Software Product Portfolio Management: Towards improvement of current practice

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Abstract

In recent years, the growing importance of product portfolio management has made organizations aware of the costs when not done properly. Wrong investment decisions, lacking product information, inefficient use of resources and above all a misfit with strategy are just few of the consequences of bad portfolio management. But product portfolio management is not a clear cut, one time implementation of tools. Instead it is a dynamic decision process where processes, products and projects are constantly updated and revised. Another difficulty is posed by the fact that also project portfolio management and product lifecycle management are strongly related to product portfolio management.

For all of the subjects methods, best practices and models exist, but as far as known no method exists to implement the entire process within software organizations while the relation between each subject has been agreed upon. Also, whilst often maturity situations are described, no concrete actions are presented to actually reach these maturity situations. These are indeed situational, but generic pointers could be given to enable the realization of the maturity situations.

This research aims at facilitating the implementation of product portfolio management within software organizations. By performing literature study, key issues have been identified that need to be taken care of to successfully implement product portfolio management processes. To enact upon these key issues, guidelines have been created. And based on the guidelines the software product portfolio management implementation model has been created. In this model the implementation of product portfolio management is described as well as the implementation of related subjects that facilitate the portfolio management process.

To clearly show the increase in maturity that is realized, also a maturity matrix was created. In this matrix capabilities are presented that serve as a measurement of the current processes and guide towards the next level in maturity. Finally, to ensure the practical value of the implementation model and maturity matrix they have been applied at UNIT4. Initial results show that the model can indeed be used to implement more mature product portfolio management processes within software organizations.

1 INTRODUCTION

This thesis project aims to create a set of guidelines for the implementation or improvement of software product portfolio management practices within a software company. In this chapter an introduction will be made to the context and the problem description will be given, also the research questions and research scope are presented.

1.1 Context and problem definition

In today's highly competitive environment, companies are under high pressure to provide the right products to their customers. Especially since success is, as Ameri and Dutta (2005) state, "*by and large determined by the success of the products they introduce to the market*". However, confronted by challenges like the continuous need for innovations, increasing customer demands and shorter time-to-market (Ming, Yan, Lu & Ma, 2005), the task of delivering the right products has become more difficult. To be able to remain standing in such a market, the company's internal processes should be such to support the company in overcoming these obstacles.

Looking at software companies, the challenges remain the same, but there are (subtle) differences that should be taken into account. For example, software products can be changed easily and updated through patches and the release frequency is relatively high compared to non-software products (van de Weerd, Brinkkemper, Nieuwenhuis, Versendaal & Bijlsma, 2006). Keeping track of the product information is a difficult task considering the rapid changes that can take place. An even more difficult task is to use this product information for further decision-making regarding the product or even using the information for other products and processes in the company.

The research topic that addresses this issue is that of product lifecycle management (PLM). PLM is brought forward in the last couple of years as "*a business approach integrating people, processes, business systems and information to manage the complete life cycle of a product across enterprises*" (Lee, Ma, Thimm & Verstraeten, 2007). Saaksvuori and Immonen (2008) add to this that the core of PLM is handling information such that the required information is available for daily operations. This is supported by Sudarsan, Fenves, Sriram and Wang (2005) which state that PLM holds "*the promise of seamlessly integrating all the information produced throughout all phases of a product's life cycle to everyone in an organization at every managerial and technical level, along with key suppliers and customers.*". Ameri and Dutta (2005) add to this that PLM is "*...all about knowledge management.*". Note that in these definitions no distinction is made between software and non-software products. But this does not mean that they are not there, especially considering the differences pointed out earlier. The PLM solution for each industry is totally different because of the individual business processes (Abramovici & Sieg, 2002).

Considering the acknowledged importance of PLM (Sudarsan et al., 2005), it seems inevitable that companies have a proper set of information technology (IT) systems in place to make this kind of information handling possible. But as with the gross of IT-systems available, simply installing the systems is not sufficient. PLM is not an exception. In order to reap benefits from PLM and utilize its full potential, the corporate strategy and processes should be supported by the PLM system in place (Ameri & Dutta, 2005). This is in line with Saaksvuori and Immonen (2008) who state that "*... the return on investment for PLM is based on a broader corporate business value...*" where the company should be able to "*... make informed*

decisions over the complete product portfolio during the lifecycle of each individual product.". But where research has been done on the concept of PLM itself, the IT-systems that are used and the information that comes to play, no research has been done on actually implementing the PLM way of 'doing business'. In other words; where the scientific attention for PLM is sufficient, the support for practical application is lacking behind.

But before continuing to the formal problem statement, product portfolio management (PPM) should also be taken into consideration. It is seldom the case that a company only has a PLM implementation on its own. The reason for this, as the reference framework for software product management by van de Weerd et al. (2006) (Appendix A) shows, is that product lifecycle management is part of the product portfolio management process. Product portfolio management is the term used for managing investment decisions over time following profit and risk criteria (Kittlaus & Clough, 2009) and concerns the strategic information gathering and decision making across the entire product portfolio (Bekkers, van de Weerd, Spruit & Brinkkemper, 2010). The overlap with the PLM concept becomes visible through the fact that PLM is aiming precisely at providing the right information about the products for this decision process. Considering this overlap it is impossible to leave PPM out of this research as it would be a painstaking process to allocate research results specifically to either one of these intertwined subjects.

PPM has been around since Henderson and the Boston Consulting Group introduced 'the product portfolio' in 1970 resulting in perhaps their most popular work, the Boston Consultancy Group Product Portfolio Matrix (Henderson, 1979). This matrix made it possible for companies to classify their products and use this information for decision making regarding the product portfolio. Since then a number of matrixes has emerged and ongoing research has focused on different aspects of portfolio management. Ranging from diagnosing the product portfolio (Day, 1977) and comparing it to financial stock portfolios (Wind, n.d.) to the recent trends of new product development portfolio management (Kavadias & Chao, 2007), the role of the product manager (McNally, Durmusoglu, Calantone & Harmancioglu, 2007) and project portfolio management (Killen, Hunt & Kleinschmidt, 2008).

One subject that has been left on the side however, is the subject of PPM implementation. Each subject mentioned above, while related to PPM, does not clearly explain how to implement an entire PPM solution in an organization. We are not implying that there is one solution for implementation, nor that the research so far is insignificant, but only that results from previous research will have minimal impact if they cannot be converted into practical solutions.

Now it is clear what needs to be done in this area, a remark should be made on the scope of the results that will be presented in this document as well as the results of future research. As stated earlier each industry has different processes and thus each industry requires an individual study. As such, the results in this document are specific for the software industry. Initial findings have confirmed that research on PPM specific for software products is lacking behind. Considering the impact software has on current business and the great quantity of software products and vendors available, PPM seems an important necessity for software suppliers to gain the most benefits from their product portfolio. Results could be applicable across industries though, but caution is required to avoid unwanted results.

1.2 Research questions

Based on the problem definition above the formal research question for this thesis is formulated as follows:

"How can product portfolio management be implemented in software businesses, such that it is able to support the organizations' corporate strategy?"

Note that PLM is not explicitly mentioned in the formal problem statement since, as explained above, PLM is part of PPM. And as a request project portfolio management (PM) will also be included in the research. The literature study will show PM to be closely related to PPM.

To complement this question, the following sub-questions are formulated:

a) What is the current state of PPM, PPM and PM applications in literature and at UNIT4?
   i. What is the (standard) scenario for PPM? (e.g. trigger, processes and decisions)
   ii. What performance matrixes are used to assess the portfolio?
   iii. What does the decision making process look like and who are involved?
   iv. How do new product, or incremental update, development projects influence the PPM and PM process?
   v. What are the PLM phases and the action in these phases?
   vi. How are PLM implementation projects initiated and presented to management?

b) What guidelines and model can be constructed for PPM, PLM and PM implementation?
   i. What are current methods and why are they not sufficient?
   ii. What are the bottlenecks for applying these methods in practice?
   iii. What are lessons learned from practice?
   iv. How can the organization assess its product management needs?
   v. How to get product management in line with the corporate strategy?
   vi. How can the new form for knowledge management be fit into the organization?

c) Are the constructed guidelines, implementation model and maturity matrix valid?
   i. Are they complete?
   ii. Are they applicable in organizations in varying size, branch and maturity?
   iii. Is the required result within reach?

The objective of this research is to create a complete set of guidelines that can be used to implement the PPM, PLM and PM principle in an organization or improve existing implementations. With these guidelines we will need to take into account the differences in the needs of organizations. Taking, for example, the differences in size, branch, product portfolio and the resources available into consideration are key as not every organization requires the same maturity level regarding their PPM processes. A practical example is that, due to expected high costs for introducing and customizing a PLM system, most small and medium-sized organizations avoid PLM technology (Abramovici et al., 2002). The guidelines will thus include an assessment where the organization will decide on what is actually required.

1.3 Research scope

Looking back at the definition and the framework by van de Weerd et al. (2006) we see that PPM includes PLM, partnering and contracting, market trend identification and product line identification. Each of these topics are a research area on their own, thus it is impossible to include all of these topics. If the business objectives require a more thorough understanding of a particular topic, like the case of PM, a short sidestep will be made. But from the framework the main scope of this research is limited to PPM including PLM and PM.

1.4 Scientific relevance

In most cases organizations already have some form of PPM processes operational, ranging from ad-hoc decision making to formally defined methods and processes (Cooper, Edgett & Kleinschmidt, 1999). But PPM is not a clear cut, one time implementation of tools, but a dynamic process where processes, products and projects are constantly updated and revised. It is especially dynamic considering the fact that it depends on several external parties like the market environment (van de Weerd et al., 2006). It is widely acknowledged that the environment for any organization can be subject to frequent change to say the least. The PPM solution should be able to adapt to these changes and guide the organization to the most valuable and profitable configuration for their resources at that particular moment. With that said, the research on portfolio management specific for software products is lacking behind. While the findings from other areas might also apply to software products, the results are not all applicable to software products.

A recent line of research on PPM focuses on new product portfolio management (NPPM) and the role of the product manager. NPPM is concerned with methods and tools that ensure effective resource allocation among an ensemble of innovation efforts (Kavadias & Chao, 2007). The product portfolio is still managed, but the focus has shifted towards fitting in new innovative products. This still remains portfolio management though since decisions are made that influence the organizations' product portfolio. With regard to the role of the product manager, research has shown that "… *managers' dispositions are one factor potentially limiting firms' improvements*" (McNally, Durmusoglu, Calantone & Harmancioglu, 2007). Whilst the role of the product manager is a new topic, over the years general management and management support have always been key issues regarding PPM (Cooper, Edgett & Kleinschmidt, 2001).

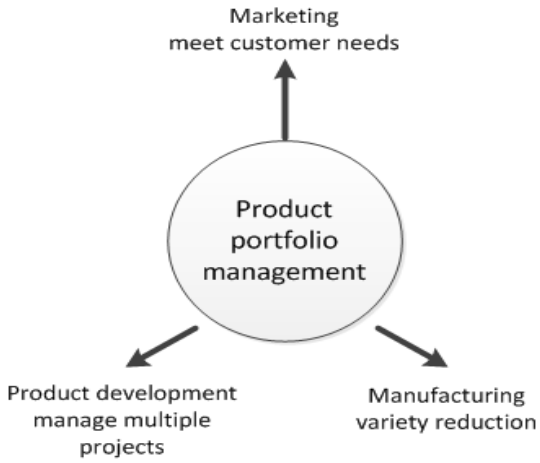

Figure 1 - The pressures of portfolio management by Cantamessa (2005)

Taking a step backwards though, issues remain with regard to classic portfolio management. While it is clear what PPM should bring, the problems it brings remain complex (Cantamessa, 2005). Thus the focus will be on this classic portfolio management process, keeping in mind the results of this recent line of research. An advantage we will gladly make use of is that, based on earlier research, we know better where to look for useful PPM implementations. For example, the useful elements can be derived from benchmark business and the less useful elements, like mathematical models, can be left aside since mathematical models cannot be sold to management (Cooper et al., 1999).

1.5 Practical relevance

From the scientific perspective it is apparent that the PPM landscape is under heavy construction and will remain a construction yard until standards are made and full organizational support is in place for PPM and PPM implementations and processes. The advantages of a solid PPM process are visible in the form of more innovative products, shorter time to market, higher success rate of new products introduced and reduced costs (Ming et al., 2005; Lee et al., 2007).

But being able to use PPM to its full potential and actually experiencing these advantages can only be done with a sound implementation of the entire PPM concept. Not installing IT systems and telling people to use it, but explaining how and why to use it and make it part of the standard business processes. Actually using the information that has become available is the organizations decision making; reusing business intelligence if you like (Miller, n.d.). With the guidelines and model that will be constructed in this research, organizations will get better insight in the processes that are involved with PPM and be more able to take advantage of the possibilities it brings.

2 RESEARCH APPROACH

The approach for the research is explained using the information system (IS) research framework by Hevner, March, Park and Ram (2004). This framework states that IS research consists of two complementary phases; behavioral science and design science. According to Hevner et al. (2004) "*The goal of behavioral science is truth…*" and "*… the goal of design science is utility*". The research will create a new artifact with the purpose of fulfilling the identified business need for product portfolio management. Thus the research can be defined as an IS research best described as design science. On a different note the research is theory-oriented research as "*the objective is to contribute to theory development*" where "*…ultimately, the theory may be useful for practice in general*" (Dul & Hak, 2008).

2.1 Research model

The research model is shown in Figure 2. Note that the research objects are twofold; first are the academic objects and second are the business objects, indicating respectively the scientific and the practical orientation of the research. The research model is based on the research model method by Verschuren and Doorewaard (2007) where each component (rounded rectangle) represents a research object and the main research objective is represented by the solid border. The arrows indicate interaction between research objects resulting in a new research object. In the model also a distinction is made between academic research objects and business research objects. The main focus is on the academic objects, but parallel also the

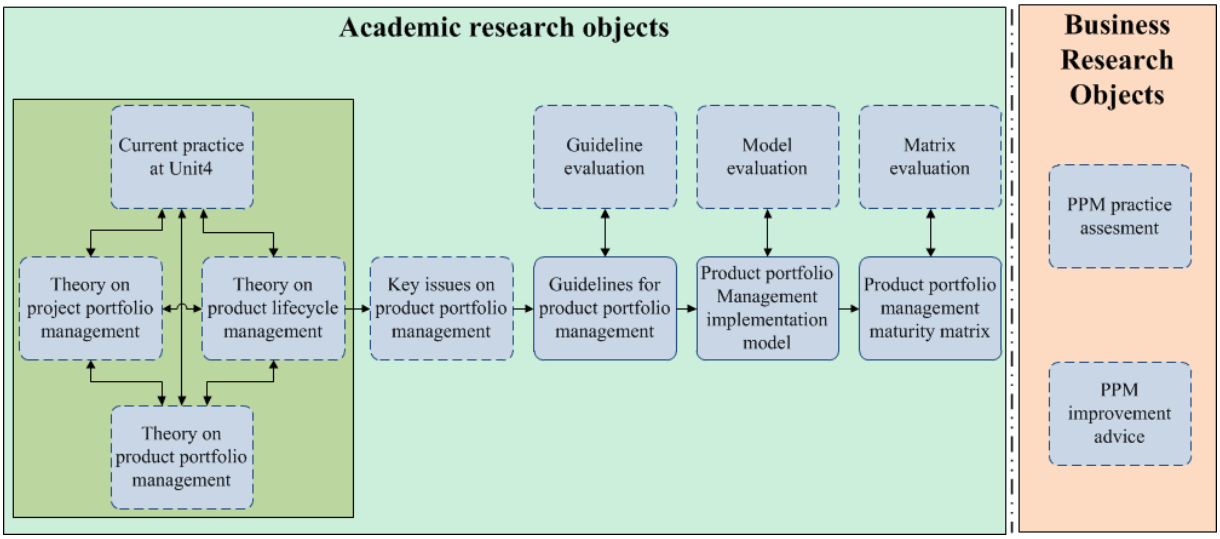

Figure 2 - Research model

business objectives will be fulfilled.
From left to right the research model implies the following:

- Based on the existing scientific literature and current practice of PPM, PLM and PM a list of key issues will be identified.
- Based on this list the set of guidelines will be constructed.
- After evaluating the set of guidelines an implementation model can be constructed.
- After evaluating the implementation model a maturity matrix can be created, which in turn will again be evaluated.

As for the business objects, first the current practice will be researched where the process will be documented and strengths and weaknesses will be identified. Second an advice will be given, based on the findings of the research, that can be used to improve the current practice at UNIT4.

2.2 Research method

The research method for constructing the guidelines is depicted in Figure 3 in the form of a process-deliverable diagram and shows the activities that will be performed along with documents or research object that will be delivered.

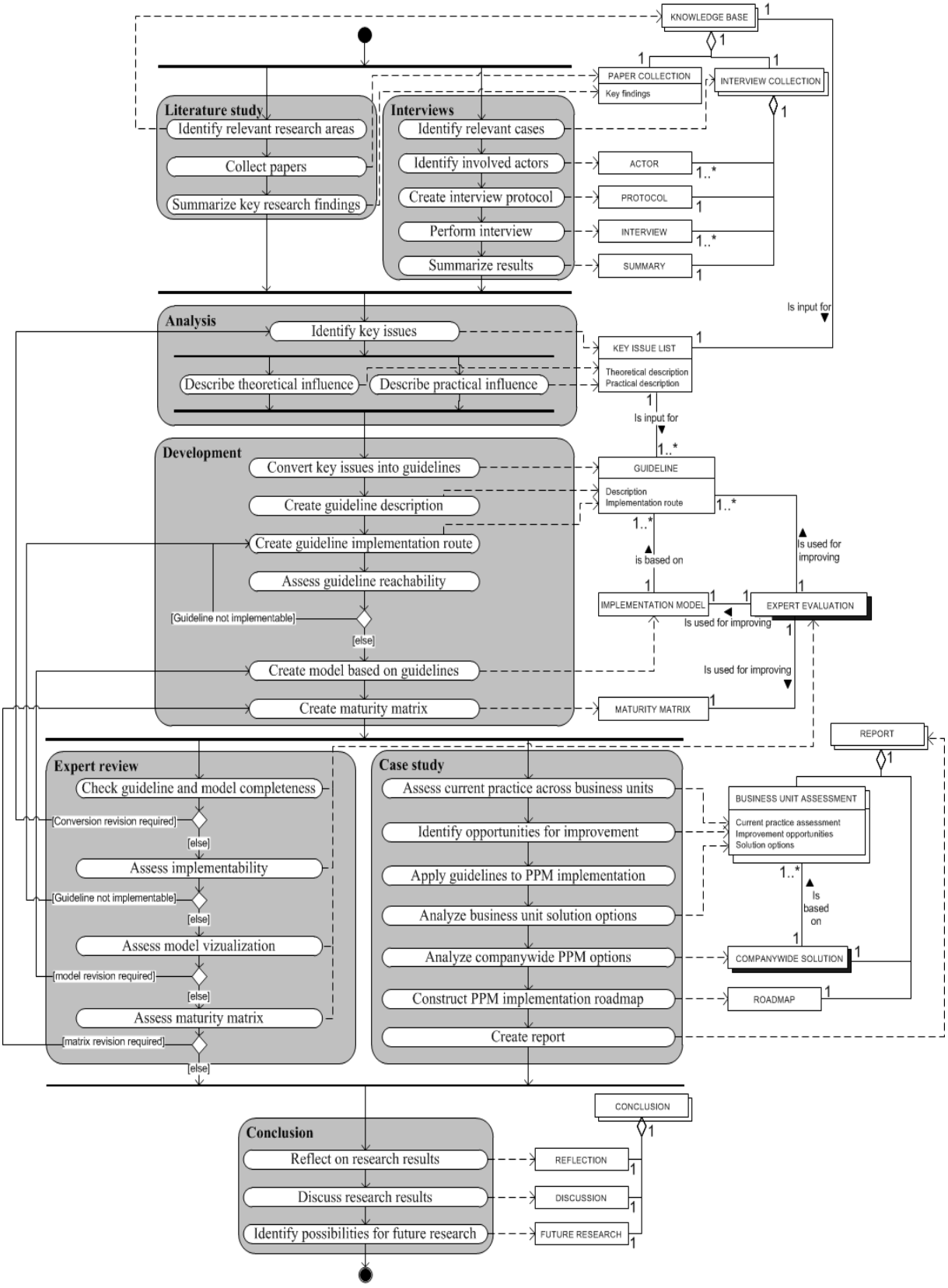

Figure 3 - Process-Deliverable Diagram

The proposed method is in line with the approach for design research by Takeda, Veerkamp, Tomiyama and Yoshikawam (1990), which identified the following five phases:

1. Awareness of the problem
2. Suggestion
3. Development
4. Evaluation
5. Conclusion

The awareness of the problem has been described in the context and problem description, so the figure starts from the suggestion phase. Using literature study and interviews the key issues for the 'problem' will be identified. In the development phase the results will be transformed into the set of guidelines. Based on these guidelines the initial implementation model will be constructed and based on these the maturity matrix will be constructed. The evaluation phase consists of experts reviews and adjustments will be made accordingly. Parallel to this a case study will be performed. In the conclusion phase the final model and set of guidelines will be presented. Each phase is explained in more detail below.

2.2.1.1 Literature study

Literature from journals, conferences, books and other (internet) sources will be gathered through 'scholar Google' and the Utrecht University library to create an extensive knowledge base for this research. This knowledge base will contain information on all subjects identified so far (PPM, PLM and PM) and on subjects that are acknowledged to be related to these subjects. Initial keywords will thus be '(software) product portfolio management', '(software) product lifecycle management', '(software) project portfolio management' 'portfolio strategy', 'portfolio management implementation' and 'software product management', where related subjects could be 'portfolio management methods' and 'performance matrixes'. The subjects that will be included should have a clear added value for implementing PPM, preferably in the case of software products.

As described in the context and problem definition, there is not much research on PPM with regard to implementation and software products. So the papers, articles and books that will be added to the knowledge base have to comply with two criteria:

1. The findings in these sources are also acknowledged by other authors
2. The authors have significant experience (at least 2 papers) in the area of PPM or related areas.

Since also literature from other disciplines than software products will be included in the literature study, the criteria will serve the purpose of ensuring that already established methods are included. Though the methods might be industry specific, elements could be extracted that are related to software products. Each relevant subject will be discussed and this information will be the basis for the key issues and thus the guidelines.

2.2.1.2 Interviews

Purely theoretical guidelines can be useful and educational, but following the principle of design science there is a business need to be fulfilled. This implies that the guidelines should also have practical value. Therefore the PPM practice within UNIT4 will be assessed by interviewing managers of different business units and on different layers of management. The interview results will fulfill two purposes, a scientific one and a practical one. The scientific purpose is complementing the results found in literature and the practical purpose is for performing a case study at UNIT4. The actual interview that was used, can be found in (Appendix C) and will be elaborated upon shortly in this section.

According to Dul and Hak (2008) there are two types of research; practice-oriented and theory-oriented. Practice-oriented research is where "*the objective is to contribute to the knowledge of one or more specified practitioners*" and theory-oriented research is where "*the objective is to contribute to theory development … the theory may be useful for practice in general*" (Dul & Hak, 2008). The research model as presented in Figure 2 indicates that this research is theory-oriented, where the theory is ultimately applied in a case study.

The interview itself is made semi-structured. A structured interview would lead to answers on questions directly related to what will already be discussed in the theoretical chapter. Conducting a completely unstructured interview could lead to (product) managers focusing on only certain aspects leaving a lot of questions unanswered. The semi-structured interview (Appendix C) brings every aspect to the front and also gives room for highlighting other important aspects and, of course, questioning these. In other words there are different levels of questions; single case level and more general levels (Yin,2008).

For processing the results, each interview will be recorded and notes will be made during the sessions. These notes summarize findings on the subjects that have been discussed. Afterwards, each interviews will be played back and the notes will be complemented with new findings on the important issues brought to attention. These will be categorized as either issues for PPM practice in *general* or issues *specific* for the PPM practice at UNIT4. This qualitative method is explained further in the analysis section below.

The general, issues will be used as a complement of the results found in the literature study and, in some cases, the findings will triangulate these. These results will be used to construct the guidelines for the PPM implementation model. Note that whilst the research is performed in a qualitative manner, the issues added to the general category have to be mentioned by at least four interviewees or confirm theoretical results with additional information to be considered as general issues. This is due to the fact that no experts were interviewed, but 'just' practitioners. The specific category will form the basis for the case study, which will be explained in the case study section below.

2.2.1.3 Analysis

The analysis of the results is an analysis of the key issues are that are of influence for PPM. After discussing a subject, the key issues of this subject will be presented. These key issues are identified using three guidelines:

1. elements that are mentioned by most (or all) authors,
2. subjects that can (logically) be linked to other important aspects to create a solid framework,
3. subjects that can be linked to the product portfolio management maturity matrix or other matrixes and models.

The key issues will be coded and referred to in the guideline construction to easily locate the source of a guideline. All the codes for this purpose are constructed in the following manner:

- The first part of the code shows the source of the element.
- The second part specifies the subsection.
- The third part specifies the exact issue.

In case of the maturity matrix stemming from the software product management competence model (Bekkers et al., 2010) an exception will be made as this matrix forms the basis of the research. For this matrix an example code is: "mm-ma-a" where "mm" indicates the maturity matrix, "ma" indicates the 'market analysis' subsection and "a" specifies situation 'a'. In

general if a key issue stems from theory it will be preceded by a ‘t’ and if it stems from an interview is it preceded by ‘iv’.

This method is in line with the principles of qualitative analysis as described by ‘t Hart, Boeije and Hox (2006, p.276). According to ‘t Hart et al. (2006) “a*nalysis is the processing of data into results and conclusions*” where two main activities are identified; coding and continuous comparison. Coding is the process of categorizing the data and naming the categories. Continuous comparison means that research data is constantly compared with each other to identify the relations between the categories. How these processes are applied in this research, will be explained in the ‘development’ section.

2.2.1.4 Development

From the analysis, the key issues will need to be transformed into guidelines. To do so the key issues will be grouped into categories (using the coding scheme explained in the analysis section) and the maturity matrixes and implementation trajectories will be used (continuous comparison). Mapping the key issues on the matrixes and trajectories gives an indication of the maturity level that each key issue brings. The next step is to deviate from the matrixes and describe what the most mature situation could be for an organization with regard to a specific topic.

Then, using the key issues, a ‘reverse engineering’ process will be followed, going from the most mature situation towards a set of actions that actually describe how an organization can get to that particular situation. The key issues are linked to those specific actions, assuring that all key issues are handled. Generalizing these actions will bring the guidelines to surface. Note that when following this method, the actions identified should provide to be the best detailed description of a guideline.

When the guidelines are identified and described the implementation model can be constructed. This model directs an organization in its endeavor to implement of improve its product portfolio management processes. The model will contain an overview of the areas of interest (the categories of the key issues), with a focused implementation model for each area in the form of a product-deliverable diagram (van de Weerd, 2009). This focused implementation will consist of the actions identified with each individual guideline and deliverables associated with implementation.

From the implementation model the maturity matrix will be created. In this process the same process for developing a maturity matrix will be applied as in (van de Weerd, 2009) where three main steps are followed:

1. Identification and description of the capabilities
2. Positioning the capabilities in the maturity matrix
3. Validating the maturity matrix

For this research the identification of the capabilities will be done using the guidelines and implementation model, where a capability is “*a demonstrable ability and capacity to perform a certain process at a certain level*” (van de Weerd, 2009). Positioning the capabilities in the matrix will be done based on the identified maturity levels in the research while taking into the intra- and inter-process capability dependencies. Finally, validating the matrix will be done by expert evaluation as described in the next section.

2.2.1.5 Expert review

Though the guidelines, and the forthcoming implementation model and maturity matrix, have been created from both a theoretical and a practical perspective, an evaluation is still required for scientific validity. For this reason an expert review will be conducted, independent from all earlier participants in the research. The term 'expert' refers to a persons specialized on a certain area of interest. In this research the area of interest is software product portfolio management or even software product management in general.

The review that will be conducted will not be an entire research on its own, the reason being limits in time and resources. Instead the review will be a semi-structured expert interview as identified by 't Hart et al. (2006, p. 275). According to 't Hart et al. (2006) an interview is structured when four elements are controlled:

- The content of the questions
- The way the questions are posed
- The order in which the questions are posed
- The answers on the questions

Due to limited resources, no actual interviews will be conducted but the interview questions will be sent to the experts per email, meaning that the first three elements are controlled. The fourth element, however, is unstructured, making it a qualitative semi-structured interview.

The questions that will be posed are aimed at evaluating the constructed guidelines, implementation model and maturity matrix. Each guideline will be evaluated in general; whether it is situational in some kind and whether should adjustments be made. Also the list will be assessed on completeness; is the whole PPM process covered or should additional guidelines be created. With regard to the implementation model, key questions will be on the presentation, completeness and affordance and the maturity matrix will be assessed on the capabilities and their respective placement in the matrix.

2.2.1.6 Case study

A case study will be performed at UNIT4 to improve the current practice with regard to PPM. Based on this study, which will be done using the interview method as explained earlier, a report will be written. The aim of this report is to fulfill the business objectives as presented in the research model by applying the research results and help UNIT4 in reaching more mature processes regarding PPM. In this section the case study will be explained including the methods that will be used.

Yin (2008) identifies five central components of a case study:

1. A study's question
2. Study's propositions
3. Units of analysis
4. Logic linking data to the propositions
5. Criteria for interpreting the findings

Baxter and Jack (2008) add to this that a novice researcher has the responsibility to ensure that: "*the case study research question is clearly written, propositions (if appropriate to the case study type) are provided, and the question is substantiated; case study design is appropriate for the research question; (c) purposeful sampling strategies appropriate for case study have been applied; (d) data are collected and managed systematically; and (e) the data are analyzed correctly*".

According to Yin (2008) "*... case studies are preferred when 'how' and 'when' questions are being posed, when the investigator has little control over the events and when the focus is on a contemporary phenomenon within some real-life context*". Note that the case study that is going to be performed, conforms to the preferred situation. The interview, as explained earlier, will focus on how managers cope with PPM issues and when certain actions are applied. Also, being the investigator, no control can be taken over the PPM process, which is a current issue in the organization. Also direct observation is a method, though this is to a minimal extent.

The study's propositions are mentioned and described with the research question and sub-questions. The attention is focused on PPM, PM and PLM and the related strategic aspects. The units of analysis are the managers of the individual business units. At this point it is still unclear which business units will be included as the requests for interviews still have to be sent out. What is clear is that this case study concerns a single case with embedded units (Baxter and Jack, 2008; Yin, 2008). A more detailed description of the units of analysis will be given in chapter 4.

The method for collecting the data, linking them to the propositions and interpreting the findings was explained in the analysis section. Yin (2008) continues and a good analysis relies on all relevant evidence, all rival interpretations are dealt with, most significant issue is addressed and prior expert knowledge is used in the study. The prior expert knowledge refers to skills and characteristics the researcher should poses to successfully conduct a case study. These have been identified by Yin (2008) are:

- Good knowledge of the phenomenon (no routine)
- Sensitivity for new or unexpected issues
- Asking good questions (the interview will be reviewed by co-researchers)
- Being a good "listener"
- Adaptiveness & flexibility

Yin (2008) also identifies common criticisms towards case studies which should be taken into account. For example there appears to be a lack of systematic handling of data and there is no basis for scientific generalization. However, the correcting solutions are also known being the systematic reporting of all data (in this case using notes and sorting in categories) and generalizing by linking to theory (in this case included only when mentioned four times and mentioned in theory). The approach as described should prove reliable to design the intervention that is to take place. The implementation and evaluation of the intervention (Dul et al., 2008) are out of the scope of this study.

2.2.1.7 Conclusion

In the conclusion an answer will be given on the research questions that were posed. By then the guidelines, implementation model and maturity matrix will be theoretically grounded, evaluated by experts and will have been used in practice in the consultancy report for UNIT4. After answering the research questions, a critical reflection on the research and the results will be presented and a direction for future research in this area will be given.

3 THEORETICAL FRAMEWORK

In this chapter the theoretical framework for the research will be constructed. But before we go further in this extensive section, two items should be discussed. First is the coding of the key issues. The principle of coding has already been explained in the research approach section, but given their importance they will be shortly explained again. The key issues are presented right after a subject has been discussed. These key issues are important aspects on these subjects and will form the basis of the guidelines and therefore the implementation model and maturity matrix. The key issues can be used as a reference to the source of the guidelines.

An example code is '**t-plm-1**'. Where 't' indicates its source is theory, 'plm' indicates the PLM subsection and '1' indicates that it concerns issue number one. In general, if a key issue stems from theory it will be preceded by a 't' and if it stems from an interview is it preceded by 'iv' with an exception to the maturity matrix stemming from the software product management competence model (Bekkers et al., 2010) as this forms the basis of the research.

Second is a central term that should be explained. In the introduction and in the research question the focus of the research has deliberately been put on software products. As this is our field of research, one of the triggers for this research is the fact that not much research has been done on PPM with regard to software products. Just to be clear with the section to come, we will define what a software product is.

Software is a term that is both an ease as well as a pain is present economic perspective. It is a fast expanding market with high potential of continuously making processes easier and more efficient, but on the other hand the high costs of software development, the great variety of products available and the uncertainty of reaching the sketched potential oblige management to handle with care. Note that the term software is used without restraint here as most people at least have a common understanding of what software is. A summary of definitions given in dictionaries make clear that software is everything that can be digitally stored on a computer. But no-one stamps a self-created text document or a paint drawing as a software product.

When people use this term in business context they usually refer to product software. "*Product software is defined as a packaged configuration of software components or a software-based service, with auxiliary materials, which is released for and traded in a specific market*" (Xu & Brinkkemper, 2007). Where software products can be Commercial-Of-The-Shelf (COTS) software, shrink-wrapped software and packaged software, accompanied by commercial services and auxiliary materials like documentation. The final part of the definition emphasizes on the commercial value of the software product.

In their work, Xu and Brinkkemper (2007) make a distinction between software with different purposes. They identified tailor-made software specific for one customer, a micro program as an appliance for one customer, embedded software as an appliance for many customers and finally product software as software for many customers. Relating this to the product portfolio a distinction can and should be made as the amount of time, money and other resources invested in these different purposes can differ significantly. Nevertheless the software is part of the product portfolio and should thus be accounted for.

With this explained we will continue with the literature on PPM. In this theoretical section we will first look at the reference framework for software product management, a software product management maturity matrix, product portfolio management, product lifecycle

management, project portfolio management, new product portfolio management, software product management, strategy development and performance matrixes. This is in accordance with the theory-building study as Dul and Hak (2008) propose, where candidate concepts must be found for a conceptual model of a relative unknown concept like PPM.

3.1 Reference framework for software product management

The starting point for this research is the reference framework for software product management by van de Weerd et al. (2006). The framework, shown in Appendix A, shows that software product management consists of four major process areas and is dependent on a number of parties, both internal and external, like research and development, partner companies, the company board and the customer. The major process areas are portfolio management, product roadmapping, requirements management and release planning. Each of these areas deals with different types of work on artifacts from distinct hierarchy levels. Note that no specific (chronological) order of fulfillment is suggested between these areas.

From the narrow focus in the introduction it is clear that only portfolio management is subject of this research. However since research results we could come across might also apply to the other process areas, a short introduction to these areas will be made. Starting with product roadmapping. "*Roadmapping is a popular metaphor for planning and portraying the use of scientific and technological resources, elements and their structural relationships over a period of time.*" (Vähäniity, Lassenius & Rautiainen, 2002). However, according to Whalen (2007), roadmaps are not just the output of a process, but instead are a snapshot of a 'rolling' strategy at a certain moment in time. Whalen continues and identifies two roles roadmaps play; first they establish links across all business functions to meet prioritized targets and second they offer a palette where alternative strategies, future scenarios and innovative opportunities can be assessed.

Requirements management "*contains the activities of gathering, identifying, revising and organizing incoming requirements from the various stakeholders*" (van de Weerd et al., 2006). This is illustrated in the framework by the input from all external parties to the requirements gathering process. Being short on this subject does not mean that requirements management is simple. As Goldin and Finkelstein (2006) state "*one of the most difficult challenges in requirements engineering is understanding the information provided by the stakeholders so as to establish the requirements*". And of course a balance has to be made up as to what extent finding another requirement is beneficial, which of these requirements are most important and how to keep everything within budget.

Release planning, or software release management as van de Weerd et al (2006) call it, involves decisions on what software is made available to the users and how. In this process requirements are selected, new release definitions are constructed and validated and the product launch is prepared. Different issues arise in the release planning process, for example which method will be used for determining the set of requirement for the next release (i.e. integer linear programming), how to prioritize the product requirements, how to write a release definition and get it validated. Also there are differences between different types of software products. Tailor-made software, for example, does not require release planning to be as formal compared to standard software products (Xu & Brinkkemper, 2007).

Now returning to the main subject portfolio management. According to the definition by van de Weerd et al (2006) portfolio management encompasses the following actions:

- decision making about the set of existing products
- introducing new products
- making decision about the product lifecycle
- establishing partnerships and contracts

which are represented by the main processes:

- Partnering and contracting
- Market trend identification
- Product lifecycle management

Also product line management was added to these processes. "*A software product line is a set of software-intensive systems sharing a common, managed set of features that satisfy the specific needs of a particular market segment or mission and that are developed from a common set of core assets in a prescribed way*." (van de Weerd et al., 2006). Product line management encompasses creating a product line where the initial set of products and markets for the line and the commonalities and variability for products are defined (Käkölä & Dueñas, 2006).

Recent developments with regard to this research has led to a change of the constructed framework (Bekkers et al., 2010). The most influential change in the Software Product Management Competence Model (Appendix B) is, next to a visual makeover, the fact that product line management has been excluded from the major process area of portfolio management. It is still an issue with regard to software product management though, as Savolainen, Bosch, Kuusela and Männistö (2009) state that eventually final products of the product line are a compromise between what is desired and what can be achieved. But it is no longer a main process in the area of portfolio management.

3.2 The software product management maturity matrix

An extension to the newly developed competence model is the software product management maturity matrix. This matrix, a so called focus area maturity model, lists all important activities within the competence model and structures them in a best practice implementation order. Organizations can compare their processes to the capabilities in the maturity matrix and identify the areas that can be (incrementally) improved based on this assessment.

In the matrix for each activity there are two indicators with regard to the maturity. First is the focus area specific maturity level, represented by letters A-F. For each character a specific situation is described with increased maturity when going from A (least mature) to F (most mature). The second maturity indication is a relative indicator, namely a scale from 0 (being the least mature) to 10 (being the most mature). Each of the characters is placed on this ten point scale indicating their relative maturity. Note however that this not mean that F is per definition rated as 10 on the numerical scale. For example in the requirements gathering activity the specific situation F is partner involvement. In this maturity situation the requirements are systematically gathered from partner companies. On the numerical scale this situation is rated as an 8. This indicates that while partner involvement is the most mature specific situation identified as of now, more mature situations for requirements gathering are thinkable of in the (near) future. With regard to portfolio management the last four lines of the matrix (Figure 4) are the most interesting. The lines show the three main processes and their respective maturity situations A to E. Note that for all three processes the maturity situations E have gotten a rating of 10 on the numerical scale. In table 1 the specific situations are mentioned and explained for each main process, all drawn from Bekkers et al. (2010).

Portfolio management										
Market analysis				A		B	C	D		E
Partnering & Contracting					A	B		C	D	E
Product lifecycle management				A	B			C	D	E

Figure 4 - Portfolio management in the software product management maturity matrix

Market analysis	
A	**Market trend identification (mm-ma-a)**
	There is an active search for market opportunities. Market research is carried out in markets related to or similar to the organization's market and conferences are visited. All findings are documented.
B	**Market Strategy (mm-ma-b)**
	A plan is created telling which markets to pursue and which products can be developed.
C	**Customer win/loss analysis (mm-ma-c)**
	A win/loss analysis is performed to research why customers did or did not choose to buy the organization's products. Not only the product features are included but also the sales process is reviewed.
D	**Competitor analysis (mm-ma-d)**
	A competitor analysis is performed to analyze what competitors offer, what they are going to offer and what their strengths are.
E	**Custom market trend identification (mm-ma-e)**
	External parties are used to perform market analysis specific for the current product portfolio.
Partnering & contracting	
A	**Service level agreements (mm-pc-a)**
	Standard service level agreements are set up for customers.
B	**Intellectual property management (mm-pc-b)**
	Measures are in place to protect the intellectual property of the organization and manage the used intellectual property of other organizations.
C	**Investigate distribution channels (mm-pc-c)**
	A process is in place to periodically verify current distribution channels and identify alternatives.
D	**Establish and evaluate pricing model (mm-pc-d)**
	A process is put into place to establish the pricing model and periodically assess whether it still fits the market.
E	**Monitored Partner network (mm-pc-e)**
	A monitored partner network or portals are used to regulate partnering. Key performance indicators are set up to monitor the performance of partners.
Product lifecycle management	
A	**Product lifecycle analysis (mm-plm-a)**
	The current lifecycle phase is determined at least annually for each product. The analysis is based on both financial and technical aspects and information collected from relevant internal stakeholders.
B	**Portfolio innovation (mm-plm-b)**
	A decision process is in place to decide whether or not to incorporate trends in the organization's current and future products.
C	**Portfolio scope analysis (mm-plm-c)**
	A product scope analysis is performed to identify overlaps and gaps between the products in the portfolio.
D	**Business case (mm-plm-d)**
	A business case is performed for major product revisions.
E	**Product lines (mm-plm-e)**

	Product lines are developed where the architecture of the product line is documented and its goal is clearly defined.

Table 1 – Specific portfolio management maturity situations

Comparing this maturity matrix to the IT portfolio management maturity model by Jeffery and Leliveld (2004) we see an overlap. Whilst this maturity model is applied to a different branch and is meant for a different purpose, the model brings an important point to attention. Namely that the more mature the method for portfolio management, the more the business strategy is taken into account in the decision making and the more higher level management is involved. This same point becomes clear in the maturity matrix, going from an action, by Jeffery and Leliveld (2004) defined as ad-hoc, to actions directed towards reaching organizational goals, which is defined as synchronized. In the synchronized situation management teams are actively involved and make use of their ability to align investment portfolios with business strategy.

When agreeing with the proposed maturity matrix and the associated maturity situations, a word of caution should also be noted. Rothaermel, Hitt and Jobe (2006) have examined the law of diminishing returns with regard to management involvement and the product portfolio. The law of diminishing returns holds that increasing a particular aspect can lead to positive results but too much of anything can cause a deterioration in the results. In their research Rothaermel et al. (2006) found that this law holds for vertical integration within the organization and the product portfolio of this organization. This implies that, dependent on the organizational needs, a balance should be found between the maturity of the portfolio management processes and the extent to which management is, and should be, involved in the processes.

The situations of the maturity matrix are the first examples of 'best practice' situations. In this section more top performer characteristics and maturity models will be presented that will be used to create the guidelines. Another use of these however is benchmarking. "*Benchmarking is the process of continuously measuring and comparing one's business processes against comparable processes in leading organizations to obtain information that will help the organization identify and implement improvements*" (Watson, 1993).

Looking at the matrix from a practitioners side, a lot of information is required to be able to perform certain tasks or reach a desired level. An essential part in this regard is the presence of a gatekeeper (Eisenhardt & Martin, 2000) (**t-spmmm-1**). These individuals form the explicit linkage between the organization and (knowledge) sources in the external environment. In the topics to come, it will become clear that the gatekeeper tasks cannot be missed when an organization wants to become more mature.

3.3 Product portfolio management

The term product portfolio management has been brought to attention a number of times. Recall that it has been formally defined as the term used for managing investment decisions over time following profit and risk criteria (Kittlaus & Clough, 2009) and concerns the strategic information gathering and decision making across the entire product portfolio (Bekkers, van de Weerd, Spruit & Brinkkemper, 2011), where criteria could be development costs, likelihood of technical success, profitability, size of potential market and development time.

The term portfolio management was introduced in 1970 by the Boston Consultancy Group and became popular this organization presented the BCG matrix (discussed in the performance matrixes section). Based on Pohl, Böckle and van der Linden (2005) we can say that a product portfolio is "*a set of products and product lines that are offered by a company*". Note that services are left out of this definition, but that services are delivered alongside the organizations' products and usually involve solving implementation and adaption issues. Portfolio management is about choosing which products should be introduced and which should not, which are in line with the organizational strategy and seem profitable and which are not. These decisions are made in a rapidly changing environment with changing information and opportunities, multiple goals and strategic considerations, interdependence among projects and multiple decision-makers and locations (Cooper et al., 2002).

But portfolio management also includes reviewing the current portfolio and deciding on which products should remain in the portfolio, which should be phased out and how the organizational resources should be allocated accordingly. In other word portfolio management is a complicated process which involves many different facets whereby a business's product portfolio is constantly updated and revised and requires dedication to be successful. But does it pay off? Yes it does! This is shown by the case of Unilever in the period between 2000 and 2004 which identified that 90% of the turnover was caused by 25% (400 of 1600) products. Cutting in the other products lead to significant improvement in their processes and results.

From a business perspective, proper PPM and the forthcoming information streams provide in the information requirements of processes and departments. This will become more clear during the course of the theoretical section. Also, proper PPM gives more insight in the monetary streams between departments and provides decision makers with the right information to ensure the right products and projects are pursued.

The interest for portfolio management can be explained very easy. If you get your portfolio management wrong, you can expect serious negative consequences in your total new product efforts (Cooper et al., 2001). According to their research poor portfolio management could possibly lead to the following issues:

- Missing strategic criteria in projects selection, in other words no alignment with the organizational strategy
- Low value projects because of bad go/kill decisions leading to mediocre product in the product pipeline
- Lack of focus because of bad go/kill decisions leading to a too wide spread of the organizations' resources. Or as Jiao, Zhang and Wang (2007) describe, the law of diminishing returns also counts for product variety
- The wrong projects are selected because no formal method is in place and decisions are not based on objective criteria.

Cooper et al. continue by confirming that portfolio management is typically poorly handled in organizations which lead to company management confessing the presence of these issues in the current processes.

PPM has been the subject of ongoing research conducted by Cooper et al (1999; 2001; 2002).In their work of 2001 they identified eight key reasons why portfolio management is important. These are, amongst others, financial reasons, reasons with regard to the competitive position, the alignment with the business strategy and the balance between short and long term projects. Saaksvuori and Immonen (2008) also identify four reasons why portfolio management should be part of an organization, namely:

- To offer a range of complementary/related products and services to better serve your customers
- Spread risks in case a product turns out to be unsuccessful
- To balance across lifecycle phases
- To support decisions on resource allocation

PPM is about balancing conflicting goals that occur when maximizing the financial value of the portfolio, linking the portfolio to strategy, balancing the portfolio on relevant dimensions (like markets, risks, dependencies, product lines and lifecycle phases) and ensuring the total number of ongoing activities is feasible.

A more important aspect in the research of Cooper et al. (2001) are the methods they identify for portfolio management. Note that a portfolio management method is a way in which a portfolio can be assessed. The methods are the following:

- Financial methods including profitability and returns metrics (NPV).
- Business strategy as the basis for allocating resources.
- Bubble diagrams or portfolio maps for categorizing products.
- Scoring models used for rating the products on a number of questions and criteria.
- Check lists for a product where a product needs to get a number questions answered with 'yes'.

They continue their research with a list of six metrics that comprise a good portfolio:

- Aligned with business objectives
- Contains high value projects
- Reflects business strategy
- Makes it possible to do projects on time
- Has a good balance of projects
- Has the right number of projects

Where strategic alignment can only be achieved if the portfolio strategies are properly cascaded down and communicated (Haines, 2009). If not, product managers will misinterpret those directions and fail to connect mission and vision to the manner in which product work is carried out. This is a common problem as "*many companies do not adequately consider the connection between top-level strategy and lower-level execution*" (Haines, 2009).

In more recent work Cooper and Edgett (2008) identified tools that best performers use for portfolio management decision-making, these are:

- Strategic buckets; allocating resources to 'buckets'.
- Product and technology roadmap; map out development initiatives over a period of time.
- Scorecards; qualitative method to select and prioritize the development projects.
- The productivity index; financial tool to maximize the economic value of the portfolio.

Cooper and Kleinschmidt (2007) identify portfolio management and the accompanying resource allocation as one of the four major performance drivers of new product development. On which goal an organization emphasizes will in turn influence the choice of portfolio methods, with the four goals being value maximization, balance, strategic direction and the right number of projects (Cooper et al., 2002).

They conclude their research (1999; 2001; 2002) with three characteristics of the top performers of the organizations in their study. First, top performers score better on all six portfolio metrics but really excel at achieving the right balance of projects and having the right number of projects for the resources available. Second, they state that top performers

have an explicit method in place, with clear rules and procedures, which enjoys management support and is consistently applied. They have a mix of the methods mentioned in place where a clear distinction is observed between average performers focusing more heavily on financial methods and top performers putting the alignment with the business strategy up front. And third, with regard to implementing portfolio management, they state "*just do it!*" (Cooper et al., 2002) as those organizations that do engage in having a systematic portfolio management process outperform the rest.

In his book Haines (2009) also brings PPM to attention. Though in his research PLM and PPM are combined as lifecycle product portfolio management, the concept remains the same; "*…decisions about products should be made within the context of the entire budget for all products within the portfolio*" and "*… the company needs to ensure that the overall corporate portfolio – and each product in that portfolio – are strategically significant for the firm, competitively positioned, and capable of providing the optimal return*" (Haines, 2009). He continues with the five most important messages for PPM:

1. It should be ongoing; analyzed frequently enough.
2. It is multidimensional; many strategic market factors as well as internal factors should be considered.
3. It is multiphased; each product should be considered across the entire life cycle.
4. It should be based on decision-making methodology; working towards best practice.
5. Achieve balance; investments should be balanced to achieve a diverse product portfolio.

When an organization spans multiple business units or divisions a product portfolio review board should be established to lead the way. A product portfolio review board consists of senior business leaders (e.g. sales executive, finance executive, product development executive) that should be "*accountable and responsible to collectively make cross-product and cross-functional decisions*" (Haines, 2009).

The key issues that can be derived with regard to PPM are presented below. These key issues will be presented after each theoretical section and will be used to construct guidelines for PLM implementation further on in this research document. Note that the same codification scheme holds for these key issues as presented at the software product management maturity matrix. For the theoretical section the source is indicated with a ´t´ for theory.

Strategy is the first key issue of this section **(t-ppm-1)**. Notice that in almost each research presented, strategy is the recurring subject. On a higher level strategy should guide decisions on which products to develop and which not on and on lower levels strategy should guide the manner of execution with regard to specific product work. Thus letting strategy shine through the organization is of utmost importance.

The second, and final, key issue of this section is to 'just do it' **(t-ppm-2)**. Reflect on the product portfolio in terms of what a good portfolio compromises, systematically apply portfolio management methods and make use of the right tools to make decisions. PPM is making decisions on the product portfolio and should lead to a portfolio that better fits the organization's strategy.

Making decisions on the product portfolio and all of its aspects, encompasses much more than described in this section. These are all issues bound to subjects related to PPM. All of these issues will be clarified more in depth in the sections to come.

3.4 Product lifecycle management

Intertwined with PPM is PLM. Recall that PLM is "*a business approach integrating people, processes, business systems and information to manage the complete life cycle of a product across enterprises*" (Lee et al., 2007). In other words its managing a (software) product through it complete product lifecycle from its introduction until it is finally phased out. PLM enables the product software companies to make better and faster product decisions (towards the market) as more product information is available to the decision makers, it reduces total cost and enables the reuse of business intelligence (Miller, n.d.).

The word lifecycle implies that there are phases in a products lifetime and that this is a cyclical process. Indeed Rachuri, Subrahmanian, Bouras, Fenves, Foufou and Sriram (2008), Sudarsan et al. (2005) and others confirm that there are phases and explain their research based on these phases. Investigation in this matter resulted in four lifecycles which are shown in Table 2.

Authors	**Lifecycle phases**								
Ameri and Dutta (2005)		Design	Build		Sell		Use		Recycle
Abramovici and Sieg (2002)	Concept development	Product design	Prototyping and testing	Process planning		production	Delivery/ installation	Service	Removal/ disposal
Ming et al. (2005)	Portfolio management	Product design		Process design	Supply	Production	Launch	Service	Recycle
Haines (2009)	Concept	Feasibility	Definition	Development	Launch	Growth	Maturity	Decline	Exit

Table 2 – Lifecycle phases

Combining these phases into one software product lifecycle brings the phases as shown in Figure 5 (based on Saaksvuori and Immonen (2008) and Grieves (2006)). The cycle integrates the phases identified above into the core elements. As the lifecycle phases presented above are not all based on software products, Haines' cycle (2009) complies the most with this figure, with the major difference being that Haines is more detailed in his description. The reason for being more general is because the failing of a product (a possible occurrence) can more easily be described under the 'evolution' element, than under 'growth' and 'maturity'.

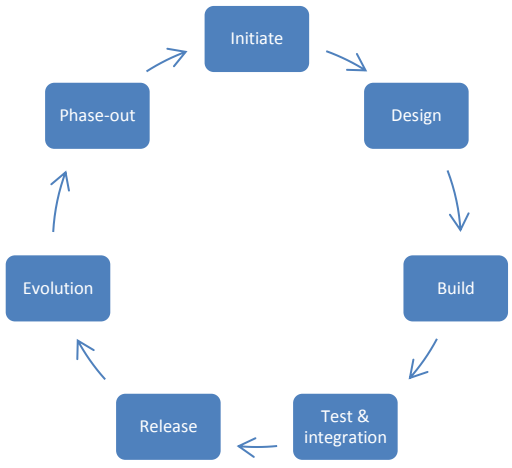

Figure 5 - Software product lifecycle

The initiation phase involves the development of the concept. The design and build phases are consistently found in all lifecycles and thus included. Testing is found in only one lifecycle, however since software is involved testing is an essential phase. Integration is added considering the fact that software might need to be integrated with other software. The release phase complies with the sell and supply phase in the lifecycles. Since software is involved it is officially called a software release.

Also with software products there is room for changing the product after it has been made available to the market (van de Weerd et al., 2005), thus the next logical phase is evolution

with possible changes being made through patches and other updates. In closing the cycle it is common among the lifecycles to indicate a recycle phase. However within software organizations the term recycle is not correct as software is phased out of the product portfolio. Phased out because a software product usually cannot be stopped immediately because a company might have running service contracts. The cyclical nature of the process indicates that (new) products are continuously added as others are phased out.

In the lifecycle phases, Haines (2009) also mentions the phases of the PLM lifecycle from an economical perspective. He identifies the launch, growth, maturity, decline and exit phases. With different terminology, Ameri and dutta (2005) and Ming et al. (2005) also show this perspective by placing them in a curve as shown in Figure 6. The axes are labeled with the incubation, growth, maturity, decline and end of life phases and a negative and positive cash flow, where the blue line actually shows the cash flow over the lifetime of a successful product.

Figure 6 - PLC from an economical perspective

The figure shows that the product initially costs money as it is being developed and is first introduced into the market, but, if all goes correctly, will start to make money after its incubation time. To minimize losses in this period three possibilities are suggested:

1. Lower development costs through engineering efficiency and knowledge re-use.
2. Reduce the cost of late changes in product and process development.
3. Faster product introduction. With possible advantage of being the first provider. Or as Ming et al. (2005) put it, a shorter time-to-market.

When the product has become profitable, the positive cash flow should be maximized. This does not necessarily mean creating a higher peak but also extending the profitable period of the product. Based on the work of Saaksvuori et al. (2008) and Grieves (2006) the following actions are proposed, in chronological order from the growth phase to the end of life phase:

- Improved market and customer requirements fulfillment and greater ability to customize to order
- Rapid innovation and responsiveness to market changes, for example add new variant quickly
- Sustained end-customer value from consistent product quality and performance

After the peak:

- Flexibility to enter new markets and develop mid-life kickers
- Ability to extend business value in the aftermarket
- Create an economy of service (Ming et al., 2005)

Ameri and Dutta (2005) also identify this room for improvement but do not suggest options to actually improve this cash flow. They do identify room for improvement in the learning capacity though, that is brought about by proper lifecycle management.

To date a lot of research into this area focuses on PLM systems and requirements with regard to standards and other technological solutions. But companies still struggle with implementing PLM because, as Batenburg, Helms and Versendaal (2006) state, PLM is a concept rather than a system. "*The core of product lifecycle management is the creation, preservation and storage of information relating to the company's products and activities, in order to ensure the fast, easy and trouble-free finding, refining, distribution and reutilization of the data required for daily operation."* (Saaksvuori & Immonen, 2008). And the "*... main premises are to improve sustainable advantage through agility and innovation.*" (Batenburg et al., 2006).

Implementing PLM boils down to preparing for knowledge management (Ameri & Dutta, 2005). Knowledge management provides frameworks and the infrastructure for knowledge creation, distribution and knowledge-based innovation (Helms, Ahmadi, Jih & Ettkin, 2008). Which is exactly what is required for cross-functional and long-term cooperation between actors in- and outside the firm as explained by Batenburg et al. (2006). To get a common understanding of the information made available by such systems, the organization should undergo a thorough endeavor identifying and defining various features of the business processes (Saaksvuori & Immonen, 2008). This complies with the first stage in their PLM maturity model presented in Table 3 **(t-plm-mm1)**.

PLM maturity model		
1	**Unstructured**	• PLM has been recognized and its importance agreed • Define and develop the PLM concept and standards • No defined approaches • All issues are solved by individuals on a case-by-case basis.
2	**Repeatable but intuitive**	• Similar procedures are followed by different people undertaking the same task • No formal development, training or communication of standard processes • All responsibility is left to individuals • High reliance on individual knowledge and therefore errors occur
3	**Defined**	• Processes and basic concepts are standardized, defined, documented and communicated through manuals and training • All work is completely or partially manual from the process point of view • IT systems support individual parts of processes • PLM processes are not best-of-breed or uniform throughout organization but just formalized
4	**Managed and measurable**	• Possible to monitor and measure compliance between processes • Processes and concepts are under constant improvement including best practices • Partial (limited) process automation • Processes and concepts are clear throughout the organization (uniform)
5	**Optimal**	• Processes and concepts are refined to the level of best practice based on continuous improvement and benchmarking with other

		organizations • IT is used in an integrated manner and the entire process is automated from an end-to-end basis.

Table 3 - PLM maturity model by Saaksvuori and Immonen (2008)

The maturity model shows PLM from an almost ad-hoc basis towards defined processes and IT support finally resulting in an optimal situation with best practices put in to place as well as IT systems able to support the entire process. Comparing this to the framework of Batenburg et al. (2006), we consider the maturity model by Saaksvuori and Immonen as a less useful management aid. Mixing the different organizational aspects does not make clear what areas are lacking behind compared to others and thus what areas require additional resources or attention.

In their framework Batenburg et al. (2006) have also defined a maturity model for PLM as shown in Table 4 **(t-plm-mm2)**. But the framework explicitly takes business dimensions into account as defined by Scheper (2002). The rationale behind this combination can be explained using the term alignment. Alignment holds that "*IT implementations should come along with a careful consideration of business processes and other organizational issues*" (Batenburg et al., 2006). Implementing state of the art IT systems whilst the organization is not able to make use of these systems is a waste of resources. As such IT systems for PLM should be aligned with the other processes regarding PLM, as Scheper (2002) shows, IT is just one of the five business dimensions.

The combined result of the research by Batenburg et al. (2006) is shown in Figure 7 below. Using this framework an organization, or individual business unit, can assess its PLM achievements thus far and efficiently direct resources towards alignment or increased maturity. Alignment can be depicted by drawing a line through the grey level areas the organization is placed in. If the line is a straight vertical one, there is perfect alignment across the business dimension. Note that it is not a necessity to reach the highest level of maturity; instead it should assessed what level best fits the organizational needs.

Ad hoc level	Level 0	• Nobody responsible and no vision for PLM • No consistent processes and supporting systems • Scattered information
Departmental level	Level 1	• PLM is data management on departmental level • No vision to coordinate initiatives • At least information on early phases is stored
Organizational level	Level 2	• PLM is interpreted as business problem requiring corporate vision and integral approach • PLM processes are defined with cross-departmental and PLM systems implemented for support • PLM is integrated with major enterprise system
Inter-organizational level	Level 3	• PLM is a business problem that spans the complete product lifecycle • Supply chain involvement in defining PLM vision • Cross-organizational borders and PLM systems are integrated with suppliers to enable collaboration • All product information stored centrally making the product lifecycle more transparent and enabling proper decision-making

Table 4 - PLM maturity according to Batenburg et al. (2006)

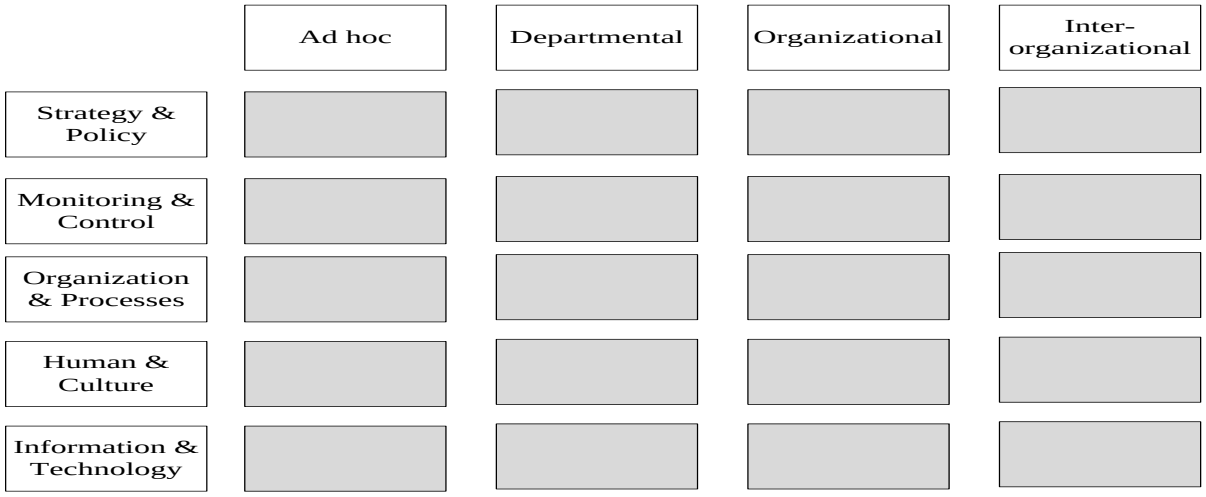

Figure 7 - PLM framework by Batenburg et al. (2006)

Using the frameworks and models presented above the following key issues regarding PLM can be identified. The first key issue **(t-plm-1)** is the acknowledgement of the importance of PLM for the organization. The organization or business unit has to be prepared to implement PLM concept and at least have an understanding of the concept.

A second key issue **(t-plm-2)** is the PLM roadmap. Before a costly and time and resource heavy trajectory is chosen to implement the PLM concept, it should be clear what is required regarding PLM. It should be obvious that small and medium-sized enterprises (SME's) could require a different PLM implementation than big multinationals. A clear vision on PLM should be established throughout the organization. This roadmap should also include the requirements and actions required when cross-departmental and/or inter-organizational PLM is a future ambition.

Third is formalizing PLM processes **(t-plm-3)**, actions and other related issues. To reach alignment as sketched above, the actions should be standardized so each process can be performed by any individual while still giving the same result. One step further is uniformity of the PLM processes between not only the five business dimensions but also across business units, which is defined as a protocol. Formally documenting the processes and associated deliverables ensures the PLM processes are consistently applied throughout the entire organization.

A fourth key issue **(t-plm-4)** is the need for refinement of the PLM concept. Learn by doing, as the probability of implementing the (situational) best practice right from the beginning is zero. Even when the situational best practice has been put into place the entire PLM concept will need to be monitored as different requirements can come up caused by, for example, organizational and environmental (external) changes.

The final key issue is IT **(t-plm-5)**. Throughout all maturity models and frameworks IT is mentioned as having a supportive role and being an enabler of the processes. This is a key issue as the IT system should support the processes put into place, be integrated with current enterprise software, possibly automate one or more parts of the process and in almost all cases requires a significant investment of money and other resources to implement. The most prominent role of the IT system is however making the information available that is required for PLM decision making.

3.5 Project portfolio management

Another important subject related to PPM is project portfolio management (PM). Why is project management important, because "*in uncertain times companies focus even more on effective allocation of scare worldwide resources to their development projects*" (Stantchev, Franke & Discher, 2009). After all the quality of a project is the most influential factor for the product's market success as well as for the customer satisfaction (Mantelli, van de Weerd and Brinkkemper, 2010). With regard to PPM Clarckson and Eckart (2005) state that project management is the basis for portfolio management, as depicted in Figure 8. According to Rajegopal, McGuin and Waller (2007) PM holds that the project portfolio is managed such, that the contribution to the organization is maximized.

Stantchev et al. (2009) define PM as the "*…central management of one or several portfolios in terms of identification, prioritization, authorization, organization, realization and controlling of its associated projects*". Where a portfolio is "*a group of projects that are carried out under the sponsorship and/or management of a particular organization*" (Blichfeldt & Eskerod, 2009). Note that the term project is used freely but is officially defined by Stantchev et al. (2009) as a singular endeavor, explicitly distinguished from each other, governed by a project manager. However the definition does not show what the purpose of the effort is nor what is the goal of the endeavor and thus is considered incomplete. Schwalbe (2009) gives a more thorough definition of a project, namely "*…a project is a temporary endeavor undertaken to create a unique product, service or result*". Schwalbe continues and identifies the following attributes of a project:

- It has a unique purpose
- It is temporary
- It requires resources
- It should have a primary customer or sponsor
- It involves uncertainty

And the following constraints:

- There should be a clear scope
- The project should be finished on time
- The costs of the project should be controlled

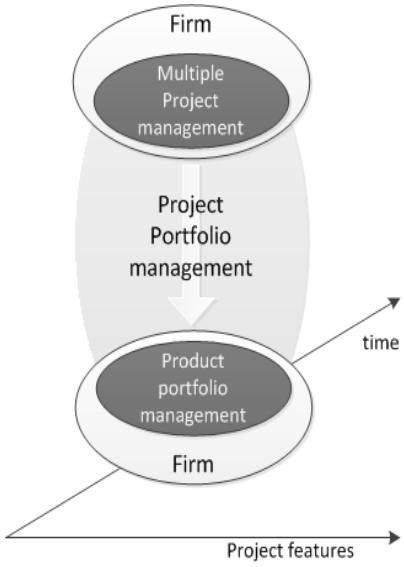

Figure 8 - PM related to PPM

In general, many organizations manage their projects poorly. They lack the decision process for realizing the benefits of a project and project prioritization, as well as an empowered executive teams with the ability to make go/kill/hold/fix decisions in order to balance projects as business investments (Rajegopal et al., 2007). Note that these issues occur on the strategic level of the organization. Schwalbe (2009) identified a clear distinction between tactical and strategic goals. Tactical goals are related to individual project management and encompasses issues such as carrying out the projects right and staying within time and budget. On a strategic level, related to portfolio management, issues arise regarding working on the right projects, investing in the right areas and having the right resources to remain competitive.

An interesting issue arises with this difference. On one hand Rajegopal et al. (2007) identify problems with a bottom-up approach (tactical) whilst on the other hand Blichfeldt et al. (2009) state that problems occur when organizations rely too heavily on the management perspective (strategic). From the bottom-up perspective PM is project centric without further thought on how the project deliverable will tie into the business. Issues like an organization

spending resources on projects that do not fit the organization, leading to a misfit with the organizational strategy could arise. From the management perspective projects could be not completed according to plan, with a lack of overview of ongoing projects and stress as resources are continuously reallocated across projects to make ends meet (Blichfeldt et al., 2009).

PM challenges the narrow tactical focus and draws attention to the broader strategic perspective, but based on the issue above a balance should be found in this focus. Rajegopal et al. (2007) state that it is not enough to just manage the project mix without managing the projects themselves; PM is critical for decision making on ensuring the projects support the organizations business objectives and project management is critical to ensure that budgets, activity and work are accurate and delivered on time. PM importance also shows from the product lifecycle as product projects and product development only absorb resources compared to current products that actually make a positive contribution to the organizational cash flows (Haines, 2009). But each individual project's progress should be evaluated periodically and with each evaluation it should be assessed whether it is still feasible to continue.

Having a PM implementation has a positive impact on the project performance and reduces project related problems (de Reyck, Grushka-Cockayne, Lockett, Calderini, Moura & Sloper, 2005). But how to implement PM. According to Rajegopal et al. (2007) the core components of PM are the following:

- Building a registry; gathering a registry of all projects in the company in a single database. This includes amongst others the name, length, return on investment, business objective and benefit of the project. According to Schwalbe (2009) the software in place should integrate information from multiple projects to show the status of active, approved and future projects across an entire organization.
- Identify strategic objectives; create a list of projects that meet strategic objectives for the upcoming period (for example upcoming year).
- Prioritizing and categorizing; rank projects in terms of importance. Fund the projects closest to the strategy first.
- Manage and review portfolio; actively manage the portfolio by reporting project progress to management office and store process information in the database.

In this section the necessity for balance between a tactical and strategic focus has been mentioned. From a strategic point of view the question is how to choose between the projects that are available. In literature a number of methods have been recognized, presented in Table 5 (Cantamessa, 2005).

Method	Description
Financial	Evaluate projects according to net present value and other relevant cash flows, development and manufacturing costs and revenue (not considering sunk costs). Essential is to discount the cash flow at a rate appropriate to the risk.
Optimization	Using integer linear programming models to represent and solve PM problems. Constraints are added to ensure realism (for example limited resources).
Multi-criteria	Compare projects on a number of criteria (economic value, risk, strategic fit, complexity, etc.). Simplistic models often do not bring the desired results.
Mapping	Visualizing the project portfolio (bubble diagrams). The implicit message here is having a balanced portfolio, but mind that this does not have to be the optimal one.

Table 5 - Project selection methods

The methods show different criteria to take into account when making decisions regarding the project portfolio. These were discovered by case studies at different organizations that had the PM concept implemented. In addition Cantamessa (2005) identified the characteristics of the top performers (so called benchmark business):

1. PM methods are established, explicit, formal and with clear rules
2. PM method is constantly applied
3. PM method considers al projects together
4. Management follows recommendations from PM methods
5. PM is based on financial methods and tools that help evaluate the degree to which projects fit with the firm's strategy

Cantamessa adds to this that organizations using only or mostly financial methods showed the worst results. However, some financial aspects are of critical importance. As Schwalbe (2009) mentions, there is a difference between discretionary and non-discretionary costs in that non-discretionary costs are necessary costs for the company to stay in business.

This section will be concluded with a trajectory for implementing PM based on the work of de Reyck et al. (2005). The trajectory **(t-pm-mm1)** shows implementation in three stages with increasing maturity of the process and contains key elements for project management, Afterwards PM key issues will be presented which can be of influence for PPM.

Stage 1*: *Portfolio inventory

- A centralized project administration
- Risk evaluation procedures
- Explicit incorporation of resource constraints
- Increasing business leaders' accountability for project results

Stage 2*: *Portfolio administration

- Project categorization
- Evaluation of customer impact of the project portfolio results

Stage 3*: *Portfolio optimization

- A project portfolio committee (top executives managing the portfolio)
- Assessment of the financial worth of the portfolio
- Management of project interdependencies
- Tracking project benefits

The PM concept has been explained, however, as to be expected, not every element is applicable to PPM. Still the importance for PPM is apparent through the fact that the projects are essential in deciding which products will be added to the product portfolio. As stated PM is the basis for PPM, so proper PM should be in place to remain successful in PPM. Below the key issues with regard to PM are presented.

The first key issue **(t-pm-1)** is the balance between the strategic and tactical focus with regard to projects. Both are of importance, tactical for properly managing the individual project and strategic for making sure the right projects are realized.

Second is the management of the projects using IT **(t-pm-2)**. The software should integrate information from multiple projects and show the status of active, approved and future projects across an entire organization. Making this information clear and accessible should ease decision-making regarding which projects should or should not be pursued and the status of current projects. A proper IT system can also help in finding the right allocation of the

organizational resources and prevent that more resources are used than are available through resource constraints.

A third key issue is to actually manage the project portfolio **(t-pm-3)**. At some point, most literature discussed earlier brought the role of PM management to the front. One suggests executive teams with the authority to make decisions whilst others suggest establishing a PM committee. Summarizing their suggestions comes down to actively managing the project portfolio. There should be executive teams (including PM manager) with the ability to make go/kill/hold/fix decisions and that should report project statuses to higher level management. Higher management on their account should prioritize and categorize projects in terms of importance, link them to strategic objectives, evaluate the risk associated with projects and select the proper methods for choosing between projects.

The fourth and final key issue **(t-pm-4)** is establishing the methods for PM with clear rules so that it can be consistently applied. These methods should be explicit and formal, to such extent that management also follows the recommendations that stem from these methods.

3.6 New product portfolio management

The area of new product portfolio management (NPPM) is specific for product development. In literature the subjects of PM and NPPM are treated as both separate as well as related subjects. Most literature on NPPM could be related to PM, thus literature on this subject will be treated as a complement of the previous section. A short explanation will be given on NPPM and also for this subject key issues will be identified.

A company engaging in NPPM has to deal with the important problem of allocating the resources between innovation initiatives in a portfolio (Kavadias & Chao, 2007), which complies with what has been stated on the subject of PM. But According to Cooper et al. (2002) NPPM has some unique facets, namely NPPM:

- Deals with future events an opportunities
- Has a dynamic decision environment
- Projects are at different stages of completion
- Resources are limited

According to Kavadias and Chao, these facets make NPPM decision-making one of the most challenging issues in current business. However, one can question the fact that these facets are unique for NPPM. Reflecting on the literature presented above, these facets also hold for PM. Differences could occur comparing services to products however. For example the decision environment for products could significantly differ from that of services.

Continuing with literature, Chao and Kavadias (2007) conclude that NPPM (referred to as new product development (NPD) portfolio management) presents the challenge of allocating resources between different innovative programs where each program might conflict with others in terms of corporate strategy. Looking at best practices for NPPM we come to Cooper and Kleinschmidt (2007) who identified nine critical success factors (CSF's) for product development:

1. A high-quality new product process
2. A defined new product strategy
3. Adequate resources of people and money
4. R&D spending

And five with less impact on performance:

5. High-quality new product project teams
6. Senior management commitment
7. Innovative climate and culture
8. Cross-functional project teams
9. Senior management accountability for results

Taking a closer look at the first CSF's some interesting notions are made. For example simply having a new product process does not drive the performance, rather the quality and nature of the process influenced performance. Thus emphasis is required on constant improvement leading to best practice.

For implementing the NPPM concept we will draw on the work of Stantchev et al. (2009). In their proposed model, shown in Figure 9, they show a project evaluation process including so called 'business services' for each process step. The proposed process is a so called stage-gate process as it has clearly defined stages (phases) that are separated by gates. The gates act as thresholds to measure and guarantee a certain level of quality. A small note that has to be made, is that the models and associated processes are not static by any means. Cooper (2009) has shown that organizations have made the stage-gate system more flexible, adaptive and scalable to better fit the organizational requirements. Thus the model presented can (and should) be adjusted to fit the situation.

The process begins with defining strategic drivers and categorizing projects accordingly. A 'business service' for this is the strategic bucket method which will be explained later in this section. From there on an extensive stage has to be gone through, including research, selection and planning phases, where unprofitable and invaluable projects are rejected early before finally reaching the controlling stage where the running portfolio is actively monitored. Stantchev et al. (2009) state that this is the stage where "*new incoming project proposals compete with active projects for budget and resources*". Optimization takes place in terms of strategic and financial value; current projects with low benefits will most likely be re-prioritized using go/kill/hold/fix decision-making possibly leading to a cancellation of the project. Looking at the CSF's for product development, the proposed model as such can be a valuable starting point for implementing a NPPM process.

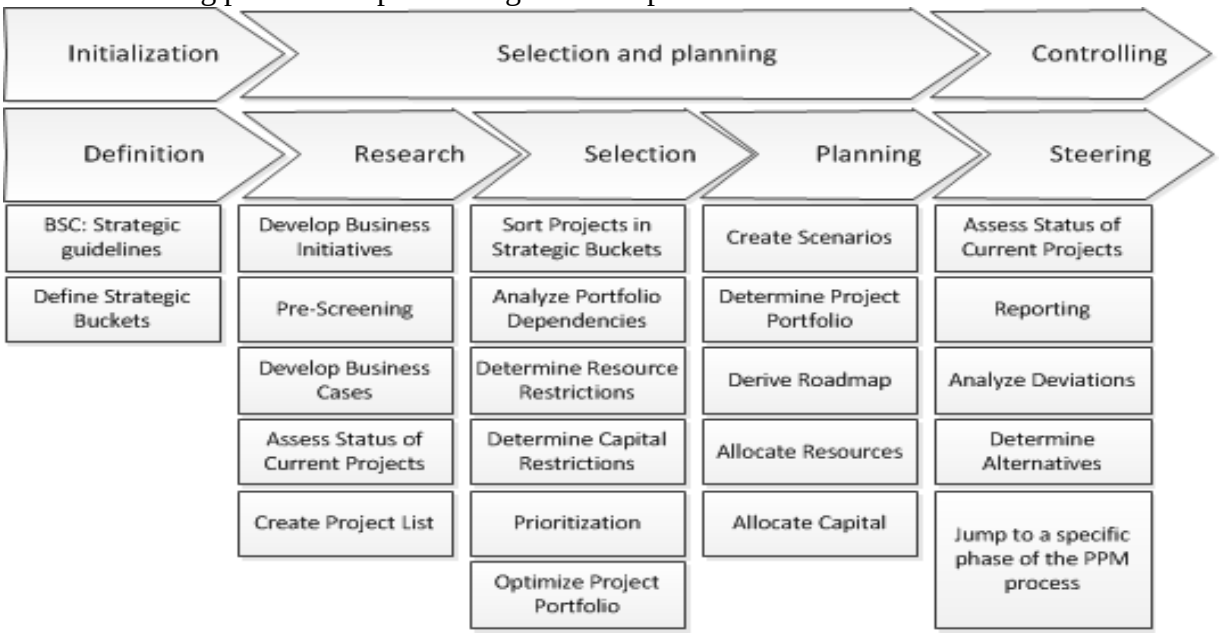

Figure 9 - Proposed PPM process by Stantchev et al. (2009)

The term strategic buckets has been mentioned before. A short side-step will be made towards explaining this concept. Strategic buckets help allocating resources to the right areas and from there on to the right strategic projects. The strategic bucket method "*helps management define where the development dollars should go, by project type, by market, by geography or by product area*" (Cooper & Edgett, 2010). Each bucket, defined as "*a collection of NPD programs that are aligned with a particular innovation strategy*" (Chao & Kavadias, 2008), represents for example a different market or strategic focus and management strategically decides how many resources should go to each bucket.

Within each bucket, projects are ranked and funded until that specific bucket runs out of resources. Using strategic buckets ensures that projects that might appear relatively unattractive at first do get resources. This might seem illogical, but consider for example a situation where a specific project is not highly ranked in monetary terms but is top-ranked in terms of strategic purpose. Valuing this project as part of the entire project collection could lead to resources being directed towards other projects instead of this top-ranked strategic project. Putting this specific project in the bucket for strategic projects, increases the probability that this project does get the funding it requires to be fulfilled. Thus strategic buckets seem a welcome method for resource allocation.

Before summarizing the key issues regarding NPPM, we will take a look at seven principles that Cooper and Edgett (2008) found to maximize productivity with regard to new product development. Where productivity is defined as in equation 1, or simply put 'getting the most bang for your buck'.

$$Equation\ 1: \qquad NPD\ productivity = \frac{Sales\ (or\ Profits) from\ NPD}{R\&D\ Spending}$$

The seven principles are as follows:

1. Customer focused; the customer must be an integral part of the development process.
2. Front-end loaded; get the right front-end homework done, for example the right market and technical assessment.
3. Spiral development; continuously test products with the customer.
4. Holistic approach driven by effective cross-functional teams.
5. Metrics, accountability and continuous improvement; put metrics into place so you can 'measure what you manage'.
6. Focus and effective portfolio management.
7. 'NexGen' stage-gate process; reinvent the NPD process towards organizational best practice.

With this said, the key issues of NPPM will be summarized. Remember that NPPM and PM are closely related, so issues related to PM could also apply to NPPM and vice versa. The two lists with key issues should thus be seen as a complement of each other.

The first key issue **(t-nppm-1)** is explicitly linked to PM in the text, namely the unique facets making (NP)PM decision-making one of the most challenging issues in current business. Management should be aware of this and of all the aspects that are related to their decision-making. Also, as indicated, there could be differences between products and projects that should be taken into account.

Second is the balance between incremental and radical innovation **(t-nppm-2)**, or put otherwise the balance between short-term and long term benefits. Radical innovations bring

about more risks, especially with regards to maintaining a positive future cash flow, where incremental innovations are less risky but in most cases provide relatively small cash flow injections for the short term.

The third key issue **(t-nppm-3)** is a direct complement of the management issue described with regard to PM. In the previous it section was suggested that management should prioritize and categorize projects and link them to strategic objectives. We know now that, amongst others, the strategic bucket method can be used for this purpose. Added to this are the CSF's for product development and the seven principles to maximize productivity. Both are regarded as good starting points for NPPM and are the responsibility of the management to put into practice.

3.7 Software product management

Software product management is the broader concept encompassing all subjects related to managing a product. Ebert (2007) formally defines it as "*the discipline and role, which governs a product (or solution or service) from its inception to the market/customer delivery in order to generate biggest possible value to the business*". While this is an interesting subject to dive in to, since product portfolio management is part of product management (Appendix B), describing this entire concept would be out of the scope of this research. Extensive research has already been done, and still is being done, on this subject (Weerd, Versendaal & Brinkkemper, 2006; van de Weerd et al., 2006; Ebert, 2007). To maintain focus in this section, there is one subject that is particularly useful for PPM and PPM related issues as discussed in this research, namely the role of the product manager and in its explanation we will draw heavily on the work of Ebert (2007) as his research describes best practices.

According to Ebert (2007) "*the product manager holds responsible for product requirements, release definition, product release lifecycles, creating an effective multifunctional product introduction team and … preparing and implementing the business case*", or, put in other words, "*the product manager is a mini CEO representing the enterprise or business unit in strategy definition and operational execution*". A product manager has to balance projects, people and politics and acts as a business owner in setting objectives, but also in achieving them. Schwalbe (2009), supported by Haines (2009), adds to this that a portfolio manager, a function that a product manager will also fulfill, should have strong financial and analytical skills and above all have a deep understanding of how certain projects can contribute to meeting strategic goals. Introducing the role of product manager involves the following actions (Ebert, 2007):

- Define and agree the role in relationship to other functions
- Empower the product managers to own the product in a true business sense.
- Train future managers on the role and its execution
- Emphasize on life-cycle management, negotiation skills, business case and roadmapping as these are typical weaknesses of a product manager.

Compared to a product manager, a project manager 'only' determines how an individual project can be best executed. One might ask why this importance on this particular role within an organization, well, as Ebert (2007) states, "*companies win or fail depending on their product managers*". Ideally product manager, marketing manager and project manager must form a multifunctional core team that is fully accountable for the success of a product. Committing to this team and giving them the right to 'own' the projects is essential.

With regard to best practices for the product manager the following aspects have been identified:

- Define clear goals; only goals that have been identified can be measured and with that the odds of achievement will increase.
- Accountability; commit to agreed milestones, contents and/or quality targets. Linking the project plan to requirements is mandatory.
- Product success; the product success is not about having no delays, but about the trade-off of business needs, project duration, cost and contract commitment.
- Formalize requirements; formalizing requirements on a high level of abstraction helps in identifying reusable aspects of systems at a level independent of any particular solution or component structure.
- Roadmapping; use roadmapping to align requirements to release planning.
- Full portfolio visibility; access and asses all projects continuously and in totality. Independent of the size of the organization costs and benefits, contents and roadmaps, threats, risks and opportunities are evaluated comprehensively in order to implement a coherent strategy.

Looking at the maturity levels in Table 6 **(t-spm-mm1)** by van de Weerd, Versendaal and Brinkkemper (2006), we see that maturity increases going from ad hoc towards formalized processes with continuous improvement. In this explanation you can see the overlap with other PPM processes as these share a similar maturity set up in getting towards best practice. Linking this to the product manager, it is clear that he is the main actor in this reaching higher maturity.

	Associated PM maturity level
Increasing maturity ↑	*Continuous improvement lead by external orientation* Continuous process improvement is enabled by external orientation, e.g. innovative ideas and technologies, customers and partners.
	Organization-wide integration and optimization Detailed measures of the product management process and product quality are collected. Both the product management processes and products are quantitatively understood and controlled from an organization wired perspective.
	Product (line) orientation The different product management processes are standardized, documented and integrated into one standard product management process. Only approved, tailored versions of the organization's standard product management processes are used. The focus is on product level, controlled sequences of releases of product versions.
	Release orientation Basic product management processes are established to track costs, schedule and functionality. The necessary process discipline is in place to repeat earlier successes on similar releases.
	Ad hoc Product management processes are characterized as ad hoc. Few processes are defined and success depends on individual effort.

Table 6 - Product management maturity levels

Before concluding with the key issues of this section, a closer look will be taken into the subject of roadmapping. Recall that roadmapping is part of software product management (Appendix B) and, while not the focus of this research, would be brought to attention if a situation presented itself. Ebert's (2007) view complies with our definition on roadmapping

and he continues by giving best practice for how the product manager should use product roadmapping. The following steps were identified:

- Identify key needs across markets and technologies
- Coin product vision with essential features mapped to releases
- Evaluate requirements depending on customer value, cost structure, complexity in development and maintenance, extendibility and internal lifecycle costs.
- Map major requirements to releases. Describe and maintain a functional roadmap for each product line
- Describe and maintain a more detailed technology roadmap
- Decide and communicate within the entire company which products, platforms, features or even markets are active, which are on their phase-out and for which you have effectively stopped working
- Use an incremental or iterative approach spanning the entire product definition and engineering process
- Set concrete time-to-profit targets for increments and releases

Bekkers et al (2010) go further into the matter of roadmapping by identifying three focus areas; product analysis, core asset roadmapping and product roadmapping. Product analysis is the focus on the technological and societal trends concerning an individual product. Ranging from analyzing a products' strong and weak points, to creating an overview of developments in the market and technology, to including partner developments in the roadmap. Core asset roadmapping concerns the centralized management of components that span a multitude of products. In this focus area the subjects of a identifying these core assets and the make-or-buy decision are important next to a centralized registration. The final focus area is the overall product roadmapping where the short- and long-term plans are portrayed ensuring stakeholder support. In the end creating a variety of roadmaps for external parties.

The list and the focus areas make clear that a roadmap is a useful tool to link product to strategy and give a product manager an overview of the products, their status and the resources assigned to them with the possibility to 'pave' a different road when required.

The key issues of this section are the essential role a product manager plays **(t-spm-1)** in not only a products success, but also in managing the product lifecycle and the product portfolio and the roadmap. The product manager links products to strategy, identifies the most efficient process for developing a product (possibly through re-use), makes sure only profitable product remain in the portfolio, creates and adjusts the roadmap **(t-spm-2)** and helps the entire organization in reaching higher maturity levels with regard to software product management. Thus it is essential that an organization acknowledges this important role and facilitates the product manager to perform the assigned tasks.

3.8 Developing a strategy

The subject of having a clear strategy and linking products to this strategy is a recurring issue in almost all subjects discussed above. According to Chandler (1962) a strategy is "*the determination of the basic long-term goals and objectives of an enterprise, and the adoption of courses of action and the allocation of resources necessary for carrying out these goals*". But what exactly is a good strategy, how to formulate and communicate this strategy and how to ensure the organization keeps being innovative are key questions in this regard. These questions will be addressed in this section based heavily on the work of Cooper and Edgett (2010), which is in accordance with the work of Haines (2009).

Before continuing, two notions have to be made. First, the research presented is not a clear cut plan to create the perfect strategy, but instead these are early directions, a starting point, in developing a strategy. Second the research focuses on product innovation strategy and thus also involves issues concerning how to enter a (new) market. Balancing the portfolio might involve introducing new products, but not all steps might be directly applicable to PPM. In any case, keep in mind that these are directions for developing a strategy where management should decide how this fits with organizational objectives.

The first is step is to define goals and objectives **(t-s-d1)**. Cooper and Edgett (2010) state that strategy "*… begins with the goals for the business's product innovation effort and a clear understanding of how these product innovation goals tie into the broader business goals*". A common issue is that organizations lack these goals or do not communicate them well, leading to a lack of direction with regard to the product to invest in. The key point of formulating these goals is to create a common purpose for everyone involved that shows how a particular product adds in fulfilling the organizational objectives.

Second is to establish a focus with regard to the products and derive a portfolio strategy **(t-s-d2)**. Which strategic areas (e.g. markets and technology) should be taken into consideration and, perhaps more important, which should definitely not. Cooper and Edgett (2010) refer to this as specifying 'strategic arenas'. Of course not every arena is equally attractive, so the next step after identifying these is to evaluate them. The portfolio strategy is to be derived from the overall corporate strategy and should give direction to the future of current products and make clear how the companies' products contribute to realizing the corporate strategy.

The third step is developing a specific strategy for a particular arena (t-s-d3), a so called attack plan. How to enter the market and whether or not to involve a partner (make-or-buy decision) are examples of questions at hand. With regard to PPM this step is less applicable. Indirectly though note that with this a shift is made from strategic to tactical. Recall that this is line with research presented regarding PM where both the portfolio of projects and the individual projects have to be managed. This implies that a strategy should also be applied on tactical level.

Fourth and fifth step are familiar issues; namely allocating organizational resources (t-s-d4) and creating a strategic roadmap (t-s-d5). "Strategy becomes real when you start spending money" (Cooper et al., 2010), but the question is how to spend it. In this regard the subject of strategic buckets has already been explained. With regard to roadmapping, the roadmap is portrayed as an effective way to plot the mayor initiatives on how to get where the organization wants to go. But also this subject has already been discussed.

The key issue of this section is to have a strategic fit between products in the portfolio and the organizational strategy (t-s-1). Not only formulating a nice strategy to tell to others, but also letting the strategy shine through the organization and the product portfolio. Questions concerning how new products fit into the organizations' overall plan and what is in bounds and what is out of bounds with regard to this strategy should be addressed by the portfolio strategy.

3.9 Performance matrixes

The literature discussed thus far has looked at how to manage a portfolio of products and projects. In this final section of the chapter, assessing the current product portfolio will be

discussed. Portfolio analysis holds that the product portfolio is analyzed on predefined dimensions. Most organizations already have a(n) (extensive) product portfolio in place which needs to be assessed in order to understand where the organization is standing right now and what actions need to be taken to get where the organization wants to go. This is where the so called performance matrixes come in.

Performance matrixes, as the name suggests, can be used to assess the performance of specific aspects concerning the organization and, more importantly, can be used to assess the current products in the portfolio. The most famous and influential performance matrixes are the famous BCG matrix (Table 7) and the GE/McKinsey matrix (Figure 10). The basic performance matrix shows two axes, with varying labels, where products are placed accordingly. The term matrix is an indicator of the quadrants that can be identified. Taking the BCG matrix as an example, four quadrants are visible. Each quadrant has a specific name and matching characteristics, based on the axis labels, for the products that are assigned to them. In this section a number of matrixes will be presented.

High **Market growth**	STAR (STRATEGIC)	WILDCAT or PROBLEM CHILD (HIGH POTENTIAL)
Low	CASH COW (KEY OPERATIONAL)	DOG (SUPPORT)
	High Share	**Market Low**

Table 7 - BCG matrix

The BCG matrix is a great starting point for assessing the current portfolio. Using the matrix, questions can be answered concerning the potential of products in the portfolio. An organization can for example find out that a product is in a market with low growth and market share (a 'dog') and decide to pull the plug out of this product. The other extreme is to find a 'star' and take actions to turn this product into a 'cash cow'. An extension of this matrix is to map these quadrants on strategic, high potential, key operational and support products (Ward & Peppard, 2006) as shown between brackets in Table 7.

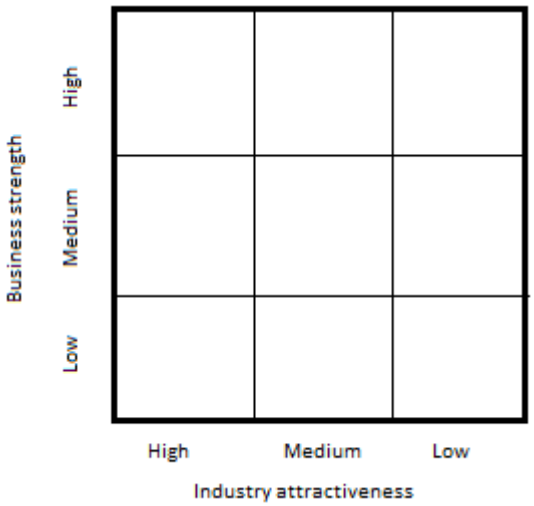

Figure 10 - GE/McKinsey matrix

In the strategic category Ward and Peppard (2006) identify continuous innovation and vertical integration as key concept. Innovate to increase the value added to the business and integrate to make management understand how further enhancements can be made to add more value. In the key operational section the key issues are defensive innovation, only enhance when threats arise, high quality, having significant business contribution, and effective resource utilization where the main issue is to reduce the amount of resources required for maintaining the product. The high potential products' issues are process R&D, minimal integration and cost control to prevent 'over-engineering' in search of the ultimate product, keep them

separated from main activities and staying within budget. And finally the key issues regarding support products being disinvest/rationalize and sustained quality and efficiency. Disinvest to reduce the organizations' commitment to the product and sustain the quality of the system in proportion to the cost of failure and resources involved.

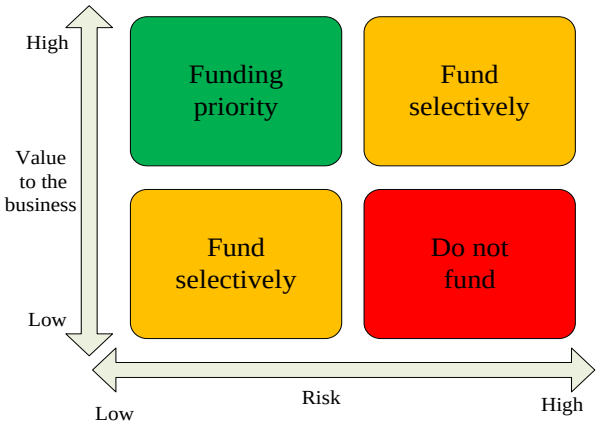

Figure 11 - Visualization example (Jeffery et al., 2004)

The GE/McKinsey matrix can be used to assess the strength of a business unit involved in a particular industry. To this end the labels on the axes are the industry attractiveness (market size, growth rate, opportunities) and the business unit strength (market share, production capacity, profit margins) which can lead to the grow, hold or harvest resource allocation recommendation based on the position in the matrix. Assessing a business unit might not seem directly related to PPM, however the possibility exists that 'weak' products stem from one and the same business unit. Assessing this business unit could lead to changes in strategy and through that changes in the product status.

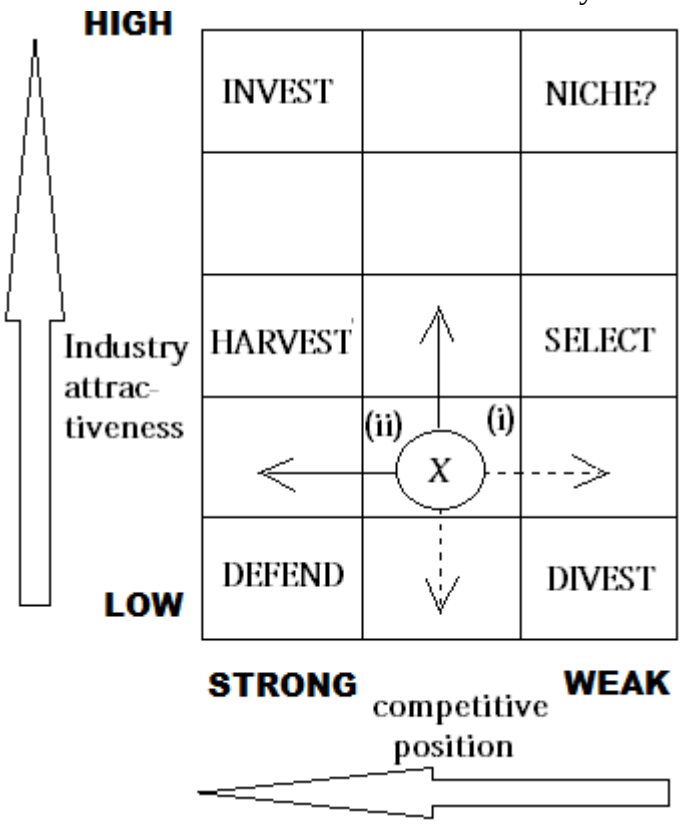

Figure 12 - Policy/portfolio matrix (Ward and Peppard, 2006)

With regard to PM, risk is a more central theme when assessing the portfolio. A project brings about risks which should be outweighed by the benefits of the project. An example is the matrix by Jeffery et al. (2004) in Figure 11 where the risk of a project is weighed against the value to the business, aiding in deciding whether or not to fund a particular project. Other labels for PM could be the time before a project finishes or becomes profitable against the relative amount of resources required and the short- and long-term projects against cash flow forecast. Ward and Peppard (2006) also identify matrixes involving the number of product and the number of customers and the degree of dependence on the product for doing business and its potential to contribute to future business goals.

As can be seen there is a great variety of labels and matrixes that can be created and in this section examples have been given on what can be expected from these matrixes. However, "*the first stage in using any of these matrices is to understand the current position of the business unit or product*" (Ward & Peppard, 2006). To this end, policy matrixes, see Figure

12, come to play. Using these matrixes an organization can decide where to go with a product (line) or business unit. In the figure, for example, (i) indicates a path to develop the industry by innovation, whereas (ii) indicates gaining market share from competitors. Also with this

The overall key issue **(t-pmx-1)** is to find the right axis labels and create various matrixes that can be used to assess the portfolio, processes, projects and even business units to be able to have a clear view on the related aspects for PPM decision-making. As Haines (2009) states "*no one model is perfect*". The 'simple' allocation of a product to a quadrant in a matrix, can give insight in how this product influences the organization and thus gives a sound basis to decide how to handle this product in the future.

3.10 Summary

In this section the theoretic part of the knowledge base for this research has been constructed. Apart from PPM, PLM and PM, the subjects that have been discussed are the following:

- The reference framework for software product management
- The software product management maturity matrix and the recently created competence model
- Strategy and strategy development
- New product portfolio management
- Software product management
- Performance matrixes

With regard to these subjects it can be stated that they are clearly related to PPM in software organization and should be taken into account for implementation. The next chapter will discuss the practical part of the knowledge base by examining the state of affairs at UNIT4.

4 PPM STATE OF AFFAIRS AT UNIT4

The theoretical framework is purely based on findings from literature and have proven useful to get an understanding of PPM and its related subjects. However, theory and practice can differ substantially. Therefore PPM practice has been assessed at UNIT4, a large, multinational software company with a great portfolio of product software. In this chapter a company profile will be sketched, a brief explanation of the contents will be given, the interviewees will be introduced and finally the results will be presented in the form of key issues that will lead to additional guidelines for PPM practice.

4.1 Company profile

UNIT4 is a large software company, with more than 100 products in countries worldwide. Starting in the Netherlands the company in 1980 the company grew to become an NV in 1997 and entered the stock market in 1998. From there on the company rapidly expanded through takeovers of, amongst others, the Norwegian Agresso and became an international player in the software industry. During this period the name was changed to Unit 4 Agresso.

In 2008 the biggest takeover in its history took place when CODA, producer of software for financial management, was added to the organization. UNIT4 is a global business software and services company aimed at helping dynamic public sector, and commercial services organizations to embrace change simply, quickly and cost effectively in a market sector it calls 'Businesses Living IN Change'. UNIT4 incorporates a number of the world's leading change embracing software brands including Agresso Business World, the flagship ERP suite for mid-sized services intensive organizations and Coda, the best-of-class financial management software. In 2010 the company rebranded their organization by changing the name to UNIT4. One identifiable name, for a global player.

The structure of the organization is shown, simplified, in Figure 13. It shows the UNIT4 organization with multiple departments in the Benelux and the through acquisition added (foreign) departments. In the figure the white color indicates that this particular department, business unit or management team has been included in the research. More specifically this means that at least one person from this division has been interviewed.

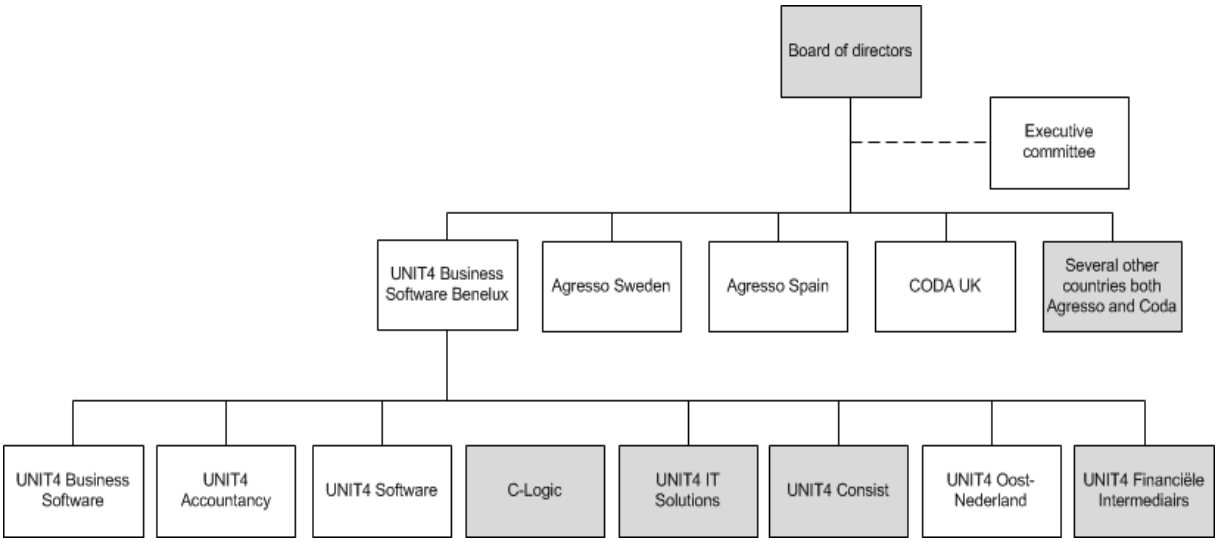

Figure 13 - Organizational structure of UNIT4

4.2 Interview

The protocol for the interview has already been discussed in the research approach and the interview is presented in Appendix C. As can be seen the interview has been structured according to the different subjects of interest brought to attention. These are:

- Strategy, organization and process
- Product portfolio management
- Product lifecycle management
- Project portfolio management

These are the main subjects to gain insight in the managers understanding and opinion on these subjects, in the current practice at UNIT4 and in the points for improvement regarding the (ideal) future situation.

Imbedded in each section are the other subjects like roadmapping, IT systems and the information requirements to ensure the complete set of theories has been discussed. Also, to make sure the interviewees had an understanding of the subject in line with the research, definitions were given of the major subjects brought to attention.

4.3 Interviewees

In total eleven persons were interviewed for this research. To get the best insights into the PPM practice and the best basis for the consultancy report, a mixture of functions, business units and management layers has been chosen. To give an impression, the functions range from product managers, to managing director to vice president product marketing. For most interviews it was possible to arrange a formal meeting, but due for geographical reasons two interviews were conducted via video conference. For this purpose Cisco WebEx software was used.

4.4 Results

The method for processing the interviews has already been explained in the research approach. To recap, these results are placed in the general category, opposed to the specific category, and assigned to the subjects they apply to. Only when an issue was mentioned by at least four of the interviewees or confirms theoretical results with additional information, it is added to the results. The following subjects were brought to attention: the external environment, roadmap, strategy, partnering, requirement prioritization, PLM, process formalization and software product management. These will now be discussed in a manner that summarizes the interview results. Note that the key issues for this section start with ‘iv’ indicating that the interviews are the source.

4.4.1 External environment

With regard to the software products in the portfolio there are several external factors that are of influence. The external environment was mentioned by every interviewee as a major factor to take into consideration. The factors that were mentioned were:

- Rules and legislation **(iv-ee-1)**; as with other products there are rules for software products. Consider accounting software, for example, that has to comply with tax rules and other monetary legislation.
- Market demand **(iv-ee-2)**; in the current environment the core functionality of software is given, but adjustments can be made to tailor the software to the specific

requirements of the customer. If an organization does not comply with such demands, it risks losing the customer.

- Technology **(iv-ee-3)**; technology is perhaps the most important external factor for software products. The organizational need to keep up with the technological environment was mentioned in almost every interview and were critical to make sure the organization does not fall behind compared to its competitors. The following key issues regarding technology were brought to attention:
    - Technological partners; in this specific case the organization wants to be a certified partner of Microsoft. In other words, they have to keep up with technological developments to comply with the rules for this certificate.
    - Deployment; developments like SaaS, virtualization and, more recent, cloud computing bring about a number of different possibilities to bring the software to the customer. No longer installing from a physical disk on each desktop, but delivering an application as a service available through the internet could reduce cost, but requires changes.
    - Improved programming tools; when an organization keeps the 'old' tools and methods in place the efficiency often drops significantly. For example, creating a particular button (with a modern look) could take 5 minutes in older tools compared to 2 clicks in newer ones in which this the new standard.

To make the link between these external influences and the software products more explicit, consider the amount of resources that have to be spent on actually changing along with the environment. Resource management is an important issue in this regard.

4.4.2 Roadmap

The roadmap concept has already been explained in the theoretical section. From the interviews it appeared that the roadmap is indeed a tool to portray an organization's strategy with two purposes. First, seven interviewees stated that using a roadmap an organization can easily communicate its future direction to their customers **(iv-r-1)**. Customers know what to expect and know what the organization will be able to do for them. Second, of those seven, four also stated that a roadmap is useful for internal communication **(iv-r-2)**. Developers often do not know what purpose for their work is; how it contributes to the organization. Using a roadmap developers have insight into how their work contributes to the bigger picture.

This section will be concluded with a list of subjects that came forward as a source of information for constructing the roadmap, these are:

- Competitors; keep up with competitors.
- Market; select the best time for sales and consultancy to add a new product.
- Rules, laws and other legislations.
- Technology; keep up with technology.
- Acquisitions; keep track of the products, knowledge and technology these will add to the organization.
- Customers; maximize customer satisfaction and improve the user experience.

4.4.3 Strategy

The importance of the organizational strategy has been mentioned a number of times before. In the interviews the importance was confirmed, though not acted upon as literature suggests. First to note is the fact that four interviewees mentioned that strategy is implemented on different layers **(iv-s-1)**. On top there is the organizational strategy, then there should be a

strategy on different levels of the organization and, finally, there should be a strategy for each product. Note that this approach covers both the tactical and strategic aspect of handling software products as discussed earlier.

Second are the underlying values an organization adheres to **(iv-s-2)**. Not every aspect of importance is implemented in strategy, but these are certainly important to act upon. For example, five interviewees stated that sustainability does not have to be explicitly mentioned in the strategy, but often is an important underlying value to take into account. These underlying values should be considered as an extension of the strategy and should be reflected in the organizational culture.

4.4.4 Partnering

Though partnering is an important aspect of portfolio management, the biggest concern is about losing control and visibility over the development and the entire process **(iv-p-1)**. Ten interviewees support this statement. But when an opportunity arises, a make-or-buy decision is made to decide whether or not to engage in a partnership. If decided to develop in-house, again it comes down to managing the available resources. Developing one project could slow down another. When decided to outsource the project a suitable partner has to be found. This comes down to having a technological and organizational match with a partner and the future potential of this partner.

4.4.5 Requirements prioritization

An important aspect of managing software products is prioritizing the requirements. A choice has to be made on which requirements to implement first and which bugs or errors, usually stemming from customers, to fix first in the end determining the customer satisfaction of a product. The following list, a summary of all interviewee responses, shows **(iv-rp-1)** how the requirements are prioritized to make ends meet:

- Customer demand; requirements from customers are usually fixed when they are selected from a list, unless specific service contracts are in place that require bugs to be fixed instantly.
- Sales and consultancy timing; upgrading software is a selling point for sales and raises questions from customers at the consultancy department. Thus these upgrades should be done when the resources are available to handle this (temporary) increase in workload.
- Categorization; the requirements are categorized according to the problems they cause. The categories were ‘system down’, ‘mission critical’, ‘major problem’ and ‘problem’ in descending order of priority.

- Theme fixing; the requirements are categorized according to a commonality called a theme. When a theme gets a substantial body, the entire theme gets fixed.

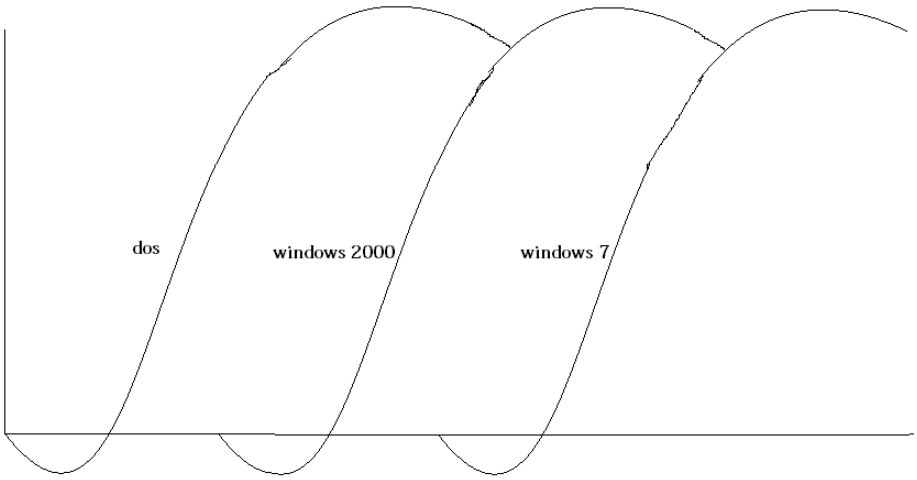

Figure 14 - Parallel development lifecycle

4.4.6 Product lifecycle management

The subject of lifecycle management brought about the same conclusion in every interview; extending the lifecycle is done through technological updates of the software. This could be pressure from external parties, like competitors and customers, or a desire from within to keep up with technology. But, unlike theory, extending the lifecycle in practice is often not keeping a product in the maturity region of the cycle. Instead, seven interviewees noted that there is parallel development **(iv-plm-1)** as shown in Figure 14. The figure shows new, updated versions of the same product being developed and launched while the older ceases to exist. A reason could be that, considering the older technology, it is too costly to extend the lifecycle compared to creating an updated product. When using this method though keep in mind not to spend too much resources on the older version as changes made to this, should also be made in the new version requiring extra resources. Note that this is not a typical end-of-life decision as the product is still continued.

Another difference with theory is on the cost side of the lifecycle. The cycle shows costs are made when developing a product, but nothing on costs after product launch. Five interviewees pointed out that after development still significant costs are incurred **(iv-plm-2)**. Costs for service and consultancy for example. Though they agree with the cycle, there should also be awareness of the other costs that come with managing software products like Haines (2009) suggests.

The final issue on PLM is the end-of-life decision. Ending a product is often phasing the product out where the main issue is to inform customers on time of the decision. As mentioned earlier, external parties also influence this decision. If a product works on the Windows 2000 operating system and Microsoft stops supporting this operating system, seven interviewees mentioned that six months later the support for that specific product stops. An interesting issue arises is when delivering a suite, instead of individual products. For a suite it holds that the whole is greater than the sum of its parts. But too little attention was spent on this subject to actually say something about it.

As external factors are, of course, not the only reason to end a product, this section will be concluded with a list of reasons that were mentioned to this end **(iv-plm-3)**. These are:

- Technically outdated products; this has been explained thoroughly already.
- Statistics; less customers and less turnover could indicate that a product is indeed at the end of its life. When a downward trend is discovered, there should be a decision about when to end a product before it becomes a burden for the organization.
- Lack of resources; this is not the lack of resource in general, but rather the lack of the right resources. Often older products are developed by older employees, and these employees also provide support for these products. However, when these employees leave the organization, a gap is created in the resources available for this specific product.
- Replacements; often with older products there are a number of replacements within reach. It could be that the cost of updating the product is too high, especially when considering that a cheaper solution is within reach.

4.4.7 Process formalization

With regard to formalization of the processes, four pointers **(iv-pf-1)** were given on how to make the process the most effective and efficient. These were:

- Leave room for passion.
- Not too much formalization.
- Not too much higher management involvement.
- Manage the risks as the organization changes the way it works.

During the interviews it became clear that there is a need for formalization, but, as suggested in literature, only to a certain extent. Too much formalization slows the process and too much management involvement could make the process too rigid **(iv-pf-2)**. Every interviewee agreed to with this issue, though also acknowledged the importance of formalizing the processes.

4.4.8 Software product management

On this subject, every interviewee came to the conclusion that software re-use is important for more efficient processes and that a modular approach improves software re-use **(iv-spm-1)**. Modules make it possible to make different products, using the same code.

4.5 Evaluation

This chapter is concluded with an evaluation of the entire interview process. The first comment to make is on the difference between having an actual face-to-face interview compared to a video conference. In the face-to-face situation, the possibility to easily show figures and other information in some cases helped to explain the question. Using video conference software this option was also available, but it felt different and in the end took longer to explain. Put otherwise, the interviews held face-to-face went smoother. Also, listening back to the recordings it became clear that the sound quality differed between the interviews and sometimes dropped significantly during the interviews. Nevertheless using video conference software is a good option when being on geographically different locations as it did provide proper results.

Evaluating the content of the interview, it became clear that making it semi-structured was the right way to go. The questions made the interviewees think about the subjects discussed in the theoretical section and also triggered people to go beyond and discuss their personal experiences within the business unit and their management team. However, this is also where

a remark has to be made. As shown, the interviewees all had different functions on different locations and in different layers of management. This brought about significant differences and lead to different stories; though equally interesting, difficult to compare. This does not mean that the results are not valid, but when comparison of the results is required this should also be a ‘controlled variable’. When comparison is really a key issue, one should ‘screen’ the available persons before adding them as interviewee.

Also giving formal definitions of the subjects that were brought to attention was helpful. This way each person knew what they were asked and could give an appropriate answer. Though every interviewee had a common understanding of the principles, there were differences. For some functions in the business units, a project, for example, meant something else. For some a project was the process of realizing a new product where for others a project was ‘just’ making a component for an existing product. This is not a problem, as each add to the project portfolio, requires resources and thus should be accounted for, but knowing this beforehand could be useful to ask more specific questions on how these specific instances are managed and influence the business unit. Thus an improvement would be to study a particular business unit better beforehand.

All in all, as the results have shown, the interviews provided the right information to construct general guidelines based on PPM practice as well as evaluating the specific PPM practice within UNIT4. Whether or not the results from the case study will be used, in most cases the interview did create awareness around the subject of PPM.

5 SOFTWARE PRODUCT PORTFOLIO MANAGEMENT IMPLEMENTATION MODEL CONSTRUCTION

In this chapter the set of guidelines will be presented. Recall that these guidelines are based on the key issues as presented in the theoretical and state of affairs chapters and linked to the various maturity situations discussed throughout this document. Each guideline is based on a number of key issues. Appendix E shows the list of guidelines and the codes for the key issues that have been used for its construction. A summary of the codes can be found in Appendix D.

The guidelines are structured according to a categorization of the associated subjects. There are strategic processes, these are the subjects of initiation, strategy implementation and gatekeeper introduction. The supporting processes, which are process formalization, information technology and tool construction. And finally the core processes which are PPM, PLM and PM. The category describes the role that subjects fulfills within the entire portfolio management process.

After presenting the guidelines, the implementation model will be presented and explained. This chapter is concluded by presenting a maturity matrix, and the associated capabilities, that are based on the implementation model.

5.1 Guidelines

5.1.1 Strategic processes

The strategic processes are processes that guide an organization in ensuring a strategic fit with predefined strategy, deciding on the implementation process and the acquisition of information. These processes are required to have a successful implementation of PPM and each of the related concepts. In this subsection the guidelines on the subjects of initiation, strategy implementation and gatekeeper introduction are presented.

5.1.1.1 Initiation

	Assess current situation and associated processes
Explanation	Before deciding where an organization wants to go it should be clear where it is right now. What the current state of the processes is, if they provide sufficient information for daily tasks and what restraints can be identified are examples of questions in this regard. When comparing the organization to others, benchmarking could for example give insight into if the competition excels in particular areas, the aspects that are related to this excellence and the areas to focus on to keep ahead. Also a thought should be spent on the product portfolio. The portfolio plan should encompass changes that enable the organization to operate, taking into account the current status of the portfolio and its future strategic direction.

	Choose future position and create implementation trajectory
Explanation	After it is clear where the organization is, it is time to choose where it wants to go. Determine what is required within the organization on the subjects presented in the guidelines. A relatively small organization with few products for example, does not require a full scale IT implementation as the costs could outweigh the benefits. Also concerning the processes a cross-departmental

	implementation might not be the right solution given the current structure of an organization. Assess what is required, construct a list of actions required to reach the desired stage and establish a time frame to do so.

	Commit to trajectory
Explanation	The final guideline is to commit to the created implementation trajectory. Commitment means that the trajectory is taken as a reference each time important decisions are to be made. Thus higher management support is essential, since they should be the ones steering the change process. Especially in the case of cross-departmental processes. Commitment also means that all other stakeholders support the trajectory. Stakeholders can be employees of any kind but since their ´way of working´ is about to change, their support is vital. The finalized portfolio plan should thus be constructed with the input and support of the stakeholders.

5.1.1.2 Strategy implementation

	Define and communicate goals and objectives and establish underlying values
Explanation	The first step in implementing a strategy is to create a common purpose within the organization through (short term) goals and objectives. The common purpose shows how an employees' efforts contributes to the entire organization and could improve involvement and motivation. Also the underlying values should be established to direct the processes when no explicit document, guideline or strategic direction is available Important in this step is to communicate everything clearly.

	Establish focus for each product and strategic area and derive portfolio strategy
Explanation	Apart from the departmental strategic directions, each product should have its own strategy (e.g. defend market share or invest in niche) based on the situation in the market. Going up one level brings the strategic areas to attention. These strategic areas, like specific markets or technologies, require a plan on how to react uniformly from within an organization. Keep in mind that the individual product strategy should be in line with the portfolio strategy, showing how the products contribute to realizing the corporate strategy.

	Create and commit to strategic product roadmap and refine when required
Explanation	In this guideline the focus shifts to a higher strategic level. Using a roadmap the development projects over a longer period of time are laid out and the path for the organization is paved. A product roadmap offers a palette where alternative strategies , future scenarios and innovative opportunities can be assessed and easily communicated to internal and external parties. The strategic product roadmap is the final step in ensuring strategy is implemented in the different layers of the organization. But, an organization needs to commit to the decisions in the roadmap, using it as a guideline when deciding on how to spend money and prioritize organizational objectives. Considering the multitude of influences outside, but also within, the organization, the roadmap

	could be subject to (frequent) change. So when a roadmap is constructed there should not only be commitment by management, but also the possibility to refine when required.

5.1.1.3 Gatekeeper introduction

	Introduce gatekeepers in the organization
Explanation	Gatekeepers are the organizations' connection to the outside environment. Gatekeepers are trend watchers and technology scouts, keep an eye on interesting organizations to engage in partnerships with and keep track of the progresses competitors make. A gatekeeper provides the organization with the required information on developments in the external environment. Note that a gatekeeper does not have to be a newly introduced function, but the tasks can also be added to the tasks of an already externally oriented function within the organization (e.g. marketing). Using this information for the individual product strategies is the first step.

	Include gatekeeper findings in higher management decision-making
Explanation	Going to a more strategic level, the information a gatekeeper provides is important to take into account for realizing a departmental or even organizational strategy, could give useful insights for creating a roadmap and could support overall decision-making where the external environment is involved. With regard to the information that is provided, there should be proper information channels to distribute the findings. This could mean introducing a system for this end, but this is situation specific. The gatekeeper does not have to be a part of the decision process, as long as his findings are clearly communicated and available to those that are.

5.1.2 Supporting processes

The supporting processes are designed to facilitate the organization in creating the required instruments to support all processes related to portfolio management. The subjects are process formalization, tool construction and information technology.

5.1.2.1 Process formalization

	Find a balance between formalization and process efficiency
Explanation	The only guideline for this subject is that whilst formalization is often desired, too much formalization can slow the processes. Each organization, or department, should find a balance between formalizing the processes and the efficiency of the process. This can differ significantly as small teams often do not require (much) formalization, whereas a large number of employees do require a certain structure in their way of working. A first step is to define goals, standardize the actions and define the deliverables making it possible that each process can be performed by different individuals with the same result. Regarding management involvement; management should be aware of the processes, the results that are gained from them and decide whether or not these are satisfying. However, the law of diminishing returns holds for management involvement; too much involvement deteriorates the processes. In the end

	protocols should be in place throughout the organization, which are all the rules and agreements for a certain area of interest and make clear how they work in conjunction.

5.1.2.2 Tool construction

This section covers the tools that can be used to implement the concepts in the organization. Note that some supporting processes actually result in a tool or bring tools along as they get further developed within the organization. The tools themselves are not guidelines since they are used and do not require implementation of any kind. However, as they still need to be constructed and internalized for usage, a general guideline holds for this section and individual explanation on the tools identified in this research is given separately.

	Create, establish and operationalize proper tools for usage within the organization
Explanation	To be clear, the usage of tools should not be forced on each process within an organization. Instead, it should be looked into per situation. Tools are supportive in nature and should thus be treated as additions to the business processes. A tool in the form of a performance matrix, for example, could be used as a means of communicating developments concerning products in the portfolio. Creating tools and facilitating their usage can provide to become useful assessment and communicative extensions.

Performance matrixes

Performance matrixes are tools that can help in evaluating products, processes, the market position and many other facets. For constructing these matrixes the main issue is to properly label the axes. The first thing to make clear is what a matrix should point out and second the right axes should be chosen. Profit margins versus development costs points out something different than market share versus competitive position for example. The third action is to select the proper information to fill the matrix with. Uncertain information, like forecasts, could become a problem when the forecast turns out to be not accurate.

Strategic roadmap

The strategic roadmap is not only the organizational map for high level management, but also serves as a communication tool. First the roadmap can be communicated internally, making clear how the employees contribute to where the organization wants to go. And secondly, the roadmap can be used as an external communication tool showing customers where the organization wants to go and what to expect from future initiatives. Note that the process of creation is part of the strategy implementation process, but that information to internal stakeholders often differs to that what is communicated to the outside.

Benchmarking

The process of benchmarking is difficult to perform. A logical first step is to decide on what aspects the organization should be benchmarked, for example process efficiency, and define what are and are not part of these aspects. Gathering the information required for benchmarking is the most difficult part. Competitors will not willingly show their internal processes and will certainly not show strengths and weaknesses to one another. However, research literature contains a number of case studies comparing performance and practice across an industry, which can be used for this purpose. But whilst there are a number of options, the process of gathering the right information remains difficult and time-consuming.

The next step is to assess the organization based on the relevant subjects for the benchmark. Probably best done by an independent party to prevent biases in the assessment. The results can then be compared with the benchmark database, where differences should be brought to light and discussed whether they are subject to change. The final step is to realize these improvements. Considering the multitude of results possible from the benchmarking process, this action is kept general. Note that the process is iterative. As processes evolve over time, they should be benchmarked on a regular basis to at least ensure the organization is not lacking behind.

5.1.2.3 Information technology

Though IT is essentially a tool within the company, it is discussed separately to stress its importance in the processes.

	Assess current need for IT, implement systems and ensure alignment
Explanation	As often is the case, the first step is to analyze the current situation and implement IT that is able to support the processes. To keep track of information, in the early phases a simple spreadsheet or document could suffice. But often the information stream rapidly becomes too complicated to handle using these tools. Commit to a system able to handle the information needs and train employees to make use of the possibilities it brings. In other words align IT with the processes in place. Keep in mind that this system must have the potential to also be of use in the (near) future. Implementing a different system every time a change has occurred is a costly and inefficient endeavor. Also make sure every individual requiring information has access to it, this also applies to higher level management.

	Partly automate the processes
Explanation	When the information systems in place are sufficient to provide in the information requirements, the next step is to partly automate the process. Analytical tools, for example, could automate the task of finding trends in product information leaving ‘only’ the evaluation of the trend to the decision maker. Or report generators could automate the generation of standard reports for management. By automating parts of the processes, the overall efficiency should increase.

	Integrate with other (major) enterprise systems
Explanation	The final guideline is on integration with the other (major) enterprise systems. As more information becomes available, more automation of the process can be realized and decision makers will in general be better informed. With complete integration not only general portfolio information will become available, but also individual information of specific products. An issue here is to maintain a balance between the amount of information available and the information that is actually presented. In this case a company specific best practice best practice should be realized, this time with regard to IT usage.

5.1.3 Core processes

The core processes are the main processes concerning portfolio management and consist of product portfolio management, product lifecycle management and project portfolio management.

5.1.3.1 Product portfolio management

	Assign product manager and review the current product portfolio
Explanation	Formally assigning a product manager ensures the products are properly handled on a tactical level. A product manager, amongst others, keeps track of all the information regarding a product, links a product to strategy, reports to higher management and manages the requirements and forthcoming releases. This person should be empowered to fulfill these tasks and review the current portfolio. Identify how the products contribute to the portfolio in place, what is the right number of projects given the available resources, if the portfolio reflects business strategy, if the portfolio makes it possible to do projects on time and create a (departmental) roadmap towards portfolio improvement.

	Establish rules and processes with management support and introduce multifunctional core teams
Explanation	The second guideline is on formally establishing rules and processes for maintaining the departmental portfolio while keeping in mind the 'process formalization' process already explained. Requirements management could for example be formally put into place, establishing prioritization methods that fit the department. Also keeping in mind that resources are distributed in line with the constructed roadmap. Considering the fact that a products success also depends on other factors, a multifunctional core team should be established consisting of product manager, marketing manager and project manager that are fully responsible for the success of a product. Higher management support is essential to enable this team to carry out the tasks at hand.

	Analyze external environment and evaluate distribution channels
Explanation	By now the processes in place and the evaluation methods should be sufficient for managing products on departmental level and, depending on the other processes, the organization should have sufficient information available to make informed decisions. With this in place the focus can shift to the external product environment. With activities like trend watching, pricing model assessments and competitor analysis, decisions can be made for each product made that better fit the market. (Note the role a gatekeeper can have in providing this information) Also, if required, the roadmap can be adjusted according to these findings. With regard to the distribution channels, new technological advances can be kept track of and opportunities can be identified (e.g. cloud computing).

	Introduce portfolio review board
Explanation	Often an organization consists of multiple business units and the product portfolio is the sum of what these business units deliver. With a portfolio review board, consisting of high level executives representing the business units, the collective efforts can be managed in terms of cross-product and cross-functional decisions. This brings about more efficient resource management,

	promotes software reuse throughout the organization and paves the road towards software product lines. Also portfolio scope analysis can be performed to identify overlaps and gaps in the portfolio, for respectively collaborative and integration efforts. To amplify the importance to co-evolve, in this case, IT systems, consider the information required for such a board to function properly.

5.1.3.2 Product Lifecycle Management

	Establish PLM vision and create central information storage on at least the early phases of a product
Explanation	The guideline regarding PLM is to implement the PLM concept into the department. Define the PLM concept and develop standards so the principles are clear on departmental level. In this case defining the concept means to define how PLM, and the information that is made available, can add to the current processes. For this end a central storage should be created containing information on at least the development and growth phase of the products, as these are the phases with that are mostly handled internally and are relatively easy to keep track of.

	Make PLM a business wide issue with formalized processes and integrate with major enterprise systems
Explanation	As PLM is essentially about providing information on individual products and activities, the next step is to shift from a departmental focus to a companywide focus establishing a corporate wide vision for PLM. This corporate vision should ensure PLM is structurally taken up and product information is structurally kept track of. A welcome addition to the information base for PLM can be found in the integration with the major enterprise systems also creating cross-departmental opportunities for integration.

	Span the entire lifecycle with central storage of product information and improve the PLM processes
Explanation	This guideline is on making PLM span the entire lifecycle of a product. If applicable the maturity and phase-out phase of each product should be added where the main difficulty is in collecting the right information (in some cases external parties have to be involved that perform market analyses) and deciding on the phase of the lifecycle that it applies to. The premise of spanning the entire lifecycle and learning from decisions made on specific products in their respective phases in the lifecycle could provide a valuable source of inspiration for better management of not only individual products, but also the entire product and project portfolio.

	Integrate the entire supply chain
Explanation	The supply chain shows the path of the products from development to the end customers. Integrating the supply chain in the PLM process makes information available on the impact the product has on the actors in the supply chain and vice versa. Using this information factors like the pricing model for each product can be analyzed as to whether they still fit the market. The lifecycle is more transparent enabling better decision making by each link in the chain;

	each link understands how their actions impact the product and can act upon minimizing consequences for others in the chain.

5.1.3.3 Project portfolio management

	Create a central project administration with incorporation of risks and resource constraints and assign project managers.
Explanation	The first guideline is on building a central project administration. Information like the name, length, return on investment, business objective and the benefits of multiple projects should be stored as well as an indication of the active, approved and future projects across the entire organization. This central administration also gives insight in the risks and resources currently involved in the portfolio. Furthermore project managers should be assigned that are accountable for the project and its results.

	Identify strategic objectives and categorize projects.
Explanation	The guideline is on creating a balanced project portfolio and managing the projects accordingly. Categorize the projects according to strategic objectives and rank the projects by the expected benefits that can be realized. Creating a separate business case of each project for example, could give insight into the financial benefits to be gained from a project. With regard to balancing the portfolio, the categorization of the projects should be accompanied by dedicating resources to each category. This way projects of each category are picked up, fulfilling different business functions, instead of only attractive projects that bring the most short term gains. With this more strategic focus higher management involvement is essential, as they should be aware of the categorization and follow the recommendations coming from it.

	Design processes towards constant monitoring and decision making capability
Explanation	A common issue with PM is that the organization is unable to kill a project after its initiation. As technological projects often take significant time to develop and deploy in the market, there is the possibility that a project (or its result) becomes less interesting during its development. For example because substitute products have become available, technology has become outdated or even because a different projects have become more interesting. The ability to make go/kill/hold/fix decisions at any stage of a project requires that the deliverable of a project is frequently evaluated in the light of the market that it will be deployed in. When done correctly this process makes it possible to manage the available resources better and more quickly and thus significantly improves the PM process.

	Introduce project portfolio committee
Explanation	The previous guidelines focused on the departmental or business unit level, but project portfolio management is also an interesting subject when considered companywide. The project portfolio committee is an committee consisting of project managers that are assigned to keep an eye on project interdependencies and manage cross business unit (or even cross organizational) projects. Not only stimulating partnerships, but also improving the efficiency when it comes

	to software re-use and resource management. Of course such a committee should be empowered to perform their tasks.

5.2 Software product portfolio management implementation model

To summarize and present the guidelines, the software product management implementation model has been created. The model is divided into an overview (Appendix F) and separate process-deliverable diagrams (PDDs) (Appendix G) for each of the nine subjects presented in the overview. Note that in this model that the activities presented with each subject in the PDDs are all drawn from the guideline explanations.

The overview shows all the subjects for which guidelines have been created, but then placed in the context of the organization. As became clear in the theoretical section, different departments are all involved in or influenced by the portfolio management processes. The overview shows an example of the information stemming from the portfolio management processes that is provided to the different departments. Apart from the theoretical angle, these information streams have also been identified from a practitioners' perspective.

Zooming in into the subjects brings the PDDs (Appendix G) to the front. Each PDD presents the actions required for implementing that particular subject in the organization. Following the paths identified in the PDDs, enables a software company to implement the guidelines and establish the deliverables along the way. Note that deliverables, per definition, do not have to be documents or systems but also for example committees and protocols like in the cases of project portfolio management and process formalization.

A number of the deliverables have also been specified in more detail. Taking a look at the 'information requirement definition' deliverable of the 'gatekeeper introduction' PDD, it has been specified what specific information could be required for the gatekeeper to acquire from the external environment. Keep in mind though that this specification is situational and intended as pointer in the right direction. The deliverables that have not been specified, like information technology, are situational to the extent that each organization has to assess for themselves what is actually required. However, each deliverable is described in more detail in the concept definition list in Appendix H.

Three final remarks on the PDDs of the model are on the unordered activities, the iterative nature of the activities and on the actual implementation. First note that a number of activities are not specifically ordered using arrows. This implies that these activities can be performed in no particular order, but still have to be performed before continuing to the next (set of) activities. Second is the absence of the end state in certain PDDs. This implies an iteration in the activities. Refining protocols that have been put into place, for example, is an activity that needs to be repeated as the protocols evolve over time. For this reason the choice was made to omit the end state. And finally, a remark with regard to the implementation of the processes. No order is specified for implementing the subjects of the model. Instead all subjects need to be implemented rather simultaneously as they all depend on one another, mainly in terms of information requirements.

5.3 Maturity matrix

During the construction of the guidelines and the implementation model, it became clear that the increase in maturity, though present, has not been properly brought to attention. Each of the subjects shows a shift from implementation on departmental level to implementation on

organizational level, all the while extending the focus from local product to the entire organizational portfolio. But there is no concrete notion of the increase in maturity.

For this reason a maturity matrix has been created. The matrix contains the subjects[1] presented earlier, again divided into the three process categories, but this time capabilities have been identified for each of these subjects. Each of these capabilities encompass a measurement of maturity and can be used to determine the current situation with regard to each subject and as a reference guide towards the next improvement. The capabilities are based on the deliverables that have been identified in the PDDs of the implementation model. The matrix is presented in table 9.

The maturity matrix follows the same notation as used by Bekkers et al. (2010) and described by van de Weerd (2009). First off, the capabilities are represented using an alphabetical letter ranging from 'A' to 'E' where 'A' is the least mature and 'E' the most. The guidelines are also positioned on a maturity scale from 0 to 10. The capabilities do not have to start in the least mature situation (0), nor have to end in the most mature situation (10). In the case of project portfolio management for example, the matrix suggests that more mature situations could be identified by the placement of capability 'E' on '9'.

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Strategic processes											
Initiation			A		B	C					
Strategy implementation				A			B	C			
Gatekeeper introduction						A	B				
Supporting processes											
Process formalization							A		B		
Tool construction							A				
Information technology					A			B			C
Core processes											
Product portfolio management		A			B	C			D		E
Product lifecycle management		A	B				C				D
Project portfolio management			A		B		C		D	E	

Table 8 - Guideline maturity matrix

The construction of the matrix will be finalized by presenting all the capabilities, along with an explanation and a rationalization of their placement in the matrix. Recall that the capabilities are based on the guidelines and the implementation model. therefore, to prevent repetition, the explanation has been kept short. Note that the decision to construct a maturity matrix has been made after the evaluation as presented in chapter 6. For this reason the revised PDDs are used for identifying the capabilities of the three core subjects (Appendix I).

Initiation

A	***Performed initial assessment***
Explanation	An investigation of the current state of affairs including, amongst others, a business assessment, competitor assessment and portfolio overview.
Placement	This self-assessment is rather straightforward, but gives valuable insights in

[1] Within maturity matrixes these elements are often labeled 'focus areas', but for reasons of consistency the term 'subjects' has been kept intact.

rationale	what is required based on where the organization is right now.

B	***Created implementation trajectory***
Explanation	The results of the initial assessment are transformed into a concrete action plan to take the organization to the next level.
Placement rationale	Not a hard task to perform, but make sure enough granularity is provided in the plan to ensure it can be referred to when issues arise.

C	***Created portfolio plan***
Explanation	Create a document that makes clear what the future direction is regarding the portfolio management process and the products in the portfolio.
Placement rationale	The difficulty is in getting the desired detail and the required commitment to implement it successfully since conflicting goals could come to surface.

Strategy implementation

A	***Established strategic direction***
Explanation	Ensure the most basic implementation of strategy that is lived up to, including short-term goals and objectives and a strategy for individual products and strategic areas.
Placement rationale	This capability is to ensure that even on departmental level some strategic direction is available. Trivial, but often not naturally established in organizations.

B	***Created strategic roadmap***
Explanation	Create a document that is shows the evolution of an organizations' products over time.
Placement rationale	Not a hard task to perform, but make sure enough granularity is provided in the plan to ensure it can be referred to when issues arise.

C	***Created portfolio strategy***
Explanation	Combining the strategic direction and the strategic roadmap into a document describing how the portfolio is to fulfill the corporate strategy.
Placement rationale	Apart from the individual product focus the entire portfolio and its future direction is now taken into account.

Gatekeeper introduction

A	***Defined information requirements***
Explanation	The information that is to be acquired from the external environment is formally defined.
Placement rationale	Formally defining this information requires a proper awareness of the external environment and the influences on the product portfolio.

B	***Created gatekeeper function description***
Explanation	The creation of a document making clear what functions should be performed by a gatekeeper.
Placement rationale	When the external information requirements are significant, the introduction of a separate function is the next step.

Process formalization

A	***Defined processes***
Explanation	Each process is defined in terms of goals, actions and deliverables and can be performed by any individual delivering the same result.
Placement rationale	Defining processes is a difficult task, let alone standardizing them. Formalized processes however, helps in defining the information requirements throughout an organization.

B	***Defined protocols***
Explanation	Uniformity of the processes is established not only within departments, but also across the organization.
Placement rationale	It is a difficult task to create uniformity in processes across departments, business units, or other instances. Especially when these go against the processes already in place.

Tool construction

A	***Established tool collection***
Explanation	There is a collection of tools available for multiple purposes that is operationalized and updated when required.
Placement rationale	Tools are relatively easily created, but operationalizing them with the proper information is often the difficult part.

Information technology

A	***Current systems assessed***
Explanation	The current information systems are evaluated on their ability to provide in information for the daily tasks and the desired ability is defined.
Placement rationale	On lower levels of the organization it is relatively easy to find an IT solution that is able to provide in the information requirements.

B	***Processes are automatized***
Explanation	When information requirements are met, the next step is to identify parts that can be automatized like trend analysis and report generation. More parts are automatized as systems are more aligned and processes are more standardized.
Placement rationale	Clearly defining the results of these processes and the information that is required for getting these results is a difficult task to perform.

C	***Systems are integrated***
Explanation	The information of individual systems is constantly (automatically) integrated with each other to create an extensive knowledge database with all information available within the organization.
Placement rationale	Integration requires a clear definition of the information, how it is to be interpreted and how it can be meaningfully combined and is considered one of the most difficult tasks with regard to information technology.

Product portfolio management

A	***Defined product manager tasks***
Explanation	The tasks of a product manager are formally defined.
Placement rationale	A fairly standard capability for each organization, but essential considering the influence a product manager can have on the success of a product.

B	***Constructed departmental portfolio roadmap***
Explanation	A document is created describing the improvements of the product portfolio over a certain period of time for a certain department within an organization.
Placement rationale	Since the focus is still departmental the capability is considered to be relatively easy to perform.

C	***Established multifunctional core teams***
Explanation	A multifunctional core team is made responsible for the management and thereby the success of a product.
Placement rationale	The combination of knowledge that is realized in such a team offers different perspectives for managing a product. Its implementation is considered fairly simple as it is common practice in some organizations.

D	***External assessment is performed***
Explanation	For the individual products in the portfolio a number of externally oriented aspects are assessed to improve the organizations' ability to tailor products to the markets' needs.
Placement rationale	Acquiring this information is a difficult task to perform, gatekeepers could be helpful in this regard, but also making the right decisions based on this information requires significant attention.

E	***Established portfolio review board***
Explanation	A board is established that is actively managing the entire product and project portfolio of an organization.
Placement rationale	The most mature capability with regard to this subject as it requires a good understanding of the organizational portfolio and the right information to support decisions. Its decisions affect the entire organization.

Product lifecycle management

A	***Defined corporate PLM vision***
Explanation	The role of PLM is defined throughout the organization describing the role of PLM.
Placement rationale	As with all corporate statement, they are on a high level and relatively easy to establish.

B	***Defined departmental PLM vision***
Explanation	A statement is created, derived from the corporate PLM vision, that defines how PLM will contribute to the departmental processes.
Placement rationale	This vision is on lower level and makes clear how individual processes are affected by the PLM principle. A bit more attention is required compared to the corporate vision, considering its direct practical influence.

C	***Established central product information storage***
Explanation	A central system is created where information on the entire lifecycle of each product is stored.
Placement rationale	This is relatively simple to set up, but finding the right information and linking it to the tight lifecycle of a product could prove a difficult task.

D	***Integrated supply chain***
Explanation	Information on the supply chain of each product is added to the central product information storage.
Placement rationale	Establishing this integration requires extensive collaboration with supply chain partners and information on external factors. This is considered to be the most mature situation with regard to PLM.

Project portfolio management

A	***Central project administration established***
Explanation	A central system is created where project information is structurally stored and resource constraints are taken up.
Placement rationale	The introduction of such a system is rather straightforward and, considering the basic information that is to be stored, can be picked up fairly easy.

B	***Business cases created***
Explanation	Projects are structurally transformed into business cases by adding a strategic ranking and risk assessment.
Placement rationale	Transformation requires information on the risks and strategic objectives associated with a project. Also a ranking method should be in place. All in all an easy to realize capability.

C	***Separate portfolios defined***
Explanation	Separate portfolios are defined based in defined criteria and each project/business case is allocated to a different portfolio.
Placement rationale	Defining the criteria for allocating a project is straightforward, a difficulty could be the actual definition of portfolio.

D	***PM processes defined***
Explanation	The processes regarding PM are defined for the purpose of standardization, optimization and constant decision making.
Placement rationale	Defining a process is a difficult task, but when going towards a situation of continuous decisions making is still required.

E	***Corporate PM tasks defined***
Explanation	The tasks concerning PM on corporate level by the portfolio review board are defined
Placement rationale	Managing projects across an organization, realizing collaborations and still ensure projects are realized within time and budget is difficult and the most mature situation that has been identified in this research.

6 EXPERT EVALUATION

In this chapter the constructed model will be evaluated as described in the research method. First a short word on the scope of the evaluation and the questions that were used, followed by an introduction of the experts that participated. Then the results will be presented and the resulting alterations to the model. This section will be concluded by a reflection on the evaluation itself.

6.1 Evaluation scope

The method for the evaluation of the guidelines, the implementation model and maturity matrix has already been explained in the research method. Whilst still a qualitative evaluation, the evaluation will not be performed exactly as stated in that section. This is due to limitations in the availability of experts in this research area and a restraint on the scope of the evaluation. First, finding experts appeared to be more difficult than expected. Especially those than possess enough knowledge on all the aspects concerned in the research and product portfolio management in particular. Out of six experts that were approached, four have replied with an evaluation of the model.

The second restriction of the evaluation is the narrowing of the scope. Presenting the complete list of guidelines and the full implementation model and the maturity matrix to the experts would have brought several difficulties to the evaluation. First, the odds of demotivating (or even preventing) experts from answering the questions increases with the size of the content. Presenting a smaller chunk, would increase the chances of response from the (scarce) experts. Related to this is the number of questions posed to these experts. Too many questions on different topics, not only compromises the quality of the questions but often also of the answers. When focusing on only certain subjects the questions and answers can go into more detail, instead of relatively superficial questions on all the subjects.

For these reasons the choice was made to evaluate only the PDDs of the core processes (PPM, PLM and PM). These PDDs represent the main focus of the research and are thus considered to be the most important aspect for scientific evaluation. Note that only the PDDs are included as these already contain all the actions identified for implementing the subjects and thereby also implicitly represent the constructed guidelines. As explained the decision of constructing a maturity matrix was made after this evaluation was performed. Therefore the matrix has not been evaluated.

6.2 Interview questions

The six questions and sub questions that have been created for this evaluation are presented below. Along with these questions a document will be sent out containing the PDDs on the subjects of PPM, PLM and PM. To ensure the experts are on the same page concerning these terms, the definition of these subjects, as used throughout this research, will also be included.

1. Do you think that the diagrams are complete? If not, what should be added?

2. Do you think that the activities for each subject are in the correct order? If not, please specify.

3. Do you think that it is feasible for organizations to implement the presented activities at that particular moment in the diagram? (For example in figure 3 (PPM); is the organization prepared to incorporate a portfolio review board after following all the previous activities?)

4. Do you feel that there is a clear increase in maturity when you follow the activities of each subject from beginning to end?
    a. If so, are the maturity increments manageable or should more (sub-)activities in between be introduced?
    b. If not, why?
5. What is your general opinion upon seeing the model and the diagrams? (e.g. presentation)

6. Do you have any other comments?

The first two questions are aimed at the completeness and on the suggested order of the activities in the PDDs. These are basic questions to check if all important aspects are taken into consideration and whether the order seems logical. The third question also assesses the order of the activities, but goes more into the details. To be more precise, it assesses whether an organization is properly prepared to perform an activity (for example incorporate a board) based on the preceding activities. The fourth question is also more detailed and asks the experts to give an opinion on the increase in maturity that should be realized. The fifth question is aimed at the presentation of the model. Any other comments can be given as an answers on the sixth question.

6.3 Experts

The experts that were approached for the research are all researchers and/or practitioners in the area of software product management and have sufficient knowledge of portfolio management. Of those that have responded, a short biography will be given explaining their suitability for the evaluation.

6.3.1 Dr. Karl Michael Popp

Dr. Karl Michael Popp works in the corporate development team at SAP AG, one of the largest software companies in the world. In this function, he specializes in analyzing and executing mergers and acquisitions. In this past functions he managed the evaluation and contracts of several dozen OEM and Resell supplier relationships and the continuous improvements in processes for supplier management. His current research interest is on structures of the software industry, especially ecosystems of companies, management of ecosystems and business models for partnerships between software vendors and on mergers and acquisitions. He also researches supply chains in the software in industry as chains of OEM relationships. In addition, Karl continuously researches in the field of business process modeling and linking business process models to application systems for more than twenty years.

6.3.2 Dr. Christof Ebert

Christof Ebert is managing director and partner at Vector Consulting Services. A trusted advisor for companies around the world he has helped numerous companies to optimize technical product development and to manage organizational changes. Prior to that, he held

engineering and management positions for fifteen years in telecommunication, IT and transportation. An internationally renowned keynote speaker, SEI certified CMMI Instructor and steering chair of the IEEE conference series on Global Software Engineering, he authored several books including his most recent book "Global Software Engineering" published in 2010.

6.3.3 Aad 't Hart

Historically Aad 't Hart has a background in mechanical engineering, but moved into IT almost 20 years ago. During his professional career the IT as an industry started to evolve form pushing technology towards adopting market demand. The role of IT is changing and continues to change from automating repetitive transactions and optimizing business processes towards supporting social interactions. This is new in a very engineering driven industry and he is building bridges between business and IT and facilitating a transformation towards user centric design methodologies in strategic software product development. Aad is a serial-entrepreneur who describes himself as an innovator, technology expert, user experience evangelist and social computing enthusiast with specialties in innovation, cloud technology, user centric design and software architecture.

6.3.4 Hans-Bernd Kittlaus

Hans-Bernd Kittlaus is the owner and CEO of InnoTivum Consulting which he founded in 2001. Before he was Director of SIZ GmbH (Computing Center of the German Savings Banks Organization) and Head of Software Product Management and Development units of IBM. He is focussed on the cooperation of business and IT units with both corporate IT organizations and companies in the IT industry. Hans-Bernd Kittlaus has published numerous articles and books (see Publications). He is Diplom-Informatiker (corresponds to M.S. in Computer Science) and certified Practitioner of the Project Management Standard PRINCE2. He is member of ACM (Association for Computing Machinery, USA), GI (Gesellschaft für Informatik, Germany) and ISPMB (International Software Product Management Board).

6.4 Results

The results of the evaluations are presented below. The results are not presented per expert or per question, as not only the questions were answered but also generic comments were given. Instead a summary of the answers, comments and discussions that were obtained as part of the evaluation is presented. In total there are four major remarks on the view of the diagrams, the presentation, the differentiation between PPM and PM and the merging of processes and a number of small remarks.

The first remark is on the view that is taken up in the diagrams. According to all four experts there currently is a mixture of actions on corporate level and on process level. When implementing processes is the aim of the diagrams, the focus should be on setting up the processes in the organization and preparing the organization for these processes instead of individual actions that are part of these processes. And if all three are presented, a clear distinction should be made. Note that this change in view is only applied to the PDDs that are part of the evaluation as these concern processes that explicitly span the entire organization. This is however not a problem considering the supportive function of the other subjects in the model. A corporate level view would most likely inhibit the implementation on business unit, or even departmental, level which could result in deficiencies in providing product information.

Second, with regard to the presentation of the diagrams the experts suggested to differentiate between organizational prerequisites, the process of setting up the organization and processes and the execution of the processes. Considering the remark on the view the activities on the level of execution will not be presented as activities. Instead they are presented as properties of deliverables so an organization better knows what is the purpose of a certain (high-level) deliverable. The other two differentiations however, are not taken up in the diagrams as the order in the activities is appropriate for preventing issues concerning these two categories.

A third remark, made by three experts, is on the subject of project portfolio management in relation to product portfolio management. At first product portfolio management was formally defined as "*... a dynamic decision process, whereby a business's list of active new product (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, Edgett & Kleinschmidt, 2002) and project portfolio management as "*...central management of one or several portfolios in terms of identification, prioritization, authorization, organization, realization and controlling of its associated projects*" (Stantchev et al., 2009). The overlap in these definitions does not make a clear distinction between products and projects and the process for managing them, where a clear distinction should be made.

Also the definition used by Cooper et al. (2002) is limited to products that are the direct result of a project. Therefore the definition has been altered into the term used for managing investment decisions over time following profit and risk criteria (Kittlaus & Clough, 2009) and concerns the strategic information gathering and decision making across the entire product portfolio (Bekkers, van de Weerd, Spruit & Brinkkemper, 2011). With this definition a distinction can be made between PPM, concerning investment decisions and information management, and PM, where the project portfolio is managed to create a unique product, service or result as the organization requires. To make an even further distinction, it was suggested to make a distinction according to "*different 'product' elements, such as IT provisioning, application development, service, hosting, etc.*". But this has not been taken up as this would most likely make the diagrams even more process-centric.

A fourth remark is on merging the processes. It was suggested to merge product and project portfolio management as they both are performed on corporate level, whereas PLM is performed on individual product level. However, as portfolio management has also been explained as an individual process, the choice was made to not completely merge these processes. The merger is made visible in the diagram through the fact that no separate portfolio committee is created, but that the project portfolio in the end is also managed by the portfolio review board. This decision shifts the focus of the diagram for PM towards tactical level, implying that PPM is indeed the main subject of the model.

Another change with regard to portfolio management is the creation of separate portfolios as described by Kittlaus et al. (2009). This makes sense as projects not only refer to new product and product requirements but also services. Also there is a difference in granularity between the projects. New product developments often require a significant effort, whereas there often is a clear cut process in place for handling requirements. So in this case projects concerning requirements are part of a different portfolio than new product ideas and services. The strategic bucket method could then be applied within each portfolio when a further (strategic) division of the resources is required.

Finally, as small remarks one expert argued that the diagrams should have end states and another that first a corporate vision should be established and from there on a departmental vision. On the end stated, even though a number of actions are iterative in nature, there is agreement on the fact that implementing these processes should "*deliver results that are available and valid for some time*". If actions need to iterated the organization should be able to manage to do so, as long as the processes are implemented. With regard to the vision, the expert is correct.

6.5 Alterations to the model

The results brought about a number of changes that had to be made to the diagrams in the model. Again note that these alterations only concern the diagrams that were part of the evaluation (PPM, PLM and PM) and are presented below. The revised diagrams are presented in Appendix I with the updated versions of the concept definition lists.

The alterations for PLM are the following:

- Switched places of the 'establish corporate PLM vision' and 'establish departmental PLM vision' activities
- 'PLM concept definition' property moved to the 'CORPORATE PLM VISION' deliverable
- Renamed 'integrate with major enterprise systems' and 'make information available for processes' activities to 'integrate with departmental en enterprise systems' and 'establish information communication channels'
- Changed the properties of the 'CENTRAL PRODUCT INFORMATION STORAGE' to 'individual product information' and 'supply chain information'
- Renamed 'integrate the supply chain in the process' activity to 'integrate supply chain partners in the PLM process'
- Omitted the 'PARTNER EVALUATION' deliverable
- Created the 'SUPPLY CHAIN INFORMATION' deliverable with 'partner evaluation', 'external factor evaluation' and 'partnering options' properties
- Omitted '(re-)establish processes', 're-evaluate external oriented factors', 'create awareness for partnering possibilities' and 'evaluate supply chain partner impact' activities
- Added end state to the diagram

For the PDD on PPM, the following alterations have been made:

- Integrated the 'define product manager tasks' and 'assign product manager' activities into 'define product manager tasks and assign product managers'
- Omitted 'empower product manager function' activity
- Changed 'evaluate current portfolio' activity to 'perform departmental portfolio evaluation'
- Renamed 'Assign multifunctional core team' to 'Assign multifunctional core teams'
- Omitted 'assign team responsibility for product success' activity
- Combined the 'assess pricing model', 'perform competitor analysis', 'investigate new distribution channels' and 'investigate new deployment methods' activities into the 'perform externally oriented assessment' activity
- Omitted the 'adjust portfolio roadmap' activity
- Combined the 'create product and project overview', 'perform portfolio scope analysis', 'identify possibilities for collaboration' and 'identify product integration options' activities into the 'define portfolio review board tasks' activity
- Added end state

And finally for the PDD on project portfolio management the following alterations are made:

- Added the ‘define separate portfolios’ activity
- Added the ‘portfolio collection’ property to the ‘CENTRAL PROJECT ADMINISTRATION’ deliverable
- Changed ‘involve higher management’ activity to ‘define higher management involvement’
- Omitted the ‘balance projects on relevant aspects’ activity
- Omitted the ‘introduce more frequent evaluation cycles’ activity
- Changed the ‘assign business unit representative’ and ‘establish project portfolio committee’ activities to ‘integrate PM with portfolio review board’
- Omitted the ‘empower committee to actively manage projects across business units’ activity
- Added end state

6.6 Reflection

Given the limited scope and the limitations in time and resources, the evaluation has still proven to be useful for improving the implementation model. Had it not been for these limitations however, the entire model would be part of the evaluation and more experts would have been approached. With regard to the questions it became clear that the intended narrow scope was covered by them, but that the experts often gave more information. In the form of generic comments or discussions more insights were gained into how the PDDs can be improved.

Though positive overall, an inhibiting factor was the usage of email to perform the evaluation. Though answers were obtained, experts themselves often indicated that further discussion of the subject would improve their understanding of the diagrams and thereby improve their feedback. In some cases this was done per email, but that was not an ideal solution. A different setting, with a planned telephone call or video-conference would probably have worked better.

7 CASE STUDY

CASE STUDY REMOVED FOR CONFIDENTIALITY REASONS

8 CONCLUSION, DISCUSSION AND FUTURE RESEARCH

In this chapter the conclusion, discussion and directions for future research are presented. In the conclusion the results of the research will be summarized by answering the research questions posed in chapter 1. In the discussion the limitations of this research and the applied methods will be elaborated upon and finally the opportunities for future research will be presented.

8.1 Conclusion

The conclusion will be drawn by answering the research questions that was posed in the first chapter. Recall that the main research question is as follows:

"How can product portfolio management be implemented in software businesses, such that it is able to support the organization' corporate strategy?"

With this question the related subjects of product lifecycle management and project portfolio management were explicitly added to the research. An initial study into these subjects made clear that there are a number of issues that need to be taken care of in order to successfully implement the processes in an organization. Therefore the answer to this question is to take up a holistic view while implementing product portfolio management, as has been done in the constructed implementation model and maturity matrix. This answer will be explained further by answering the sub-questions below.

Sub-question 1: What is the current state of PPM, PLM and PM applications in literature and at UNIT4?

Right from the beginning it was clear that the PPM, PLM and PM have been the subject of research many times but not so much in the context of software products. Starting from the 'Software Product Management Competence Model', product portfolio management is placed on the top level of the diagram and encompasses market analysis, PLM and partnering and contracting. Within these competences issues like market strategy and trend identification, partner networks and portfolio scope analysis are the subjects of attention. This model also shows that, within a software organization, portfolio management is a process that has to be done in conjunction with product planning, release planning and requirements management.

On the subject of product portfolio management, the current focus is on the strategic information gathering and decision making across the entire product portfolio. Classically PPM was on making investment decisions and this focus remains to date. However, research into the processes at top performers has shown that decisions should be made using a mixture of methods where a heavy focus on the alignment with business strategy appears to deliver the best results. Implementing PPM processes in an organization requires an initial departmental preparation, ensuring products are properly managed on tactical level, while steadily shifting the focus towards a more strategic level for managing the entire organizational portfolio. The process of information gathering is not formally picked up in PPM research, but is often linked to PLM and PM.

The subject of PLM is thoroughly researched in the scientific community. The complete lifecycle of a software product (initiation, design, build, test and integration, release, evolution and phase-out) has been brought into chart and actions have been identified to get the most benefits from a product despite its phase in the lifecycle. Also maturity models have been

constructed with the aim of establishing PLM processes within an organization. These models take the organization from an unstructured situation with scattered information, to data management on departmental and organizational level, all the way to supply chain involvement. The main premise of PLM is to provide in the information on products that is required for daily operation.

PM is also a subject that has been thoroughly researched. PM is about the effective allocation of scarce resources to development efforts and is argued to be the basis of portfolio management. PM is strongly related to PPM and therefore requires the same approach for implementing. First ensuring the match with corporate strategy on departmental level, before continuing to realize the benefits of managing projects across departments. All the while making sure that still the right projects are taken up to be executed and realizing continuous decision making capabilities are implemented. The link with PPM becomes especially apparent as the processes are eventually merged in the implementation model.

The actors in these processes are in all cases the individual product or project manager and, more importantly, higher management. For the actors the same principle holds as for the processes themselves. Individual product and project managers are for the tactical level, whereas higher management should be assigned to manage the portfolios on strategic level. With regard to the different kinds of products and projects the conclusion is that separate portfolios should be defined. As each of these types requires a different approach, they should also be managed accordingly. The process often remains the same, but different priorities are established. For evaluating these portfolios and their performance a number of tools can be used. The ones identified are the strategic roadmap, performance matrixes and benchmarking tools. No definitive set up has been given though, as the main conclusion is that they are situation specific.

Sub-question 2: What guidelines and model can be constructed for PPM, PLM and PM implementation?

The guidelines that have been constructed concern the PPM, PLM and PM processes and six other subjects (initiation, strategy implementation, gatekeeper introduction, tool construction, information technology and process formalization) that have been identified as essential for successful implementation. These guidelines are based on current methods, but improve them in one dimension: the guidelines give a holistic view of all processes. The methods that have been identified in literature and practice are mostly limited to a single subject whereas it was generally agreed upon that all the subjects are interrelated.

Another difficulty in applying the current models in in the fact that whilst these models describe maturity situations, they do not describe how these can be reached. Of course implementation is situation specific, but even general steps are often not part of these models. Therefore the guidelines have been used as input for creating an implementation model. The implementation model includes actions that guide an organization in the process of implementing the guidelines towards more maturity of their portfolio management process. The model consist of strategic processes ensuring the strategic fit and market awareness, supporting processes helping in information availability, assessment and communication and of core processes which are the high level activities for actually implementing the PPM, PLM and PM processes. The subjects in the model are intended for simultaneous implementation, after the initiation process.

From a practical perspective implementation requires a thorough understanding of the organizational processes. The guidelines that are constructed represent how the key issues can be taken care of, but the definitive implementation of a guideline depends on how it fits the organization. Note that the guidelines go on until the most mature situations (that have been identified) are realized, but the organization should assess what level suffices. No method was found on how the assess what is sufficient, but from practice it appeared that in essence the organizational ambitions decide what is sufficient.

Sub-question 3: Are the constructed guidelines, implementation model and maturity matrix valid?

To validate the guidelines and the model an expert evaluation was conducted. However due to resource limitations, concessions had to be made on both the scope of the evaluation as well as the number of experts. In the end four experts were found with enough knowledge in this area to evaluate the implementation model on completeness, maturity increase and ease of implementation. Overall, the models appeared to be complete and also an increase on maturity was acknowledged. On the ease of implementation however, a number of changes had to be made to the model.

The most important changes concerned the point of view of the model and the differentiation between the core processes. At first the point of view in the model was mixed with activities for both establishing as well as executing processes. To facilitate implementation, the model was restructured to only include activities for establishing the processes. On the differentiation between the processes, some elements were redefined and in the end merged to make a more consistent whole. All in all the model should enable software organization to establish more mature portfolio management processes.

Additionally the choice was made to construct a maturity matrix to clearly show the increase in maturity brought about by the implementation model. The capabilities identified for the matrix are based on the deliverables in the PDDs of the implementation model and the final result showed that indeed a maturity increase can be realized. However, there are a number of limitations to this matrix presented in the discussion.

8.2 Discussion

In this section the limitations of this research will be pointed out and the results will be discussed. The issues raised here could not be altered or prevented in this research, but can be taken up as points of examination for research at a later moment in time.

Guidelines, implementation model and maturity matrix

A limitation of this research is on the creation of the guidelines and the implementation model. Firstly, the key issues that have been identified as a source for the guidelines has not been validated. Though the key issues have been carefully identified based on their prominence in scientific literature and business value, it could be the case that key issues were missed or were wrongfully labeled as key issues. A review of these key issues could have identified such errors, which would have improved the quality of the guidelines and the implementation model.

A second limitation is on the evaluation of the maturity matrix. As the maturity matrix was constructed after the evaluation, there were no possibilities left for evaluating this new

artifact. A review of this matrix would help in better defining the capabilities as well as their respective placement in the matrix.

Another limitation is on the models specificity for software products. During literature study the main focus was on portfolio management with regard to software products, but in some cases there was insufficient information available. Therefore it was inevitable to use research results that apply to other disciplines than software. This was somewhat made up for by investigating the state of affairs at an actual software company, but investigating only one organization still limits the specificity of the results.

The final limitation on this subject is the fact that the case study was performed at just one software organization. This organization indeed had portfolio management processes but, also according to their own saying, these processes are not mature enough to effectively manage the entire organizational portfolio. When more (mature) organizations would have been involved, a more thorough practical perspective on portfolio management could have been acquired.

State of affairs

The investigation of the state of affairs at UNIT4 was a useful addition to get a more practical perspective of the portfolio management processes. However, the processes in place are not considered to be best practice in this regard. So investigating more software organizations or organizations with more mature processes, could have given more insight into the key issues from a practical perspective.

Another limitation concerning this subject is on the fact that the results of this investigation were used for both the key issues and for the case study that has been performed at the organization. It was tried to keep the impact of this limitation to a minimum by adopting a different method for processing the results, but still this situation poses limitations on the results. In an ideal situation separate interviews would have been conducted or, even better, independent organizations would have been approached for the two purposes.

Evaluation

Also with regard to the evaluation of the model a number of limitations can be identified. First is the limited amount of experts that were involved. Though qualitative in nature, to properly evaluate a model more experts should have been involved. Ideally also the scope of the interview would not have been narrowed to the core processes of the model. Instead not only the implementation model would have been included, but also the guidelines, concept definition list and even the key issues.

Another limitation is the fact that the evaluations have been performed through email. Even though answers were obtained, in a face to face setting more information could be acquired through posing follow-up questions and discussions. Even planned telephone or video calls would have brought this possibility and should have been done considering the possible added value to the information that was obtained.

Another kind of evaluation of the model was done via the case study. In this case study the model was mapped to the processes at UNIT4 in order to improve their portfolio management capabilities. In essence this is the only correct way to ensure the model has practical value in that it is actually implementable within software organizations. If possible, more case studies

should be performed, at organizations of different size, to verify whether the model is indeed generic enough to be applied to a variety of organizations.

8.3 Future research

In the conclusion and discussion sections a number of issues have already been presented for future research. But also the work that has been done in this research and the findings that result from it offer ground for further research. In this section these options will be presented.

First of all, further research can be conducted into the processes of top performers to get a more clear picture of the state of affairs. This information enables to get more key issues on the practical side of portfolio management and get a more complete view of actually implementing portfolio management within software organizations.

Secondly, research should be conducted on the PPM an PM processes on higher level and their possible integration. Both subjects have often been researched individually but on higher level, especially with regard to implementation, the differences are often not clear anymore. Integration has been suggested in this research, but research should be done to actually confirm this integrative effort and to describe the influence it has on the actual processes.

A third pointer for future research is the validation of the implementation model via case study. When agreed upon its completeness and possibilities for implementation, is should be validated as to whether its practical contribution can be realized. This will also show whether the model can be implemented at any organization, despite its size, structure and portfolio composition, or that the model is too situational to serve a broad audience.

A fourth area for future research is on the nine subjects that are part of the model. Each subject has been researched and has been described in relation to portfolio management. However, research on each of the subjects could still bring additions to the model or different view on the subjects role. With regard to tools for example, three tools have been covered but even more can be identified and practically integrated into the portfolio management processes. In this light one could even argue on the inclusion of even more subjects into the model.

A final subject for future research is the constructed maturity matrix. Though the chain of evidence has been kept intact, the lack of evaluation of this matrix is considered a serious limitation to its validity. To strengthen the chain it should be validated whether the correct capabilities have been identified, whether they are complete, where they are placed on the matrix and if their maturity ratings are correct.

All in all we hope to have contributed to the knowledge on and practical value of product portfolio management, project portfolio management and product lifecycle management and their role in realizing organizational strategy, and encourage the scientific community to keep enriching this area of interest.

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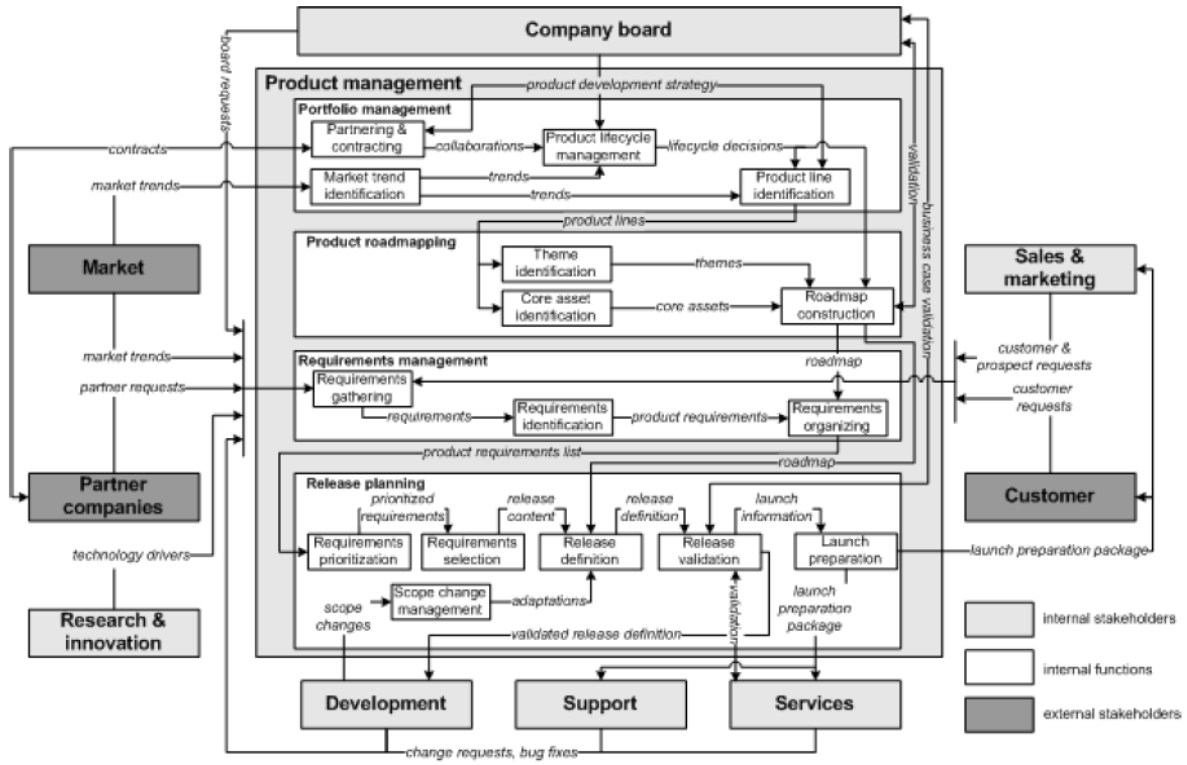
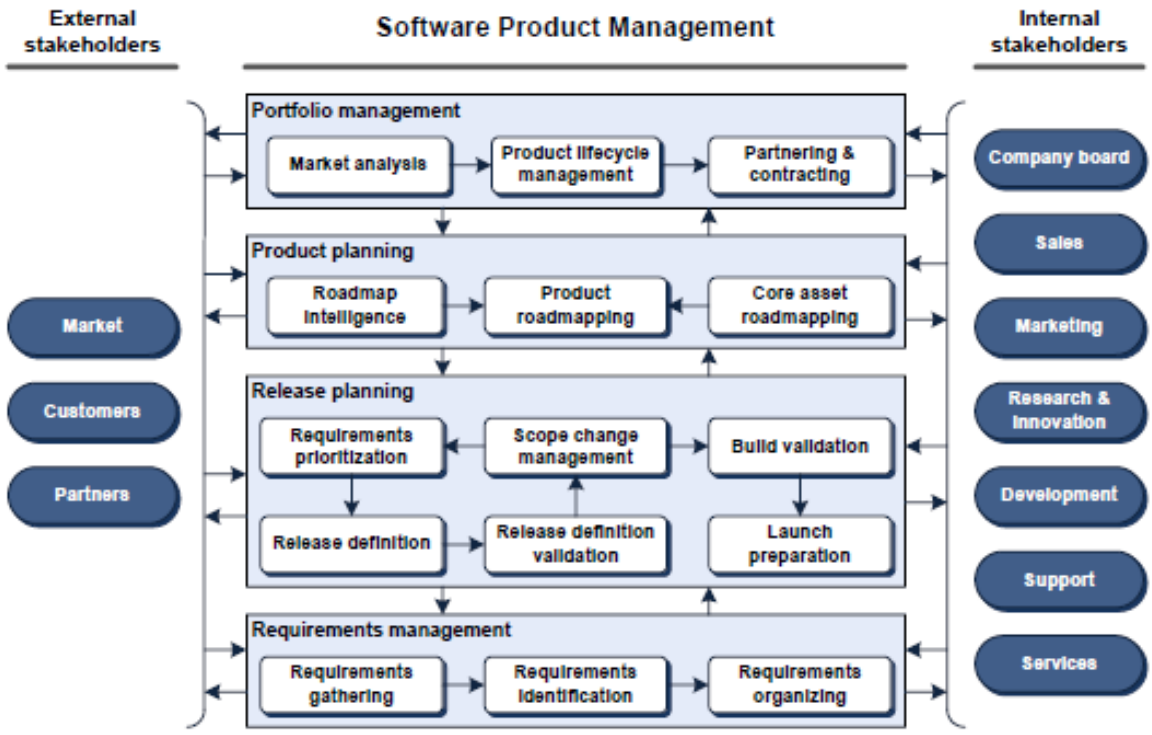
Appendix A: Reference framework for software product management



Appendix B: The Software Product Management Competence Model



Appendix C: Interview

Strategy, Organization and Process

- What do you understand under PRODUCT portfolio management?
- What do you understand under PROJECT portfolio management?

Product portfolio management = a dynamic decision process, whereby a business's list of active new product (and R&D) projects is constantly updated and revised. In this process, new projects are evaluated, selected, and prioritized; existing projects may be accelerated, killed, or de-prioritized; and resources are allocated and reallocated to the active projects.

Project portfolio management = the central management of portfolio(s) in terms of identification, prioritization, authorization, organization, realization and controlling of its associated projects" where a portfolio is a "clearly marked of collection of associated projects.

- Can you describe your role as product manager? What are your tasks?
- Who are involved in both PRODUCT and PROJECT portfolio management process and what roles do they fulfill?
    - How is the/your management involved in this process? (supportive, controlling)
- Can you give a short description of strategy in your organization / business unit?
- What tools (software etc.) are in place for portfolio management?
- Do you use a product roadmaps for managing the products in the portfolio?
    - How do you construct and use these roadmaps?

Roadmapping = a popular metaphor for planning and portraying the use of scientific and technological resources, elements and their structural relationships over a period of time. But roadmaps are not just the output of a process, instead they are a snapshot of a 'rolling' strategy at a certain moment in time.

Product portfolio evaluation

- What do you think of the products in the current PRODUCT portfolio considering the organizational (or business unit) strategy?
    - Do you believe that the current product portfolio fulfills this strategy?
    - Is there room for improvement? (where)
    - Do you change the process based on earlier findings? (towards best practice)
- How do you evaluate the current PRODUCT portfolio?
    - What performance matrixes do you use? (e.g. BCG)
    - What triggers are there for particular decisions? (e.g. stop a product)
    - Is your product portfolio evaluated on a continuous base or periodical?

    - Alignment with business objectives?
    - Does it have the right balance? (e.g. right number, high value projects)

- What external factors influence the portfolio management process in your organization?
    - What external parties?
    - What events / occurrences?

- How do you assess the need for new products?

- How do you make decisions on the need for a new version of a specific product?

- How does the corporate/business unit strategy influence this decision? (e.g. does it give guidance and if so, what level of guidance?)

- What information do you use for making decisions on the product portfolio?

    - What are key indicators to take action?
    - Do you use different indicators for new products/modules vs End-of-Life decisions? If so, what are the differences?
    - What information do you present to convince management of your decisions?
    - What is the influence of the strategy?
    - How long does it take to gather this information?

- From you own experience, what do you want to change in the current situation?

Lifecycle management

- How do you go about product lifecycle management?
    - Can you describe the current process?
    - What are the key areas?
    - What is the sort of information you are looking for?
    - How do you use the information you find?
    - How is IT used in this process?

- What are areas for improvement regarding product lifecycle management?

Project portfolio management

- According to what criteria will a project be assessed for inclusion in the portfolio?

- How do you make project portfolio decisions?
    - What methods do you use to make decisions on resource allocation?
    - What is balance in your opinion?
    - How do you keep or create balance?
    - Do you make use of project roadmaps and how do you construct these?

- Do you use product roadmaps of existing products when managing the project portfolio?
    - How do you adjust current product roadmaps based on the project portfolio?
- From you own experience, what do you want to change in the current situation?

Appendix D: Coding scheme

CODE	EXPLANATION
mm-ma-a	Market trend identification.
mm-ma-b	Market strategy
mm-ma-c	Customer win/loss analysis
mm-ma-d	Competitor analysis
mm-ma-e	Custom market trend identification
mm-pc-a	Service level agreements
mm-pc-b	Intellectual property management
mm-pc-c	Investigate distribution channels
mm-pc-d	Establish and evaluate pricing model
mm-pc-e	Monitored partner network
mm-plm-a	Product lifecycle analysis
mm-plm-b	Portfolio innovation
mm-plm-c	Portfolio scope analysis
mm-plm-d	Business case
mm-plm-e	Product lines
t-spmmm-1	Gatekeeper importance
t-ppm-1	Strategy is a recurring subject
t-ppm-2	Just do it
t-plm-mm1	Saaksvuori and Immonen's (2008) PLM maturity model
t-plm-mm2	Batenburg et al.'s (2006) PLM maturity model
t-plm-1	Acknowledge PLM importance
t-plm-2	Create PLM roadmap
t-plm-3	Formalize PLM processes
t-plm-4	Need for refinement of PLM processes
t-plm-5	Proper IT for support
t-pm-mm1	De Reyck et al.'s (2005) implementation trajectory
t-pm-1	Balance between tactical and strategic focus
t-pm-2	Project management using proper IT
t-pm-3	Be able to manage the project portfolio using go/kill/hold/fix decisions and management involvement
t-pm-4	Establish clear methods
t-nppm-1	Unique facets for NPPM
t-nppm-2	Balance incremental and radical innovation
t-nppm-3	Link projects to strategic objectives
t-spm-mm1	Maturity table by van de Weerd et al. (2006)
t-spm-1	The essential role of the product manager
t-spm-2	The importance of the roadmap
t-s-d1	Define goals and objectives
t-s-d2	Establish product focus and portfolio strategy
t-s-d3	Develop strategy for particular arena
t-s-d4	Allocate resources properly
t-s-d5	Create strategic roadmap
t-s-1	Create a match between products and strategy
t-pmx-1	Find the matrixes that fit the organizational information needs
iv-ee-1	Rules and legislation influence

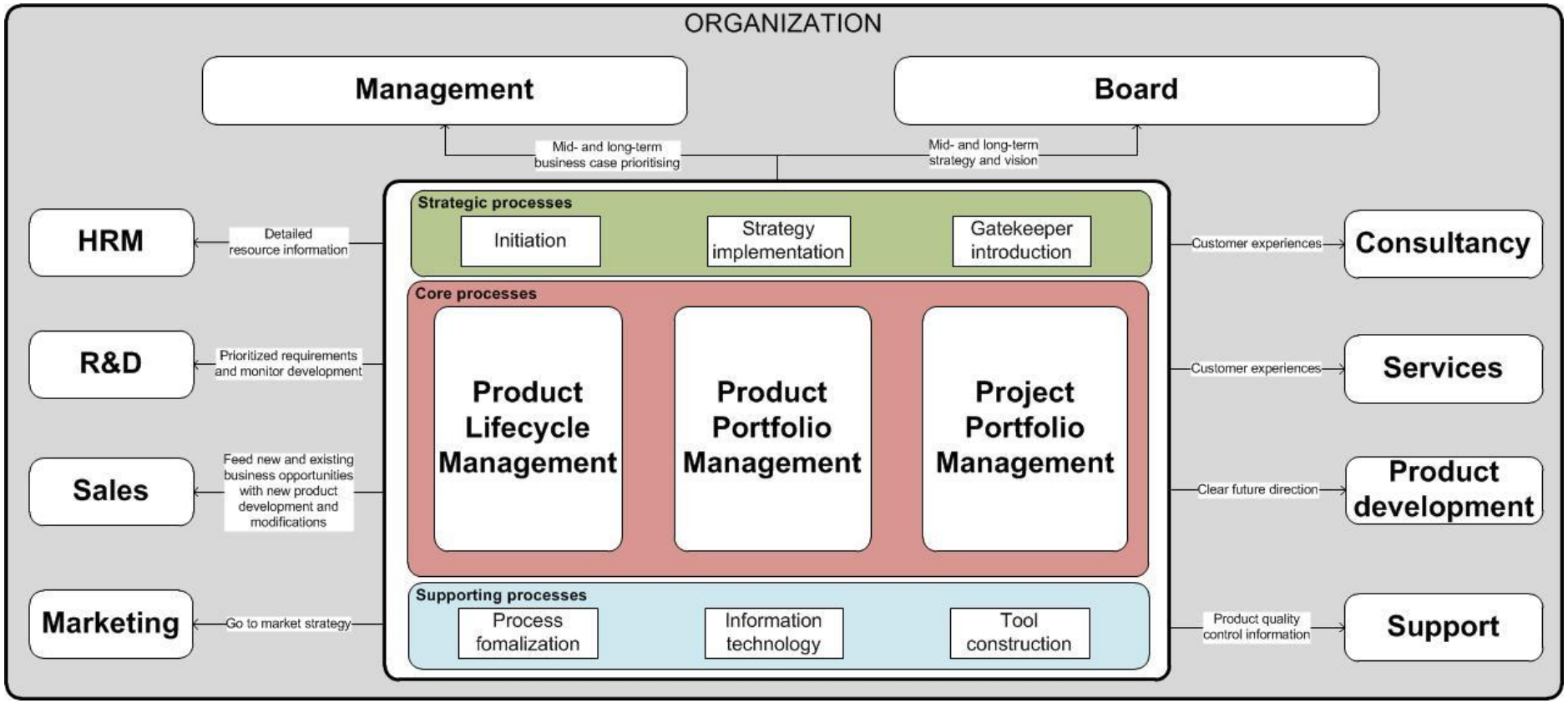
iv-ee-2	Market demand influence
iv-ee-3	Technological influence
iv-r-1	Roadmap for external communication
iv-r-2	Roadmap for internal communication
iv-s-1	Implement strategy in different layers
iv-s-2	Take underlying values into consideration
iv-p-1	Partnering leads to less control and visibility
iv-rp-1	How to prioritize requirements
iv-plm-1	Parallel development
iv-plm-2	Be aware of costs after development and launch
iv-plm-3	Reasons to end a product
iv-pf-1	Don't formalize too much
iv-pf-2	Balance management involvement
iv-spm-1	Promote software re-use

Appendix E: Guideline source reference list

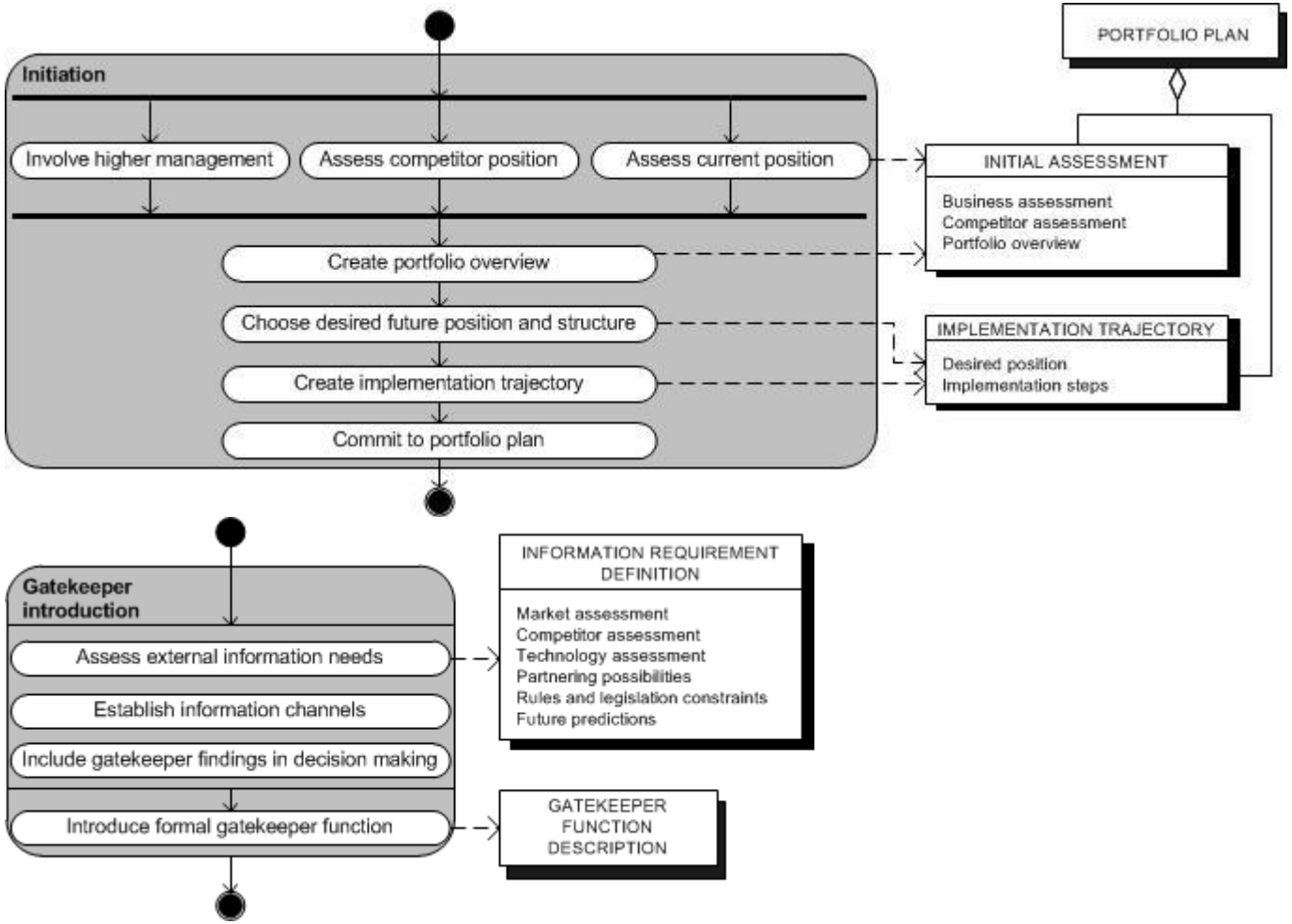
Guideline	**Source**
Assess current situation and associated processes	t-plm-2
Choose future position and create implementation trajectory	iv-r-1, iv-p-1
Commit to trajectory	iv-r-2
Define and communicate goals and objectives and establish underlying values	t-s-d1, iv-s-2, t-ppm-1, iv-rp-1
Establish focus for each product and strategic area and derive portfolio strategy	t-s-d2, t-s-d3, t-s-1, iv-s-1, mm-ma-b, t-nppm-2, iv-ee-2, iv-p-1
Create and commit to strategic product roadmap and refine when required	t-spm-2, t-s-d5, t-s-d4, iv-ee-3
Introduce gatekeepers in the organization	mm-ma-a, mm-ma-d, mm-ma-e, mm-pc-c, t-spmmm-1, iv-ee-1, iv-ee-2, iv-ee-3, iv-plm-3
Include gatekeeper findings in higher management decision-making	t-spmmm-1, iv-r-1, iv-p-1, iv-plm-3
Find a balance between formalization and process efficiency	t-plm-3, t-plm-4, iv-r-2, iv-pf-1, iv-pf-2
Create, establish and operationalize proper tools for usage within the organization	t-spm-2, t-pmx-1, iv-rp-1, t-plm-mm1, t-plm-mm2, t-plm-5, t-pm-2, t-s-d5, t-s-1, iv-ee-1, iv-ee-2, iv-plm-3, iv-spm-1.
Assess current need for IT, implement systems and ensure alignment	t-plm-mm1, t-plm-mm2
Partly automate the processes	t-plm-mm1, t-plm-mm2, iv-pf-2
Integrate with other (major) enterprise systems	t-plm-mm1, t-plm-mm2, iv-pf-3
Assign product manager and review the current product portfolio	t-nppm-3, t-spm-1, iv-s-1, iv-rp-1, iv-plm-3, iv-spm-1
Establish rules and processes with	t-nppm-2, t-spm-mm1, t-spm-1, iv-spm-1, iv-

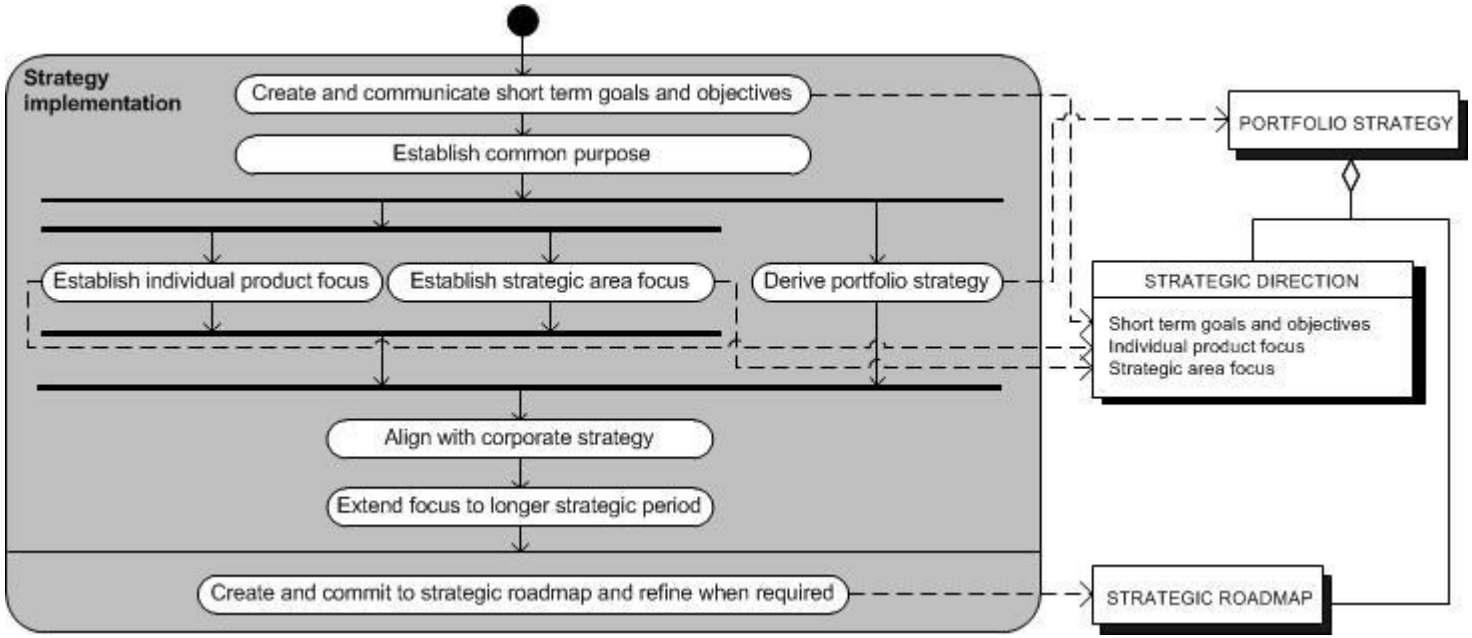
management support and introduce multifunctional core teams	spm-2
Analyze external environment and evaluate distribution channels	mm-pc-c, mm-pc-d, mm-pc-e, iv-ee-2, iv-ee-3, iv-r-1, iv-p-1, iv-plm-2
Introduce portfolio review board	mm-plm-c, mm-plm-e, iv-spm-1
Establish PLM vision and create central information storage on at least the early phases of a product	t-plm-mm1, t-plm-mm2
Make PLM a business wide issue with formalized processes and integrate with major enterprise systems	t-plm-mm1, t-plm-mm2, mm-plm-a, t-plm-2, iv-plm-1, iv-plm-2
Span the entire lifecycle with central storage of product information and improve the PLM processes	t-plm-mm1, t-plm-mm2, mm-ma-c, t-plm-2, t-spm-mm1, iv-ee-2, iv-ee-3, iv-plm-1, iv-plm-3
Integrate the entire supply chain	t-plm-mm1, t-plm-mm2, mm-ma-d, t-spm-mm1, iv-ee-2, iv-ee-3, iv-r-1, iv-p-1
Create a central project administration with incorporation of risks and resource constraints and assign project managers.	t-pm-mm1, mm-plm-b, t-pm-1, t-pm-2, t-spm-1
Identify strategic objectives and categorize projects.	t-pm-mm1, mm-plm-b, mm-plm-d, t-pm-1, t-pm-3, t-nppm-2, t-nppm-3, iv-pf-2
Design processes towards constant monitoring and decision making capability	t-pm-mm1, t-pm-3, t-spm-mm1
Introduce project portfolio committee	t-pm-mm1, t-pm-4, iv-spm-1

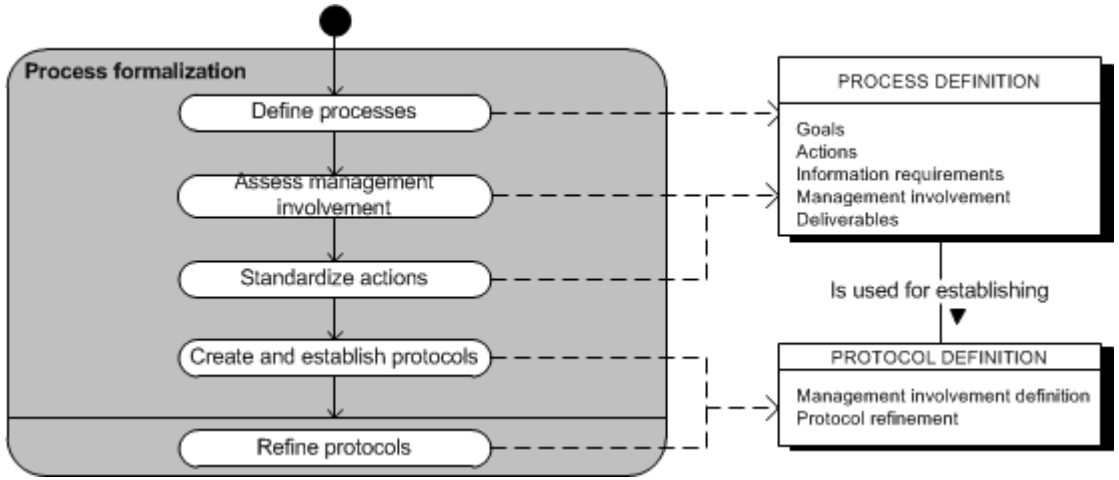
Appendix F: Software product portfolio management implementation model overview

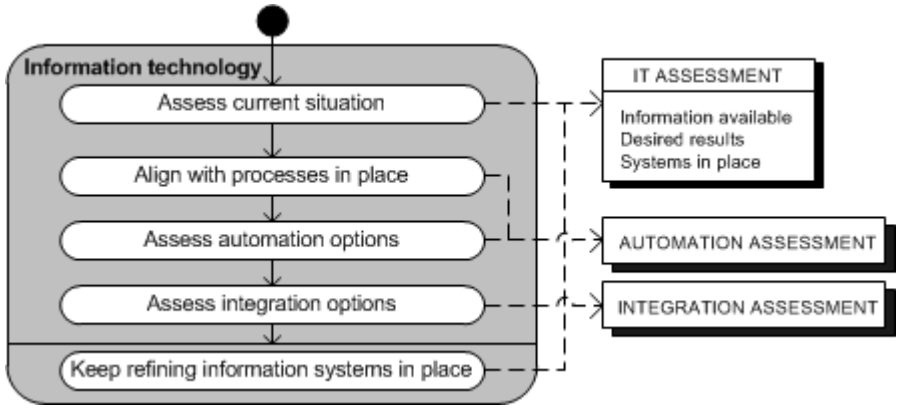


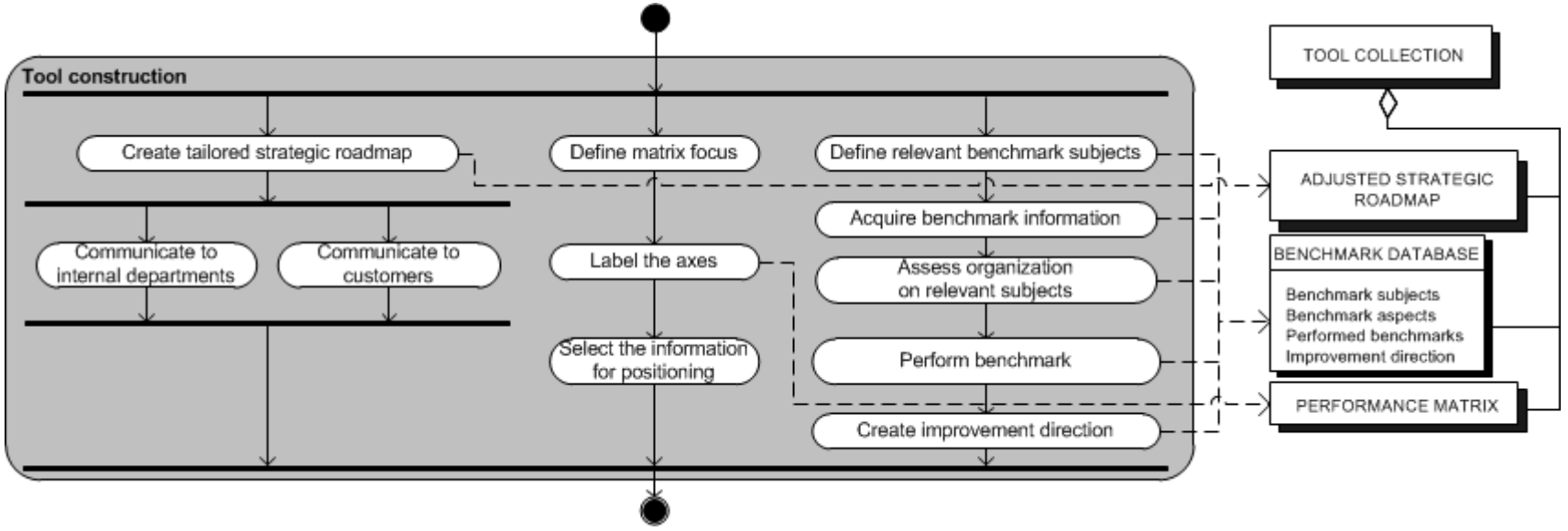
Appendix G: Software product portfolio management implementation model process-deliverable diagrams

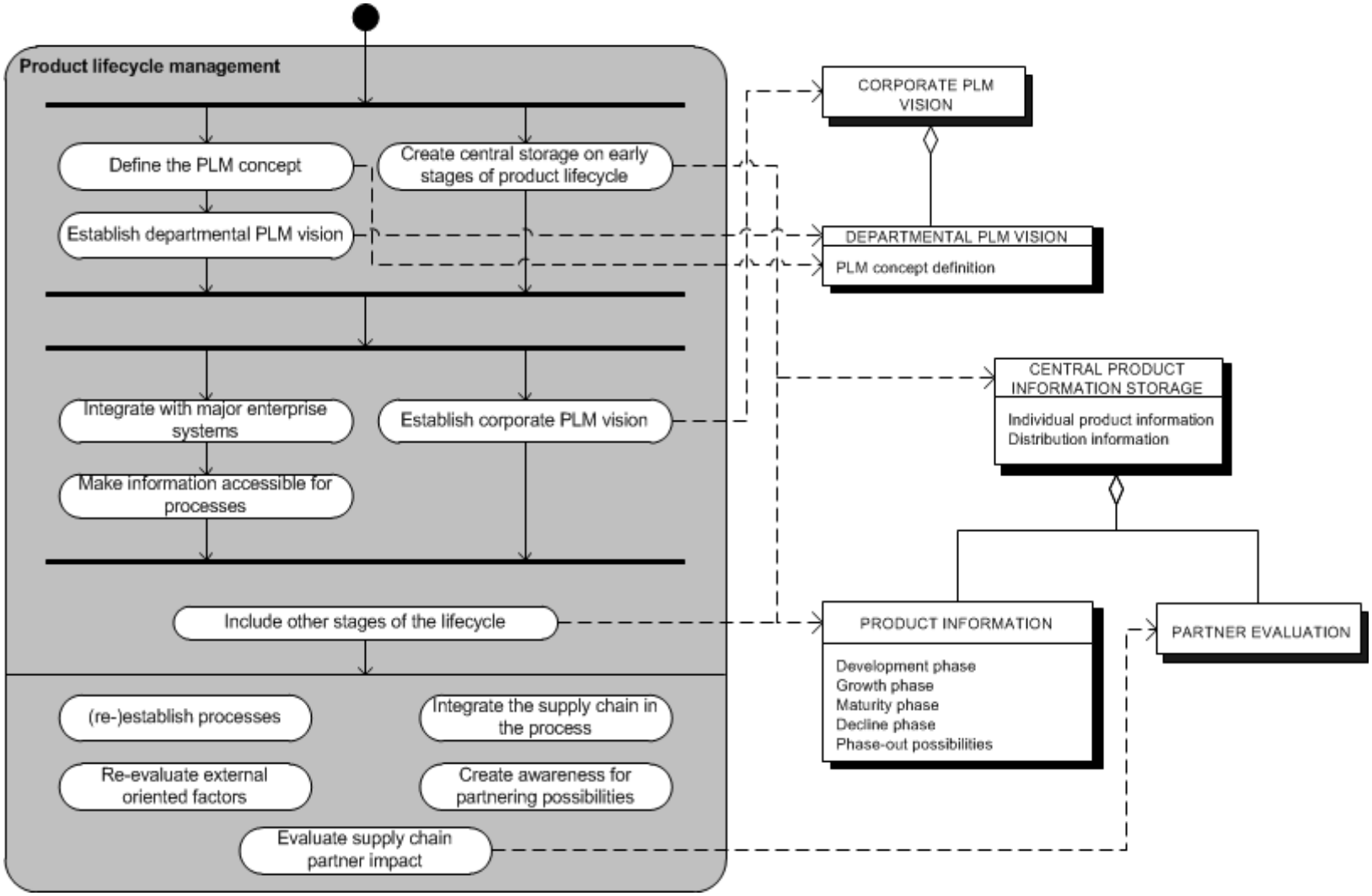


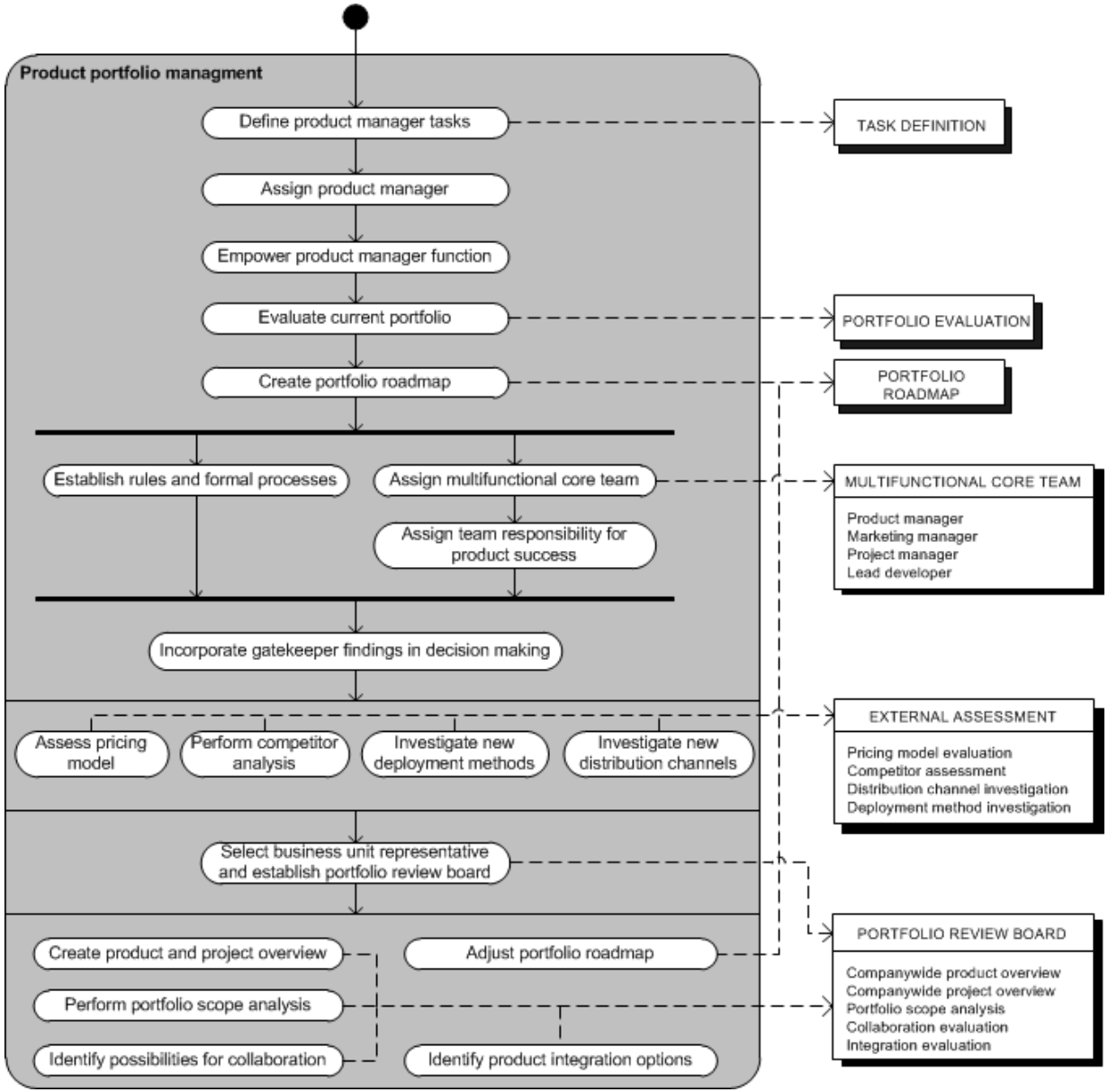

Strategy implementation
Create and communicate short term goals and objectives
Establish common purpose
Establish individual product focus
Establish strategic area focus
Derive portfolio strategy
Align with corporate strategy
Extend focus to longer strategic period
Create and commit to strategic roadmap and refine when required
PORTFOLIO STRATEGY
STRATEGIC DIRECTION
Short term goals and objectives
Individual product focus
Strategic area focus
STRATEGIC ROADMAP

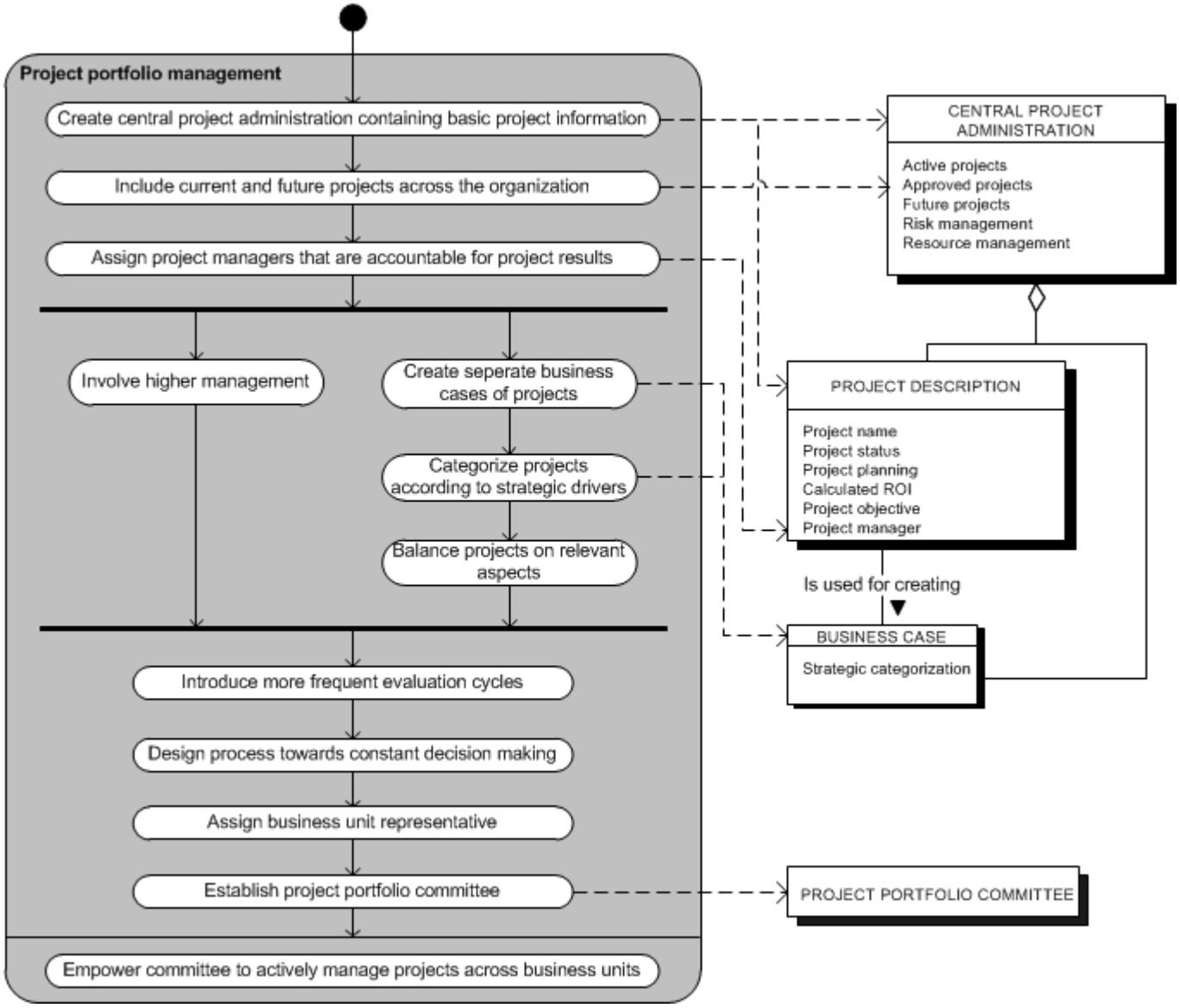

Process formalization
Define processes
Assess management involvement
Standardize actions
Create and establish protocols
Refine protocols
PROCESS DEFINITION
Goals
Actions
Information requirements
Management involvement
Deliverables
Is used for establishing
PROTOCOL DEFINITION
Management involvement definition
Protocol refinement


Information technology
Assess current situation
Align with processes in place
Assess automation options
Assess integration options
Keep refining information systems in place
IT ASSESSMENT
Information available
Desired results
Systems in place
AUTOMATION ASSESSMENT
INTEGRATION ASSESSMENT


Tool construction
Create tailored strategic roadmap
Define matrix focus
Define relevant benchmark subjects
Communicate to internal departments
Communicate to customers
Label the axes
Acquire benchmark information
Assess organization on relevant subjects
Select the information for positioning
Perform benchmark
Create improvement direction
TOOL COLLECTION
ADJUSTED STRATEGIC ROADMAP
BENCHMARK DATABASE
Benchmark subjects
Benchmark aspects
Performed benchmarks
Improvement direction
PERFORMANCE MATRIX


Product lifecycle management
Define the PLM concept
Create central storage on early stages of product lifecycle
Establish departmental PLM vision
Integrate with major enterprise systems
Establish corporate PLM vision
Make information accessible for processes
Include other stages of the lifecycle
(re-)establish processes
Integrate the supply chain in the process
Re-evaluate external oriented factors
Create awareness for partnering possibilities
Evaluate supply chain partner impact
CORPORATE PLM VISION
DEPARTMENTAL PLM VISION
PLM concept definition
CENTRAL PRODUCT INFORMATION STORAGE
Individual product information
Distribution information
PRODUCT INFORMATION
Development phase
Growth phase
Maturity phase
Decline phase
Phase-out possibilities
PARTNER EVALUATION


Product portfolio managment
Define product manager tasks
Assign product manager
Empower product manager function
Evaluate current portfolio
Create portfolio roadmap
Establish rules and formal processes
Assign multifunctional core team
Assign team responsibility for product success
Incorporate gatekeeper findings in decision making
Assess pricing model
Perform competitor analysis
Investigate new deployment methods
Investigate new distribution channels
Select business unit representative and establish portfolio review board
Create product and project overview
Adjust portfolio roadmap
Perform portfolio scope analysis
Identify possibilities for collaboration
Identify product integration options
TASK DEFINITION
PORTFOLIO EVALUATION
PORTFOLIO ROADMAP
MULTIFUNCTIONAL CORE TEAM
Product manager
Marketing manager
Project manager
Lead developer
EXTERNAL ASSESSMENT
Pricing model evaluation
Competitor assessment
Distribution channel investigation
Deployment method investigation
PORTFOLIO REVIEW BOARD
Companywide product overview
Companywide project overview
Portfolio scope analysis
Collaboration evaluation
Integration evaluation


Project portfolio management
Create central project administration containing basic project information
Include current and future projects across the organization
Assign project managers that are accountable for project results
Involve higher management
Create seperate business cases of projects
Categorize projects according to strategic drivers
Balance projects on relevant aspects
Introduce more frequent evaluation cycles
Design process towards constant decision making
Assign business unit representative
Establish project portfolio committee
Empower committee to actively manage projects across business units
CENTRAL PROJECT ADMINISTRATION
Active projects
Approved projects
Future projects
Risk management
Resource management
PROJECT DESCRIPTION
Project name
Project status
Project planning
Calculated ROI
Project objective
Project manager
Is used for creating
BUSINESS CASE
Strategic categorization
PROJECT PORTFOLIO COMMITTEE

Appendix H: Concept definition list

Initiation

CONCEPT	DEFINITION
PORTFOLIO PLAN	A document containing the INITIAL ASSESSEMENT and the IMPLEMENTATION TRAJECTORY making clear what the future direction is regarding the portfolio management process and the products in the portfolio through the PORTFOLIO STRATEGY.
INITIAL ASSESSMENT	A document containing an overview of the current status of an organization and its portfolio in terms of the own organization, competitor analysis and a portfolio overview.
IMPLEMENTATION TRAJECTORY	A document containing the implementation steps that are required to reach the desired position over a certain period of time.

Gatekeeper introduction

CONCEPT	DEFINITION
INFORMATION REQUIREMENT DEFINITION	A document containing an overview of the information originating from the external environment (e.g. technological developments), that is to be gathered by the gatekeeper or the person that performs the gatekeeper tasks.
GATEKEEPER FUNCTION DESCRIPTION	A document describing the task a gatekeeper should perform when a person is formally assigned to this function.

Strategy implementation

CONCEPT	DEFINITION
PORTFOLIO STRATEGY	A document describing the future of current products and the strategic arenas to pursue, in order to fulfill corporate strategy.
STRATEGIC DIRECTION	A document, part of the PORTFOLIO STRATEGY, containing short term goals and objectives with a distinct strategic focus for each product and strategic area.
STRATEGIC ROADMAP	Part of the PORTFOLIO STRATEGY containing a portrayal of each product and its desired evolution over a certain period of time.

Process formalization

CONCEPT	DEFINITION
PROCESS DEFINITION	A document that defines a process in terms of its goals, the associated standardized actions, the required information, the involvement of management and the deliverables
PROTOCOL DEFINITION	A document describing the collection of processes in a certain area, based on the PROCESS DEFINITION, in terms of a management involvement definition and refinements to the protocol.

Information technology

CONCEPT	DEFINITION
IT ASSESSMENT	An initial analysis of the current systems, the information that is available for daily operation and the desired results with regard to information technology in the organization.
AUTOMATION ASSESSMENT	An assessment of the possibilities to automatize parts of processes using information technology.
INTEGRATION ASSESSMENT	An assessment of the possibilities for integrating different information systems for the purpose of creating a more thorough information database.

Tool construction

CONCEPT	DEFINITION
ADJUSTED STRATEGIC ROADMAP	A tool that is a portrayal of a specific part of the portfolio, derived from the STRATEGIC ROADMAP, used for communicative purposes.
PERFORMANCE MATRIX	A tool used for evaluating products, projects or entire portfolios depending on the labels assigned to the axes of the matrix.
BENCHMARK DATABASE	A collection of data on benchmark subjects (e.g. competitors) and benchmark aspects (e.g. sustainability) used for benchmarking the organization and identifying improvement directions.

Product lifecycle management

CONCEPT	DEFINITION
CORPORATE PLM VISION	A vision on product lifecycle management that is agreed upon throughout the entire organization and connects the individual DEPARTMENTAL PLM VISIONS.
DEPARTMENTAL PLM VISION	A definition of the product lifecycle management concept that is in line with the CORPORATE PLM VISION and defines how PLM can contribute to the business processes.
CENTRAL PRODUCT INFORMATION STORAGE	An information system that is centrally available and contains individual PRODUCT INFORMATION and a PARTNER EVALUATION with regard to a products' distribution channel.
PRODUCT INFORMATION	An information system that is part of the CENTRAL PRODUCT INFORMATION STORAGE containing information on the lifecycle phases of each product.
PARTNER EVALUATION	A document or system, part of the CENTRAL PRODUCT INFORMATION STORAGE, keeping track of the impact a supply chain partner has on a product.

Product portfolio management

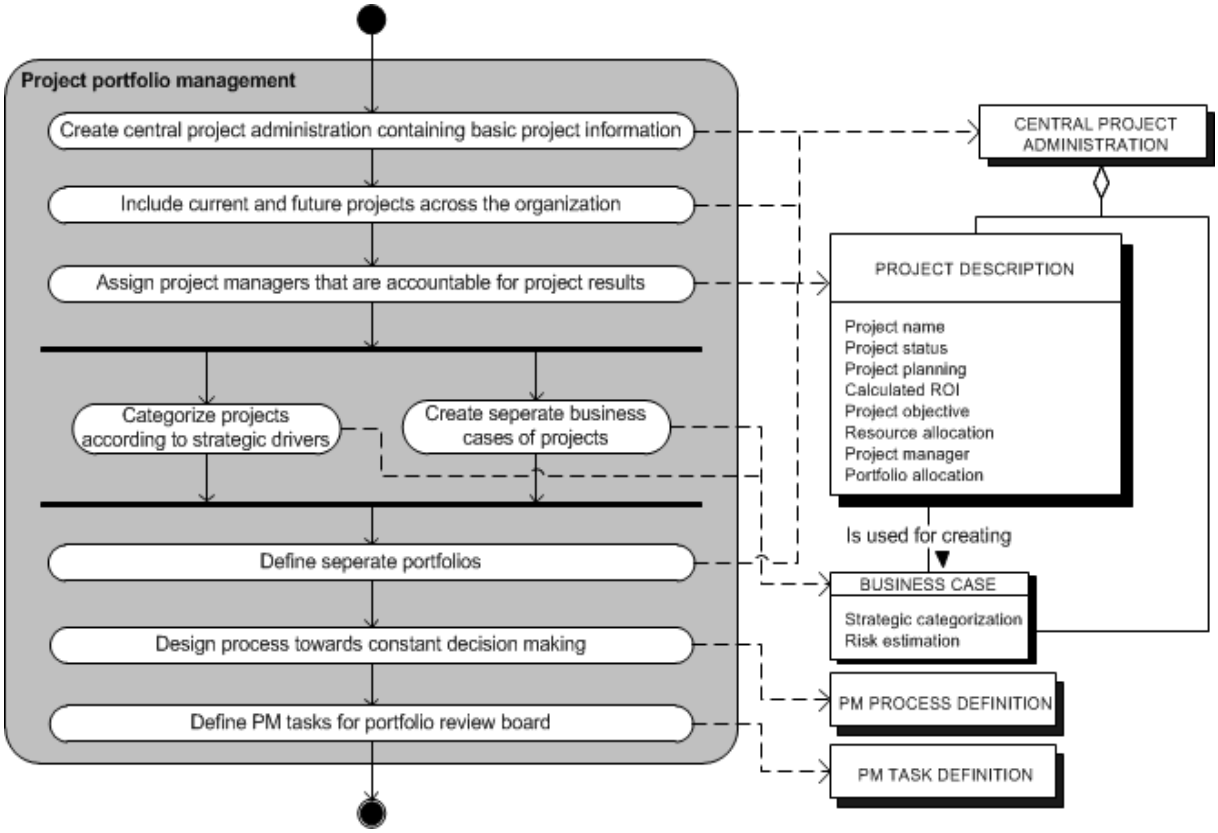
CONCEPT	DEFINITION
TASK DEFINITION	A document that formally describes the task a product manager should perform.
PORTFOLIO EVALUATION	An endeavor resulting in a document that assesses the current product portfolio, with the use of tools like PERFORMANCE MATRIXES, that is useful for constructing the PORTFOLIO ROADMAP.
PORTFOLIO ROADMAP	A document describing the plan of an organization to improve the current product portfolio within a certain timeframe, based on the PORTFOLIO STRATEGY.
MULTIFUNCTIONAL CORE TEAM	A team, consisting of representatives from different disciplines, that is responsible for the success of a product.
EXTERNAL ASSESSMENT	An endeavor, resulting in a document, that analyses the external factors influencing each product in the portfolio. Possibly complemented by the PARTNER EVALUATION and the information found by the gatekeeper as identified in the INFORMATION REQUIREMENT DEFINITION.
PORTFOLIO REVIEW BOARD	A board consisting of business unit or departmental representatives assigned to manage the entire organizational product portfolio on a strategic level in terms of cross-product, -functional and -departmental decisions.

Project portfolio management

CONCEPT	DEFINITION
CENTRAL PROJECT ADMINISTRATION	An information system consisting of information on current and future projects, containing a PROJECT DESCRIPTION of each project and BUSINESS CASES that enable for more efficient management of the organizations' resources.
PROJECT DESCRIPTION	A document describing the basics of a project before transformed into a BUSINESS CASE.
BUSINESS CASE	A project that is ranked, based on the PROJECT DESCRIPTION, in terms of its strategic contribution to the organization.
PROJECT PORTFOLIO COMMITTEE	A board, that gets input from the PORTFOLIO REVIEW BOARD, consisting of business unit or departmental representatives assigned to manage the projects across departments.

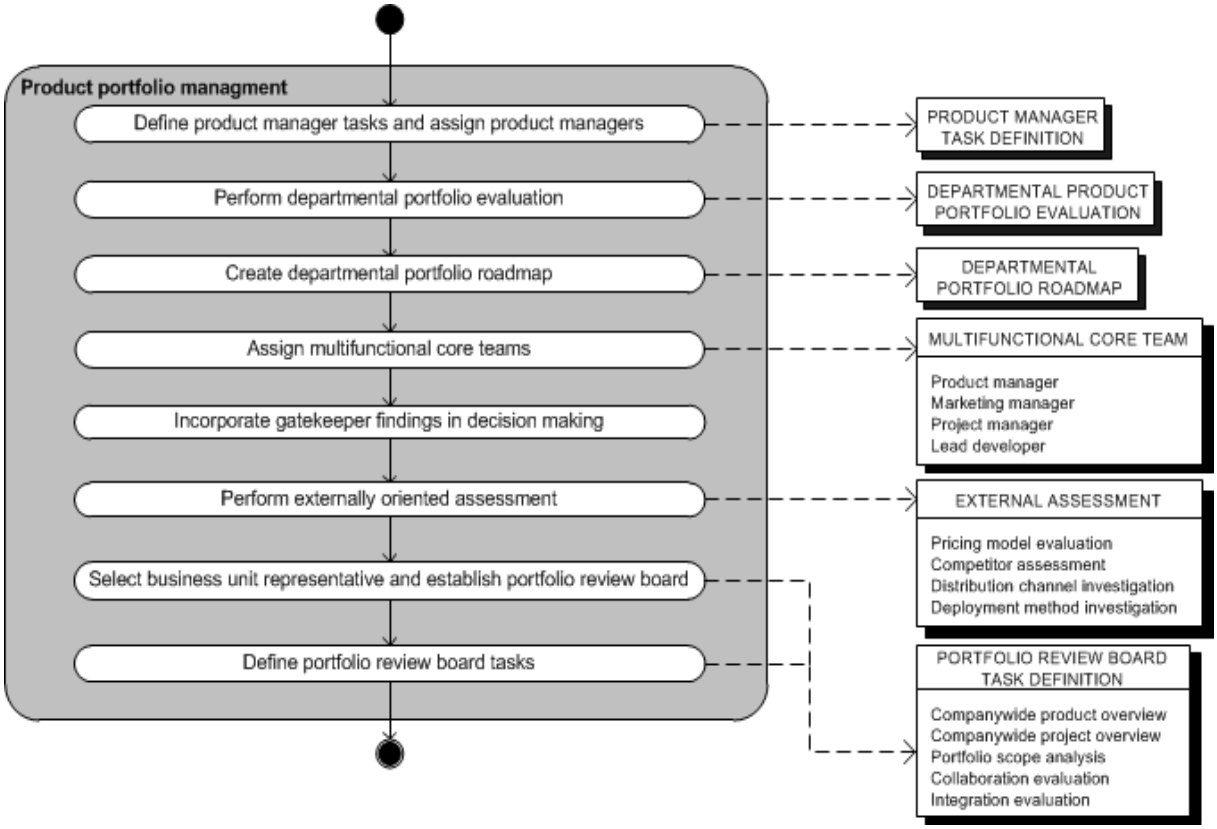
Appendix I: Revised process-deliverable diagrams

Project portfolio management



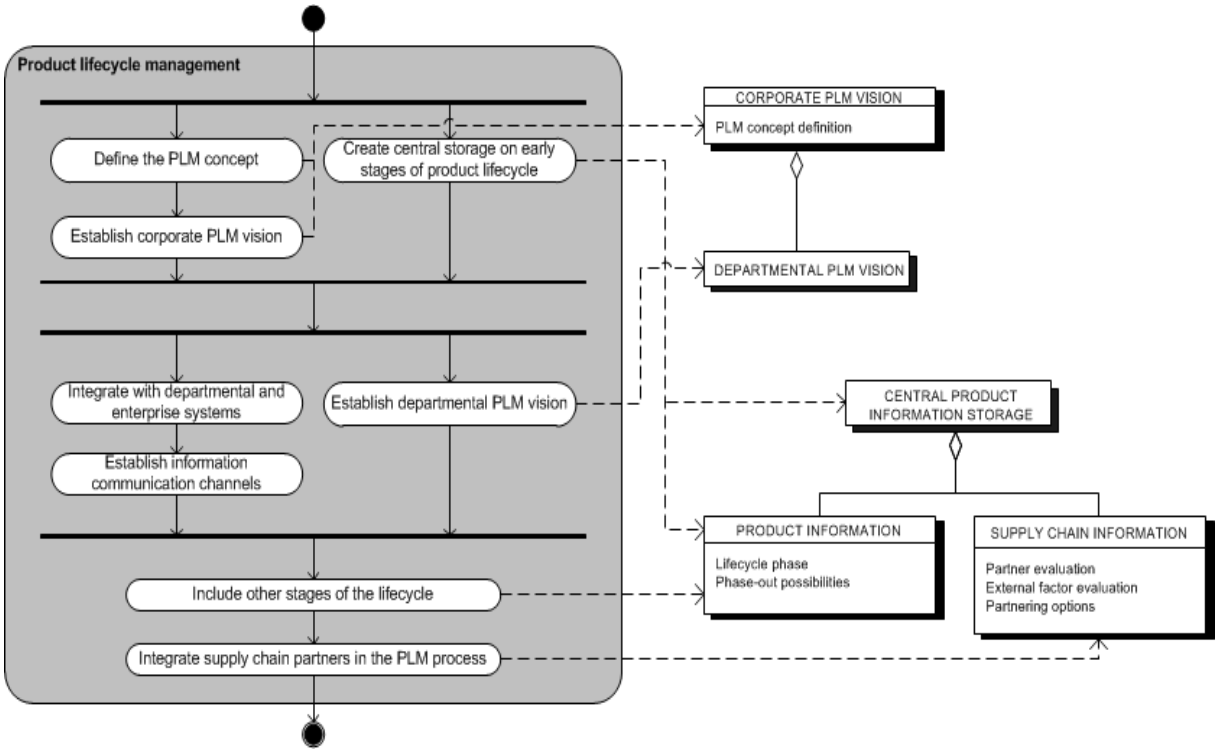
CONCEPT	DEFINITION
CENTRAL PROJECT ADMINISTRATION	A system consisting of information on current and future projects in each of the defined project portfolios of the portfolio collection, containing a PROJECT DESCRIPTION of each project and BUSINESS CASES that enable for more efficient management of the organizations' resources.
PROJECT DESCRIPTION	A document describing the basics of a project and the portfolio it is allocated to, used as input for creating a formal BUSINESS CASE.
BUSINESS CASE	A project that is ranked, based on the PROJECT DESCRIPTION, in terms of its strategic contribution to the organization and estimated risk.
PM PROCESS DEFINITION	A document formally describing the process with regard to managing a project throughout its entire realization. More mature processes can be established based on its definition.
PM TASK DEFINITION	A document describing the tasks that the portfolio review board has to perform with regard to managing the corporate project portfolios.

Product portfolio management



CONCEPT	DEFINITION
PRODUCT MANAGER TASK DEFINITION	A document that formally describes the task a product manager should perform.
DEPARTMENTAL PRODUCT PORTFOLIO EVALUATION	An endeavor resulting in a document that assesses the current product portfolio, with the use of tools like PERFORMANCE MATRIXES, that is useful for constructing the DEPARTMENTAL PORTFOLIO ROADMAP.
DEPARTMENTAL PORTFOLIO ROADMAP	A document describing the plan of an organization to improve the current product portfolio within a certain timeframe, based on the PORTFOLIO STRATEGY.
MULTIFUNCTIONAL CORE TEAM	A team, consisting of representatives from different departments and disciplines, that is responsible for the success of a product.
EXTERNAL ASSESSMENT	An endeavor, resulting in a document, that analyses the external factors influencing each product in the portfolio. Possibly complemented by the SUPPLY CHAIN INFORMATION and the information found by the gatekeeper as identified in the INFORMATION REQUIREMENT DEFINITION.
PORTFOLIO REVIEW BOARD TASK DEFINITION	A definition of the tasks that a board, consisting of business unit or departmental representatives, should perform to manage the entire organizational product and project portfolio on a strategic level in terms of cross-product, -functional and -departmental decisions.

Product lifecycle management



CONCEPT	DEFINITION
CORPORATE PLM VISION	A vision on product lifecycle management that is agreed upon throughout the entire organization and connects the individual DEPARTMENTAL PLM VISIONS including a definition on how PLM can contribute to the business processes.
DEPARTMENTAL PLM VISION	A departmental vision on product lifecycle management that is in line with the CORPORATE PLM VISION.
CENTRAL PRODUCT INFORMATION STORAGE	An information system that is centrally available and contains individual PRODUCT INFORMATION and SUPPLY CHAIN INFORMATION with regard to a products' distribution channel.
PRODUCT INFORMATION	An information system that is part of the CENTRAL PRODUCT INFORMATION STORAGE containing information on the lifecycle phases of each product.
SUPPLY CHAIN INFORMATION	A document or system containing information on and evaluations of partners in the supply chain with the aim of integrating them in the PLM processes.

Appendix J: Capabilities comprising maturity matrix

This appendix contains the full list of capabilities that comprises the maturity matrix as presented in chapter 7 of the book "Software Project Management for the 21st Century". This list is presented here due to restrictions with regard to appendices for the book.

Initiation

A	Performed initial assessment
The current state of affairs is documented including, amongst others, a business assessment, competitor assessment and portfolio overview.	
B	**Created implementation trajectory**
The results of the initial assessment are transformed into a concrete action plan to take the organization to the next level.	
C	**Created portfolio plan**
The future direction of the products in the portfolio and product portfolio management is described in a portfolio plan.	

Strategy implementation	
A	**Established strategic direction**
Short-term goals and objectives as well as a strategy for individual products and strategic areas are documented and used by product managers.	
B	**Created strategic roadmap**
A roadmap is created showing the evolution of an organization's product over a certain period of time.	
C	**Created portfolio strategy**
A document is created describing how the current portfolio, and future adjustments, are to fulfill the corporate strategy.	

Gatekeeper introduction	
A	**Defined information requirements**
The information that is to be acquired from the external environment, for example (competing) technological innovations, developments at the customer and adjustments to rules and legislation, is formally defined.	
B	**Formalized gatekeeper function**
The role and responsibilities of a gatekeeper are described and at least the responsibilities are assigned to a person within the company.	

Product portfolio management	
A	**Defined product manager tasks**
The tasks of a product manager are formally defined.	
B	**Constructed departmental roadmap**
A document is created describing the future developments of the products in the portfolio over a certain period of time for a certain department within an organization.	
C	**Established multifunctional core teams**
A multifunctional core team is responsible for the management and thereby the success of a product.	
D	**Defined organizational portfolio**
The entire organizational portfolio is defined in terms of products, components and core assets, documented and communicated. All stakeholders (e.g. product managers) provide input for this mapping and validate the end result.	
E	**External assessment is performed**
In conjunction with the gatekeeper function, a number of externally oriented aspects (e.g. pricing model and competitor advancements) are assessed for each product in the portfolio to improve the organizations' ability to tailor products to the markets' needs.	
F	**Established portfolio review board**
A board is established that is actively managing the entire product and project portfolio of an organization. For example through the usage of service catalogs.	

Product lifecycle management	
A	**Defined and communicated corporate PLM vision**
The role and importance of PLM is defined and communicated by high level management throughout the organization.	
B	**Defined departmental PLM vision**
On departmental level the corporate PLM vision is translated into concrete actions concerning the lifecycle of the individual products.	

C	PLM integrated in roadmap
The lifecycles of the products are integrated with the roadmaps of the products and other strategic plans.	
D	**Established central product information storage**
The information on the lifecycle of each product is stored and maintained centrally.	
E	**Ecosystem integration**
PLM processes are cross-organizational to enable collaboration (for example with partners) and PLM information is integrated in the major enterprise systems to make the lifecycles more transparent.	

Project portfolio management	
A	**Central project administration established**
Project information is stored and maintained centrally and resource constraints are embedded in this administration.	
B	**Business cases created**
Projects are structurally transformed into business cases by adding a strategic ranking and a risk assessment.	
C	**Structured project portfolio**
Separate project portfolios are defined for each strategic goal, based on a number of predefined criteria. Each project is allocated to one of the defined portfolios and a budget is allocated to each portfolio to ensure a balance in the projects that are being realized.	
D	**Defined departmental PM process**
Agreements, rules and protocols for project portfolio management are established for the purpose of standardization, optimization and enabling (product) managers to constantly make decisions on the projects in the defined portfolios across departments.	
E	**Corporate project portfolio management process and tasks defined**
The process and tasks concerning project portfolio management on a corporate level are defined and executed by the established portfolio review board.	

Process formalization	
A	**Defined processes**
Processes are defined in terms of goals, actions and deliverables such that they can be performed by each individual delivering the same results.	
B	**Uniform protocols**
Uniformity of the processes is established not only within a department but also across the organization.	

Tooling	
A	**Established tool collection**
A collection of tools is operationalized and there is awareness of their availability amongst employees.	
B	**Dedicated tools available**
Dedicated tool are in use to support the individual and collective software product management practices within the organization.	
C	**Governance tooling available**
Dedicated tool are in use to support the decision making process on portfolio level.	

Information technology	
A	**IT is assessed regularly**
The current information systems are evaluated on their ability to provide in information for the daily tasks at least once a year.	
B	**IT processes are automated**
Parts of the IT processes are automated. Consider for example trend analysis and report generation as examples of IT processes that can be performed on a regular basis (based on predefined criteria) without the interference of an employee.	
C	**Systems are integrated**
The individual systems are integrated with each other to create an extensive knowledge base containing information of the entire organization.	