Managing the New Product Portfolio.
Towards an end-to-end approach

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Managing the New Product Portfolio
Towards an end-to-end approach

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Abstract

Product development companies are increasingly confronted with an unforgiving global marketplace, which urges the top management to pursue every product development opportunity that appears on the road. However, a company cannot typically fund all the product development opportunities which are available. This situation incurs an important question: Which product development opportunities should a company choose to pursue in order to maximize the business results?

Portfolio management is an essential means to accommodate this paradox. Starting from the theory of the product development process and contemporary portfolio management theories this research investigates three central aspects: 1) the structural elements and principles of portfolio management, 2) the phenomenon over-commitment, and 3) the dynamic development portfolio. The three major contributions documented in this dissertation are a reference model for portfolio management, and a mindset together with three supporting tools.

The reference model builds on a set of defined and interrelated elements, which in total comprise the portfolio management architecture in a company. The model accentuates that it is beneficial to discriminate between at least three generic classes of portfolios when making decisions about the new product project portfolio mix. This supports a nuanced and coherent end-to-end approach to portfolio management.

The suggested mindset explains the dynamics of the burdensome phenomenon over-commitment. The thinking pattern rests upon the fundamental assumption that over-commitment well may be rooted in an unrealistic perception of the product development capability within the company compared to the portfolio.

The three supporting tools encompass the dynamic portfolio map, the project evaluation matrix and the project planning matrix. These are interrelated tools, which in combination can be utilized to visualize the dynamic portfolio. An explicit and dynamic linking between each project's development process and the portfolio overview forms the crux of the tools.

The research project has been carried out at the Technical University of Denmark (DTU) and, partially, at the Massachusetts Institute of Technology (MIT). The results of the dissertation build on research literature and empirical studies in leading Danish and American companies. All contributions have been confronted with industrial portfolio management practices or industry professional's judgement.

The contributions encourage an improved understanding of the portfolio management concept as well as support industry professionals in their efforts to compose and continuously maintain a business wise strong product development portfolio.

Keywords: portfolio management, program management, project selection and product development.

Resumé

Virksomheder konfronteres i stigende grad med et globaliseret marked, hvor den skærpede konkurrence stiller store krav til at virksomhederne lancerer nye produkter i et højt tempo. Situationen tilskynder ledelsen i mange virksomheder til at forfølge alle ideer til nye produkter, som viser sig. Kun de færreste virksomheder har imidlertid ressourcer nok til at realisere alle ideer. Det giver anledning til et vigtigt spørgsmål: Hvilke ideer til nye produkter bør en virksomhed vælge at realisere således at forretningsskabelsen maksimeres?

Portfolio management er et centralt middel til at imødekomme dette paradoks. Med afsæt i procesteori for produktudvikling samt portfolio management teorier undersøger denne forskning tre centrale aspekter: 1) de strukturelle elementer og principper i portfolio management, 2) fænomenet over-commitment, og 3) den dynamiske udviklingsportefølje. De tre hovedresultater dokumenteret i afhandlingen består af en reference model for portfolio management og et tankemønster (mindset) sammen med tre understøttende værktøjer.

Referencemodellen bygger på en række definerede og sammenhængende elementer, som samlet set udgør portfolio management arkitekturen i en virksomhed. Modellen fremhæver, at det er fordelagtigt at skelne mellem mindst tre generiske porteføljetyper, når der skal træffes beslutninger om sammensætningen af porteføljen af udviklingsprojekter. Det understøtter en nuanceret og sammenhængende tilgang til portfolio management.

Tankemønstret forklarer de dynamiske aspekter af det byrdefulde fænomen over-commitment. Tankemønstret er baseret på antagelsen, at over-commitment i virksomheden kan skyldes en urealistisk opfattelse af produktudviklingskapabiliteten holdt overfor porteføljen.

Det dynamiske porteføljekort, projektevalueringsmatricen og projekt-planlægningsmatricen udgør de tre understøttende værktøjer. Værktøjerne kan i kombination bruges til at visualisere den dynamiske portefølje. Kernen i værktøjerne består i en direkte og dynamisk kobling mellem hver projekts udviklingsproces og et overblik for projektsættet.

Resultaterne bidrager til en styrket indsigt i portfolio management konceptet ligesom de understøtter fagfolk i deres bestræbelser på at sammensætte og løbende fastholde en forretningsmæssig stærk produktudviklingsportefølje.

Forskningsarbejdet er sponseret af Dansk Industri (DI) og er delvist udført på Massachusetts Institute of Technology (MIT). Afhandlingens resultater bygger på litteraturstudier kombineret med omfattende empiriske studier i førende danske og amerikanske virksomheder. Alle resultater er blevet konfronteret med industriel portfolio management praksis eller industri fagfolks vurderinger.

Stikord: portfolio management, porteføljeledelse, projektporteføljestyring, programledelse, projektudvælgelse og produktudvikling.

Preface

This PhD dissertation documents the outcome of a research project, which was initiated in 2003 at the Technical University of Denmark (DTU).

The project has been accomplished in collaboration between the Department of Mechanical Engineering (MEK) and the Confederation of Danish Industries (DI). The project has been interrupted for 12 months, while consultancy has been carried out for the DI corporate development division.

The work is primarily aimed at an academic audience within the fields of product development, innovation and business management. It is my hope that industry professionals also will find the dissertation readable, inspiring and productive.

It would have been impossible to accomplish a work of this magnitude without the help and support from many people, to whom I here would like to express my gratitude.

Firstly, I would like to thank the MEK department for hosting me and providing good conditions for the work.

In particular, I would like to express my gratitude to Lars Hein for his role in enabling this research project during his position as head of the section of construction and product development at MEK.

Thanks to professor Per Boelskifte who by virtue of being the current head of the section of construction and product development at MEK has supported the completion of the work by providing favourable terms.

Then I would like to show my sincerest appreciation of the guidance and support I have received from my supervisor Associate Professor Niels Henrik Mortensen. Thanks for your inspiring ability always to see opportunities where it would have been easier to see obstacles.

Additionally, I would like to thank my co-supervisors professor Mogens Myrup Andreasen and professor Lars Hein for sharing their impressive and inspiring product development knowledge and ideas with me.

I am also indebted to other colleagues including PhD-students at the MEK institute for engaging in fruitful discussions and acting as sources of encouragement throughout the study. Saeema Ahmed, Niki Bey, Claus Thorp Hansen and Ulf Harlou are among the former.

Furthermore, I would like to thank Professor Christopher Magee at the Center for Innovation in Product Development for hosting my 9 months stay as a visiting researcher at the Massachusetts Institute of Technology (MIT).

DI and the member companies of DI have been generous enough to fund the research. Thanks to the numerous industry professionals in Denmark and in the United States who have generously shared their time and contributed to the research in many valuable ways. In particular, I owe a debt of gratitude to Dr. Richard E. Albright from the Albright Strategy Group, who without hesitation referred me to many of his colleagues in the American industry.

I would also like to thank the management board at DI and my many colleagues within the ranks of the corporate development division in DI. In particular the good will of Bjarne Palstrøm, the former director of productivity and innovation, towards this project cannot be overestimated. My sincerest thanks go out to you for so strongly supporting my decision to pursue the PhD-study, and providing the exceptional opportunity to a man, who originally started out as a blue collar worker at MAN B&W Diesel factory back in 1985.

Equally, I would like to express my genuine gratitude to my colleague senior advisor Kristian Stokbro for supporting and encouraging the research all the way from its very beginning to completion.

Moreover, I am indebted to Deputy Director General, Bolette Christensen and director of productivity and innovation, Jens Kristian Jørgensen for their encouraging support. The good conditions you both provided for the completion of the work are gratefully acknowledged.

Finally, and most importantly I want to thank my family and friends for their love and support during the course of the project.

Above all, I would like to express my deepest gratitude to Malene, who in the meantime became my wife, and also gave birth to our wonderful little daughter, Maja. My decision to pursue this degree has been blessed by your invaluable support, understanding and patience from the very first moment.

Flemming Larsson
Lyngby, September 2007.

Content

1 Introduction

1.1 New products are vital to business creation

Companies are increasingly confronted with an unforgiving global marketplace. Many companies offer competing products and services to customers whose demands for new and surprising ways of meeting their needs seem insatiable. At the same time the company's shareholders insist on earning a superior return on their investments, which further stresses the need for excellent business performance. In order to meet and exceed these multiple and rising expectations it is imperative for companies to continuously adapt and enhance their business models.

The development and introduction of new and innovative products to the market is ever more becoming an inherent part of top management thinking due to its vital and strategic role in achieving the ambitious objectives. Here several management ideas compete for the senior management's attention, and at least the four themes described in the following are central on their agenda:

Innovation
User-driven innovation and front-end innovation are two innovation philosophies, which currently are on the agenda in many Danish companies.

The user-driven innovation philosophy is being strongly promoted across the country by The Danish Council for Trade and Industry. The starting point for user-driven innovation is an identification of the users' recognized and non-recognized needs. This knowledge is combined with knowledge regarding technology and business in order to develop a product or service, which fulfills the user's needs and expectations.

The front-end innovation concept acknowledges that a steady stream of quality ideas for new products is a prerequisite for maintaining a strong development portfolio. According to Koen*, et al.* (2001) the recognition of the front end of innovation indicates that approaches different from those related to the formalized and well-structured new product development process are needed in order to produce strong ideas which exploit the increasing volatility and discontinuities of markets and the rapid evolution of industries.

The initiatives within both fields are multifarious and aim at implementing "best practice" approaches related to tools, methods, and organizational aspects linked to the improvement of the efforts in the early phases of product development. The two philosophies do not exclude each other.

Platform development
The development of product platforms has received significant attention over the recent years, because they play a central role in enabling the creation of product variety and reducing the time-to-market for new

products. The main goal of a platform project is to create a technological basis and/or a set of components which can be shared across a family of products according to Robertson & Ulrich (1998). Hence when a platform first has been developed, the firm may base a set of smaller (in terms of cost and development time) derivative product development projects on this platform.

Lean product development
The lean philosophy originates from the Japanese car manufacture Toyota. At its core lean production thinking provides a way to do more with less and less. According to Womack & Jones (1996) the idea is to use less of everything, i.e. manufacturing space, raw materials, tooling, labour and inventory, while coming closer and closer to providing customers with exactly what they want. The lean philosophy rests on five principles, namely 1) value, 2) identifying the value stream, 3) flow, 4) pull and 5) perfection. In the recent years there has been a growing interest in translating these lean principles from the production domain to the product development domain. Initiatives to adopt the ideas underlying the Toyota product development process to other companies have been made according to Ward (2002).

Portfolio management
Portfolio management is concerned with the role of top management and key decision makers in creating purposeful product development investments which are harmonized with the resources and capability at hand in the company. The concept of portfolio management recognizes the need for complementing the management of individual projects with high-level management of the aggregate set of projects in order to create a strong development portfolio with an unambiguous link to business strategy and objectives.

Already in the early nineties Roussel*, et al.* (1991) envisaged that the management and prioritization of product development projects would become a vital management task. Eight years later Dye & Pennypacker (1999) asserted that project portfolio management had become a significant factor in the long-term strategic success of project oriented organizations. Recently we have seen that executives are under continued strain to satisfy the rising expectations from customers and shareholders, who require frequent introductions of new products.

Not alternatives

When a company chooses to pursue one of the mentioned themes it does not exclude the relevance of pursuing the other themes. Rather, they might well complement each other.

1.2 Focus of this research: Portfolio Management

The focus of this research is on portfolio management for new product development. Accordingly the object of manipulation is the product development portfolio.

The product development portfolio is considered to consist of a set of product development projects, i.e. projects which aim explicitly at

business creation by means of developing and introducing new products to the market. The resulting product may be a radically new product or a product based on a more or less extensive manipulation on previously developed products. Additionally, projects which lead to technologies to be included in the products are also considered included in the product development portfolio.

Product development activities consist of both projects and tasks, which are quite different in nature. A project typically is a long-term complex effort with a well-defined objective, schedule, and budget which relies on contributions from several functional departments across the organization. A task, conversely, is typically a short-term effort requiring limited resources which may be executed without cross-functional contributions worth mentioning. Additionally, the execution of tasks is characterized by routine due to their uniform nature and frequent appearance according to Mikkelsen & Riis (1992). Thus it is important to distinguish between a task and a project, and only the latter is considered in this research.

Definition of project

A project is a temporary, unique endeavour undertaken to create a product or service within defined parameters.

Project Management Institute - PMI (1996)

Furthermore, it is central to distinguish between the product development portfolio and the product portfolio. From a business perspective the *product development* portfolio can be considered as speculative because it consists of projects with a *potential* for business creation which have yet to be realized. The *product* portfolio, however, consists of products already developed and introduced to the market. Therefore the product portfolio represents *existing* business. Although the management of the product development portfolio and the product portfolio is closely interrelated this research primary investigates portfolio management for product development projects.

The term *portfolio management* refers to the business process by which the product development portfolio is handled. This research adheres to the following definition of the phenomenon proposed by Cooper and colleagues:

Definition of portfolio management

Portfolio management for new products is a dynamic decision process whereby a business's list of active new products and R&D projects is constantly updated and revised. In this process, new projects are evaluated, selected, and prioritized. Existing projects may be accelerated, killed, or deprioritized and resources are allocated and reallocated to the active projects.

Cooper, *et al.* (1997a)

This research focuses on how companies deliberately may utilize portfolio management as a means to create and maintain a strong

portfolio of product development projects which encompasses a high potential for business creation.

1.3 Why is it relevant to dedicate research effort to this topic?

It is not only within product development many projects compete for the scarce resources. The same conditions apply within the research domain. By way of introduction it is therefore relevant to justify the importance of dedicating research awareness to portfolio management for product development, which is the topic chosen for this dissertation.

In the following sections the author will substantiate the importance of the chosen topic in terms of both industrial and academic relevance.

1.3.1 A response to business challenges

Companies are facing a changing global marketplace that has no precedence, and the implications for companies' product development are serious. The following quote convey a sense of the view held by a senior manager in a company:

"The increased globalization has made it much more challenging to pursue business through product development, because everybody instantly knows who's doing what, where, and when. The consequences for business are immense if we don't hit the window of opportunity timely with the right product in the right quality. Consumers simply won't tolerate low quality products today".

It seems more imperative than ever for companies to have a business wise strong and well composed development portfolio. Cooper (2005), however, argues that many corporations carry development portfolios which he describes as "harmful to their business health". He reports that recent studies indicate that the impact of product development on the sales and profits of many corporations is down, when looked at it in terms of contribution to total sales and profits. Cooper explains that this is due to an inexpedient portfolio balance, when he writes:

"*Simply stated, today businesses are preoccupied with minor modifications, product tweaks, and minor responses to salespeople's requests, while true product development has taken a back seat*".

In order to meet the rising expectations from customers and other stakeholders it is tempting to pursue every business opportunity that appears on the road. A company, however, typically cannot fund all the potential investment opportunities that are available. This situation incurs an important question: Which product development projects should a company choose to invest in, in order to maximize the business results?

Inexpedient choices may be fatal

Inexpedient choices may be fatal due to the complex nature of modern product development projects. Product development today is increasingly

characterized by the concurrent development of multiple products aimed at several market segments in order to reap the benefits of rationalization. The reuse of technologies across products is a central means to achieve this objective. Moreover, involvement and contributions from various corporate departments around the world are essential. As a result the interdependence between the projects increases dramatically.

The disadvantage of this approach, however, relates to increased risk associated with business creation by means of product development, i.e. when things go wrong, the failure multiplies:

- Firstly we lose the earnings from the product,

- Next, we also sacrifice the earnings we might have gained from investing the development resources in other and more prosperous projects,

- Finally, due to the strong interdependence among projects there is the imminent risk that the problems in one project will affect other projects negatively. We might also lose earnings from these projects.

Portfolio management is important

The stakes of modern product development are high and it is evident that the selection of projects for the product development portfolio has crucial implications for the potential business value of the portfolio. In the worst case one failed project can eliminate an entire year's profit or perhaps close the company.

Hence it is important that the company's management processes are geared to support the composition of a strong portfolio. This highlights the relevance of a sound portfolio management process. This is in line with the findings of Cooper*, et al.* (1998), which show that the businesses that feature a systematic portfolio management process outperform the rest.

Challenges

In order to obtain an understanding of the challenges companies are facing in relation to portfolio management extensive interviews with senior industry professionals in both Danish and American companies have been carried out during this research. Due to the limited sample the survey cannot be regarded as representative for the industry in general. Rather the statements serve as indications of the industrial problematic.

Despite the fact that all the companies have implemented portfolio management practices which might well be characterized as good in many dimensions, the responses indicate that there is plenty of room for improvement. A sense of the situation can be gained from the quotes presented in the following section.

The first quote conveys an idea of the view held by a marketing manager regarding the company's approach to prioritization of the product development efforts:

"*We have too many projects, and lack an explicit prioritization of them – large projects are weighted like small projects and vice versa*".

An inadequate explicit discrimination between projects may ultimately lead to a proliferation of projects. Inconsistent decisions regarding which projects to pursue will eventually result in an inconsistent product portfolio mix, which tend to be more and more unfocused, and hence may jeopardize the company's competitive edge. The following quote from a production manager indicates another consequence of pursuing such a strategy, namely over-commitment of the development resources:

"*Too few people work on too many projects in parallel*".

The personnel consequently end up being overloaded with work and this situation may well become counterproductive. According to the next statement the situation undermines the development process in terms of speed and quality:

"When you pursue many projects simultaneously it's like downloading many files in parallel from the internet: It takes very long time until a single file has been transmitted completely, and the risk of errors and time-out conditions increases".

Thus negative consequences for the resulting products seem unavoidable, and they furthermore contribute to maintain and intensify a negative pattern.

It appears to remain a very complicated task for the management in some companies to establish a proper project prioritization. The following paragraph clearly illustrates the magnitude of the anxiety one R&D director is confronted with:

"We are good at strategic aims and opportunities, but not good at choosing. When I ask people to choose between alternative projects I only meet frustration. I always end up as the bad guy - people don't want to make choices. Instead we put in under the table - and it ends up between two chairs. People think they loose something by saying no to another project. But it is really the opposite. In reality both projects will be late due to the chain of events".

A product manager in another company pinpointed the paradox he is confronted with in his job, due to the local R&D departments' pre-occupation with starting "new" projects, when he straightforwardly stated:

"As soon as a project reaches a certain stage, R&D tends to start new projects which they like better then finishing and industrializing the

previous products. It is hard to motivate and it needs a close follow-up to "force" R&D to finalize the committed product releases".

Additionally, when a project is initiated it appears difficult to stop it again. Apparently, one of the mechanisms originally intended to weed out improper or poor projects seem to be somewhat deficient in some companies. The observations indicate that personal preferences and emotions seem to play a significant role. As one product management director ironically and bluntly stated:

"If you want to stop the Medusa project you'll have to kill John!"

Despite the humorous undertone the quote conveys a sense of the serious forces at play. Consequently, people continue to be stretched across too many projects, since no company has unlimited resources at their disposal. Such a conduct, however, appears to give rise to resource conflicts between projects in the portfolio according to the next statement:

"Resources are 'stolen' from projects without an assessment of consequences".

When new opportunities appear or a project is in a crisis it is tempting to shift resources from another project already underway. The problem emerges when this reshuffling of resources is done without consideration of the project's importance for the company. In that situation resources may be spread across too many projects, and subsequently the quality of project execution may be compromised.

A R&D manager pinpointed another interesting perspective on the dilemma when he frankly stated:

"We forget resources; that's why strategy never gets implemented".

The challenges reported here seems consistent with the observations of other researchers. For example, a benchmark of current business practices related to portfolio management carried out by EIRMA (2002) reveals that many companies over-commit their resources. They report that:

"*A significant number of organizations do not have enough resources in place to make their project portfolios achievable".*

Moreover, Cooper, *et al.* (2004b) stress the need for improving portfolio management practices in industry, when they write:

"*In spite of the recent emphasis on NPD portfolio management, the benchmarking evidence suggests that most businesses have a long way to go in terms of implementing best practices and achieving desired results from portfolio management*".

Research is imperious

In sum the observations indicate that some companies do encounter considerable problems during the management of the product

development portfolio. The implications for the productivity of product development are serious, and this stresses the need for supporting industry professionals in their effort to establish and maintain a strong development portfolio.

Hereby the author asserts that the industrial relevance of devoting research effort to the topic of portfolio management for product development is reasonably justified. In the next section the focus will be directed towards confirming the academic relevance of researching the topic.

1.3.2 A response to academic interest

Portfolio management for product development has gained considerable attention in both academia and industry as a means for improving business results. The concept of portfolio management, however, is not new. It comes from the domains of economics and financial management, where the portfolio may comprise any kind of asset (Markowitz 1952). Portfolio management focuses on the basic paradox consisting of resource limitations and an almost infinite space of investment opportunities.

This mindset has since the 1960s been adopted by the professionals of product development. They both recognized the similarity between financial investments and investments in product development projects, and the challenge of composing a product development portfolio with the potential to maximize the business results. Many contributions to the field have been made during the years, and they aim to strengthen different aspects of portfolio management.

The range of tools and methods proposed for portfolio management is wide. It span sophisticated quantitative tools which consider the composition of a portfolio as a mathematical optimization problem to qualitative scoring techniques aimed at ranking projects based on their relative benefit contribution to the company as well as mapping approaches.

Yet there does not seem to be any dominant school of thought embracing the phenomenon according to Archer & Ghasemzadeh (1996), which often appears in literature under other names such as product planning, product management, pipeline management, aggregate project planning, project management, project selection etc. It appears that a coherent and consistent terminology to describe and discuss these matters is lacking.

Early techniques within the field had a strong focus on profit and profitability. The payback period and the related average annual rate of return were widely used as criteria for determining the feasibility of project investments. Baker & Freeland (1975) found that such single criteria models are insufficient, since the decision problem is characterized by multiple and often interrelated criteria, which cannot easily be quantified.

The *Analytical Hierarchy Process* developed by Saaty (1980) is an example of a technique which addresses this shortcoming, since it

recognizes that multiple criteria often are needed in decision-making. Other multiple criteria models have been provided from the field of operations research, and they include mathematical programming models like integer programming, linear programming, goal programming and dynamic programming according to Hall & Nauda (1990).

Several pundits, however, have over the years called attention to the existence of a tremendous gap between theory and practice, since many of these techniques and models not have been adopted by the industry as indicated by Cooper*, et al.* (2004b), Levine (1999), Archer & Ghasemzadeh (1996), and Martino (1995).

One reason for this tremendous gap between perceived application and practical realities might be that many of the techniques were developed in academic settings, and they do not adequately reflect the realities faced by industry professionals according to Martino (1995).

Mapping approaches**,** however, seem to have gained a foothold in industry according to Cooper*, et al.* (1999) and Kappel (2000). They aim at providing visual representations, like portfolio diagrams and roadmaps, of central portfolio dimensions.

The strong dissemination of these approaches is interesting, since they lack a solid theoretical grounding according to Archer & Ghasemzadeh (1996). Nevertheless, the idea of visualizing the portfolio seems to appeal to industry professionals.

Later contributions recognize the need for understanding how to organize portfolio management properly, since there does not seem to be a self-evident way to do this. This entails frameworks for organizing tools and techniques logically in a flexible process in order to allow decision makers to utilize a desired subset of available methodologies in a flexible manner as suggested by Archer & Ghasemzadeh (1999). Dawidson (2006) claims that it is important to better understand aspects related to the arranging of portfolio management activities (e.g. decisions, preparations and discussions) and the manner of using tools, methods and techniques in these activities as well as the way of involving organizational participants in the activities.

The daily management of portfolios is another aspect of portfolio management which increasingly is attracting the attention of academia (Engwall & Jerbrandt 2003), (McDonough & Spital 2003), (Blichfeldt & Eskerod 2005). Here the fundamental assumption is that the day-to-day management of a portfolio is critical to its success.

Research is relevant

It seems that the phenomenon portfolio management emerges as a recurring research theme in academia spanning several decades. Contributions have been offered from many academic domains, and this indicates the diversity and importance of the field. The numerous conferences held and papers and books published on this subject,

indicates that portfolio management is still truly an important business challenge.

It appears to constitute a challenge for academia to understand the phenomenon portfolio management, and its context of use. Such a situation is untenable, since it impedes the development and transfer of proper methods and tools to industry professionals. Thus the author asserts that the academic relevance of dedicating research attention to the topic of portfolio management for product development is rendered probable.

The existing contributions within the field form the point of departure for this research project. The main contributions from this project are briefly outlined in the next section.

1.4 Conclusion & structure of thesis

This research contributes to the body of literature concerned with finding ways to improve industrial portfolio management for product development. The research introduces three primary contributions. These and their relevance are outlined in the following.

A reference model

The first contribution is a proposal for a theoretically based reference model, which explicates central elements and principles of the portfolio management concept in a company. It highlights the structure and key processes, elements and their linkages inherent in portfolio management.

The model represents a means for supporting the company's management during the implementation of portfolio management in industry, together with providing a bridge to the theoretical foundations that underpin portfolio management.

The conceptual model is assumed a critical prerequisite to describe and discuss these matters. Hence the contribution is intended to support the further academic exploration and development of the terminology and knowledge within the research area portfolio management and product development.

A productive mindset

Next, the research introduces a mindset, which explicates the dynamics of the critical phenomenon of over-commitment in portfolio management. The mindset explicates a number of circumstances and their sequential linking in an overall pattern of inherent causality. The mindset is based on the assumption that over-commitment well may be rooted in an unrealistic perception of the product development capability among the management team within the company.

It is asserted that the virtues of the mindset originate from its ability to capture and explicate the negatively self-reinforcing and dynamic nature of the phenomenon. Moreover, the mindset seems to offer an easy way to impart industry professionals an enhanced understanding of a highly complex pattern of problems, which holds the potential to seriously degrade the productivity in product development. Thus the contribution

shall be considered as a productive thinking pattern for industry management professionals, which complements the conventional tool-oriented approach to portfolio management.

Three tools

Finally, the research proposes three tools which should be used in combination to map the dynamic development portfolio starting from the individual projects.

The contribution entailed in the proposed tools constitutes a reaction to an observed tendency among decision makers in some companies to execute portfolio decisions based on a weak understanding of the development portfolio's actual condition. Henceforth the tools are intended to encourage transparency and qualify dialogue between the managers concerning the condition of the dynamic development portfolio.

The work rests on the assumption that such a dialogue can promote an improved understanding of the company's development capability among the management group in the company. This is considered necessary for carrying out expedient portfolio decisions. Thus the contribution might help to unlock or prevent the occurrence of the destructive pattern articulated by means of the previously described mindset.

The visualization of the portfolio is the crux of the tools, which builds on mapping techniques and the involvement of people from central functional areas and organizational levels. The tools also incorporate principles from the unweigthed factor scoring model and dynamic rank ordered lists. The tools do not constitute decision models, which can devise how a proper portfolio should look. Rather, the tools are intended to provide support to decision makers by displaying large amounts of relevant but also complex data in a useful way.

Other contributions

An overview of existing theories and contributions to theories related to portfolio management constitutes an additional contribution from the research. Furthermore, extensive empirical studies have been carried out during the course of the research. The reported observations stemming from the studies do also form a contribution, since they in their entirety are assumed to represent a plausibly indication of contemporary industrial portfolio management practices.

Structure of dissertation

The dissertation is structured into the following six main parts:

Chp. 1-3: Setting the stage for the research
The first three chapters of the dissertation introduce the framework of this research. Initially, the research problem and the objectives are presented. Next, the scientific aims, methods and activities utilized in the research are explained. Finally, the theory areas which are needed in order to conduct research into the matter are identified. The theory of the product development process is chosen for the scientific viewpoint of the research.

Chp. 4: State-of-the-art in portfolio management
Chapter four of the dissertation comprises an investigation of the phenomenon portfolio management based on a study of state-of-the-art contributions offered in the literature.

Chp. 5-6: Proposal for a reference model for portfolio management
The fifth chapter proposes a reference model which captures the central elements and their relationships which comprise the portfolio management process in a company. The model's ability to describe the structural aspects of portfolio management in industry is examined in chapter 6 by structuring and describing observed industrial portfolio management principles according to the model.

Chp. 7: Explaining the dynamics of over-commitment
Chapter seven rests on the assumption that over-commitment forms an essential problem in industrial portfolio management. Henceforth the chapter departs from an examination of this aspect. Subsequently, the chapter introduces a mindset for management professionals, which forms an explanation of the dynamics of the phenomenon.

Chp. 8: Supporting tools for portfolio management
This chapter introduces the project planning matrix, the project evaluation matrix, and the dynamic portfolio map. These are three interrelated tools, which deployed in combination might help to unlock or prevent the occurrence of the destructive pattern articulated by means of the mindset suggested in the previous chapter. The validity of the tools is rendered probable by means of a preliminary verification.

Chp. 9: Conclusions and further research
Finally, the results of this research are discussed, and the dissertation is concluded by highlighting the most salient issues for future research in the area.

2 Scientific approach

2.1 Phenomena to be studied

Three closely related phenomena are studied during this research, namely the portfolio management process, the portfolio, and the sub-phenomenon of over-commitment in portfolio management. These are described in the following.

Multi-level process

The portfolio management process is the primary phenomenon to be studied. It is assumed to be the process whereby managers continuously evaluate, select and prioritize new product projects for the portfolio in order to maintain and improve its potential business value. The research acknowledges that portfolio management does not exist in a vacuum within a company. Rather, it is multi-dimensional phenomenon closely interrelated with other aspects like organization, tools and methods in the company. The portfolio management process is considered to span several organizational levels and functional areas, and it works in a close interplay with a number of processes within the business.

The portfolio

The portfolio itself do also comprise a phenomenon to be examined, since the author asserts that it is irrational to study portfolio management without taking the object of manipulation into account. This research recognizes that a portfolio is more than merely a portfolio. Different portfolio classes can be identified, and their nature implies that it is expedient to manage them individually.

Over-commitment

The last phenomenon to be examined is over-commitment in portfolio management. The phenomenon occurs when a combination of too many and/or infeasible projects are pursued compared to the resources and competencies available. Over-commitment might well encumber product development critically. It is relevant to include the phenomenon in the research since resource allocation in the firm is central to portfolio management.

2.2 Scoping the research

The research is based on product development process theory and a strategic management perspective is applied. It rests upon two fundamental assumptions. The first assumption recognizes the overwhelming complexity inherent in portfolio decision making:

Assumption #1

Basic assumption on portfolio decision making
Decision making regarding the portfolio mix is far too complex to be solved by means of a decision model.

The assumption states that we cannot expect to be able to put forward portfolio models, which can provide answers to how a strong product development portfolio should be composed. Rather, models are expected to constitute *decision support* to decision makers by displaying relevant data in a useful way.

The second assumption implies that models, which visualize one or more aspects of a portfolio, enable better decision making concerning the portfolio, because the complexity becomes manageable.

Assumption #2

Basic assumption on explicit and visual models
Explicit and visual models of a product development portfolio support better decision making regarding the composition of the product development portfolio.

The latter assumption recognizes that a portfolio is a complex entity which is comprised by a number of unique projects which are more or less interrelated. Therefore it can be fatal to the company if changes are imposed without a good understanding of what is changed and the corollary of the change.

Delimitation

Strictly product development

Today much work within virtually all functional areas in companies is organized as projects. Hence participation in projects forms a condition of work for many employees regardless of their functional affiliation within the human resource department, marketing, production or it-support. This research, however, solely focuses on product development projects, i.e. projects aimed at the development and introduction of new products, and product related technologies.

Project portfolio

The research acknowledges that it is necessary to perform portfolio management in an "end-to-end" context, i.e. we should acknowledge the gradual transformation of a product idea into a product project which results in a product. Therefore both the "front-end" and "back-end" of portfolio management is examined. The primary contributions of this research, however, relate to the *project* portfolio.

Not strategy development

Despite the obvious relation between portfolio management and strategy development the latter is considered outside the scope of this research.

Not product design

Similarly, the actual designing of products is not covered.

Not service products

The primary focus is on companies developing physical products, i.e. mechatronic products complimented with supporting software solutions. Hence service products are not included.

2.3 Theoretical goals

The accomplishment of the following three theoretical goals is intended to enhance the knowledge and terminology within portfolio management for product development. Thus it should enable formulation of models and methods to be utilized for the handling of the portfolio management task. The goals are described in the following:

A reference model
The first theoretical goal is to synthesize a coherent and consistent conceptual model of the portfolio management concept in a company. The model should explicate the structure, as well as identify and position inherent key elements and their linkages. Central aspects to be included in this reference model must at least be:

- Multi-level processing, i.e. an identification of how the portfolio management process works in a close interplay with a number of processes within the business.

- Integration, i.e. an identification of how the portfolio management process supports the achievement of integration across organizational levels (i.e. vertical integration) and functional areas (i.e. horizontal integration).

- The object of manipulation, i.e. an identification of how portfolio management should be performed in an "end-to-end" context which acknowledges the gradual transformation of a product idea into a project which results in a product.

Such a contribution is assumed a critical prerequisite to describe and discuss the topic portfolio management. Other contributions may for example be referred to the model.

A mindset
The second theoretical goal is to articulate a thinking pattern, which enrich our understanding of the phenomenon *over-commitment* in portfolio management for product development. Over-commitment arises when too many and/or infeasible projects are pursued compared to the resources and competencies available in a company. The thinking pattern must explicate the subtle nature and content of the phenomenon.

The establishment of such a thorough understanding of the critical phenomenon over-commitment is asserted to be an important prerequisite for examining the phenomenon and finding ways to improve industrial portfolio management.

Mapping tool
The third theoretical goal is to propose a tool and a related method, which can be deployed to visualize the dynamic product development portfolio. The tool is intended to support the management while exercising portfolio management. Such a contribution is asserted highly relevant, since it seems that the idea of visualizing the portfolio seems to appeal to industry professionals according to Cooper*, et al.* (1999).

Correspondingly it is important that such a tool has a coherent and proper theoretical grounding within process theory for product development and portfolio management theory.

Terminology & knowledge

In total the achievement of the outlined three main theoretical goals are intended to support and encourage the further academic exploration and development of the research area.

The theoretical contributions are primary formulated in relation with models of the phenomena.

2.4 Industrial goals

The industrial goal of the research is to support industry professionals in their efforts to compose and continuously maintain a business wise strong product development portfolio. This is to be realized by providing productive models and tools which conveys an enhanced understanding of the portfolio management concept and its essential elements to practitioners.

Furthermore, the involvement of companies in the research does also play an essential role in achieving the goal. This entails engaging in case-studies and experiments with companies as well as giving presentations on the topic for senior managers. Both present opportunities to confront practitioners with the proposed contributions in order for them to validate their relevance as well as to cultivate awareness in industry on the importance of portfolio management. The cultivation of awareness in a broader sense includes writing and publishing non-academic articles on portfolio management targeted at the senior managers in industry. Such articles should have a strong focus on the practical relevance and applicability of the concepts.

2.5 Research questions

The research is guided by three research questions, which are described in the following section.

Research question 1

The first research question is motivated by the assumption that it is necessary to have a framework that illustrates the portfolio management concept in a company. Hence we must identify and understand the key elements of portfolio management and their linkages:

Research question #1
Which structural elements and principles are inherent in portfolio management for product development? What is their central interplay and how can they be modelled and visualized?

The term “elements” denotes processes, structures, activities, concepts and events. The principles are asserted to constitute the interaction, i.e. the dynamic interplay, between the elements.

This question supports the establishment of a unifying model, which explicates central aspects of portfolio management such as multi-level processing, integration and the object of manipulation. Thus the research

question aims at achieving the first of the three theoretical goals described in section 2.3.

Research question 2

The next question is founded on the assumption that many ailments in portfolio management for product development stem from an over-commitment of the product development capability:

Research question #2
How can the dynamics of over-commitment in portfolio management for product development be explained? What is the nature of the phenomenon?

This question supports the achievement of an enriched understanding of the realities that many practitioners are confronted with as outlined by the second theoretical goal. The understanding is considered imperative to resolve the burdensome phenomenon.

Research question 3

The last question rests on the assumption that the decision makers in some companies tend to execute portfolio decisions based on a weak understanding of the dynamic portfolio's actual condition. However, in order to make proper decisions regarding the portfolio mix, transparency is asserted a fundamental necessity. That is, we need to be able to see the portfolio we decide about:

Research question #3
How can the dynamic portfolio be mapped utilizing the individual projects as points of reference?

The following aspects are of primary interest to be mapped:

- Projects currently underway in the development process.
- Each projects progress compared to plan.
- The recent quality of execution for each project in the portfolio decomposed in accordance with the contributing functional areas.
- Projects priority relative to each other.
- Central interdependencies between projects.
- Projects which can be characterized as unplanned rework.
- Resource distribution across product and technology development projects and business areas.
- The estimated financial contribution from each project and business area.

It is asserted that the visualization of the mentioned aspects is fundamental and indispensable in order to promote and qualify the dialogue and understanding of the dynamic portfolio's condition between the managers during portfolio decision making. Thus the mapping is intended to support managers in making well-informed and sound portfolio decisions. The research question aims at achieving the third and last theoretical goal outlined in section 2.3.

2.6 Research methods

This research is based on the paradigm suggested by Jørgensen (1992). It recognizes that both a theory based problem and a practical based problem can serve as the outset for research. In this research the starting point was an assumption regarding lacking industrial proficiency in portfolio management for product development, i.e. a practical based problem. This problem is then analyzed in the context of the theoretical basis, which mainly is process theory for product development.

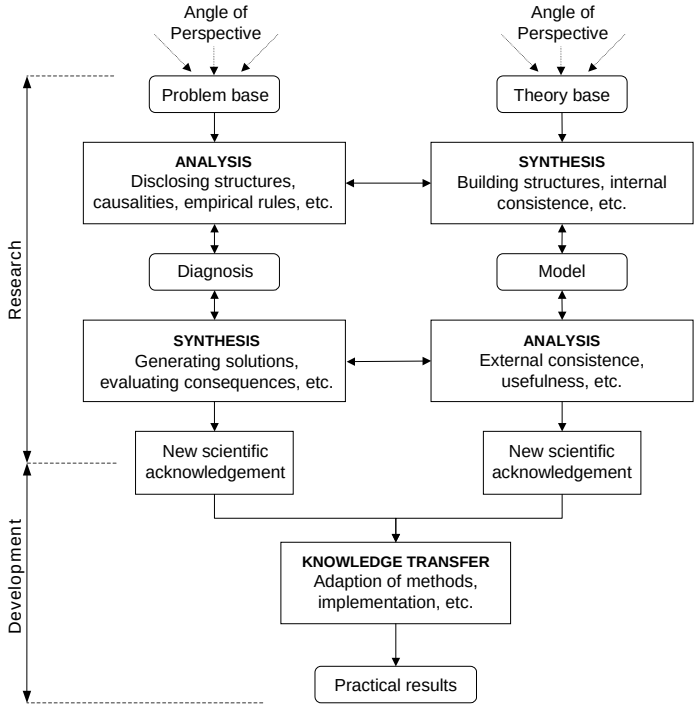


Figure 1. A paradigm for research recognizing the interplay between theory and practice according to Jørgensen (1992).

Simultaneously, assumptions and models regarding the phenomenon portfolio management are derived. To verify their validity and practical applicability they are presented to industry professionals and researchers. It is important to recognize that the nature of the deployed research paradigm is cyclical, i.e. constantly pending between the empirical world and the theory base in order to gradually build knowledge in accordance with the progress in the research, which eventually is merged in knowledge transfer to realize practical results. Besides Jørgensen's paradigm the research is complemented by applying a combination of inductivism and critical rationalism as research advances.

Inductivism

The central principle of the inductive[1] approach is that all new knowledge comes from some form of induction that involves drawing general conclusions from observed instances, i.e. empirical verification is based on observation. As industrial practice is observed the body of information grows, general aspects emerge and hypotheses can be formulated and

[1] This approach is primarily attributed to Francis Bacon (1561-1626).

tested against further observational material. Thus an attempt is made to move from a finite number of instances to one universal law.

Critical rationalism

The idea of critical rationalism[2] is to offer guidance in acquiring new knowledge, in assessing the validity of knowledge offered by others and in taking action to solve problems using the information that is at hand. The means is to subject all theories to rigorous criticism, trying to falsify the ideas by finding countervailing evidence. In this process existing theories, models and methods are further developed so they better reflect the empirical reality.

Scientific tools

In accordance with the qualitative and explorative nature of this research a number of scientific tools have been chosen ranging from the study of relevant literature, explorative interviews, empirical observations, logical structuring and suppositions.

Literature study

Portfolio management for product development has implications on many different organizational functions within a company, and is, indeed, a cross-functional topic with contributions from fields such as innovation management, economics, strategic management, marketing, and operations management. This is also reflected in this research.

Semi-structured interviews

The collection of primary data is based on interviews with staff from senior management such as portfolio manager, director of product development, vice president of new business, vice president of product management etc. The interviews have been conducted as face-to-face interviews on location in the sample companies. Interviews have been chosen as a tool, because it is very flexible and has in this research proven to offer at least two major advantages. First, the interview brought the researcher in good position to be able to judge the quality of the responses on the subject, and to notice if a question has been properly understood. Furthermore the approach makes it possible to reassure and encourage the respondents to be full in his/her answers. In addition, the interviews facilitated instant explanations of complicated processes and relations, i.e. complicated issues could be further explained in-depth by the respondent by means of sketching and writing on a whiteboard in the meeting room or office. Second, it enabled the respondent to support answers during the interview by providing "real" documents, i.e. documents that reflects the empirical reality, due to the respondent's direct access to retrieve relevant company specific documents.

Empirical observations

A vast mount of original industrial documents disclosing portfolio management practices was collected during the interviews. These have been analyzed and structured in accordance with the portfolio management activity they are intended to support. Subsequently, the documents related to each activity has been examined in order to identify

[2] Critical rationalism is particular associated with the Austrian philosopher Karl Popper (1902-94).

which phenomenon they address, and what the "points of inquiry" related to that phenomenon they intend to illuminate.

Logical structuring & suppositions

The idea behind logical structuring and suppositions has been exploited as an iterative process throughout the research project, shifting between the logical structuring of information, and the synthesizing of knowledge by formulating hypothetical statements on the nature of the phenomenon to be validated.

Verification

Verification of results is based on *logical verification* and *verification by accept* in accordance with Buur (1990), who suggests these techniques as realistic means of verification within design theory. The techniques are considered appropriate to overcome two major challenges facing the research field in terms of result verification: First, the nature of the research field makes it impossible to repeat experiments, because several factors influence the result. In other words, it is unattainable to prove cause-effect relationship. Second, the nature of the research field is random - the design process might create an opportunity for success, but it cannot assure success. Four distinct virtues characterize logical verification:

- Consistency: there are no internal conflicts between individual elements of the model.
- Completeness: all relevant phenomena observed previous can be explained or rejected by the model.
- Well established and successful methods are in agreement with the theory.
- Cases and specific design problems can be explained by means of the models.

Verification by accept is a dual oriented technique. It implies that not only should models and methods derived from the theory be acceptable to experienced industry professionals, the theory should also be accepted by a relevant scientific community.

2.7 Research activities

Interviews and case studies in industry

The starting point for this research was a practical based problem. It was assumed that there exists a need for supporting industry professionals in their effort to establish and maintain a strong development portfolio. Consequently, strong industrial involvement characterizes the work. In total, eleven Danish and six American based companies have been involved during the course of the research.

In order to convey a sense of the companies engaged while maintaining their anonymity the following section provides an overview of the type of industries whereto the seventeen companies approximately can be related.

Machine industry Mechanical products as well as mechanical products with electronic controls form the core of the portfolios of the companies within this category. The products are distributed to consumer markets as well as business-to-business markets.

Medico industry Companies within this category develops, manufacture, and markets both technologically advanced products aimed at consumers as well as medical instruments and accessories aimed at hospitals and clinics.

Printing industry The companies within this industry primarily offers printing and packaging solutions aimed at the business-to-business market. Products entail printing and packaging machines combined with a high degree of software automation.

Electronics industry Highly advanced system solutions, products and electronic components based on communication technology form one of the common denominators for companies within this group. The majority of the companies within this group serve the business-to-business market.

The outset for the work has been an initial framing of the research entailing interviews with senior managers in eleven of the companies.

Next, extensive interviews have been made with senior managers in five companies. This includes collection and review of documentation.

In order to obtain a deeper understanding of the challenges facing the industry within the field three extensive case studies have been completed within two of the companies. Each study consists of 6-10 interviews complimented by collection of documents.

Each engagement has been documented in separate memorandums and reports, and has provided important background material for the research. Due to confidentiality reasons these have not been include in this thesis.

Training industry
Results from this research have been communicated to industry through several workshops for senior management in various companies. In addition, eight articles on the phenomenon portfolio management targeted at the senior management in companies have been published throughout the project.

A list of publications made during the research is provided in section 10.

Conferences and workshops
Conferences and workshops have provided valuable insights in this project. Some of the key conferences and workshops attended are:

- NordDesign 2006, Reykjavik, Iceland.
- Design2006, Dubrovnik, Croatia, 2006.
- Produktudviklingsdagen, DTU, K&P, Lyngby, Denmark, 2005.
- Blue Ocean Strategy, Dansk Industri, Vejle, Denmark, 2005.

- Strategic Management, Copenhagen Business School, Copenhagen, Denmark 2005. Doctoral course.
- Design2004, Dubrovnik, Croatia, 2004.
- PDMA Strategic & Operational Portfolio Management, Ft. Lauderdale, USA, 2004.
- Service Innovation for the 21st Century, IBM Research center, Almaden, USA 2004.
- Technology entrepreneurship & integrated product/process design, MIT Sloan School of Management 2004.
- Spirer din Produktudvikling?, Dansk Industri, Copenhagen, Denmark, 2003.
- Int. Summer School on Engineering Design Research, Tuheljske Toplice, Croatia, June 2003. Doctoral course.
- Int. Conference on Engineering Design, Stockholm, Sweden, 2003.
- Int. Summer School on Engineering Design Research, Baden-Baden, Germany, August 2003. Doctoral course.
- PDMA Managing the Front End of Innovation, Cambridge, USA, 2003.
- Portfolio Management for New Products, U3 Innovation Management, Glostrup, Denmark, 2003.
- Udvikling af forretningsidéer, U3 Innovation Management, Skodsborg, Denmark, 2003.
- Leadership Development, European Foundation for Management Development, London, England 2003.
- Produktudvikling der skaber værdi, Dansk Industri, Copenhagen, Denmark, 2002.

Experiments

Experiments have been an important activity during the research in order to verify assumptions and models. The industrial experiments have been executed as individual projects in companies, supporting senior management's own efforts towards improving their understanding and definition of the portfolio management task within their organizations.

Research in the United States of America

The project included a 9 month stay at Massachusetts Institute of Technology as a visiting research at Center for Innovation and Product Development (CIPD) with Professor Christopher Magee. Here I participated in the course New Enterprises at the MIT Entrepreneurship Center. The stay did in general provide a good opportunity to discuss the matter with colleagues and professors from both the academic community and the industry. Besides the MIT community, I engaged in discussions with Professor Steven C. Wheelwright and Associate Professor Allan MacCormack at the Harvard Business School. As mentioned earlier, the US stay enabled me to pursue interviews with senior industry professionals in six American companies. In addition, I discussed the topic with several members of the Consortium for the Management of Accelerated Technology Insertion (MATI[3]), which has a particular focus on the roadmapping approach.

[3] http://mati.ncms.org/

3 Theoretical basis

3.1 Introduction

In the previous chapter the goals, research questions, and methods of this research were identified. In this chapter it is recognized that research in portfolio management requires consideration and inclusion of several theory domains in the underlying theoretical basis. Hence the purpose of this chapter is to provide an overview of relevant theories associated with the research topic, and subsequently identify and discuss the scientific viewpoint suitable for this research.

3.2 Different theory areas and their role within portfolio management research

This research has found seven main theory domains or "schools of thought" which contribute significantly to research in portfolio management for product development. These include:

- Theory of the product development process.
- Portfolio management theory.
- Theory of strategic management.
- Innovation theory.
- Theory of technology management.
- Decision theory.
- Project management theory.

These theory domains and their relevance for this research are investigated in this section. Subsequently, the theory of the product development process is scrutinized in detail, since this theory is chosen as the scientific viewpoint for this research.

3.2.1 Theory of the product development process

It is widely recognized that a formalized and systematic development process is needed in order to progress ideas into successful products in the marketplace. The theory of the product development process is a comprehensive theory, which aims at explaining and supporting this process of product design (Andreasen & Hein 2000), (Cooper 2001), (Wheelwright & Clark 1992b), (Ulrich & Eppinger 2004). The theory provides descriptive and prescriptive models and procedures for the management of the process. Andreasen & Hein (2000) argue that it is useful to describe the process on four distinct levels of abstraction, namely: product planning, product development, product synthesis and problem solving. Hence the theory is not solely concerned with the execution of individual design projects. It covers tasks on operational, tactical and strategic levels in a company.

The theory of the product development process is considered vital for this research, because it provides a fundamental understanding of the product development process and its role in business creation by means of

developing and introducing new products in the marketplace. This theory is investigated in more detail in section 3.3.1.

3.2.2 Portfolio management theory

According to Dye & Pennypacker (1999) portfolio management can be described as the art and science of applying a set of knowledge, skills, tools, and techniques to a collection of projects in order to meet or exceed the needs and expectations of an organization's investment strategy. It is obvious that theories for management of project portfolios are fundamental for this research. In comparison with the theory of the product development process, however, this research has missed contributions in the literature to a similar coherent and comprehensive theory for portfolio management. The contributions within the field are highly heterogeneous covering virtually all types of projects and this reflects the breadth of the subject. Existing theories seems to be limited by mainly providing mechanistic descriptive and prescriptive statements for discrete activities like project selection, portfolio balancing and resource allocation (Frame 1999), (Matheson & Menke 1994), (Martino 1995). Some contributions, however, recognizes that portfolio management is more than project selection; it is an insidious and wide-ranging business process, which extends beyond these discrete activities (Cooper, *et al*. 1997b), (Nelson, *et al.* 1997), (Wheelwright & Clark 1992a).

3.2.3 Theory of strategic management

According to Schendel & Hofer (1979) strategic management is a process that deals with the entrepreneurial work of the organization, with organizational renewal and growth, and more particularly, with developing and utilizing the strategy which guides the organization's operations. Hence strategic management addresses how a company can pursue value creation on a continuous basis. There is consensus within the field that the creation of competitive advantage is instrumental in achieving this objective. Many means may be utilized in creating competitive advantage, and two viewpoints seem to be dominant.

Proponents of the *resource based* view argue that competitive advantage is created internally in the company (Penrose 1959), (Barney 1991), (Peteraf 1993), (Teece, *et al*. 1997). This may for instance be due to the way a company collect and share knowledge or create core competencies based on the organizations capability according to Prahalad & Hamel (1990). In other words, the fundamental question within the resource based view is how a company best can organize itself around its resources to create competitive advantage.

Porter (1979), Porter (1980), Porter (1987) and Porter (1998) advocate for the *industrial organization view.* He claims that competitive advantage can be created if a company organizes according to the company's product markets, i.e. company external factors. The underlying assumption is that the management team should analyze the industry, erect barriers for competition, and position the company accordingly.

The theory of strategic management is highly relevant for this research, because it deals with the creation of competitive advantage. A company's product portfolio and hence product development plays an important role in achieving this objective which is essential for successful business creation. Hence it is central that portfolio management is anchored and integrated in the strategic management of the firm.

3.2.4 Innovation theory

Innovation is in the management literature broadly accepted as a mean for organizations to enhance their competitiveness. Innovation might encompass change or renewal in several dimensions, and can occur at every level in an organization in interplay with markets and technology according to Tidd, *et al.* (2001).

From a technological perspective innovation is concerned with change in the organization's offerings, i.e. the products, services and the process by which they are manufactured and delivered to the customer and thus commercialized. The degree of change in products, services, and process may vary. Change can span from minor (incremental) improvements over major or radical improvements to transformations. Innovation may contribute to increased effectiveness and/or efficiency. Effectiveness refers to the potential value of a business opportunity. Efficiency refers to how well a company exploits its capability while pursuing opportunities.

Several "schools of thought" exists and complements each other within the field. Proponents of the so called fuzzy front end of innovation focus particularly on those activities that take place in the early phases of the product development process (Khurana & Rosenthal 1997), (Smith & Reinertsen 1998), (Koen, *et al*. 2001). The basic assumption is that the front end presents a significant opportunity for improving the overall innovation process by generating high value ideas.

The "blue ocean strategy" suggested by Kim & Mauborgne (1999) and Kim & Mauborgne (2004) is another approach to innovation which recently has gained considerable attention in management communities. They suggest that companies should be innovative in terms of their market position. Instead of pursuing a greater share of a limited market crowded with many competitors companies should expand the boundaries of the existing markets and thus create new and uncontested markets.

User-driven innovation represents another interesting perception of innovation. It is based on the assumption that user or consumer needs are important sources of innovation as opposed to e.g. new technology. The core of user driven innovation is to determine a more systematic way to understand and develop solutions that respond to user needs according to The Danish Council for Trade and Industry (2004).

Leifer, *et al.* (2000) introduces the concept of the innovation hub, which enables the linking of ideas, evaluation and key people in an organization. Hence they acknowledge the need for organizing towards innovation if a company intends to pursue radical innovations, i.e. innovation characterized by a high degree of newness.

Innovation theories are important sources for understanding how the composition of the product development portfolio directly and indirectly influences corporate renewal. Furthermore innovation theory is closely linked with the idea of creating competitive advantage and therefore the theory is strongly linked with the theory of strategic management.

3.2.5 Project management theory

According to the Project Management Institute, project management can be described as the application of knowledge, skills, tools, and techniques to a broad range of activities in order to meet the requirements of a particular project. Mikkelsen & Riis (1992) suggests that project management can be perceived as consisting of four management tasks, namely: 1) creation of the project results, 2) the management of the project team, 3) the management of the project in terms of external stakeholders, and 4) controlling the project in terms of quality, time, resources etc.

In their effort to point out the underlying theoretical foundation for project management Koskela & Howell (2002) reports that there seems to be a surprising lack of an explicit theory within the field. They argue that project management today is practiced on an implicit theory, which they attempt to derive from the Project Management Body of Knowledge-guidelines proposed by the Project Management Institute (2000). They conclude that the theoretical foundation for project management is constituted by three other theories of management:

- Management as planning

Here it is assumed that the organization consists of a management part and an executing part. Management is seen to consist of the centralized creation, revision and implementation of plans.

- Communication

This aspect is related to the communication of the assignment, i.e. the written or oral authorization or notification to start work. The underlying theory seems to be the classical theory of communication, where a set of symbols is transmitted from sender to receiver.

- Controlling

The process of controlling consists primarily of performance reporting related to project execution and the associated corrections to execution. The concept is explicated in modern control theory, which according to Ogunnaike & Ray (1994) consists of the following elements:

- there is a standard of performance.
- performance is measured at the output (or input).
- the possible variance between the standard and the measured value is used for correcting the process so that the standard can be reached.

The successful completion of the projects within a portfolio is a prerequisite to realizing the expected business value of the portfolio. Project management plays a critical role in realizing this objective, and

this justifies the inclusion of project management theories in the theoretical basis for this research.

3.2.6 Decision theory

Many of the methods and models for portfolio management suggested in the literature seems to build on the assumption that decision making regarding the portfolio is a rational process which per se leads to the optimum choice. In this "ideal world" perspective decision making typically follows a formal and systematic approach comprised of three sequential steps starting with problem definition, identifying the alternatives, and choice of the best alternative followed by implementation of the decision.

However, in the real world politics, relationships, friendships, coalitions, and emotions are deeply inherited in the decision process (Garvin & Roberto 2001), (Hammond, *et al*. 1998). This approach is also known as the advocacy-approach, where e.g. a project manager tries to persuade a decision maker to select and fund the proposed project. Such meetings may come off as more of a sales opportunity or a contest than a dialog to uncover the idea or project with the highest value for the organization. Furthermore, it is also common to see that this approach encourages participants to go along with the dominant view to avoid further conflict, which eventually may suppress innovation as argued by Garvin & Roberto (2001). According to Skinner (2001) the problem with this approach is that the real value of the choice and where it comes from is usually never understood in the organization. Additionally, Kim & Mauborgne (1997) argue that if participants do not perceive the decision process as fair they are reluctant to commit themselves to the outcome of the decision process. Consequently this can impede the implementation of the decision.

From a portfolio management perspective the consequences of the advocacy-approach may find expression in an inconsistent product portfolio mix, which tends to be more and more unfocused. Hence decision theory is important for this research, because it comprises a natural basis for obtaining a deeper understanding of the decision processes inherent in portfolio management.

3.2.7 Theory of technology management

Even though the importance of effective integration of technological considerations into business decision making is widely recognized, there seems to be a lack of a common theoretical base where to all contributions may be referred according to Probert*, et al.* (2004).

The European Institute for Technology and Innovation Management (EITIM) has proposed the following definition of the subject: Technology management addresses the effective identification, selection, acquisition, development, exploitation and protection of technologies needed to maintain a market position and business performance in accordance with the company's objectives.

Tschirky (2004) suggests companies manage technologies with four purposes: technologies enable researchers and engineers to develop new products and services, they allow products to perform specific functions, they serve manufacturing to produce products, and, finally, they enable companies to operate their administrative processes and infrastructure.

Within the theory domain of technology management, models and methods related to the management of product technologies are of particular value to this research. This is because technologies play a central role in enabling the creation of product functionality and variety.

It is important to distinguish between technology development and product development. According to Bone & Saxon (2000) the former can be described as a process of acquiring knowledge, which can later be utilized in the design of new products to meet market needs

Technology projects require extensive investments and therefore every attempt is made to incorporate them into several products. Hence when a technology first has been developed the firm may base a set of smaller (in terms of cost and development time) derivative product development projects on this technology. Thus technologies often form the foundation for generations of products. However, as opposed to product development, the outcomes of technology development efforts are unpredictable and hence associated with significant risk. Ajamian & Koen (2002) argues that the premature introduction of a technology into the product development process often leads to project delays, project uncertainty, and project cancellation.

The strong relationship between technologies and product development projects' highlights the importance of understanding the technology management phenomenon. This justifies the inclusion of technology management theories in the theoretical basis for this research.

3.3 Scientific viewpoint

The theoretical basis for this research is comprised by seven theory areas, which all have been presented in this chapter. One of these theory areas – the theory of the product development process - has been chosen as the scientific viewpoint for this research. This theory in particular offers a comprehensive and coherent theoretical foundation for understanding the product development context wherein portfolio management is exercised. The theory is discussed in more detail in the next section.

3.3.1 Theory of the product development process

Product development is a complex phenomenon which involves activities on strategic, tactical and operational level. Andreasen & Hein (2000) advocates that it is useful to consider the development of products on four levels: product planning, product development, product synthesis and problem solving. This research primarily relates to the product planning and product development levels. For the sake of completeness, however,

all four levels and the totality they constitute are investigated in this section.

Business creation as a cyclical activity
The four levels of activities associated with the development of products are implemented as a cyclic process consisting of six distinct activities according to Andreasen & Hein (2000). The process comprises a control loop, where the existing products' business performance on the market and the market conditions are monitored.

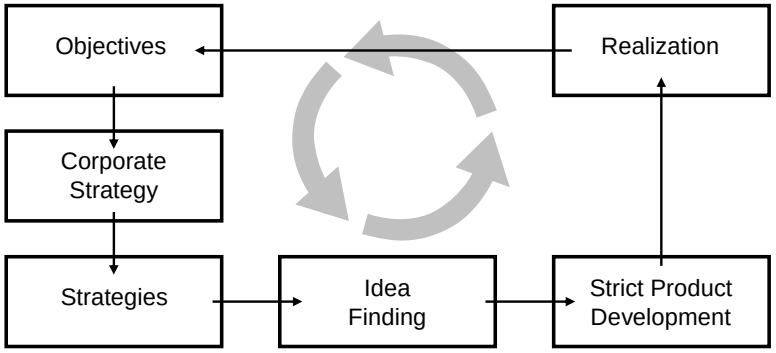


Figure 2. Product development is a cyclical activity.

This performance together with internal conditions within the company gives reason to adjustment of the organizations objectives. Adjusted objectives might cause a need for a reformulation of the corporate strategy, which in turn implies adjustment of lower level strategies (i.e. marketing strategy, production strategy, design strategy etc.). The next activity in the control loop is idea finding, and this is where product development kick-in. After a business opportunity has been identified then the actual development phase is initiated. This closes the control loop. It is within this overall process context business creation by means of product planning, product development, product synthesis and problem solving is implemented.

Product planning
Product planning can be characterized as a recurring activity which aims at providing a strong basis for the development of new business in a company as illustrated in Figure 3. It deals with the initiation of product development projects based on indications from the surroundings such as suggestions from marketing, customers, research, competitors and legislation.

Product planning depends on the integration and coordination of many disciplines. It generally involves decision making by the senior management which has crucial effect on the company's ability to carry out its long-term strategic objectives.

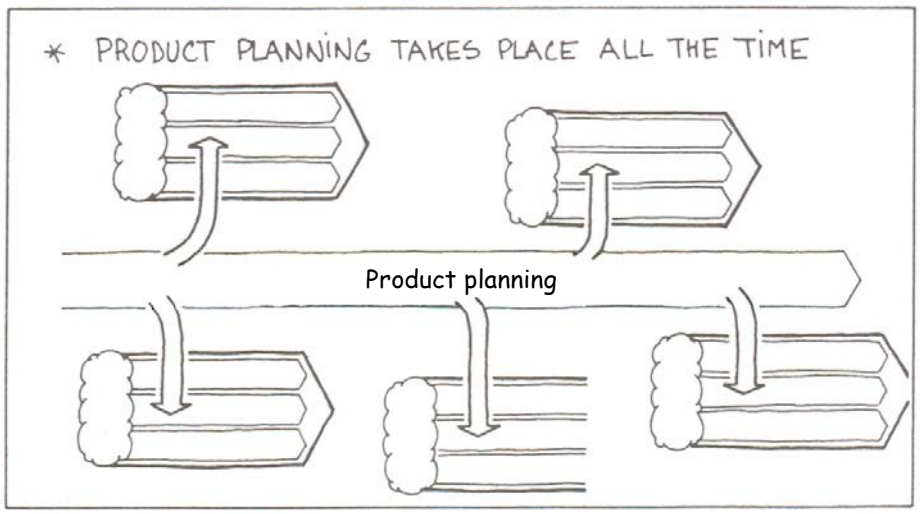


Figure 3. Product planning is the basis for development of new business (Andreasen & Hein 2000).

According to Andreasen & Hein (2000) product planning includes execution of the following tasks:

- Formulation of product strategy.
- Searching for business ideas and screening them.
- Initiation and following up of product development projects.
- Top-level control of resources.
- Monitoring the results of product development.
- Coordination of the current project in relation to other development projects and other activities within the company that require resources.

Hence product planning does not only take place before a development project is formally approved and resources are allocated, but it is also closely integrated with each of the individual development projects during development as shown on Figure 4. This does in particular take place during pre-specified key points throughout the project, where the project quality regularly is re-evaluated. The concept of key points is described in more detail the following section.

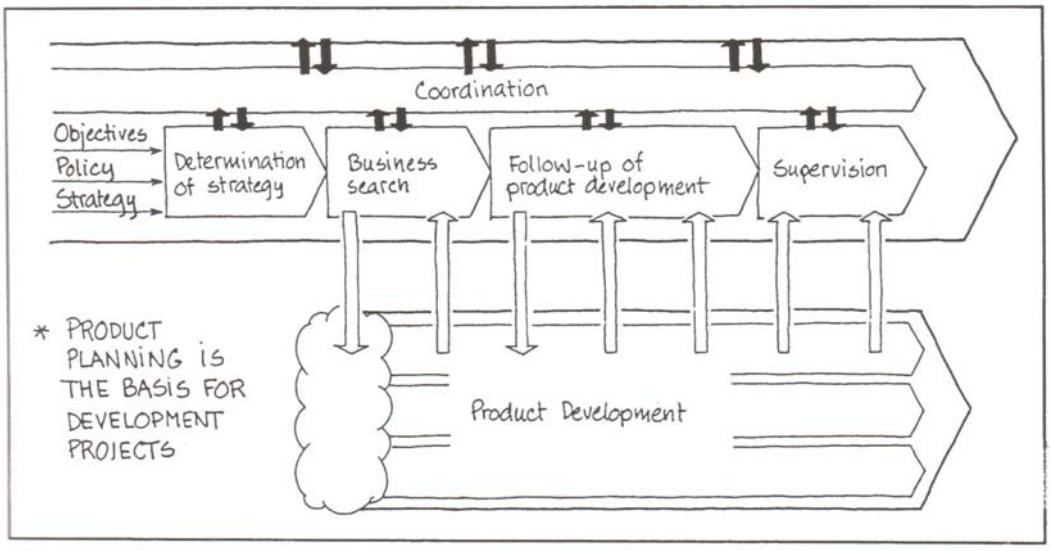


Figure 4. Product planning interacts with each product development project.

According to Ulrich & Eppinger (2004) the product plan shown on Figure 5 is a fundamental tool for product planning. It identifies the portfolio of products to be developed by the company and the timing of their introduction to the market. Hence it is imperative that the product plan continuously is feasible and consistent with the business context wherein the company operates. For that reason the plan should be reevaluated frequently and modified based on the most recent information from development teams, customers etc.

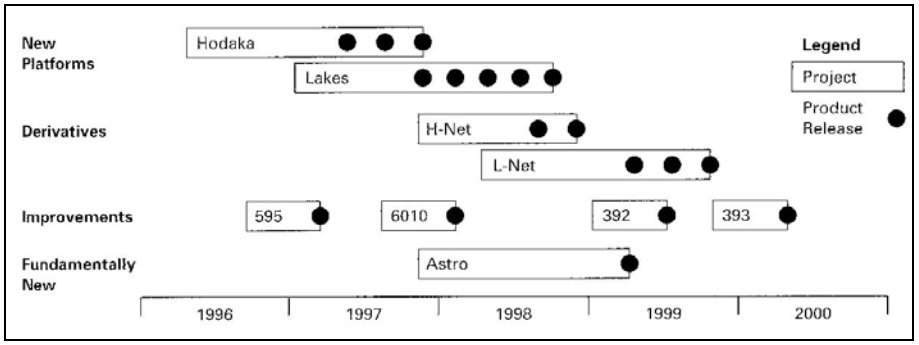


Figure 5. The product plan identifies the portfolio of projects to be pursued by the company (Ulrich & Eppinger 2004).

Product development

It is widely accepted that the overall purpose of a product development project is to create a prosperous business. Hence product development goes beyond the "mechanistic" design of the physical artifact; contributions from other functional areas are imperative in order to improve the probability of business success. These circumstances are recognized by Andreasen & Hein (2000) who suggest a process model for product development projects which explicate the need for the parallel execution of specific activities related to market aspects, the product and production aspects as shown on Figure 6.

Distinct phases

The recognition of a diffuse "need" to be explored forms the starting point for the model for product development. The remaining part of the model is structured into five distinct and sequential phases. The idea of structuring the development process in distinct phases – or stages was also recognized by Cooper (1990) who introduced the Stage Gate process model. All the phases require contributions from marketing, design and production, and this is explicated in the model by means of the three arrows. A variety of methods and tools may be associated with the different phases of the product development model. The development of a product do not necessarily need to progress through each phase in the same level of detail. A project resulting in a product characterized by a high degree of newness may require the "longest path" in the model, whereas a project aimed at minor modifications on an existing product may not require comparable extensive work in some of the phases.

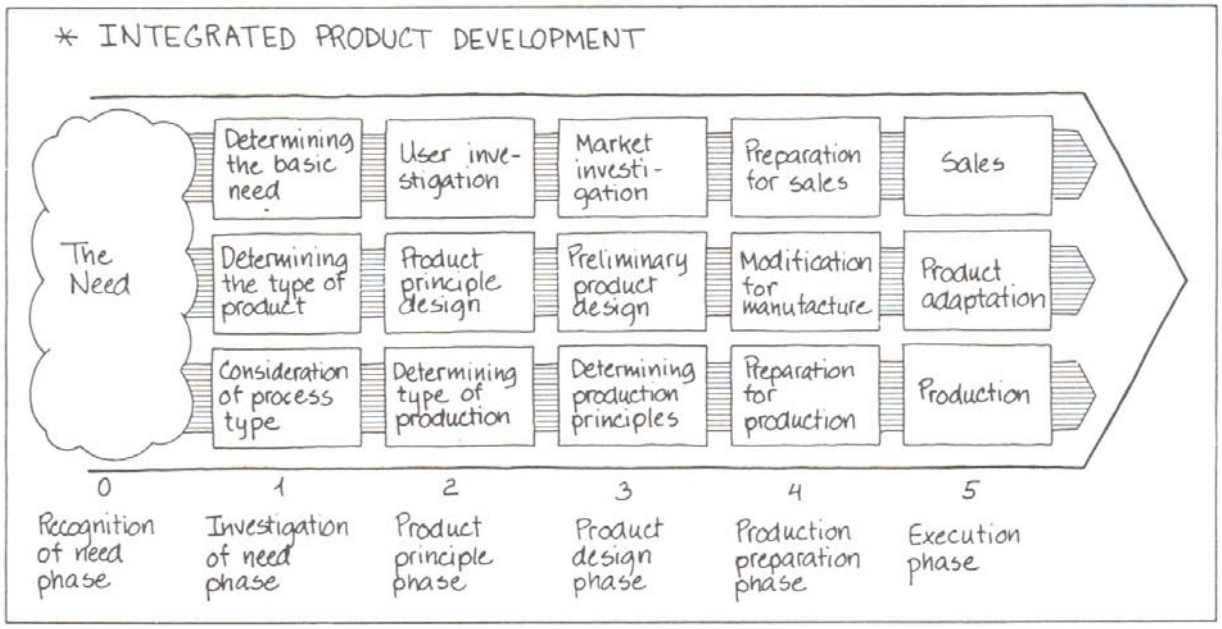


Figure 6. The model for integrated product development explicates the need for the parallel execution of specific activities related to market aspects, the product and production (Andreasen & Hein 2000).

Wheelwright & Clark (1992b) do also recognize that the creation of strong products do require integration across the major functions in the business. It is central that all the functional activities fit well together. They propose a framework for cross-functional integration illustrated on Figure 7 in order to demonstrate the impact that integration has on the role of the functions in product development. The framework captures the development phases and the related functional activities.

Wheelwright & Clark have identified the major activities in each of the phases of development within each of the functions engineering, marketing, and manufacturing along the development path from initial concept to full commercial operation.

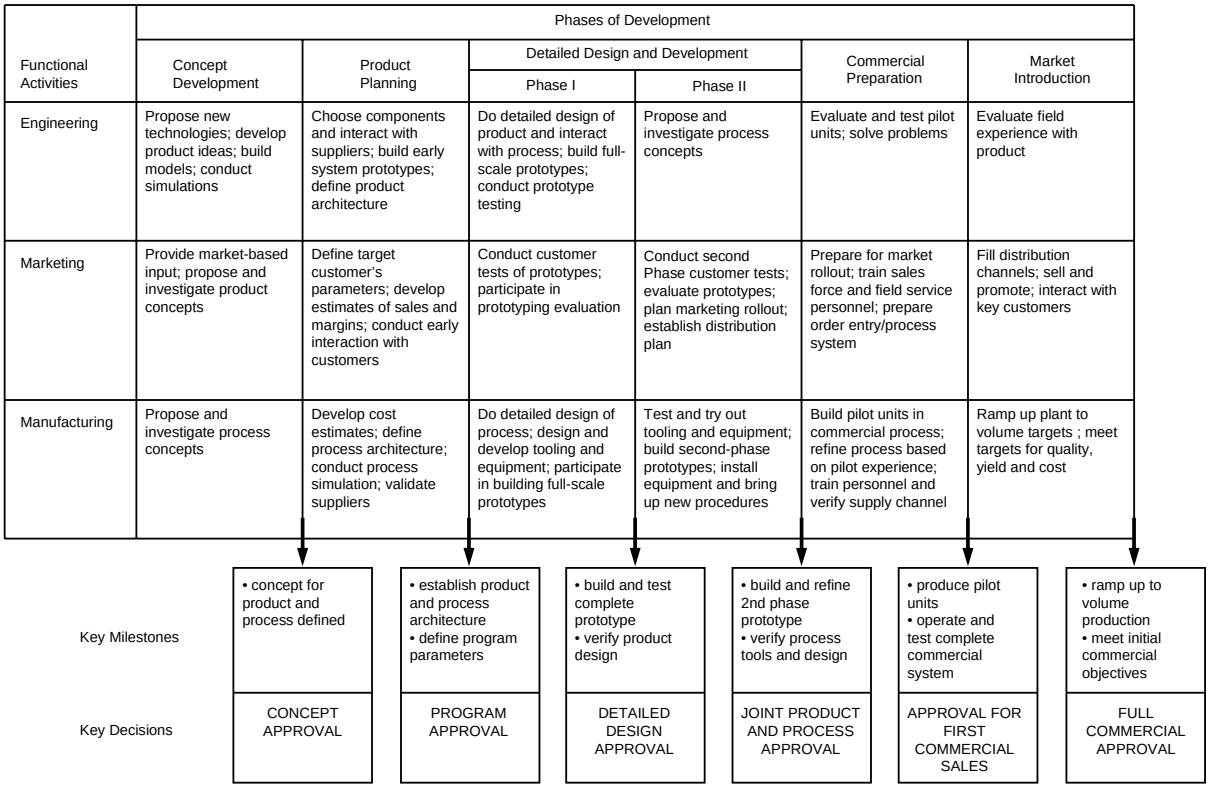


Figure 7. Functional activities under cross-functional integration (Wheelwright & Clark 1992b).

Key points

The phases in the product development process are separated by means of key points. They mark a rise in our understanding of the project and the potential business it represents as shown on Figure 8. Hence key points are critical points where management needs to evaluate the feasibility of the project and its results before the project is progressed into the subsequent phase. Andreasen & Hein (2000) advocate that the following activities should take place in the key points of a project:

- The status of the project is measured; decisions which have been taken are evaluated.
- The result is evaluated in relation to the project objective.
- The result is evaluated in relation to the company's other activities.
- The consequences of stopping and of continuing the project are evaluated.
- The decision is made as to whether the project is to be continued (or stopped).
- The project is adapted to the company internal/external conditions.
- The status of the project and the decisions made are noted.

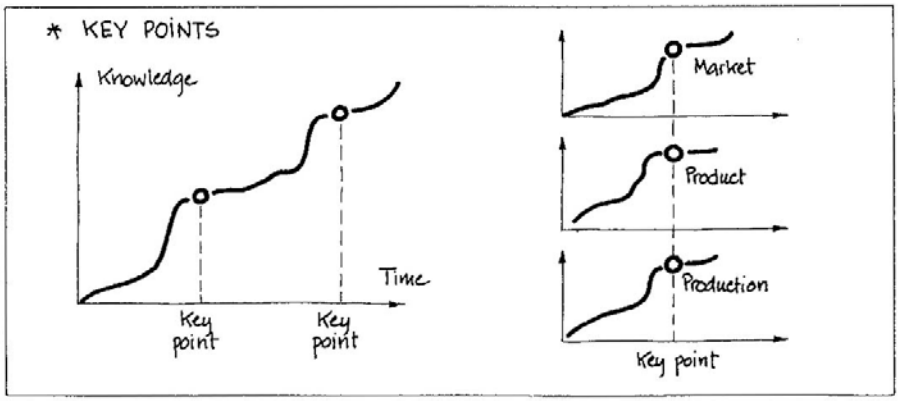


Figure 8. Key points should be placed at points in projects where the development team notes a marked rise in their understanding of aspects related to the product, the market and the production (Andreasen & Hein 2000).

Cooper (2001) argues that meetings related to a projects key points'[4] should have three main components, namely deliverables, criteria and outputs. Before a key point meeting can be effective it is crucial that the project leader and the team in advance understand what they are expected to deliver and present at the meeting. The lack of information will otherwise impede the management's ability to make proper decisions regarding a projects further existence. Next, operational and visible criteria understood by all are needed to assess the project against. Cooper distinguishes between must-meet criteria and should-meet criteria, which both may be quantitative and qualitative. This is in line with Andreasen & Hein who denotes the "must-meet" criteria for requirements, which are needed to separate a solution from a non-solution. The "should-meet" criteria are used to judge the goodness of a solution.

The final component of a key point meeting is the output of the meeting. It includes a decision (continue, stop, hold or recycle the project) and a path forward (an approved project plan, and a date and the list of required deliverables for the next key point). It is central that the output of a key point meeting is clearly articulated

Product synthesis

Whereas product planning and product development encourage a business perspective on the development of new products the level of product synthesis solely focuses on the process of designing the product itself, i.e. the technical system. Tjalve (1989) suggests a model for synthesis of products. It consists of a sequence of stages where about it is useful to structure the design work. The recognition of distinct stages enables the utilization of various design methods relevant within each of the stages.

Even though the model implies that the design process follows a linear transition from one stage to the following stage it is important to recognize the iterative nature of designing, i.e. the designer is free to jump back and forth between the various activities in the model.

[4] Cooper (2001) uses the term "gate" for the same phenomenon.

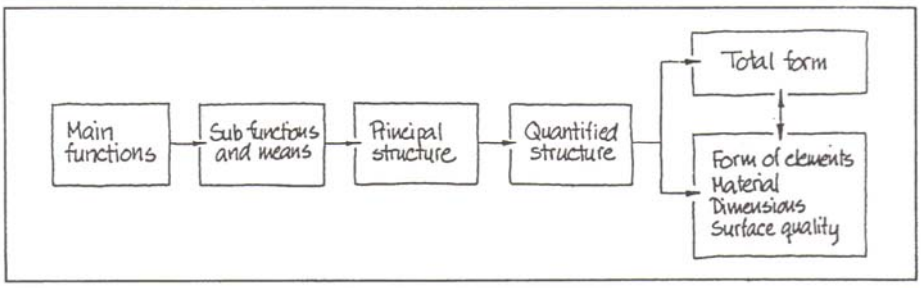


Figure 9. The model for product synthesis is useful for designing mechanical products Tjalve (1989).

Problem solving

The model for problem solving may be utilized in the search for the solution of general problems related to design work. It encompasses five steps, and several methods and tools may be utilized to assist the work within each of the steps. The process starts with the formulation of the actual problem in order to delimitate the solution space.

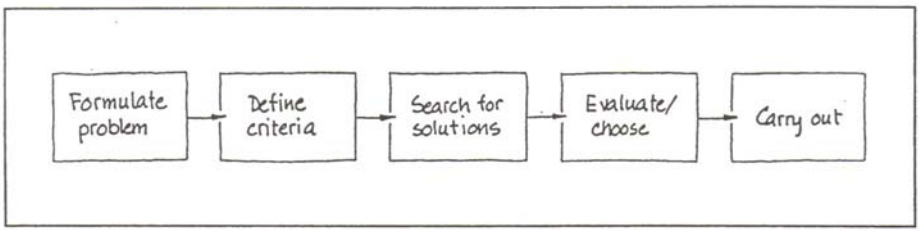


Figure 10. The model for general problem solving can be used for any kind of problem within design work.

Next, criteria for the evaluation of the proposed solutions are established. Then a number of possible solutions are identified, and subsequently their utility are evaluated and compared by means of the previously established criteria. Finally, at least one of the proposed solutions is selected for execution.

The totality of the product development process

The theory of the product development process can be explicated by means of the four described models according to Figure 11. This theory is chosen as the scientific viewpoint of this research due to its high degree of coherence and completeness in explicating the totality of the product development process.

In particular, it enables identification of essential activities related to individual projects and to product planning which are relevant to portfolio management. Furthermore, it acknowledges the necessity of linking and coordinating all projects in accordance with the overall business objectives and strategy on a recurring basis.

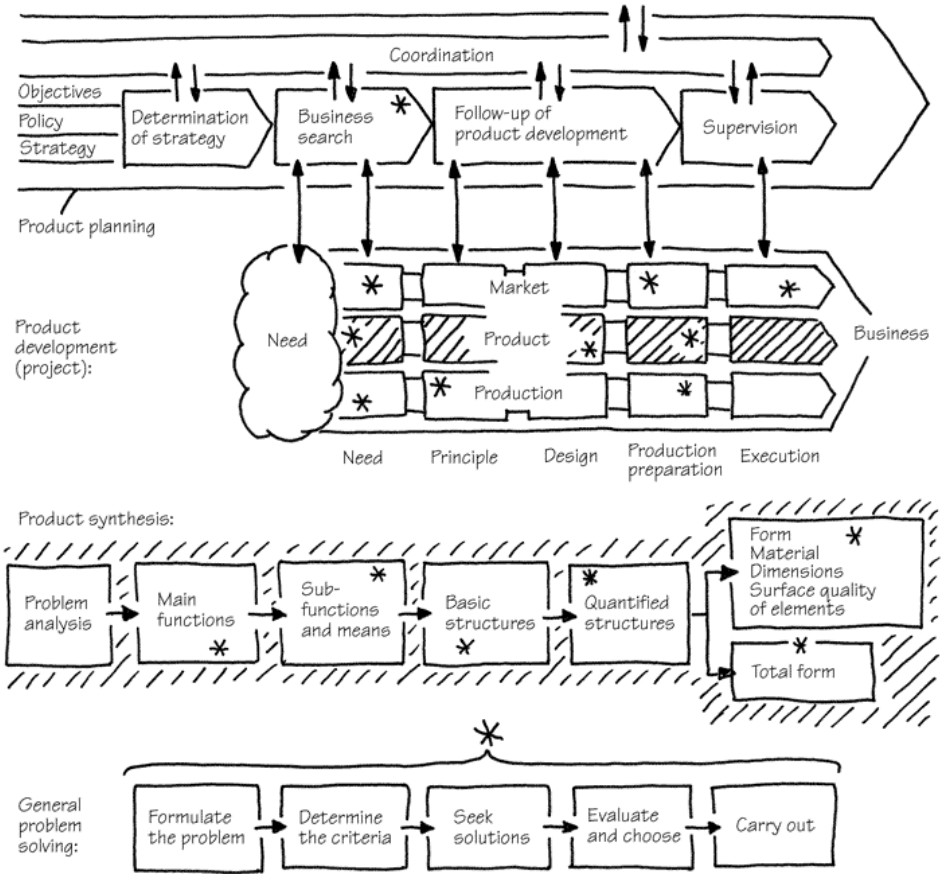


Figure 11. The design process can be described by means of models on four levels (Andreasen & Hein 2000).

3.4 Conclusions on theoretical basis

In this chapter it is recognized that it is relevant to include at least seven different theory domains in this research in order to obtain a proper understanding of the portfolio management phenomenon. In particular, the theory of the product development process is considered crucial for investigating the matter. It provides a theoretical framework which is assumed to have the potential to encompass and explain the portfolio management phenomenon. Within this theory the research focuses on the levels of product planning and product development. Each of the seven identified theory domains will be applied throughout this thesis as necessary. Hence none of them will be treated in isolation.

4 State-of-the-art in portfolio management

4.1 Introduction

The main purpose of this chapter is to obtain an overview of existing theories and central contributions to theories related to portfolio management for product development. Furthermore, the literature study is intended to identify research opportunities, where contributions from this research are relevant and valuable. Hence the study forms the base for introducing contributions in the form of models and tools in later chapters.

Structure of chapter

First of all a structure is laid down which can guide the study. It is assumed that it is possible to structure and outline influential perceptions of portfolio management according to four aspects. Subsequently, relevant literature related to each aspect of the structure is investigated: Firstly, central perceptions related to the goals of portfolio management are scrutinized. Next, the processes which constitute the portfolio management process are examined. Then the attention is directed towards the various organizational roles and responsibilities which need to be filled in by people across the organization in order to implement proper portfolio management. Subsequently, we explore contributions to major families of tools and methods frequently used and referred to in the literature. The examination of contributions related to each of the mentioned aspects finishes with a sub-conclusion. Finally, the study ends with an overall conclusion in the last section.

4.2 Framework for investigating the phenomenon portfolio management

Many authors from different research domains, including operations research, business management and project management, have contributed to the area. This might be one of the reasons for the highly heterogeneous nature of the contributions, which, indeed, is challenging to classify and categorize. However, in order to pursue research within the area of portfolio management identification and understanding of the related state-of-art literature is necessary. Hence the purpose of this chapter is to establish such a suitable foundation for discussing the phenomenon.

This research recognizes that portfolio management does not exist in a vacuum. On the contrary it is a complex and multi-dimensional phenomenon closely interrelated with other aspects in a company. Central aspects addressed in the literature include:

- The goals of portfolio management (value, balance, strategy).
- Processes inherent in portfolio management (strategy, review, gating).
- Organizational roles and responsibilities related to portfolio management (product committee, ad hoc teams, process responsible).
- Supporting tools and methods (score lists, diagrams, roadmaps, etc).

Each of the aspects is briefly introduced below, before the related contributions from the literature are investigated in the next chapter. This is assumed a crucial prerequisite in order to establish a thorough understanding of the phenomenon portfolio management and the related normative theories.

The goals of portfolio management
At a first glance it seems obvious that the ultimate goal for portfolio management is to support the achievement of the company's business objectives. However, since different companies have different objectives it is difficult to define specific goals which are valid across all companies. Value maximization, portfolio balance and strategic alignment are examples of high level generic goals for portfolio management often referred to in the literature.

Processes inherent in portfolio management
A central aspect of portfolio management is to link a company's strategy with the concrete new product investments, i.e. projects. Thus the overall portfolio management process spans strategic and operational levels in the company, and this emphasizes the pervasive nature of the phenomenon. In order to accomplish this linkage the overall portfolio management process may be seen as comprised by multiple processes, which are closely integrated. A strategy process, portfolio review process and the development process are the typical processes considered by different authors.

Organizational roles and responsibilities
In order to perform effective portfolio management the participation and contributions from many people across the organization are needed. Many important roles and responsibilities should be delegated in order to establish and maintain the required organizational anchoring of the process and the portfolio. Some of the dominant approaches involve arrangements of a permanent character like the assignment of product committees, executive committees, front-end teams and/or portfolio managers. The formation of ad hoc task forces or strategy groups are examples of approaches of a more temporarily nature.

Supporting tools and methods
Many tools and methods have been proposed in the literature during the past decades to help managers with portfolio management and to decide which projects to fund. Some of the most common tools are economic models, scoring models, checklists, and mapping approaches, which aims at providing visual representations of central portfolio dimensions.

This research assumes that it is possible to identify and outline influential perceptions of portfolio management by structuring the literature study according to the aspects mentioned above. The aggregated knowledge from the study comprises the foundation for the model, mindset and tools, which are introduced in chapter 5, 6, and 7.

4.3 The goals of portfolio management

It may seem evident that the overall goal for portfolio management is to compose a strong portfolio. This is, however, an elusive goal, which is difficult to implement in practice. In order to compose a strong portfolio it is of paramount importance that we achieve a better understanding of the goals of portfolio management, i.e. the characteristics of a strong portfolio. The focal point of this section is to investigate contributions in the literature related to this matter.

In the following we will see how some authors explicitly aim at articulating goals, which a portfolio should meet. Others pursue a more holistic approach, when they outline the development task, i.e. the sum of activities to be executed by the company's development function. Goals for the portfolio in particular can subsequently be derived from the latter.

4.3.1 Value, strategy & balance

Cooper, *et al.* (1997a) found that value, strategy and balance are three high-level goals which dominate the management's mindset in companies. These are examined in this section.

Value maximization

Firstly, managers attempt to allocate resources so as to maximize the *value* of the portfolio in terms of some company objective. This is not only in terms of potential financial value, but rather in terms of a high degree of benefit contribution to the company, for example financial value, market attractiveness, leverage of competencies and resources, strategic importance etc. Hence these objectives may be a combination of financial and strategic objectives. Cooper and colleagues do not pursue any further investigation of this (or the two following) goals, but indicate that certain portfolio approaches seems more applicable to some goals than others. Hence in order to decompose these goals it may be beneficial to study some of the parameters incorporated in the methods, which Cooper found companies utilizing. Cooper, *et al.* (1997a) reports that the best industrial example of parameters they have seen to be utilized for assessing the value of projects are from the company Hoechst, which is illustrated on Figure 12.

It is interesting to observe how Cooper and colleagues relate the proposed model and parameters to the goal of value maximization. A closer look at the parameters included in Figure 12 reveals that two of the five groups of parameters concerns strategic matters. It is arguable whether the suggested model addresses the goal of value maximization or the goal of strategic alignment.

The model may be overlapping and addressing both goals and this situation reflect the challenges associated with classifying the industrial approaches according to the suggested high level goals.

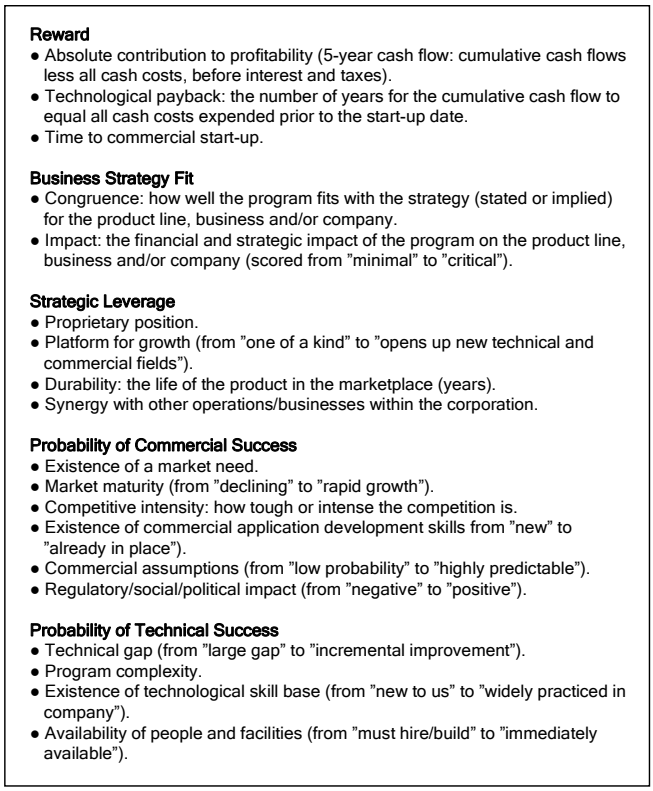


Figure 12. Hoechst's 19-question scoring model (Cooper, *et al*. 1997a).

Balance

The next goal concerns the *balance* of the portfolio. The concept of balance relates to several parameters, e.g. balance between resources available and projects pursued, and the balance among the project types (improvements, platforms or short/long time horizon etc) in the portfolio or the balance between risk and reward associated with each project in the portfolio. Cooper, *et al.* (2001b) found that companies considers and compares some of the following parameters in order to explicate the portfolio balance:

- Fit with business or corporate strategy (low, medium, high).
- Inventive merit.
- Strategic importance to the business.
- Durability of the comparative advantage (short, medium, long-term).
- Reward based on financial expectations (modest to excellent).
- Competitive impact of technologies (base, key, pacing, and embryonic technologies).
- Probabilities of success (technical and commercial success as percentages).
- R&D cost to completion (dollars).
- Time to completion (years).
- Capital and marketing investment required to exploit (dollars).
- Markets or market segments (market A, market B, etc.).
- Product categories or product lines (product line M, product line N, etc.).
- Technology or platform types (technology X, technology Y, etc.).

- Project types (new products; product improvements; extensions and enhancements; maintenance and fixes; cost reductions; and fundamental research).

Strategic alignment
Strategic alignment of the portfolio is the last of the three goals. The idea is to ensure that the final portfolio of projects actually reflect the company's business strategy, i.e. that the allocation of resources (funds, human resources, facilities etc.) across projects, areas, markets is directly tied to the business strategy. Cooper and colleagues suggest that this goal can be decomposed into the following three objectives:

Strategic fit: Are all the projects consistent with the articulated strategy? For example, do the projects fit into the key focus areas (certain technologies or markets) defined by the management?

Strategic contribution: What projects must the company do if management wants the business strategy to be realized and the goals achieved? For example, what projects should the company do to be successful in a certain, new segment?

Strategic priorities: Does the breakdown of the spending across the portfolio reflect the strategic priorities? For example, if the company pursues a growth strategy, it follows that the majority of the R&D resources should be invested in projects that have the potential to grow the business.

Potential conflicting goals
Cooper, *et al.* (2001b) recognizes the paradox of potential *conflict* between the goals. The achievement of one of the goals for the portfolio may compromise the fulfillment of another goal. For example, even if the portfolio is comprised of high-value projects, the portfolio may not fulfill the balance requirements. This would be the case if too many of the projects are targeted at the same market segment, and thus are skewing the portfolio profile.

4.3.2 Strategic alignment and balance

The European Industrial Research Management Association assume that a strong portfolio is characterized by being *strategic aligned* and in *balance* (EIRMA 2002).

They suggest that a strategic aligned portfolio reflects corporate and business strategies. A misalignment of any project will result in reduction of speed to market and substantial waste of resources. A balanced portfolio has a R&D spending across markets, project types, technologies, time scale etc., which reflects the strategic objectives and criteria of the business. They write:

"The basic reason for spreading projects is to manage risks and opportunities and provide the opportunity for planned R&D outcomes as well as serendipity to occur".

It is obvious to see how diversification of the new product development investments is an essential means for managing risk.

Portfolio drivers
Similar to Cooper and colleagues EIRMA (2002) do not pursue any further clarification of these high-level goals. They do, however, introduce the concept of *portfolio drivers* (or *business drivers*), which they advocate affect the strategic alignment and balance of the portfolio. Examples of common internal and external portfolio drivers are:

- Economic reward.
- Quality and availability of capability.
- Risk.
- Importance of a technology or project for the company.
- Degree of difficulty in realizing a project.
- Strategic intent.
- Markets, products, technologies and project types.
- External awareness.
- Social, political, economical, regulatory, environmental issues.
- Impact of new innovative technology on production plants.
- Organizational changes.

These portfolio drivers seem similar to those parameters Cooper found that companies consider in order to explicating the portfolio balance. The only difference seems to be the terminology used, i.e. *portfolio drivers* or *parameters*.

Portfolio value - not articulated as a goal
It is interesting to observe how EIRMA (2002) does not explicitly consider the concept of portfolio value like Cooper and colleagues suggest, but instead assume it to be encompassed in the concept of strategic alignment.

This may be due to the challenges associated with defining the concept of value for a new product development portfolio. As formerly mentioned the concept of portfolio management origins from the domain of financial management, where the concept of value equals economical value. The portfolio management mindset together with the intellectual appealing concept of portfolio value has been adopted by the professionals of product development. However, whereas the appraisal of the economical value of a portfolio comprising financial assets may be more or less straightforward, the similar exercise for a product development portfolio is quite challenging, since value within this domain is much more intangible than purely economical value.

4.3.3 The development task

Andreasen, *et al.* (1989) does not explicitly consider the new product portfolio as a distinct object in product development. Consequently, they neither explicitly consider the characteristics of a strong new product

development portfolio. Instead, they introduce the concept of the development task which they describe as:

"*the overall sum of planning and execution of tasks related to the creation and maintenance of products and utilization of technologies*".

The development task is executed by the company's development function. The latter should not be confused with the company's R&D function in particular. Rather, it rests on the broad and cross-functional concept of product development introduced in section 3.3.1.

The operational level of the development task can be broken down into three task types: 1) the development of new products, 2) the solving of tasks belonging to other functional areas, and 3) the development of readiness. A plethora of different activities such as for example implementation of CAD systems and training programs for the staff are included in these tasks. Furthermore, it is evident that the new product development portfolio is a subset of the development task as illustrated on Figure 13.

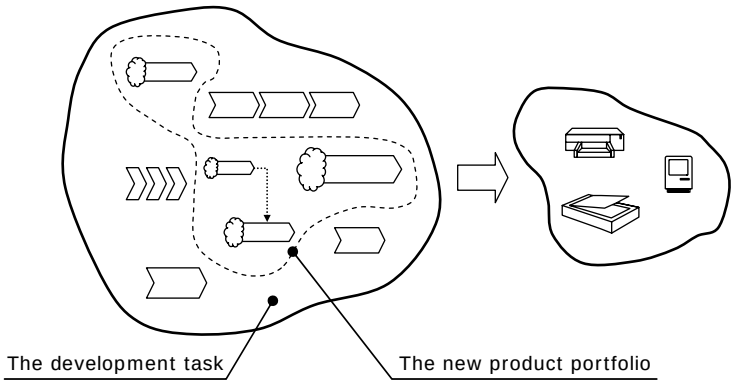


Figure 13. The new product development portfolio is a subset of the development task according to Andreasen, *et al.* (1989).

Andreasen, *et al.* (1989) advocates that the well-structured and arranged development task possesses a number of characteristics. These are shown on Figure 14. Since the new product development portfolio is a subset of the development task this research assumes that these characteristics (where relevant) also are applicable for the new product development portfolio.

It is interesting to observe how they articulate portfolio characteristics which also recognize the need for maintaining and developing the company's product development function. Two of the eight groups of characteristics are assigned to this purpose. Additionally, we notice that Andreasen, *et al.* (1989) also explicate characteristics related to the time- and resource planning of the portfolio.

Wheelwright & Clark (1992a) pursue a similar line of thinking when they suggest their concept of "aggregate project planning". They argue that the greatest value of the aggregate project plan may be its ability to shape and

build long term development capability, both individually and organizationally. They write:

"*It provides a vehicle for training development engineers, marketers, and manufacturing people in the different skill sets needed by the company*".

Thus Wheelwright & Clark recognizes that a product development project represents an opportunity to refine or modify an organizations set of capabilities. Additionally, they recognize the importance of proper resource allocation and timing of projects across the portfolio. The aggregate project planning approach is investigated in section 4.6.2.

Figure 14. Characteristics of the well-structured and arranged development task according to Andreasen, *et al.* (1989).

4.3.4 Conclusion

The focal point of this section has been to investigate significant contributions in the literature related to the goals of portfolio

management, i.e. the characteristics of a strong new product development portfolio. There seems to be regularity regarding the following matters:

Multiple goals
It is not expedient to put forward one single goal, which a strong product development portfolio should meet. Rather, a strong development portfolio must comply with multiple and complex goals simultaneously.

Conflicting goals
The achievement of the multiple goals is a delicate matter, since some of the goals can be mutually conflicting. The implication is that we should be attentive to trade-offs incurred, since the achievement of one goal well may jeopardize the achievement of another goal.

Portfolio value extends far beyond economical value
The concept of portfolio value is conceptually very appealing, but extremely difficult to handle in practice. The reason is that the value of a portfolio cannot solely be defined as economical value. Intangible aspects need to be factored in. The value of cultivating new development skills and probabilities of success are examples of such aspects, which are next to impossible to quantify.

Closely related to business strategy
Consensus exists about the perception that the product development portfolio represents a concretization of a part of the overall business strategy. Therefore it is imperative that a strong portfolio continuously reflects the business strategy of the company.

Balance is fundamental
The proper balance among the product development projects in the portfolio in terms of a number of parameters is widely recognized as a central characteristic of a strong portfolio. The balance concept may well be directly adopted from the domain of financial management where diversity in the investments is considered essential for managing risk.

Portfolio goals are highly company specific
In sum the goals and the corresponding parameters, which a strong product development portfolio should meet, seem to be described from a broad, open-ended and high-level perspective in order to be valid across all companies. The industrial application of the goals, however, seems to be highly dependent on the individual company's preferences and situation. Thus an interpretation and decomposition of the goals in relation to those aspects are needed.

Implications for this research
It is imperative that tools introduced by this research in chapter 7 provide indications about the portfolio's balance, strategic alignment and potential value, since this appear to be three high-level goals that dominate the management's mindset in companies.

4.4 Processes inherent in portfolio management

The management of the product development portfolio does not occur by means of a single and isolated process. It is rather realized as a result of several processes in interplay, where people employ various methods and techniques in a complex pattern of activities across the company. Contributions related to these processes and their interplay forms the focal point for the investigation presented in the following sections.

Structure of study

Initially, the investigation focuses on the idea that portfolio management consists of four decision processes. Then the attention is directed towards the perception that the portfolio management process is inherent in the product planning process. Next, the position and interrelation of the portfolio management process within a hierarchy of management processes is examined. After that, the study focuses on the perception that it is beneficial to consider portfolio processes as consisting of a portfolio planning process and portfolio management processes. Finally, a conclusion is presented in the last section.

4.4.1 Four decision processes interacts

Based on a study of 35 firms in various industries Cooper, *et al.* (1997b) found that four decision processes interacts in deciding the business's portfolio of development projects: corporate planning, strategy development at the business unit level, product development process and the portfolio review, as illustrated on Figure 15. The corporate planning process overarches all the strategic business units in the company, and deals with resource allocation among those. With regard to the three other decision processes Cooper and colleagues writes, "- *these occur within the business unit and comprise what we call the portfolio management process*". Hence business strategies and new product strategies for the individual business units are developed in a process within each of the units, and this strategy drive the two other decision processes in the unit, namely the portfolio review and the product development process.

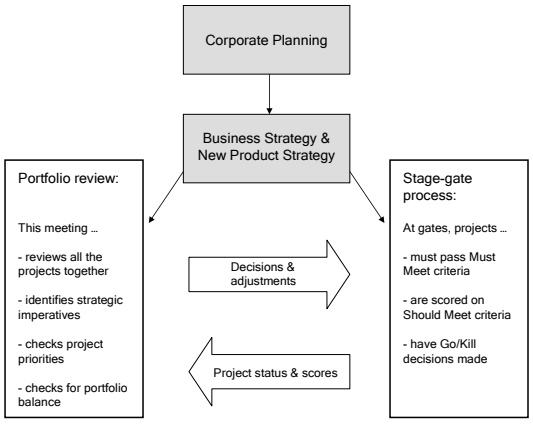


Figure 15. Four decision processes interacts in deciding the business's portfolio. Modified in accordance with Cooper, *et al.* (1997b) and Cooper, *et al.* (2001a).

Cooper and colleagues emphasizes, *"The three decision models ideally are integrated, in harmony and feed each other."* Thus the portfolio review feeds the product development process, which in turn feeds the portfolio review. Both processes are in sync and driven by strategy.

The business strategy / new product strategy process

According to Cooper, *et al.* (2001b) a business strategy process overarches the decision and project selection process as illustrated in Figure 15. The purpose of this process is to develop the business strategy and the product innovation strategy. They argue that it is almost impossible to perform effective portfolio management without a well defined product innovation strategy. Cooper and colleagues suggests that the product innovation strategy is a component of the business strategy for the business unit in question. It outlines the strategy with regard to the business' total new product efforts as he writes, "*it is the essential link between your product development effort and your total business strategy*". Thus the process includes the interpretation of the business strategy's consequences for product development activities.

Cooper (2001) stresses that, "*if companies lack an articulated product innovation strategy it might lead to ad hoc decisions made in isolation from each other, and thus projects are selected with little regard to fit into the overall portfolio resulting in a lack of focus for the aggregate set of projects*". Cooper & Kleinschmidt (1995) found that the existence of an articulated strategy is strongly linked with business performance, and they clearly identify having such a product innovation strategy as "best practice". They identified this strategy as one of the three critical success factors of new product development performance. The two other factors are the existence of a formalized product development process and adequate resources.

Although they do not explicitly state it, it seems that Cooper, *et al.* (2001b) assume that the process of developing the product innovation strategy encompasses project and portfolio selection. Otherwise it would not be possible to specify the product roadmap, which they consider a central component of this strategy.

The development process - Gating

Cooper, *et al.* (2000) considers a structured development process with well-defined phases separated by decision points - or gates – as a vital part of the overall portfolio management process. He writes:

"*Experience dictates that it is very difficult to implement portfolio management without an effective new product process in place*".

The gates – typically 5 – occur in accordance with the progress of the individual development projects from the idea stage to launch of the final product into the market. These gates are in particular important for portfolio management, because they form the integration points between each development project and the totality of projects during the portfolio review meetings. The purpose of the gate meetings is to evaluate the quality of the project with respect to business rationale, execution and the

further plan of action for the project. These aspects are not only evaluated in the start phase of a project, but continuously during the project at every gate with an increasingly stronger commitment to the project. Decisions made by the management team during a gate meeting may result in change of scope or re-allocation of resources for the project. Even though the utilization of a structured development process is vital to portfolio management, it is only a partial solution by itself since it only focuses on the individual projects. The concept of portfolio management implies consideration of the totality of projects, which is the purpose of the portfolio review process. The portfolio review process is briefly described in the following section.

The portfolio review process

Portfolio reviews are periodic meetings with participation of senior management held two to four times throughout the year to consider the entire set of development projects together. McDonough & Spital (2003) found that successful companies reviewed their portfolio quarterly, while less successful companies reviewed their portfolios semi-annually. They argue that more frequent reviews may improve performance by reducing the feedback cycle, reducing uncertainty about the projects more rapidly, and helping the team to make corrections or change direction before it is too late.

The purpose of the review is to consider the portfolio as an investment portfolio to assure that the projects as a whole supports and reinforce the business strategy, and hence the realization of the expected business results. It is rarely the purpose of the portfolio review meetings to perform major manipulations on the portfolio. Rather, the meetings serves as checkpoints where it is investigated whether the right projects are active (versus on hold), that the priorities are right, and that the resource allocation across the portfolio is consistent with the strategic priorities. If for instance a competitor launches a new product in a market which is essential for the company to dominate, it can be necessary to immediately start a project with a similar product in order to impede the competitor from gaining a strong position in the marketplace. Hence a review meeting may lead to minor changes in the portfolio, i.e. course corrections. Cooper*, et al.* (2001b) reports that in some companies the portfolio review meetings work as proactive decision meetings, where every individual project is examined meticulously. Other companies do only consider the totality of projects.

The strategy process vs. the review and Stage-Gate process

We observe how Cooper*, et al.* (1997b) decomposes the portfolio management process into three distinct decision processes, which work together and apparently occur in diverse time domains and at different strategic levels in the company as illustrated on Figure 15. The strategy process drives the review process and the stage-gate process by means of guidelines derived from the former. The guidelines, which he refer to as the *product innovation strategy* or *new product strategy*, specify what is "*inside*" and "*outside*" the company's product development focus. Cooper (2000) pinpoints four central components of the product innovation strategy;

Product innovation strategy

- Initially, measurable goals should be defined which explicates the role of product development within the company together with goals for the business's total product development efforts. The role of product development might be defined as its contribution to the business results, e.g. the percentage of the business sales in year 3 that will be derived from new products introduced in that three year period. The goals for the total product development effort can e.g. be defined as number of new product ideas to be considered annually.

- The second component is the definition of arenas of strategic focus. This might be markets, technologies, or product categories including priorities.

- The third component relates to resource deployment, i.e. how the company intends to allocate the resources across the arenas of strategic focus. Resources should in this context be perceived broad, e.g. R&D funds or people, marketing resources, capital resources etc.

- The final component focuses on the "plan of attack", i.e. how and when the company intends to approach each of the defined arenas. A fundamental element here is the product roadmap, which specifies the timing of each new product initiative in terms of its introduction into the market.

These guidelines are to be implemented through the review process and the stage-gate process. Here the portfolio or the individual project is compared with the various dimensions of the guidelines for consistency and coherence. According to Cooper's model of the portfolio management process on Figure 15 it appears that he assumes the interaction between the strategy process and the review and stage-gate process as an one-way interaction. That is, the arrows indicate that the outcome of the strategy process – the product innovation strategy - flows down into the two other processes, but not vice-versa.

Portfolio review vs. Stage-Gate process

The interplay between the portfolio review process and the stage-gate review can be compared with the cyclical process of controlling as outlined in section 3.2.5. The status or performance of the individual projects is measured against the pre-established criteria at the gate meetings during project execution. This might reveal the need for adjustments in the actual project. For example, the project team may be expanded with new members, deliverables may be changed, the timing of activities may be reprioritized or the project may be stopped.

Next, project status from all the active projects are reported to the portfolio review meeting (left arrow on Figure 15). Here the status of each of the projects is considered, new projects may be proposed and the consequences for the set of projects are evaluated. This perspective on the projects may disclose the need for modifications in the portfolio, which otherwise is difficult to perceive during gate meetings within the

individual projects. In other words; even though a project is progressing as planned, changes may be needed in the project due to circumstances outside the scope of the project in question. Consequently, it may be decided to shift resources between projects, change project priorities, start new projects or stop projects. These decisions are then reported to the projects in question for implementation (right arrow on Figure 15).

Gate / review dominates
Cooper, *et al.* (2000) found two fundamentally different approaches to the portfolio management process: either the gates or the portfolio review dominates. In the approach where the gates dominate the emphasis is on making good decisions within the individual projects during gate-meetings, where the project is subjected to an in-depth review. Hence decision making during a projects development cycle encompass prioritization and resource allocation at every gate-meeting, one project at a time. In this situation the portfolio review is only carried out once or twice yearly, and it constitutes merely a check to ensure that the gates are working well. Due to the extensive evaluation of projects during the gate meetings, the portfolio reviews may not result in too many decisions or significant corrective actions. Cooper reports that the "gates dominate" approach seems mostly to be utilized in larger companies within science-based industries and where projects are lengthy (e.g. the chemical process industry).

The second approach works somewhat opposite. It rests on the assumption that every project must compete against the others. Consequently, all projects are considered together 2-4 times a year. In this approach the purpose of the gate-meetings is to confirm that projects are executed as planned and that the business assumptions continuously are valid. Cooper reports that this approach may be convenient for faster-paced companies, such as software and electronics firms.

It is interesting to observe how Cooper and colleagues examines the phenomenon of portfolio management without recognizing the concept of product planning. This makes it difficult to distinguish the two processes from each other.

4.4.2 Product planning

Ulrich & Eppinger (2004) acknowledges the concept of product planning when they write:

"*Product planning is an activity that considers the portfolio of projects that an organization might pursue and determines what subset of these projects will be pursued over what time period.*"

The overall purpose of the product planning activity is to ensure that product development projects support the broader business strategy of the company. Ulrich & Eppinger regards product planning decisions as a part of the firm's strategic planning, and it generally involves the senior management of the organization.
Ulrich & Eppinger differentiate between product planning and portfolio management when they explain the latter as consisting of two central

activities within the product planning process as illustrated on Figure 16. They write:

"*First, multiple opportunities are prioritized and a set of promising projects is selected. Resources are allocated to these projects and they are scheduled.*

These planning activities focus on a portfolio of opportunities and potential projects and are sometimes referred to as portfolio management, aggregate product planning, product line planning or product management".

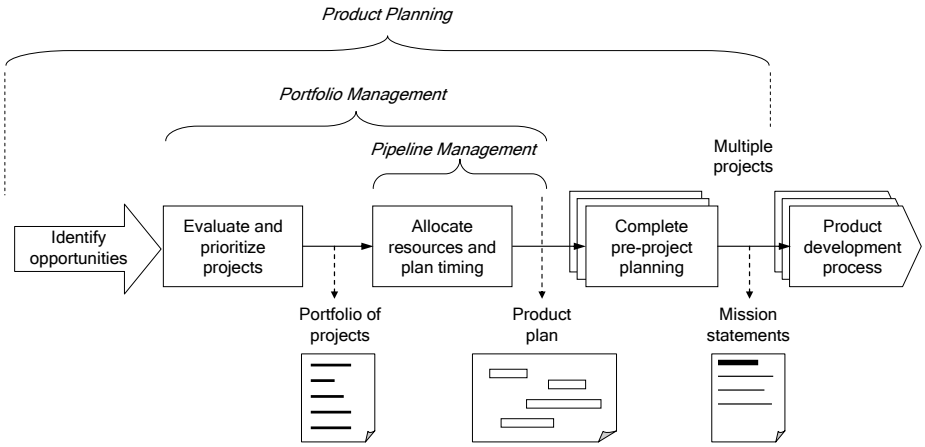


Figure 16. The product planning process modified after Ulrich & Eppinger (2004).

Ulrich & Eppinger stresses the iterative nature of the process, when they write:

"*Although we show the planning process as essentially linear, the activities of selecting promising projects and allocating resources are inherently iterative. The realities of schedules and budgets often force a reassessment of priorities and further refinement and culling of potential projects".*

Ulrich & Eppinger uses the term *product plan* about the output of the portfolio management process. It basically captures portfolio attributes like products to be developed, product types and their timing, i.e. product release time.

Bridges (1999) argues that almost every organization will flow through a similar thought process to build a portfolio of projects. She advocates that it is the methods and techniques employed that differ.

Periodic reviews

The product plan is not a static document. In order to reflect changes in the competitive environment, changes in technology, and information on the success of existing products they suggest the product plan should be updated on a periodic basis, perhaps quarterly or annually, as part of the

firm's strategic planning activity. The latter imply integration with the strategy process within a company.

Activities outside the portfolio management process
Ulrich & Eppinger (2004) regards the activity "opportunity identification" as preceding portfolio management. The activity is intended to deliver input, i.e. opportunities, to the portfolio management process. The portfolio management process is followed by a pre-project planning activity and the concrete product development process. Planning research and technology development activities is considered closely coupled, but outside the purview of the product planning process.

The theory of the product development process suggested by Andreasen & Hein (2000) has previously in section 3.3 been chosen as the scientific viewpoint of this research. It is interesting to observe how the term "portfolio management" is absent in their contribution. Instead they suggest a close integration of the product planning and product development process, when they write:

"Product planning forms a part of and works together with integrated product development".

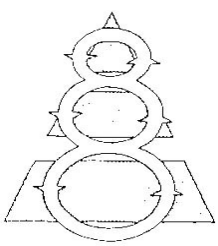
That is, during the execution of the product development projects there is an interaction between the product planning process and the individual projects. A closer look at the two processes reveals that several of the embedded activities are similar to those addressed by other authors under the label "portfolio management". The initiation and follow up of product development projects is one example. They write:

"*On the basis of the company's policy and preliminary marketing plans, decisions are made as to whether the project proposal should be started, what priority it should have, or whether it should be kept until later".*

Further, after a project has been approved, Andreasen & Hein (2000) argue that the role of management is to:

"… make the decision to start, and to monitor whether the group of current projects together appears, with a reasonable degree of probability, to be leading to the required commercial results".

The two quotes outline activities which can be described as core activities within portfolio management in accordance with Sommer (1998), who argues that portfolio management is an *ongoing process* that includes decision-making, prioritization, review, realignment, and reprioritization. Andreasen & Hein (2000) recognize that these activities together with the other activities inherent in product planning (see section 3.3.1) give rise to several sequences of management activities at different organizational levels, when they argue:



"These activities become part of the cement which must bind the various layers within the company together as a whole".

We observe how Andreasen & Hein consider the portfolio management task to be included in product planning – even though they do not explicitly define the portfolio management task. Since the product planning process is closely integrated with the product development process it seems that these two processes interact in deciding the portfolio of development projects.

4.4.3 Management process levels

Nelson, *et al.* (1997) enhances the perception of the portfolio management process. They introduce the concept of a management process hierarchy combined with an expanded process view of product development, which extend beyond the realization of ideas and their launch into the market.

The management pyramid

Nelson and colleagues argue that the product development process concept embodied in frameworks such as the stage-gate model suggested by Cooper (1990) is excellent for the execution of individual projects, but it is insufficient when it comes to managing the totality of projects. They write:

"*Decisions on which programs to continue are made at the review gates in the context of a single program with no clear way to compare benefits from program to program*".

In order to overcome these shortcomings they suggest that product development processes needs to be seen in a much broader perspective, which encompass the entire business planning. They suggest a *management pyramid* as a way of explicating and distinguishing between four management processes central to product development as illustrated on Figure 17. Firstly, they perceive project management as the basic set of practices, which is a prerequisite for implementing a development project. Second, they advocate that a formalized process model for product development projects is necessary in order to control the development activities. Next, they argue that the portfolio management process is crucial to allow the product development effort to respond to the complexities of managing multiple projects over time.

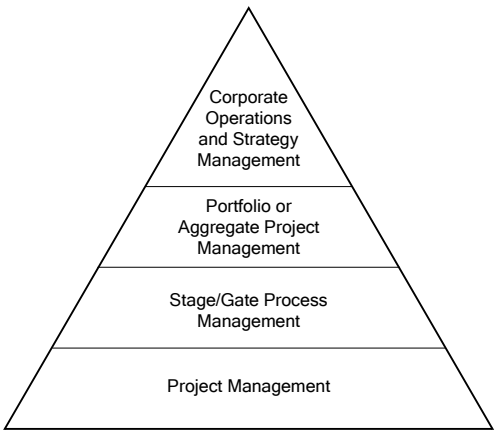


Figure 17. The Management Pyramid (Nelson, *et al* 1997).

Finally, the view provided by the portfolio management process enables the linking of the product development efforts to the company's strategies and objectives.

The expanded product development process
Nelson, *et al.* (1997) report that companies think in terms of an expanded process view of product development in order to realize holistic and integrated new products management. They write:

"*The expanded process begins not with an identifiable program or product concept but in the broader arena of strategic goal setting and opportunity identification, and it ends not with a successful product launch but with successful integration of new products into the ongoing business*".

They advocate that the expanded product development includes three sequential sub-processes. Firstly, they identify an innovation sub-process, which according to Nelson and colleagues is:

"*… characterized by openness and the nurturing of new ideas and opportunities*".

This sub-process is followed by the development sub-process where the various ideas are being realized as products and launched in the marketplace by means of a systematic and formalized development process. Finally, they denominate the third sub-process as a "market value generation sub-process", which they describe as:

"*…characterized by order and integration of new products into the existing product line. It includes post-launch reviews and the planning of product ramp up and decline (product life cycle planning)*".

Systematic reviews
These three sub processes are tied together by systematic reviews which allow product development decision makers to address issues dealing with both individual programs and with the portfolio of programs:

- Strategic portfolio management reviews make decisions about the selection and resourcing of the portfolio of products. These reviews are held in the context of the corporations overall planning calendar.

- Operational reviews support ongoing decision making about projects in the development pipeline. These reviews are held regularly by the functions responsible for this aspect of the development process.

- Stage-gate reviews are focused on individual programs, and are held as appropriate in terms of the programs timetable and milestones.

We observe how Nelson, *et al.* (1997) points to the importance of making decision regarding the development portfolio in the context of strategic goals, current development projects and products already existing in the

market. Additionally, they distinguish between two types of portfolio reviews, namely strategic and operational portfolio reviews.

The concept of positioning the portfolio management process within a hierarchy of management processes (Figure 18) is also recognized by the European Industrial Research Management Association (EIRMA 2002).

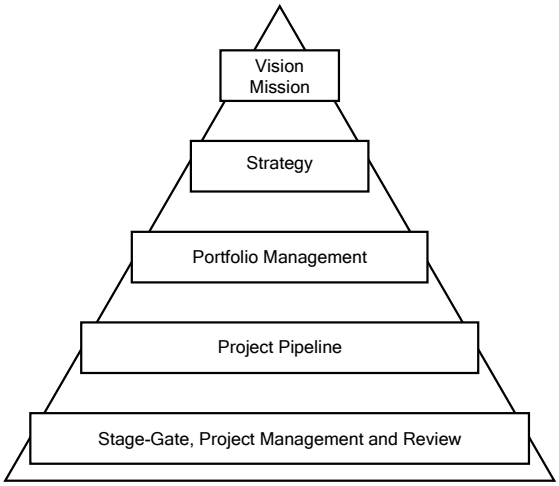


Figure 18. The Context for Portfolio Management (EIRMA 2002).

In line with Nelson, *et al.* (1997) EIRMA recognize that portfolio management can be seen as a link between corporate strategy and the management of a project pipeline.

4.4.4 Portfolio planning and management

Patterson (2005) clearly distinguishes between portfolio planning and portfolio management. He considers portfolio planning as a strategic process which concerns the business leadership team, whereas the latter includes portfolio assessment, resource management and portfolio review, which he considers as tactical tasks. These four portfolio processes are explicated inside of the dashed boundaries in his proposal for a framework shown on Figure 19.

Portfolio planning process

According to Patterson the portfolio planning process includes the creation of a strategic plan for new products and technologies in accordance with the firms overall business strategy. The portfolio planning process is based upon gathered and analyzed internal and external information related to markets and technologies of interest to the firm. Roadmaps for products and technologies are among the important outputs from this process. Patterson suggests that the resulting maps may be subjected to a periodic review by top management as often as once a quarter, or only once a fiscal year.

Portfolio management process

Patterson (2005) perceives the portfolio management process as consisting of portfolio assessment, resource management, periodic project reviews and project gate reviews. Portfolio assessment should be done on

a frequent, perhaps monthly, basis. Here the management considers each project in the portfolio. The purpose is to ensure that the portfolio is likely to realize the anticipated financial returns while moving the company along the desired strategic path. Furthermore, the purpose is to make certain that the actual portfolio reflect the best possible use of available resources in view of changing conditions.

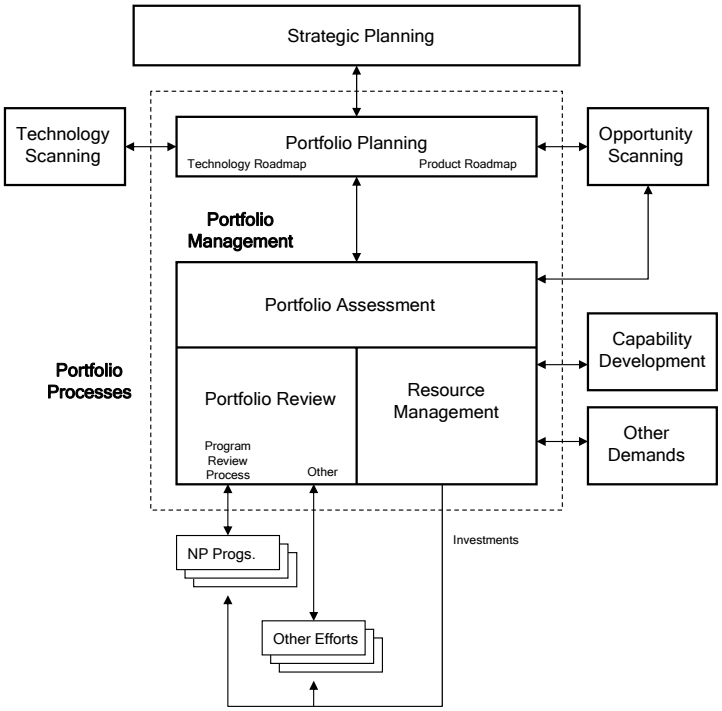


Figure 19. A Framework for Portfolio Planning & Management (Patterson 2005).

Patterson suggests that it is necessary to complement the portfolio assessment process with a portfolio review process which further includes periodic project reviews. The purpose of this compared to the portfolio assessment process, however, seems unclear.

The objective of resource management is to make sure that available resources are effectively applied to achieve the goals of the portfolio. Since many functional departments within the company contribute with resources to product development the responsibility for proper resource allocation reside with the managers for the departments in question. Hence the responsibility within the portfolio management team is merely of an overseeing character.

Project gate reviews includes evaluation of the individual projects performance. It is carried out in accordance with the progress of the project.

Activities outside the portfolio processes

Patterson's framework recognizes that the four portfolio processes are distinct from, but closely coupled with other business processes like strategic planning, capability development, technology scanning etc.

4.4.5 Conclusion

Inconsistent use of terms

From the excursion into the literature we observe how different authors use different terminology about the process aspect of portfolio management. For example, it is interesting to observe how the term "portfolio management" is absent in the contribution from Andreasen & Hein (2000). Instead they adhere to the concept of "product planning". The latter concept is not recognized by Cooper*, et al.* (1997b), who solely use the term "portfolio management" in their work. Ulrich & Eppinger (2004), however, use both terms, and suggest that portfolio management is an activity inherent in product planning.

One explanation of the inconsistent uses of the terms may be attributed to the time of introduction for the various contributions. They span thirty years, and the usage of language may have changed during that period. It seems, however, that the different uses of the terms are basically pointing to the same core phenomenon, and there seems to be consistency regarding the following matters:

A link between strategy and product development
The purpose of the portfolio management process is to make the strategy operational, i.e. to establish and continuously maintain a *linkage* between strategy and product development actions across the company. Hence it is imperious that criteria for portfolio selection are derived from the business strategy.

An ongoing process
Portfolio management is an *ongoing* process, i.e. it is a task which never can be considered completed.

A dynamic process
Portfolio management is a *dynamic* process, i.e. the frequency and type of the embedded activities should ideally respond to the changing company external and internal conditions of the business environment. The purpose is to ensure that the portfolio to any given time is adapted to reflect the best use of available resources.

A multi-level controlling process
It seems that the portfolio management process is comprised by processes with management activities at both strategic and tactical level which feed each other in order to integrate different organizational levels in the company. Hence the overall process may be characterized as a multi-level *controlling* process (see also 3.2.5).

Strategic level – preparation focus

Planning process

The process on strategic level can be characterized as a planning process, since the purpose is to *prepare* a plan, which explicates the totality of the products the company intends to develop in the future. Hence the process includes selection of product development projects to execute, their timing and top level resource allocation. The resulting product plan together with the detailed plans for each project can be perceived as the standard of performance as well as a central process interface between

business strategy and product development. This standard of performance is dynamic, since the plans continuously are adjusted and updated to reflect the changing business conditions.

The nature of this process is highly strategic since it entails interpretation of the business strategy and business context with respect to the product development activities.

Tactical level – execution focus
Whereas the previous process aims at the concretization of the business strategy into a plan for the products to be developed, the two processes on tactical level are centered on the *realization* of the prepared plan.

Product development process

The product development process is considered a vital process since it is the vehicle for realizing the individual products in the product plan. The control of the project occurs in the projects key points, which may be regarded as a central process interface. Here performance is reported and compared to the (dynamic) standard of performance and subsequently corrective actions may be devised.

Review process

Since the product development process only focuses on the individual projects, it is only a partial solution to the management of the portfolio by itself. As a respond to this inadequacy a *review process* is suggested in the literature. These periodic reviews support ongoing decision making about the totality of projects in the portfolio.

Different time domains
The three identified processes occur in different time domains. The process on strategic level is in sync with the company's overall planning calendar, which typically follows the fiscal year. The time domain for the product development process on the tactical level is defined by the key point sequence embedded in each individual project. The time domain for the review process seems to be in sync with the dynamics of the business environment. In order to adjust the portfolio to reflect changes in the competitive environment, technology etc. reviews may be done quarterly or even more frequently.

Support processes
Updated knowledge about the company's external and internal business environment is a prerequisite for decision making in portfolio management. The three identified primary portfolio processes are distinct from, but closely coupled with other business processes, which serve the purpose of providing a steady stream of information regarding the market, competitors, technology and opportunities.

Implications for this research
The literature study reflects the richness, diversity and relevance of portfolio management. The inconsistent use of terms, however, indicates a comparative conceptual weakness in terms of the lack of a common theoretical base to which all contributions may be referred.

Such a base is assumed important, because portfolio management apparently is carried out by means of processes, which engage people and other resources in specific activities across the company. It is thus necessary to have a clear view of the process architecture. That is, what these processes are, and how they span strategic and tactical levels in a company as well as their linkage.

This research addresses this observed weakness in chapter 5 by proposing a reference model for portfolio management, which includes the identified aspects of consistency.

4.5 Organizational roles and responsibilities

The previous sections indicate that portfolio management is a complex and multifaceted business process. Decision making and other tasks need to be handled at different organizational levels. In order to do this in a professional manner, it is a prerequisite that various roles and responsibilities are assigned to people across the organization in the company. The purpose of this section is to investigate contributions in the literature related to this matter.

Structure of study

In section 4.4 we found that the portfolio management process is comprised by three core processes, namely a planning process, a review process and the product development process. The identification of organizational roles and responsibilities related to the processes are structured according to these processes. Next, the attention is directed toward the involvement of staff from several functional domains, since this appears to be imperative in order to make proper portfolio decisions. After that, the study focuses on responsibilities related to process ownership in portfolio management. A conclusion is presented in the last section.

4.5.1 Product development process

Andreasen & Hein (2000) argue that the responsibility for the technical aspects and business aspects of a project needs to be clearly delegated in order to manage a project properly. Responsibility for technical aspects and project progress should reside with a technical project manager whereas responsibility for the product idea and business optimization should be delegated to a product manager.

Technical responsibility

Business responsibility

The idea of assigning business responsibility in product development projects with a single person has originally been credited to the company Procter & Gamble. Kotler (1997) reports:

"*In 1927 a new company soap, Camay, was not doing well, and one of the young executives, was assigned to give his exclusive attention to developing and promoting this product. He did it successfully, and the company soon added other product managers*".

Andreasen & Hein (2000) suggests that project leader responsibilities includes several tasks: participate in evaluation/choice of project

proposals, participate in formulation of project, perform project, control project, lead project, educate personnel, and participate in control of product development (external control).

Three roles at a higher organizational level

In order for the product development process to be successful, Watson (2005) advocates that it is particular central to assign three ownership roles for the process, 1) a process champion who can promote the product development process internally as a vehicle for product innovation, 2) a process sponsor who is ready to support the process with the needed resources, and 3) a process manager who is the "keeper" and expert at all aspects of the NPD process. The latter role is particular interesting from a portfolio management perspective, since it also requires an understanding of product development at the portfolio level.

Key point evaluations

In accordance with the progress of the individual development projects from the idea stage to launch of the final product into the market the project is subjected to key point or "gate" evaluations. The evaluation is carried out by a management group, which according to Watson (2005) typically comprises functional managers, with strong knowledge of the various complexities involved in getting new products into the marketplace. The group's role is to evaluate deliverables from project teams, i.e. evaluate the quality of the project with respect to business rationale, execution and the further plan of action for the project, and make the critical decisions regarding the project's further destiny.

Gatekeepers

In order to enable the enforcement of the required decisions Cooper (2001) devises the following "rules of thumb" for the choice of group members (or "gatekeepers"):

- The gatekeepers at any gate must have the authority to approve the resources required for the next stage.
- The gatekeepers must represent different functional areas to the extent these functions contribute to the project in question.
- At gates involving high spending levels (substantial resource and financial commitment) the group should include more senior managers.
- There should be some continuity of gatekeepers from gate to gate.

Depending on the project size the group size may vary, i.e. if only minor resources are involved the decision authority may be delegated to subordinates.

4.5.2 Review process

In section 4.4 we learned that the purpose of periodic reviews is to assure that the aggregate set of projects support and reinforce the business strategy. According to Cooper, *et al.* (2001b) the people who review the portfolio typically are the same people who participate in the more

Portfolio committee

important gates in the product development process, i.e. gates where decisions imply substantial resource allocation. The portfolio review group is often referred to as a *portfolio* or *product committee*.

4.5.3 Planning process

The purpose of the planning process is to prepare a plan which explicates the totality of the products the company intends to develop in the future as identified in section 4.4. The process is highly strategic in its nature. Cooper, *et al.* (1997b) and Patterson (2005) argue that since strategy development is the job of the senior management of the business, they should own the creation and execution of this process. This is also how senior people first become engaged in the project selection and portfolio management processes. The overall responsibility includes determination of the company's strategic direction explicated by means of product and technology roadmaps. Wheelwright & Clark (1992a) write;

Senior management ownership

"It is not appropriate to give one department – say, engineering or marketing – sole responsibility for initiating all projects because it is usually not in a position to determine every project's strategic worth."

In order to establish a proper foundation for the creation of these roadmaps the process needs to gather and analyze internal and external information related to markets and technologies of interest to the firm. This is however, an overwhelming task for the senior management to cope with. In order to overcome this hurdle Patterson (2005) suggests:

"Ideally, all members of the firm's business leadership team, from the CEO on down to first line managers, will take part in gathering and processing this information".

Different perspectives

Sharpe & Keelin (1998) also recognizes the need for involving personnel from different organizational levels in the planning process in order to obtain different and valuable perspectives on issues. They report how the company SmithKline Beecham deploys a three phase dialogue between the project teams and the company's decision makers in order to make better resource allocations. The process focuses on the inputs to the resource-allocation decisions and the role of the organization in preparing those inputs.

Resource allocation responsibility

With regard to the concrete resource allocation decisions McDonough & Spital (2003) found that companies with more successful portfolios used a single senior manager to allocate resources. Their finding may reflect the fact that senior managers typically possess a broader perspective than the portfolio managers about issues that affect allocation decisions. This is in line with the reasoning of Patterson (2005), who writes:

"The manager of each functional department involved in new product development related activity should be able to estimate the resource impact of a proposed new project and decide whether it can be supported".

When the product and technology roadmap with resource allocations are prepared Patterson suggests that the portfolio management team (see 4.5.5) should review and approve the plans.

4.5.4 Inter-functional involvement

A product development project is typically a highly complex task involving contributions from several functional domains. Hence it constitutes a challenge for one individual to evaluate all aspects of a project in order to appraise the entirety of the project. The involvement of staff from various functional departments such as marketing, production, R&D, sales etc. is widely recognized as a crucial means to overcome this challenge (Andreasen & Hein 2000). The challenge, however, intensifies on portfolio level since decision-making encompass not one, but the aggregate set of projects. This indicates that it is imperative that decision-making regarding the portfolio is founded upon debate between staff from relevant functional areas - irrespective of whether the decision-making takes place within the product development process, review process or planning process.

Functional champions

McDonough & Spital (2003) found that the emergence of a "functional champion" can inhibit inter-functional integration in decision-making regarding resource allocation at both project and portfolio level. If decision-making at portfolio level is dominated by individuals representing one specific functional area like e.g. R&D, this may encourage technical aspects to dominate evaluation criteria at the expense of information regarding other central aspects like the customer, the market or the competitive dynamics. According to Perks & Greenland (2005) such functional champions may impede the decision-making process. They write:

"- the domination of single functions, acting as functional champions, can induce bias and functional resentment, leading to the exclusion of appropriate functional involvement in resource allocation decision-making, impacting the whole portfolio".

Multi-functional debate

Their empirical study indicates that companies seek to dilute potential functional biases in decision-making by encouraging multi-functional debate through attendance at regular committee meetings (see also 4.5.2).

Dawidson (2006) further emphasizes the importance of obtaining different and valuable perspectives on issues through inter-functional participation in portfolio management decision-making when he concludes that:

"Managers representing all areas of knowledge relevant for the distinct types of projects included must be involved in managing the different parts of the project portfolio".

The nature of the decision making process

Biased decision making

Even though all the "right" people participate in the decision making process this is not *per se* any guarantee for proper decision making. Garvin & Roberto (2001) argue that decision making always to some

extent is based on the *advocacy-approach*, i.e. decision making biased by politics and "gut feelings". The problem, however, is if this get out of hand. Bonabeau (2003) argues that intuition (i.e. "gut feelings") is unsuitable for assessing the complex and dynamic context of product development. He writes:

"It's not valuable if you're an executive faced with a pressing decision about investing millions in a new product for a rapidly changing market".

Furthermore, in such situations where politics, intuition and competition dominate, decisions may already have been negotiated "behind the scenes" before the meeting.

This is in line with Christiansen & Varnes (2006). They found that decision makers at gate meetings in product development projects do not apply the rational decision making model which is prescribed in the structured product development process model. Furthermore, the different levels of information in the various projects do not seem to make any difference for the debates that takes place at the meetings.

Thus the broad involvement of people during the meetings appears to be merely of a formalistic nature. Firstly, this may provide a breeding ground for flawed decision making according to Hammond*, et al.* (1998) since fundamental assumptions underlying the decisions are left unchallenged**.** Second, this may subsequently impede the implementation of the decisions in question, since people do not feel their point of view sincerely considered in the process – they simply lose the motivation according to Birkinshaw (2001) in Lovén & Krus (2006).

Inquiry approach

In order to avoid this situation Garvin & Roberto (2001) suggest that decision-making should be based on the *inquiry-approach*, which encourages fair co-operation among the participants in order to identify the "best" decisions. They advocate that inquiry-based decision making is characterized by three virtues. Firstly, cognitive conflict, i.e. creative and constructive disagreement about ideas and assumptions, is necessary (as opposed to affective conflict involving "personal friction"). Second, it is central that all participants experience that their statements are considered in the process. Finally, timely closure of the decision-making process is important in order to ensure that all alternative decisions have been considered properly.

Social operating mechanism

Charan (2001) emphasizes the value of such a process, which he regards as a *social operating mechanism*. He writes:

"Because such dialogue is a process of intellectual inquiry rather than of advocacy, a search for truth rather than a contest, people feel emotionally committed to the outcome".

He even argues that the decisive dialogues and robust operating mechanisms and their links to feedback and follow-through comprises a competitive advantage for the company since they cannot be easily duplicated.

Dimensions of quality

It is interesting to observe how the quality in portfolio management decision-making is composed by at least two fundamental dimensions, namely the timely involvement of people with the necessary skills and insights, and the nature of the decision-making process. The latter is a prerequisite to reap the benefits of the former.

4.5.5 Process management

According to Cooper, *et al.* (2001b) the portfolio management process is destined to fail unless senior management "buy-in" and commit to the concept of portfolio management. They argue that it is crucial that a person – a portfolio or process manager - is charged with the responsibility of making the portfolio management process happen.

Process ownership

Patterson further emphasizes the need for process ownership when he advocates that company executives should define an entire team responsible for the overall process of portfolio planning and management. This portfolio management team should assume overall responsibility for the effectiveness of the integrated process and the results it produces. He writes:

"If any part of the process performs short of expectations, this group should detect the problem and take corrective action".

Furthermore, Patterson (2005) advocates that the portfolio management team also should own the *efficacy* of the portfolio, which involves the portfolio's, 1) expected financial impact, 2) implied strategic direction, 3) balance, and 4) expected competitive impact. Finally, the team should also evaluate candidate projects in order to control the contents of the portfolio.

Process analyst

In special cases where a company adheres to a process which devours large amounts of quantitative in-process and output data then a process analyst may be needed according to Watson (2005). This person's job is to generate the necessary process metrics and guide the flow of process information.

It is evident that Patterson (2005) associates the portfolio management team with considerable responsibilities and a variety of tasks to be solved. An interesting aspect, however, is that he does not assume all tasks to be solved by the team, when he writes:

"The team should delegate the tasks of developing and carrying out the various parts of portfolio planning and management".

Hence the portfolio management team has the authority to delegate tasks inherent in the process across the organization.

A diverse picture

Based on an extensive study of portfolio management practices in European companies EIRMA (2002) found a more diverse picture regarding allocation of the responsibility for the overall portfolio management process. They report that the ultimate accountability remains with the company's Top Management or the Board. In practice, however,

responsibilities are delegated to various organizational levels. Their findings indicate that the responsibilities can lie with:

- The CEO.
- The top management of a business unit.
- The top management of R&D.
- A specific "project office".
- Strategic planning units.
- A programme / portfolio development group.
- A project planning group.

Furthermore, EIRMA reports:

"- many companies have established project offices for collecting and distributing project information in a common format. Portfolio planning groups are found less widely".

Project office vs. portfolio mgt. team

This is in contrast to Patterson's recommendations of establishing a Portfolio Management Team (Patterson 2005). The interesting question, however, is whether the term "*project office*" and "*portfolio management team*" basically are addressing the same core concept. According to O'Connor (2004) this seems to be the case, when he writes:

"Two worlds are converging in portfolio and pipeline management: the world of project management and the world of new product development".

He argues that project management has evolved from an orientation towards excellence in project execution, augmented this with an orientation toward excellence in multi-project execution, and then added project selection and mix management. New product development, on the other hand, started with project selection, added project mix management, and then supplemented this with multiple project execution. Hence the difference between the two is indistinguishable from a distance.

NPD projects vs. non-NPD projects

A central dissimilarity, however, is whether non-NPD projects are included as objects of manipulation. O'Connor (2004) suggests that a project management office would emphasize the inclusion of non-NPD projects into PPM, whereas an NPD orientation may not.

The findings from Ragnarsdóttir (2006) support this perception. She reports how the company Össur hf. has developed a "*project office*" in order to facilitate parallel project management. She writes:

"The project office uses strategic procedures to prioritize and select a project portfolio by optimizing the portfolio relative to parameters and constraints that reflect the corporate objectives".

It is evident how the term "*project office*" is utilized in the context of managing (i.e. prioritizing, selection and optimizing) a portfolio

consisting of NPD-projects as well as non-NPD projects such as production projects.

Same core concept

Hence it seems that the term "*project office*" and "*portfolio management team*" basically are addressing the same core concept. An interesting distinction is whether a phase-gate process is deployed as the sole vehicle for project execution, since this according to Schmidt (2005) implies a certain discipline and rules in decision making during key-point evaluations.

4.5.6 Conclusion

The literature study clearly indicates that portfolio management is a task which requires the involvement of many people. In order to proactively manage the product development portfolio many sub-tasks need to be represented. In an ideal world it seems that several related roles and responsibilities need to be delegate in the company depending on the size and nature of the company, product development portfolio and business dynamics. In reality, however, many of these roles and responsibilities may reside with just a few individuals in the company.

Contributions in the literature indicate that at least the following aspects are central to consider when roles and responsibilities related to portfolio management are to be delegated in the company:

Overall portfolio responsibility
The overall responsibility for the portfolio resides with the CEO, and ultimately with the board of the company. They must encourage, support and require the implementation of portfolio management while firmly providing resources to the purpose.

Process responsibility
A person (e.g. a portfolio manager) or a group of persons (an organizational unit) should be provided with the responsibility for the proper functioning and maintenance of the overall portfolio management process. This includes process facilitation and identification and delegation of tasks such as retrieving internal and external information associated with projects, technologies, market, customers and competitors to relevant personnel in order to establish a sound foundation for decision-making regarding the portfolio. The responsibility also includes the delegation of the implementation of agreed decisions. Furthermore, the responsibility for the efficacy of the portfolio may also reside with this person or group.

Inter-functional involvement
Irrespective of where decision making regarding the portfolio occurs (i.e. within the product development process, review process or planning process) it seems to be imperative that decision-making is founded upon debate between staff from relevant functional areas and organizational levels.

Strategic alignment and resource commitment

The senior management should ensure that the business strategy is reflected in the portfolio, and subsequently commit the needed resources

to the execution of the projects. If a decision regarding the initiation or continuation of a project does not imply significant resource consumption the decision authority may be allocated with lower level managers, e.g. line managers or project managers.

Specialist' perspective on projects

Staff from the various functional domains such as marketing, production, R&D, and sales should contribute with their specialist knowledge related to the individual projects in order to support a proper appraisal of the projects.

Fair decision-making process

A group consisting of representatives from various functional domains represents a substantial knowledge resource which is a prerequisite for "good" decision-making. In order to realize this, however, it is imperative that politics, "gut feelings" and personal friction do not dominate the decision-making process. Hence it seems that the decision-making process should encourage intellectual inquiry and fair co-operation among the participants in order to identify and take the "good" and unbiased decisions. Additionally, this approach contributes to unite the group of participants, which subsequently may support the implementation of the decisions.

Implications for this research

Due to the pervasive nature of portfolio management, the activity involves many people across the company. Since this research contributes with supporting tools for portfolio management in chapter 7 it is asserted to be essential that we understand and are aware of these organizational aspects of portfolio management. Thus it is regarded improper to develop and propose tools for portfolio management without also taking the identified aspects into account.

4.6 Supporting tools and methods

A wealth of tools and methods for managing the portfolio has been developed and proposed by academics and practitioners during the last decades. This fact indicates that portfolio management is considered a problem of significant importance. The aim of this section is not to provide an exhaustive review of literature within the field. The intent is merely to investigate contributions to major families of tools and methods for portfolio management frequently used and referred to in literature, and thus available for industry professionals. This knowledge is regarded as a central prerequisite for introducing new contributions within the field of portfolio management.

Several typologies for structuring tools and methods for portfolio management have been suggested in the literature (Baker & Freeland 1975), (Hall & Nauda 1990), (Meredith & Mantel 1999), (Martino 1995), (Archer & Ghasemzadeh 1996), (Cooper, *et al*. 1997a), but no single typology seems to have gained foothold among academics.

The structure of this investigation resembles the typology suggested by Fleming, *et al.* (2005). Their typology is interesting since they clearly distinguish between tools for evaluation and selection of individual

projects and tools for evaluation and selection of the aggregate set of projects, i.e. the portfolio. The typology has been slightly modified for usage in this investigation. Inspired by the typology suggested by Meredith & Mantel (1999), a supplementary class has been added. This class is designated "non-structured approaches", and concerns approaches to portfolio management which is not supported by formal tools. Hence the virtue of this class is that it accommodates and explicates the existence of more or less irrational evaluation and selection approaches. In sum, the typology used for the study is comprised by four main classes of tools and methods.

Structure of study

To begin with the study focuses on project evaluation and selection models. This entails economic value models and relative value models. The latter is used for providing intangible measures of project value. Next, the attention is directed towards portfolio selection models, which includes strategic frameworks, mathematical programming models, roadmapping, and portfolio diagrams. After that, the study focuses on procedural approaches, which offers procedures for portfolio selection. Subsequently, we look at non-structured approaches for portfolio management, which does not necessarily presume well structured and rational decision making. As a final point, a conclusion is derived in the last section.

4.6.1 Project evaluation models

Economic value models

Economic value models are perhaps the most popular tools for project evaluation. They use profitability as a central criterion for project selection. Since economic metrics are widely accepted as the "language of business" this approach to selection may particularly appeal to the senior management's mindset. In general, the economic value models are relatively simple to use.

Assumptions

The concept assumes we will follow a predetermined plan, regardless of how events unfold. That is, all decisions are made in the beginning without the ability to change and develop over time. Next, Smith & Barker (1999) suggests that the discounted cash flow concept rests on the assumption that it is uncomplicated to trace cost and revenue back to the investment decision. Finally, the discounted cash flow concept assumes that the investment will provide an ongoing revenue stream according to Smith & Barker (1999).

Paradoxically, these assumptions are only of limited validity for product development, which often is characterized by being highly dynamic and uncertain (Cooper, *et al*. 2000). One way to compensate for some of these shortcomings is to factor *risk* in the calculations. In the following sub-sections economic value models are investigated in sequence according to their ability to factor in risk.

Basic cost-benefit models

Net Present Value (NPV), Internal Rate of Return (IRR), cash flow payback and the Productivity Index (PI) are among the common measures used to estimate a project's potential financial contribution to a company.

Net present value

The *NPV* model compares future returns with current expenditures, and it recognizes the value of time by factoring in a discount rate for the investment in a project. In other words, it recognizes that money received today is more valuable than money received in the future.

$$\text{NPV (project)} = A_0 + \sum_{t=1}^{n} \frac{F_t}{(1+k)^t}$$

F_t = the net cash flow in the period

k = the required rate of return

A_0 = initial cash investment (outflow, thus negative)

n = years - total time period

Figure 20. The Net Present Value model factor in the value of time (Martino 1995).

The model assumes that the project in question will be successful, and it utilizes the associated cost and revenue. Since the model factor in the value of time the use of it may encourage the management to tend to select short-term projects with a short payback period at the expense of long-term and strategic important projects according to Cooper & Edgett (2003).

Internal rate of return

The *IRR* model is used for comparing alternative investments in terms of the rate of return on the investment. A potentially attractive project is characterized by a high IRR value. The model enables another approach to economical appraisal of projects. By deciding the minimum return on the invested capital the management can accept, it is possible to iteratively calculate the minimum (accumulated) cash flow needed in order to fulfill the required internal rate of return.

Payback model

The *payback* model is perhaps the most basic approach since it addresses the estimation of the point in time when the project investment is counterbalanced by the cash flow, i.e. when the net cash flow becomes positive, according to Meredith & Mantel (1999).

Productivity index

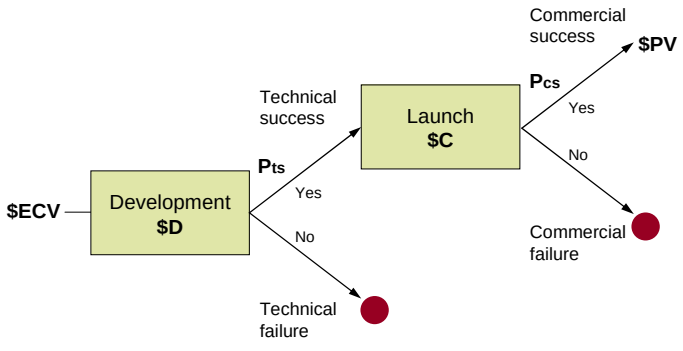
The *productivity index* is also known as the benefit-cost ratio according to Smith & Barker (1999). It comprises the ratio between the NPV of the cost and the NPV of the revenue of a project. A ratio higher the 1 indicates that a project is potential acceptable. Whereas PI is intended to be used for evaluation of new projects a variant addresses the need for evaluation of projects already underway. Cooper, *et al.* (2001b) denotes this variant as the "bang-for-bucks" index which consists of the ratio between the NPV and the total resources remaining to be spent on the project. Since the index focuses on the *remaining* costs of a project it recognizes the concept of *sunk costs*, i.e. resources already spent, which is

central to consider in investment decision making in order to avoid sending "good" money after "bad" money, according to Hammond, *et al.* (1998). Smith & Barker argues that it is necessary to exercise caution when the productivity index is used for comparison of projects. Since the index represents a relative number the extent of the project is disregarded. This is inexpedient because a good project costing $20 mill. often is more attractive than a better project costing $½ mill.

Expected commercial value

The models looked at so far do not accommodate the uncertainty associated with product development. Cooper, *et al.* (1997a) found a particular model – the Expected Commercial Value (ECV) model - utilized in industrial practice which incorporates considerations regarding this aspect.

The model illustrated in Figure 21 acknowledges that a successful technical development phase followed by a successful commercialization phase is a precondition in order to proclaim a product development project as successful.



ECV = [(PV * Pcs – C) * Pts] - D

ECV = Expected commercial value of the project
PV = the present value of the cash flow after launch – the income stream
Pcs = the probability of commercial success (from 0 to 1.0)
C = commercialization or launch costs remaining to be spent on the project
Pts = the probability of technical success
D = development costs remaining to be spent

Figure 21. The expected commercial value model is an attempt to include considerations regarding the uncertain nature of product development (Cooper, *et al*. 1997a).

Decision tree models

The decision tree model is useful in situations where a decision maker is confronted with a sequence of choices. Each choice may result in one or more consequence which is weighted by the probability of occurrence according to Martino (1995). The series of choices and consequences can be illustrated as a "decision tree" as shown on Figure 22. The starting point of the tree is the initial decision (the "root"), which is further decomposed into consequences and subsequent decisions. When the decision tree has been developed the next step is to calculate the highest expected value from the series of choices. The decision tree model relies on the NPV model for calculating the value of each potential outcome. The model acknowledges that an investment in a project may be pursued

Gradual investments

gradually in accordance with the progress of the project, and that a choice may result in different outcomes. This is a strong point for applying it to product development projects since the underlying process model resembles such a pattern.

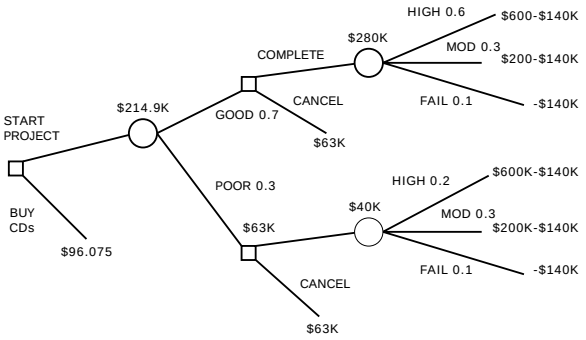


Figure 22. The decision tree model decomposes a series of choices into consequences with chances (Martino 1995).

In order to use this technique it is necessary to know the possible consequences and the chances of each when the initial decision is made. In an ideal world this may be straightforward. In reality, however, it may be quite challenging to determine the chances of each potential outcome.

Monte Carlo simulation

Recognizing uncertainty

Monte Carlo simulation is a stochastic technique, which can be used to estimate a project's value. Whereas the previous models assume the input parameters to be point estimates the Monte Carlo technique recognizes the uncertainty associated with each parameter. Hence a probability distribution is assigned to the input parameters. Next, multiple scenarios of the project's possible value is calculated based on randomly chosen input parameters and their probability distribution according to Mun (2002). Together these scenarios give a range of possible project values, some of which are more likely to occur than others. The former is considered the approximate value of the project. Since numerous scenarios and hence several iterations are needed (e.g. 10.000 - the more the better) the technique is highly computer intensive.

Real options

The value of options

The real options method differs strongly from the models based on the concept of discounted cash flow. It acknowledges that a company's investments typically are multi-staged, i.e. projects are seldom funded in one step. Furthermore, it recognizes the value of options, i.e. the fact that the decision maker can choose to postpone a decision or simply do nothing. Mun (2002) argues:

"Traditional approaches assume a static decision-making ability, while real options assume a dynamic series of future decisions where management has the flexibility to adapt given changes in the business environment".

The method enables the financial justification and hence the selection of projects of a highly strategic nature, whereas the traditional methods

based on discounted cash flow will seriously underestimate the value of such projects.

This implies that even though a project may contribute with little, none or even negative cash flow it may be highly valuable to the company because of the potential strategic positioning it represents. The uncertainty associated with the payoff of the project will often be reduced over time as the understanding of the situation increases. Hence the management can make the decision to either further develop the technology if the potential payoff exceeds the cost or cancel its development if the opposite seems to be true. The point is that this *option* represents a value to the company, which the traditional valuation models neglects. Putten & MacMillan (2004) emphasizes that option valuations only make sense when applied to projects that can be terminated early at low cost if things do not go well.

Limited use

Real options are a relatively new phenomenon. Mun (2002) reports that the concept only started to receive corporate attention in the early 1990's. Though it seems intellectually appealing management has been reluctant to adopt the method according to Putten & MacMillan (2004). This might be because the calculation of the real options value is complex and involves sophisticated mathematics.

Relative value models

The models investigated in the previous sections have in common that they aim at valuating projects solely in terms of their economic value.

Value more than economical value

Economic value, however, is just one aspect of the value a project may contribute with to a company. Aspects related to strategic fit, leverage and competitive advantage may also constitute relevant evaluation criteria during project ranking despite the fact that they are not easy to quantify. Relative value models such as *comparative models* and *scoring models* aim at providing such intangible measures of project value. The former is used to compare projects mutually, and the latter compare projects against fixed scales. Martino (1995) argues that none of these models can help to determine whether any of the projects under consideration are really excellent projects. Thus there is an inherent risk that we may be comparing and choosing among sub-standard projects. Furthermore, depending on the amount of projects and criteria, the methods can be highly time-consuming.

Comparative models

A group of projects can be ranked relatively by means of *pairwise comparison.* By comparing projects in pairs a group of decision makers can judge which of each pair is preferred. All projects are ultimately compared which each other on one or more criteria. The criteria may be adjusted with weights in order to factor in their importance according to Martino (1995). Brenner (1994) suggest that the method allows for better understanding and discussion in the group of decision makers, since they only need to deal with two projects at a time. Furthermore, the systematic approach helps people to think more clearly and succinctly about each criterion.

Q-Sort

Q-sort is a method for prioritization of projects in rounds. It is regarded as one of the most uncomplicated methods. According to Cooper, *et al.* (2001b) users claim that it is one of the simplest and most effective methods for rank-ordering a set of new product proposals. The method requires the active participation of each member in the decision making group. First, each project is briefly described on a card. Thus the deck of cards comprises the totality of projects to be rank ordered. Next, each group member receives a deck of cards, which they individually should sort into piles in three rounds as illustrated on Figure 23.

Finally, after the development of the rankings, they may be presented and discussed among the group members in order to pursue consensus on the prioritizations. The discussions may lead to a reshuffling of cards or even a new sorting. Archer & Ghasemzadeh (1996) assert that Q-sort is most adaptable to achieving consensus in a group situation.

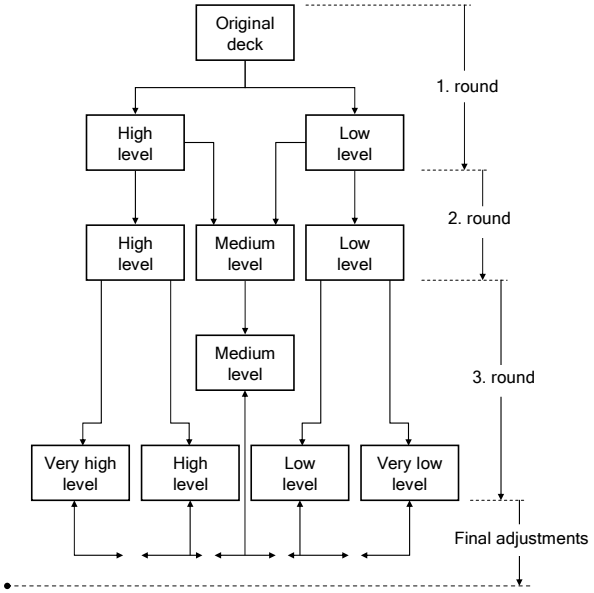


Figure 23. The Q-sort method (modified after Meredith & Mantel 1995).

AHP

The *Analytical Hierarchy Process* developed by Saaty (1980) is useful when making complex decisions involving multiple criteria. The strong point of the method is its ability to decompose an overall evaluation into a hierarchy of evaluations of less importance while simultaneously keeping the part in the overall evaluation. The criteria are assigned weights according to their relative importance (e.g. by means of pairwise comparisons), and these sums up to 100% of the project decision. According to Brenner (1994) the decision model can be developed by the management group, which subsequently evaluate all projects on the criteria in order to compute an overall rating of each project. Finally, the projects are ranked based on the ratings.

Scoring models

Unweigthed 0-1 factor model

Scoring models are in general easy to understand, but can vary strongly in terms of complexity and information requirement. The *unweighted 0-1 factor model*, which also is known as a checklist, is considered as the

most basic of these models. A group of decision makers' assess each project against pre-defined criteria in order to determine whether the project in question qualifies. The *unweighted factor scoring model* accommodates a more nuanced assessment of a projects compliance with the criteria according to Meredith & Mantel (1999) and Cooper & Edgett (2006). It includes the definition of a scale (e.g. good, fair, and poor) for the projects assessment. The *weighted factor scoring model* is slightly more advanced since the importance of the criteria is considered by assigning weights to each criterion. The factors and the weights to be included in the models can be derived empirically. The NewProd™ project selection model proposed by Cooper (1981) is an example of such a model.

Unweigthed factor scoring model

Weigthed factor scoring model

The *constrained weighted factor scoring model* is a further extension of the previous models, which includes a number of constrains, i.e. requirements (e.g. resource limitations) to be fulfilled besides the criteria.

Constrained weigthed factor scoring model

Cooper and colleagues advocates for the use of the *dynamic rank ordered score list* to rank and select projects, due to its simplicity. The model rests on the assumption that projects are not interdependent. All projects under consideration are listed in the left column in Figure 24. Next, each project is scored on the criteria, and a total score is calculated in the right column. This procedure is repeated for each of the projects. Subsequently, the projects are shifted in the list according to their total score, i.e. the projects with highest score are shifted to the top of the list and vice versa.

Dynamic rank ordered score list

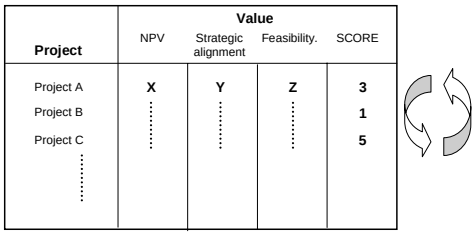


Figure 24. The dynamic rank ordered list can be used for portfolio selection (Cooper, *et al*. 2001).

By adding a resource constraint the models may be used for portfolio selection according to Archer & Ghasemzadeh 1996. This requires that each projects expected resource consumption (or other critical resources) is estimated and accumulated in a column in accordance with the ranked project list. Next, projects to be included in the portfolio are determined by picking projects from the top of the list until the resources are exhausted.

Cooper, *et al.* (2001b) suggests the benefit in using these models are related to the process perspective, i.e. a group of decision makers are able to discuss each project and relevant criteria.

4.6.2 Portfolio selection models

Strategic frameworks

In section 4.3 we found that strategic alignment is one of the characteristics of a good portfolio. Strategy can be linked to the portfolio by means of the tools investigated in the previous sections by incorporating strategic criteria in the models. Hence each project's contribution to the fulfillment of this criterion will be judged during the rating process. Cooper, *et al.* (1997b) found companies using a complementary *top-down* approach to ensure that the set of projects mirrors the strategy. They designate the approach *strategic buckets*, because it focuses on allocating resources in amounts according to the underlying strategic objectives.

Strategic buckets

Strategic discussions among the senior management form the starting point for this process. Next, managers are forced to make choices in order to ensure consistency between intentions and actual spending. Hence spending priorities across markets, geographical areas, products, project types, or segments are derived. The spending priorities provide a top level outline of the portfolio composition, and it can be used to guide the selection of projects for the portfolio.

Aggregate project plan

Wheelwright & Clark (1992a) propose a framework for "good" portfolio planning which they call the *Aggregate Project Plan*. The method illustrated on Figure 25 rests on the assumption that it is necessary to establish a realistic and concrete picture of the organizations available resources together with the expected resource consumption and duration of each project type the organization typically execute.

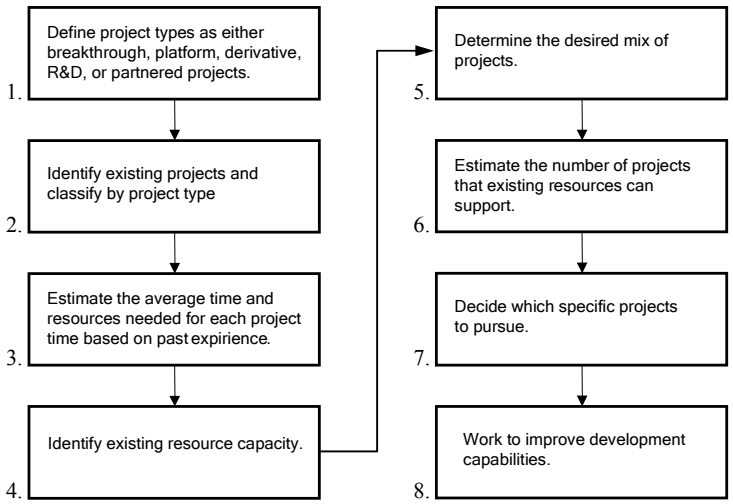


Figure 25. The Aggregate Project Planning procedure modified after Wheelwright & Clark (1992a).

Next, based on this information it is possible to estimate how many projects of various types the portfolio should comprise. This estimate comprises the *top-down* boundaries of the portfolio and it may be used to guide the selection of projects for the portfolio. During an iterative process with participation of managers and specialists the list of potential projects is confronted with the derived limitations. In order to compose a

portfolio which satisfies the business objectives best possible, projects are shifted in and out of the portfolio until the available resources are exhausted.

Development of project alternatives

The concept underlying the framework suggested by Sharpe & Keelin (1998) is interesting, since it explicitly encourage the development of project alternatives. Whereas other tools and methods assume the scope of projects to be fixed, their framework recognizes that several approaches to a project may be viable. The framework is based upon a three phase dialogue between the project teams and the company's decision makers.

The aim of the first phase is to generate at least four alternatives to a project. These alternatives are valued in the second phase, and finally, the portfolio is created and resources are allocated in the third phase.

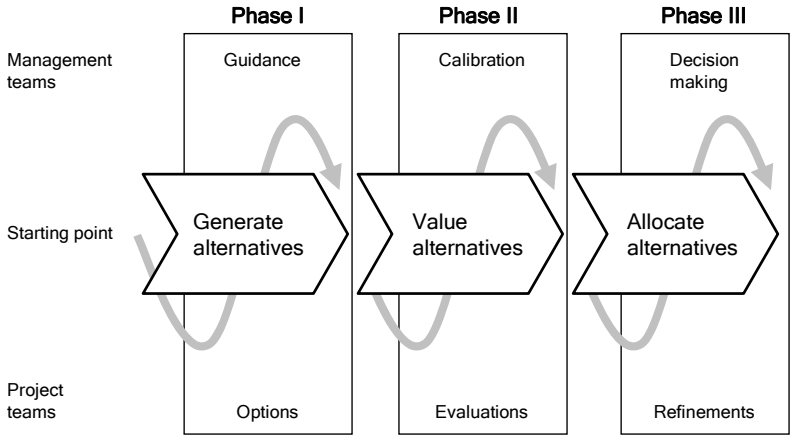


Figure 26. This three-phase process allows SmithKline-Beecham to find more value in its portfolio of development projects according to Sharpe & Keelin (1998).

Mathematical programming models

Mathematical programming models like integer programming, linear programming, goal programming and dynamic programming can be used for composing a portfolio of projects out of a larger group of projects. They origin from the field of operations research, and they seek to optimize the portfolio by selecting the set of projects that offers greatest benefit (the objective function) to the company subject to specific constraints such as capital expenditures, man-days, competencies etc. according to Hall & Nauda (1990).

Limited use

Such models may seem rigorous and conceptually convincing according to Graves, *et al.* (2000). Nevertheless, an exploratory study by Cooper, *et al.* (2001a) on industry practices within the field did not point out any companies where these methods were utilized. Hence it seems that the use of them is not widespread, and this may well be due to the mathematical complexity of the models.

Roadmapping

Direction for product evolution

The term *roadmapping* refers to the activity of creating and communicating roadmaps according to Kappel (2000). Phaal, *et al.* (2001) suggest that the method can be applied for a variety of purposes like for example process planning, knowledge asset planning, and long-range planning. In the context of product development product and technology roadmaps are of particular importance. They articulate a direction and schedule for product evolution to communicate with customers and internal audience. Kappel (2000) defines the domain of product technology roadmaps as:

"Roadmaps are documents that recognize the key defining parameters of the markets, products and technologies for one part of the business".

Albright (2002) extends this perception when he proposes that a roadmap is the view of a group of how to get where they want to go, or achieve their desired objective.

The distinct feature of roadmaps is the explicit articulation of the time domain for the introduction of each (potential) product in the portfolio. Hence the timing of product introductions to the market is the heart of roadmapping. This particular aspect is also acknowledged by Cooper, *et al.* (2001b), who emphasizes the role of roadmaps as the "attack plan" in portfolio management. Roadmaps appear in many graphical formats, but according to Phaal, *et al.* (2001) the map illustrated on Figure 27 is among the most common.

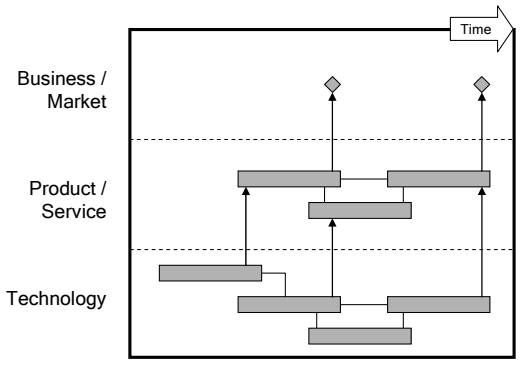


Figure 27. Generic three layer roadmap (Phaal, *et al*. 2001).

They argue that in order to develop a roadmap knowledge regarding the market ("*know why*"), product ("*know what*"), and technology ("*know how*") is essential. One of the central virtues of roadmaps is the possibility to explicate the key *linkages* between these perspectives according to Albright & Kappel (2003). In other words, the relationship between a technology and the products wherein it is supposed embedded can be visualized. Similarly, it is possible to show the relationship between a product and its target market segments.

Encourages communication

Even though the ultimate outcome of roadmapping is the specific roadmaps, much of the value of roadmaps results from the roadmapping process. The process encourages functions to communicate, and this

provides an opportunity for learning by utilizing the collective knowledge within the company. Albright & Nelson (2004) write:

"The essence of mapping lies in the creation of graphical presentations of information that have been build from the frequently tacit information residing in different functional areas".

Kappel (2000) found that roadmapping influences a groups understanding on three levels. The first level concerns the establishment of a shared *understanding* of the current and expected business context for the company. This is manifested in the roadmap. At the second level the emphasis is on obtaining and allocating the resources needed to realize the content of the roadmap. Hence the maps are intended to *persuade* the senior management to "buy-in" on the suggested roadmaps. Next, the implementation of the roadmap can begin, and this marks a shift in the groups understanding. *Synchronization* is the overriding theme of understanding at the third level. Here roadmaps may be closely tied to project plans on a continuous basis in order to ensure coordination.

Portfolio diagrams

Portfolio diagrams (*also known as portfolio matrices, maps or charts*) constitute a type of graphical tools, which provides two-dimensional pictorial representations of the set of projects under consideration. They are typically high level and strategic in nature and their ability to visualize the balance of projects in the portfolio is supposed to enable the decision makers to compose a rational mix of projects according to Archer & Ghasemzadeh (1996). The diagrams provide companies with a way of examining and displaying selected aspects of the project portfolio. Numerous variations of the diagrams exist, and their graphic format is typically a XY plot where bubbles, histograms, bar charts, or pie charts represent projects. They may be further enhanced by adding attributes like colors, shading, and shapes to represent key characteristics of projects.

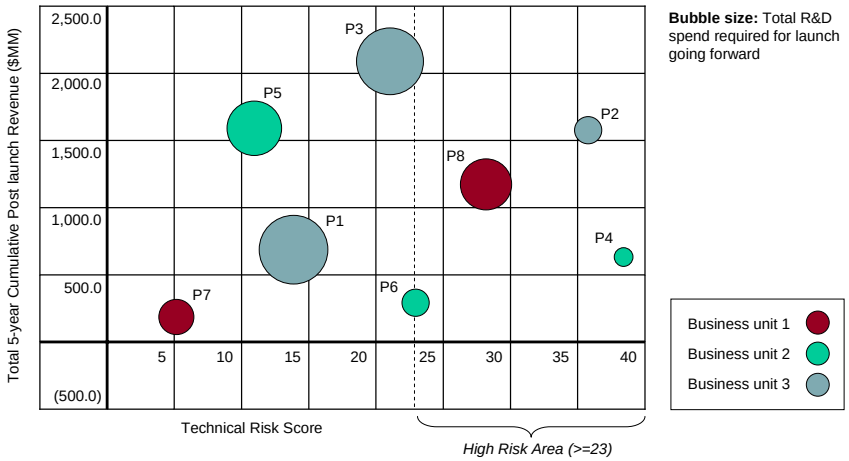


Figure 28. Risk-reward project portfolio diagram.

Widespread use

Cooper, *et al.* (1997a) found that portfolio diagrams are prevalent in industrial practice since a total of 41% of companies uses bubble

diagrams. Furthermore, diagrams within this category which plot projects according to a risk dimension and a reward dimension are widely used in industry. Examples of alternative dimensions are shown in section 4.3.

Not a new phenomenon

The idea of visualizing a portfolio on a diagram is not new, but can be traced back until the 1970s according to Hax & Majluf (1996). Consulting firms' detected managers need for achieving a better understanding of the competitive position of the overall portfolio of businesses. As a respond they developed the concept of portfolio diagrams which also today is broadly utilized in strategic management. The "directional policy matrix" (*also known as the GE/McKinsey portfolio classification*), and the growth/share matrix proposed by the Boston Consulting Group, Inc., and the life cycle matrix developed by Arthur D. Little, Inc. are among the most popular diagrams. These diagrams, however, are not similar to the diagrams used for portfolio management for product development. Whereas the former focuses on the current performance of *existing* businesses (i.e. strategic business units) the latter deal with the *potential* performance of future and current product projects. This distinction is central since it implies a high degree of uncertainty associated with the data underlying the diagrams. The position of a project on a map may be derived from score lists and financial calculations. Since the trustworthiness associated with the output from these tools is doubtful (*see also section 4.6.1*) it follows that this uncertainty is transferred to the diagrams. Portfolio diagrams do not provide decision-makers with any guidance to determine whether a portfolio is properly balanced.

4.6.3 Procedural approaches

The concept of a *procedural approach* for portfolio management may be compared with the process model for product development. The latter provides well-defined phases for developing a new product wherein various product development tools can be applied according to the project members' preferences. Similarly, procedural approaches recognize the need for a structured process for portfolio selection which leverages existing tools and methods. Archer & Ghasemzadeh (1999) suggest the framework illustrated on Figure 29 for a project portfolio selection process.

Flexibility to choose techniques

It enables such organizing of techniques logically in a flexible process. The process is divided into five activities: pre-screening, individual project analysis, screening, optimal resource allocation, and portfolio adjustments. The decision makers have the flexibility to choose from a variety of techniques or models within each activity.

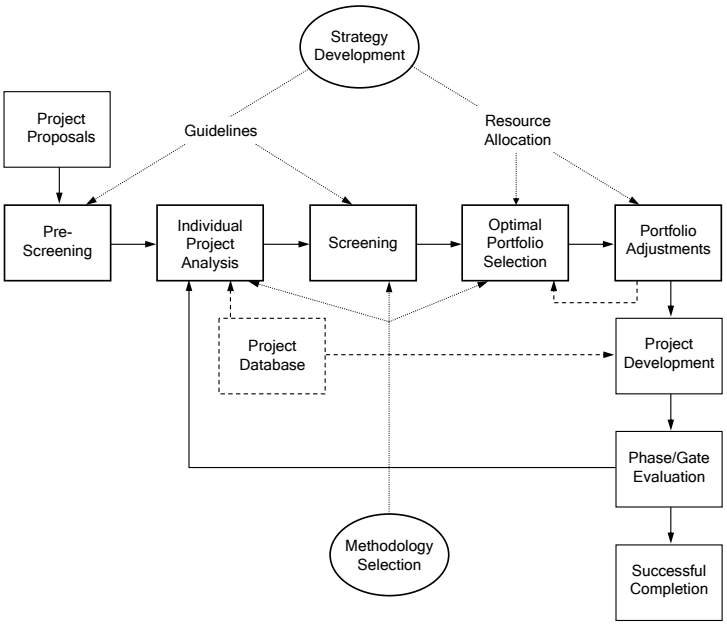


Figure 29. Framework for Project Portfolio Selection suggested by Archer & Ghasemzadeh (1999).

Bridges (1999) suggest that almost every organization will flow through a high-level thought process illustrated on Figure 30 comprised by the four sequential activities: Identify opportunities, assess the fit, analyze the details and finally, develop and select the project for the portfolio.

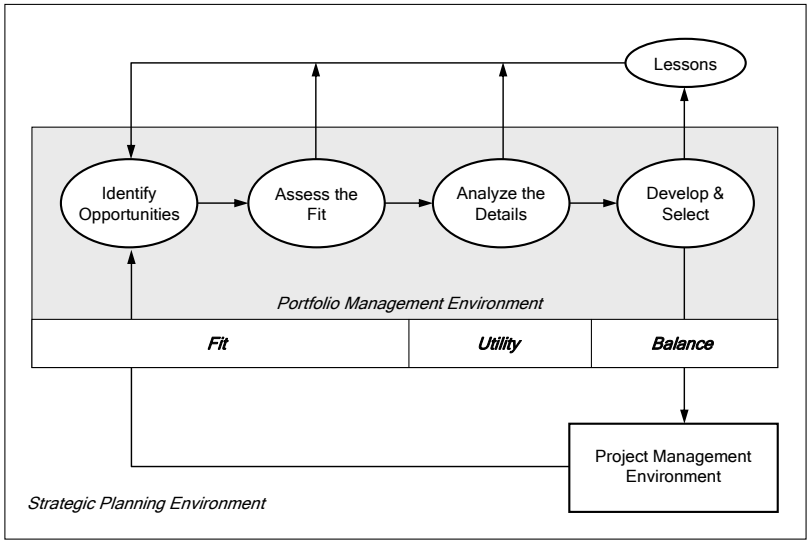


Figure 30. The Fit, Utility and Balance Paradigm (Bridges 1999).

Hall & Nauda (1990) acknowledges that such frameworks cannot stand alone, when they also indicate the people (i.e. the senior management, middle management or technical staff) who should be involved in each activity.

Structural support

Whereas the strategic frameworks investigated in section 4.6.2 are founded on a concept, such as spending priorities or capability the procedural approaches merely offers a *structure* for organizing the work.

4.6.4 Non-structured approaches

The tools and methods reviewed so far presumes that project and portfolio selection is a well-structured, rigorous and rational decision-making process where each project alternative is confronted with a series of derived evaluation criteria. Based on this evaluation the projects that offer most benefit to the company are chosen. Other approaches exist, which do not rest on the concept of rigorous rationality. Such approaches bypass the formalized portfolio management system, because projects are initiated and undertaken outside the system. This occurs more or less remote of the senior management's purview and approval.

The sacred cow

The sacred cow refers to the project selection approach where charismatic leaders believes in, and insists on starting a certain project. Due to the leader's decision-making authority these projects typically receive much support and attention and they can be funded and started without being scrutinized as normally prescribed in the company. Cooper, *et al.* (1998) argues that these projects have a poor track record, since their failure rate is higher than the average project.

The genius award

Hall & Nauda (1990) refers to the concept of the *genius award* approach for project selection. It is based upon the assumption that if a researcher in previous work has proven interesting results then it is likely to happen again. Hence the approach simply provides funding to researchers to work on a project of their own choice.

Competitive necessity

Sometimes the market dynamics can force the management to initiate and undertake a new project fast in order to maintain the company's competitive position on the market. This may happen if a competitor suddenly introduces a new product type, which has the potential to capture a critical market share. In such situations consensus about the necessity and value of a counter-offensive project may be evident for the management. Furthermore, since urgent decision-making is required, a project may be initiated without going through the standard procedures for project evaluation, prioritization and selection.

Customer requests

Depending on the type of business, requests from customers can short circuit decision-making regarding the portfolio. This is the case when a large-scale customer requests the development of a complete new product. Since the customer account for a major share of the company's revenue stream – and hence possess great bargaining power - the inquiry can take priority over other evaluation and selection criteria.

Operating necessity

Problems with product quality can sometimes be serious, because they may jeopardize the user's safety. Defective brake systems or electrical systems in cars are well-know examples of such problems. Hence the manufacturer has to withdraw the products from the market in order to

improve it, e.g. by replacing a sub-system in the product in order to prevent injuries on individuals and subsequently, avoid irremediable damage to the business. The urgent need for initiating projects aimed at improving or developing such a sub-system is obvious, and it may very well take priority over all other activities.

Emergent projects
Leading companies recognize the importance of encouraging employees to work on projects of their personal interest in order to promote creativity according to Zien & Buckler (1997). The concept rests on the assumption that many of these projects would not survive the standard procedures for project evaluation with the management group. Hence some resources are not allocated up front, but used for small amounts of experimental work in order for innovative ideas to emerge. The company 3M and their 15%-rule is perhaps the most well-known example of this approach. Here employees are allowed 15% time to work on self-defined innovations (Cooper, *et al.* 2004a).

Furthermore, the empirical findings of Blichfeldt & Eskerod (2005) indicate that a portfolio also consists of many smaller – and more or less official - projects which are not subjected to portfolio management. These projects are undertaken by one or a few people located in the same department. Blichfeldt & Eskerod (2005) argues that these smaller projects in aggregate consume quite a substantial proportion of the resources.

Darwinian selection
Darwinian selection is a quite different approach to product planning. It rests on the idea of "testing" the market by developing and presenting numerous products in a minor scale to initial groups of early adopters. Depending on their response the relevant products are identified, and full-scale investment in the corresponding projects are initiated according to Leonard-Barton (1994).

4.6.5 Multiple methods seems to yield the best results

It is evident that a variety of tools and methods exist to support portfolio management. Cooper, *et al.* (2001a), however, found that no single method gives the correct results. On the contrary, the best performing companies tend to rely on a hybrid approach based on three or more methods like economic models, scoring models or portfolio diagrams. In particular the business strategy methods are the preferred approach for the best performing businesses. Financial methods dominate portfolio management, despite the fact that they, paradoxically, yield the poorest results.

4.6.6 Conclusion

The abundance of tools and methods for portfolio management proposed in the literature reflects the huge effort which academics and practitioners have invested in solving the portfolio problem over the past 50 years. As with all models they are simplified representations of reality and therefore they all involve assumptions. Rigorous rationality is the prevailing

assumption for the majority of the models, i.e. the tools and methods assume timely choices based on rational analysis of all the available information.

Assumptions unsuited for NPD

Many of these assumptions seem to be reminiscences from the domain of economics, where the portfolio management phenomenon originates from. It is, however, problematic to apply these assumptions to the domain of new product development, since the nature of the domains is quite dissimilar. It is, indeed, challenging next to impossible to assign an economic value to the first hesitant beginnings of a product development project. Furthermore, it is very complicated to trace cost and revenue back to the investment decision. Additionally, projects are interrelated. Hence decisions made about one project may influence other projects or products. Product cannibalization, i.e. when one product takes sales from another product offering is a classic and commonly known example of this interdependence. In total, product development can be characterized as highly dynamic and uncertain.

Multiple criteria evaluation

Several of the models recognize that it is necessary to base portfolio decision making on the evaluation of several criteria. At a first glance many of these models seem to be based on sound and deceiving logic. The question, however, is if this "mathematical" logic is suitable for product development projects. For example, does it really make sense to measure a project's potential benefit contribution to a company on a number of parameters which subsequently are accumulated to provide an overall score for the projects value? It seems reasonable to raise the question whether the group of decision makers trusts the outcome of such models.

Widespread use of mapping techniques

It seems that the industrial adaptation of the highly sophisticated models has been quite limited. Mapping techniques, however, seems in particular to appeal to management professionals, since they have gained a strong foothold in industry. This might be due to their ability to provide an overall perspective of all projects underway, and the balance among them based upon a small amount of information.

Information overload

Paradoxically, though, in an ideal world portfolio decision making is highly complex. Multiple dimensions need to be factored in the process. This seems to comprise a challenge, since it is limited how many items the human mind can compare simultaneously. Hence there is the risk of confronting decision makers with lots of different information which may be difficult to apprehend.

Data quality

Next, a general problem with portfolio tools is that the quality of the output "answers" will not be better than the quality of the input data. Moreover, in situations where the output of an evaluation is a number, it may well imply imaginary precision.

Decision support

The study indicates that there seems to be a growing recognition that portfolio management tools and methods should go in and/or provide a systematic process (*as opposed to an event*), which encourage involvement of personnel from various functional areas in structured

discussions. Hence the models themselves are not expected to provide the "correct" answer about which projects to select. Rather, the models support the decision-makers in asking questions to the organization and its business context by explicating evaluation criteria, and considering and comparing the projects' potential benefit contribution to the company.

Finally, contemporary research increasingly acknowledges the existence and impact of more informal approaches during the day-to-day portfolio management, which does not assume stringent prudence.

Implications for this research
It seems that the majority of the tools is aimed at supporting the evaluation, selection and prioritization of projects based on our *expectations* of their potential business value and potential feasibility decomposed on a number of criteria. The subsequent realization of the selected portfolio seems to be presumed executed flawless by means of coordinated contributions from the company's various functional departments unified by the product development process.

It seems, though, that none of the tools can provide us with an indication of whether the latter actually is the case despite the fact that it is critical to the portfolios success. It is nevertheless asserted to be a simple necessity that we have an indication of how good we actually are at realizing the current portfolio in order to make proper portfolio decisions.

This research deals with this observed shortcoming in chapter 7 by suggesting three tools, which can be used in combination to map the dynamic development portfolio starting from the individual projects.

4.7 Conclusions on state-of-the art

This chapter has provided an overview of the main influential perceptions of the phenomenon portfolio management. The overview is structured according to four central aspects of portfolio management, namely the goals, processes, organization and supporting tools and methods. This approach was asserted necessary in order to obtain a rich understanding of the pervasive phenomenon, which can form a suitable basis for discussing the matter.

Despite the rather simple definition of portfolio management provided in section 1.2 it is clear that the concept by no means is simple or evident. On the contrary the complexity inherent in portfolio management is overwhelming.

Even though portfolio management has gained considerable attention in both academia and industry as a necessary means for improving business results, this study shows that portfolio management is an ambiguous concept, which is neither palpable nor easy to implement. This justifies the need to extend our understanding of this phenomenon in order to reap some of all the highly praised benefits portfolio management may lead to.

Even though many scholars have contributed to this research area, it is also clear that there are opportunities for additional contributions. Some of the research opportunities addressed by this research in the subsequent chapters are:

Establishment of a common theoretical base: Numerous terms, words and concepts have been used by many different authors from diverse domains in their effort to describe the phenomenon portfolio management.

The inconsistent use and sometimes confusing mix of terms, however, indicates a comparative conceptual weakness in terms of the lack of a common theoretical base whereto contributions may be referred. This situation forms an inappropriate starting point for describing and discussing this essential matter.

Hence this research asserts that there is a need for such a base, which can provide a route to a better common understanding of the structural and functional elements and their relations inherent in portfolio management for product development in a company context.

Modelling the dynamic product development portfolio: The modelling approaches for product development portfolios found in the literature primarily encourages modelling of the *static* portfolio. This research advocates that there is a need for a detailed and formal representation of the *dynamic* product development portfolio. Such a portfolio representation is asserted to be a simple necessity in order for a company's management to make proper portfolio decisions.

In the following chapter the effort is directed towards synthesizing the identified contributions into a common theoretical base which can constitute a suitable point of reference for describing and discussing portfolio management in a company.

5 Proposal for a reference model for PM

5.1 Introduction

In the previous chapter opportunities for additional research contributions within the domain of portfolio management for product development were identified.

Aim of chapter

The aim of this chapter is to address one of these opportunities by proposing a reference model for portfolio management. Such a model should promote an enhanced understanding of the elements in portfolio management and their relations within a company context.

The term "elements" denotes processes, structures, activities, concepts and events. The principles are asserted to constitute the interaction, i.e. the dynamic interplay between the elements.

Theoretical purpose

The theoretical purpose of such a framework is to provide a theoretically based and consistent reference model, which explicates central elements and principles of the portfolio management concept in a company. That entails processes, structures, activities, concepts and events and their dynamic interplay. The framework is assumed a critical prerequisite to describe and discuss these matters since other contributions may be referred to the framework. Hence the contribution is intended to support the further academic exploration and development of the terminology and knowledge within the research area portfolio management and product development.

Industrial purpose

Even though such a model initially may appear of primary interest to academia, this research assumes that it is also important to industry professionals. Hence the industrial purpose of the framework is to provide the management with a model for guiding the development and implementation of effective and integrated portfolio management systems in industry. Thus the unifying framework is intended to highlight the structure and a number of key elements and their linkages inherent in portfolio management.

The research will be guided by the following research question:

Research question 1

Which structural elements and principles are inherent in portfolio management for product development? What is their central interplay and how can they be modelled and visualized?

Propositions

In order to further focus the research a number of propositions are initially introduced. It is asserted essential that a potential reference model conforms to these propositions.

Proposal for a model

Based on the fulfillment of the stated propositions the research then establishes a reference model, which unravels the task delineated by the research question. Multi-level processing, integration and the object of manipulation are among the vital themes contained in the model.

Structure of chapter

Initially, eighteen propositions vital for a reference model to fulfill are suggested. Next, a reference model which meets the stated propositions is introduced. After that, the elements comprising the framework and their relations are identified, considered and described separately. Next, the model's ability to explain portfolio management principles and elements in practice is examined. This verification is carried out by structuring and describing observed industrial portfolio management practices in four companies according to the principles explicated in the framework. Finally, a conclusion is presented in the last section.

5.2 Propositions for a reference model

The goal of this chapter is to synthesize a reference model for portfolio management for product development.

"End-to-end" context

This research assumes that it is necessary to perform project portfolio management in an "end-to-end" context which acknowledges the gradual transformation of a product idea into a product project which results in a product. Thus it is asserted that at least three distinct portfolio classes should be considered when making decisions about the product project portfolio, namely portfolios of ideas, projects and products. This is due to the assumed causality indicated below:

- A strong *idea* portfolio constitutes a proper basis for the realization of a strong project portfolio.
- A strong *project* portfolio constitutes a proper basis for the realization of a strong product portfolio.
- A strong *product* portfolio constitutes a proper basis for the capitalization of new product investments.

Different management approaches

Each of the portfolios, however, may well be managed different since their nature is dissimilar in terms of their clarification. For example, the management of a portfolio consisting of embryonic and fragile ideas might be different from, but closely related to the management of a portfolio composed of more firmly defined projects. Similarly, the management of a portfolio consisting of projects, i.e. speculative and uncertain products, may well be diverse from the management of a portfolio composed of existing and certain products.

Propositions

The author assumes that it is essential that a potential reference model conform to a number of propositions, which are introduced in the following. They are structured in accordance with the concepts they relate to. The propositions are derived from the aggregated knowledge from the examined literature in the previous and current sections. All of the listed propositions are assumed relevant, but the list is not necessarily complete.

The object of manipulation

Proposition 1 A model should explicate the object of manipulation in portfolio management for product development.

This is considered as an indispensable necessity, since the portfolio is the vehicle for business creation in product development.

Proposition 2 A model should acknowledge that we need to distinguish between portfolios of ideas, product projects, technology projects, and products during portfolio management in accordance with the gradual transformation of a product idea into a product project which results in a product.

This proposition is a reaction to a particular confusion observed in the literature. Here different terms like projects, pre-projects, idea proposals, opportunities, products etc. have been used by different authors in a confusing mix in order to describe the object of manipulation in portfolio management. Hence the purpose of visualizing this aspect is to clearly articulate that we should discriminate between several portfolio classes, since it indicates that it is possible to improve the potential business value of a "portfolio" in several stages.

Proposition 3 A model should acknowledge that we need to distinguish between technology projects and their outcomes, i.e. technologies, packages or modules while managing the development portfolio.

This distinction is fundamental since it is directly linked to the controlling of risk associated with embedding new technology in product development projects.

Proposition 4 A model should emphasize that no causality exists between the portfolios of *current* ideas, *current* projects, and *current* products. Rather, the portfolios are mutually displaced in time in concordance with the staggered nature of product development.

This is an essential characteristic to accentuate since it implies that many of the consequences stemming from portfolio decisions first are revealed with a time delay.

Proposition 5 A model should outline how investments in the development of new products ideally occur on an incremental basis in concordance with the rise in our understanding of the idea or product and the potential business it represents.

This is a vital facet in portfolio management to illustrate since it is directly linked to the controlling of risk associated with the investments.

Proposition 6 A model should illustrate that projects and products may appear as either *active* or *planned* depending on the resources they currently take up.

This distinction between active and planned initiatives is imperative, since it explicates the importance of dynamic planning. That is, in parallel with project execution we should continuously plan and prioritize future projects and products in concordance with the available resources.

Proposition 7 A model should recognize the existence of projects, which are excluded from the formalized portfolio management process.

The rationale behind indicating such supplementary projects are to draw attention to the fact that not all projects automatically neither should nor are included in the portfolio management process. Some projects may consciously be excluded in order to simplify the portfolio management task. In other situations un-authorized projects may exist outside the formalized portfolio process.

Proposition 8 It should emerge from a model that each of the different portfolio classes can be manipulated individually.

The reason for emphasizing this facet on the model builds on the observed confusion previously described in relation to proposition 2.

Portfolio management processes

Proposition 9 A model should explicate the central decision/planning processes and their respective time domains, which in sum comprises the multi-level portfolio management process.

This is considered a fundamental requirement in order to convey an understanding of the coherence needed between the processes in order to accomplish the link between strategic and tactical levels in the company.

Proposition 10 A model should take into account that the multi-level portfolio management processes occurs within the context of a corporate strategy process and a project execution process.

The purpose of illustrating these processes is to provide clarity regarding the position of the overall portfolio management process within a company as well as indicating their interplay.

Proposition 11 A model should outline that the multiple processes feed each other respectively with information regarding actual performance and corrective actions or plans.

This planning/reporting interplay is essential to include, because it forms the basis for the controlling mechanism inherent in portfolio management.

The front end of innovation

Proposition 12 A model should accentuate that evaluation, selection and prioritization of ideas occurs in the *front end* of innovation process, which are distinct

from, but closely related to those which occur in the multi-level portfolio management process.

The rationale behind visualizing this process is to emphasize that we need to generate, clarify and grow a number of ideas sufficiently, so that they subsequently become manageable for the formalized portfolio management process. This relates to the assumption that portfolio management should be exercised in an *end-to-end* context as previously assumed.

The back end of innovation

Proposition 13 A model should emphasize that evaluation, selection and prioritization of products occurs in the *back end* of innovation process, which are distinct from, but closely related to those which occur in the multi-level portfolio management process.

The purpose of visualizing this process is to emphasize that we need to maximize the capitalization of formerly undertaken new product investments, i.e. to make the most business of the products during their market life cycle. This relates to the assumption that portfolio management should be exercised in an *end-to-end* context as previously assumed.

Integration

Proposition 14 It should appear from the model that portfolio management requires horizontal and vertical integration within the company. Hence staff from various functional areas and organizational levels should be involved in portfolio management.

The explication of integration is vital in order to explicate that portfolio management does not exist in isolation in a company. Rather, it is all-encompassing and is highly dependent on contributions from many people in the company.

The business environment

Proposition 15 A model should indicate that portfolio management take place under influence and consideration of company *external* factors such as market dynamics, competition, and legislation, which are outside the company's sphere of control.

This is regarded crucial to acknowledge, because we need to record and understand external influences in order to allocate resources to those projects which in aggregate best accommodate opportunities and threats.

Proposition 16 A model should signify that portfolio management take place under influence and consideration of company *internal* factors such as resources

and competencies and their linking, which contributes to the realization of products. As opposed to the external factors, the internal factors are within the company's sphere of control

This is fundamental to communicate, since a thorough understanding of the capability at hand is a fundamental prerequisite to execute proper management of the development portfolio.

Proposition 17

The model should indicate that decision-making regarding the portfolio composition is initiated by means of an impulse, which might origin from company external or internal sources.

The visualization of the impulse is central, since it is asserted that the nature of the impulse has implications for the extent of the decision making activity. That is, a company's pattern of reaction should correspond to the recorded impulse.

Integrated product development

Proposition 18

The model should be congruent with and capable of encompassing the phenomenon portfolio management in relation to product planning and product development. The latter constitutes the two top level processes contained in the theory of the product development process.

Since the theory of the product development process has been chosen as the scientific view point for this research it is relevant that the proposed model is consistent with this theory.

Starting from these eighteen propositions this research introduces a reference model in the next section.

5.3 Proposal for a reference model

This section introduces a proposal for a reference model for portfolio management for product development, which consists of a set of defined and interrelated concepts as illustrated on Figure 31.

The concepts

The definition of the concepts embedded in the suggested framework and the relations between them is an important step in creating a model-based theory. In the following the concepts, which correspond to the stated propositions, are listed below and their relations are identified, considered and described separately.

- Integration
- Portfolio management processes
- Front end of innovation process
- Back end of innovation process
- Object of manipulation
- Business environment
- Integrated product development

The model suggests that the management of the *project* portfolio occurs by means of the portfolio management processes suggested in section 5.3.2. The management of the *idea* portfolio occurs in the "front end" of innovation process as proposed in section 5.3.3. Finally, the management of the *product* portfolio occurs in the "back end" of innovation process as advocated in section 5.3.4. These processes are regarded as distinct from, but closely related to each other.

The processes and their corresponding portfolio are illustrated on the model with the same colours. The portfolios and their nature are scrutinized in section 5.3.5.

Reservations

In order to explain the model and make the various phenomena embedded in the model operational it has been necessary to designate distinct terms to them. It is recognized, though, that different authors and industry professionals may possibly devote different expressions for similar phenomena than those utilized in the model.

For example, what one company calls a *product committee* may possibly be designated a *portfolio management committee* in another company. What equally constitutes an *idea proposal* in one business unit might be termed a *project proposal* by others even within the same corporation.

Next, it is recognized that the framework does not constitute a solution to portfolio management on its own behalf. Rather, it needs to be complemented with aspects like organizational setup, procedures, tools, and mindsets as indicated in section 5.4.

Lastly, not all the explicated principles are necessarily relevant for all companies. Their relevance is assumed to depend on product types, customer characteristics, business models and specific management preferences.

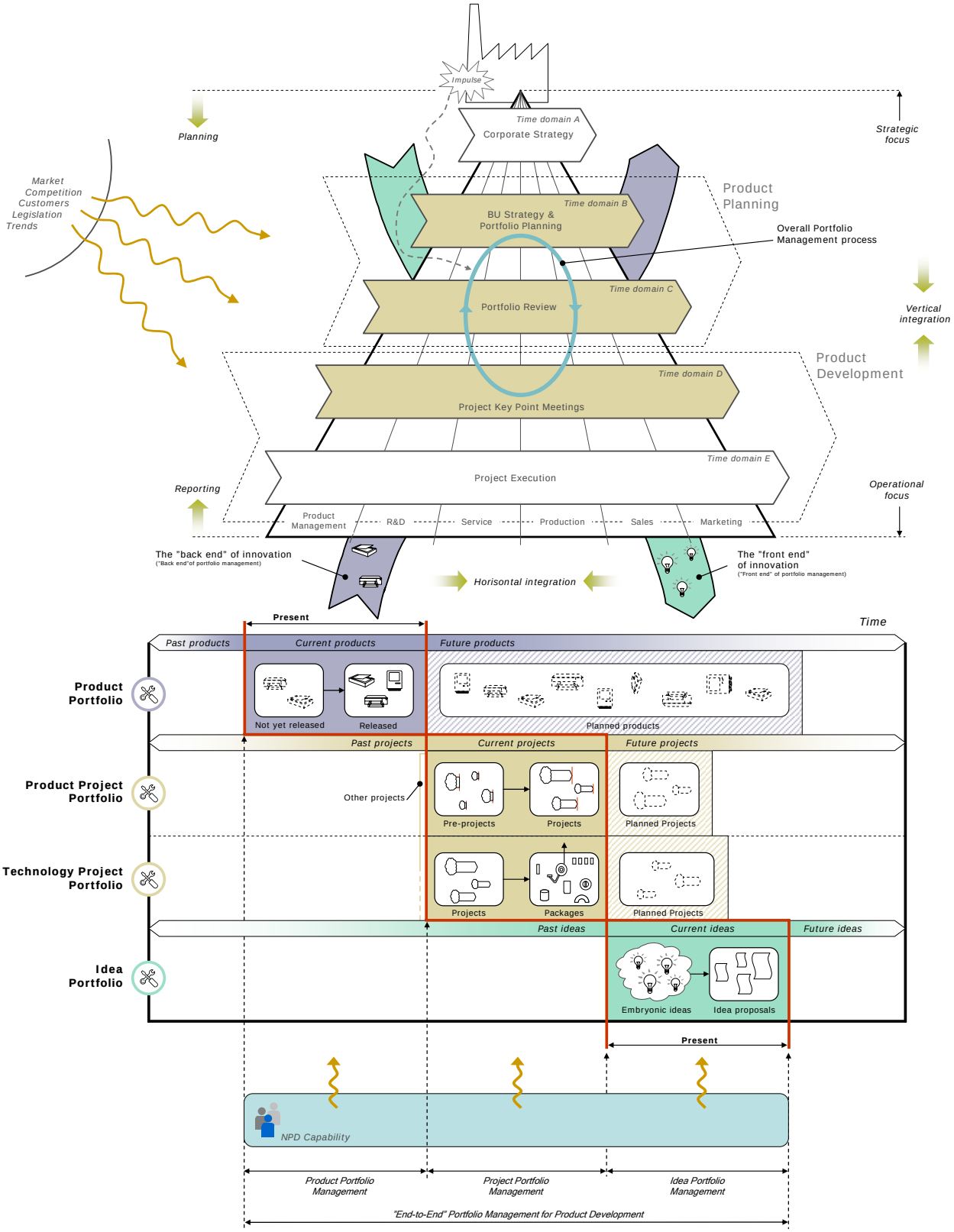


Figure 31. A proposal for a reference model for portfolio management for product development.

5.3.1 Integration

Portfolio management cannot be confined to one function in the company due to its thorough nature. The literature study (section 4.5.4) revealed the importance of involving staff from various functional areas (R&D, marketing, sales etc.) and organizational levels (top managers, line managers, project managers, specialists etc.) in portfolio decision making. Such an exploitation of the company's collective knowledge in order to obtain a proper appraisal of the portfolio seems to be a critical foundation for portfolio management. This justifies the inclusion of both horizontal and vertical integration on the model, which emerges from the model by means of the triangular structure emphasized on Figure 32 below.

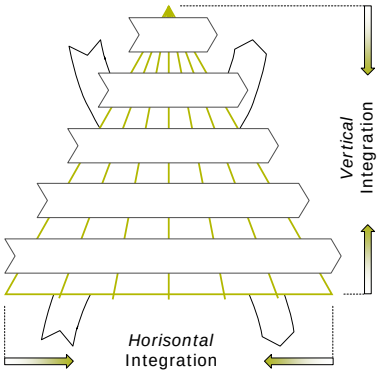


Figure 32. Horizontal and vertical integration appears from the triangular structure.

The triangular structure resembles the decision hierarchy concept suggested by Andreasen, *et al.* (1989) illustrated on Figure 33.

Horizontal integration

The decision hierarchy accommodates the visualization of *horizontal* integration since the general functional areas in a company are represented.

Vertical integration

Vertical integration is illustrated by means of the triangular shape which symbolizes the management hierarchy. Decision making in the top of the hierarchy is characterized by having a strong strategic focus attended at the upper management levels. Decision making at subordinate levels gradually shifts downwards from having a strategic focus towards an operational focus in the bottom of the hierarchy.

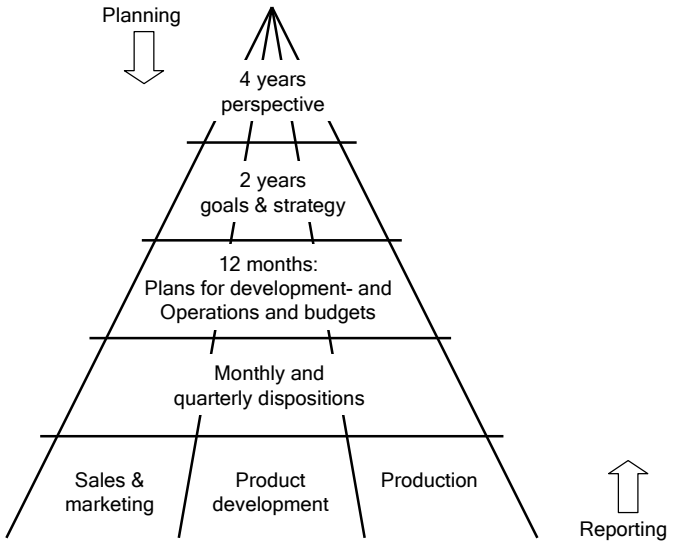


Figure 33. The decision hierarchy is a sub-system of the development system according to Andreasen, *et al.* (1989).

5.3.2 Portfolio management processes

In section 4.4.5 it was concluded that several processes constitutes and interacts in portfolio management at both strategic and tactical level. These are explicated on the reference model be means of the horizontal process arrows, which are emphasized on Figure 34.

Three of the processes (business unit strategy and portfolio planning, portfolio review, and project milestone meetings) are crucial for the overall portfolio management process as concluded in section 4.4.5. They are described in the following. These processes are illustrated by means of three brown arrows on Figure 31. The corresponding *project* portfolio, which is investigated in section 5.3.5, is similarly depicted in brown.

Assumptions

It seems reasonable to assume that a strong project portfolio constitutes a proper basis for the realization of a strong product portfolio. Here the traditionally emphasized portfolio management processes plays a critical role. It is supposed that the potential value of the project portfolio can be improved in at least two ways, namely by:

1) Improving the management of the project portfolio, i.e. decision making regarding evaluation, selection and prioritization of projects.

2) Improving the quality of execution of the individual projects in the portfolio.

The first way, i.e. the management of the project portfolio, is the focal point of this research.

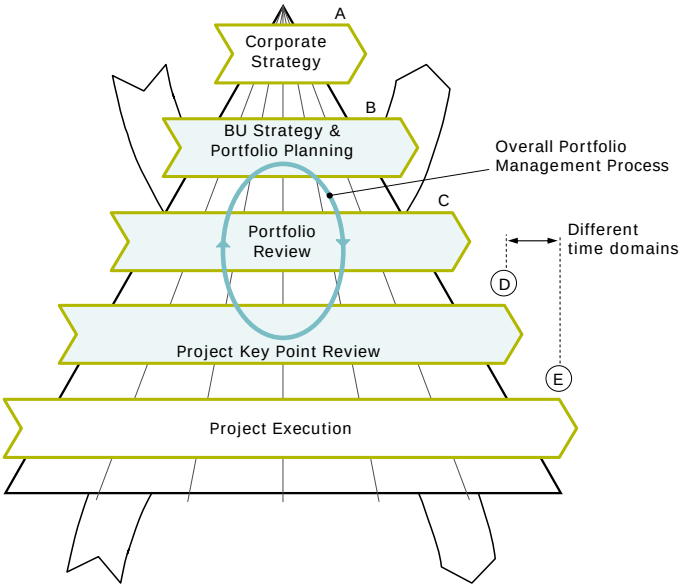


Figure 34. The horizontal arrows illustrate five processes related to portfolio management.

BU strategy & portfolio planning process

The business unit strategy process is merely focused on how the company is pursuing business creation within a particular market or product area according to Johnson & Scholes (1999). A part of this strategy process entails the development of the product innovation strategy and portfolio planning, i.e. selection of product development projects to execute, their timing and top level resource allocation. In concordance with the findings from section 4.4.5 the resulting new product strategy and the product plan together with the detailed plans for each project can be perceived as a central process interface between the business strategy process and product development.

Portfolio review

The portfolio review process is the periodic review of all the projects underway. It considers both active projects as well as those on hold, and aims at ensuring consistency between the aggregate set of projects, the product plan and the new product strategy. The review is strategic in its nature, and decisions may result in starting new projects, re-scoping or stopping existing projects. In general, however, decisions made during the review should merely be perceived as course correction to decisions made earlier during the portfolio planning.

Key point review

The third decision process is comprised by the totality of project key point meetings within each product development project. The decision process is closely integrated with the defined development process (for example, a stage-gate process) for supporting systematic product development, which surrounds each of the individual projects. As opposed to the portfolio review the focus of the key point review is on the control of the individual projects. Decisions made during the key point review of a project may result in an approval of the continuation of the project according to plans or a re-scoping (e.g. changing requirements, or shifting resources) or perhaps stopping the project. Hence this review is highly tactical in its nature.

Different time domains

Each of the specified processes is recurring in different time domains as identified in section 4.4.5. Hence the business unit strategy development and portfolio planning may take place annually, and the portfolio review might happen two to four times per year. The process related to project key point meetings are synchronized with each individual project's progress.

Overall PM process

It is essential to realize that none of the three processes described above comprises the portfolio management process by them selves. Rather, it is the totality and the interplay of the three processes which forms the portfolio management process according to Cooper*, et al.* (2001b). Hence if one or more of these are dysfunctional it will impede the portfolio management process. This relationship is symbolized by means of an ellipse on the model. It couples the three processes previously described together across functional domains, organizational levels and time domains. Hence it should not be perceived as another distinct planning process.

Supplementary processes

It is assumed that it is beneficial to supplement the decision hierarchy model with at least two other processes in the company, namely the corporate strategy process and the project execution process. The purpose is to provide clarity regarding the position of the overall portfolio management process in a company wide decision structure. These processes are described in the following.

Corporate strategy

Corporate strategy is considered as a top level process in the company's decision hierarchy. It explicates the overall policy of the total company according to Johnson & Scholes (1999). This includes the ethics, values and beliefs which the company is founded upon, and it encompasses considerations regarding the company's role in the society and its corporate responsibilities. The overall portfolio management process does not directly interact with this decision process. However, since it feeds the business unit with guidelines for its strategic development, it is considered relevant to explicate the process on the model.

Project execution

The process denominated *project execution* is illustrated at the bottom stage of the hierarchy. It concerns the daily execution of the individual projects, which occurs between the formalized key point meetings. Operational tasks and activities within each project are carried out each day during this process. The process is not considered embedded in the portfolio management process, but it does, however, feed the key point reviews with information regarding the project (i.e. progress, timeliness, challenges, staffing etc.). The fact that the quality of the project execution has serious implications for the potential business value of the development portfolio justifies the inclusion of the process on the model.

Reporting & planning

The literature study moreover indicated that the portfolio management process can be characterized as a multi-level *controlling* process (see also 3.2.5). In order for the process to function properly it is fundamental that management activities at tactical and strategic level feed each other

respectively with information regarding actual performance and corrective actions or plans. This gives a sound reason for illustrating the planning and reporting mechanism on the reference model. The previous mentioned decision hierarchy concept shown on Figure 33 accommodates the mechanism. The principle is highlighted on Figure 35.

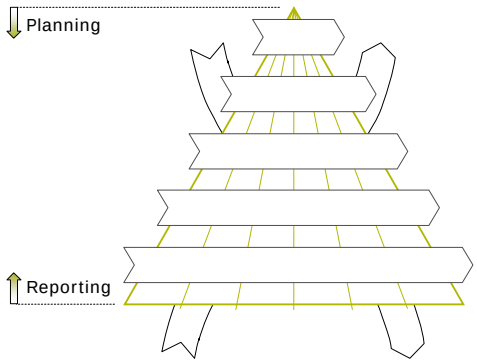


Figure 35. The model accommodates the principle that management activities at tactical and strategic level feed each other respectively with information by means of the decision hierarchy and the outmost left arrows.

The planning of activities cascades from the top of the decision hierarchy towards the bottom, while plans gradually are decomposed into more detailed plans at each subsequent level. Decision making is based on information collected from the bottom of the hierarchy, and reported upwards in the hierarchy. During this process the information is gradually accumulated and consolidated into reports at each preceding level.

5.3.3 The “front end” process of innovation

The notion of the *front end* concept, that is, the fuzzy zone between when the opportunity is known and when the organization mounts a serious effort on the development project, was introduced by Smith & Reinertsen (1991). The front end of innovation process is illustrated by means of a green arrow on the reference model, and underscored on Figure 36 . The process corresponds to the *idea* portfolio similarly depicted in green, which is investigated in section 5.3.5.

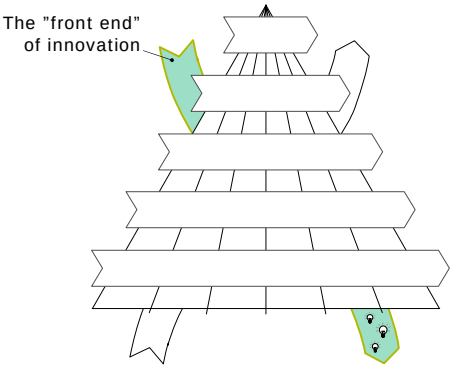


Figure 36. The front end of innovation process is illustrated by means of the green arrow on the reference model.

Assumptions

The front end process provides potential candidates for the project portfolio. It seems reasonable to assume that a strong idea portfolio constitutes a proper basis for the realization of a strong project portfolio. It is supposed that a strong idea portfolio might be realized in at least three ways during the front end innovation process, namely by:

1) Improving the quality of ideas.
2) Improving the quantity of ideas.
3) Improving the evaluation, selection and prioritization of ideas.

It follows that the front end process has serious implications for the potential value of the project portfolio, and for this reason it is included in the model. This research work focuses on the third way of composing strong portfolios, i.e. the management of the portfolio of candidates for new products.

Distinct but related

It is, however, presumed that the front end of innovation encompasses idea selection-processes, which are distinct from but related to those which occur in the three sub-processes of formalized portfolio management as described in section 5.3.2. For this reason the front end process and its corresponding idea portfolio is explicated and separated from the formal portfolio management processes and the related project portfolio.

The nature of the front end process is examined in the following in an attempt to further justify the inclusion of and the graphical placement of the process on the model.

The FEI span many functional areas and organizational levels

The front end of innovation is visualized as a process which span *across* many functional areas and organizational levels. The purpose is to reflect that front end innovation cannot be confined to a single area in the company due to its informal and pervasive nature.

Uncertainty

This is concordance with Koen, *et al.* (2001) whom considers the FEI more experimental and unpredictable than the structured, disciplined and goal-oriented NPD process which follows a project plan. This is due to the high degree of uncertainty inherent in this early stage of innovation. In an attempt to provide clarity and a common language to the front end Koen and colleagues proposes a New Concept Development (NCD) model illustrated on Figure 37. It is a theoretical construct of the front end of innovation. The circular, NCD relationship model implies absence of a sequential process structure as opposed to the FEI model suggested by Khurana & Rosenthal (1997).

Iterative process

The NCD model recognizes that ideas are expected to flow, circulate and iterate between and among the five elements in any order or combination. Further, the influence from the outside world (i.e. competitors, customers, market dynamics etc.) is explicitly captured in the model – illustrated as the periphery. The engine symbolizes organizational leadership and culture. Koen and colleagues considers idea generation, evaluation and

selection as an iterative process pending between the various elements in the NCD model.

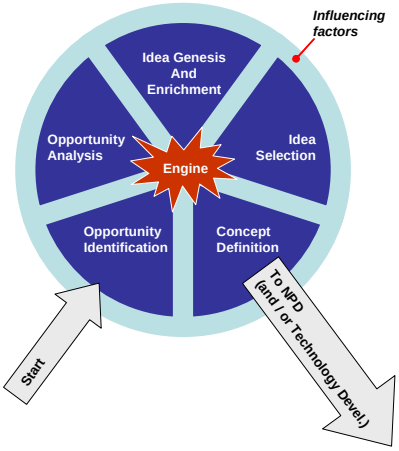


Figure 37. The New Concept Development Model suggested by Koen, *et al.* (2001).

Leifer, *et al.* (2000) suggests an innovation hub as a systematic approach to generate ideas for potential breakthrough products (i.e. radical innovation), and identify those with significant business potential followed by a process of initial evaluation.

Ideas may be requested

The generation of ideas can occur more or less spontaneous. As identified in section 4.6.4 some companies urge their employees to pursue experimental activities of their personal interest in order to promote creative ideas of every kind to emerge. In other situations the quest for ideas is requested, targeted and guided by the management in accordance with Crawford & Benedetto (2003), Cooper (2001) and Leifer, *et al.* (2000).

Closely related, but distinct from project portfolio management

The FEI is illustrated as a *background* process in the decision hierarchy. This indicates that the process is closely related and highly important to, but distinct from the project portfolio management process, since the selection of embryonic and fragile ideas is different from the selection of more firmly defined projects. In other words, early ideas are often insubstantial and too ill-defined for decision makers to decide whether they represent an attractive business potential in order to allocate a sizeable amount of resources to their realization. Hence since resource allocation is a central dimension of portfolio management it might prove difficult to subject sprouting and speculative ideas to formalized portfolio management.

According to Koen, *et al.* (2001), the purpose of the FEI seems to be to generate, clarify and grow a number of ideas sufficiently, so that it subsequently is possible to prioritize between them in order to decide which ones should enter the NPD process. An interesting question, however, is exactly *when* an idea is developed sufficiently to be transformed to a project and enter the formalized project portfolio management process. According to Cooper, *et al.* (2001b) this varies from company to company. This aspect is discussed in section 5.3.6.

5.3.4 The “back end” process of innovation

The back end process represents commercialization of the products during their market life cycle, i.e. from the time when a product is introduced and sustained in the market until it eventually is withdrawn according to Kahn (2001). The back end process is illustrated by means of a purple arrow on the suggested reference model, and accentuated on Figure 38. The process corresponds to the product portfolio similarly depicted in purple, which is investigated in section 5.3.5.

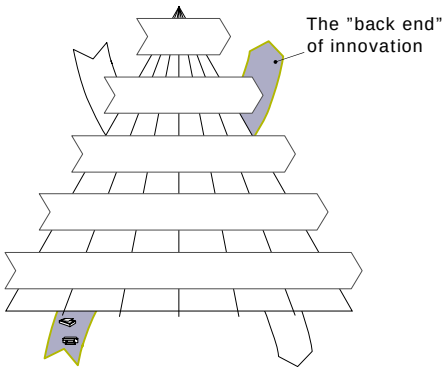


Figure 38. The back end process is illustrated by means of a purple arrow on the suggested reference model.

Assumptions

It seems reasonable to assume that a strong product portfolio constitutes a proper basis for the realization of strong business results. Here the back end process plays a critical role in the capitalization of new product investments. It is supposed that this capitalization of a portfolio of *existing* products might be improved in at least two ways, namely by:

1) Improving the management of the product portfolio, i.e. decision making regarding which products to sustain, promote, improve, delete or request developed.

2) Improving the quality of execution of the activities initiated to support the commercialization of the products. Such activities may incorporate distribution support, advertising, education of sales teams, education of customers, targeting new markets, price adjustments, product bundling and so on.

The back end process is included in the model due to the serious implications for the realized value of the portfolio. The first way, i.e. the management of the product portfolio, is considered particular relevant to this research.

Distinct but related

As previously indicated it is presumed that the back end of innovation includes a portfolio management process, which is distinct from but related to those which take place in the formalized project portfolio management as described in section 5.3.2. Thus the back end process and the related product portfolio is visualized and detached from the formal project portfolio management processes on the model.

The nature of the back end process is investigated in the following in an attempt to give further reason for the addition of and the graphical placement of the back end process on the model.

The nature of the back end process

When the development of a product is finalized it is transferred from the development system into the system of daily operations which is responsible for the ongoing production, marketing, distribution, service etc. of the product. This is visualized as a process which span *across* the company in order to indicate the cross functional nature of the work as well as the notable dissimilarity between the two systems.

Product life cycle

In order to ensure that the product portfolio continuously reflect the changing market needs after launch it is necessary that it regularly is evaluated throughout the products life cycles on the market. The management of the product portfolio is typically considered the responsibility of a product management function.

According to Kotler (1997) a product life cycle entails four main stages, which provides insights into a products competitive dynamics on the market:

- Introduction: A period of slow sales growth as the product is introduced in the market. Profits are nonexistent in this stage because of the heavy expenses incurred with product introduction.
- Growth: A period of rapid market acceptance and substantial profit improvement.
- Maturity: A period of a slowdown in sales growth because the product has achieved acceptance by most potential buyers. Profits stabilize or decline because of increased marketing outlays to defend the product against competition.
- Decline: The period when sales show a downward drift and profits erode.

The idea of the evaluation is to identify where adjustments are needed in order to maintain the portfolios market appeal and competitive advantage as well as avoiding gaps in the product line. The aim is to sustain and extend the financial returns. For example, Baker & Hart (1999) writes:

"…the purpose of portfolio analysis is to determine the composition of the ideal or optimum portfolio taking into account basic preferences for fixed or variable yields, short or long term returns etc".

The scope of the evaluation can be quite broad and encompass dimensions such as customer satisfaction, product performance, competition, and company expectations. A plethora of methods can be applied in this analysis, some of them being: product benchmarking, SWOT analysis, perceptual mapping, and portfolio diagrams. The analysis of the products or impulses from the surroundings (market, company, competition) may reveal a need for corrective actions related to

the business, which the products represent. Such actions may incorporate distribution support, advertising, education of sales teams, education of customers, targeting new markets price adjustments, product bundling and so on. Other corrective action implies manipulations on the product portfolio according to Gorchels (2000), who writes:

"The product manager must evaluate the product line to look for gaps where new products need to be developed and/or to determine when to delete products".

In some situations it is obvious what kind of development to initiate (e.g. a cost reduction or a minor product improvement). In other situations the concept of what to develop may appear vaguer defined and ideas are needed. Both situations mark a shift from the back end process to the front end of innovation.

The effects of product development are exposed

It seems obvious that project portfolio management should be performed under consideration of the portfolio of existing products during their market life cycle. The reason is that this is where the previously undertaken development projects should prove their earning potential and other gains across the company in accordance with the theory of dispositions suggested by Olesen (1992), who writes:

"By a disposition we understand that part of a decision taken within one functional area which affects the type, content, efficiency or progress of activities within other functional areas".

Not only positive effects

However, less attractive effects of product development might also be harvested in the back end of innovation. These effects may be caused due to inexpedient dispositions made during the developments of the products. For example, if the product is designed with only little regard to the subsequent production in terms of reuse of existing components and facilities it might prove unnecessary expensive to produce. Similarly, an impractical product design may hinder the access to certain product parts, and consequently it might be troublesome to service. Inadequate user friendliness of products may comprise yet another example of poor development dispositions since it can enlarge the customer support task significantly during the products market life. Furthermore, if incomplete products are transferred from development to the production, procurement, sales, service etc. this might result in *noise generation* according to Andreasen, *et al.* (1989). Noise generation leads to new jobs, numerous tasks, time consuming problem fixing, changes, and firefighting etc.

Trade-offs

Naturally, it is not likely that all negative dispositional effects can be avoided since it is hard to foresee all consequences in the business system implied by decisions made during product development. Furthermore, decision making in product development might often be a matter of balancing trade-offs between alternative effects.

A symptom

However, when the negative dispositional effects get out of control it may possibly be a symptom of a poor working pattern in the development function which ultimately finds expression in declining productivity.

In sum unfortunate dispositions may possibly pre-empt a considerable amount of product development resources, which consequently cannot be deployed for the cultivation of new business opportunities. This might jeopardize the expected business creation stemming from product development.

In conclusion it appears evident that product development dispositions have serious implications for the cost structure related to the business constituted by the product from its launch in the market to withdrawal. This circumstance reinforces the relevance of considering the portfolio of existing products during project portfolio management.

Closely related, but distinct from project portfolio management

As in the case with the front end process the back end process is likewise illustrated as a *background* process in the decision hierarchy. This indicates that the process also is closely related and highly important to, but distinct from the project portfolio management process. The reason is that the decision-making related to existing products is different from decision-making related to projects. In concordance with the findings of section 4.6.2 the former focuses on the current performance of *existing* products on existing markets, and the latter deal with the *potential* performance of future or current product projects. This distinction is central since it implies a high degree of uncertainty associated with the allied decision-making. Furthermore, this distinction is acknowledged by The European Industrial Research Management Association – EIRMA (2002), who writes:

"The descriptors of the product portfolio require different tools for analysis …".

In sum it seems that the management of the portfolio of existing products aims to maximize the capitalization of formerly undertaken new product investments, i.e. to make the most business of the products during their market life cycle, until they ultimately are retracted from the market and hence exits the product portfolio.

5.3.5 The portfolios: An overview

Four generic classes

The model is based on the assumption that it is necessary to perform portfolio management in an "end-to-end" context, i.e. we should acknowledge the gradual transformation of a product idea into a product project which results in a product. This research suggests that at least four generic classes of portfolios needs to be considered when making decisions about the new product project portfolio mix, namely the idea portfolio, the product project portfolio, the technology portfolio and the product portfolio. These portfolio classes are embedded in the lower part of the reference model, and pointed out on Figure 39.

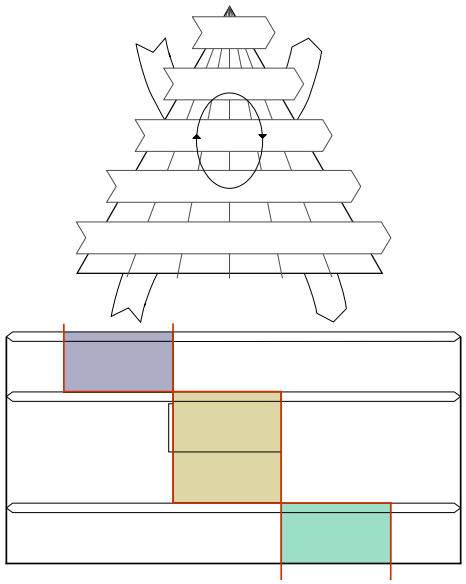


Figure 39. At least four generic classes of portfolios need to be considered when making decisions about the new product project portfolio mix. These emerge from the model.

Three variants

It is asserted that each of the four portfolio classes exists in three variants, namely a past, current and future portfolio.

It is assumed purposeful to emphasize the *current* portfolios since they represent the ideas, product projects, technology projects and products which the company at any given point in time is engaged in, and thus devote resources to for their execution. The current portfolios are framed by means of the red lines on the model.

The current portfolios are mutually displaced on the model in order to resemble the staggered nature of product development. The rationale behind this principle is to accentuate the following:

- The idea portfolio, which currently attract the management's attention are not the cause of the projects currently underway. The latter originate from the portfolio of *past* ideas.

  The *current* idea portfolio aims at realizing *future* projects.

- The project portfolio, which currently consume resources are not the reason for the products currently sold in the marketplace. The latter come from the portfolio of *past* projects.

  The *current* project portfolio aims at realizing *future* products.

Thus the model implies that the current business performance is associated with *today's* product portfolio, which is the outcome of *yesterday's* project portfolio that originates from the idea portfolio from the *day before yesterday*. Conversely, the result of today's portfolio management practices will first be revealed in the future.

Different nature

Each of the portfolio classes may well be managed different since their nature is dissimilar. For example, the *idea* portfolio contains early and fragile ideas and can be managed in the "front end" of innovation as suggested in section 5.3.3. The *product* portfolio comprises concrete products, and may be managed during the "back end" of innovation as suggested in section 5.3.4. The management of the *project* portfolio, which entails defined projects, typically occurs by means of the portfolio management processes as suggested in section 5.3.2.

Decision points

In many business situations investments are made as distinct events. This is not the case for investments in new product development. The development process is typically designed in such a way that investments in NP elements are pursued gradually in accordance with our increased understanding of the elements business potential. Thus from a portfolio management perspective is it central to understand an elements degree of clarification and the associated implications for the elements business potential. The clarification of an element follows the systematic development process, which is designed with formalized, cross functional milestone meetings in order to mitigate risk during development.

It is assumed useful to focus on particular key points of an element's clarification, namely those stages where extraordinary implications for the business potential (e.g. value and expenses) are about to appear. These decision points might represent significant shifts in the firmness of our commitment to the elements realization. At such strategic junctures it is typical possible to obtain a more firm indication of the amount of resources that are required in a given sequence to bring the element forward in the process combined with an indication of the elements business potential.

Sub-portfolios

In concordance with the recognition of the decision points previously described it is assumed beneficial to decompose the idea portfolio into at least two sub-portfolios, namely the portfolio of *embryonic* ideas and the portfolio of idea *proposals*. Similarly, the project portfolio is divided into a *pre-project* portfolio and a *project* portfolio. The product portfolio is also divided into two portfolios, namely *released* products and *withholded* products.

Technology projects

The development and inclusion of technologies is a crucial prerequisite for the development of products. Since the nature of technology projects is different from product development projects it is relevant to distinguish between portfolios consisting of technology projects and product projects.

Furthermore, it is assumed beneficial to decompose the technology portfolio into at least two sub-portfolios, namely a portfolio of technology *projects* and a portfolio of technology *packages*. The latter symbolizes technologies ready for inclusion in product development projects.

Supplementary projects

The findings in section 4.6.4 indicate that projects which are not subjected to formalized portfolio management exist in a company. This consideration is taken into account in the model and illustrated by means of the portfolio denominated "supplementary projects", which is

separated from and positioned slightly behind the product project portfolio.

The "supplementary projects" portfolio is assumed to encompass trivial product projects, i.e. typically smaller projects that for example aim at maintaining previously developed products. The "supplementary projects" portfolio is also assumed to include projects different from product development projects, i.e. projects related to the improvement of other aspects of the business.

In the following sections (5.3.6 - 5.3.11) the aspects outlined above and their relations are identified, discussed and described separately.

5.3.6 The idea portfolio

An idea encompasses a potential for change. This change may vary from an incremental change to a quantum leap change, and can be associated with many activities like products, marketing, production and distribution in the company's business system according to Tidd, *et al.* (2001). Thus ideas may be described as *potential* candidates for either the product project portfolio or other kinds of project portfolios. The idea portfolio results from the initial selections of ideas in the front end of innovation as discussed in section 5.3.3.

Potential projects

Two sub-portfolios

The idea portfolio may be perceived as consisting of two sub-portfolios with different kinds of ideas, namely *embryonic* ideas and idea *proposals*, which both appear from the reference model in concordance with the section illustrated on Figure 40. The main point of distinction is the completeness in the articulation of the ideas.

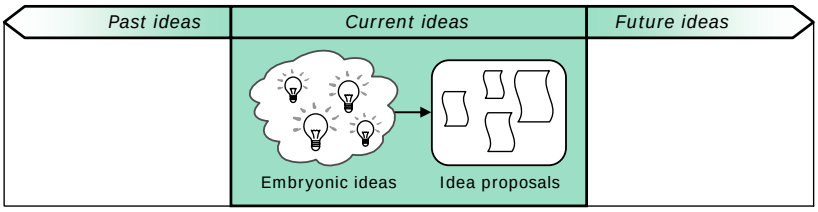


Figure 40. It appears from the reference model that the idea portfolio can consist of at least two sub-portfolios, namely embryonic ideas and idea proposals.

In the following it is argued that an idea proposal might signify the first potential and viable entry point to the portfolio management process, because it is the first formal documentation of an idea, which is visible and presented for the management.

Embryonic ideas

Embryonic ideas can be considered as the very first and informal articulation of an emergent idea. It is assumed that these early ideas are generated, circulated and considered on a continuous and informal basis in the various functional areas in the company. Embryonic ideas may emanate spontaneous between debating colleagues or e.g. from a salesperson's visit with a customer. Subsequently, the identified idea's viability may be informally discussed with colleagues in other functional

Informal evaluation

areas. The majority of these embryonic ideas may well be rejected during this informal idea evaluation process, since they may appear too speculative or lacking organizational support. Hence only a subset of this idea flora is ever proposed as potential new candidates for the product development portfolio.

Weak articulation

Embryonic ideas are important to a company, since they comprise a source of corporate renewal. However, it seems pointless (and next to impossible) to subject emergent ideas to portfolio management due to their elusive nature. Firstly, the articulation of emergent ideas is often weak and inconsistent due to their volatile nature. This aspect impedes the collecting of information needed for portfolio management. Furthermore, and perhaps most important, it typically does not require a noteworthy amount of resources to progress embryonic ideas to the next level of clarification by means of an idea proposal. Hence since resource allocation is a central dimension of portfolio management it does not seem to make sense to subject sprouting and speculative ideas to formalized portfolio management.

Idea proposals

First formal evaluation

If consensus in the organization regarding an emergent idea's quality exists, the preparation of an idea proposal may be initiated. A completed idea proposal may be regarded as the first formal documentation of an idea and it indicates a rise in the clarification of the idea. According to Smith & Reinertsen (1998) a way to define when a product idea enters the idea portfolio is when two conditions have been met. First the idea must be documented as an opportunity, and thus visible to management. Second, the technology to implement the idea must exist somewhere in the world. The second criterion is important because it marks the critical distinction between product development and technology development.

Hansen & Andreasen (2005) advocate that it is important that a product idea is defined and understood in at least eight dimensions in order to select the idea for further development according to Figure 41.

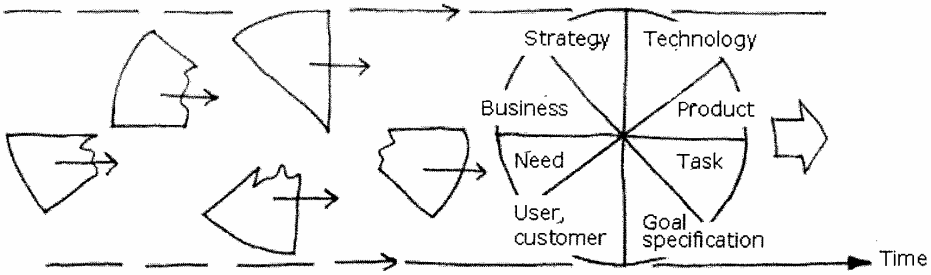


Figure 41. The product idea should be gradually developed in eight dimensions according to Hansen & Andreasen (2005).

When should ideas enter the PPM process?

Potential entry point

At this point it is relevant to raise the question regarding exactly *when* an idea is ready to enter the formalized portfolio management process. It is presumed that the completed idea proposal marks the first *potential* entry point for the idea proposal into the formalized portfolio management

process. This is due to two reasons. First, the idea is visible to the management since it is documented. Next, the progressing of the completed idea proposal into the development process typically necessitates a noteworthy amount of resources. Thus it may be relevant that the management evaluates and prioritizes ideas in order to decide which ones should be allocated resources and further pursued.

Early inclusion

At least three aspects speak for an early inclusion of the idea proposals in the project portfolio management process. Due to the fact that the idea portfolio represents potential new product candidates it also represents a vital opportunity for the management to guide the front end innovation and improve the business potential. Firstly, an early inclusion might be a strong way for the management to communicate their expectations toward idea contributions and the importance here of in the company. This may enhance the employees' motivation for pursuing ideation in the "right" direction. Second, it is commonly recognized that without a constant flow of ideas, a business is condemned to obsolescence. The inclusion of idea proposals in the formalized portfolio management process provides the management a vital opportunity to continuously and explicitly survey and assess vital information regarding the company's innovation proficiency. Examples of such information may be idea quantity and quality, idea types, degree of idea innovativeness, the frequency and source of ideas etc. Third, when the management requires the idea proposals included in the portfolio management process they signal attention towards the up-front preparation of projects. Cooper (1999) report that the quality of this early work is strongly correlated with financial performance.

Two different views

Cooper*, et al.* (2001b) found two different views regarding the point of inclusion of ideas in the portfolio management process. Some managers argue that projects should enter very early, i.e. at the idea stage. Hence the portfolio management process should not only consider *projects* already underway, but it should include brand-new *proposals* or ideas and make decisions based on those. Other argue that projects should enter at later stages, that is projects should pass at least one or two gates in the development process before they are included in the portfolio management process. Cooper reports that the majority of firms took the latter position, allegedly because they regard proposals at this stage too weakly defined for decision makers to consider or because the implied resource commitment is insignificant.

The model

The proposed model illustrated in Figure 40 does not attempt to prescribe at what stage of clarification an idea or a project should enter or exit the project portfolio management process. Rather, the model recognizes and accommodates the description and consideration of both approaches.

5.3.7 The product project portfolio

As indicated in section 1.2 a project can be defined as a temporary, unique endeavour undertaken to create a product or service within defined parameters. Thus a product project comprises a *potential* candidate for the *product* portfolio. The project portfolio originates from the selected product idea proposals which subsequently are transformed into projects.

Product projects may result in the development of a radically new product or a product based on a more or less extensive manipulation on previously developed products already introduced on the market. Thus these projects typically are intended to generate revenue within a foreseeable time horizon. Furthermore, these projects have in common that their realization seems to follow a formalized and systematic development process.

Three variants

Three variants of the product project portfolio might be considered as indicated in section 5.3.5, namely the past, current and future project portfolio. These variants are described in the following sections.

5.3.7.1 The past product project portfolio

The portfolio of past projects refers to the sum of all product projects the company has undertaken over time. The portfolio is historical in the sense that these projects are considered either complete or cancelled, and thus do not consume resources or otherwise require management attention. The outcome of such projects, i.e. the products, however, may well still be sold and supported on the market. This facet is described separately in section 5.3.8.

5.3.7.2 The current product project portfolio

It emerges from the suggested reference model that the project portfolio might be perceived as composed of at least two sub-portfolios with different kinds of elements, namely *pre-projects* and *main projects*.

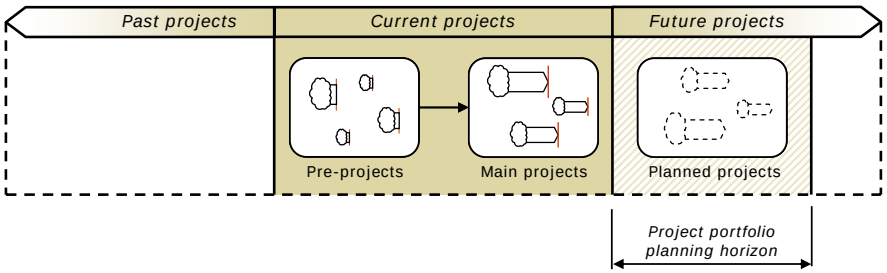


Figure 42. The project portfolio might consist of at least two sub-portfolios, namely pre-projects and main projects.

Two sub-portfolios

In the following it is argued that it is beneficial to distinguish between these sub-portfolios during project portfolio management, due to their distinct characteristics.

Pre-projects

An element is assumed to enter the *pre-project* portfolio at the moment when an idea proposal has been selected and resources for its further investigation have been allocated.

Preparatory phase

The investigation might possibly be carried out during the *preparatory* phase, which precedes the actual development of the project in accordance with Andreasen & Hein (2000) who writes:

"A preparatory phase is therefore set going, with the aim of creating a well-defined project objective …".

Project proposal

They suggest that the output from this phase is a concrete *project proposal* with a description of how the idea can be realized and at what cost. The proposal does only provide a vague sketch of the expected commercial results and the scope of investment needed. Cooper (2001) does also recognize the existence of the phase which he describes as:

"*… a detailed investigation stage that clearly defines the product and verifies the attractiveness of the project prior to heavy spending*".

He suggests that the aim of this phase is to define the product and the business, which include target market definition, delineation of the product concept, specification of a product positioning strategy, product benefits, desired features and the value proposition.

Substantial resource allocation

Based on the project proposal the management can decide which projects to start. Andreasen & Hein (2000) denominates this particular decision as the managements "purchase" of the project, because the decision represents the management's commitment to allocate significant amounts of resources to the project in order to bring it into the development phase. Hence the "purchase" of a project is one of the central decision points for portfolio management.

Main projects

The moment when a pre-project, i.e. a project proposal, has been completed and it has been selected for further realization and resources for its execution have been allocated, can be identified as the transition point between the *pre*-project portfolio and the *main project* portfolio. At this point the projects business specification along with detailed plans for the realization of the idea has been prepared.

Development phase

The execution of a main project implies that the prepared development plans are translated into concrete deliverables while the product is physically developed. Ulrich & Eppinger (2004) suggests this is implemented by means of formal and structured methods throughout four distinct phases:

- *System level design* involves the definition of product architecture and the decomposition of the product into subsystems and components together with functional specifications.

- During *detailed design* the complete specification of the geometry, tolerances etc. are prepared. Furthermore, the process plan for each part to be fabricated within the production system is established.

- *Testing and refinement* includes the construction and evaluation of multiple pre-production versions of the product, in order to check performance and reliability.

- During *production and ramp-up* the product is made using the intended production system. The transition from production ramp-up

to ongoing production is usually gradual. At some point in this transition, the product is launched and becomes available for widespread distribution.

Before a main project is allowed to progress from a phase to the following phase it is reviewed to confirm that the phase is completed and to determine whether the project proceeds.

The output

Besides the actual product the output of the development phase is the established production and sales activities, which is a prerequisite to market the idea.

Decision points during project execution

Based on studies of industrial practice Cooper, *et al.* (2001b) reports, that once past the "go to development" gate, projects often are not reprioritized. They are simply "in the portfolio", unless they turn sour. However, theory suggests that every now and then decisions are made during projects which imply additional heavy resource allocation aimed at preparing the manufacturing system. Andreasen & Hein (2000) writes:

"A crucial point here is the decision on whether to invest in production equipment, at which point careful evaluation of the project must take place".

This implies that is relevant to consider at least one additional decision point during main project execution, since resource allocation is a fundamental facet of portfolio management. Hence in order to compare projects at a similar stage of clarification and decision-making, a third sub-portfolio may be introduced into the product project portfolio. The relevance of such a third project sub-portfolio, however, is assumed to depend on the industry in question. Whereas it may be important within traditional manufacturing industry it might be less crucial within software or service development, since the investment pattern may differ.

5.3.7.3 The future product project portfolio

The execution of pre-projects as well as the completion of main projects typically requires a notable amount of resources, which currently may not be at hand. For this reason it is assumed that neither pre-projects nor main projects are automatically initiated. First they are subjected to a planning activity which might result in either the immediate execution of the project or a postponing for future execution.

Planned projects

From a resource consumption perspective it thus can be relevant to distinguish between the *planned* project portfolio and the current project portfolio as illustrated on Figure 42.

Planning horizon

The time span from present time to the point in time when the last project contained in the plan is expected completed designate the planning horizon for the project portfolio.

From planned to current project

The moment when a pre-project or a main project is progressed from the planned project portfolio to the current project portfolio, can be defined in several ways. Smith & Reinertsen (1998) suggests that a rigorous marker

is when the team has been fully staffed, since little will in reality happen without a team in place.

5.3.8 The product portfolio

Three variants

The product portfolio can also be considered as composed of a past, current and future product portfolio. These variants are depicted on Figure 43, and described in the following sections.

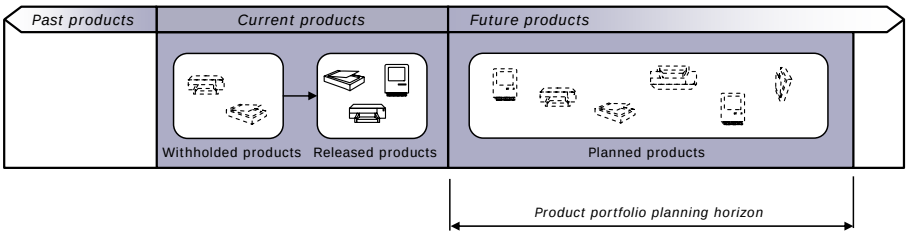


Figure 43. The product portfolio can be considered as composed of a past, current and future variant of the product portfolio.

5.3.8.1 The past product portfolio

The portfolio of past products refers to all the products the company has developed over time. This portfolio is historical in the sense that these products for various reasons not are offered for sale to customers anymore. Thus they neither consume resources or otherwise require management attention nor do they contribute with revenue.

5.3.8.2 The current product portfolio

Once development is over, the main project exits the development portfolio and the realized product enters the company's portfolio of current products.

Release for sale

At this point no more "purchase"-decisions resulting in heavy resource allocation typically needs to be made. However, according to Andreasen & Hein (2000) another vital decision needs to be made:

"Of equal importance is the decision as to whether to release the product for sale, where the reputation of the company is at stake and where one has to commit oneself in relation to one's customers".

Hence products are not necessarily launched in the market place immediately after development. Andreasen, *et al.* (1989) writes:

"It is important to distinguish between the moment of technical and commercial readiness".

Situations arise where a product launch is terminated or has to await the development of other products, the establishing of distribution channels, or perhaps the proper "window of opportunity".

Two sub-portfolios

This facet is captured in the model by means of the sub-portfolio denominated "withholded products". A product is assumed to progress from the latter to the portfolio of released products when the product has been launched into the market, and thus is available for paying customers.

The content of a product portfolio

In order to describe a product portfolio Booz-Allen & Hamilton (1982) in Cooper (2001) suggests that products can be classified according to their newness in a company dimension and a market dimension as illustrated on Figure 44.

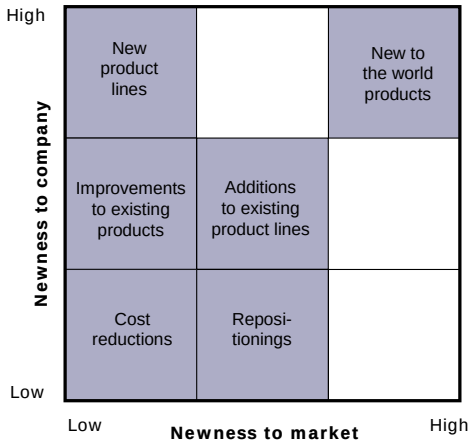


Figure 44. A product's newness can be defined in a company dimension and a market dimension (Booz-Allen & Hamilton 1982).

Hence a product development project may result in a radically new product or a product based on a more or less extensive manipulation on previously developed products:

New to the world products: These new products are the first of their kind and create an entirely new market.

New product lines: These products are not new to the market, but are new to the company. They allow a company to enter an established market for the first time.

Additions to existing product lines: These are new items to the firm, but they fit within an existing product line that the company already produces. They may also represent a fairly new product to the marketplace.

Improvements to existing products: These "not-so-new" products are essentially replacements of existing products in a company's product line. They offer improved performance or greater perceived value over the "old" product.

Repositionings: These are essentially new applications for existing products and often involve retargeting an old product to a new market segment or for a different application.

Cost reductions: These are the least "new" of all new product categories. They are new products designed to replace existing products in the line, but they yield similar benefits and performance; but from a design and production viewpoint, they could represent significant change to the firm.

From speculations to facts

The portfolio management task changes significantly when a product has been launched as indicated in section 5.3.4. Now the focus is on monitoring what happens to the product in the market, to initiate modifications and finally to decide when and how the product is to be discontinued. Hence we see a fundamental shift in the nature of portfolio decision making. Where it previously has been based on speculations on how the product *may* perform, it is now based on hard facts derived from the products *actual* market performance.

An important factor

The importance of including considerations regarding the *product* portfolio in the management of the development portfolio is supported by EIRMA (2002). They write:

"The existing product portfolio is an important factor in assessing this balance [by which individual R&D projects are distributed in different categories].

This enables the life cycle management of products to be properly executed - the cradle to grave concept - and will also allow a better appreciation of the correct portfolio balance relative to the strategic drivers".

5.3.8.3 The future product portfolio

The proper business wise exploitation of product development requires the timely introduction of a stream of products which in aggregate provide a continuous and adequate coverage of target segments.

Planned products

In order to accomplish this purpose, potential products are subjected to a planning activity. It might result in a plan that outlines the products to be developed by the company sequenced in time for their introduction to the market as illustrated on the right part of Figure 43.

From planned to current product

One way to identify the moment when a product is progressed from the planned product portfolio to the current product portfolio is when the development is complete and the product is ready for release.

Planning horizon

The time span from present time to the point in time when the last product contained in the plan is expected launched designate the planning horizon for the product portfolio.

5.3.9 The technology portfolio

Three variants

Three variants of the technology project portfolio might be considered as indicated in section 5.3.5, namely the past, current and future project portfolio. These variants are illustrated on Figure 45, and described in the subsequent sections.

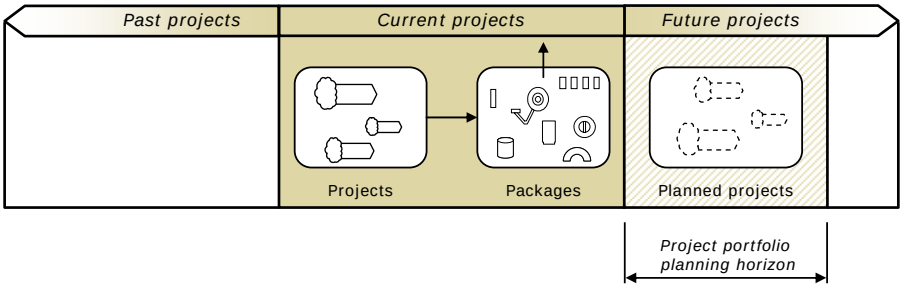


Figure 45. The reference model explicate that the technology project portfolio also might be considered as composed of a past, current and future variant of the project portfolio.

5.3.9.1 The past technology project portfolio

The portfolio of past technology projects refers to the totality of all technology projects the company has carried out over time. The portfolio is historical in the sense that these projects are considered either complete or cancelled, and thus do not consume resources or otherwise require management attention. The outcome of such projects, i.e. the technologies and technology packages, however, may well still be utilized and embedded in current and future product projects.

5.3.9.2 The current technology project portfolio

It is considered crucial to distinguish between the technology portfolio and product project portfolio during portfolio management due to the great differences between the portfolio types. Thus the technology portfolio is illustrated separately on the model, and emphasized on the section shown on Figure 45.

Technology projects

According to Probert*, et al.* (2004) technology can be broadly defined as the "know-how" of the firm, which emphasizes the applied nature of technological knowledge. Technology projects are intended to provide a technological basis for products. They are typically long term projects of a highly strategic nature which are not being directly pulled by the market. Hence, they are not supposed to generate short term revenue by them selves. Furthermore, for most companies' product development is essentially a known, predictable, and repeatable process. Ajamian & Koen (2002) refer that 70-85 percent of the process is the same from product to product, even for a totally new offering. This is not the case with technology projects. The often explorative and uncertain nature of technology projects implies a higher risk level than usually associated with product development projects. Furthermore, due to the unpredictable nature of technology development the "purchase" or investment decision points may be less predetermined than for product projects, because it does not fit the systematic pattern of the product development process.

Despite this matter Andreasen & Hein (2000) reports that it is a common approach in industry to carry out technological development within the framework of a product development project. The lacking ability to manage technology projects separately, however, is frequently the cause of cancelled or significantly delayed product development projects. One

reason is that it often is difficult to determine when the new technology is ready for transition to product development. Thus the synchronization between technology development and product development is jeopardized.

Risk reduction

The separation of technology development from product development is widely accepted as a means to overcome this problem and to reduce risk. For example, Ajamian & Koen (2002) recommends that a distinct technology stage gate (TechSG) process, is needed to manage technology development efforts when there is high uncertainty. According to Schwartz, *et al.* (2004) it is difficult to know with certainty whether a technology based project should be managed with a distinct technology development process. They write:

"Realistically, the choice is often based on management judgment rather than on quantitative evaluation".

Schwartz and colleagues suggests that the management should consider the seven dimensions illustrated on Figure 46 when they are determining whether a project should be managed as a technology project or a product development project.

Product platforms

Technology projects span fundamental research programs to platform projects. In particular the development of product platforms has received significant attention over the last decade, because they play a central role in enabling the creation of product variety (Harlou 2006). Robertson & Ulrich (1998) defines product platforms as intellectual and material assets shared across a family of products. According to Cantamessa (2005) platform projects may be described as large-scale projects whose main goal is to create a technological basis and/or a shared set of components. Platform projects may often require extensive investments and therefore every attempt is made to incorporate them into several products.

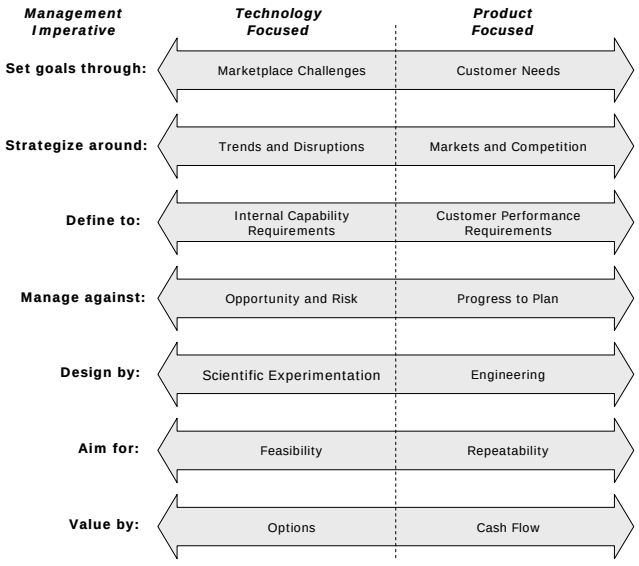


Figure 46. Differing attributes of technology development and product development according to Schwartz, *et al.* (2004).

Hence when a platform first has been developed the firm may base a set of smaller (in terms of cost and development time) derivative product development projects on this platform.

It is evident that the development of platforms is a crucial prerequisite to modern product development. Cantamessa argue that platform projects do not only link to the derived products, but also to the utilization of particular technologies.

Technology packages

Besides *technology projects* the technology portfolio is assumed to contain a second sub-portfolio with different kinds of elements, namely *technology packages* which represents the outcome of technology projects. In the following it is suggested that it is beneficial to also distinguish between these two sub-portfolios during portfolio management, due to their dissimilar nature.

Technology packages

Once the development of a technology is over the realized technology enters the portfolio of technology *packages* which according to Andreasen, *et al.* (1989) can be described as *off-shelf* technology. They write:

"During a product development project the prepared technology packages are taken off-shelf and embedded in the product".

The principle is illustrated on Figure 47 below.

Technology maturity

The moment when a technology project is completed, i.e. the technology is ready to enter the technology package portfolio, depends on the *maturity* of the technology. It is difficult to prescribe exactly when a technology is ready for inclusion in a product development project. Rather, it is assumed to be highly variable depending upon on the individual company's preferences and industry characteristics.

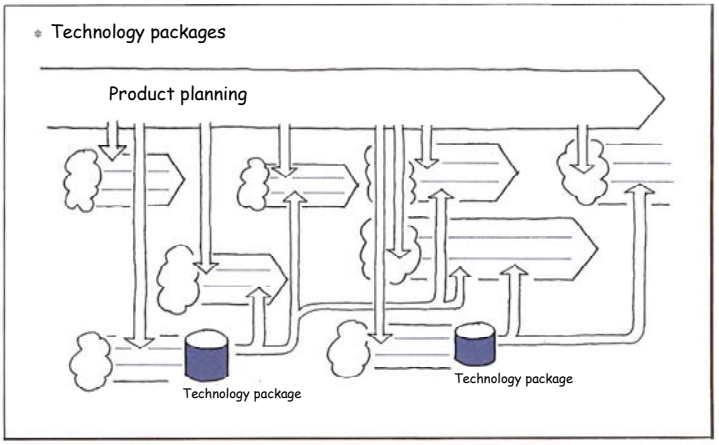


Figure 47. A coherent planning of technology- and business oriented development is necessary (Andreasen, *et al*. 1989).

The acknowledgment of prepared technology packages as an approach for risk reduction is addressed in the model by means of a separate and explicit technology package portfolio.

5.3.9.3 The future technology project portfolio

Similar to product projects the execution of technology projects also requires a significant amount of resources, which currently may not be at hand. For this reason it is assumed that technology projects are not automatically initiated. First they are subjected to a planning activity which might result in either the immediate execution of the project or a postponing for future execution.

Planned technology projects

From a resource consumption perspective it thus can be relevant to distinguish between the *planned* technology project portfolio and the current technology project portfolio as illustrated on Figure 42.

Planning horizon

The time span from present time to the point in time when the last project contained in the plan is expected completed designate the planning horizon for the technology project portfolio.

From planned to current project

The moment when a technology project is advanced from the planned portfolio to the current project portfolio, can be identified as the moment when the team has been fully staffed. Little will in reality happen without a team in place.

5.3.10 Supplementary projects

The portfolios denominated "supplementary projects" on the model is separated from and positioned slightly behind the product project portfolio as stressed on Figure 48. The purpose is to acknowledge the fact that it is not likely that all projects in a company is subjected to the same formalized portfolio management.

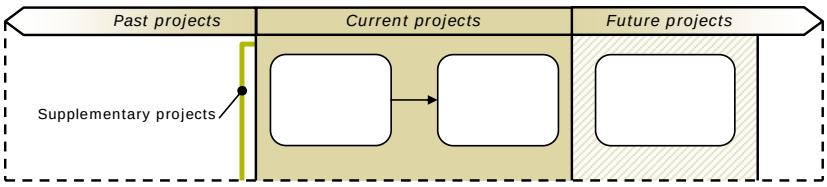


Figure 48. The reference model acknowledges that projects might exist outside the formalized portfolio management process.

Such projects may be un-enacted, i.e. the projects might exist outside the purview of management in concordance with the findings of Blichfeldt & Eskerod (2005).

By separating out projects distinct from product and technology projects the proposed model reflects the fact that portfolios consisting of different project types require different management approaches. In an ideal world it might make sense to include all project types together in the same portfolio management process. The question, however, is whether this is feasible in reality, because it does increase the magnitude and complexity of the portfolio problem according to Cooper, *et al.* (2001b). The

inclusion of all projects implies that a huge amount of information needs to be managed and different portfolio management approaches needs to be applied. Dawidson (2006) found that if *all* project types are to be included in the portfolio management process then:

"*… the process of selecting projects for the portfolio must allow taking into account different strategies, different ways of evaluating projects, and involvement of managers representing different areas of knowledge*".

The suggested model accommodates this recognition by means of the "supplementary projects" portfolio. This may well compete for the same resources. Therefore these projects have to be factored in during decision making regarding e.g. resource allocation.

The portfolio of supplementary projects is asserted to comprise trivial product projects and other projects. These projects together with the relevance of this distinction are discussed in the following.

Trivial product projects

In general not all product development projects result in extensive innovation in the resulting product. Some projects aim at supporting previously developed products, and such projects can be characterized by routine. Examples of these projects are design modifications with small evolutionary improvements aimed at maintenance, cost reduction, and product enhancements.

Such a project may not require significant resources, nor have the potential to change the company's strategic direction. If all such projects should be approved by senior management it might result in needless bureaucracy. This is supported by Archer & Ghasemzadeh (1999), who writes:

"- the likelihood of making sound business choices may be compromised if large numbers of projects must be considered unnecessarily".

Hence from a senior management perspective decision making regarding the initiation and execution of such projects may be considered as a triviality.

Other projects

Other projects are assumed to constitute projects related to the improvement of other aspects of the business, i.e. projects different from product projects, such as e.g. capability development projects in accordance with Patterson 2005.

In congruity with the findings of Dawidson (2006) it seems that the fundamental difference in project types complicates their comparison. Firstly, it seems reasonable to assume that there are significant differences in the nature of new product projects and, for example, a business development project aiming at establishing a strategic partnership with another company. Next, the projects within the latter category may not follow a process comparable to the formalized and systematic product development process. Finally, it is obvious that projects within this category often will not be manifested as physical

products. Rather, the outcome may be of an intangible nature. A capability development project may, for example, result in a new distribution channel. Consequently the product life cycle concept may not apply for the outcome of these projects. These characteristics emphasize the relevance of distinguishing between product projects and other projects during portfolio management.

5.3.11 Portfolio manipulations

As asserted in section 5.3.5 each of the portfolios may well be managed differently due to their dissimilar nature. It follows that each of the portfolio classes can be manipulated individually. This is important to explicate on the reference model since it conveys an understanding that it is possible to improve the potential value of a product portfolio in stages. This characteristic is highlighted on Figure 49.

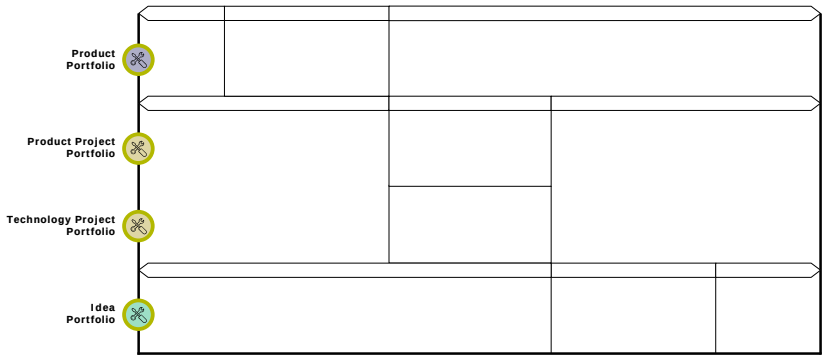


Figure 49. Each portfolio can be manipulated individually.

Potential manipulations

Decision-making regarding the composition of one or more of the portfolios described in section 5.3.5 is assumed to open into one of the following two basic decisions: either to do nothing, i.e. manipulations are not executed on the portfolio in question or the opposite, i.e. manipulations are executed on the portfolio.

The consequence of the latter choice may be to *add, remove* or *change* one or more elements (i.e. an idea proposal, a pre-project, a main project, or a product) within one or more of the portfolios. The implicit assumption is that the manipulation results in portfolios which are intended to have a higher degree of "goodness" than the initial portfolios.

5.3.12 The business environment

Portfolio decision making does not take place in isolation. Rather, portfolio management takes place under influence and consideration of factors originating from the company *external* and *internal* business environment. Both factors are indicated on the reference model as pointed out on Figure 50, and discussed in this section.

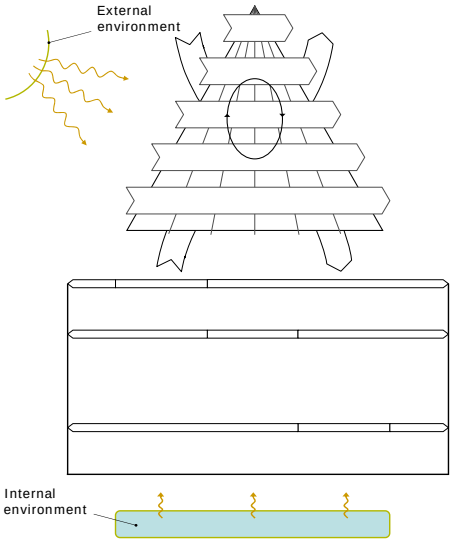


Figure 50. The model acknowledges that portfolio management is subjected to company external and internal factors, which may be in- or outside the company's sphere of control.

The external environment

The external business environment encapsulates many different influences which are outside the company's sphere of control. Never the less it is important that these influences are factored in during strategic decision making since the influences in sum forms a view of the really important developments taking place around the organization according to Johnson & Scholes (1999). This is emphasized by Andreasen & Hein (2000) who writes that product planning includes:

"… setting product development projects in motion against a background of indications from the world outside".

The external environment comprises numerous aspects like for example, competitive intensity, customer needs, market trends, legislation, and social, political and environmental issues. The careful appreciation of such aspects leads to an understanding of the attractiveness of the industry in which the business resides. The "five-forces" framework proposed by Porter (1980) is among the most famous approaches for profiling an industry's attractiveness.

EIRMA (2002) does also recognize the necessity of considering aspects related to both the external and internal business environment when they write:

"Let us consider how changes in common internal and external business drivers affect the portfolio alignment and balance and the company's future".

Examples of such portfolio *drivers* or *parameters* are reported in section 4.3. It is evident that it is of crucial importance for the management to understand the external influences on the company in order to do proper

resource allocation between the wide arrays of projects competing for a share of the resources. For this reason this aspect is recognized and explicated on the model.

The internal environment

As indicated in the previous section portfolio decision making also encompass considerations regarding the company's internal business environment. This is further supported by Archer & Ghasemzadeh (1999) who write:

"Strategic decisions concerning portfolio focus and overall budget considerations should be made in a broader context that takes into account both external and internal business factors, before the project portfolio is selected".

The internal environment extends beyond the company's R&D department, and includes aspects inside the company's sphere of control which contributes to the procurement of products. This consists of the capability to perform product development at the level which is required for success given the environment surrounding the company.

Three main factors

Johnson & Scholes (1999) advocate that the strategic capability of a company can be related to three main factors: the *resources* available to the organization, the *competence* with which the activities of the organization are undertaken and the *balance* of resources, activities and business units in the company. Resources and competencies do not only relate to human resources. Rather, it should be perceived in a broad sense including production facilities, distribution channels, technologies, product brands, sourcing partnerships, alliances etc. In sum it constitutes the *fundament* of the firm, which supports the development and delivery of competitive products and services.

It seems reasonable to assume that the better we understand a company's resources and competencies the more likely we can obtain a realistic picture of the company's strengths and weaknesses in relation to the external environment wherein the company operates. It follows that such an understanding strongly influences portfolio composition. It improves the probability that the resulting portfolio is congruent with and exploits the company's development capability, i.e. the organization can support the portfolio, and is capable of completing it over the planning horizon.

Like in the case with the external environment it seems that a thorough understanding of the company internal influences also is necessary for sound portfolio management. Accordingly this facet is also acknowledged and illustrated on the model.

5.3.13 The impulse

Decision-making regarding the portfolio composition is assumed to be initiated by means of an *impulse*, which has central implications for the portfolio decision making activity. The impulse is depicted on the reference model, and accentuated on Figure 51.

The impulse may origin from company external sources like customers, competitors or internal sources like, for example, when a new product idea is suggested or resources needs to be shifted between projects. The impulse may be recorded anywhere in the company and communicated into the portfolio management process in many different and subtle ways.

For example, a salesperson may have noticed that needs exist within a customer group, which is not currently addressed by a product or service on the market. Next, the salesperson may informally discuss his observations with a product manager, and together with the R&D manager they may conceive the first embryonic ideas for a relevant new product. If consensus regarding the idea's quality exists in the organization, the preparation of an idea proposal might be initiated as suggested in section 5.3.5. Subsequently, the idea can be suggested at a portfolio review as a potential new product candidate for the portfolio.

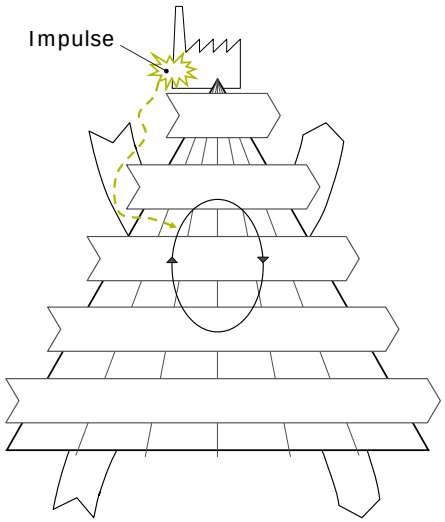


Figure 51. Portfolio decision making is initiated by means of an impulse originating from company external or internal sources.

The situation outlined here is an example of portfolio decision-making initiated by an impulse stemming from company *external* sources. The development of a new technology and its exploitation in new or existing products may serve as an example of an impulse stemming from company *internal* sources.

Events drive portfolio management

The recognition of the impulse is fundamental, since it reminds us that portfolio management is not a rigid and mechanistic exercise dictated by the portfolio reviews scheduled in the calendar. Rather, the model explicates that the calendar (indicated by means of the time domains) reminds us, but events drive portfolio management. Thus it is central to acknowledge the dynamic environment and to allow flexibility and different patterns of reaction.

5.3.14 PM and integrated product development

The literature review revealed that different authors use different terminology about the process aspect of portfolio management. In particular the term "portfolio management" is absent in the framework for

integrated product development proposed by Andreasen & Hein (2000). Instead they adhere to the concept of product planning, which for example Cooper, *et al.* (2001b) do not refer to. It was, however, concluded in section 4.4.5 that the different uses of the terms basically are pointing to the same core phenomenon.

Since the theory of the product development process has been chosen as the scientific view point for this research it is relevant that the proposed model is consistent with this theory. The aim of this section is to render probable that this is the case.

As we recall from section 3.3.1 product development can be described on four levels, namely product planning, product development, product synthesis and problem solving. However, since this research primarily relates to the product planning and product development levels the justification will focus on how the model appears to be congruent with and capable of encompassing these two levels. They emerge from the model as accentuated on Figure 52.

The product planning level

The findings from section 4.3.4 indicate that evaluation and selection between candidate projects for the development portfolio occurs as interplay between three processes: strategy and portfolio planning, portfolio review and the product development process. These processes are all explicated on the suggested model.

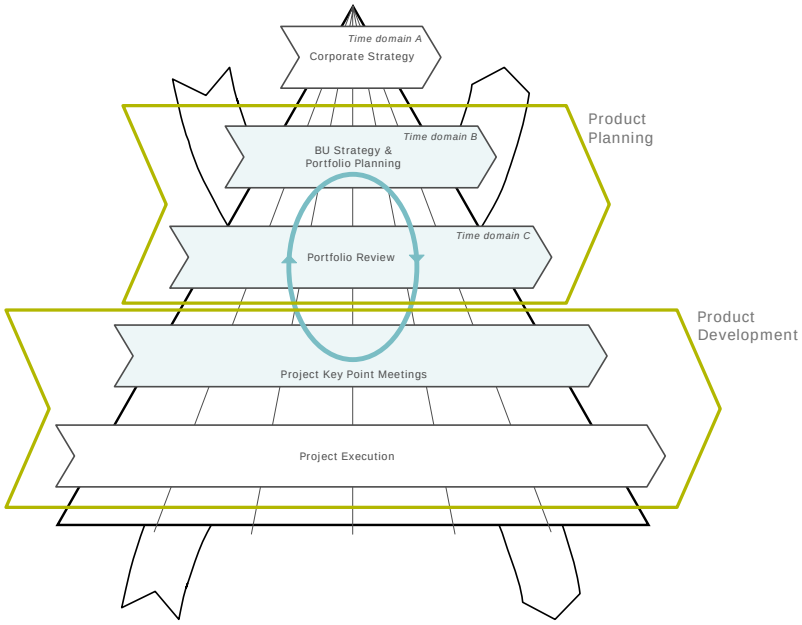


Figure 52. The model encompasses portfolio management in relation to the two top levels of integrated product development.

Portfolio planning

It appear realistic to assume that the strategic oriented portfolio planning process occurs within the domain of product planning, since product planning comprise the *basis* for development of new business according to Andreasen & Hein (2000). Additionally, the concept of integrated product development recognizes the existence of such a process when

Andreasen, *et al.* (1989) describe how product plans should be prepared annually by a strategy group in advance of the budget.

Portfolio review

Similarly, the portfolio review process is presumed to be embedded in product planning. This is supported by Andreasen & Hein (2000) who advocate that after a project has been approved the role of management is to:

"… make the decision to start, and to monitor whether the group of current projects together appears, with a reasonable degree of probability, to be leading to the required commercial results".

This cannot occur during key point meetings since the focus here is on the individual project – not the aggregate set of projects. Hence the described monitoring activity seems to occur within the domain of product planning.

Strategic nature

Both processes are positioned in the upper half of the decision hierarchy in order to symbolize the strategic nature of this work. Similarly, the product planning level in integrated product development is illustrated as the top level in the framework overarching the remaining processes.

Integration

The processes spans across the decision-hierarchy in order to emphasize the importance of cross-functional involvement during product development. The same aspect constitutes the core of integrated product development.

Product planning is more

As stated in section 1.2 this research adheres to the definition of portfolio management proposed by Cooper *et al*, 1997, which solely focuses on evaluating, selecting and prioritizing between candidate projects for the development portfolio. However, product planning is more than this. According to Andreasen & Hein (2000) it also encompasses determination of strategy, business search, follow-up of product development and supervision in order for the management to close the loop of Figure 2 (p.33). It seems reasonable to assume that the proper execution of these activities is a crucial *pre-requisite* to perform portfolio management as defined by Cooper, *et al.* (1997b). Thus Cooper and colleagues argue that it is almost impossible to perform effective portfolio management without a well defined product innovation strategy. Similarly, a steady stream of quality ideas for new products is a prerequisite for maintaining a strong development portfolio.

Activities beyond evaluating, selecting and prioritizing between candidate projects for the development portfolio are not explicated on the model, but are assumed inherent in the indicated product planning process.

Conclusion

In sum it seems sensible to suggest that the portfolio planning and portfolio review processes on the proposed model are in concordance with the product planning level of integrated product development.

The product development level

The primary difference between the development process on the proposed model and the product development level process in integrated product development is that the former is decomposed into two processes, namely a key point review process and a project execution process.

Two processes

The purpose is to distinguish between the actual executions of tasks within projects from the project milestone meetings. According to Cooper, *et al.* (2000) the latter process is crucial for portfolio management. Hence this process is positioned above the project execution process.

A sub-process

Both processes are positioned at the lower half of the decision hierarchy in order to symbolize the operational nature of this work. Similarly, the product development level in the integrated product development framework is illustrated as a sub-process to product planning.

Integration

The processes range across the decision-hierarchy in order to accentuate the necessity of involving staff from various functional areas in the company during product development. The same aspect is highly stressed in the concept for integrated product development.

Conclusion

Hence it appears reasonable to suggest that the model encompass the product development level in accordance with the framework for integrated product development.

5.4 The framework cannot stand alone

A framework which explicates the central elements and principles inherent in portfolio management in a company context has been suggested and described in the previous sections. The framework is intended to constitute a proper support of the company's management during implementation of portfolio management. However, it is central to recognize that the framework does not constitute a solution to portfolio management on its own behalf since it does not deal with all of the challenges inherent in portfolio management. For example, the model covers the parameters which we can manipulate in order to achieve a portfolio which meets the three high level goals of portfolio management. The model, however, does not devise how the parameters should be adjusted in order to realize a balanced and high value portfolio which is strategic aligned.

Moreover, it is recognized that the implementation of elements in the framework should be complemented with a least three other dimensions as illustrated on Figure 53, namely organizational setup, tools and methods, and management mindsets. The specific application of these dimensions requires customization in order to integrate portfolio management activities with existing company systems, processes and methods.

Degree of implementation differs

It is assumed that all the tasks contained in the reference model needs to be solved regardless of the company's size. It is only the degree of implementation which differs.

The organizational dimension was investigated in detail in section 4.5, and it concerns roles, responsibilities and inter-functional involvement during portfolio management. Similarly, tools and methods were scrutinized in section 4.6. The mindset dimension, however, is briefly discussed in the following.

Mindsets

Even though the process, organization and tool play an important role in portfolio management it is not sufficient to perform proper portfolio management. Andreasen (2003) emphasize the paradox with the following analogy:

"It is impossible to buy a violin and get one proper tone out of it, if you have never played a violin before".

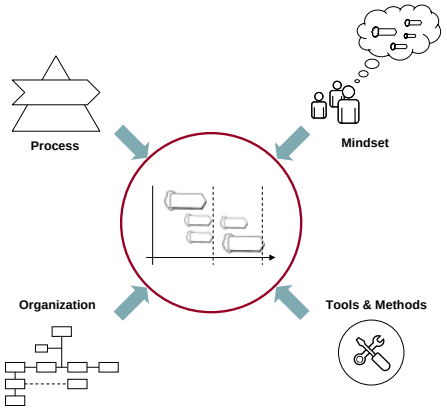


Figure 53. The implementation of portfolio management should be introduced as a broad programme encompassing at least four dimensions: process, organization, mindset as well as tools and methods.

Similarly in portfolio management it is a pre-requisite that the people involved in portfolio management demonstrate an appropriate behavior and a professional approach based on a proper perception, i.e. mindsets, of the tasks to be solved. Thus mindsets are made up of high-level knowledge, which imparts people the appropriate values, beliefs and attitudes towards portfolio management. For example, it is central that the management has knowledge about the importance of composing a *balanced* and *strategic aligned* portfolio.

Mindset implementation

According to Mørup (1993) the management can be imparted a mindset in at least three ways. Attuned to portfolio management they are:

- Direct confrontation with the 'effects' of portfolio management.
- Documented company policies/visions, formulated values.
- Visually based methods, explanatory models, methods, tools, and techniques which have a very graphically mode of expression.

This research contributes with a visually based mindset which explicates some of the effects of portfolio management in section 6.3. The proposed mindset is based on an assumption that resource shortage in product development may be caused due to an unrealistic perception of the product development capability among the management team within the company.

In addition, the research also contributes with three tools which can be used in combination to map the dynamic development portfolio starting from the individual projects. They are introduced in chapter 7.

5.5 Summary

Based on the fulfillment of eighteen stated propositions the research has introduced a reference model which captures some of the central elements and key principles inherent in portfolio management. It consists of a set of distinct and interconnected concepts, which in total comprise the portfolio management process in a company.

The relationship between the declared propositions and the suggested reference model is pinpointed on the overview presented on Figure 54 on the following page.

The unifying framework represents a conceptual model for supporting the company's management during the implementation of portfolio management in industry, together with providing a bridge to the theoretical foundations that underpin portfolio management practices.

Since the proposed framework originate from a research effort some kind of verification of its validity is essential. Thus attempts to verify the model is presented in the following section 5.6.

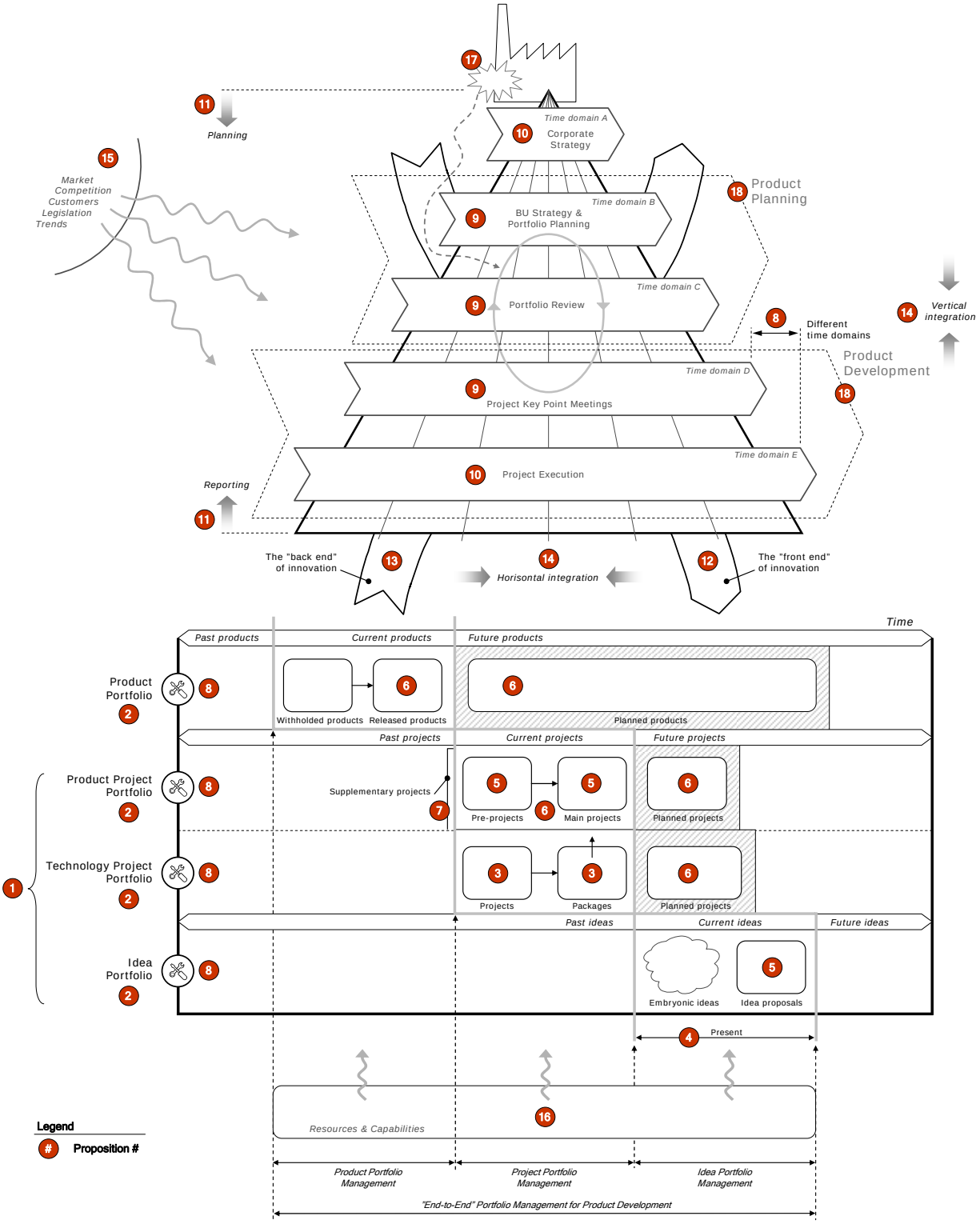


Figure 54. Principles and elements inherent in the suggested reference model reflect the propositions declared in section 5.2.

5.6 Verification

5.6.1 Introduction

Aim

The aim of this section is to verify the proposed reference model's ability to contain a true and fair view of industrial portfolio management elements and principles.

A challenge

It is well-known that verification of contributions within design science forms a challenge due to the stochastic nature of the design process and the immense number of influencing factors according to Buur (1990).

For example, one just has to think of the "five-forces" framework proposed by Porter (1980). How can its validity be truly verified? It is simply not possible to make a test to check whether the suggested framework is true or false. Yet it is among the most famous approaches for profiling an industry's attractiveness.

Approach

Verification of the reference model suggested by this research is attempted by qualitative means, namely logical verification and by demonstrating the model's ability to explain portfolio management principles in practice.

Logical verification

The logical verification includes logical reasoning, i.e. the sections which describes the distinct and interconnected concepts, represents a line of argumentation to show that the concepts embedded in the framework conform to a theoretical basis, and are internally consistent.

However, it is recognized that even though each individual concept appear valid in isolation it is not guaranteed that the resulting framework comprising all the concepts *per se* is valid.

Demonstration

Next, in order to further verify the framework, its ability to describe the portfolio management in a company is examined. This is carried out by structuring and describing observed industrial portfolio management practices derived from empirical studies in four companies during this research according to the framework.

Structure of section

Firstly, the conditions underlying the empirical study are explained. Next, the observations from the study of four companies are reported. This is carried out by structuring and describing the observed industrial portfolio management practices according to the principles explicated in the framework. Finally, a conclusion is presented in the last section.

5.6.2 Conditions for empirical study

In the following sections the model's ability to contain and explain industrial portfolio management practices is examined. This is done by confronting the central principles in the framework previously reported in section 5.5 with industrial portfolio management practices derived from empirical observations in four companies during this research.

Not de facto standard

All the cases origins from companies with several business units or divisions dispersed across many geographical locations. It is important to recognize that the reported practices cannot be regarded as an expression of a de facto standard for portfolio management for the involved companies. On the contrary, different business units may very well perform portfolio management differently as well as utilizing different vocabulary for similar aspects of the discipline.

A state of development

Furthermore, none of the companies engaged in this research report that they perceive their portfolio management practices to be in a condition of continuity and repeatability. Rather, they characterize their practices as "experimental" and in a state of development. This was also the reason given from one company when they declined to participate in the research.

In fact, some companies indicated that they only recently have begun addressing portfolio management for product development explicitly as a reaction to business performance problems. In other words, when a crisis arise which challenges the company's continued survival the top management appears to be more motivated to prioritize how the development resources should be deployed.

Confidentiality

Obviously, a company's portfolio management practices are a highly sensitive matter since it concerns a business process which is vital for corporate prosperity. Accordingly, it has not been possible to get unlimited access to all relevant aspects. Much information and many documents, however, have been provided. The material in its entirety is believed to represent a plausibly indication of contemporary industrial portfolio management practices. In order to reproduce the material in this thesis all types of company specific information related to industry sectors, actual projects and products have been removed or disguised.

Different level of detail

It has not been possible to carry out each case study with the same level of detail. Consequently is has not been possible to observe practices corresponding to all themes contained in the framework in every company. However, it is assumed that the *totality* of the observations from the case studies provides a reasonable indication of the framework's ability to contain and explain industrial portfolio management practices

Furthermore, due to the mentioned differences in detail the cases are not reported according to a similar pattern. Instead it has been necessary to describe each case in line with an individually customized structure.

Case structure

The report of the observations from each company is structured as follows: Initially, an overview of the observations made in terms of principles contained in the reference model is presented. Next, these observations are documented and further explained in subsequent sections. Each section finishes with a conclusion on how the observations support the reference model. Lastly, a unifying conclusion for the entire industrial verification effort is presented.

5.6.3 Case 1

In terms of the principles contained within the reference model the following observations are made:

Strategy development and portfolio planning

The management deliberately utilizes an annually **strategy and portfolio planning process** to synchronize the product development portfolio. During this process information is collected and reported upwards in the organization, and agreed plans flow downwards. This **reporting** and **planning** interplay is central for the process.

The portfolios

The managers consider and **manipulate** at least three **portfolio classes** individually, namely portfolios of **ideas** (proposals)**, projects, and products.** Moreover, a **current** and **planned** variant of the project portfolio and the product portfolio is considered.

This emphasizes how portfolio management for product development occurs in an **end-to-end** context under influence and consideration of influences from the **external** and **internal business environment**.

Portfolio execution

The company utilizes a **portfolio review process** in combination with **key point meetings** in the **project execution process** for execution of the portfolio. These processes together with the strategy and portfolio planning process operate in different **time domains,** and they are depending on the **integration** of staff from several functional areas and organizational levels.

Management of the idea portfolio

A **distinct idea evaluation and selection process** occur which precede those inherent in project portfolio management. Here an idea portfolio consisting of at least two distinct sub-classes of ideas is considered prior to the project portfolio, namely **embryonic ideas** and **idea proposals**.

Management of the product portfolio

A **distinct product evaluation and selection process** occur which succeed those inherent in project portfolio management.

In the following sections these observations are documented and further explained in accordance with the structure outlined above.

5.6.3.1 Strategy development and portfolio planning

The evaluation of which projects to start occurs continuously throughout the year at the company. In addition a *strategy process* is carried out annually which has a major impact on the design of the product development portfolio. The following statement from a R&D manager conveys a sense of the purpose of the strategy process:

"The evaluation of projects is a continuous process but each year we are motivated to clean it out and take some decisions. The continuous process tends to create some hanging projects (will we do it or not?)".

The process is depicted on Figure 55, and it consists of several sessions and activities and lasts for a period of 90 days in total. These activities comprise a thorough discussion resulting in business decisions spanning the following years. The overall output of the process is a comprehensive strategic plan, which contains the information presented and knowledge developed during the sessions in a consolidated form. It constitutes condensed product roadmaps, project master plans and action plans which in total documents the decisions made related to the development portfolio.

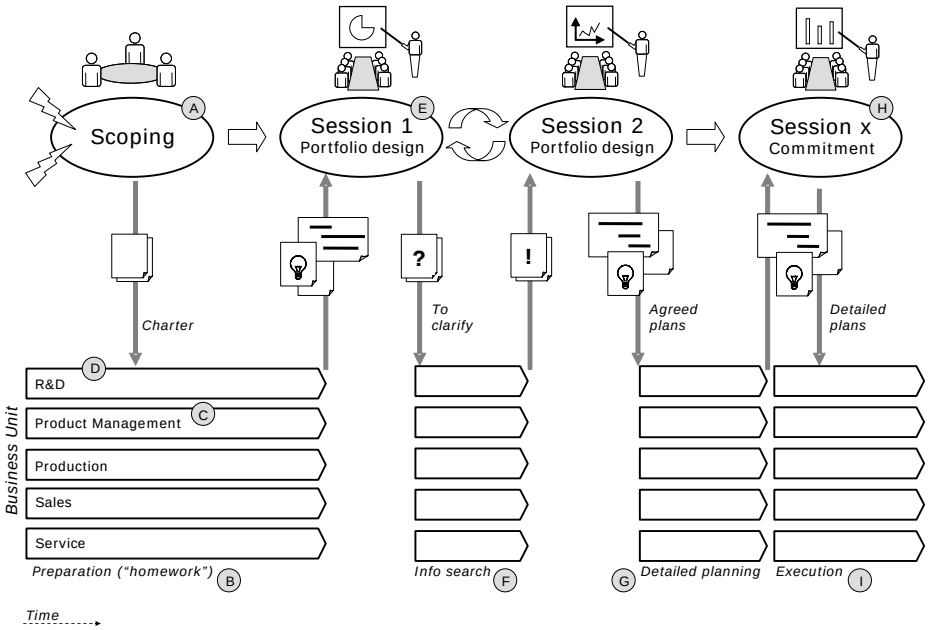


Figure 55. The annual strategy process consists of several activities.

The process consists of five major activities, scoping (A), preparation (B), synthesis (E), investigation (F) and finally, detailed planning (G). These are described in the following.

Scoping

The strategy work is initiated by senior management, who appoints a core group for the strategy process. The focal point for the group is to scope the process (activity A), while considering the company's internal and external situational context, i.e. define purpose, topics, meetings, content, participants and expectations to the participants in terms of "upfront homework", which they are expected to prepare in advance of the

meetings. This is captured in a Powerpoint presentation, and presented at a kick-off meeting covering all business areas.

Preparation

Next, work streams consisting of workgroups comprised by cross functional staff related to the various business areas are established within each business area. In advance, each group member is obliged to prepare (activity B) in terms of gathering intelligence relevant to questions formulated by the core group.

Synthesis

The core activity of the strategy process is cross-functional meetings (3-5 days duration each) with 3 weeks in between. Each meeting is guided and moderated by 2 "independent" coordinators. People from product management, customer service, sales, production and R&D participate here. They present their prepared homework, thoughts on market trends and development, ideas etc. which are discussed. Information is presented, investigated, developed and consolidated iteratively during the meetings. Project prioritization at the first meeting (activity E) is based on "gut feeling" and base knowledge.

Investigation

In addition, prioritizations during the following meetings are based on further investigation (activity F) of questions evolved during the meetings. Only major existing and new projects are discussed. The selection method can be compared with "bubble sort"[5] where every participant has one vote. Consensus is gradually built during the meetings about which ideas and projects to pursue.

The strategy sessions conclude with a list of agreed and prioritized projects and other tasks to do, which is distributed to each department in the company for detailed planning (activity G).

Detailed planning

Based on the agreed list of projects the R&D manager begins detailed planning (activity G), which entails an update of product plans and allocation of resources to the projects. This is done as an iterative top-down process, based on experience and dialogue with the staff. Furthermore, the corresponding budget is refined. Eventually, the updated material is presented for the senior management for final approval and commitment (activity H). Finally, the implementation of the plans is initiated (activity I).

Conclusion

The reported observations illustrate how the management deliberately utilizes a *distinct, annual process* to consolidate and synchronize the product development portfolio. Moreover, the observations show that the planning of the portfolio is highly integrated with strategy development in the company. This seems to highlight the relevance and importance of including a distinct strategy and portfolio planning process on the suggested reference model.

Additionally, it is evident that the process occurs in an iterative pattern where information is collected from the bottom of the organizational

[5] Bubble sort is probably the simplest way to sort a list of projects. The basic idea is to compare two neighbouring objects, and to swap them if they are in the wrong order.

hierarchy, and reported back upwards. Subsequently, plans flow downwards. This pattern appears to support the *reporting* and *planning* interplay indicated on the reference model. The observations furthermore show how the process is highly dependent of the involvement of staff from several functional departments in the company. Additionally, both representatives from the top management, and functional managers as well as specialists participate in the process. This seems to underscore the principle of both horizontal and vertical *integration* which also is explicated on the reference model.

5.6.3.2 The portfolios

The product management group handles one of the work streams (activity C) for the strategy meeting by preparing an extensive business analysis of each market segment related to the following matters:

- Market situation
- Competitors and their strength/weaknesses
- New technology threats and opportunities
- Product strategy (What will we sell to whom?)
- Partner strategy
- Product development strategy (road map)
- Distribution and sales strategy
- Marketing strategy

At the macro level this includes prioritization of all the product areas in order to focus the development effort as indicated on Figure 56. Additionally, threats and opportunities for the market in total are identified as illustrated on Figure 57.

Current products

Moreover, each individual product area is investigated in detail in accordance with the following aspects: the total number of potential customer sites, units installed, target price, remaining unit potential, current products together with an indication of products missing, i.e. gaps in the portfolio.

Figure 56. Customer segment prioritization.

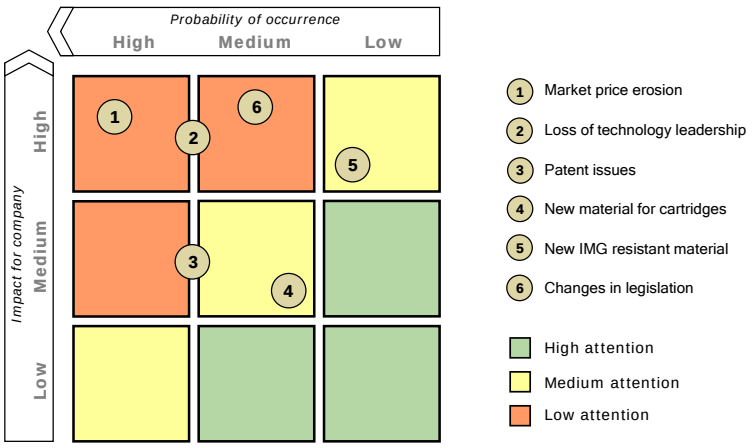


Figure 57. Mapping and prioritization of threats.

The R&D team is also responsible for one work stream during the strategy session. Here an overview of the active projects, and idea proposals, as well as roadmaps and a master plan forms central elements. The documents contain implications for the budget, which preliminary are included in the budget process, which occurs in parallel. The material is subsequently presented at the first strategy session (activity E). Each of these documents is described in the following.

Active projects

The overview of active projects is basically a list of all the development projects currently underway as illustrated on Figure 58. Projects are listed in the outmost left column. The list is structured with columns in accordance with the milestones defined in the company's formal development process. It explicates information regarding:

- Which projects are we working on?
- Who is the project manager?
- When is the project expected to pass the various milestones in the development process?
- Where is the project right now in terms of progress in the development process?
- To what extent is the project delayed?
- When was it decided to change dates for passing the milestones in the development process?
- Comment field to explain causes of delays.

This overview is not only used for the annual strategy meeting. It builds on information from the individual projects, and is updated every month. Here an additional row is inserted below each project in the Excel sheet to explain current status with regard to the above mentioned aspects. In this way the development history is logged.

PROJECT	PROJECT MANAGER	PRODUCT DEVELOPMENT PHASES KP-0	KP-1	KP-2	KP-3	KP-4	CHANGED	KP-2 DELAY	COMMENT
FiberCaster	KJ				CANCELLED	CANCELLED	mar-06		Project cancelled, conflict with SW
FlashPoint	KJ		12-apr-05	19-apr-05	10-may-05	11-jul-05			
				21-maj-05	29-jun-05	18-jul-05	apr-05	1½ months	
				20-may-05	26-jun-05	01-aug-05	may-05		
				20-may-05	15-jul-05	10-sep-05	may-05	2½ months	
					12-okt-05	01-nov-05	aug-05	4½ months	Testing not progressing as planned
					15-oct-05	01-dec-05	sep-05	5½ months	Testing still not progressing as planned
					30-oct-05	15-jan-06	oct-05	6 months	Testing still slow
					25-oct-05	15-feb-06	nov-05	7 months	
						01-nov-06	jun-06		
						01-apr-07	dec-06		
						11-mar-07	mar-07		Finalize 2 new input packages
						15-jul-07	apr-07		Finalize new flashlogic output unit
						05-aug-07	jun-07		NDA / commercial agreement with QW delayed
									(finally signed in week 37)
						12-dec-07	aug-07		Wait for QV to implement new data exchange module
									to their balancing machines (we cannot finalise
									testing before)
Medusa 50	JP		13-jun-04	09-mar-05	01-jul-05	11-oct-05			
			28-aug-04	01-apr-05	01-jul-05	01-sep-05	aug-04	1½ month	G-1 delayed because of Gazelle G-3
			11-sep-04	01-apr-05	02-aug-05	01-sep-05	sep-04		
				06-apr-05	sep-05	jan-06	mar-04	3 months	Problems with reflection -> more streams
				01-apr-05	sep-05	jan-06	may-05	3 months	Gate meeting delayed because of exposition
				05-jul-05	sep-05	jan-06	jun-05	3 months	Stability problems
				19-jun-05	30-dec-05	apr-06	jul-05	6 months	Replanned at G-1
					30-nov-05	aug-06	dec-06		8 systems to be installed in 2HO8 (limited rel.)
						sep-06	jun-06		Collect more customer experience before final G-3
									(but full commercial launch as planned in jul-07)
						sep-06	sep-06		Slipped into Oct due to difficulty to find common
									meeting date
AdecTech	HK			21-apr-04	01-may-04	25-may-05			
				23-apr-04	02-may-04	02-jun-04			
					19-jun-04	31-jul-04	jun-04	1½ month	Redesign for manufacturability
					28-aug-04	01-oct-04	aug-04	3 months	Product is shipping before G-2!
					01-sep-04	15-nov-04	sep-04	3½ months	Shift G-3 to allow for proper testing
						15-feb-05	nov-04		TZ approval delayed
						W29-05	dec-04		TZ re-certification
						Q1-05	jan-05		TZ approval dragging
						Q1-06	jul-05		Waiting for EU certifiation
						Q3-06	sep-05		Delay problems with EU
AutoAdapto	HK			01-apr-04	15-jun-04	01-sep-04			
				28-apr-04	15-jun-04	01-sep-04	apr-04		
				07-jul-04	15-aug-04	01-oct-04	jun-04	2 months	
				04-sep-04	01-nov-04	15-dec-04	aug-04	3½ months	Caution – test window is shrinking
				11-sep-04	22-dec-04	01-feb-05	sep-04	5½ months	Replanned to allow for proper testing
					01-mar-05	01-may-05	nov-04	8½ months	Redesign of texo module
				aug-04	dec-05	may-06	jun-05	18 months	Merge full & limited designs; redo G-1
					to-be-decid.	to-be-decid.	jan-05	to-be-decid.	Await decision on design-for-production
				oct-05	jan-06	may-06	aug-05	19 months	Manufacturing problems with new unit
				to-be-decid.	**to-be-decid.**	**to-be-decid.**	sep-05		Project suspended – new G-1 required
Low-Cost Carrier	WJ			01-apr-05	01-sep-05	01-jan-06			
				15-jan-05	01-sep-05	01-jan-06	jun-04		G-1 moved forward for enhanced testing
				15-feb-05	01-okt-05	01-jan-06	jun-04		Moved back again due to delays at Smartex systems
				to-be-decid.	to-be-decid.	to-be-decid.	jan-05		Await decision on design-for-production
				to-be-decid.	jun-06	jan-07	mar-05	9 months	Focus on Trade-fix to get that done in 2006
				W26-05	aug-06	feb-07	apr-05	9 months	Redesign the product in Atlanta after trade show
				to-be-decid.	aug-06	feb-07	apr-05	9 months	Choose supplier before redesign
				to-be-decid.	**to-be-decid.**	**to-be-decid.**	sep-05		Project suspended – new G-1 required

Figure 58. The project overview constitutes a list of development projects currently underway in a business area.

Project vision documents

The list of active projects is complimented with a strategy report, which includes a list of project vision documents discussed during the year. Project vision documents have previously been described, and an example is shown on Figure 60.

The list merely includes envisioned products which require significant funding in order to realize them or products which seem radically different from the existing product types in the portfolio. Less radical ideas requiring a smaller amount of funding are brought to the product committee on continuous basis during the year. Here engineers and project managers present idea proposals with recommendations. The product committee is described separately in a later section.

Product roadmaps

Additionally, temporary product roadmaps are prepared for each product category, which reflects the envisioned products previously described. An example of a roadmap for two (software) product categories is illustrated in Figure 59. It specifies the intended evolution of the product in terms of

the product platform and the associated product features as well as their launch dates together with the product generations expected market exposure. Additionally, the roadmaps indicate how features are expected to be realized by means of shared modules across product categories.

The color codes signify the status of resource commitment to the related development projects, i.e. whether pre-projects have been completed and accepted at milestone KP1 and resources have been allocated in the budget for the projects further execution.

Project master plan

The temporary roadmaps are complemented with a corresponding temporary master plan. The master plan constitutes a condensed view of the aggregate set of projects implied by the product roadmaps. The potential projects are attuned for the available resources and sequenced according to the roadmaps and the projects interdependencies.

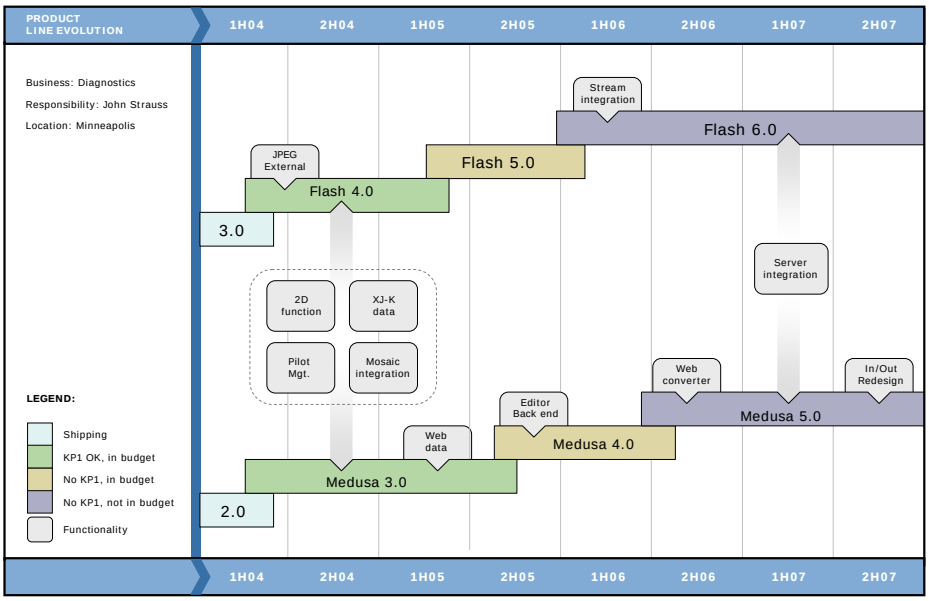


Figure 59. Example of a product roadmap for software products.

The master plan mainly concerns new projects for which available resources exist. A sense of the concept can be gained from the following quote from a R&D manager:

"The master plan does not consider projects already active – only new projects. But of course we consider the already allocated time and as such this time is unavailable for other projects. We indeed do NOT revisit the planning of already running projects. Once KP1 is passed, there must be very good reasons to change the plan".

Not all available resources are allocated on the master plan. Some are left for smaller projects according to the next statement from a R&D manager:

"In practice, about 70 % of the resources in my department are on the master plan (and then distributed on more detailed planning). The rest

does not appear on the master plan and is available for smaller projects or maintenance/coordination".

Hence the un-allocated resources might be used for initiating minor projects on a case-by-case basis during the year as previously indicated in the section "project vision documents".

Impact of the strategy process

The described documents constitute input to the strategy process. Hence it is presented at the meeting in order to communicate status of current projects, and sketch out new potential projects. Here the proposed product roadmaps are confronted with market intelligence etc. prepared by other departments. In concordance with the rise in the collective understanding of the business situation the group evaluates and prioritizes the envisioned products and the related projects iteratively as indicated on Figure 55.

The strategy session conclude with a list of agreed and prioritized projects to do, which reflects the decided roadmaps. Additionally, resources are allocated to the projects. For every project an individual project plan is prepared by means of MS Project. This takes place during the detailed planning, which is indicated as activity G on Figure 55.

Conclusion

In sum the observations clearly show that the management considers and distinguishes between the following three portfolio classes during management of the product development portfolio:

First, the list of project vision documents can be compared to the idea proposal portfolio on the reference model, which is a sub-class of the *idea* portfolio.

Second, the overview of active projects and the master plan reflects two variants of the product *project portfolio* which emerges from the reference model. The former resembles the *current* project portfolio and the master plan bear a resemblance to the *planned* project portfolio

Third, the observations indicate that the examination of the *current* product portfolio plays an important role during the design of the development portfolio. This is in concordance with the *product* portfolio included on the reference model. Additionally, the roadmaps illustrate the products which the company intends to realize in the future. Thus the roadmap constitutes a representation of the portfolio of *planned* products. This portfolio variant is also accentuated on the reference model.

The totality of the observations appears to reinforce the relevance of including and discriminating between the three portfolio classes on the reference model. Moreover, this also supports the assumption that the management of the development portfolio should be performed in an end-to-end context.

As a final point, the observations indicate that decision making regarding the development portfolio entails an appreciation of the company's business situation in terms of market dynamics and available resources in the widest sense. It seems reasonable to compare this to the influences

from the external and internal environment indicated on the reference model.

5.6.3.3 Portfolio execution

Once the annual strategy session is over and the detailed planning is completed, the nature of portfolio management seems to change. During the rest of the year the main focus is now to ensure that the selected projects are executed as planned and necessary adjustments are made. This is done by means of a product committee and the product development process.

Product committee

Whereas the development process focuses on the detailed execution of individual projects, it seems that the monitoring of progress and coordination of projects at an aggregate level is done by means of a *product committee*. The committee is a formal body, which is defined in a Product Committee document. The committee is composed of four permanent members (VP R&D, VP Customer service, VP Marketing and VP Production) and temporarily members (R&D section managers, product manager, and project manager) associated with actual projects.

Main responsibilities

The committee meets bi-monthly and is responsible for initializing, monitoring, coordinating, and allocation resources for product development. This encompasses:

- matching products to the strategic direction set out by the top management,
- goal setting for the different projects and continuous monitoring the progress,
- ensuring cohesiveness of various products,
- drafting of project start documents detailing the project prior to project start,
- review phase reports including follow-up on deviations from planned schedule.

Limited mandate

Only some types of new idea proposals can be brought for the Product Committee for approval and resource allocation, because the product committee is not strategic in its nature. Thus the committee does not decide whether the company should enter into a new business area or not. Those decisions are dealt with at the annual strategy session. The committee does only make decisions on projects that do not begin "big new things".

If the committee consider that a proposed idea could lead to prosperous business and "free" resources exists (i.e. resources not allocated to projects in the master plan), the proposal is approved for further investigation. This approval is not a definitive commitment to the proposal, but rather a tentative commitment ensuring that there are funding and resources available to establish a pre-project. This is required to prepare a business case and design the project in order to progress the idea towards the second milestone KP1 in the development process.

Product management, supported by R&D, is also the driving force behind the preparation of the proposal.

Pre-projects

When a pre-project is prepared it is presented and reconsidered in the product committee (or at the annual strategy session). If the project is considered feasible, and resources exist it may be selected for further development. This second approval is an extensive commitment to the project, because it implies heavy resource allocation. A committee decision can typically result in 3 kinds of actions:

Typical actions

- Ok, everything is fine – continue the project.
- We feel uncomfortable with your plan (e.g. testing is missing) – please refine it.
- Stop the project.

Decision making in the committee is based upon key documents (project overview, product business plan) and dialogue. Engineers and product managers presents projects with recommendations. In advance of the meetings, the R&D director prepares an agenda stating the objectives of the meeting.

Development

The company uses a defined framework – the "key point" model to take ideas and develop them to successful products launched in the marketplace. The key point model does not provide a portfolio perspective of all the development projects, but supports the individual projects during the execution. The model divides the development of new products into five manageable stages. Each stage contains a number of parallel and coordinated activities, and the progress from one stage to the next is indicated with key points:

Five stages

- KP-0 (project vision)
- KP-1 (product plan)
- KP-2 (product development)
- KP-3 (product release)
- KP-4 (product retirement)

Key point meetings

Each key point – or milestone – plays an important role in the management of the project, and the milestones initiate a formal project meeting with participation of involved staff such as the project manager, engineers, product manager etc. The scope of the meeting is decision making on a tactical level with regard to the project in question: does it fulfill the business specifications, does the execution follow the plan, is the project staffing sufficient, should we speed up the project, etc. Key point checklists are utilized to ensure that requirements are met before a project progress from one stage to the next.

Conclusion

The empirical observations appear to underpin four aspects of the presented reference model:

Firstly, it seems reasonable to compare the product committee meetings to the *portfolio review process* pinpointed on the reference model.

Second, the utilization of the key point model with key point reviews focused on the individual projects resembles two processes included in the reference model, namely the *project key point meeting process* and the *project execution process*.

Third, the product committee meetings occur bi-monthly as a cyclical activity whereas the key point reviews follows the progress in the individual projects. Thus the processes appear to operate in *different time domains*, and this principle is as indicated on the reference model.

Lastly, both the product committee meetings and the key point reviews entail involvement of staff from several functional areas and organizational levels. This is in support of the *integration* aspect contained in the reference model.

5.6.3.4 Management of the idea portfolio

Ideation

Ideation and idea evaluation and selection occurs on a continuous basis in the company during the year. Ideation seems to follow a cyclical pattern depending on workloads, tradeshows etc. It seems, however, that immediately before an annual strategy session (described in section "Strategy sessions") a consolidation of the ideas at hand takes place in order to determine which ones should be proposed for inclusion in the portfolio for the following period at the strategy session.

Informal idea documentation

The person who comes up with the idea documents it as he want, i.e. the format is free until the idea enters the formalized portfolio management process. Initially, the vast majority of ideas are expressed verbally in meetings possibly supported by brochures with competing products, drawings, models, animations or a few lines of written description etc.

Explorative evaluation and selection

The evaluation of the idea seems to be an explorative practice. When for example a product manager wants to suggest a product related idea, the person either proposes the idea to his/her boss or directly to the R&D manager. This initiates a discussion regarding the ideas quality, involving people from R&D, product management, sales depending on the nature of the idea. No particular tools are deployed during this process besides a mutual understanding of the organizational and market situation. Gradually dimensions of the idea are investigated (e.g. competitive aspects, business potential, risk) and captured in various documents such as meeting reports, drafts, Powerpoint presentations etc.

The selection of ideas to be further pursued seems likewise to be an informal process based on discussions with R&D managers, product managers and project managers etc. combined with "gut" feeling and a good understanding of the market. The following quote from a R&D manager convey a sense of the approach:

"*I make a list of the ideas and confront other people with it to see how they react*".

Thus ideas seem to be circulating in the organization, where they are discussed, evaluated and tentatively selected during the year.

Formal idea documentation

If consensus regarding the ideas quality evolves, and a sponsor among the permanent members of the product committee (which is a prerequisite) has been identified the preparation of a "KP-0 Project Vision" document is initiated. Product management, supported by R&D, is the driving force behind the preparation of the proposal. It represents the first formal documentation of the idea, and it entails aspects shown on Figure 60.

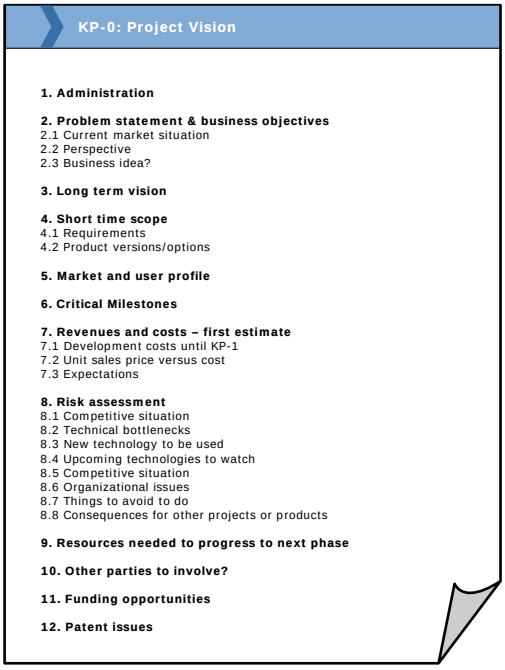


Figure 60. The KP-0 Project Vision document represents the first formal documentation of the idea.

Formal evaluation and selection

This document is required in order for the management to decide whether it is relevant to invest in the idea, and bring it into the formalized product development process. This formal approval may be obtained either through a product committee or through an annual strategy session, which both are described later.

Accepted idea proposals

The point when the idea proposal has been accepted for a pre-project mark the entry to the formalized portfolio management process. From this moment the pre-project is recorded on the *overview of current projects* illustrated on Figure 58. The dashboard contains a list of the larger product development projects currently underway in the actual business unit. This comprises a high level monitoring of the development portfolio which is captured in an Excel sheet. The dashboard is a central document for communication about the portfolio between the managers from the various business units in the company.

Conclusion

The observations seem to support the concept of structuring the idea portfolio into sub-portfolios of *embryonic ideas* and *idea proposals*, which precedes the formal portfolio management process. The main point

of difference is the comprehensiveness in the articulation of the ideas, and this characteristic is illustrated on the reference model.

Additionally, in concordance with the reference model the observations indicate the existence of a *distinct idea evaluation and selection process* which precedes those inherent in formalized project portfolio management.

5.6.3.5 Management of the product portfolio

Products already on the market are not only scrutinized during the annual strategy session. They are examined on an ongoing basis. This appears also to be the responsibility of the product management function. The following quotes from a marketing director convey a sense of the inherent tasks:

"The roles of Product Management can be divided in an internal and external part: the internal part comprises the preparation of development cases for R&D, follow-up of internal business processes, participating in the development process, to pick up info (wants/needs) from customers, identify gaps in product portfolio, initiate actions where sales processes fail etc..

The external part of the job is to evangelize the product message in the market, train and inform our direct and indirect sales channels, attend industry seminars and tradeshows, write press articles, give lectures, etc…".

Conclusion

The observations indicate that a process seems to occur where decisions regarding the product portfolio are made on a continuous basis. This process appears dissimilar from, but closely related to the decision processes inherent in project portfolio management. The observation appears to justify the inclusion of a *distinct process* dedicated to the *management of the product portfolio* on the reference model.

5.6.4 Case 2

In terms of the principles contained within the framework the following observations are made:

The managers consider at least four **portfolio classes** individually, namely portfolios of **ideas, product projects, technology projects, and products.** The first three of these seems to be **manipulated** individually.

The project portfolio seems to be regarded as consisting of two sub-portfolios, namely **pre-projects** and **main projects**.

Moreover, a distinction is made between **past**, **current** and **planned** projects in the project portfolio.

This emphasizes how portfolio management for product development occurs in an end-to-end context under influence and consideration of influences from the **external** and **internal business environment**.

Lastly, the company utilizes a **portfolio review process** in interplay with **key point meetings** in the **project execution process** for execution of the portfolio.

In the following sections these observations are documented and further explained.

5.6.4.1 Idea portfolio

Planning enquiry

Elements enter the formalized portfolio management process at the moment when an idea is suggested for further clarification by an employee by means of the "planning enquiry" illustrated on Figure 61. The following quote from a portfolio manager convey a sense of the approach:

"Ideas enter the PM system through a "planning enquiry", which is one page with a very brief description (a few lines of text) of the idea. This is presented to the VP product strategy & portfolio management or the VP of marketing, either of whom can decide whether and what additional clarification of the ideas potential is worthwhile".

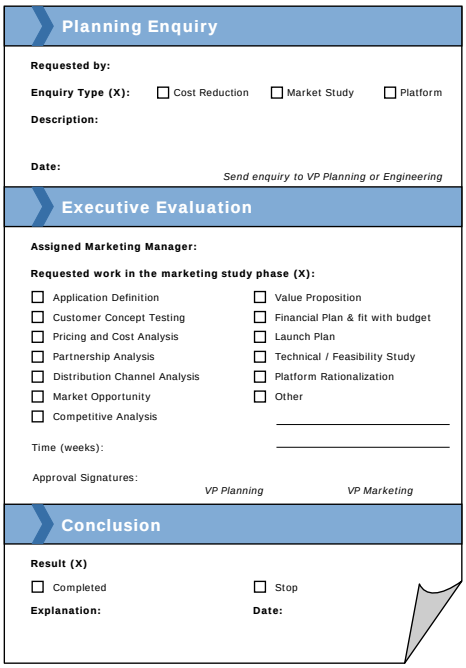


Figure 61. An element enters the portfolio management process via a planning enquiry.

Conclusion

The observations appear to underpin the relevance of including a distinct *idea* portfolio consisting of early and fragile ideas on the reference model, which should be managed in relation to, but distinct from the project portfolio.

5.6.4.2 The product project portfolio

Business opportunity document

If it is decided to further investigate an idea the preparation of a "business opportunity document" is initiated. The document is gradually built in accordance with the clarification of the idea. At key point 2 in the development process it is regarded as complete. Basically it covers the following aspects:

Business Opportunity Document

- Value proposition
- Strategic alignment
- Positioning strategy
- Customer applications
- Competitive analysis
- Alternative solutions
- Applicable distribution channels and supply chain considerations
- Pricing strategy
- Portfolio rationalization
- Feasibility study
- Target market segments and customers
- Target costs
- Revenue opportunity and market window

Front end roadmap

When the preparation of a Business Opportunity Document is started, the initiative is also recorded on a "Front End Roadmap" as shown on Figure 62. It provides an overview of planned and active efforts and their focus for investigation (marketing, feasibility, planning) related to the preparation of the Business Opportunity Documents.

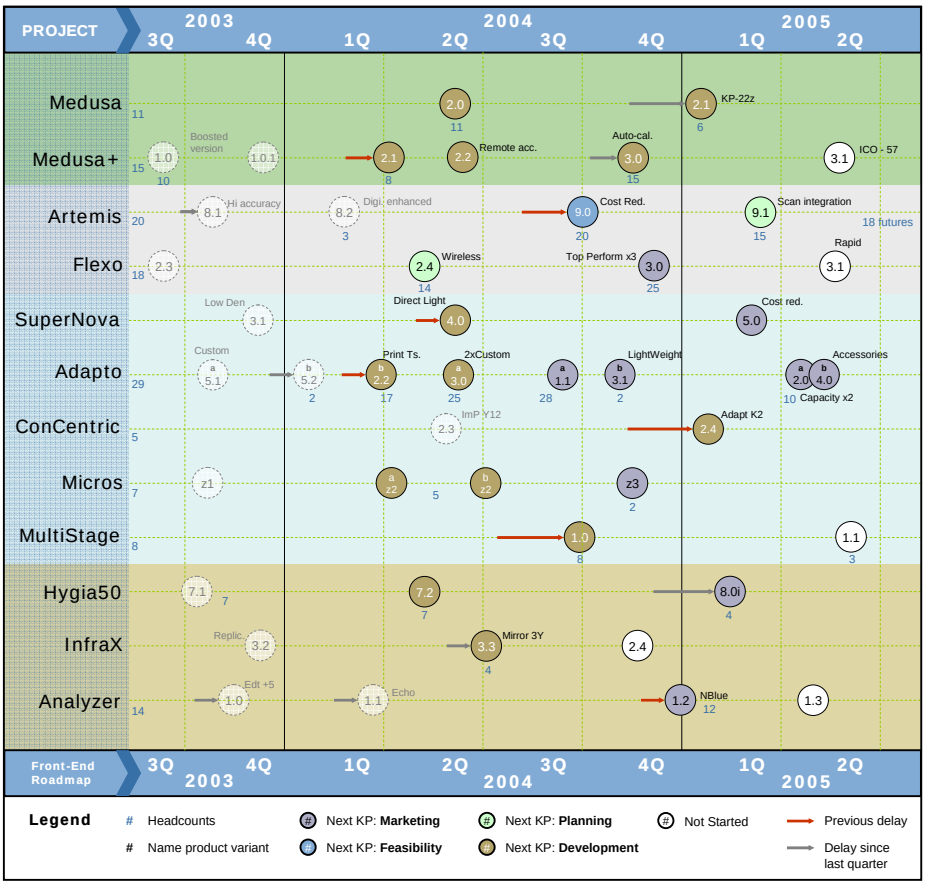


Figure 62. The Front End roadmap indicates planned and active efforts.

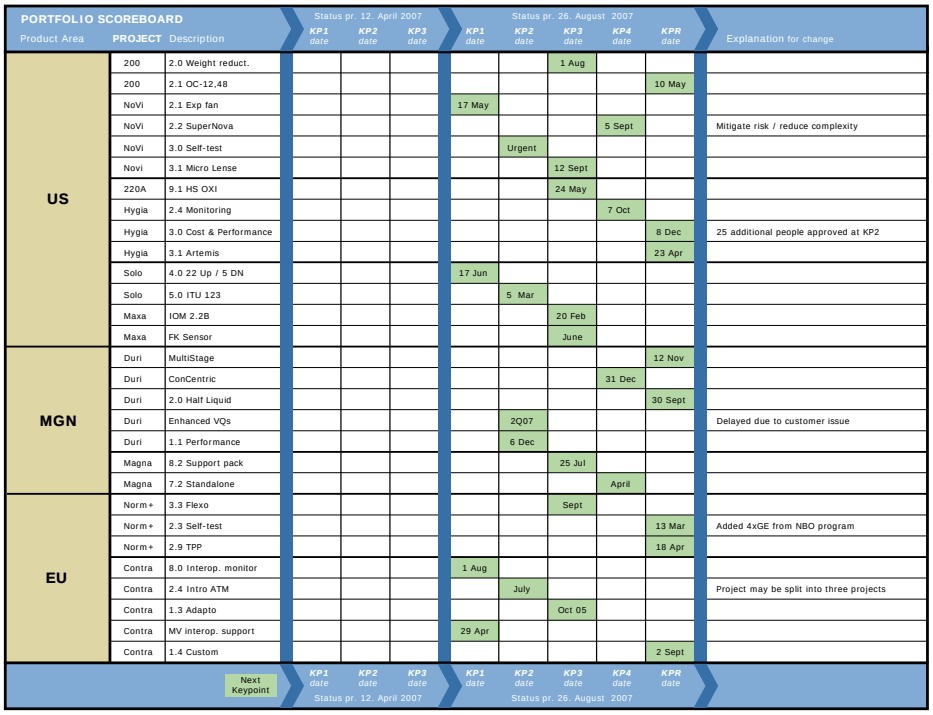
Portfolio scoreboard

When a project is recorded on the front end roadmap it is also recorded on the "portfolio scoreboard". The latter is a table that provides a detailed view of all the product development projects underway within various product areas as illustrated on Figure 63. The dates when the projects are expected to reach their next key points are shown. Possible changes to projects are described.

Front end committee

The front end work is managed by a cross functional "front end executive committee" with members from the product divisions, operations, marketing, and the portfolio management group. They meet on a regular

basis for the purpose of reviewing the validity of business cases for work in progress, resolve planning roadblocks, jeopardy escalations where development cannot meet the timeframe or costs, etc. This group is also a review body for decisions made by the portfolio management group regarding alternative resource allocations for ongoing product developments.



PORTFOLIO SCOREBOARD

Product Area	PROJECT	Description	Status pr. 12. April 2007 KP1 date	KP2 date	KP3 date	Status pr. 26. August 2007 KP1 date	KP2 date	KP3 date	KP4 date	KPR date	Explanation for change
US	200	2.0 Weight reduct.						1 Aug			
	200	2.1 OC-12,48								10 May	
	NoVi	2.1 Exp fan				17 May					
	NoVi	2.2 SuperNova							5 Sept		Mitigate risk / reduce complexity
	NoVi	3.0 Self-test					Urgent				
	Novi	3.1 Micro Lense						12 Sept			
	220A	9.1 HS OXI						24 May			
	Hygia	2.4 Monitoring							7 Oct		
	Hygia	3.0 Cost & Performance								8 Dec	25 additional people approved at KP2
	Hygia	3.1 Artemis								23 Apr	
	Solo	4.0 22 Up / 5 DN				17 Jun					
	Solo	5.0 ITU 123					5 Mar				
	Maxa	IOM 2.2B						20 Feb			
	Maxa	FK Sensor						June			
MGN	Duri	MultiStage								12 Nov	
	Duri	ConCentric							31 Dec		
	Duri	2.0 Half Liquid								30 Sept	
	Duri	Enhanced VQs					2Q07				Delayed due to customer issue
	Duri	1.1 Performance					6 Dec				
	Magna	8.2 Support pack						25 Jul			
	Magna	7.2 Standalone							April		
EU	Norm+	3.3 Flexo						Sept			
	Norm+	2.3 Self-test								13 Mar	Added 4xGE from NBO program
	Norm+	2.9 TPP								18 Apr	
	Contra	8.0 Interop. monitor				1 Aug					
	Contra	2.4 Intro ATM					July				Project may be split into three projects
	Contra	1.3 Adapto						Oct 05			
	Contra	MV interop. support				29 Apr					
	Contra	1.4 Custom								2 Sept	

Next Keypoint — KP1 date / KP2 date / KP3 date — Status pr. 12. April 2007 — KP1 date / KP2 date / KP3 date / KP4 date / KPR date — Status pr. 26. August 2007

Figure 63. The Portfolio Scoreboard provides a view of all the product development projects underway within various product areas.

Portfolio management group

A distinct portfolio management group is appointed in the company. The group is responsible for the overall resource allocation across front end projects and development projects together with the revenue plan associated with the portfolio. The group consolidates portfolio information provided from several sources in order to identify options and frame and present central decisions to be made to the top management. The financial controller provides headcount data, i.e. how the staff currently is allocated among the projects and the expected allocation within a years view. The front end executive committee provides status for front end work in progress. The product managers provide information regarding the *projects key point status* and content of features. The engineering managers provide information concerning schedule and reasons for delay ("slips"). The portfolio management group schedules and hosts *quarterly portfolio reviews*.

Development projects

Eventually, when the business opportunity document has been prepared this committee together with the portfolio management group decides whether the initiative is to be funded for development and hence established as a development project. After the actual development is started it seems that the project is monitored less meticulously.

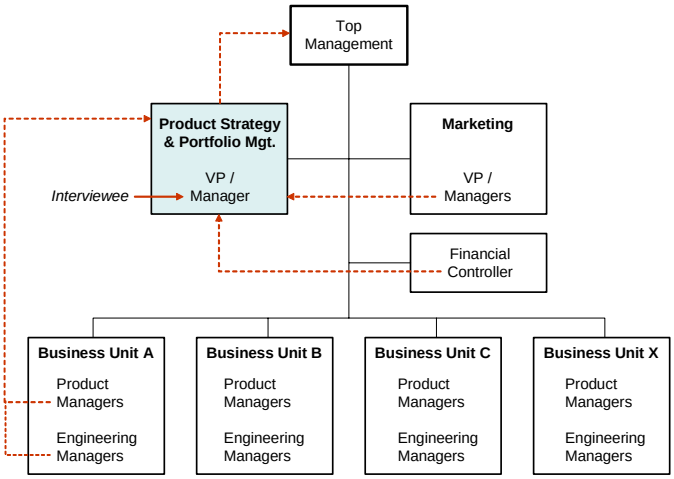


Figure 64. Organizational setup for the portfolio management group.

A sense of the view held by a portfolio manager can be gained from the following statement:

"When a project passes key point 2, we do not include it in our quarterly reviews. From here, it is handled at the key point meetings".

Core project map

The "core project map" illustrated in Figure 65 is owned by portfolio management and it plays a central role for the group. The map is defined as projects between key point 0 and market release which is *consistent* with the *resource allocation plan* and *revenue plan.*

Thus the cancellation of a core project will affect the revenue plan negatively. The map describes which features will be included in which variant releases and when. It displays the name of the feature package, their specific features, current key point, slip (previous slip and slip since last quarter), and staff assigned. Further, it indicates "ghost projects", which are projects (illustrated on the right side of the red line) that can be stopped without affecting the revenue plan negatively if resources are further constrained. Finally, this map is also used to identify engineering that is proceeding in advance of approval.

Conclusion

These observations seem to support the concept of structuring the project portfolio into sub-portfolios of *pre-projects* and *main projects* according to a central decision point as suggested in the reference model. The reported observations illustrate how the management explicitly considers and distinguishes between front end projects and development projects within the project portfolio. Milestone KP2 is emphasized as a central milestone, since it marks the transition between front end projects and development projects. Even though projects progressed to development are not included in the portfolio review it seems that they still are *monitored* by the portfolio management group in terms of resource consumption, progress and potential revenue.

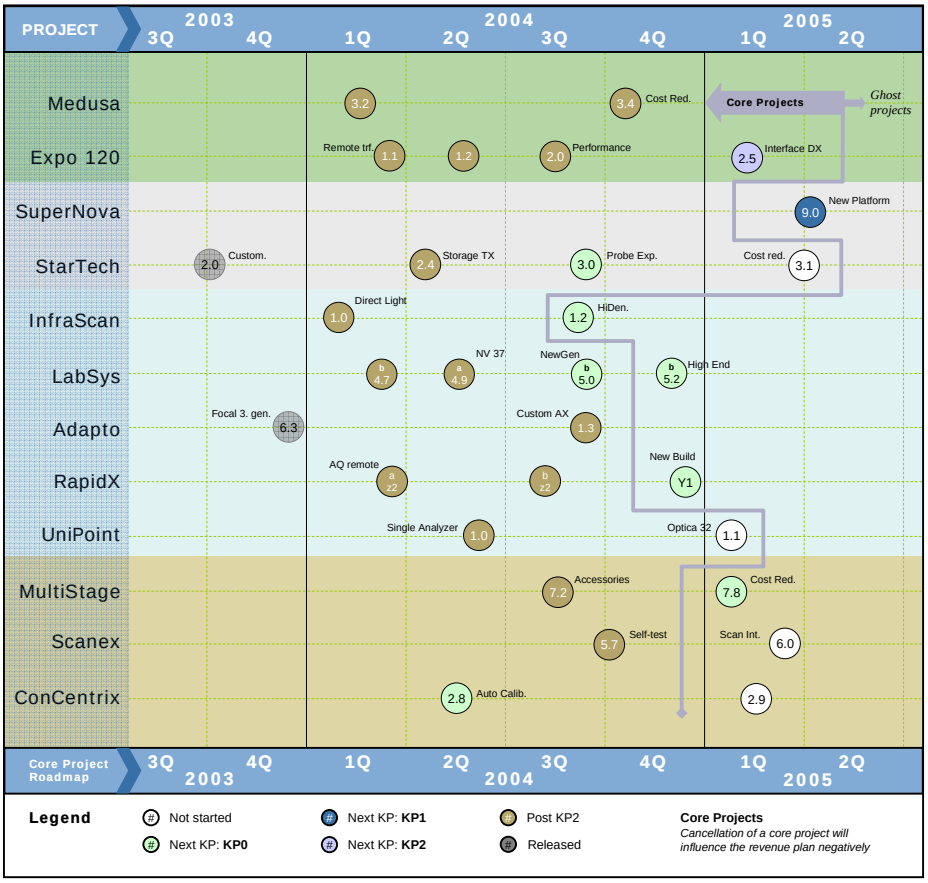


Figure 65. The core project map provides an overview of the active and planned development projects consistent with the resource allocation plan and revenue plan.

The observations also underpin the idea of distinguishing between three variants of the project portfolio, namely the portfolio of *past*, *current* and *planned* projects.

Furthermore, the observations indicate the existence of, and interplay between a *gating process* and a *portfolio review process* related to the *project execution process*. This supports the explication of these processes on the reference model.

5.6.4.3 Technology project portfolio

Off-map projects

The mentioned graphical maps do all capture development initiatives which follows a formal product development process with predefined key points. The company, however, does also consider projects, which seems not to follow the same predefined process. These are denominated "off-map projects", and are described as research and technology projects. They are aggregated in a list which provides an overview of the projects, their objective, time frame, assigned leader and relation to internal product team. These projects are not included on the core project map.

Product division	Off-map PROJECT	Status	Objective	Market window	Time frame	Staff size	Business Leader SIM	PSM	JP
	Laser-Flux	Approved	Improve transfer speed	26 April	1Q06	7	McKenna		
	Echosplit	Approved	Reduce elevation overlap	9 May	3Q05	2	Fleming		
	Mini Mag	Approved	Customer demo on XTS	28 May	4Q05	3	O'Neil		
	Kryptox 50	Approved	Proof of concept prototype	5 June	4Q06	4	Sanders		
	Profilex	Approved	Benchmark against competitor	10 July	2Q06	1	Charles		

Figure 66. Off-map projects are considered separately.

Conclusion

This observation seems to support the idea of separating and managing the *portfolio of technology projects* from the product project portfolio, which is explicated in the proposed reference model.

5.6.4.4 Product portfolio

Other tools

The preparation for decision making regarding the project portfolio entails consolidation of knowledge about the business conditions. During this work the management explicitly scrutinizes the performance of current products by means of various tools. Extracts of these are illustrated on the figures below.

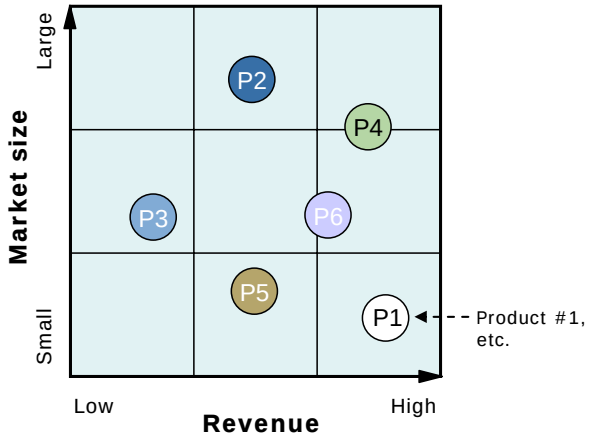


Figure 67. Monetary value.

Product Rank	´05 TM	´05-´08 AGR	´05 share (current)	Competitive Intensity	Total Score
P4					3
P2					2
P1					2
P6					2
P5					1
P3					1
Px					1

TM: Total Market
AGR: Annual Growth Rate

Figure 68. Product line ranking: Market attractiveness.

Product Rank	Strategic Fit	Competitive Advantage	Platform Leverage	Total Score
P4				3
P2				2
P1				2
P6				2
P5				1
P3				1
Px				1

Figure 69. Product line ranking: Strategic importance.

Conclusion

The observations appear to underline two aspects of the suggested reference model. Firstly, it seems relevant to consider a distinct portfolio class consisting of *current products* in relation to, but distinct from the project portfolio. Second, the consideration of the product portfolio seems to support the assumption that portfolio management for product development should be performed in an end-to-end context.

5.6.5 Case 3

In terms of the principles contained within the framework the following observations are made:

Management of the idea portfolio

A **distinct idea evaluation and selection process** occur which precede those inherent in project portfolio management. Here an idea portfolio consisting of at least two distinct sub-classes of ideas is considered prior to the project portfolio, namely **embryonic ideas** and **idea proposals**.

Portfolio execution

The company utilizes a **portfolio review process** in combination with **key point meetings** in the development process for execution of the portfolio. These processes depend on **integration** of staff from several functional areas and organizational levels.

Additionally, the managers consider and distinguish between portfolios of **projects** and **products,** and this indicates that portfolio management occurs in an **end-to-end** context**.**

Initiation of portfolio decision making

The management dynamically adapts portfolio management to the type of **impulse** recorded.

In the following sections these observations are documented and further explained in accordance with the structure outlined above.

5.6.5.1 Management of the idea portfolio

Ideation and idea evaluation and selection occurs on an ongoing basis in the corporation throughout the year. It appears to occur within various functions of the organization. This activity seems to constitute a pre-selection of ideas, which are going to be presented for and subjected to evaluation by two formal bodies, namely a product committee and a project assessment committee. These committees are described in a later section. The following examples convey a sense of the continuous ideation and selection process.

Idea screening

In one situation the R&D director and one of the engineers from the staff did go through a number of internal vision documents in order to identify ideas to potential new products implied in these. Ideas were derived and added to a list, which they then went over asking the question (in terms of technology):

"*Which idea can immediately be realized?".*

Those ideas eligible for immediate realization was objected to various tests and modeling in order to examine the ideas further.

Cross functional idea sessions

In order to generate plenty of new ideas for products and services, and subsequently select the "best" ideas to pursue further an "idea generation" event was arranged. Staff from several functional areas was involved in the event, which was facilitated by an external consulting company. After a vast number of ideas were proposed the most promising ideas were selected by the group for further investigation. This selection was based on a prioritization of the ideas according to their practicability in relation to time, i.e. to what extent the idea could be realized within a short term, middle term or long term perspective.

Project specification

Before an idea can be progressed further in the realization process a project specification has to be prepared. This document is subsequently presented for the product committee. Based on this document the committee decides whether the idea should be approved in order to enter the formalized development process.

Conclusion

These observations show that distinct *idea evaluation and selection processes* occur which precede those inherent in project portfolio management. It seems reasonable to compare these processes to the front end process included on the reference model. Thus the observations appear to underpin the proposed reference model.

Furthermore, the observations point towards a portfolio consisting of *early ideas* and *project specifications* is considered discretely prior to the project portfolio. The main point of distinction is the completeness in the articulation of the ideas. This appears to be in line with the principle of an idea portfolio comprised by two distinct sub-classes of ideas (embryonic ideas and idea proposals), which also is accentuated on the reference model.

5.6.5.2 Portfolio execution

Selection of ideas to be further realized by means of the formalized development process is anchored within a product committee and a project assessment committee. Their work is centered on a defined development process, which is supported by several tools and activities as illustrated on Figure 70.

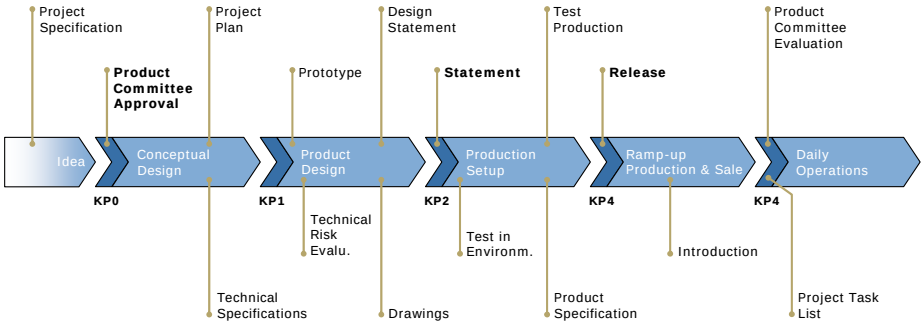


Figure 70. Process, tools and activities applied in "product development" projects.

Product committee

The product committee is responsible for the product portfolio management, and it represents the highest authority in terms of decision making regarding the project and product portfolio. This committee shall review the business unit's product range and, if necessary, initiate updates or development of new products, and add new business areas in accordance with the general strategies. This also includes necessary cost reductions to improve profitability and competitiveness. The product committee authorizes projects based on recommendations from the product assessment committee.

The product committee constitutes members from regional sales divisions, the R&D manager, business managers, product line manager and the CEO of the business division. The latter chairs the committee. In particular, the regional sales presidents have the decisive say in Go/No-Go decisions in the Product Committee, because they represent the customers in this situation.

The order of priority of the product projects are to be determined by the product committee. Additionally, the product committee's approval is needed several times in order to progress an idea through to commercialization. Before an idea can enter the formalized development process and hence the portfolio management system it needs to be approved by the product committee at the initial milestone KP0. As previously described this decision is based upon a project specification which has to be prepared in advance. Next, the product committee has to approve the project before the establishment of production facilities is initiated at milestone KP2. Finally, the committee's approval is a pre-requisite to begin the production and sales phase.

Project assessment committee

The project assessment committee is responsible for the evaluation of all on-go projects in the business unit. The committee is supposed to monitor progress in relation to the project specifications and plans and co-ordinate the necessary resource allocation. Finally, the committee is responsible

for preparing information and recommendations to the product committee. In particular, the group is expected to review projects and make recommendations to the product committee before the milestones KP0, KP3 and KP4.

The project assessment committee comprises the R&D manager, a sale and marketing manager, a plant manager, a business manager and the product line manager, which is the chairman of the committee.

The project managers are obliged to personally present the project to the committee at milestones. Moreover, project managers can present issues to the project assessment committee at any appropriate time.

Conclusion

The observations appear to underpin the following four aspects of the suggested reference model.

Firstly, it seems that the product committee meetings constitute a portfolio *review process* as pinpointed on the reference model.

Second, it appears that the product committee considers both the portfolio of *products* and *projects*. Hence it seems possible and relevant to consider a distinct portfolio class consisting of products in relation to, but distinct from the project portfolio in concordance with the reference model. Moreover, this appears to support the assumption that portfolio management for product development should be performed in an end-to-end context.

Third, the existence of the project assessment committee together with the utilization of a phase model with key point reviews focused on the individual projects resembles two processes included in the reference model, namely the *project key point meeting process* and the *project execution process*.

Finally, both the product committee meetings and the project assessment committee meetings involve staff from several functional areas and organizational levels. This supports the *integration* principle contained in the reference model.

5.6.5.3 Initiation of portfolio decision making

The development and selection of ideas and projects do not always follow the previously described and systematic sequence. Sometimes opportunities arise which necessitate faster portfolio decision making than the scheduled product committee meetings accommodate. The following four examples describe such situations:

Competitive dynamics

At one point the Italian sales organization noticed that a competitor launched a certain product type on the Italian market. This resulted in an increase in the competitor's market share. The management could not ignore this, and decided that the company also should pursue a share of this market. Hence the development and launch of a similar product was initiated immediately.

Opportunity "knocks on the door"

An entrepreneur contacted the business division in an attempt to raise funds for a certain product he was developing. The product, however, did not relate to the division's existing product areas with regard to production competencies. Nevertheless it presented an opportunity for the division to expand the business through related diversification. For this reason it was decided to acquire the entrepreneurs' company, and with that, the actual development project.

Partner projects

In other situations opportunities comes from other business divisions or corporate functions as offers to participate in projects. For example, in one situation the manager of a strategy function identified a sensor technology, which probably could be utilized in new products. Two projects were outlined and proposed to the senior management in a business division, who decided to exploit the opportunity and get involved in the projects.

Customer inquiry

Sometimes an inquiry directly from an OEM-customer requires swift decision making, since the opportunity might otherwise well be lost. The projects in question range from minor product modifications to the development of complete product lines.

Conclusion

The observations indicate how the management dynamically adapts portfolio management to the type of events encountered. This readiness seems to be necessary in order to exploit suddenly arisen opportunities or correspond properly to threats. This observed phenomenon bear a resemblance to the concept of the *impulse* included on the proposed reference model. It signifies that the calendar merely reminds us, while events drive the management of the development portfolio.

Moreover, the observations imply that it is inexpedient to dispose of all the available resources for a given planning horizon. A part of the resources should be left un-allocated in order to accommodate unforeseen situations. That is, opportunities for new products which are not contained in the current product plan.

5.6.6 Case 4

In terms of the principles contained within the framework the following observations are made:

Portfolio planning process

The planning of the greater part of the portfolio seems to occur during an annual **portfolio planning process**. The management acknowledges that portfolio management is not an inflexible and mechanistic exercise. This seems to underpin the relevance of the **impulse** concept.

Technology project portfolio

The portfolio of **technology projects** is considered and **manipulated** separately from the portfolio of product development projects.

Additionally, the management seems to distinguish between technologies under development and technologies ready for inclusion in product

projects. This appears to underpin the division of the technology project portfolio into two sub-portfolios on the reference model, namely technology **projects** and **packages**.

In the following sections these observations are documented and further explained in accordance with the structure outlined above.

5.6.6.1 Portfolio planning process

Potential candidates for the portfolio can enter the portfolio management process at any time by means of a so called “memory pusher”, which is illustrated on Figure 71. It is basically a sheet of paper divided in four quarters. It is build upon preceding discussions in the organization, and is supposed to capture emerging key points, principles, and issues in a brief format.

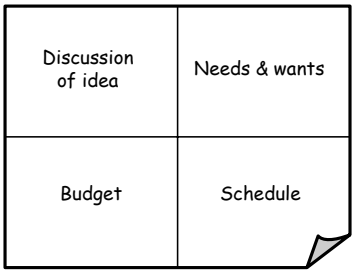


Figure 71. The "memory pusher" is used to describe ideas.

Most ideas once submitted, however, are held until the proper time for including them in the annual planning and budgeting cycle, which is initiated during the first months of the year. Not all resources are allocated to specific projects during portfolio planning. The following statement conveys a sense of the concept:

“A budget reserve is held for most of the year to fund important ideas where it is not in our interest to wait for the regular annual planning cycle”.

In general, the portfolio is maintained during the year. Only smaller projects may be subject to change. Once the portfolio planning is done only the top management may change the portfolio configuration during the year. As the following quote indicate this can occur due to one of the following situations:

“Portfolio manipulations might be caused by major changes in the business environment such as new opportunities, new requirements from the customer, a new customer contact, or lost business”.

Conclusion

The observations illustrate that a process which entails *portfolio planning* and allocation of the majority of the development resources occurs annually. This seems to resemble the concept of the strategy and portfolio planning process depicted on the suggested framework.

Additionally, the observations show that the management in the company anticipates the dynamic nature of portfolio management. When they reserve a part of the available resources for ideas which may come into existence during the year they allow for flexibility and different patterns of reaction. This support the concept of the *impulse* on the reference model, which reminds us that portfolio management is not an inflexible and mechanistic exercise dictated by the calendar.

5.6.6.2 Technology project portfolio

The "valley of death"

A technology readiness evaluation tool was developed and implemented as a reaction to challenges previously experienced during the embedding of technologies in products within the company. The following statements from a R&D director captured during this research disclose some of the dilemmas experienced:

"Much technology never gets inserted in products, because product development doesn't know what technologies the Technology Development Group intends to deliver".

"The Technology Development Group doesn't want to commit them selves to a plan".

"The Technology Development Group will only develop the technology to a certain maturity stage (widgets – only little testing), where the Product Development Groups does not dare to use it. We call this gap in maturity The Valley of Death".

Today they have complemented portfolio decision making with an overview of technologies needed to insert into the products. It describes the technologies and their readiness for product development. The latter is derived from the 9-level scale depicted in Figure 72.

The technology readiness evaluation tool is used to quantitatively measure the maturity of technology by means of the principle from the un-weighted factor score model (see also section 4.6.1, score models).

The tool or model is applied to evaluate the readiness level of technology with respect to the maturity of the technology itself, the process that procures the technology and the simulation quality, i.e. the ability to simulate the real world by means of the underlying models. These dimensions are evaluated towards a 9-level scale, where each level is pre-defined and described qualitatively. When a technology reach level 6 on all three dimensions it is assumed ready to include in product development projects.

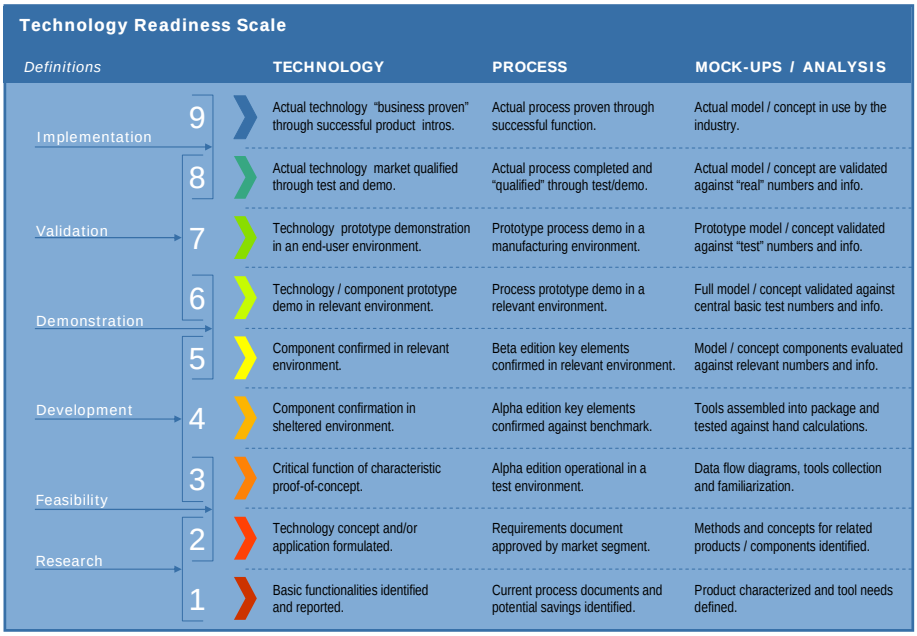


Figure 72. Technology readiness scale descriptions.

Conclusion

The observation highlights the important principle of managing the *portfolio of technology projects* distinct from the product project portfolio. This is explicated in the proposed reference model.

Moreover, the fact that the management assesses the readiness of technologies under development implies that the technology at a certain point in time is ready to be considered as off-shelf technology. That is, ready to be included in a stock of technology packages and modules ready for immediately utilization in product projects.

This appears to reasonably underpin the division of the technology project portfolio into two sub-portfolios on the reference model, namely technology *projects* and *packages*.

5.6.7 Conclusion

The aim of this section has been to verify the proposed reference model's ability to contain a true and fair view of industrial portfolio management elements and principles.

This has been done by confronting the central elements and principles in the unifying framework with industrial portfolio management practices derived from empirical observations in four companies.

Many of the principles contained in the reference model have been observed in the companies. The extent of congruity between the empirical observations and the principles laid down emerges from the overview presented on Figure 73 on a following page.

No explicit evidence has been retrieved, which underpin the following four elements inherent in the reference model: The corporate strategy process, planned technology projects, the sub-portfolio of withholded

products, and supplementary projects. This is, however, not the same as assuming that they do not exist in industrial practice and thus are irrelevant to include in the model.

Due to the small sample size the study cannot be regarded as statistical representative for the industry in general. Nevertheless, the author assumes that the totality of the observations provides a plausible indication of contemporary industrial portfolio management principles. The fact that the four cases are taken from different product development contexts, but still illustrate significant commonalities appears to underpin the assumption.

In sum the proposed reference model's ability to contain a plausible view of principles and elements inherent in industrial portfolio management seems to be reasonably verified.

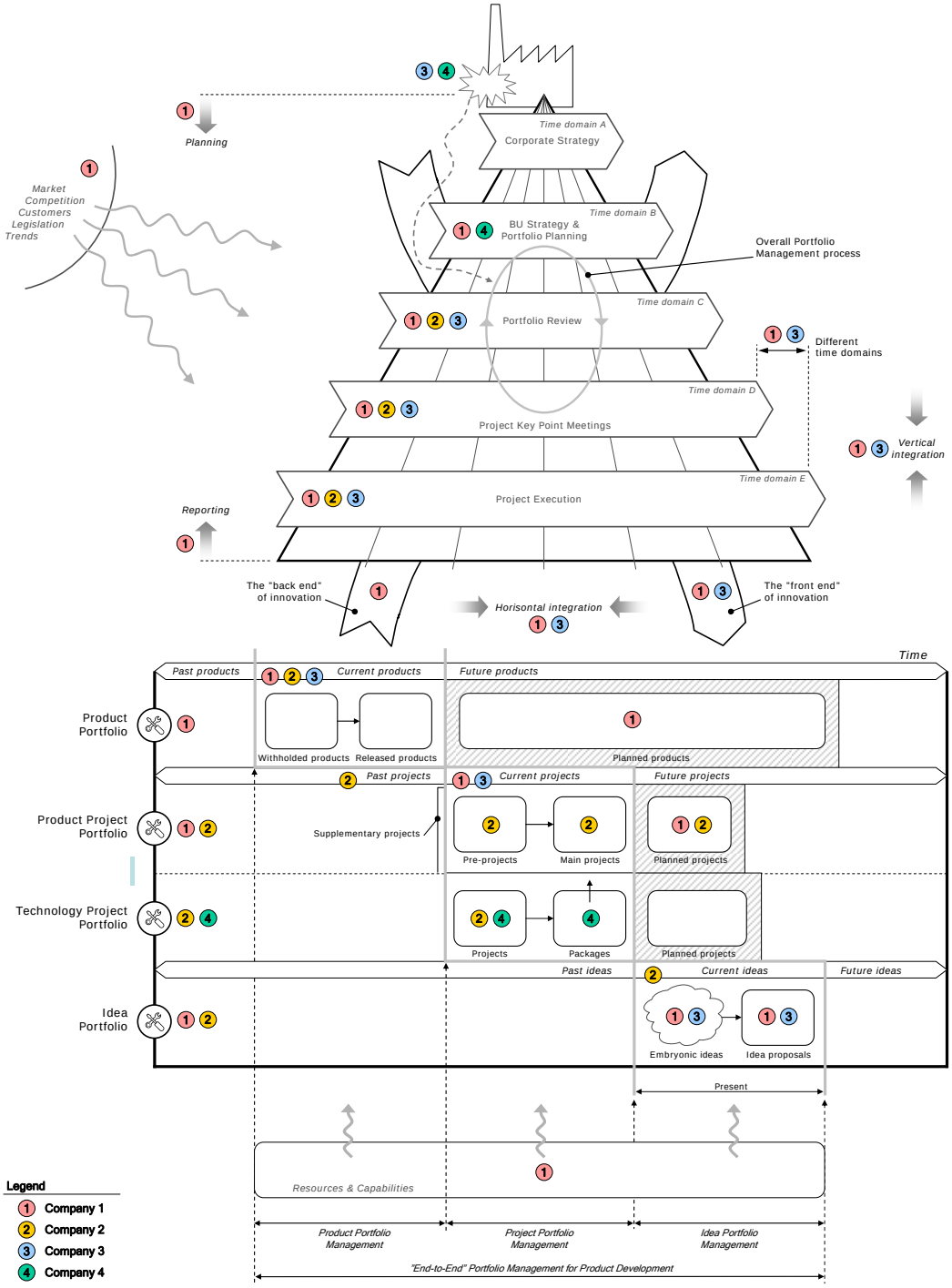


Figure 73. Many of the principles contained in the reference model have been observed during the empirical studies.

5.7 Conclusion

The aim of this chapter has been to propose a reference model for portfolio management for product development, which can promote an enhanced understanding of the essential elements and principles in portfolio management and their relations within a company context.

Purpose

The work is a reaction to an observed comparative conceptual weakness in terms of the lack of a common theoretical base whereto contributions may be referred.

Since portfolio management is among the most crucial business processes in a company, it is evident that the observed weakness is an unacceptable foundation for the further academic exploration and understanding of the phenomenon. Even though such a model initially may appear of primary interest to academia, it was also asserted important to industry professionals. This is due to such a model's potential to guide the development and implementation of effective and integrated portfolio management systems in industry.

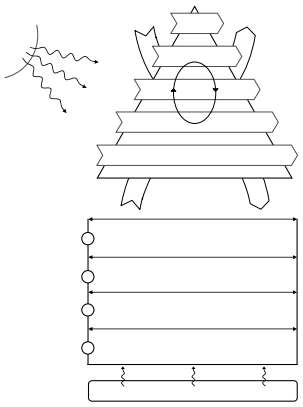
The research has been guided by the following question:

Research question 1

Which structural elements and principles are inherent in portfolio management for product development? What is their central interplay and how can they be modelled and visualized?

The proposed model

Based on the fulfillment of eighteen stated propositions the research has introduced a theoretically based and consistent reference model which explicates the following central elements inherent in portfolio management:



- The object of manipulation (idea, project, product).
- Portfolio planning process.
- Portfolio review process.
- Project key point review process.
- The front end of innovation process.
- The back end of innovation process.
- Portfolio manipulations.
- Integration (horizontal and vertical).
- The external business environment (market, competition, legislation).
- The internal business environment (the development capability).
- The impulse which initiates portfolio decision making.

Key principles in portfolio management emerge from the explanation of these elements and their interaction, which in total comprise the portfolio management architecture in a company.

Originality

The principal originality of the proposed model lies in:

- The theory of the product development process forms the starting point for the model. Hence the *theoretical based* model is explicitly dedicated to portfolio management for product development with the considerations this implies. This is unique since many contributions within portfolio management do not seem to distinguish between the domains of application.

- This model accentuate that it is beneficial to discriminate between and consider at least *three generic classes of portfolios* when making decisions about the new product project portfolio mix, namely the idea portfolio, the (product & technology) project portfolio, and the product portfolio.

  Thus the model acknowledges the gradual transformation of a product idea into a product project which results in a product. This supports a more nuanced and coherent *end-to-end* approach to portfolio management, since it indicates that it is possible to manipulate and improve the potential business value of a "portfolio" in several stages. Moreover, this distinction is vital since the management of the various portfolios requires dissimilar processes, techniques and tools.

- The portfolio management *concept is divided* in accordance with the nature of the object of manipulation.

  The model suggests that the management of the *project* portfolio occurs by means of dedicated project portfolio management processes. The management of the *idea* portfolio, however, is asserted to occur in the "front end" of innovation process. The management of the *product* portfolio occurs in the "back end" of innovation process. Both processes are illustrated as background processes on the model in order to indicate that the processes are closely related and highly important to, but distinct from the project portfolio management process.

  This distinction is central since it acknowledges the disparate degree of uncertainty associated with the allied decision-making during portfolio management.

- The model emphasizes the need for horizontal and vertical *integration* of personnel in portfolio management. The explication of integration is vital in order to state that portfolio management does not exist in isolation in a company. Rather, it is all-encompassing and highly dependent on contributions from many people in the company.

Validity

The central elements and principles in the unifying framework have been confronted with industrial portfolio management practices derived from empirical observations in four companies. The confrontation seems to verify the model's ability to contain a plausible view of industrial portfolio management within the studied companies.

Future prospects

The author assumes that the proposed unifying framework will be an imperative step in the direction of supporting the further development of the terminology and knowledge within the research area portfolio management and product development.

6 Explaining the dynamics of over-commitment in portfolio management

6.1 Introduction

A proper match between the number and types of projects pursued and the available capability is fundamental in portfolio management. This may sound as an easy task, but that is certainly not the case.

Room for improvement

Observations made during the course of this research and presented in the introductory chapter indicate that there is still plenty room for improvement of industrial portfolio management practices. The elements and principles included in the formerly proposed reference model are among the means to accomplish this ambition.

Too many projects, too few people, unsteady project selection and poor prioritization of projects are among the recorded challenges companies struggle with on a daily basis. They all contribute to degrade the productivity in product development.

As indicated in section 2.5 the author assumes many of these ailments originate from an over-commitment of the product development resources. That is, the situation which occurs when the management commits to undertake too many and/or improper projects simultaneously for the capability at hand.

The author asserts that a thorough understanding of the dynamics of the phenomenon over-commitment and its underlying mechanisms constitute the key to resolve many of the observed burdensome problems. This forms the justification for investigating the phenomenon in this chapter.

Aim of chapter

The aim of this chapter is to contribute with a thinking pattern, which explains the dynamics of the phenomenon over-commitment in portfolio management. Such a mindset should enrich our understanding of the realities that many practitioners are confronted with.

Theoretical purpose

The theoretical purpose of such a mindset is to provide a theoretically based and consistent thinking pattern. Such a pattern should explicate some of the central causes and their interlinking in an overall pattern of inherent causality, which forms a plausible explanation of why over-commitment might arise. The understanding conveyed by such a thinking pattern is assumed indispensable in order to support companies in improving their portfolio management practices and thus to resolve the burdensome over-commitment phenomenon.

Industrial purpose

The proposed mindset is intended to support the management in industry (i.e. R&D managers, portfolio managers, product managers etc.) in understanding the phenomenon of over-commitment and subsequently preventing the derived problems to arise. Thus the contribution shall be considered as a productive mindset for industry management professionals, which complements the conventional tool-oriented approach to portfolio management.

The research will be guided by the following research question:

Research question 2

How can the dynamics of over-commitment in portfolio management for product development be explained? What is the nature of the phenomenon?

Proposal for a mindset

Based on the aggregated knowledge from the literature study and the initial empirical observations the research introduces a mindset, which attempts the stated research question. The thinking pattern is based on the assumption that over-commitment well may be rooted in an unrealistic perception of the product development capability among the management team within the company. The mindset consists of a set of defined and interrelated causes which are embedded and linked in a cyclical pattern that explicate the negatively reinforcing and dynamic nature of the phenomenon.

Structure of chapter

Initially, relevant literature is reviewed in order to identify and analyze aspects that can reveal insights on the dynamics of over-commitment and thus help to pinpoint essential aspects which a potential mindset should reflect. Then a mindset is synthesized, which aims at explaining why over-commitment may arise. Subsequently the mindset is presented to industry professionals for verification. Finally, a conclusion is presented in the last section.

6.2 Investigating aspects of over-commitment

6.2.1 Introduction

In order to synthesize a thinking pattern which explains the dynamics of over-commitment, it is necessary that we understand central aspects of the phenomenon. Hence the aim of this section is to investigate the literature in order to identify such aspects which a potential mindset should reflect.

Structure of investigation

The findings from the literature reported on the following pages are roughly structured as follows:

Firstly, the connection between a fundamental lack of resources for product development and over-commitment is examined.

Second, the attention is directed towards the assumption that over-commitment well may be due to an unrealistic perception of the product development capability in the company.

Third, the study focuses on how a continuously growing amount of tasks and activities which either are remote to the development functions core tasks or caused by work that previously has been done insufficiently can add to over-commitment.

Next, it is explored how an inadequate management of the dynamic portfolio might lead to over-commitment of the product development resources.

After that, the relationship between a general reluctance to stop improper projects and over-commitment in companies is considered.

Finally, a conclusion which accentuates central aspects of over-commitment for a potential mindset to incorporate is derived and presented in the last section.

6.2.2 Lack of resources

Cooper, *et al.* (2004b) suggests that many of the problems companies encounter are rooted in a significant shortage of resources devoted to product development. In their major benchmarking study for the American Productivity and Quality Center, the lack of focus and inadequate resources surfaced as the number one weakness in businesses' new product development efforts. A lack of resources devoted to product development across all functions was among the most serious deficiencies as illustrated on Figure 74.

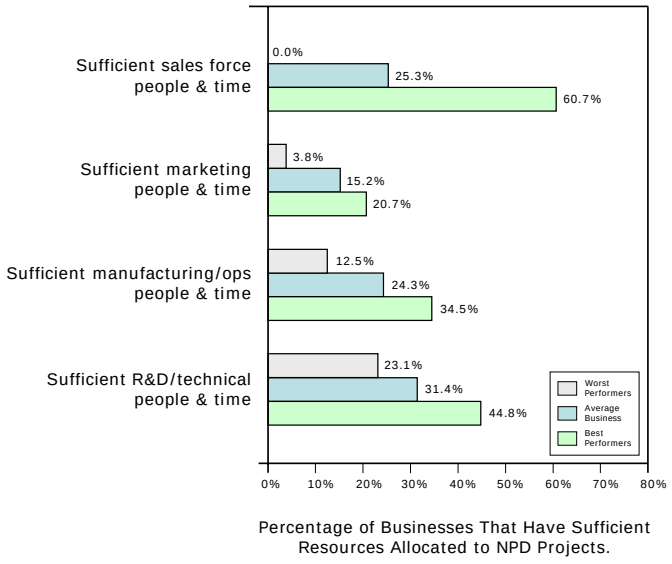


Figure 74. Resource availability by functional area – impact on performance (Cooper, *et al*. 2004b).

Cooper and colleagues stresses the severe consequences of the pervasive resource deficiencies in many businesses when they write:

"Indeed, adequate resources from the functional areas are a major discriminator between Best and Worst Performers, and adequate resources in all four areas are strongly correlated with NPD performance, particularly with new product profitability and success".

The scarcity of product development resources causes several problems, which eventually results in low profitability in product development according to Cooper & Edgett (2003). They explain the relation between inadequate resources and declining productivity by means of series of interconnected cause-effects, which in its totality forms the complex pattern illustrated on Figure 75.

Short term profitability

The senior management's preoccupation with short term profitability is considered a fundamental cause for the insufficient amount of resources devoted to new product development.

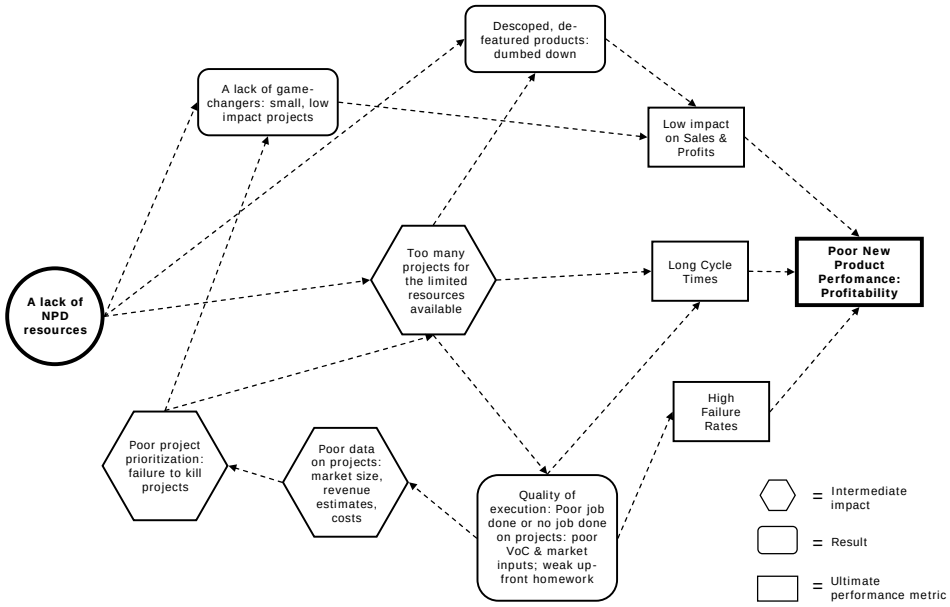


Figure 75. A lack of NPD resources has many negative consequences, ultimately resulting in low NPD profitability (Cooper & Edgett 2003).

This encourages people to pursue projects which contribute to the near term bottom-line combined with cost-cutting according to Cooper & Edgett's observations:

"To meet short term financial goals, business unit management was caught in a dilemma: They could do what was good for the business for the longer term, or resort to short term maneuvers - cost cuts and resource freezes - in order to achieve the immediate goals set by corporate headquarters".

Too many projects

In order to compensate for the latter situation technical staff are spread across too many projects. Consequently, everyone has to work harder while trying to balance their attention between several projects as well as handling a variety of day-to-day tasks. Cooper & Edgett (2003) writes:

"*Indeed, the term "pipeline gridlock" was used by some managers to describe the situation in their business".*

As indicated by Figure 74 not only the technical people are exposed to this predicament. Rather, it is a pervasive phenomenon which affect all functions, and in particular the marketing people.

Speed to market

Cooper & Edgett (2003) suggests an overemphasis on speed to market as the final reason. As formerly indicated senior management are preoccupied with short term profitability. Accordingly, they may strive to reduce cycle time in order to realize fast profits. This multiplies the resource shortage problem as they write;

"*As time to market are compressed the rate of projects entering the pipeline increases".*

In other words, the departments and project teams must handle and shift their attention among even more projects per year. Cooper & Edgett (2003) advocate that projects therefore are trivialized and the quality of execution is compromised.

We notice that Cooper and colleagues imply that companies actually do pursue the adequate number of projects needed to achieve the stated business targets. Paradoxically, however, there seems to be an imbalance between the business objectives the company strives to achieve by means of product development, and the amount of resources they dedicate to their achievement.

In spite of the resource shortage the projects needed to accomplish the business objectives are pursued anyways. Hence it seems that over-commitment of the development resources invariably will form the starting point for product development.

This gives rise to many ailments, which are interconnected in a *complex*, *pervasive* and *dynamic* pattern that appears to be *multiplying negatively*. This problem complex ultimately contributes to degrade the productivity of product development.

Un-enacted projects

Blichfeldt & Eskerod (2005) contribute with another perception of the resource shortage issue. They propose the gap between the needed and available resources for product development is due to the existence of smaller projects that are not being enacted by the senior management. This set of unauthorized projects drain resources from the projects that the resources, initially, were dedicated to. They suggest that at an aggregate level the "un-enacted" projects qualify as "resources crunches" in so far these projects are not considered a part of the enacted portfolio.

The findings of Blichfeldt & Eskerod (2005) imply that the senior management in companies is lacking the necessary leadership or control to ensure that their decisions get implemented as planned. This underlines the difficulties associated with *controlling* the productivity in product

development. Additionally, a *fact-based understanding* of the organization's development capability seems to be missing. Consequently, it seems that the senior management plans with and allocates resources which in reality are not available. This increases the probability for over-commitment of the development resources to occur.

Patterson (2005) also acknowledges the problems stemming from projects' initiated and existing outside the purview of senior management. He argues that this activity should not be accepted as clandestine behavior. Instead, resource pools for such projects should be consciously allocated as a part of the R&D investment portfolio. This would allow the staff to autonomously pursue minor projects within the resource boundaries defined by the senior management. Patterson (2005) recognizes the dilemma regarding control and creativity in product development when he writes:

"A certain freedom for experimentation is desirable and can lead to important learning, even breakthroughs".

On the one hand a key part of the portfolio management responsibility is to ensure that the R&D investment is being spent as intended. On the other hand, new and innovative projects often begin by "spontaneous combustion" in many firms, and thus not as "official" projects.

Thus it is inexpedient to control resource allocation in detail, since it is important that there is room for improvisation. It is vital, though, that the latter does not get out of hand since it can add to over-commitment of the resources.

6.2.3 Unrealistic perception of the development capability

Wheelwright & Clark (1992a) acknowledge that companies all too often seriously over-commit their development resources and end up having far too many projects going at once. Paradoxically, they observed that the potential business value of the development portfolio did not reflect the increase in costs or projects, as they write, since many of the projects in the development pipeline no longer seemed to reflect the needs of the market. For example, they refer to their PreQuip case when they write:

"For some months, the development budget had been rising even as the number of completed projects declined", and also, *"The more projects they added, the more their productivity dropped".*

Furthermore, they report the following observations:

"They [the management] discovered that 30 projects were under way - far more than anticipated, and, they suspected, far more than the organization could support. Further analysis revealed that the company had two to three times more development work than it was capable of completing over its three-year development planning horizon".

Wheelwright & Clark (1992a) advocate that over-commitment in product development well may be rooted in an unrealistic perception of the product development capability within companies.

Wrong projects

Besides the obvious over-commitment of resources Wheelwright & Clark also reports that companies lack sufficient strategic guidance for project selection:

"When questioned, project leaders admitted that the strategic objectives outlined in the annual business plan had little bearing on project selection".

As a consequence, not only are the company's resources spread too thinly across many projects, the set of projects is also inconsistent with the company's development strategies. According to Wheelwright & Clark (1992a) this means that the development portfolio does not reflect and reinforce the company's business strategy, i.e. facilitate and create synergy effects. This might in turn also jeopardized the company's long term capability development.

We note how the findings of Wheelwright & Clark (1992a) seem to indicate that over-commitment in product development stem from the management's unrealistic perception of the company's development capability. Furthermore, the phenomenon can be characterized as being both *dynamic* and *negatively reinforcing*.

Projects and functions viewed discretely

Harris & McKay (1996) suggests that the absence of a fact-based understanding of the organization's development capability encourage the formulation of unrealistic product development strategies. Furthermore, they consider the planning approach applied in many companies as inadequate for a high-performance product development process. The problem is that projects and functions are viewed discretely, not in aggregate. Hence cross-project management on a continuously basis is omitted. They write:

"Usually, the connection between strategy, project management, and functional management is limited to the annual budgeting process - a holdover from the functional orientation of the past ...".

Need for day-to-day management

Harris & McKay (1996) argue that this situation results in development output which is far from being maximized, connections between strategic plans and actual deployment of resources are nebulous, and the organization lacks the flexibility to respond rapidly to changes. In other words, they claim it is not sufficient to only address the totality of projects during an annual portfolio planning activity if the potential business value of the development portfolio is to be realized. Rather, it is necessary to complement the annual assessment with attention to the portfolio during the remaining year.

6.2.4 Increasingly burdensome "debt"

Andreasen, *et al.* (1989) introduces the concept of debt in product development. Debt consists of tasks and activities which either are remote

to the development functions core tasks or caused by work that previously has been done insufficiently (i.e. poor execution of the work). Typically, the debt is continuously growing as a result of an inexpedient working pattern in the development function. Andreasen and colleagues argues that debt arises from three main sources:

An enormous project and product portfolio, which tends to be more and more unfocused, combined with a misallocation of resources among the projects.

Noise generation is the result if an incomplete development task is transferred from development to the production, procurement, sales, service etc. Noise generation leads to new jobs, numerous tasks, time-consuming problem fixing, changes, and firefighting etc. resulting in increased costs.

Volume "sickness" arises when the product development function is unable to determine when to release what product, and which features to include. Due to this unsteady sense for business creation many product variants are introduced causing a random growth in the product portfolio.

The problem with debt arises from the fact that an increasing amount of the product development resources intended for "true" product development well may be over-committed due to the *disturbing* and *increasingly burdensome* "repayments" on the growing debt.

Firefighting

Repenning (2001) also recognizes the existence of the unplanned allocation of resources to fix problems late in a product's development cycle. He designates the phenomenon *fire fighting*, and he claims that firefighting is a main reason for why many companies do not reap the benefits from their product development process. He suggests that fire fighting can be a self-reinforcing phenomenon that leads to a downward spiral, as he writes:

"Once it starts in one project, it is likely to spread to others, permanently degrading the capability of the development system".

He argues that the problem multiplies when the development system is multistage and multi-project oriented, which, indeed, is the situation for many companies today. Such systems are far more susceptible to fire fighting than is currently appreciated.

In other words, the risk for companies to implicitly over-commit their development resources due to resources curbed by firefighting increases with the size of their project and product portfolio due to the *amassing, cyclical* and *contagious* nature of the burden.

Poor rework efficiency

At the level of individual projects Gouel & Fixson (2006) found that the efficiency in rework, i.e. the unplanned repetition of work thought to be completed, tend to be degraded if the problem-solving is constrained by a tight resource and project schedule. Such conditions may prolong the problem-solving process since there is not set time aside such that every

problem is properly root caused during the project. Additionally, the team may find the equipment and prototypes needed to verify solutions unavailable in time due to resource shortage. Finally, a strict timetable may even compel the development team to cut corners and thus omit proper verification of solutions. Gouel & Fixson (2006) contemplate that the pattern described above is exacerbated in accordance with the complexity of the products to be developed. Furthermore, they acknowledge the negative impact of such problems at portfolio level, when they write:

"For the product development organization as a system this implies that more ongoing problems remain in the system and require attention than would be optimal".

In other words, if a company confronted with over-commitment attempts to improve the situation by tightening the timetable and cut down expenses for projects, it is likely to slow down the speed of problem-solving. Hence more ongoing problems remain in the development system which diverts resources from other vital activities. Consequently, the productivity is further degraded instead of being enhanced. This underlines the *pervasive* and *escalating* nature of the situation.

6.2.5 Inadequate dynamic management of the portfolio

Based on their study of 85 companies McDonough & Spital (2003) explain that many difficulties in portfolio management well may be attributed to inadequate day-to-day management of the development portfolio. This include the policies, practices, procedures, tools and actions the management takes to e.g. manage resources and make allocation decisions across the portfolio. McDonough & Spital (2003) pinpoint three common pitfalls which are destructive to business performance, namely: 1) stretching the people resource, 2) stretching the money resource, and 3) switching team leaders and members. These pitfalls are briefly examined in the following.

Stretching the people resource

The prospect of benefiting from using one person's expertise on more than one project seems to tempt many managers to assign the same individual to several projects. McDonough & Spital (2003) found that project personnel in less successful project portfolios were working on a significantly greater number of projects than people in successful portfolios. In an attempt to find an explanation of why such situations arise they quote a portfolio manager:

"In the past, part of the answer regarding why project personnel were over-allocated was how we allowed projects to get started. R&D personnel were given 10-15 percent of their time to be creative and inventive. Therefore, large numbers of projects came about. But people began these projects without an understanding of the ramifications of downstream problems. They always underestimated or under-appreciated what it would take to make things happen down-stream".

The quote indicates that project selection decisions in some situations seem to be made in isolation, i.e. on the basis of the individual project

with only little concept of the resource and capability requirements implied at portfolio level for the company. It seems reasonable to assert that this situation increases the probability for over-commitment of the development resources to arise.

Stretching the money resource

The second common pitfall McDonough & Spital (2003) found was the idea of spreading the financial development resources too thinly across their project portfolio since this can result in shortages of vital equipment, prototype modelling or testing.

Switching team leaders and members

Furthermore, according to McDonough & Spital (2003) the strain on resources may intensify due to the inexpedient switching of team leaders and members during the lifetime of a project. Among the causes is the loss of tacit knowledge the members possess about the specific projects. Additionally, the change of managers is likely to disturb the project dynamic since each manager subtly imparts his own management style on the team. Consequently, it can take considerable time to rebuild an effectively functioning team. Moreover, a new leader may not feel prompted to acknowledge responsibility for recovering the project from prior schedule slippages.

Engwall & Jerbrant (2003) similarly found that that the prime challenge of managing project portfolios' evolved around the dynamic resource allocation and how the management tries to coordinate the portfolio in action. Portfolio managers were overwhelmed with shifting the scarce personnel among projects in the portfolio in an attempt to make ends meet. They write:

"Furthermore, when resources were redistributed it often produced negative effects on other projects in the portfolio. This forced the management to continuous fire fighting, resulting in reactive behavior and short-term problem solving".

Engwall & Jerbrant (2003) advocate that these problems well can be rooted in the use of management accounting systems that is dysfunctional for multi-project management as well as opportunistic project management behavior.

Dysfunctional accounting systems

The former refer to situations where the management accounting systems unconsciously are designed in such a way, that they accidentally discourages different departments in the company to contribute to the achievement of overall productivity improvements for the company. Consequently, the department managers indulge in narrow-minded, sub-optimization of resources. For example, they report how they in one company found that the R&D department's resources were allocated according to engineering hours spent on contracted projects whereas non-project time like department meetings, education, and idling was accounted as cost. Thus from the department managers perspective the financial incentive was to spend as many engineering hours as possible on every individual project instead of seeking overall productivity improvements for the company. In other cases engineering hours was not

registered at all, and subsequently the management had no combined information about the actual allocation of resources across projects.

Opportunistic project management

Engwall & Jerbrant (2003) pinpoint opportunistic project management as the second mechanism underlying the observed problems. Since the resources are scarce the project managers compete to get the best people allocated to their projects. Engwall & Jerbrandt reports situations where project managers could not come up with the arguments for raising a projects priority. Instead, they deliberately did push the project to such a crisis that it had to gain priority if it should survive at all. The protection of acquired personnel constitutes another variant of the opportunistic approach. Engwall & Jerbrant (2003) explains how some project managers recognized the risk of loosing resources if these were temporarily borrowed to other projects. As a response some project managers take precautions by keeping personnel occupied, busy and unavailable.

6.2.6 Cognitive blindness

Collective belief

Royer (2003) introduce the concept of *collective belief* when she explains why it appears so surprisingly difficult for companies to weed out poor projects from the portfolio despite mounting evidence that their success is unlikely to be achieved. Her study of two companies revealed the harsh consequences two companies experienced due to their reluctance to stop two major development projects. For one of the companies the loss exceeded $50 millions in 1990 dollars over a period of 10 years. The other company had to accept costs in the region of $30 millions in 1992 dollars during 7 years.

Royer describe the collective belief as a very human impulse which is the result of the human desire to believe in something, which in this case is in the projects' ultimate success. The belief emerges from an individual, who is strongly convinced about the projects' value to the company. Such a resolute and enthusiastic belief is typical contagious, and can thus easily spread to others in the organization. When first such a belief attains a strong foothold in the company it tends to perpetuate itself. Individuals may find it overwhelmingly difficult to voice critical concerns due to the groups' unanimity. Furthermore, a strong collective belief can also jeopardize normal organizational procedures and safeguards. For example, at the beginning of a project that seems bound for glory managers may easily forget to establish such structures or simply ignore their existence.

In sum it appears that when team members enter into such a state of "cognitive blindness" it can seduce an otherwise rational organization into some very irrational behavior due to the emergence of wishful thinking by decision makers. In other words, the concept of the collective belief explains why it can be so difficult for a company to resolve burdensome over-commitment by releasing and re-allocating resources restrained by inexpedient projects.

6.2.7 Conclusion

The aim of this section has been to identify and analyze central aspects of the phenomenon of over-commitment in portfolio management, which a potential mindset should reflect.
The excursion into the literature combined with the observations reported in the introductory chapter has revealed that over-commitment of the development resources is a multifarious and complex occurrence. In particular the following five aspects seem to characterize the dynamic phenomenon:

Aspect 1

The effects of over-commitment are displaced in time

In concordance with the staggered nature of product development the effects of over-commitment are also displaced in time. Thus many of the consequences stemming from over-commitment of the development resources might first be revealed in other of the company's functional areas with a time delay outside the decision makers' purview.

The product managers, for instance, are among the few people in the company who actually follows products closely from "cradle to grave", i.e. from their conception in the early phases of product development to their development and introduction to the market where the product is commercialized, sustained, and eventually withdrawn. Accordingly product managers are confronted with many of the effects of dispositions made during the development of the products. Quality problems and declining sales constitute examples of such effects. Thus it seems reasonable to assume that a substantial proportion of a product manager's workload well may be correlated with the consequences of decisions regarding products made before and during their development.

It may, however, be difficult for the senior management to spot a connection between a mounting workload of e.g. product managers and previously perpetrated over-commitment since the former type of product management work often is regarded as operational work that occurs somewhat separated from the strategic aspects of product development.

In other words, the management may never realize that they actually over-commit the development resources since they may not directly experience many of the associated negative effects. The latter might well emerge in other functional areas with a significant time delay.

Aspect 2

Over-commitment is contagious

Even though over-commitment seemingly might only concern a single project, it is likely to also influence other projects in the portfolio negatively.

For example, an apparently isolated and harmless decision regarding the initiation of an additional project C for which dedicated resources do not exist, may lead to problems in the projects A and B with meeting the quality requirements.

This situation can arise because resources are taken away from the projects A and B in an attempt to stretch the resources to support the new project. Consequently, the projects A and B are confronted with a resource shortage which probably will affect their quality of execution.

This research assumes that the amount and extent of such problems encountered in individual development projects well may *intensify* at portfolio level unless the *totality* of projects are considered and managed properly.

Aspect 3

Over-commitment is negatively reinforcing

It seems reasonable to assert that the phenomenon over-commitment is negatively reinforcing, since it give rise to a multifarious and highly complex pattern of associated problems, which in sum contribute to aggravate the resource situation. Thus over time an increasing amount of the product development resources intended for "true" product development may well be confined by problem fixing. This cyclical and increasingly burdensome working pattern holds the potential to seriously degrade the capability and productivity of the development system.

This is a paradox, because over-commitment arises as a reaction to an imbalance between the number and types of projects pursued and the resources at hand.

Aspect 4

Over-commitment is company pervasive

The phenomenon of over-commitment cannot be confined to a single functional area or department in a company. Rather, over-commitment extends across the company. It can arise everywhere in the company where decisions regarding allocation of development resources are made. Similarly, the negative effects stemming from over-commitment might emerge in any department in the company which contribute to product development.

The dilemma is that the pervasive problem can be very complex to diagnose for the management since it requires a strong breadth of view of the company and the nature of product development, which only very few individuals, if any, may possess.

Aspect 5

Over-commitment is disturbing

Over-commitment incurs many problems which continuously require resources for their fixing and coordination. Hence the attention is diverted towards short term problems, at the expense of the long term and strategic important matters. This is disturbing to product development, because it corrupts the portfolio planning, and makes it difficult to control and focus the development effort.

A mindset should reflect these five aspects

The author assumes that it is essential that a potential mindset integrates and reflects the identified aspects, which in sum seems to outline a precarious environment for product development. All of the listed aspects are assumed relevant, but the list is not necessarily complete.

Departing from these identified aspects of over-commitment the attention will in the following section be directed towards the synthesis of a thinking pattern, which explains the dynamics of the phenomenon.

6.3 Towards an explanation: The vicious circle

Over-commitment of the development resources has serious implications for the productivity in product development. Therefore it is imperative that managers are able to recognize and understand it and the related and subtle ailments. Otherwise it may prove difficult to resolve the onerous problem properly. One of the aims of this research is to derive and contribute with a productive mindset which can support industry professionals in understanding and dealing with this phenomenon.

The mindset is founded upon the knowledge extracted from the previous chapters as well as the empirical observations in the introductory chapter. This knowledge is embedded in an explicit framework articulating an overall pattern of inherent causality. The author assumes that the mindset forms a plausible explanation for the dynamics of over-commitment.

Eight of the identified sub-problems are assumed central for the explanation and thus integrated in the proposed mindset, which is illustrated on Figure 76. In the following the embedded sub-problems and the causality between them is explained.

Unrealistic perception of the product development capability (A)

Central reason for over-commitment

Based on the insights from the previous sections it is evident that many factors may cause over-commitment to happen. In line with some of the studied authors this research assumes that over-commitment and many of the associated ailments well might be rooted in an unrealistic perception of the company's product development capability compared to the task, i.e. the portfolio, within the management group. This is indicated on Figure 76 as primary cause A.

Here the term "product development capability" refers to the company's ability to realize the business implied by the development portfolio by deploying and linking the existing resources (manpower, equipment, production facilities, distribution channels etc.) with the available competencies (skills, knowledge, and behavioral characteristics associated with competitive advantage).

The relevant knowledge do exist in a company

It is asserted that companies as a starting point *do* contain the information needed to establish a realistic picture of their product development capability compared to the portfolio. This information, however, is distributed across all the individuals in the organization.

Based on the investigated literature and the empirical observations recorded during the course of this research, however, it seems reasonable to assert that this collective knowledge is not synthesized and exploited properly in several situations. Therefore inexpedient portfolio decisions might be made, which ultimately leads to over-commitment.

For example, crucial portfolio decisions seem in some situations to be subjected to functional dominance, i.e. decisions may be pushed autonomously by a few individuals in isolation. It appears unlikely that just a few individuals possesses sufficient knowledge concerning the company's overall development capability, that enables them to foresee the consequences of such decisions across a company's many functional areas. Hence the projects in question is not qualified and communicated thoroughly in the organization and the assessment of the decisions impact on the overall portfolio seems weak.

In other situations a tendency to perceive the product development function as a "black box" has been noticed. The term signifies a development function that is assumed to be capable of developing whatever product the sales, business development or other departments in the company may promise the customers. Similarly, situations exists where the engineering staff autonomously pursues "exciting" products based on new technology, where crucial considerations regarding e.g. distribution or target segments for the products are vague at best. The gap between available and needed capability in order to realize the development portfolio remains unarticulated, and in some cases, as stated by a R&D director, it seems that a miracle may be needed if the company is to deliver the intended products.

The unrealistic perception might be partly attributable to the findings of Cooper *et al,* (2004). They regard it as a major weakness that only 27.9% of businesses in their study reported that their employees actually *understand* the businesses product development process.

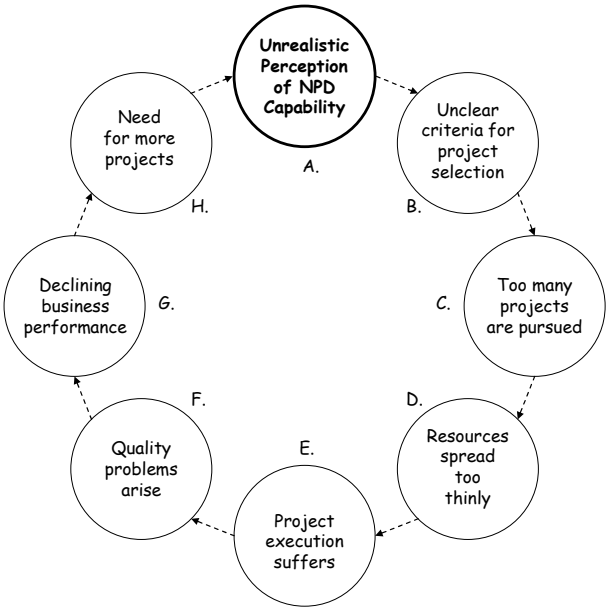


Figure 76. The phenomenon of over-commitment and the related ailments might well be rooted in an unrealistic perception of the company's product development capability.

Consequently, vital decision making regarding the development portfolio might be carried out on the basis of overly enthusiastic and unrealistic expectations to the company's development resources and competencies;

Unclear criteria for project selection (B)
It follows that it is difficult to define and articulate a product innovation strategy, which is considered crucial to provide guidance and criteria for selection of projects to the product development portfolio in accordance with Cooper (1984), Baker & Hart (1999), and Crawford & Benedetto (2003). This may well translate into an unsteady sense for business creation, and the ultimate outcome can be a fragile connection between strategic intentions and the actual resource deployment.

Too many projects (C)
The lack of explicit criteria complicates project selection and prioritization, and makes it difficult to decline a proposed project or stop a project already underway (B). This leads to a proliferation of projects in the development portfolio (C). Additionally, the set of projects may also be inconsistent with the company's development strategies. Consequently, the portfolio profile gradually gets blurred due to the unsteady focus.

Resources spread too thinly (D)
In an attempt to try to support the plethora of projects engaged, each member of the product development staff are assigned to contribute to several projects in parallel. The outcome (D) is that the resources are spread too thinly on too many projects.

Project execution suffers (E)
In order to make ends meet the engineers are constantly reassigned between the various projects and the reshuffling comprises a strain on the resources which causes delays in other projects and the internal productivity decreases due to a rise in development costs. Project managers are confronted with pressure to cut corners and compromise quality just to keep their projects moving forward, and subsequently, execution quality starts to suffer (E).

Quality problems arise (F)
This compromise in the quality of project execution will inevitably be reflected in the business the products are intended to create. First, development delays effects the timing for the introduction of the products to the market, and the "window of opportunity" may be missed. Second, the products lack competitive advantage due to missing features etc. Third, after market introduction the customers will begin to experience quality problems with the products (F).

Declining business performance (G)
The latter circumstance entails that the engineers have to spend considerable time responding to requests from manufacturing, quality assurance and field sales for help with customer problems, - all adding to the cost of the projects, and contributing to degrading the internal productivity. As a reaction to the obvious quality problems with the products, the customers gradually will switch to purchase the competitors'

products, and eventually, the revenue from products will decline. (i.e. decreasing the external productivity). The combination of a rise in costs and failing revenue is obviously hazardous for the profits of any company, and will ultimately result in declining business performance (G).

Need for more projects (H)
The notion of the declining business performance will eventually become evident for the company's senior management, who are obliged to react to the situation. The senior management faces pressure to realize short term profitability, and in an attempt to satisfy stakeholders they tend to resort to a combination of rationalization (cost cuts) and demanding more projects from their subordinates that can realize new and "innovative" products, which can contribute to improve the revenue stream (H).

Closing the circle

The latter circumstance closes the cyclical pattern, and its dynamic nature brings us back to the initial circumstance - namely the fundamental assumption that many of the problems are rooted in an unrealistic perception of the product development capability (A). Henceforward the process repeats itself in a negatively reinforcing iteration and a "vicious circle" is created.

6.3.1 Breaking the vicious circle

Even though it is beyond the purpose of this chapter to propose a solution to the problems, the author assumes that the pattern itself implies several solutions. They can be indicated by establishing a corresponding positively reinforcing pattern as illustrated in Figure 77. Thus, in other words, the efforts can potentially be directed towards establishing one or more of these conditions in order to cultivate a productive environment for product development.

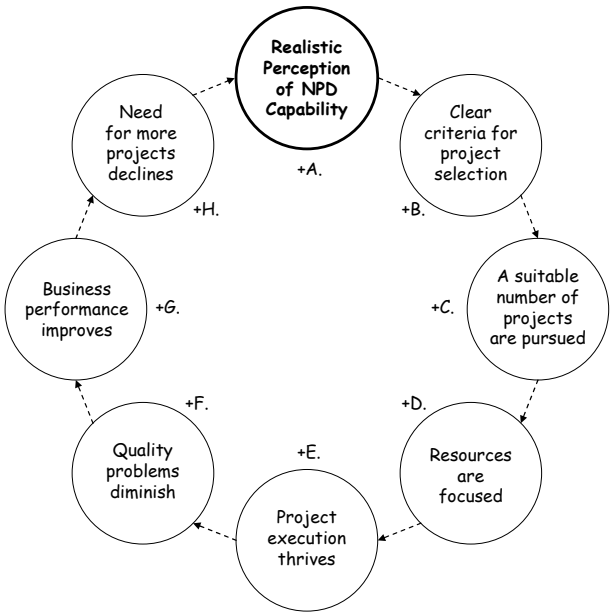


Figure 77. The “good” circle articulates a constructive version of the “vicious” circle mindset.

In industrial practice the mindset is supposed to be complemented with the deployment of various concepts, methods and tools aiming at providing solutions at strategic level, portfolio management level and tactical level. In the following chapter this research proposes three tools which can support the management in unlocking the negative pattern by explicating the dynamic portfolio starting from the individual projects.

6.3.2 Verification

The proposed explanation is attempted validated by means of logical verification and verification by acceptance.

Logical verification

The logical verification includes logical reasoning based on the knowledge derived from the industrial observations and the studied literature. Thus the previous section where the mindsets' elements and their relations have been described are assumed to represent a line of reasoning to show that the embedded elements conform to a theoretical basis and are internally consistent.

Verification by acceptance

Next, the mindset is attempted verified by acceptance of a relevant scientific community. This seems to be accomplished since the proposed explanation has been reviewed and accepted for oral presentation on the Design2006 Conference organized by the Design Society.

Finally, the mindset has been presented to experienced industry professionals in three companies for acceptance. Some of their reactions from the confrontation are captured in the following statements:

R&D Director

"When a crisis exist or ambitious goals are pursued you typically chase many ideas simultaneously. This encourages lack of focus, widespread allocation of resources and unclear prioritization. Delays, "wrong" products or even worse, no products, may be the consequence. This mechanism is unmistakably captured in the vicious circle".

Vice President, Product Management

"The core in achieving business wise success for a company on the global market is to ensure that a steady stream of innovative, high quality products with a distinct, competitive edge is introduced to the market at the exactly right time. From my 10 years of experience within product management I clearly recognize the elements and the pattern described in the model as a challenge for the realization of business goals. It is important that companies are aware of the phenomenon, so they can avoid being caught up in the destructive pattern. I see interesting perspectives in the dissemination of the model".

R&D Project Manager

"Every company wants to be innovative. But when is a product innovative enough? This is a central question we often are confronted with, and it is a dangerous cocktail when mixed with creative engineers and sales people. The answer to the question requires a deep understanding of the boundaries, i.e. the company's development capability and the market conditions. Otherwise you can continue to hunt ideas forever. The worst part is that the problem intensifies as your portfolio grows with new product lines and line extensions. This paradox is crystallized in the mindset, which I think makes perfectly good sense".

Bearing in mind the limited scope of the industrial validation, it seems that the proposed mindset also is acceptable to industry professionals.

6.3.3 Conclusion

The aim of this chapter has been to contribute with a mindset, which explains the dynamics of the phenomenon over-commitment which many industry professionals encounter during their management of the product development portfolio.

The penalty for over-commitment of the product development resources appears too high to discount: strategic misalignment, quality problems, fire fighting, loss of competitive advantage, product failures, compensation payments and questionable corporate brands are amid those recorded during the course of this research.

Purpose

The articulation of the phenomenon over-commitment and the related problems by means of such a thinking pattern is assumed indispensable in order to support companies in improving their portfolio management practices and thus to resolve the burdensome problem of over-commitment.

The research has been guided by the following question:

Research question 2

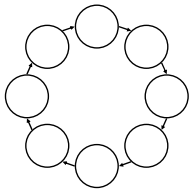
How can the dynamics of over-commitment in portfolio management for product development be explained? What is the nature of the phenomenon?

The proposed mindset

This research proposes a mindset which rests upon the fundamental assumption that over-commitment and the related problem complex well may be rooted in an unrealistic perception of the product development capability within the company.

Originality

The virtues of the mindset originate from the following:



- The mindset integrates and reflects five central aspects which characterize the dynamic phenomenon, namely, 1) the effects of over-commitment are displaced in time, 2) over-commitment is contagious, 3) over-commitment is negatively reinforcing, 4) over-commitment is company pervasive, and 5) over-commitment is disturbing.

- The thinking pattern itself implies several solutions to the problem. They emerge from the corresponding positive version of the pattern, which also is delineated.

- The mindset seems to offer an easy way to impart industry professionals an enhanced understanding of a highly complex pattern of problems, which holds the potential to seriously degrade the productivity in product development.

- The mindset is not only relevant for professionals within one specific functional area like R&D, sales or service or for professionals with specific organizational responsibilities such as project managers, functional managers or directors. Rather, the mindset is important for professionals *across* the company. This is in concordance with the pervasive and contagious nature of the problem complex, i.e. the fact that over-commitment cannot be confined to one functional area or organizational level in the company.

Limitations

The suggested mindset only represents one pattern of explanation. Since the mindset presumes the occurrence of declining business performance it implies that if a company does not experience declining business performance, then the problem complex appears to be invalid. In such situations it may well seem too convenient for the management to disregard the proposed thinking pattern. However, the author suggests that one should be careful with such reasoning. For example, accounting principles may be deceiving. Since the overall business performance of a company is often composed of contributions from several business elements like hardware and software product groups, licensing, service contracts, consulting, financial engineering etc. it might prove difficult to identify the contribution stemming from product development. In other words, even though a company does demonstrate strong business results, the product development function can experience massive problems and declining performance. The following statement from a sales manager highlights the paradox in one company:

"Our overall economic success prevents the need for general improvements. There is no need to thrill and please customers, because they come back anyway. Furthermore, our competitors are not performing better".

One can only speculate about the amount of resources confined by over-commitment, which well may hold a considerable potential for further improving the financial results by means of rationalization and stronger market exploitation.

Furthermore, as indicated in a previous section the staggered nature of product development implies that many of the consequences stemming from portfolio decisions are first revealed with a time delay. Hence the *current* business performance is a result of yesterday's portfolio management practices. But this is no guarantee that today's practices are satisfactory.

Consequently, this research recommends that managers proactively *do* consider and internalize the proposed thinking pattern *despite* the fact that their companies currently might demonstrate strong business results.

Validity

Industry professionals have been confronted with the mindset and their positive reactions give reason to believe that the mindset will be an important step towards resolving the problem of over-commitment and

the related ailments that many companies struggle with on a daily basis across organizational levels and functions.

This research contributes to the research body concerned with finding ways to improve industrial portfolio management for product development. The establishment of a thorough understanding of the over-commitment phenomenon as reported in this chapter is an important and indispensable part of this puzzle.

Thus the author believes that the understanding of the suggested thinking pattern is fundamental and imperative in order to compose and continuously maintain a strong and healthy product development portfolio.

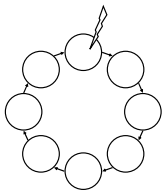
It is, however, important to keep in mind that no explicit solutions to the problem complex have been suggested in this chapter, which can support industry professionals in improving their portfolio management practices.

Resolving the problems

Henceforward, the resolving of some of the problems will form the focal point of the next chapter. Here the research proposes three tools which can support the management in breaking the negative pattern by explicating the dynamic portfolio starting from the individual projects.

7 Supporting tools for portfolio management

7.1 Introduction



The aim of this chapter is to propose supporting tools, which can contribute to solve the complex of problems identified and articulated by means of the "vicious circle" mindset suggested in the previous chapter.

It is asserted that an improved understanding of the dynamic portfolio's condition can help to unlock or prevent the occurrence of the destructive pattern. Henceforth the research will be guided by the following research question:

Research question 3

How can the dynamic portfolio be mapped utilizing the individual projects as points of reference?

Next, it is assumed essential that a potential solution conforms to a number of propositions, which subsequently are introduced.

Proposal for a solution

Based on the fulfillment of the stated propositions the research then introduces three interrelated tools, which deployed in combination accomplishes the task outlined by the research question.

The *dynamic portfolio map* constitutes a condensed view of the aggregate set of projects currently underway in the development portfolio.

The project *planning matrix* and the project *evaluation matrix* support the establishment of the central and dynamic linking between single projects and the portfolio overview.

Horizontal and vertical integration is a dominant theme for the proposed tools since their implementation presumes and encourages the involvement of people from central functional areas and organizational levels. Such a working pattern is assumed to constitute the foundation for promoting a collective realistic perception of the company's development capability among the management. This is considered necessary for carrying out expedient portfolio decisions.

Structure of chapter

Initially, nine vital propositions for a solution to fulfill are suggested. Then three supporting tools for portfolio management are proposed. Next, the intended industrial use of the tools in combination is outlined by means of use scenarios. After that the tools are presented to elleven industry professionals in order to obtain a preliminary indication of whether the tools seems reasonable to them. The chapter entails a discussion of the implications for the further development and implementation of the tools. Finally, a conclusion is presented in the last chapter.

7.2 Propositions for a solution

The goal of this chapter is to develop a tool which can promote transparency and qualify dialogue among the management team regarding the state of the dynamic product development portfolio. It is asserted that such a dialogue is fundamental and indispensable in order to improve the collective understanding of the company's development capability and hence make well-informed and sound decisions regarding the portfolio mix. The tool is presumed to be used by decision makers during periodic reviews of the portfolio.

Decision support

The research rests on the assumption that decision making regarding the portfolio mix is far too complex to be solved by means of a decision model. Hence the tool should not constitute a model, which can tell us how a proper portfolio should look. Rather, the tool is intended to provide support to decision makers by displaying large amounts of relevant but also complex data in a useful way by means of shared representations. This is in concordance with the findings of D'Astous*, et al.* (2004). They studied activities that took place in design evaluation meetings, and found that shared representations of the evaluated subject are a prerequisite for an effective meeting.

Propositions

The author assumes that it is essential that a potential solution conform to a number of propositions, which are introduced in the following. These propositions are derived from the aggregated knowledge from the empirical observations and the examined literature in the previous sections. All of the listed propositions are assumed relevant, but the list is not necessarily complete.

Proposition 1

It is fundamental that the tool can display the aggregate set of product and technology projects which comprise the actual development portfolio, i.e. **projects currently underway** in the development process, since these in aggregate constitute the object of manipulation.

Proposition 2

The tool should provide an overview of each projects **progress** compared to plans. This entails progress in terms of the realization of the product, i.e. the product development process and calendar time.

Proposition 3

The tool should present an indication of the recent **quality of execution** for each project in the portfolio. The tool should pinpoint whereto possible difficulties in projects can be attributed in terms of the contributing functional areas.

Such indications of execution quality are assumed indispensable in order for the decision makers to focus their attention while assessing the overall condition of the portfolio. Furthermore, by requesting such indications decomposed on functional areas the idea is to promote functional integration during product development.

Proposition 4 The tool is supposed to outline all projects **priority** relative to each other. The idea is to make it easy for decision makers to ensure that there is a proper correlation between the projects importance to the business and the resources devoted to them.

Proposition 5 The tool should exhibit an overview of central **interdependencies** between projects in the portfolio. The purpose of visualizing such relationships is to impart the decision makers an improved understanding of how projects in the portfolio are interrelated, and how decision making regarding one project's destiny well may influence other projects in the portfolio.

Proposition 6 The tool is supposed to include an indication of the number of projects currently underway which can be characterized as unplanned **rework.** This entails projects which arise due to work that previously have been done insufficiently in accordance with the findings of section 6.2.4.

The rationale behind explicating the extent of rework is to provide decision makers with an indication of the share of development effort detained by unplanned projects. It is assumed crucial that resources seized by such projects are factored in during portfolio decision making.

Proposition 7 The tool should outline how product and technology development resources actually are used. This encompasses **resource distribution** across business areas and projects.

The purpose of visualizing such aspects is to support decision makers in ensuring that portfolio decisions are backed up by the proper amount of development resources, but also to encourage decision makers to abstain from over-committing the available resources.

Proposition 8 The tool should present an indication of the business contribution in terms of potential **financial value** stemming from the product development investments. This entails the contribution from individual projects and business areas.

The reason for explicating such aspects is to support decision makers in evaluating the profitability of projects and the portfolio. Furthermore, when combined with the outline of committed resources (proposition 7) it enables decision makers to approximate the productivity of the product development investments as identified in section 4.6.1.

Proposition 9 The tool is supposed to enable a **user-friendly presentation** of condensed information regarding the dynamic portfolio to a group of decision makers. The tool is intended to provide a graphical (as opposed to text rich) representation of the portfolio in a brief format.

The proposition rests on the idea that such decision makers do not necessarily have neither the time nor need to learn all the details underlying each project in the portfolio. Rather, a general view of the portfolio combined with indications of project attributes is asserted to be

relevant. This may namely encourage decision makers to question the projects and, if needed, pursue a deeper investigation of selected aspects.

A solution which is based upon the propositions is suggested in the next section. It consists of three tools which are supposed to be used in combination.

7.3 Proposal for a solution

This research proposes the *dynamic portfolio map* as a tool which conforms to the propositions outlined in the previous section. The tool is described in details in section 7.6. The dynamic portfolio map constitutes a condensed view of the aggregate set of projects currently underway in the development portfolio. The tool rests on the idea that it is possible to derive an indication of the overall quality of execution of the dynamic project based on the project group's collective evaluation of the contributions from each functional area during key point meetings in each project. Thus an explicit and dynamic coupling between the individual projects and the portfolio perspective form the crux of the portfolio map.

Linking single projects to the portfolio overview

In order to support the establishment of this central coupling this research proposes two additional tools, namely the *project planning matrix* and the *project evaluation matrix.* They are supposed to be deployed in combination during the execution of the individual projects. The area of application for the tools and their interplay in terms of the overall portfolio management process structure are illustrated on Figure 78. The planning matrix is further explained in section 7.4, and the evaluation matrix is described in section 7.5.

The planning matrix and the evaluation matrix are both supposed to be deployed during a project's key point meetings. Here the evaluation matrix serves as, for example, the project manager's checklist of the project execution quality, and the planning matrix serves as the standard of performance to evaluate against. The proper use of the tools requires involvement of personnel from every contributing functional area.

Scoring model

The *evaluation* matrix builds upon the principles from the unweigthed factor scoring model. As we recall from section 4.6.1 this scoring model includes the definition of a scale (e.g. good, fair, and poor) for the assessment of a project. Hence it offers a group of decision makers an assessment of a project against pre-defined criteria.

Quality of execution

It should be emphasized that the evaluation tool illustrated on Figure 81 is designed to support the dynamic assessment of aspects related to the quality of *execution* within the project, i.e. evaluations in concordance with the projects' progress. Thus the tool is not intended to be used for the appraisal of the business quality of a project, and it does not replace other types of project documentation.

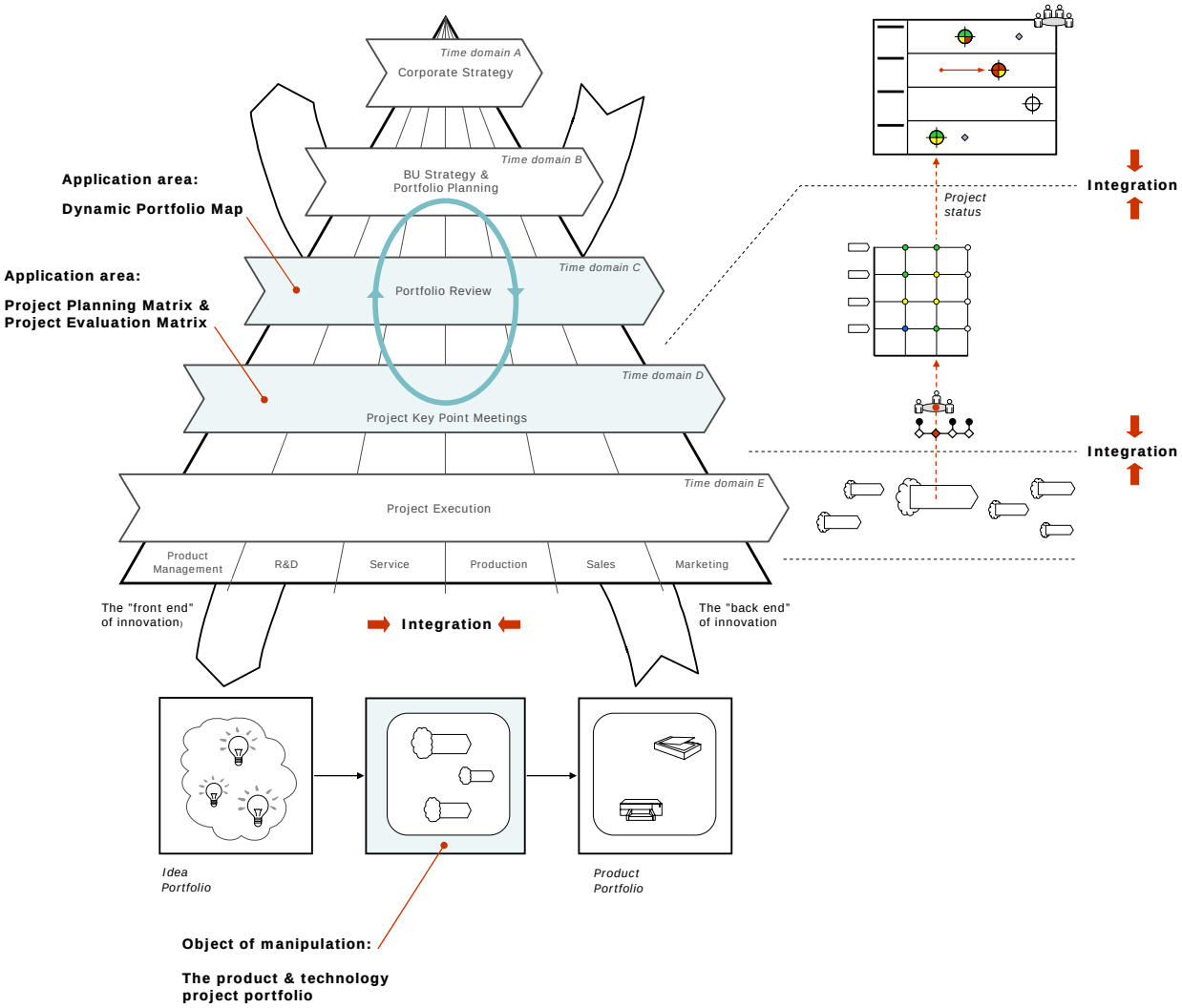


Figure 78. The three tools are intended to be used in interplay to bridge individual project level and portfolio level.

Communicating project status

Besides encouraging a cross-functional working pattern and synchronization within the individual project, the evaluation matrix also provides a way to communicate about the overall execution quality of the project to decision makers "outside" the project for whom the details of every project may be irrelevant.

For the latter purpose the derived indications from the evaluation matrix associated with each project is intended to be projected on the suggested portfolio map. In this way the map comprises a "x-ray" of the recent development portfolio. Since the dense indicators communicate important aspects concerning project progress in a brief format they encourage outsiders to question the project and, if needed, pursue a deeper investigation of selected aspects.

The *planning* matrix is intended to support the project group in defining the deliverables and when they are expected (i.e. at what milestone) from each functional area such as development, marketing, service etc. during project execution. These deliverables and criteria are subsequently utilized as a standard of performance during project evaluation supported

by the evaluation matrix. Hence the tool encourages cross-functional integration, commitment and synchronization within the product development project from its beginning.

Bridging diverse planning approaches

The tool is not intended to substitute traditional project planning methods. It is rather supposed to bridge diverse planning approaches within different functional areas by providing an explicit and easy understandable top level view of the central project deliverables structured according to the key points in the development process. This encourages each functional area to explicitly commit them to contribute to the project while allowing them to pursue their individual approach to planning at a more detailed level. Thus the tool complements other types of project documentation like project definition reports, business cases, milestone reports, project plans, and requirement specifications where deliverables are defined in details.

The details of the tools

Each of the three proposed tools, their structure and elements together with their use are described in detail in the following sections. The planning matrix and the evaluation matrix are firstly explained since the dynamic portfolio map builds upon the status indicators derived from these tools deployed in combination.

7.4 Tool: The planning matrix

The planning matrix and the evaluation matrix tool are both based on the idea of promoting cross-functional integration during the execution of product development projects. The basic structure of the tools resembles the framework for cross-functional integration illustrated on Figure 7 (page 37) proposed by Wheelwright & Clark (1992b).

Basic tool structure

The planning matrix and the evaluation matrix tool are both based on a matrix where the columns reflect the phases of the product development process. The vertical lines, that separates the columns marks the key points of the development process. The rows of the matrix represent the functional areas in a company, which contribute to the product development project. Since the development phases and the number of contributing functional areas well may vary from company to company the matrix should be adapted correspondingly.

However, in order to describe the tools and their use in the following sections it is necessary to associate them with a process model for product development. The generic model depicted on Figure 79 is utilized for this purpose.

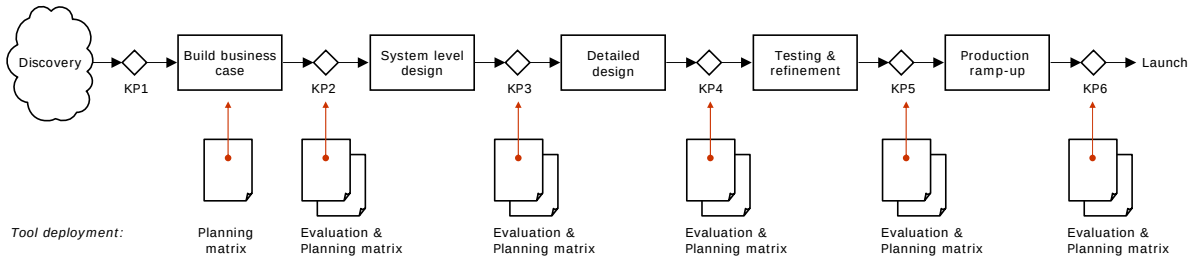


Figure 79. The product development process model utilized for the description of the tools - adapted after Ulrich & Eppinger (2004).

Timing of tool deployment

The use of the *planning* matrix presumes that the realization of a product has progressed beyond KP1 into the "Build business case" phase as indicated on Figure 79. This means that an idea has been identified, scoped and selected. Furthermore, resources for the preparation of a business case by means of a preproject have been approved, and the pre-project has been staffed. The planning matrix is intended to be used to identify the contributions each function is supposed to have in place for the various key point evaluations along the project.

The *evaluation* matrix requires that the business case and the associated upfront planning have been prepared. Hence the realization of the product is supposed to have reached KP2 in the model above. The central decision here concerns whether the company should commit a significant amount of resources for the further realization of the product.

Both matrix tools consist of several interrelated elements. The elements of particular relevance for the *planning* matrix depicted on Figure 80 are described in the following sections.

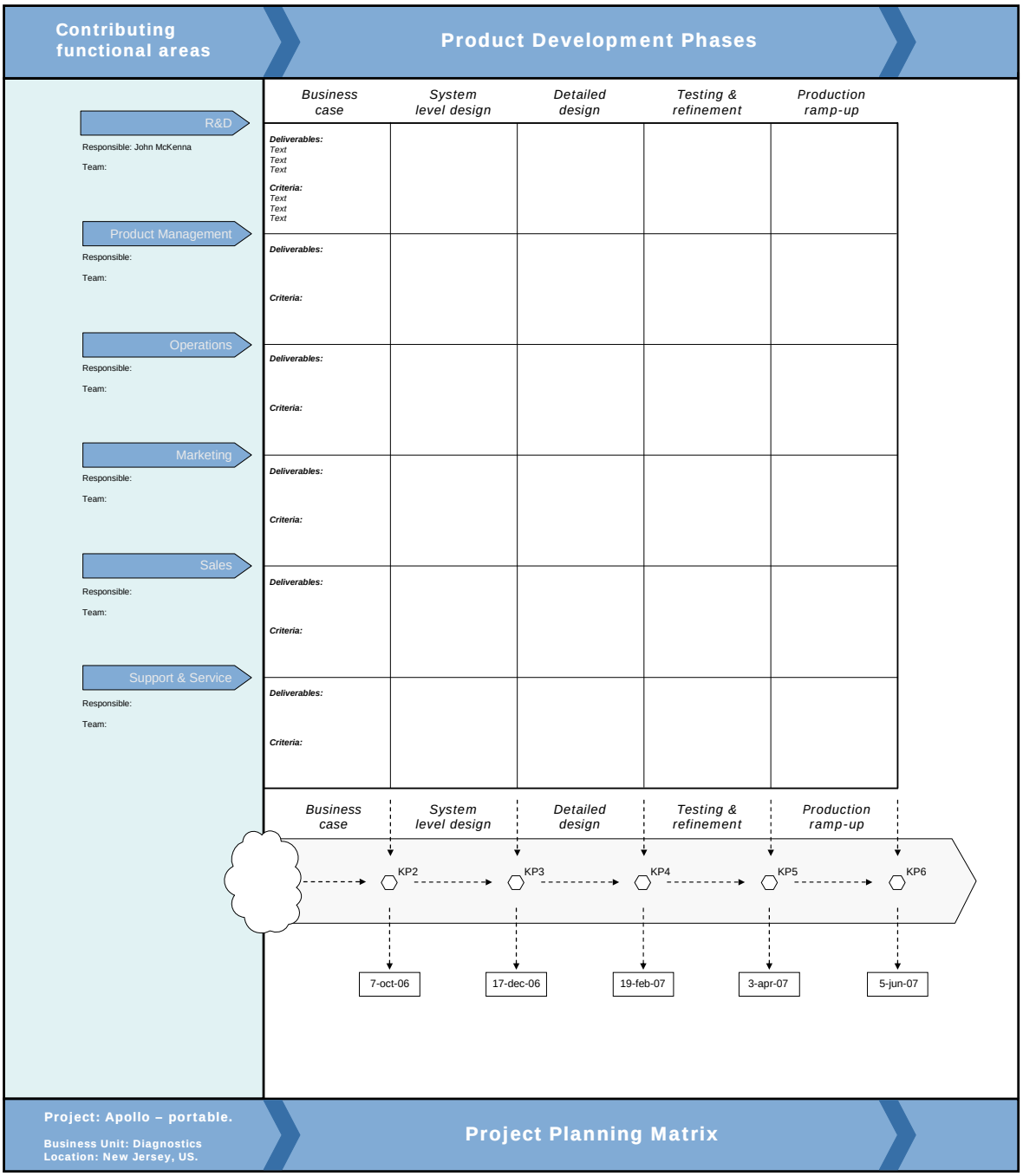
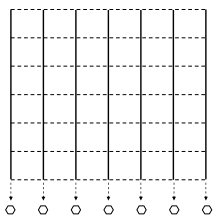


Figure 80. The project planning matrix.

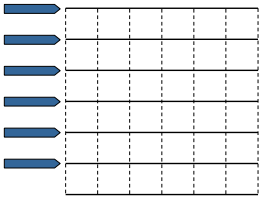


Key point lines - vertical

The vertical lines in the project score grid represent the key points in the product development process. The key point structure forms a fundamental element in the project score and it is included since it comprises a vital working pattern for the team to progress the project.

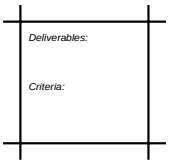
Functional area lines - horizontal

The horizontal lines in the project score grid correspond to the functional areas which contribute to product development. The functional structure is assumed essential for the project score tool and it is included and



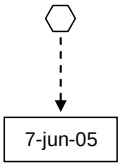
explicated since the involvement of cross-functional personnel widely is regarded indispensable in product development due to its complex character.

The blue arrows at the outmost left indicate the functional areas to be considered. Below each of the arrows there is space left to specify who the responsible person for the areas contributions is together with the name of the team members.



The cells
The key point lines and the functional area lines frame the cells. They are intended to be used for specifying the top-level deliverables that are supposed to be in place at the given time together with a standard of performance, i.e. criteria to evaluate the deliverables against. This is the fundamental aspect of the planning variant of the score tool.

The assumption is that the project leader and team should know which deliverables are supposed to be in place in order to evaluate the project before it is progressed into the subsequent phase. This is in concordance with the recommendations of Andreasen & Hein (2000) and Cooper (2001) identified in section 3.3.1.



Time display
Each key point is associated with a text box below. Here the expected due date for the key point is entered. The due date is estimated by the participants from all the contributing functional areas. Thus the functional area with the longest development time for their deliverables defines the nearest due date for the projects progress to the actual key point.

7.4.1 Use scenario 1: Upfront project planning

When the tool is used for upfront project planning during the preparation of the business case the purpose is to design aspects of the project, i.e. define deliverables to be expected from the functional areas and criteria to compare them against during future key point evaluations. Thus only the planning part of the tool is to be used for stating deliverables and criteria at the given point. The evaluation part with the scoring mechanism is not in use or considered during this scenario. A completed planning sheet, however, is a prerequisite for utilizing the evaluation tool for project assessment during the key point meetings. The evaluation tool is described in the section 7.5.

It is assumed that the tools are primary deployed during meeting events with participants from relevant functional areas. Henceforth the descriptions are roughly structured according to the chronological progress of a meeting.

Before the meeting
Initially, key personnel from the functional areas which are expected to contribute to the project should be invited. Then the project planning variant of the tool should be printed in a large format and posted on the wall in the meeting room.

During the meeting
Afterwards the team is supposed to engage in a creative process, which may be facilitated, for example, by a project manager or a process consultant remote to the project. The team should discuss and identify top level deliverables from each functional area central to the successful completion of the project, and their timing together with "must-meet" and "should-meet" criteria. Similarly, explicit commitments to the project and deliverables from the participants are a crucial aspect of this process.

Then the participants are supposed to briefly describe the deliverables etc. on a note, which subsequently is posted in the corresponding cell in the tool. Gradually, the cells are filled with notes. Some of the cells, however, may remain empty since there are no deliverables. The dynamics of the debate during the meeting might well give occasion for the group to elaborate on the notes or shifting notes between the cells or removal of notes from the poster. In this way the tool supports the planning process by serving as a structuring frame for the debate.

It might prove necessary to carry more than one of these planning sessions through in order to accomplish a proper overall planning and coordination of the project.

After the meeting
Afterwards the poster with all the notes and comments is to be transferred to an electronic document which can be stored together with other project documentation on the company's intranet. This might be done by, for example, a project assistant or the project manager. The purpose is to make a fair copy which easily can be accessed and shared across the project team.

Next, the detailed planning related to the identified and committed functional deliverables is entrusted to the corresponding functional areas. Hence they are expected to decompose their deliverables and coordinate their work on their own hand. This allows the personnel to pursue any planning approach they might prefer at this level.

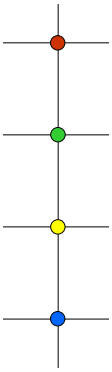
Organizational aspects

The business project manager carries the ultimate responsibility for the use and the maintenance of the tool during a project's lifecycle. This should be supported by the senior management who explicitly should require the deployment of the tool. The project manager can entrust the daily administering (i.e. minor adjustments, updates, meeting preparation etc.) of the tool to a project assistant.

7.5 Tool: The evaluation matrix

Tool structure

The evaluation tool depicted on Figure 81 builds on a matrix structure similar to the planning tool. The major difference between the two tools consists of the addition of extra elements to the evaluation tool, which supports the scoring mechanism. Other elements are maintained, but for some elements their application is different. The elements of the *evaluation* tool are described in the following sections.



Indicators at grid intersections

The intersections between the key point lines and the functional area lines are marked with circular indicators. In this way every individual key point in the development process is decomposed into *functional* key points, i.e. key points which correspond to the contributing functional areas. This decomposition rests on the assumption, that when we visualize every functional area which participates in the project, then it explicitly encourages us to ensure whether the areas contributions to the project are in place. Hence cross functional *integration* in the development process is supported. The indicators can have different colors which signify the outcome of the key point evaluation with regard to the functional area in question:

- *Green* indicates that deliverables are in place – continue.
- *Yellow* indicates that deliverables are almost in place – corrective action needed.
- *Red* indicates that deliverables critical to the project are not in place – corrective action needed.
- *Blue* indicates that the functional area is not expected to contribute to the project at the actual key point. Thus an evaluation is not applicable at this point.
- *White (or blank)* indicates that the contributions related to the particular key point have not yet been evaluated properly, e.g. due to absence of responsible personnel.

As we recall from section 3.3.1 operational and visible criteria are needed for the group to assess whether deliverables are in place. Such a "standard of performance" is assumed pre-defined during the upfront planning of the project. The rating of a deliverable on an indicator reflects the deliverables extent of fulfillment of the criteria. Whether an indicator should be green, yellow or red, however, depends on a *qualitative* assessment of the consequence for the project's continued progress. This assessment is intended to be carried out by the meeting participants and, ultimately, the project manager who carries the business responsibility. Hence the criteria specified during planning are not directly coupled to the indicators.

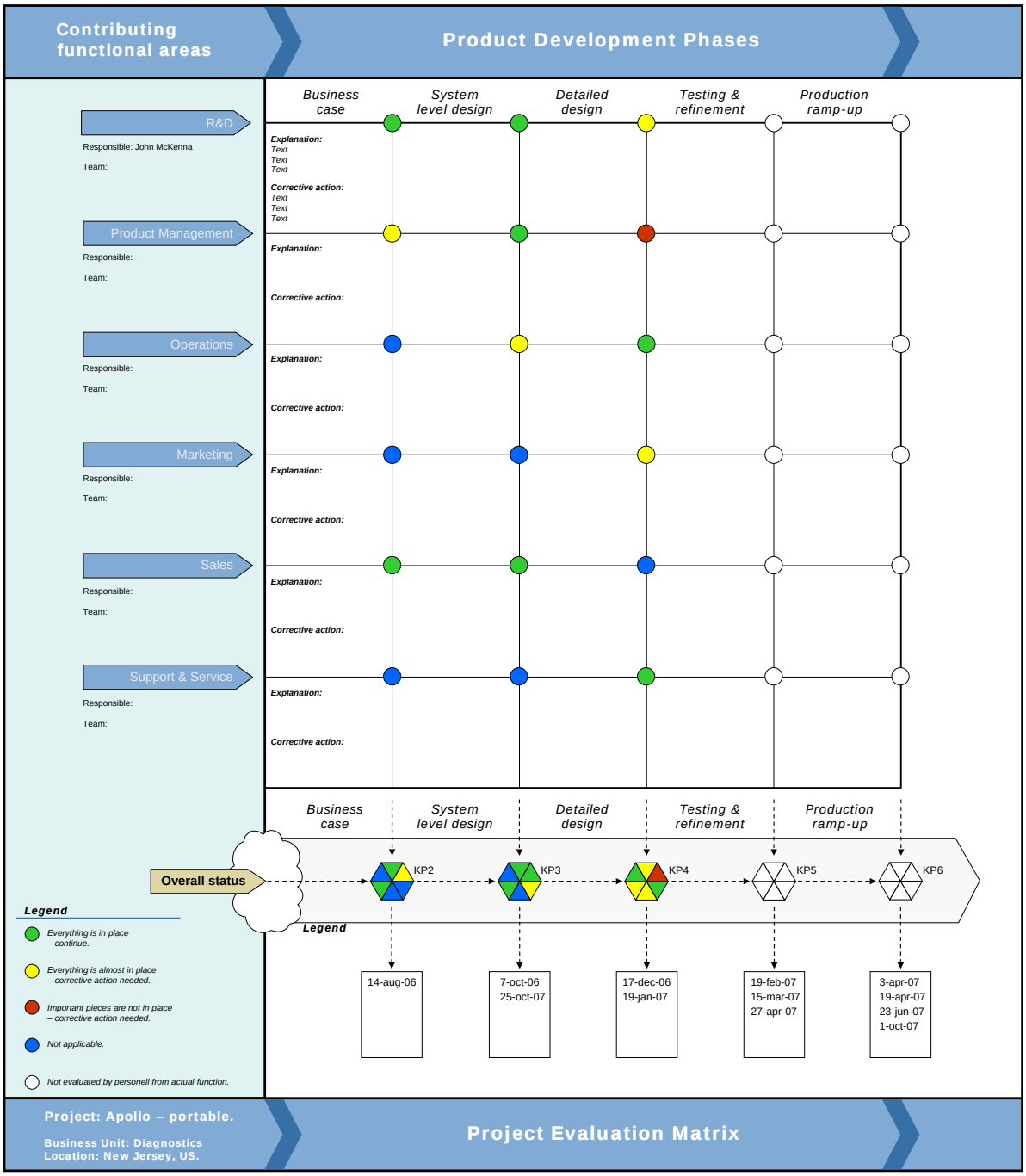
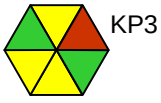
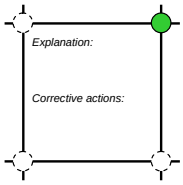


Figure 81. The project evaluation matrix.



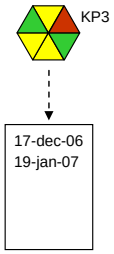
Overall status indicators

The polygons positioned below each key point line are indicators which convey a sense of the overall status of project progress. It builds upon the functional indicators in the row above, which are aggregated in one common symbol. Hence the number of sides reflects the amount of functional areas which contributes to the project. Similarly, the triangular areas in the polygon correspond to specific functional areas. It follows that the evaluation of the contributions from each functional area is a crucial pre-requisite to establish the overall indicator. The text KP# at the upper right of the indicator identifies the key point in the development process.



The cells

The key point lines and the functional area lines frame the cells. They are intended to be used for entering comments which supports the evaluation indicated in the cells upper right corner. The comments should explain the reasons for the evaluation and the decided corrective actions in order to compensate for shortcomings as well as new deliverables. Hence the deliverables and criteria are assumed continuously adjusted during key point evaluations in accordance with the rise in our understanding of the project.



Time display

Each overall status indicator is associated with a text box below similar to the planning variant of the tool. The text box in the evaluation tool, however, is intended to pinpoint and monitor project delays. Hence it is recognized that due dates may well displace as the project progresses. In such situations the new aggregate due date can by registered below the previous date and so forth. Hence project delays are continuously tracked and explicated for the team during execution.

7.5.1 Use scenario 2: Key point evaluations

As identified in section 3.3.1 it is crucial that the management meticulously scrutinizes a project at the key points before the project is progressed to the subsequent phases of the development process. This entails evaluation of the project's business potential, resource availability as well as project progress. The planning tool and the evaluation tool are intended to support the latter effort. It is assumed that both tools are deployed at a given time during meeting events with key personnel from relevant functional areas. They do not replace other activities during a key point meeting. The tools are rather intended to promote a systematic and rigorous evaluation of the project execution quality. The following scenario is roughly structured according to the chronological progress of a meeting, and the scenario strictly focuses on the use of the specific tools. Hence other aspects of a key point evaluation meeting are not included.

Before the meeting

Initially, management representatives and relevant specialists from the functional areas which are expected to contribute to the project should be invited. Next, the latest version of the planning sheet and the evaluation sheet should be printed in a large format, and posted on the wall in the meeting room.

During the meeting

At a given time during the meeting the project deliverables from the preceding phase should be evaluated. It should be emphasized that the meeting is a business meeting and not, for example, an engineering meeting. The purpose is to avoid the participants to become absorbed in technical details which well may derail the meeting. For this reason the evaluation process is lead by the project manager, who is responsible for the business aspects of the project.

The project manager should apply both the planning and evaluation sheet posted on the wall in the meeting room as a structuring frame to guide the evaluation.

Firstly, the manager identifies the column on the planning poster which displays the overall deliverables to be evaluated at the current key point.

Next, the manager invites the responsible person for each functional area like R&D, marketing, or product management in turn to give an account of the status of their deliverables in the light of the pre-defined criteria as well as the latest developments in the project and the related environment.

If everything is in place, i.e. the planned deliverables are ready in a satisfactory quality this should be registered in the corresponding functional indicator on the evaluation poster. Hence the project manager assigns the color green to the relevant indicator.

If the deliverables, however, are not in place the deviances and their causes should be identified and explained by the functional representative. Then the group should discuss and assess the situation in order to identify possible ways to compensate for the shortcomings.

Here it may prove useful to change the scope or timing of deliverables or the related criteria. It can also be necessary to add new deliverables or even omitting deliverables.

Then the group should discuss the implications for other functional areas deliverables as well as the projects further destiny. This involves an assessment of the consequences for the time schedule. New time estimates may be required.

In addition, the group should agree on a color (yellow or red) to assign to the functional indicator, which conveys a sense of how critical the identified shortcomings are for the project. At this point it should be emphasized that the indicators serves as a help for people remote to the project to obtain a sense of the project status at a glance.

It is crucial that the group and in particular the responsible for the functional area in question do commit explicitly to the changes decided by the meeting. The changes (i.e. explanation and decided corrective action) should be briefly described by the functional manager on a note, which subsequently is posted in the corresponding cell in the evaluation tool. Issues specific to deliverables and criteria should also be described on a note, but posted on the planning poster.

The process outlined above is supposed to recur for each functional area which contributes to the project. Several iterations may be needed.

Finally, the impact on the overall time schedule stemming from possible displacements of functional due dates should be estimated. The new total due date for the subsequent key point evaluations should be registered below the previous date in the time display on the evaluation poster.

After the meeting

Afterwards the electronic versions of both documents on the intranet should be updated so they reflect the decisions, notes and comments associated with the two posters from the meeting. This might be done by, for example, a project assistant or the project manager.

Planning sheet

The planning sheet should be revised with changed or new overall deliverables and criteria and due dates. As in the case with the upfront project planning scenario the detailed functional planning is entrusted to the corresponding functional areas in order to allow them to pursue any planning approach they might prefer at this level.

Evaluation sheet

The update of the evaluation sheet involves entering the assigned colors into the relevant functional indicators and the corresponding overall status indicator. Furthermore, supporting explanations together with corrective actions should be entered into the matching cells. Finally, the new resulting due date for the subsequent key point evaluations should by registered below the previous date in the time display.

Organizational aspects

Firstly, the *senior executives* should encourage and expect that both tools are implemented during key point evaluations of projects in the company. Next, the *business project manager* is responsible for the actual use of the tools during project execution, and that the data captured in the sheets provides a plausible indication of project progress to any given time.

This is crucial, since the *portfolio manager* uses the data provided in the evaluation sheet to establish a link between the individual projects and the portfolio map suggested in section 7.6. The daily administering of the tools might be delegated to a *project assistant.*

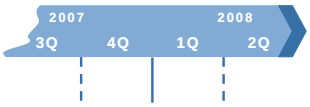
In order to execute a proper evaluation of the project the presence of *cross-functional personnel*, i.e. representatives from each of the contributing functional areas like R&D, marketing, service etc. is indispensable. However, if a representative for a functional area fails to appear at a key point meeting it obviously hinders the proper evaluation of the corresponding contributions. In such situations it might be crucial to go through with the meeting anyways, but the absence, however, should be registered on the evaluation poster. This should be done by assigning the color white (or blank) to the corresponding indicator.

7.6 Tool: The dynamic project portfolio map

The dynamic project portfolio map depicted on Figure 82 constitutes a condensed view of all the projects currently underway in the development portfolio.

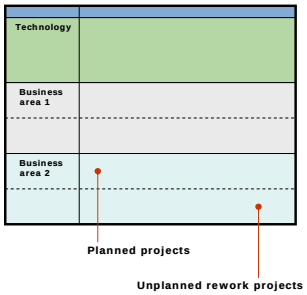
Tool structure

It is basically a calendar, which specifies when a project is supposed to reach the next key point in the development process together with an indication of the execution quality in the project. The time scale is visualized on the top of the map, and it stretches the time horizon of the current development portfolio. The colored rows below the time scale designate categories of products to which the various projects belong. Each project in the portfolio is pointed out on the map by means of the overall status indicator derived from the project evaluation matrix. The elements of the portfolio map are explained in detail in the following sections.



Timescale – horizontal axis

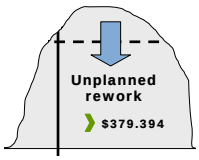
The time scale is an absolute measure which is divided into calendar years and quarters in accordance with the extent of the development horizon of the portfolio. Hence the scale always spans a certain time "window". But since the scale is progressive, the starting point of the scale shifts forward in concordance with the advancement of time.



Product or business categories – rows

The colored rows below the time scale are used to categorize the projects. Technology projects (upper row, green) and product projects (remaining rows, blue/grey) constitutes the two primary project categories due to their different nature.

The product project rows are further decomposed into categories or project groups, which reflects the business or product area they are intended to contribute to. In order to be able to distinguish between project groups the row colors shifts between blue and grey. The name of the actual project group is indicated in the upper left corner of each row



Each of the project group rows are further divided into two rows. The projects above the black dotted line signify intended and planned development projects. The projects below the line illustrate unexpected and therefore unplanned rework in terms of resource allocation. The purpose is to make post-launch development activities visible that consumes significant amounts of unexpected resources despite the fact that the project might formally be regarded as completed by the upper management. In an ideal world no projects would appear beneath the black dotted line.

The decomposition is highly company specific, and it is assumed that a similar decomposition of the technology project category well may be irrelevant, since technology often is used across business areas or product groups. Furthermore, the amount of technology projects is typically significant lower than for product projects.

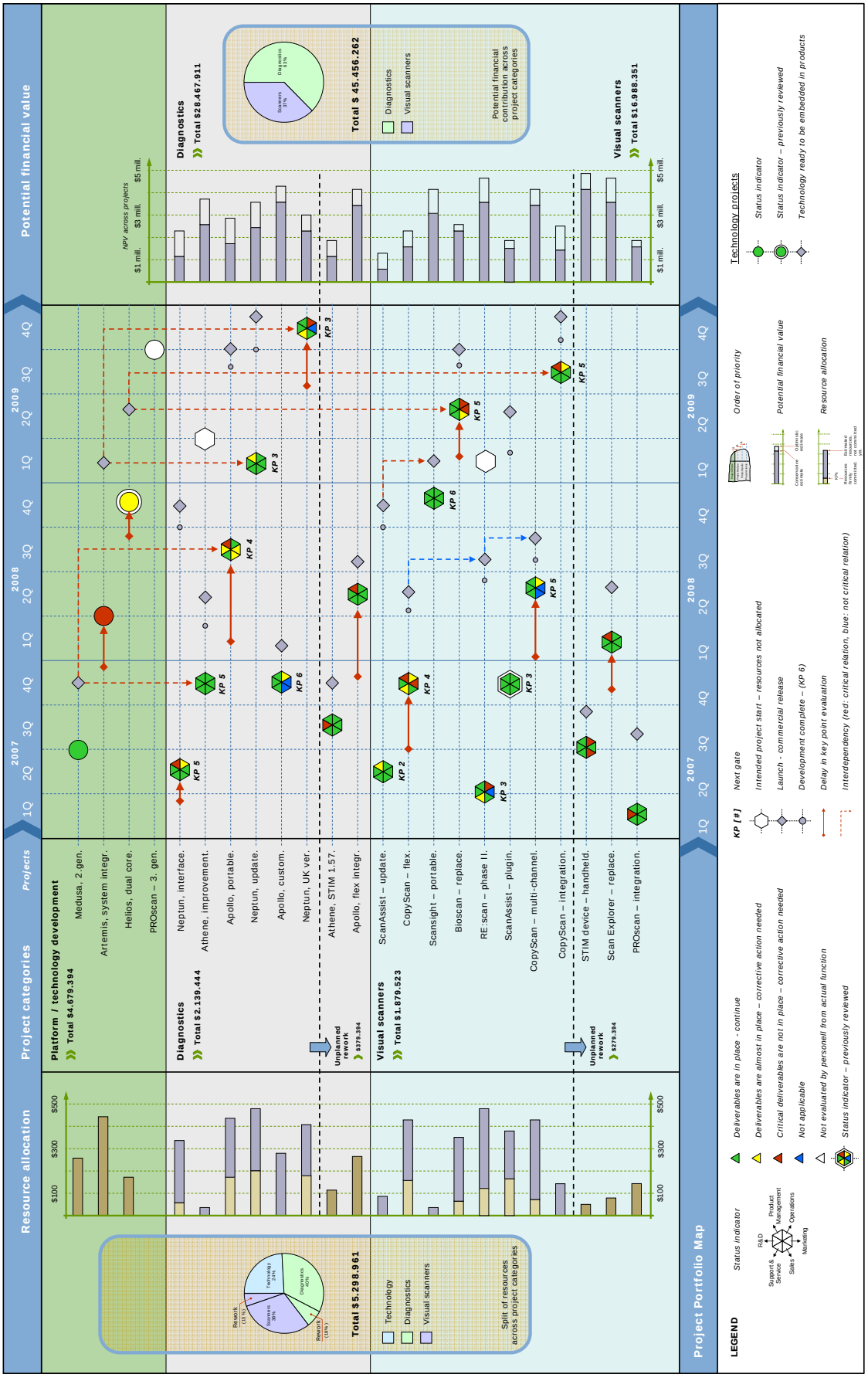
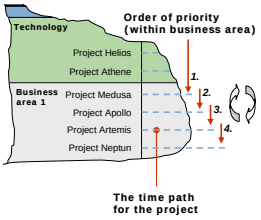
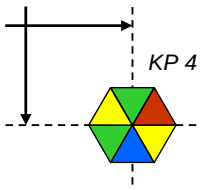


Figure 82. The dynamic portfolio map constitutes a condensed view of the dynamic development portfolio, i.e. all the projects currently underway (fictional data).



Each horizontal and dotted dark green line within the project groups represents the time path for a project. The names of the projects are marked on the left side of the dotted lines. The rank of projects signifies the order of priority, i.e. the project listed on top of the row has the highest priority and so forth. The priority of a project is assumed determined by the decision makers during portfolio review. Thus the list is rank ordered dynamically.

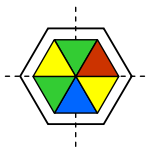
Positioning the overall status indicators



The status indicators derived from the project evaluation matrix forms the core of the portfolio map. Here only the latest completed indicator from each project score is displayed. The purpose is to convey a sense of the project's status during the most recent key point evaluation. Each indicator is vertically positioned in accordance with the project category it belongs to. The priority of the specific project determines the exact vertical position of the indicator within the actual project category. It is the progress of the individual project which determines the indicator's horizontal placement on the map. Thus the position signify when the project is expected to reach its next key point evaluation in terms of calendar time. Additionally, the text *KP[#]* above the indicator identifies the next key point to be reached. In other words, the text denotes the project's progress in terms of the product development process.

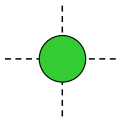
A project is supposed to be displayed on the portfolio map when the first significant amount of resources has been committed to its completion, and a preliminary indication of the projects potential business value exists. This stage equals the KP2 evaluation on the generic process model described in section 7.4, where the business case has been prepared together with the detailed planning of the project. It follows that the KP2 indicator is the first indicator to appear on the map. The corresponding text above the indicator is *KP3* since this is the next key point to be reached in the development process.

A project is assumed removed from the map when the development is completed and the corresponding product has been launched as planned. Thus the latest indicator to be displayed on the portfolio map mirrors the KP6 evaluation.



Overall status indicator – previously reviewed

An overall status indicator encircled by a blank polygon signifies that the project in question has not been evaluated since the last portfolio review. Thus the indicator is unchanged since the last review. This is pertinent in situations where the duration of a development phase exceeds the time interval between the portfolio reviews. Hence the purpose is to avoid that the same indicator inadvertently is examined repeatedly during a series of portfolio reviews.



Status indicators – technology projects

In accordance with section 5.3.5 technology projects may not follow a development process similar to product projects. Furthermore, technology projects might not require the involvement of cross-functional staff.

Henceforth the scoring mechanism constituted by the evaluation matrix is not applicable.

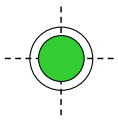
Instead a more simple qualitative evaluation is suggested. It consists of one indicator which can be assigned the color green, yellow or red depending on the state of the project compared to the predefined plans and expectations:

- A *green* indicator signifies that everything is progressing according to plans, and the project can continue.

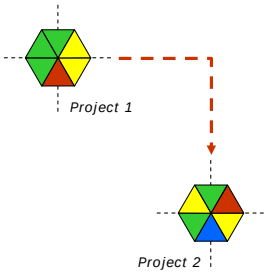
- A *yellow* indicator denotes that things are not progressing as planned and therefore corrective action is needed.

- A *red* indicator highlights that aspects critical to the project are not in place, and extensive corrective action is imperative in order to continue the project.

The R&D person responsible for the project is supposed to evaluate the project and provide the indicator to the portfolio manager, who subsequently includes the indicator on the portfolio map.



Status indicators – technology projects - previously reviewed
Like the earlier description of the overall status indicators - previously reviewed, a technology status indicator encircled by a blank circle also signifies that the project has not been evaluated since the last portfolio review. Again the purpose is to avoid that the same indicator inadvertently is examined repeatedly during a series of portfolio reviews.



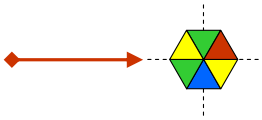
Interdependencies
The dotted arrow lines indicate interdependencies between the various projects. Interdependencies can occur in many forms. For example, a product project may be dependent on a technology project because the resulting technology package is supposed to be embedded in the product. A product project can also be dependent on other product projects if these in sum are supposed to form a full product line or a system solution.

Interdependencies might also occur between product launches e.g. due to marketing considerations. Thus the launch and commercialization of a product can be conditioned by the launch of another product.

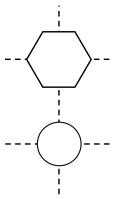
The color of the arrow line indicates the strength of the relation. A red line indicates a strong relationship, i.e. that project 1 is a critical prerequisite for project 2. Thus if project 1 is cancelled it will invariably bring project 2 to a halt.

A blue line indicates that project 1 is coupled to project 2. If project 1 is cancelled, however, it will influence project 2 negatively, but not necessarily discontinue it.

The dotted arrow lines support an immediate, rough assessment of consequences stemming from a potential decision regarding a specific project's further continuation.

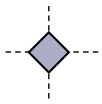


Delays
Delays are indicated by means of a red arrow. The arrow's starting point indicates when the project originally was supposed to reach the next gate. The centre of the indicator, to which the arrow head points, indicates the new expected due time for the next gate. Hence the length of the arrow indicates the total delay.

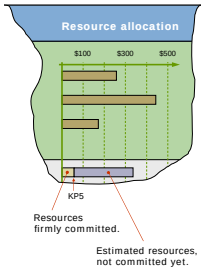


Intended project start
A blank indicator roughly outlines when the next major development project related to the specific product type, i.e. the next product version or generation, is expected to be initiated. Hence the blank indicator denotes a highly speculative project in the sense that no resources have been allocated to the project.

Development complete – (KP6)
The moment when the development of a product is completed is signified by means of a small circle. At this point the product is ready and awaiting commercial release.



Launch
The moment when a developed product is launched into the market for commercialization is symbolized by means of a rhombus. The commercial release of the product should not be confused with the completed development of the product. When the symbol is used in relation with a technology project it signifies the moment when the technology is mature enough to be embedded in commercial products.



Resource allocation
At its core portfolio management for product development is about allocation of resources among a number of promising investments in the form of projects. For this reason the left section of the portfolio map is dedicated to explicate the amount of resources committed and estimated to the realization of the projects in the portfolio. The resources can be made up in either economic terms or man-hours. In an ideal world the amount of allocated resources would encompass resource contributions from all participating areas like production, marketing, service, etc. The bars indicate the remaining resources for the projects' continuation. Hence "sunk costs", i.e. costs already consumed by the project, are disregarded as a basis for portfolio decision making. This is in concordance with the recommendations of Cooper, *et al.* (2001b).

Product projects

Resources allocated to product projects are illustrated by means of two colors. The light brown color will always form the lower part of the bar since it denotes the remaining resources from the recent key point committed to progress the project from KP2 (*go to design*) to KP5 (*go to production ramp up*).

Resources committed to progress the project beyond KP5 are illustrated by means of the purple color. Thus if a project has passed KP5 only the purple part of the bar will be visible, since the resources preceding this key point are regarded as history or "sunk costs".

In this situation KP2 and KP5 constitute central decision or investment points, and this is in concordance with the concept of incremental resource commitment, which is explicated on the suggested reference model in section 5.3.5.

The resource bar (either light brown or purple colored) nearest the (vertical) baseline in the resource diagram signifies firmly *committed* resources. The purple top part of the resource bar illustrates resource *estimates*, which should not be regarded as committed at the given moment, since the project yet has to pass the associated decision point (KP5).

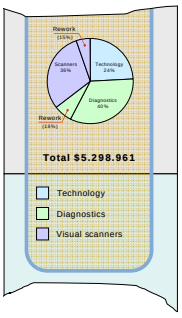
Rework projects

Resources for rework projects is not expected to follow a similar incremental investment pattern. Rather, the resources required to fix the problems are assumed to be committed on a need basis. This is illustrated on the resource map by means of one bar in the color brown.

Technology projects

Resources for technology projects is neither expected to follow an incremental investment pattern similar to product projects. It is assumed that resources for such projects are committed once and for all, and this is shown on the map by means of one brown bar. This may, however, vary from company to company and the illustration should therefore be adapted correspondingly.

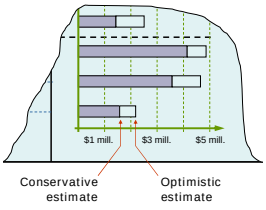
Split of spending



A pie chart is depicted on the outmost left part of the portfolio map. The chart provides a top level view of how the company currently deploys the development resources across project categories or business areas. In addition, the chart explicates the share of resources seized by unplanned rework activities.

Potential financial value

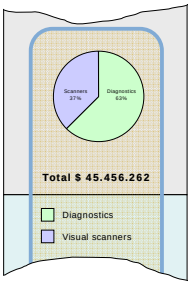
The right section of the portfolio map is devoted to the financial aspects of product development for obvious reasons. At this point it is relevant to emphasize that the author recognizes that such financial estimates are encumbered with a number of flaws as identified in section 4.6.1. Nevertheless, indications of projects potential financial value are assumed important since this is an unavoidable aspect of product development.



The bars indicate each projects potential net present value (NPV) as described in section 4.6.1. The NPV estimate come from the business case prepared during the upfront project planning before KP2. The estimate is supposed to be updated in line with the realization of the project. The estimate should be provided as a range as opposed to a point in order to explicate the uncertainty associated with the estimation. The range is illustrated by means of a blank bar above the purple bar.

The potential financial value of technology projects are omitted on the map since these projects are not expected to generate near-term revenue by themselves. Instead they are intended to provide a technological basis for products as described in section 5.3.5.

Split of NPV



A pie chart is depicted on the outmost right part of the portfolio map. The chart provides a top level view of how each project category or business area currently are expected to contribute to the company's financial results.

7.6.1 Use scenario 3: Portfolio review

In section 4.4 we found that it is crucial that the management team subjects the development portfolio to periodic reviews during the year.

The purpose of the review is to consider the portfolio as an investment portfolio to assure that the projects as a whole supports the business strategy, and the realization of the expected business results. The meetings typically serves as checkpoints where it is investigated whether the right projects are active (versus on hold), that the priorities are right, and that the resource allocation across the portfolio is consistent with the strategic priorities. Thus a review meeting may lead to minor changes in the portfolio.

The portfolio map is intended to support the management team in this work by displaying the portfolio of projects currently underway in the development system. Depending on the management's preferences the proposed portfolio map might well be complemented with other tools which further detail the portfolios' balance, value and alignment with strategy together with details concerning the individual projects.

Similar to the previous scenarios' the following scenario is also roughly structured according to the top-level chronological progress of a meeting. Unlike the planning and evaluation tools, however, the author assumes that the deployment of the portfolio map during the meeting is characterized by the absence of a sequential process structure. Rather, the map is supposed to be used occasionally during the review in at least two different ways.

Enhance the common understanding

Firstly, the map can be used for examination of the current development portfolio. In this situation the managers utilizes the map to enhance the common understanding among the group members regarding the current state of the dynamic portfolio. This can be done by formulating questions to the portfolio based on the provided visualization. Such an understanding is assumed imperative in order to make proper decisions regarding the portfolio mix.

Assess consequences

Second, the map can be used to assess some of the consequences of altering the portfolio. In this situation the map is confronted with the proposed change, and the impact of this change can be discussed among the group members.

Flow, circulate and iterate among elements

Thus in both situations the managers enquiries are expected to flow, circulate and iterate between and among the elements of the map in any order or combination when questions arise. Examples of both situations are provided in the following description, which strictly focuses on the use of the specific portfolio map. Hence other aspects of a portfolio review meeting are not included.

Before the meeting

Initially, members of the portfolio review committee and relevant project managers should be invited. Next, an updated version of the portfolio map should be printed in a large format (for example A0 or A1), and posted on the wall in the meeting room. Similarly, the recent versions of each project's evaluation matrix together with other project reports and product plans should be accessible for the meeting participants.

During the meeting

The meeting is assumed to be initiated by a review of the projects already underway in the development process. This entails an assessment of the projects' condition and progress including follow-up on deviations from planned schedule. The central part of the portfolio map can be used for guidance during this work. Since the map highlights where problem areas occurs it can encourage the group to promptly focus their attention correspondingly.

Current state

For example, the top-three most important projects within each business area are quickly identified, since the listing of projects represents their order of priority. Next, potential problems and their origin related to the quality of execution of the projects are exposed due to the polygon shaped indicators. Similarly, possible delays of the projects can be spotted by means of the red arrows in front of the related indicators. This information can form the starting point for the groups' further examination of the portfolio since for example "why"-questions can be formulated and targeted the concrete issues.

Potential manipulations

The need for portfolio manipulations may origin from the company internal and/or external business environment. For example, the previously identified state of the portfolio may imply adjustments. Equally, changes in resource availability, company objectives or business strategy can involve portfolio changes. Shifts in competitive dynamics, customer preferences, market attractiveness, legislation or technology represent examples of aspects rooted in the external business environment, which also might give cause to portfolio alterations. The author would like to point out that the proposed portfolio map does not provide information regarding *all* these aspects. Hence the map should go together with other tools aimed at providing, for example, market and competitive intelligence.

It is assumed that the group develops suggestions for potential manipulations on the portfolio such as accelerating, postponing, reprioritizing, re-scoping, deleting or adding projects based on the groups' collective understanding of the internal and external business environment.

Some of these suggestions might be strategic imperatives, i.e. manipulations that are compulsory to implement immediately in order to avoid imminent threats such as competitive pressure or problems related to project execution. Other suggestions can be optional. Before any suggested adjustments are carried out it is assumed that their consequences for the current portfolio should be assessed.

Impact assessment

The portfolio map is intended to support such an impact assessment. Each of the suggested manipulations can in turn be confronted with the map in order for the group to discuss how it might affect other projects due to interdependencies in several dimensions like resources, technology projects, rhythm of projects and product launches, potential financial value etc. Similarly the suggested manipulations should be compared with information provided by individuals or other tools in order to assess the potential consequences of the manipulations with regard to, for example, the businesses' market segments and competitive position.

Prioritization

When a feasible combination of manipulations has been synthesized, the projects' order of priority in the portfolio can be revisited. The purpose is to ensure that there is a correlation between the importance of each project and the resources devoted to them. The portfolio map can support this work since it displays the recent order of projects. Hence it can form the starting point for the debate. Subsequently, the projects are shifted in the list on the portfolio map according to the priority assigned to them by the group, i.e. the projects with highest priority are shifted to the top of the list and vice versa.

Portfolio balance

Finally, the portfolio map might be utilized to investigate certain aspects of the portfolio's balance from a top-down perspective, i.e. project distribution across the portfolio with regard to a number of parameters as for example:

- the potential financial value of projects from business area 1 vs. area 2,
- resources allocated to a business area vs. the area's financial value,
- resources allocated to planned development vs. unplanned rework,
- resources allocated to technology vs. product development,
- product launches vs. their timing,
- number of projects vs. available resources,
- resources allocated to business area 1 vs. area 2 (i.e. top-level strategic alignment).

This may give raise to a number of fundamental queries which can be scrutinized by the group members before the decided manipulations are executed. The following are examples of such queries:

How come we are spending more resources on business area 1, when our strategy state that we should move towards business area 2?

Is it reasonable that we use more than 15% of resources dedicated to product development to unplanned rework?

Why is it that we seem to make more business from area 1 than area 2 considering we spend more resources on the latter?

Do we have the resources to develop 11 projects simultaneously within business area 2?

Which other projects will be affected if we terminate project CopyScan?

Do we really want to spend more than 20% of our development resources on technology development?

This activity should be considered as an iterative exercise which might result in a re-prioritization of the projects in the portfolio, and possibly cancellation of projects in order to obtain a balanced portfolio.

After the meeting
Afterwards the decisions from the review should be implemented in the portfolio. Thus the functional managers and the project managers are supposed to ensure that, for example;

- project priorities are shifted,
- projects are accelerated, postponed or deleted,
- resources are re-allocated among projects,
- launch dates are changed,
- new projects are added,
- projects are re-scoped,
- selected aspects are further investigated.

The portfolio manager should update the electronic version of the portfolio map accordingly. For example, new project priorities should be illustrated on the map by shifting rows, new and significant interdependencies among projects should be outlined, launch indicators should be moved about, and deleted projects are to be removed from the map. Similarly, the consequences of these decisions should be reflected in both sides of the portfolio map in terms of resource allocation and the potential financial value of the portfolio.

Organizational aspects
Empowered by the senior executives the portfolio manager carries the responsibility for the use and the maintenance of the portfolio map.

The business project manager for each project is responsible for providing the recent plausible indication of project status to the portfolio manager by means of the project evaluation matrix described in section 7.5.

The portfolio review committee is responsible for the periodic review and adjustment of the development portfolio. The members of the committee are senior managers from the functional areas which contribute to product development.

Project managers and specialists may occasionally be invited to the meetings in order for them to illuminate selected aspects of the projects.

The portfolio manager is responsible for communicating the decisions carried out by the committee across the organization. The updated and intranet based portfolio map is intended to support this effort. The functional managers are responsible for translating and communicating the implications towards the personnel within their specific area.

Finally, the project managers' carries the responsibility for implementing the decided changes in the development portfolio.

7.7 Preliminary verification

The proposed solution comprised by the dynamic portfolio map, the evaluation matrix and the planning matrix is attempted preliminary verified by means of logical verification and verification by acceptance.

Logical verification

The tools' interplay, elements and their relations have been described in the previous sections. The description encompasses logical reasoning based on the knowledge resulting from the industrial observations and the examined literature. Hence the description is assumed to represent a line of reasoning to show that the integrated elements conform to a theoretical basis and are internally consistent.

Verification by acceptance

The mindset is also attempted verified by acceptance of a group consisting of 11 experienced industry professionals in one company. The utilized verification approach and the results are described in the following sections.

7.7.1 Approach

The focal point of the verification has been to present the tools and their intended combined use to industry professionals. It has, however, not been possible within the frames of the research to deploy the tools in portfolio reviews or key point evaluations during individual projects.

Instead the effort has been aimed at establishing an example of the portfolio map based on real data from the company's actual development portfolio. Since the planning and evaluation matrix have not been implemented it has though not been possible to derive status indicators based on real data from the key point evaluations of each project. Hence it has been necessary to use status indicators based on fictional data in the mid section of the portfolio map. The same is the case for data reflecting projects' priorities and interrelations.

Data collection

The data collection for the portfolio map was carried out during a one month period in interplay by the researcher and staff from various functional areas in the company by means of interviews, email correspondence and review of documents.

The starting point for the collection was to identify the set of projects currently underway in two business units.

Next, the economical resources allocated to each project from the contributing functional areas were pointed out. Subsequently, the expected financial contribution in terms of Net Present Value (NPV) associated with each project was gathered.

After that a status indicator was associated with each project together with attributes like delays, next gate, relationships and planned product launches.

Finally, the researcher synthesized and structured the data and projected it on the portfolio map prepared by means of the PowerPoint software.

Presentation for the management group

The tools and their intended combined use were presented during a two-day seminar for the management group. The group was made up of elleven managers from functional areas like R&D, marketing, service, manufacturing, support, and product management within two business areas.

The overall purpose of the meeting was business development, and the meeting's second day was dedicated to examining and improving the portfolio and product development process.

Here the researcher presented the tools and their intended interplay by means of a PowerPoint presentation. In addition, the prepared portfolio map was previously printed in a large format and posted on the wall in the meeting room. After the presentation the group commented on the suggested concept and discussed the opportunities.

The feedback from the management group and the preceding data collection highlighted a number of interesting issues. These issues and their implications for the tools further development and implementation are discussed in the following sections.

7.7.2 Findings

The group members did in general comprehend the tools quickly and did easily relate to the proposed concept.

The following statement from the vice president of the company conveys a sense of his immediate reaction. He spontaneous exclaimed; *"I like it!"*, and attributed this to the solution's ability to provide a brief visual overview of the portfolio based on a direct connection to every project.

The director of business development similarly expressed a positive attitude to the tools. He began rather quickly and enthusiastic to contemplate about the apparent possibilities for automating the tool by means of information technology support.

Provision of key point data

The manager responsible for the product development process found the idea of linking project progress documentation to the portfolio map

intriguing. He mentioned that much of this information today is captured and integrated in project progress reports. This information, however, is not structured, evaluated and presented as rigorously and explicitly as the planning/evaluation matrix encourages. He did though express concern about the practical implementation of the tool. He pinpointed that the tool in its current state implies a significant workload in terms of integration with other tools and applying data in the suggested graphical format.

The R&D manager found the map and matrix concept appealing in general, but indicated hesitation about the checklist mechanism underlying the evaluation matrix. He was concerned about having too many people remote to the R&D function participating in the meetings when he stated that: "*Marketing should not be bothered with R&D discussions*".

The researcher assumes that the skepticism partly may be rooted in the fact that the development process currently is highly R&D centric in the company in question. Since the product development process is owned by R&D, the R&D people have a strong understanding of the development phases and activities. This situation is likely to encourage functional dominance, i.e. the proper involvement of staff from other functional areas might be restrained. Consequently, problem solving regarding technical details might take over the key point meetings at the expense of a business oriented agenda.

This potential misconduct, however, is directly addressed by means of the proposed solution since explicit functional integration, which is a prerequisite for strong product development, is a central principle underlying the tools.

This aspect was particularly recognized during the meeting by managers remote from the technical development of the product such as marketing, service and support. They appreciated the tools ability to support the provision of a common picture of direction, involvement and timing for their participation in projects. The following statement expresses a sense of the view held by a corporate marketing director: *"As far as I understand this looks like the biggest process improvement in years if we can make it happen"*.

Who should do it?

Next, the lack of resources to handle the tool - paradoxically - emerged as a dominant theme. Everybody was currently occupied by other tasks, and had no resources available. The situation had already been recognized by the vice president of the company who suggested the hiring of a portfolio manager for the job.

The debate and the preceding data collection, however, confirmed that the implementation of the tools implies a shift in tasks and responsibilities across the organization in order to supply the needed data, which extends beyond the portfolio manager role.

Provision of resource data

For example, the provision of estimates for resources allocated from contributing functional areas revealed the need for changes in certain

work patterns at lower organizational levels. Whereas it appeared straightforward to gather estimates of resources allocated from the R&D function to each project it proved challenging to obtain similar estimates from other functional areas. Apparently, such estimates did not already exist in the latter. Instead, estimates were seemingly prepared as a response to the researcher's request. Furthermore, no estimates were supplied from the product management and the production function at all. The researcher assumes this is due to that resource contributions to product development from these functions are not quantified and explicated sufficiently.

The implementation of the resource side of the portfolio map, however, presupposes that each function is able to approximate the amount of resources they have allocated to each project. Thus in order for a company to utilize this (left) section of the portfolio map, it is a prerequisite that there are procedures and processes in place in each function which produce and frequently update such estimates.

Provision of financial data

It was uncomplicated to obtain estimates from one business area regarding the potential financial value of the projects in the related portfolio to be used for the right section of the portfolio map. The similar exercise for another business area with a portfolio consisting of more than 20 projects was not successful. Here it was only possible to obtain sparse data for two of the projects.

These findings combined with indications from senior management gives the researcher reason to assume that this partly might be rooted in inadequate training of the staff with respect to this matter.

In order for the company to utilize the (right) section of the portfolio map, however, it is necessary that financial estimates are available. Thus it is crucial that some of the employees are able to work out such estimates.

7.7.3 Implications

The managers' response from the described confrontation together with the experience from the preceding data collection indicates that the implementation of the tools incur a shift in tasks, processes and responsibilities across the company. Hence in order to further develop and implement the tools in industrial practice the researcher asserts that it is central that a deeper understanding of the implications described in the following are obtained.

All of the listed implications are assumed relevant, but the list is not necessarily complete. Furthermore, the implications order of appearance does not indicate any prioritization. Additionally, the researcher assumes a further industrial application of the tools will reveal the need for adjustments directly related to the design of the tools.

Implication 1

Currently some data are produced and stored by means of existing tools in the company such as project specifications, project reports, detailed plans, roadmaps etc. The implementation of the proposed tools implies that some of this work should be displaced to these tools. In order to avoid

redundant work it is central that we gain a better understanding of how this data handling should be divided between the various tools.

Implication 2

No portfolio representation is better than the quality of the information it builds on. Since the establishment of the various visualizations is based on large amounts of uncertain and ambiguous information from various sources decision makers may deceive them selves, if they assume the synthesized visualizations present a "true and fair" view of the portfolio. Facts and figures, for example, have already been filtered through corporate hierarchies and work processes. Furthermore, a significant part of the information is based on predictions about the future. Hence it is fundamental to emphasize that the visualizations merely should be regarded as *indications* to be translated by the management.

Implication 3

The implementation of the planning/evaluation matrix entails participation of personnel from all contributing functional areas during key point meetings. In order for such meetings to be productive it seems relevant to obtain a better understanding of the issues relevant to be covered during the meetings. Such an understanding can make it possible to delegate the discussion of details to separate functional meetings.

Implication 4

Data are presented in a new way. We need to know how data easily can be retrieved and applied and possibly stored in the proposed graphical format in a productive way.

Implication 5

The implementation of the tools may well encompass changes in some of the employees' tasks and responsibilities. In order to avoid overburden the staff it is central that we understand the changes implied for each individual as well as their ability to handle the implied shifts in terms of competencies and available time. This should be taken into account during the arrangement of the implementation.

Implication 6

It seems evident that the implementation of the tools incurs a workload on several levels in the company. This circumstance justifies considerations regarding the productivity of the proposed concept. Henceforth the further development of the tools should take this aspect into account. The researcher, however, assumes that it is a prerequisite that the implementation of the tools reaches a stage of continuity and repeatability in a company before it is possibly to evaluate the productivity of the concept reasonably.

7.7.4 Conclusion

Bearing in mind the limited scope of industrial validation, the confrontation indicates that the proposed tools seem both relevant and acceptable to industry professionals in one company.

The response from the management group, however, highlighted a number of essential issues which are crucial to understand and factor in during the further development of the tools.

Thus even though the tools in their current form might not be immediately practicable, the researcher asserts that the reactions from the

confrontation justify the further exploration, testing and refinement of the proposed concept with a larger sample size of companies.

7.8 Conclusion

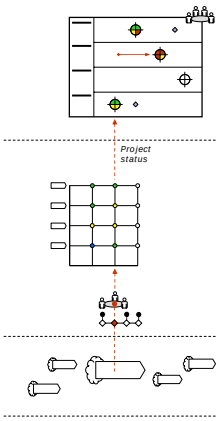
The goal of this chapter has been to develop a tool which can be utilized to map the dynamic development portfolio.

Purpose

The work rests on the assumption that a shared representation of the portfolio can encourage transparency and qualify dialogue between the managers concerning the condition of the portfolio. Such a dialogue might well promote an improved understanding of the company's development capability among the management group in the company. Henceforth such a contribution might help to unlock or prevent the occurrence of the destructive pattern explained in section 6.3. The research has been guided by the following question:

Research question 3

How can the dynamic portfolio be mapped utilizing the individual projects as points of reference?



A solution was intended to primarily encompass a mapping of the following aspects:

- Projects currently underway in the development process.
- Each projects progress compared to plan.
- The recent quality of execution for each project in the portfolio decomposed in accordance with the contributing functional areas.
- Projects priority relative to each other.
- Central interdependencies between projects.
- Projects which can be characterized as unplanned rework.
- Resource distribution across product and technology development projects and business areas.
- The estimated financial contribution from each project and business area.

A solution

Based on the fulfillment of nine stated propositions the research has introduced three tools, which deployed in combination accomplishes the task outlined by the research question. The tools build on mapping techniques and the involvement of people from central functional areas and organizational levels. The tools also incorporate principles from the unweigthed factor scoring model and dynamic rank ordered lists.

The object of manipulation is the project portfolio and the individual projects. Thus the use of the tool requires that idea proposals previously have been selected and resources for their further investigation have been allocated together with the establishment of the needed project teams.

Tool design

The *dynamic portfolio map* constitutes a condensed view of the aggregate set of projects currently underway in the development portfolio. It is basically a calendar, which specifies when a project is supposed to reach the next key point in the development process together with an indication of the execution quality in the project.

The project *planning matrix* and the project *evaluation matrix* support the establishment of the central and dynamic linking between single projects and the portfolio overview. These tools are supposed to be deployed in combination during the execution of the individual projects. The indication of the quality of execution within each project is derived during key point meetings based on the collective evaluation of the project by key personnel from contributing functional areas.

Originality

The principal originality of the proposed tools consists in the following:

- The deployment of the three tools enables the establishment of a condensed visualization of the quality of execution of the projects currently underway in the portfolio, which is rooted in an explicit, rigorous and systematic evaluation of each project.

  This visualization of the portfolio encourages the management to raise relevant questions regarding the condition of projects and examine and understand cause/effect relationships embedded in the portfolio. Such a dialogue is asserted fundamental and indispensable in order to improve the collective understanding of the company's development capability and hence make well-informed and sound decisions regarding the portfolio mix.

- An explicit and dynamic linking between each project's development process and the portfolio overview form the crux of tools. The assessment of the quality of execution within each project is derived during key point meetings based on the collective evaluation of the project by key personnel from contributing functional areas. This supports synchronization between deliverables within each project.

- By requesting indications on the quality of execution decomposed on functional areas the tools promote a horizontal and vertical integrative working pattern in product development. According to section 3.3.1 this is widely recognized as an indispensable pre-requisite for realizing strong product development.

- The tools bridge diverse planning approaches within different functional areas by providing an explicit and easy understandable top level view of the central project deliverables structured according to the key points in the development process. This encourages each functional area to explicitly commit to contribute to the project while allowing them to pursue their individual approach to planning at a more detailed level.

- The deployment of the tools provides indications about the portfolio's balance, strategic alignment and potential value, which according to section 4.3.1 are three high-level goals that dominate the management's mindset in companies.

- The tools enable the provision of a user-friendly presentation of condensed information regarding the dynamic portfolio to a group of

decision makers, who have neither the time nor need to learn all the details underlying each project in the portfolio.

Validity

A preliminary verification of the tools signifies that the proposed concept seems both relevant and acceptable to industry professionals even though additional refinement of the tools is needed in order to mature the tools for a thorough empirical demonstration.

The author asserts that the proposed concept embodied by means of the three tools represents a fundamental and absolutely necessary step towards providing the senior management with a visualization of the dynamic portfolio. Such a contribution is assumed crucial since its application allegedly presents an opportunity for managers to establish and reinforce the constructive pattern previously articulated by means of the "good" circle.

8 Conclusion and further research

8.1 Introduction

The topic of this research is portfolio management for product development. The research introduces contributions in the form of a reference model and a mindset along with three supporting tools.

The theoretical goal of this research have been to contribute to consolidation and clarification of terminology, concepts and knowledge within the research area portfolio management and product development.

The practical goals has been to contribute to strengthen the product development portfolios in industry by providing productive models, which can constitute a proper support to companies' management teams in their efforts towards performing portfolio management.

This chapter concludes the dissertation. It contains a summary and evaluation of the results. Finally, suggestions for future research within the field of portfolio management for product development are outlined.

8.2 Summary and evaluation of results

The research work documented in this dissertation has been guided by three research questions, which are described in section 2.5. In the following the corresponding contributions are summarized. Furthermore, the related limitations and implications of the results are articulated.

8.2.1 Research question 1

The first research question is motivated by the assumption that it is necessary to have a framework which illustrates the portfolio management concept in a company. This question is intended to support the establishment of a unifying model, which was asserted a critical prerequisite to describe and discuss the topic portfolio management.

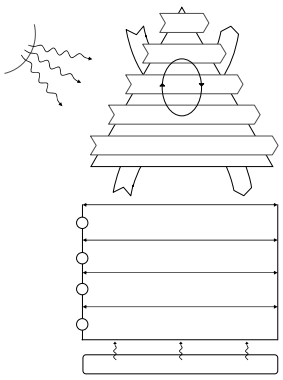
> ***Research question 1: Structural elements and principles of PM***
>
> *Which structural elements and principles are inherent in portfolio management for product development? What is their central interplay and how can they be modelled and visualized?*

Contribution

A theoretically based and consistent reference model which explicates the following central elements inherent in portfolio management has been proposed:

- The object of manipulation (idea, project, product).
- Portfolio planning process.
- Portfolio review process.

- Project key point review process.
- The front end of innovation process.
- The back end of innovation process.
- Portfolio manipulations.
- Integration (horizontal and vertical).
- The external business environment (market, competition, legislation).
- The internal business environment (the development capability).
- The impulse which initiates portfolio decision making.



Key principles in portfolio management emerge from the explanation of these elements and their interaction, which in total comprise the portfolio management architecture in a company.

The model is explicitly dedicated to portfolio management for product development, since it rests upon the theory of the product development process. This is unique since many contributions within portfolio management do not seem to distinguish between the domains of application. The principal originality of the proposed model lies in:

- The model acknowledges the gradual transformation of a product *idea* into a product *project* which results in a *product*. That is, the model accentuates that it is beneficial to discriminate between and consider at least these *three generic classes of portfolios* when making decisions about the new product project portfolio mix.

  This supports a nuanced and coherent *end-to-end* approach to portfolio management, since it indicates that it is possible to manipulate and improve the potential business value of a "portfolio" in several stages. Moreover, this distinction is vital since the management of the various portfolios requires dissimilar processes, techniques and tools.

- The concept of portfolio management is *divided* in accordance with the nature of the object of manipulation. The model suggests that the management of the *project* portfolio occurs by means of dedicated project portfolio management processes. The management of the *idea* portfolio, however, is asserted to occur in the "front end" of innovation process. The management of the *product* portfolio occurs in the "back end" of innovation process. Both processes are illustrated as background processes on the model in order to indicate that the processes are closely related and highly important to, but distinct from the project portfolio management process. This distinction is central since it acknowledges the disparate degree of uncertainty associated with the allied decision-making during portfolio management.

- The model emphasizes the need for horizontal and vertical *integration* of personnel in portfolio management. The explication of integration is imperative in order to state that portfolio management does not exist in isolation in a company. Rather, it is all-encompassing and is highly dependent on contributions from many people.

Limitations

The model includes the central parameters which we can manipulate in order to achieve a portfolio which meets the three high level goals of portfolio management. The model, however, does not devise how the parameters should be adjusted in order to realize a balanced and high value portfolio, which is strategic aligned.

Implications

Theoretical implications

Obviously, portfolio management evolves around portfolios. Nevertheless, in the portfolio management literature there seems to be a remarkable lack of attention aimed at this object of manipulation. This situation is inexpedient and hampering for the further exploration of the research area.

Firstly, the model implies that it is expedient to manage initiatives aimed at developing new products separately from other types of development efforts within other company functions such, as for example, the IT-department, human resources department, or the production area. This is due to the distinctive nature of product development.

Secondly, this research articulates that it is relevant to distinguish between three generic portfolio classes within product development. They appear in three variants, namely past, current and future portfolios. Moreover, it is suggested that each of the portfolio classes well can be decomposed into at least two sub-portfolios.

The results of this research urge other researchers henceforth to explicitly state which portfolio their contributions aims at managing and improving as well as the relation to the other portfolios.

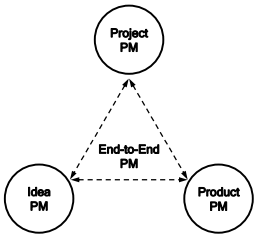
This research also introduces the concept of end-to-end portfolio management. This certainly adds to the intricacy of the field, which already is highly complex. It implies that research effort well might be directed towards improving our understanding of the portfolio "chain" constituted by ideas, projects and products instead of solely focusing on one link of the chain. Similarly, tools which support the coupling of the different portfolios in order to synthesize and portray the portfolio chain appear as highly pertinent.

Managerial implications

The conventional way of organizing in companies entails organization according to functional domains. For example, the management of the product portfolio may reside with the product marketing department. The management of the project portfolio might more or less consciously be handed over to the R&D department. Moreover, the management of the idea portfolio may in some situations be everybody's and thus nobody's responsibility.

If the management of one or more of these portfolios is exercised in isolation from the others or even omitted, the risk of sub-optimization is imminent. Hence the ultimate success of a company's product development efforts is highly dependent on the functional area's ability to

coordinate their work and foresee the consequences of portfolio decisions up- and downstream in the company.

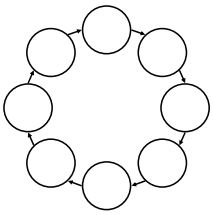


Besides highlighting the relevance of an explicit and dedicated management of each of the three portfolios the model suggested by this research implies that it is expedient to acknowledge the need for continuous end-to-end portfolio management. The latter task involves the overall coupling and coordination of the processes associated with the management of the idea, project and product portfolio. Furthermore, it entails requesting and collecting information regarding the conditions of these portfolios. The purpose is to synthesize this information into a unified whole, which can constitute a proper foundation for decision makers to execute portfolio decisions upon.

8.2.2 Research question 2

The second question is founded on the assumption that many ailments in portfolio management for product development stem from an over-commitment of the product development resources. This question supports the achievement of an enriched understanding of the realities that many practitioners are confronted with. The understanding is considered imperative to resolve the burdensome phenomenon.

> ***Research question 2: The phenomenon of over-commitment***
>
> *How can the dynamics of over-commitment in portfolio management for product development be explained? What is the nature of the phenomenon?*



Contribution

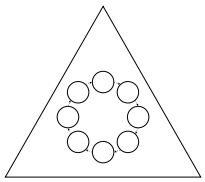
This research proposes a mindset which explains the dynamics of the over-commitment phenomenon. The thinking pattern rests upon the fundamental assumption that over-commitment and the related problem complex well may be rooted in an unrealistic perception of the product development capability compared to the task, i.e. the portfolio, within the company. The virtues of the mindset originate from the following:

- The mindset integrates and reflects five central aspects which characterize the dynamic phenomenon, namely, 1) the effects of over-commitment are displaced in time, 2) over-commitment is contagious, 3) over-commitment is negatively reinforcing, 4) over-commitment is company pervasive, and 5) over-commitment is disturbing.

- The thinking pattern itself implies several solutions to the problem. They emerge from the corresponding positive version of the pattern, which also is delineated.

- The mindset seems to offer an easy way to impart industry professionals an enhanced understanding of a highly complex pattern

of problems, which holds the potential to seriously degrade the productivity in product development.



- The mindset is not only relevant for professionals within one specific functional area like R&D, sales or service or for professionals with specific organizational responsibilities, such as project managers, functional managers or directors. Rather, the mindset is important for professionals *across* the company. This is in concordance with the pervasive and contagious nature of the problem complex, i.e. the fact that over-commitment cannot be confined to one functional area or organizational level in the company.

Limitations

The suggested mindset only represents one pattern of explanation. Since the mindset presumes the occurrence of declining business performance it implies that if a company does not experience declining business performance, then the problem complex appears to be invalid. In such situations it may well seem too convenient for the management to disregard the proposed thinking pattern. However, the author suggests that one should be careful with such reasoning, because the staggered nature of product development implies that many of the consequences stemming from portfolio decisions first are revealed with a time delay. Hence the *current* business performance is a result of yesterday's portfolio management practices. But this is no guarantee that today's practices are satisfactory.

Implications

Theoretical implications

The contribution points to the need for an improved understanding of the phenomenon capability in product development compared to the portfolio in question. It seems, however, that within the field of portfolio management we certainly cannot ignore the influence of human nature. Personal preferences, emotions and power plays can easily short-circuit even the best thought out portfolio tools and techniques.

Managerial implications

The mindset introduced by this research accentuates that it is an indispensable necessity that the selection of product development opportunities to be pursued is rooted in a realistic and proper match between the company's product development capability and the task implied by the aggregate set of opportunities in question.

It is, however, important to realize that no single individual alone possesses this knowledge. It is namely a very complex matter which concerns several functional areas and people in the company, due to the pervasive nature of product development.

Therefore it is inexpedient if decisions to initiate projects predominantly are being made by one or a very few individuals within for example the R&D, marketing or business development department in isolation. Even though they may be convinced that they can see through and undertake the project, it is unlikely that they can assess many of the downstream implications, i.e. the work implied within other functional departments

during the development of the product as well as during the products life cycle on the market.

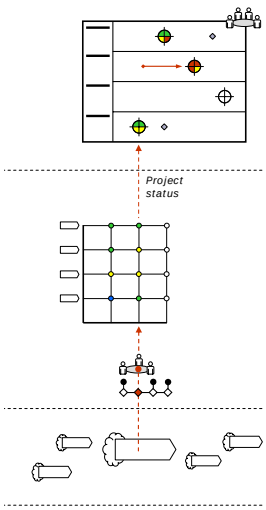
This problem aggravates considerably at portfolio level. It might namely well be next to impossible for individuals to determine the impact of such a decision on the totality of the projects. The painful process of prioritization among the projects to be pursued with the scarce development resources is simply omitted. Thus, paradoxically, such autonomous decision makers may never understand how a seemingly harmless decision well may be at the expense of several other projects already underway due to the implied over-commitment of the product development function.

One way the senior management can avoid this kind of autonomous decision making to get out of control is to call for qualified and proper portfolio decisions across the company. This entails utilizing the collective knowledge of the company by involving representatives from the contributing functional areas in order to subject the project in question to a nuanced and critical examination.

8.2.3 Research question 3

The third and last question rests on the assumption that the decision makers in some companies tend to execute portfolio decisions based on a weak understanding of the dynamic portfolio's actual condition. However, in order to make proper decisions regarding the portfolio mix, transparency is asserted a fundamental necessity. That is, we need to be able to see the portfolio we decide about.

> ***Research question 3: Portfolio visualization***
>
> *How can the dynamic portfolio be mapped utilizing the individual projects as points of reference?*



Contribution

This research introduces the dynamic portfolio map, the project evaluation matrix and the project planning matrix. These are three interrelated tools, which in combination can be utilized to map the dynamic portfolio starting from the individual projects. Every tool builds on mapping techniques and cross-functional involvement of people. The tools also incorporate principles from the unweighted factor scoring model and dynamic rank ordered lists. The principal originality of the proposed tools consists in the following:

- The deployment of the three tools enables the establishment of a condensed visualization of the quality of execution of the projects currently underway in the portfolio, which is rooted in an explicit, rigorous and systematic evaluation of each project.

This visualization of the portfolio encourages the management to raise relevant questions regarding the condition of projects and examine and understand cause/effect relationships embedded in the portfolio. Such a dialogue is asserted fundamental and indispensable in order to improve the collective understanding of the company's development capability and hence make well-informed and sound decisions regarding the portfolio mix.

- An explicit and dynamic linking between each project's development process and the portfolio overview forms the crux of the tools. The assessment of the quality of execution within each project is derived during key point meetings based on the collective evaluation of the project by key personnel from contributing functional areas. This supports synchronization between deliverables within each project.

- By requesting indications on the quality of execution decomposed on functional areas the tools promote a horizontal and vertical integrative working pattern in product development. This is widely recognized as an indispensable pre-requisite for realizing strong product development.

- The tools bridge diverse planning approaches within different functional areas by providing an explicit and easy understandable top level view of the central project deliverables structured according to the key points in the development process. This encourages each functional area to explicitly commit to contribute to the project while allowing them to pursue their individual approach to planning at a more detailed level.

- The deployment of the tools provides indications about the portfolio's balance, strategic alignment and potential value, which are three high-level goals that dominate the management's mindset in companies.

- The tools enable the provision of a user-friendly presentation of condensed information regarding the dynamic portfolio to a group of decision makers that have neither the time nor need to learn all the details underlying each project in the portfolio.

Limitations

The planning matrix tool is only intended to encompass a top level view of the central project deliverables. Thus the tool cannot substitute traditional project planning methods.

The evaluation matrix tool is in its current form not intended to be used for the appraisal of the business quality of a project, and it does not replace other types of project documentation.

The three tools are only applicable when a project has reached a certain level of concretization, namely when an idea has been identified, scoped and selected. Furthermore, resources for the preparation of a business case by means of a pre-project have been approved and staffed.

Different companies typically utilize dissimilar development processes. Since the use of tools, however, presumes a close integration with the development process some adaptation is necessary. However, a further verification of the tools utility is required before such an adaptation is attempted

Implications

Theoretical implications

It is evident that the potential value of a development portfolio is highly dependent on the quality of execution in each of the contributory projects. Paradoxically, tools and methods in the portfolio management literature seem not to clearly recognize this aspect. Rather, contributions assume flawless execution and imply little or no explicit leitmotif from project to portfolio perspective. A dubious and nebulous linking between the portfolio perspective and the underlying projects appears to be predominant.

The results of this dissertation state that in order to execute good portfolio decisions a thorough understanding of the dynamic portfolio's condition is mandatory. Moreover, the research advocates that a rigorous and systematic evaluation of the quality of execution in each contributory project forms an important part of this puzzle. Furthermore, the proposed tools accentuate that product development is highly dependent on the timely and proper contributions from several functional departments in a company.

This research implies that lack of synchronization between deliverables from dissimilar functional areas holds the potential to seriously degrade the potential value of the development portfolio. The author assumes that this situation very well may be attributed to *diverse planning traditions* within different functional domains. For example, the work in the R&D department might be planned more rigorously than work in the product management or marketing department. The latter may work in a somewhat interrupt driven mode. The question is whether product marketing and other functional areas have sufficient resources left to contribute timely with, to the product development projects typically anchored in the R&D department.

Therefore, the author would in particular welcome contributions aiming at improving our understanding of the interplay between overall portfolio planning for product development and the related planning in the contributing functional areas.

In sum the present contribution implies that it is expedient to devote research attention to the dynamic and cross-functional planning and follow-up of the development portfolio, i.e. the day-to-day management of the portfolio as opposed to the discrete preparatory portfolio planning.

Managerial implications

The contribution entailed in the proposed tools constitutes a reaction to an observed tendency among the decision makers in some companies to execute portfolio decisions based on a weak understanding of the development portfolio's actual condition. The researcher speculates that this partly might be due to the following reasons:

- The senior management lacks a view of the dynamic portfolio, which is rooted in an explicit, rigorous and systematic evaluation of each project in the portfolio. This makes it difficult for the managers to raise relevant questions regarding the project's condition and examine and understand cause/effect relationships embedded in the portfolio.

- The senior management's attention is directed towards strategizing and identifying new opportunities that can realize novel and innovative products, which may contribute to improve the revenue stream and short term profitability of the business.

- The senior management considers the realization of identified opportunities as a trivial activity, which is carried out "elsewhere" in the company. Consequently they may not devote the necessary attention towards the follow-up of initiated projects.

This research calls on the senior management in industry regardless their functional affiliation to acknowledge that their leadership responsibility extends beyond strategizing and ideation.

Ensuring that the strategies and ideas are being implemented properly and presumed business effects are harvested as intended do also form a vital and unavoidable part of the responsibility.

Paradoxically, the latter may well constitute a prerequisite for the former. If we execute portfolio decisions without a proper understanding of the state of implementation of the current development portfolio, which is presupposed to mirror the innovation strategy, it can actually impede innovation. The reason is that precious resources eventually might be confined by misaligned projects, firefighting or rework projects. These resources could otherwise have been devoted to the cultivation of new business opportunities.

8.2.4 Concluding remarks

Guided by the three stated research questions this research has contributed with a reference model, a mindset and three supporting tools for portfolio management. The contributions and the synthesizing of these correspond to the theoretical and industrial goals initially specified for the work in section 2.3 and 2.4.

All the contributions from the research have been validated by means of logical verification and verification by acceptance. The latter entails confrontation with industrial portfolio management practices or industry professional's judgement of the results. Their positive reactions give reason to believe that the contributions will be an important step towards supporting industry professionals in their efforts to compose and continuously maintain a business wise strong product development portfolio. In conclusion, the author finds it justified to state that this research project successfully has fulfilled its objectives.

8.3 Future research

During the course of this research several themes have emerged which give rise to new questions. This section concludes the chapter by highlighting three central opportunities for future research within the field of portfolio management for product development.

Different planning traditions

Contemporary portfolio management thinking points to the idea that all projects that compete for the same resource pool should be subjected to the portfolio management process. Although the concept of a common resource pool is appealing in theory it is not easy to identify in industrial practice. This is due to the profound cross-functional nature of product development. The dilemma might origin from corporate accounting practices which cause financial resources to be allocated across functional areas as marketing, R&D, service, production etc. Each of these departments is responsible for the planning and allocation of their respective resource pools. It seems reasonable to assume that their planning traditions might vary with regard to techniques and meticulousness. The author asserts that such disparities can obstruct proper portfolio management. An investigation of the interplay between such different planning traditions and portfolio management for product development presents a significant opportunity for extending this research.

Appraisal of business quality

This research has suggested three tools which used in combination can be used to visualize the dynamic portfolio. The tools are in their current form not intended to be used for the appraisal of the business quality of a project. It is, however, obvious to aim further research on extending the tools to include also this aspect of the dynamic portfolio.

The paradox of controlling and improvisation

As with many other management processes portfolio management is also confronted with the paradox of balancing the desire for controlling and stability with the need for improvisation in order to provide favorable conditions for innovation to prosper. A research effort aimed at improving our understanding of how portfolio management can accommodate these concurrent and conflicting needs appears relevant.

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