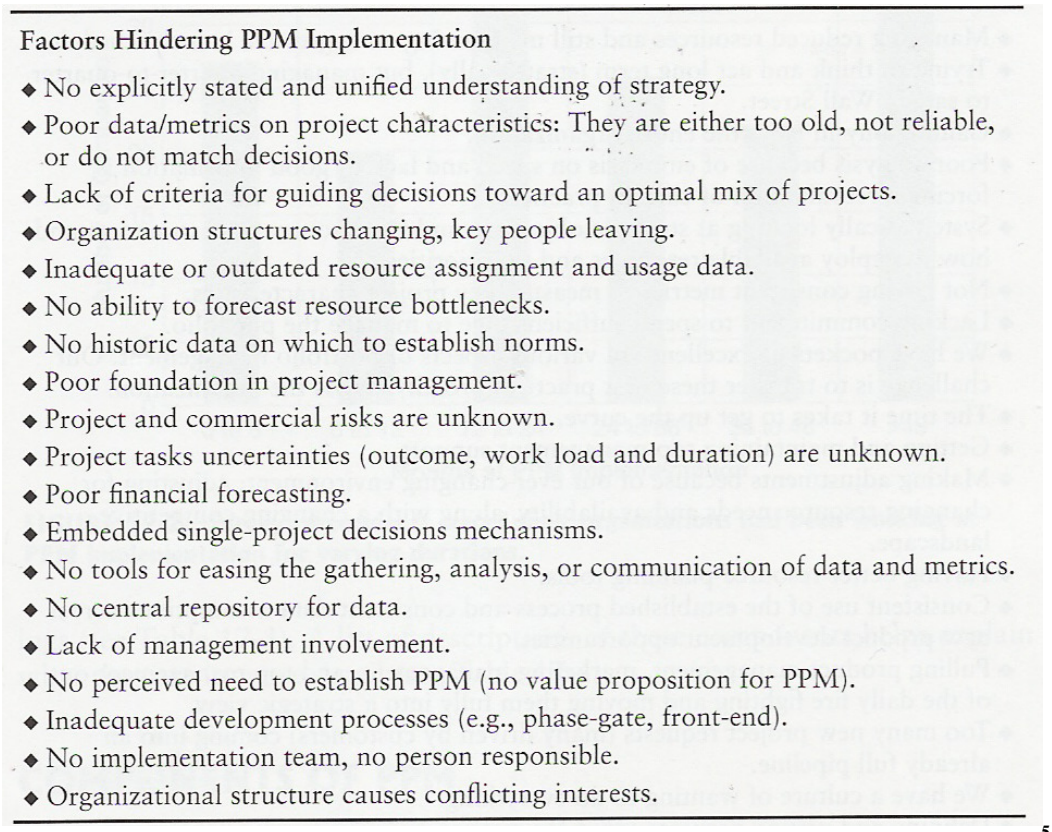
Balancing & Mapping the products in the portfolio

The second step in the product portfolio process should be to create an overview of the product portfolio in order to balance the entire portfolio. However, the balancing and the mapping of the products is not part of the current Portfolio Management Process.

In the balancing process, every product is positioned for five specific factors. The five factors are; *Growth*, *Strength*, *Alignment*, *Sales* and *Reward*.

Appendix D

Hindering factors for implementation of PMP



Factors Hindering PPM Implementation

- No explicitly stated and unified understanding of strategy.
- Poor data/metrics on project characteristics: They are either too old, not reliable, or do not match decisions.
- Lack of criteria for guiding decisions toward an optimal mix of projects.
- Organization structures changing, key people leaving.
- Inadequate or outdated resource assignment and usage data.
- No ability to forecast resource bottlenecks.
- No historic data on which to establish norms.
- Poor foundation in project management.
- Project and commercial risks are unknown.
- Project tasks uncertainties (outcome, work load and duration) are unknown.
- Poor financial forecasting.
- Embedded single-project decisions mechanisms.
- No tools for easing the gathering, analysis, or communication of data and metrics.
- No central repository for data.
- Lack of management involvement.
- No perceived need to establish PPM (no value proposition for PPM).
- Inadequate development processes (e.g., phase-gate, front-end).
- No implementation team, no person responsible.
- Organizational structure causes conflicting interests.

Figure H.1 Factors cited in literature to retard PPM implementation (Adapted from O'Connor (2004)[5])

[5] O'Conner P. "Spiral-Up Implementation of NPD Portfolio and Pipeline Management". In: Belliveau P, Griffin A, Somermeyer SM, *The PDMA Toolbook 2 for new product development*, vol.1. United States of America; 2004. p. 461-491.

- Managing reduced resources and still maintaining an aggressive launch schedule.
- Trying to think and act long term (strategically), but managing quarter-to-quarter to satisfy Wall Street.
- Gaining buy-in from the entire organization.
- Poor analysis because of emphasis on speed and lack of good information is forcing a reevaluation of current practices.
- Systematically looking at strategic objectives and the resource pool to understand how to deploy available resources and set priorities.
- Not having consistent metrics to measure key project characteristics.
- Lacking commitment to spend sufficient time to manage the portfolio.
- We have pockets of excellence in various aspects of portfolio management. Our challenge is to transfer these best practices broadly across the organization.
- The time it takes to get up the curve.
- Getting and maintaining top management support.
- Making adjustments because of our ever-changing environment; adjusting for changing resource needs and availability, along with a changing competitive landscape.
- Having better resource-planning tools.
- Consistent use of the established process and consistent data assumptions across new product development opportunities.
- Pulling product management, marketing management, and top management out of the daily fire fighting and moving them fully into a strategic view.
- Too many new project requests (many driven by customers) coming into an already full pipeline.
- We have a culture of wanting to do everything.
- Defining and getting accurate input for metrics.
- Integrating project management and portfolio management into a seamless system with a single point of data entry.
- Articulating the strategic success measures that are expected from implementing portfolio management.
- Having the right NPD portfolio analysis tools and resource management tools.

Figure H.2 Managers' statements of Top challenges in PPM implementation (Adapted from O'Connor (2004)

Appendix E

Capability Maturity Model

TableI.1 Portfolio management components (adapted from O'Connor, 2004)[6]

Component Grouping	Components	Description
Primary		
Mix Management	Project Selection Criteria	Conditions for selecting or screening projects. Usually established as part of the Phase-Gate or phase review process. As PPM is deployed and front-end processes become established, such conditions may need to be altered.
	Mix criteria	Guidelines for how the portfolio should look. Some measures are made in terms of percentages, others in terms of absolute values (e.g., count, risk, dollars, durations). Time periods may also be captured, e.g., current versus 6 months out, versus 24 months out
	Strategic Buckets	Grouping of project based on strategic rationale
	Project Impact Dependencies	One project may influence another project either positively or negatively. For example, a positive influence might be "project A must succeed for project B to succeed." An example of a negative influence is "If project A succeeds, then project B cannot succeed."
	Mix Optimization Analysis	An in-depth review of how the blend of projects matches the objectives of the portfolio, as well as recommendation of how the blend should be changed to best fit the objective.
Throughout Management	Project Management Foundation	The basic people and systems skills of project management required to carry out an NPD project
	Project Prioritization	A specific rank order of projects that enables management to assign resources in that order and, by doing so, achieve the desired objective of the portfolio
	Resources to Project Assignments	The manner in which resources are assigned and conduct work to projects
	Resource Use Forecasts	The ability to predict when each appropriate resource will be used on a specific project and when there will be shortfall or excess of the appropriate resource for each project
	Critical Chain Buffer Management	A method of project management that accounts for the uncertainty of tasks and the dependency of specific tasks on certain resources
Supportive		
Measures/Methods	Metrics	Measurements of PPM
	Financial Priority Listing	Specific rank order of projects based on financial measures such as IIR, NPV, or EVA
	Risk Assessment	The likelihood of a desired outcome happening. This may be a task, a metric, or even the commercial success of a project

[6] O'Conner P. "Spiral-Up Implementation of NPD Portfolio and Pipeline Management". In: Belliveau P, Griffin A, Somermeyer SM, *The PDMA Toolbook 2 for new product development*, vol.1. United States of America; 2004. p. 461-491.

Component Grouping	Components	Description
Software/Data	Data Gathering and Handling	The manner or method in which data is collected, stored, and submitted for analysis
	View Creation Software	Software that enables managers to create graphs and charts for displaying trade-offs that are central to PPM decision making. The trade-offs are always among multiple PPM metrics
	Enterprise Software	A software structure that pulls together all data gathering, storage, analysis, and display from across an entire organization
NPD Processes	Portfolio Objects Being Managed	The projects included in PPM: "Products-in-Development", "Products-in-the-Market", "Product Innovation Charters", "Product-Mapping-Projects", "Cost Reduction Projects" and "Special Customer Request Projects"
	Stage-Gate Redesign	The development process that, as PPM and front-end processes become established, must be revamped to new aspects of NPD
	Front-End Concept Generation	The process immediately preceding the development (Phase-Gate) process, and immediately following Product Line Planning. The input to this process is a target for innovation (Product Innovation Charter). The output from this process is a concept that may be develop into a product (Product in Development)
	Product Line Planning	A process that scrutinizes and visually maps the market and technology influences on a product line. This process follows business strategy and precedes the front-end process. The inputs to this process are target market segments and a product line. The outputs from this process are specific targets for innovation called product innovation charters.
Top Management	Top Management Involvement	The actual time spent by top management from a business entity on the development and use of PPM
	Top management Proficiency	The ability and adeptness of top management to carry out PPM decisions making and follow though on these decisions
Implementation Focus	Organizational Challenges	The hindrances that are caused by organizational factors
	Implementation Team Focus	The specific focus of the implementation teams at any given time in spiral-up implementation

Table I.2 Matrix of PPM compnents by Spiral-Up Maturity Level (adapted from O'Connor, 2004)

	Component	Maturity Level 0	Maturity Level 1	Maturity Level 2	Maturity Level 3	Maturity Level 4	Maturity Level 5
Mix Management	**Project Selection Criteria**	No project selection criteria used	Trying out selection criteria linked to strategy	Building proficiency in use of criteria	Altering criteria to reflect and link to Front-End process	Altering criteria to reflect and link to product line mapping process	Linked to front-to-back process, integrated with enterprise system
	Mix criteria	Not yet political agreement among top management	Experimenting, low political agreement among top management	Honing in, political agreement growing among top management	Defined with political agreement, linked to strategy	Defined with political agreement, linked to strategy	Integrating to Enterprise System
	Strategic Buckets	There is no evaluation of combinations of strategic buckets	Trying out various combinations of strategic buckets (project groupings)	Bucket definitions established and building historic metrics/data	Established criteria (rules) fro mix of buckets to reflect desired strategy	Exploring new, alternative buckets; linked to data handling / views	Integrating to Enterprise System
	Project Impact Dependencies	Dependencies between projects are not explored	Understanding and identifying positive and negative dependencies	Dependencies explored for impact on speed and strategic impact	Dependencies accounted for in mix optimization	Dependencies accounted for in mix optimization	Dependencies accounted for in mix optimization
	Mix Optimization Analysis	There is no analysis of how the combinations of projects fit the objective of the portfolio	Nominal group process, group voting	Continued nominal group process: trying out 'What if models' (Excel)	Combined group process and 'What if models'	Continue method, experiment with advanced algorithms	Continue algorithmic exploration selection; linking to enterprise system
Throughout Management	**Project Management Foundation**	No Project management deployed	Training PM planning and team leadership	PM software deployed, skills are building	Strong team skills in PM software use – central data repository implemented	Strong – Central repository of all PM data / CC linkage established	Strong – Central repository – Linked to CC and Enterprise
	Project Prioritization	Projects are not prioritized	Periodic, nominal group process	Set frequency of group process, exploring dependencies	Set frequency, trying out systematic method	Set frequency, established systematic method	Integrating to Enterprise system
	Resources to Project Assignments	No clear assignment of resources to projects	Functional managers decide; # of projects per resource decline; task duration and outcome highly uncertain	Cross functional decisions with PM software project roll-up and project priorities; duration and outcome remain uncertain	Cross functional decision making installed; priority projects demand full staffing; much uncertainty remains, bottleneck sensitive	Shifting to critical chain assignments (away from PM software) where CC in use	Integrating with full Enterprise system

	Resource Use Forecasts	There is no overview of resource needs and use	"Guestimates"; expect negative feedback	Trying out, assessing techniques	Forecasting bottlenecks with predictive metrics	Forecasting data integrated with Central Repository	Integrating to Enterprise System
	Critical Chain Buffer Management	There are no method for taking uncertainty and dependency of project tasks into account	Gaining awareness of Critical Chain PM	Learning about Critical Chain, building value case	If Critical Chain project management fits, piloting use and software	If Critical Chain optimization fits, deploying it	Fully deployed; integrated with enterprise support system
Measures/Methods	**Metrics**	There are no metrics used for measuring the portfolio process	Searching for right metrics; determining behaviours to influence: linking to views	Know some metrics, searching for predictive metrics; determining data gathering methods	Most metrics in place, coupling to behaviour; monitoring behaviour: key views selected	Well-established metrics, demanded, linked to implicit rewards	Well-established metrics, but seeking new metrics for newly desired behaviours
	Financial Priority Listing	There are no financial measurements for ranking projects	Periodic, estimated NPV type calculations	Continually updated; linked to prioritization; communicated to management	Experimenting with point solution (software) financial models; linked to metrics and views	Deploying and training point solution financial model usage	Integrating to Enterprise System
	Risk Assessment	There is no risk assessment for projects	Nominal group process	Continued group process, trying out modelling assessments	Modelling risk assessments of projects and portfolio	Established, training point solution risk assessment software	Integrating to Enterprise System
Software/Data	**Data Gathering and Handling**	There is no data storage for portfolio management	Using MS Office (Excel/Access)	Using MS Office (Excel/Access)	Online forms / XML to MS office (Excel / Access)	Using online forms / XML to SQL database	Integrating to Enterprise System
	View Creation Software	No graphical overviews are made for showing portfolio management trade-offs	Using MS office: Excel, PowerPoint; data gathering / handling is challenge	Learning about alternatives available, attributes and features, building value case	Selecting system, crafting customization / deployment / training plan	Piloting system / customizing a full enterprise system	Deploying and training all aspects of enterprise system
	Enterprise Software	There is no software available which gather data from across the entire organization	Observing who offers what, who uses what; understanding why enterprise system	Learning about alternatives available, attributes and features, building value case	Selecting system, crafting customization / deployment / training plan	Piloting system / customizing a full enterprise system	Deploying and training all aspects of enterprise system
NPD Processes	**Portfolio Objects Being Managed**	There are no projects managed in the portfolio management process	PIDs ('Products in Development – those in Phase-Gate); SCRPs (special customer request projects)	Adding PICs (Product Innovation Charters – Targets for innovation in the Front-End process)	Adding PIMs (Products in the market – lifecycle management)	Adding platforms, market segments, technology building blocks	Continuing, integrating with enterprise system

	Stage-Gate Redesign	No integration between stage-gate process and portfolio management process	Using as-is Phase-Gate process, integrating gates with PPM decision-flow	Revamping gates, stages: reflect PPM mix criteria / resource decision-making	Reworking framework to reflect Front-End process linkage	Building new framework into all systems / data handling	Integrating to Enterprise System
	Front-End Concept Generation	There is no Front End process	Ad-hoc approach, establishing value case for proactive FE	Designing and deploying FE process, linking to Phase-Gate process	Trying out point solution support software for FE	Training users for selected point solution support software	Integrating to Enterprise Software
	Product Line Planning	There is no Product Line Planning	Ad-hoc approach, establishing value case for product line mapping	Exploring market segmentation schemes, technology road-map	Laying out ground work; exploring segmentation strategy and PIC creation	Designing and deploying product line mapping process	Point solution support to PLM, portfolio includes PICs, PIDs and PIMs
Top Management	**Top Management Involvement**	Top management spends no time on development and use of PPM	4-8 hours per month – likely focus on portfolio triage, criteria definitions; desired views	2-6 hours per month, all resource owners participating, concern with details	2-4 hours per month – political agreement on criteria, decision making established	2-4 hours per month – focus shifts to use PPM to influence strategic outcomes	2-4 hours per month – managing at strategic level, not in details; top management owns PPM
	Top management Proficiency	Top management does no decision-making based on the output of PPM	Learning and questioning. Low consensus, yet concerned with all details of PPM	Learning and influencing changes, establishing consensus	Gaining full understanding of whole PPM process; peer-to-peer influence	Using and driving PPM as key tool in actualizing strategy	High trust in dependency on PPM
	Top management Focus	There is no top management focus on NPD portfolio management	Leading organization to make improvement in overall NPD productivity	Developing management proficiency / skills in NPD portfolio management	Streamlining decision-making and follow through; instilling org discipline	Learning, using automated supports; customizing enterprise system	Driving greater strategic impact from all efforts, demanding org proficiency
Implementation Focus	**Organizational Challenges**	There is no understanding for the need of PPM	Org structure versus authority to assign resource; terminating seemingly good projects that no longer fit	Political issues on resource assignments and project decisions being worked out	Testing strategy; developing cross-org understanding of PPM; training the org; honing behaviour with metrics	Training systems and methods, training automated supports; embracing discipline	Improving training systems, findings and evaluating new methods that improve productivity
	Implementation Team Focus	There are no implementation teams focusing on the implementation of PPM	Establishing value case, gaining top management involvement	Determine key challenges; driving / sustaining implementation	Assuring consistency in approach / sustaining implementation	Automating workflow an decision-making / sustaining implementation	Integrating full enterprise / Front-to-Back system

A description for the 5 maturity levels (O'Connor, 2004):

- **Maturity level 1 "Establishing the Groundwork".** This is the stage of trying out and getting experiences with a portfolio management process (PMP). One of the most essential parts of this stage is to get the commitment of top management. Since the PMP will be experienced as time consuming and benefits are invisible to the persons not directly involved in PMP, it is important to try to go fast to the next maturity level. So during the implementation, it must be avoided to put too many person-hours in developing the PMP in this first maturity level. It is important to get top management involved into the process. Another point is that in the first maturity levels, PMP is experienced a negatively beneficial for the company. This makes it even more important to continue with the next maturity level.
- **Maturity level 2 "Setting Up Decisions".** The objective of this level is to get agreement on what the benefits of PMP should be. The key objective is to get political agreement of all involved managers. "There is no way to get through this maturity level without involvement by key people from across the organization". It is also important to establish the project management and planning skills and to make a start with trying out software to quickly gain benefit.
- **Maturity level 3 "Anchoring the process".** In this maturity level, both the process of the portfolio mix as well as the pipeline throughput components will be combined, making this the most critical stage in the PMP implementation. Efforts should be put into integrating project characterization and resource allocation. It is also important that the organization starts to recognize the benefits of PMP (see figure 4.2). Another important fact is the development process (the NPDP) in this stage; the PMP and NPDP should be integrated to fully gain the benefits from PMP.
- **Maturity level 4 "Turning up the gains".** At this stage, the entire product development architecture should be established. In order to further increase benefits, components within the product development architecture should be further explored. The key objective is to make data available from a central repository. It is the challenge to integrate all necessary data into one database. The centralization of data reveals inconsistencies within the data, which therefore have to be solved.
- **Maturity level 5 "Automating the flow".** This last level requires the automation of the PMP. The objective is to build consistency in the use of all mechanics in the PMP system. Data should be integrated with the information from across the entire enterprise with all project management components.