PhD Thesis Proposal

Evaluating Performance in Product Development – The Case of Complex Products

Stefan Cedergren

School of Innovation, Design and Engineering

Mälardalen University, P.O. Box 883, 721 23 Västerås, Sweden

stefan.cedergren@mdh.se

April 2010

1. Introduction

The purpose of this doctoral proposal is to briefly summarize my research up until now as well as provide an outline including a time plan until my dissertation in December 2010. The outline of this document is as follows: first is a short overview of the related literature within product development, performance, and performance measurements given. In Chapter 2 a research description with the research objectives and the methods used in this research presented. This is followed by a discussion about different dimensions of validity related to the used research methods in Chapter 3. In Chapter 4 is the research contribution outlined. An outline of the thesis is given in Chapter 5 and this is followed by a list of graduate courses in Chapter 6. A time plan together with some major milestones is presented in Chapter 7 together with a discussion about risks related to the remaining work until dissertation in December. The doctoral proposal is concluded with a complete list of publications resulting from this research.

Product development and performance

Product development exist in order to attract and satisfy a set of target customers and to do so profitable (Clark and Fujimoto 1991). In today's changing business environment, characterized by technological advances, intensified global competition, as well as changing customers and needs (Goffin and Mitchell 2005), the need for a successful product development process is greater than ever (Clark and Wheelright 1993). Thus, a continuous search for improvements in the performance of the product

development process is always high on every product delivering company's agenda. Performance improvements are normally achieved through changes and improvements in processes, methods, and tools often implemented in several small steps of continuous improvements. An important step in such an improvement process is the ability to evaluate the performance of the current state in order to identify areas needing improvement.

Within manufacturing there are well developed and accepted methods for measuring the performance and these have been developed and improved for over 100 years. With this in mind, methods for measuring performance within product development are relatively immature. One indication of this is seen in the literature, both within performance measurements and product development, where there is confusion in terminology. This may be the result of two research areas, performance measurements and product development, attracting scholars with various functional backgrounds. In a review of the product development literature (Krishnan and Ulrich 2001), at least four common perspectives: marketing, organization, engineering design, and operations management were argued for. Moreover, to describe the process of developing new products, various terms like: product innovation, innovation, engineering design, NPD, R&D, and product development are used. Various terms that have evolved and adopted similar meanings (Marxt and Hacklin 2005). In this research the term product development is used to holistically describe the process of developing new products in a company, by arguing for the following definition:

"Product development is the set of activities beginning with the tools and processes used to perceive a market opportunity and ending in the production, sale, and delivery of a product fulfilling that market opportunity."

The proposed definition is an extension of the one argued for by Ulrich and Eppinger (2003) in the sense that it is stressing the importance of identifying the market opportunity, it is not always given.

The performance measurement research is also a diverse research subject, including researchers with functional backgrounds as varied as accounting, operations management, marketing, finance, economics, psychology, and sociology all actively working in the field (Neely 2007). Hence, the concept of performance is often discussed but seldom explicitly defined (O'Donnell and Duffy 2002).
When performance is defined it is commonly associated with effectiveness and efficiency. However, there are several different interpretations of effectiveness and efficiency in the literature. According to Neely et al. (2005); effectiveness refers to the extent to which customer requirements are being met, while efficiency is a measure of how economically the firm's resources are used, when providing a given level of customer satisfaction. Sink and Tuttle (1989) describe effectiveness as doing the right things at the right time, with the right quality. Efficiency is similarly described as doing things right, often expressed as a ratio between resources expected to be consumed and resources actually consumed. These examples illustrate the diversity in the present terminology associated with performance. In this thesis the definition of efficiency and effectiveness proposed by O'Donnell and Duffy (2005) based on the IDEF0 framework of an activity (Colquhoun, Baines et al. 1993) is adopted. An activity according to this framework uses resources to transform input to output under the directions of a goal or constraint. In general, effectiveness is related to the attainment of objectives or goals and efficiency relates to the use of resources (O'Donnell and Duffy 2002). Efficiency is often expressed as a ratio, hence often simpler to measure than effectiveness, whether it is based on time, money or any other dimension. In Figure 1, the definitions of efficiency and effectiveness expressed in the IDEF0 framework of an activity are shown.

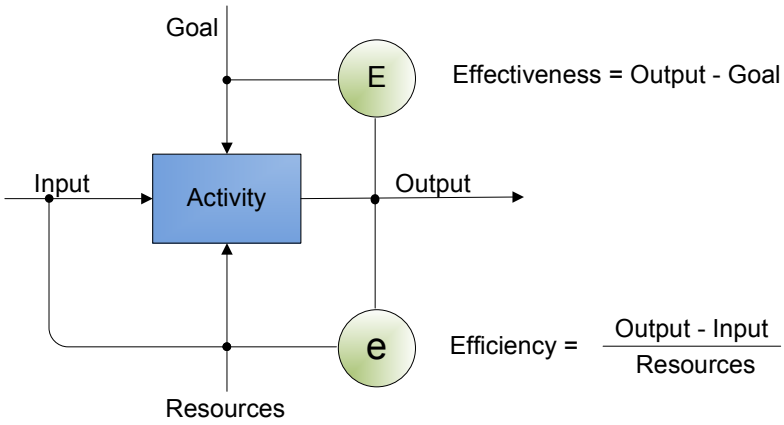

Figure 1. An activity according to the IDEF0 model uses resources to transform input to output under the direction of a goal or constraint.

Product development is more difficult to measure than most other business processes. By definition, to develop a product implies to do something new and the output of this process is an open solution space. This is in contrast to manufacturing that is more repetitive in character with a determined solution space. It is therefore not surprising that there are no broadly accepted performance measurements for product development as there are for example within manufacturing (McGrath and Romeri 1994). Moreover, Rubinstein (2004) even argue that the methods used for evaluating product development projects have not been improved much during the last 50 years.

Performance measurements

Loch and Tapper (2002) identified four main functions of the performance measurement system: alignment and prioritization, evaluation and incentives, operational control, and learning and improvement. The most relevant objectives of R&D performance measurements, as identified by Chiesa et al. (2009), are the motivation of personnel, diagnosing activity, enhancing communication and coordination, learning, reducing risks and uncertainty, and improving performance. Neely and Najjar (2006) argue that the true role of performance measurement is for management learning not management control. Since the output of product development is difficult to quantify in a certain number, focus should instead be to learn were the organization stands and how it might improve (Szakonyi 1994). With all those perspectives in mind it is important, as Neely et al. (2000) points out, to have a holistic systems perspective in the performance evaluation.

In the literature there are several different classifications of performance measurements. Leading performance indicators include measures affecting the process, while lagging indicators measure the result of already performed processes. Two other common basic distinctions are quantitative and qualitative performance measurements. For example, computational methods leads to a quantitative value, e.g. time to market has been six months, whereas assessment methods usually result in a qualitative indication of the metric value, e.g. time to market has been “good” or “unsatisfactory” (Kerssens-van Drongelen, Nixon et al. 2000). Quantitative measures are often divided into financial and non-financial measures. Research within performance measurements often focus at the design and implementation of a performance measurement system. Even though little attention has been paid to the implementation of a complete performance measurement system that would cover the complete product development process (Jiménez-Zarco, Martínez-Ruiz et al. 2006).

Kaplan and Norton (1992) introduced the Balanced Scorecard in the early 1990:s and the literature reveals that it still prevails as the dominant performance measurement system (Paranjape, Rossiter et al. 2006). The basic idea with the Balanced Scorecard is that financial measurements alone cannot adequately reflect factors such as quality, customer satisfaction, and employee motivation (Driva, Pawar et al. 2001). This was the reason behind the development of the Balanced Scorecard, to balance the financial perspective with the perspective of customers, innovation and learning, and internal business processes. Burns et al. (2000) argue that balanced measurements are designed to provide a balance by including measurements of external success as well as internal performance, together with measurements designed to give an early indication of future business performance as well as a record of

what has been achieved in the past. Even though the Balanced Scorecard seems intuitively good, successful implementations of the Balance Scorecard, however, are less prevalent and translating the Balanced Scorecard into concrete actions is still a problematic area. One recent study by Bremser and Barsky (2004) present a framework to integrate the Balanced Scorecard and the Stage-Gate model in R&D management. However, the Balanced Scorecard has not reached the same success within product development as it has within the more general business performance measurement systems. There are several models and frameworks for performance other then the Balanced Scorecard available but few explicitly focus on the product development process.

Performance measurements are important as an aid to determine priorities, e.g. within different activities, and as means for providing direction to teams by highlighting how they are performing and where improvements would be most beneficial. However, the performance measurements must be kept in perspective; they must support the product development process and goal attainment (Nixon 1997). Gharajedaghi (2006) argue that an effective performance measurement system needs to iteratively deal with both performance criteria and performance measurements (Figure 2). The performance criteria involve what to be measured and why; while the performance indicators relates to how the criteria are to be evaluated.

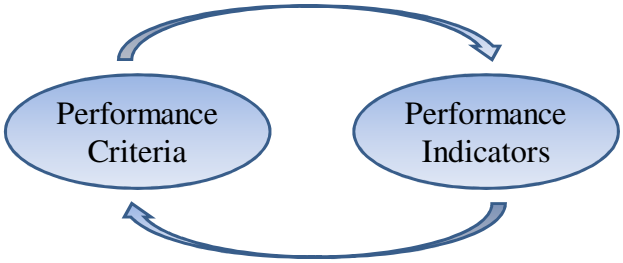

Figure 2. An effective performance measurement system needs to be grounded in performance criteria before measurements are designed.

This implies the importance of continuously evaluating the performance measurement system. Process management theory suggests that one should not only implement the correct processes, one should also monitor how well the processes are operating and, if necessary, intervene in a timely manner (Syamil, Doll William et al. 2004). However, research on performance measurements typically prescribes a new performance measurement system that will substitute the old one. Few studies focus on evaluating the currently used performance measurement system before changing or replacing it. Merely half of the ten performance measurements systems, identified in (Pun and White 2005), had some kind of assessment of the current performance measurement system in their process of designing the new system.

2. Research Description

This section outlines the research objectives, the research questions, and the research methods used in this research.

Research objectives

The main overall research objectives that this research ultimately aims for are to improve the knowledge of what performance is and how it can be evaluated in the context of developing complex products. Both these objectives are important in order to increase the understanding of the relation between technology, process, organization, competence, customer, business, and leadership. During this research journey these objectives have been narrowed down and in the doctoral thesis the main research objective is to understand what challenges and difficulties lay in evaluating performance in product development in practice. Hence, a holistic managerial perspective of performance in the product development processes is needed. Based on this understanding a framework and methods to overcome some of these difficulties has been developed. The unit of analysis under study is the product development process as defined in the introduction, with a special focus on the early activities when it is decided why and what something is to be developed but also how and when it is to be developed.

In this research the development of complex products is studied. Complex products in this thesis refer to systems often including software, electronics, and mechanical components, where the software component has grown in importance and a lot of new functionality is realized through software. These products are usually developed in large organizations, in a business to business setting. In order to manage complex products, they are often divided into smaller functional subsystems that can be either outsourced or developed in-house. Moreover, complex products usually have a long life time and the development of such products is therefore often more evolutionary and incremental in its nature. Usually, there is a platform or architecture as the basis of the product, in order to manage the technical complexity of the product and shortening the development time for a new product. In this research focus is on large organisations developing complex products where the need to evaluate performance is especially important. Typical examples of complex products are found within telecommunication, automation, defence, transportation, and the automotive industry.

Research questions

During the nearly four years of research leading up to this doctoral thesis, several questions have intrigued and guided this research. This is illustrated in the list of research papers were the particular research questions for each paper is presented. The main overall research questions that this research tries to contribute to are:

Research question 1: What challenges in evaluating performance exist in the context of developing complex products?

Despite the large amount of research published related to evaluating performance in product development, there are still challenges to be overcome before it can be performed in a satisfactory way. The objective with this research question is to improve the understanding of what the real issues are, making performance difficult to evaluate in practise. The first research question is exploratory in nature and the second research question is more oriented towards problem solving.

Research question 2: How can the performance of the activities, related to developing complex products, be evaluated from a managerial perspective?

Based on the findings from research question 1 the natural next step is how some of these challenges can be handled in practice. Hence, this research question will be more deductive in nature based on the literature and the knowledge gained in this research project.

Research method

To deal with the complexity of evaluating performance in product development, a systems perspective has been adopted. Increased complexity stresses the need for models that can be used by teams to develop a shared understanding (Katz and Kahn 1978). Systems theory is a promising effort to deal with this problem, where an understanding of a system cannot be based on knowledge of the parts alone. In systems theory, the whole could be greater than the sum of the parts. The real leverage in most management situations lies in understanding dynamic complexity, not detailed complexity (Senge 1990). Hence a holistic perspective has been guiding this research from start to finish.

In this section the various research methods and studies are outlined leading up to the dissertation. The overall objective of this research can be divided into two parts. The first part is explorative and inductive in nature. Since the area of performance measurements in product development is a relatively young research area, it is natural that a common body of knowledge is small. Hence, the first objective with this research is to explore how product development performance is perceived and measured within companies developing complex products. An important result of this part is to define a framework to reason about performance in a complex product development context. This objective is mainly achieved through exploratory case studies at five companies developing complex products. The second part of this research project is more focused on contributing to the knowledge of how to evaluate performance, especially focusing on the relationship between product management and project management.

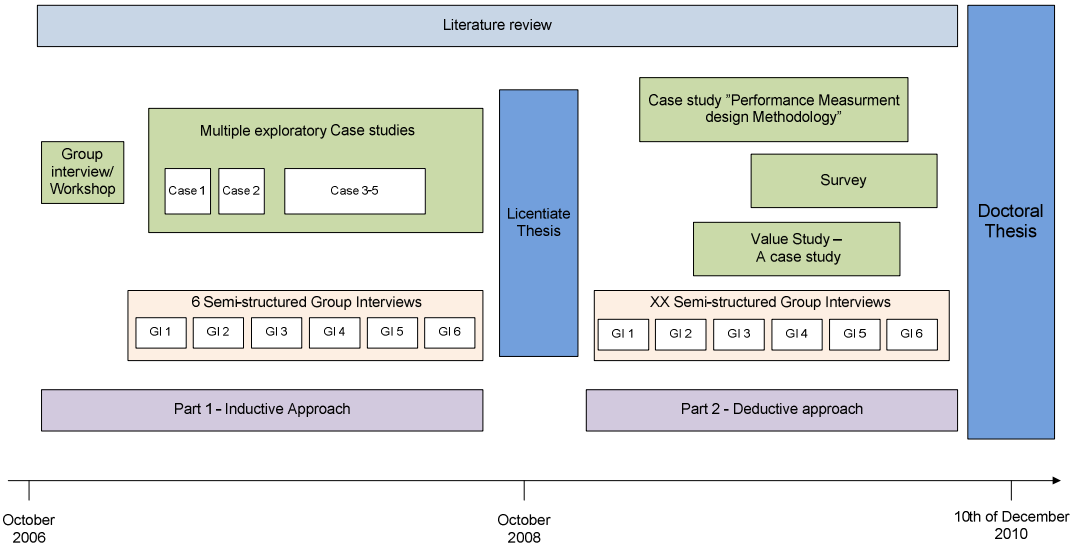

Figure 3. Overview of the different research studies deployed in this research

The inductive part

This research started with an extensive exploratory case study in order to adapt a holistic perspective of how performance is measured and perceived in complex product development.

Multiple explorative case studies

The foundation of this research project is multiple explorative case studies conducted at five companies developing complex products. The objective with the explorative case studies, other than answering the research questions, is to get a broad understanding of the needs and difficulties of measuring performance in practice. The five case companies are large organizations developing complex products and systems within telecommunications, heavy vehicles, transportation, and automation. The exploratory multiple case studies were performed in accordance with the approach presented in (Yin 2003). A case study research strategy focuses on understanding the dynamics present within a single setting (Eisenhardt 1989) and is therefore suited for exploring the perception and measurements of performance in complex product development. A total of 54 interviews with semi-structured questions have been held at the case companies. The questions asked were stated in such a way that the respondents were encouraged to talk about what they perceived as important. The respondents were all managers and decision makers at different levels of responsibility within the organization. Every interview lasted between 50 minutes and 2 hours.

The deductive part

The second part of this research is more deductive and problem-solving oriented. Three different studies where intiated based on the findings from the inductive part.

The performance measurement design case study

This study is designed to test a method for designing performance measurements based on an activity model of performance. Data is collected through structured interviews and company documents describing the development process. Moreover, non-participating observations in project meetings and workshops to present and discuss the results in order to validate the findings during progress. This study is still ongoing.

The value study

This study aims to develop a method to evaluate value during the development of a complex product, instead of only assessing it prior the development i.e. in the business case or one year or more after it has been developed. The proposed method will be tested on data from already completed projects. The main motivation for testing the method on completed projects is to speed up the process, an ongoing project can last for one year or longer. This study is still ongoing.

The survey study
The survey is still under construction but the idea is to generalize some of the findings from the exploratory case study. Especially the link between success factors and what is measured is one of the areas that will be investigated in order to increase the validity of this finding. The survey will target product managers, project managers, line managers, and similar roles in large industrial companies primarily in Sweden but also internationally. The survey will be piloted by the steering group of this research project. There will not be any papers written related to the survey instead all the results will be reported in the thesis.

Semi-structured group interviews

A central part of this research, as illustrated in Figure 3, has been semi-structured group interviews or workshops meetings with senior managers within product development from seven different companies with interest in evaluating performance in product development. These meetings contain presentations of findings and workshop activities analysing and discussing the findings of this research.

3. Threats to Validity

An important aspect in all research and particularly in qualitative research, using interviews and case studies, is validity issues. Yin (2003) propose to divided these issues into four different areas: construct validity, internal and external validity, and reliability. This terminology is adapted in this research.

Construct validity is about ensuring that the construction of the use case or interviews actually relate to the problem you wish to discuss, and that the chosen sources of information are relevant. In this research multiple sources of information have been used and in most cases the interviewees reviewed the interview material to ensure the construct validity. A specific threat to construct validity is the use of unclear terminology. During the interviews the interviewees were not provided with definitions, instead they were encouraged to state their own definitions according to their experience and their organizational context. Also, the interviewee always had the opportunity to ask for clarification during the interview as the questions where semi-structured. Moreover, the interviewees may be limited to express their views if they can be held responsible for the answers at a later point in time. This threat was addressed by guaranteeing anonymity of the interviewees.

Internal validity is important in order to ensure that the actual conclusions made are true. For example if the conclusion is that X causes Y to happen when it in fact is the unknown factor Z that actually causes Y. To ensure internal validity the questions asked during every interview was stated in an open way to minimize the possibility of affecting the answer of the interviewee. With a fairly small sample, there is a risk that a certain individual with a strong opinion can influence the result. Different measures were used here depending on the type of study. During the semi-structured interviews, all conclusions were supported by two or more independent sources e.g. two interviewees. In the more structured interview study this threat was less visible due to the nature of the questions. Also all of the findings have been presented and discussed during seminars both within academia and in industry, where support for the conclusions have been found.

External validity regards the generalization of results. Are the conclusions made valid for other areas then the one studied i.e., are results from one case company also valid in other case companies and maybe also in a general context. This can either be assured by theory or replicate case studies at other companies in different areas. Since, this research only focus on the development of complex products it is difficult to say anything outside this domain. However, the survey will support or not support some of the conclusions outside the primary case companies involved in this research.

Reliability concerns the ability for others to draw the same conclusion when analyzing the case study and the interview material. This issue is addressed by proper documentation of the study. Another question is if we would get the same results with the same case companies but at a different point in time. There are several possible reasons why the outcome could become different. One is that people tend to be influenced by the latest events, i.e. some recent, negative or positive, happening that could affect the result. With the current economic crisis in mind it is possible that some of the conclusions

have been affected. Further, the project or organization might learn from the result, and start to change based on the conclusion of this study and hence affect the result if the study was replicated at another point in time.

4. Research Contribution

The contribution of this research has been reported in terms of nine conference papers, two journal articles and one book chapter as main author, all of which are accepted for publication. Further, a number of additional conference papers have been coauthored with other researchers. The overall main contribution can be categorized into:

- Challenges related to evaluating performance
- Success factors enabling high performance
- The performance measurement evaluation matrix
- The performance criteria reference model
- A method for designing performance indicators
- Model for using value to evaluate performance during product development.

Challenges in practice

This part of the research mainly involves the result from the exploratory case studies. In the survey study there will also be an attempt to generalize some of these findings.

The purpose of this part is to investigate performance evaluation in a product development context from a manager perspective. No commonly accepted methods of evaluating performance exist in the literature. The focus of this study is to explore how managers i.e. product managers, project managers, line managers and similar roles perceive performance and how performance is evaluated in a complex product development context. Managers within the development of complex products are dissatisfied with their current way of evaluating performance. Moreover, every interviewee was asked how they perceive performance in product development. There seems to be one definition for every interviewee, but common for most of the various perception of performance is the dimensions of cost, time, and quality. Two typical perceptions of performance are

"*Performance in product development is to develop the requirements with as low development cost, product cost, to as low price, in as short time, with the highest quality possible*."

"*Performance depends on what you want to achieve with the product development activities, there are three important parameters time, cost, and quality and it is important to succeed with all three.*"

Performance measurements and the perception of performance are focused on cost, time, and quality i.e. what is easily measurable not necessarily what is important for performance. The dimensions of value creations and learning are missing. It is argued that the perception of performance is affected by how it is measured, hence limiting the scope of the performance criteria. Thus, a change in the way managers perceive performance is necessary before there can be any change to the way performance is evaluated. Other challenges identified include:

- What is important for high performance and what is measured differs
- There is a need to improve the way performance is measured
- Performance measurements are of lagging character
- The focus of the performance measurement system is to report project progress
- Performance measurements are mainly focused on the later phases of the development
- No productivity or value measurements where found
- Quality measurements are typically focused on the artifact not on the process
- The fiscal year budget process is stronger than the development project budget process
- The financial reporting systems do not focus on the development activities
- A project started is a project completed
- A performance measurement process is missing
- The result of the performance measurement is not common knowledge
- No mental/abstract models of performance exist
- A learning perspective is missing

Success factors in complex product development

This part of the research mainly involves the result from the exploratory case studies. The contribution includes a framework for a conceptual evaluation of the performance of complex product development activities. The framework promotes a holistic view of performance by considering three categories of activities: Planning, Implementation, and Sales and Delivery. Successful performance evaluation comes from acknowledging the fact that there are different objectives for each of the three activity categories. Moreover, performance may be expressed as a function of the performance of the Planning, the Implementation, and the Sales and Delivery activities.

The planning activities have been concluded, based on the identified success factors, to be categorized into why, what, how, and when something is to be developed. The implementation activities on the other hand are more operational in character. The categorization of success factors related to the implementation activities includes management, technology, people, and processes. When comparing the framework of success factors, as identified in this research, with the literature it is especially the explicit focus on the planning activities and the focus on technology including for example the product architecture that differs. This may be the result of this research's explicit focus on the development of complex products while other studies e.g. (Ernst 2002; Tang, Liu et al. 2005) are covering a more general context.

The Performance measurement evaluation matrix

The Performance Measurement Evaluation Matrix (PMEX) is a tool that has been developed for evaluating the performance measurement system of a company's product development function from a product development manager's perspective. An effective performance measurement system is based on relevant performance criteria. Hence, the PMEX has the success factors within the development of complex products as one dimension and the phases of the Stage-Gate process (Cooper 2009), representing the timeline, as the other dimension. One benefit of the PMEX is the possibility, for a product development manager, to holistically evaluate what is measured and maybe more importantly, what is not measured. The PMEX may also be used as a conceptual tool to reason about the performance measurement system, making it possible to initiate discussions of what is measured, but also why, and when something is measured. Furthermore, as the PMEX also illustrates what is not measured, it can be used when changes or new measurements are to be added, in order to ensure a performance measurement system that measures what is important in a product development manager's perspective.

Another conclusion based on the result of using the PMEX, is that the technology aspect of the product development process is only measured by one of five case companies. This is surprising since all the case companies acknowledge technology as an important success factor. Moreover, a study of the literature relating to different success factors within product development also indicates a disregard of the technology aspect of product development performance. The effect of not measuring the technology aspect is difficult to assess since the impact is mostly long term. Further research is needed, focusing on possible success factors and measures that can be used to address the technology aspects within the development of industrial products. Overall, it seems like an explicit link between what managers identify as important success factors and what is measured is weak. One interpretation is that success factors may be regarded as leading indicators, thus more difficult to quantify in measurements compared to lagging indicators such as time, cost, and quality. This will be explored further in the survey study.

A fundamental rule within the performance measurement literature is to link the strategy pursued by an organization with its measurement system (Davila, Epstein et al. 2006). However, important strategic factors such as the product development planning and the technology aspects were not emphasized in existing performance measurement systems. Instead, an overall conclusion from the case studies is that there seems to be a tendency to measure something because it is possible to measure, rather than because it is important to measure. As a result there are areas in the PMEX, which are covered by up to four different measurements. This is far from cost effective but by means of the PMEX this phenomenon can be detected.

The Performance criteria reference model

The Performance Criteria Reference Model (PCRM) makes it possible for managers to reason about performance in product development. The model consists of three generic levels of activities: product strategy, project management, and development activities. Each level of activity uses resources to transform input to output under the direction of goals and constraints. This view of an activity is based on the IDEF0 concept (Colquhoun, Baines et al. 1993). The goal of the product strategy activity is related to the business strategy. Further, the output of the product strategy activity is the goal of the project management activity. Project management translates the goal into output that becomes goals for the development activities. This way of modelling product development, with three generic levels of activities, makes it possible to analyze performance from three perspectives. Effectiveness, efficiency, and knowledge-gap are defined for the three generic levels of activities, see Figure 4. Furthermore, the PCRM can be used as a way of discussing the effect these three levels of activities have on product development as a whole.

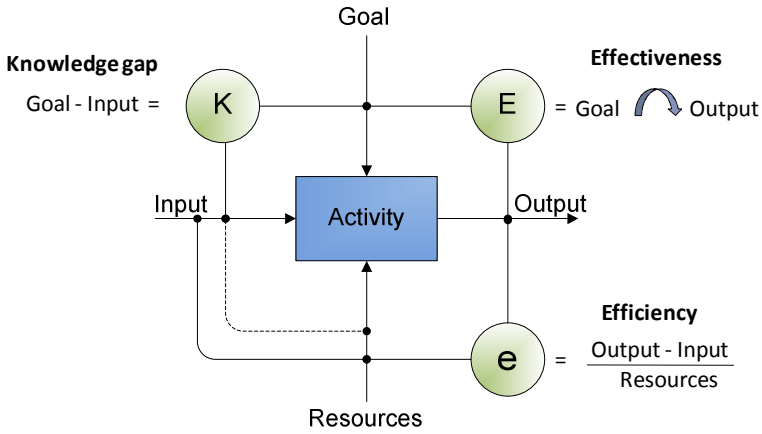

Figure 4. The IDEF0 model of an activity including the definitions of knowledge gap, effectiveness, and efficiency

Towards a performance measurement design methodology

One of the conclusions from the exploratory case studies is that managers within product development are dissatisfied with how their organization evaluates the performance of product development. Also, the performance measurement system seems to be affecting the way performance is perceived. It is argued in this study that in order to change the situation managers should focus on how the organizations perceive performance before focusing on the individual measurements. By developing relevant performance criteria the first step in developing an effective performance evaluation system is made. The main idea with developing a performance design methodology is primarily to combine the framework of success factors with the PCRM model, with the argument that an effective performance measurement system iteratively deals with first the performance criteria and then the performance measures (see Figure 2). The proposed method for designing performance measurements primarily aim to complement the current performance measurement system and not to replace it. In particular the target is to integrate the product management function and the early activities of the product development in the areas of performance measurements. In this study such an organizational specific version of the PCRM model is developed through a case study. Based on this organization specific performance criteria model, success factors from the literature are related and performance measurements derived e.g. by making the arrows in the model explicit. This study is still ongoing and the aim is to report the findings from this case study in a paper at the R&D management conference.

Towards using value as a performance measure

Product delivering companies invest resources in product development activities in order to create value. Still, when performance in product development is to be evaluated, time, cost, and quality are in focus, especially in the later stages of the development when it is expensive and difficult to make any changes. Time, cost, and quality are important dimensions of performance but they are not revealing the complete picture. The value dimension is missing. One of the basic assumptions is that in order to

create value through product development, value must first be captured through the planning activities, developed through the implementation activities and finally be realized through the sales and delivery activities.

A method is proposed for how perceived customer value can be used to evaluate performance in the product development process and describes how it is verified through a case study. By using the perceived customer value of requirements, the value propagation throughout the development is possible to monitor based on both market and scope changes. In addition, a measure of productivity can be calculated by relating the perceived value to the spent effort. This information is used in order to visualize the value propagation and productivity during the development. Hence, through this method it is possible to evaluate the productivity of activities, based on the perceived customer value, from initial ideas to a product that can be delivered to the customer. There are of course several limitations with this way of evaluating performance during the development but by using this method a value perspective is integrated into the organization complementing the time and cost focus something that is missing today.

5. Outline of the thesis

Since there are several publications related to this doctoral research and the results have evolved over time a thesis written as a monograph has been decided on. In this way a lot of the written material can be reused and updated accordingly. The outline of the doctoral thesis will be as follows.

Title, abstract, acknowledgement, preface
1. Introduction – What and Why
2. Frame of Reference – Background theory, motivate research questions
3. Research Questions
4. Research Methodology – Overall thesis perspective
5. Challenges in practice – Results from case studies + survey
6. Success factors in complex product development – Comparing the literature and practice
7. The Performance Measurement Evaluation MatriX
8. The Performance Criteria Reference Model
9. Towards a Performance Measurement Design Methodology
10. Towards using value as a performance measure
11. Discussion – Linking overall results with the literature
12. Conclusions and future work - Contribution to theory and practice + limitations

Appendix

- Measurements, research protocol, list of publications with my contributions

The frame of reference and research methodology chapters will be written with the complete dissertation in mind. To complement this holistic view the result chapters (5-10) will include the specific related literature and research method related that applies to the specific chapter.

6. Graduate Courses

In the table below are the graduate courses that are either completed, ongoing or finished but not completed shown in Table 1.

Table 1. Overview of the graduate courses as part of the doctoral dissertation

Course	Credits	Status
Research methodology	5	Completed
Översiktskurs i produktframtagning för doktorander	6	Completed
Academic writing	5	Completed
Populärvetenskapligkommunikation	2	Completed
The Fundamentals and Cornerstones in Product Innovation Management and Innovation Engineering Literature and Research.	10	Completed
Peer review kurs	1	Completed
Summer school technology management	1,5	Completed
Research methodology EIASM	?	Completed
Systems thinking	5	Completed
Frontiers in leadership	5	Ongoing
Journal writing course	?	Ongoing
Research Planning	3	Finished but not completed
Software architecture and process relations	5	Finished but not completed
Total	**48,5 + ?**	

7. Milestones and time plan

The overall goal is to present the doctoral thesis 10th of December 2010. To achieve this objective the following time plan is proposed.

April

Write and present PhD proposal
Complete the writing of IPDMC paper
Camera ready PICMET
Extended outline of the thesis finished
Write paper in the course Frontiers in leadership
Conduct the final interviews/data collection in the measurement design methodology study

May

Full paper R&D Management Conference
Complete the course Frontiers in leadership
Finalize the measurement design methodology study
Pilot the survey in the steering group
Start writing thesis by mapping and integration of papers into the thesis
Write chapter 5 and 6 in the thesis

June

Begin the distribution of the survey
IPDMC conference
Write chapter 1, 2, 3 and 4 in the thesis.

July

R&D Management Conference
PICMET conference
Write chapter 7-9

August

Write chapter 10-12

Compilation and analysis of the result from the survey
Complete the journal writing course

September

Improve the thesis based on comments from supervisors.
30 September: Apply for presenting thesis at the faculty board
Complement the remaining graduate courses

October

Complete the thesis and send for test print.

November

Send thesis to print. Thesis should be publicly available and "nailed" by November 18.

December

Present thesis 10th of December

Risks with the plan

Risks in the survey: will the result support the findings from the exploratory case study, we do not get results at all due to lack of response, delayed start, lack of time for analysis etc. Limited experience in survey research.

How part-time parental leave will affect the writing process?

Finding an opponent and grading committee.

8. List of publications

Conference publications

1. Towards Integrating Perceived Customer Value in the Evaluation of Performance in Product Development, **Stefan Cedergren**, Stig Larsson, Anders Wall, Christer Norström, to be presented at PICMET, Bangkok, July, 2010
2. Limiting Practices in Developing and Managing Software-Intensive Systems: A Comparative Study, Peter Wallin, **Stefan Cedergren**, Stig Larsson, Jakob Axelsson, to be presented at PICMET, Bangkok, July, 2010
3. Challenges with Evaluating Performance in Product Development, **Stefan Cedergren**, Anders Wall, Christer Norström, to be presented at the 17th International Product Development Management Conference, Murcia, Spain, June, 2010.
4. Analyzing the System Architecting Value Stream, Håkan Gustavsson, Jakob Axelsson and **Stefan Cedergren**, to be presented at EuSEC, Stockholm, May, 2010
5. Performance Evaluation of Complex Product Development, **Stefan Johnsson**, Diana Malvius, Margareta Norell Bergendahl, International Conference on Engineering Design, ICED'09 , Stanford, CA, USA, August, 2009
6. A conceptual evaluation framework for performance measurements within industrial product development, **Stefan Johnsson**, 16th International Annual EurOMA Conference, Göteborg, Sweden, Editor(s):Mats Johansson and Patrik Jonsson, June, 2009
7. Performance Evaluation in an Industrial Product Development Context, **Stefan Johnsson**, Performance Measurement Association Conference, School of Business, University of Otago, Dunedin, New Zealand, Editor(s): Professor Ralph Adler et al., April, 2009

8. Issues Related to Development of E/E Product Line Architectures in Heavy Vehicles, Peter Wallin, **Stefan Johnsson**, Jakob Axelsson, 42nd Annual Hawaii International Conference on System Sciences, IEEE Computer Society, Hawaii, USA, January, 2009
9. PMEX – A Performance Measurement Evaluation Matrix for the Development of Complex Products and Systems, **Stefan Johnsson**, Christer Norström, and Anders Wall, Proceedings of the Portland International Center for Management of Engineering and Technology 2008 Conference, Cape Town, South Africa, July, 2008.
10. What is Performance in Complex Product Development?, **Stefan Johnsson**, Peter Wallin, and Joakim Eriksson, Proceedings of the R&D Management Conference 2008, Ottawa, Canada, June, 2008.
11. Modeling Performance in Complex Product Development – A Product Development Organizational Performance Model, **Stefan Johnsson**, Joakim Eriksson, and Rolf Olsson, Proceedings of the 17th International Conference on Management of Technology, Dubai, U.A.E., April, 2008.
12. Modeling Decision-Making in Complex Product Development by Introducing the PDOPM, Joakim Eriksson, **Stefan Johnsson**, Rolf Olsson, Proceedings of the International Design Conference – Design 2008, Dubrovnik, Croatia, May, 2008
13. A Productivity Framework for Innovative Product Development, **Stefan Johnsson**, Lars Cederblad, Christer Norström, and Anders Wall, Proceedings of the 5th International Symposium on Management of Technology, Hangzhou P.R. China, June, 2007.

Book chapters

1. A Performance Evaluation Framework for Innovation, a chapter in Handbook of Research on Innovation Systems for Business: Technologies and Applications. **Stefan Cedergren**, Anders Wall, Christer Norström, IGI Global Inc., July, 2010

Journal publications

1. PMEX – A Performance Measurement Evaluation Matrix for the Development of Industrial Software-Intensive Products, **Stefan Cedergren**, Anders Wall, Christer Norström, International Journal of Innovation and Technology Management, Accepted for publication in 2010.
2. Evaluation of Performance in a Product Development Context, **Stefan Cedergren**, Anders Wall, Christer Norström, Business Horizons, ELSEVIER, Accepted for publication in 2010.

9. References

Bourne, M., J. Mills, et al. (2000). "Designing, implementing and updating performance measurement systems." International Journal of Operations & Production Management **20**(7): 754-754.

Bremser, W. G. and N. P. Barsky (2004). "Utilizing the balanced scorecard for R&D performance measurement." R & D Management **34**(3): 229-238.

Chiesa, V., F. Frattini, et al. (2009). "Performance measurement in R&D: exploring the interplay between measurement objectives, dimensions of performance and contextual factors." R&D Management **39**: 487-519.

Clark, K. B. and T. Fujimoto (1991). Product Development Performance: Strategy, Organization, and Management in the World Auto Industry, Harvard Business School Press.

Clark, K. B. and S. C. Wheelright (1993). Managing new product development and process development. New York, USA, The Free Press.

Colquhoun, G. J., R. W. Baines, et al. (1993). "A State of the Art Review of IDEF0." International Journal of Computer Integrated Manufacturing **6**(4): 252-264.

Cooper, R. G. (2009). "How companies are reinventing their idea-to-launch methodologies." Research Technology Management **52**(2): 47-57.

Davila, T., M. J. Epstein, et al. (2006). Making innovation work - How to manage it, measure it and profit from it. New Jersey, Wharton School Publishing.

Driva, H., K. S. Pawar, et al. (2001). "Performance evaluation of new product development from a company perspective." Integrated Manufacturing Systems **12**(5): 368-378.

Eisenhardt, K. M. (1989). "Building Theories from Case Study Research." Academy of Management Review **14**(4): 532-550.

Ernst, H. (2002). "Success Factors of New Product Development: A Review of the Empirical Literature." International Journal of Management Reviews **4**(1): 1-40.

Gharajedaghi, J. (2006). Systems Thinking: Managing Chaos and Complexity - A Platform for Designing Business Architecture. San Diego, Elsevier Inc.

Goffin, K. and R. Mitchell (2005). Innovation Management: Strategy and Implementation Using the Pentathlon Framework. London, Palgrave MacMillan.

Jiménez-Zarco, A. I., M. P. Martínez-Ruiz, et al. (2006). "Performance measurement system (PMS) integration into new product innovation: A literature review and conceptual framework." Academy of Marketing Science Review **10**(7).

Kaplan, R. S. and D. P. Norton (1992). "The Balanced Scorecard measures that drive performance." Harvard Business Review **70**(1): 71-80.

Katz, D. and R. L. Kahn (1978). The Social Psychology of Organizations New York, John-Wiley & Sons.

Kerssens-van Drongelen, I. C., B. Nixon, et al. (2000). "Performance measurement in industrial R&D." International Journal of Management Reviews **2**(2): 111-143.

Krishnan, V. and K. T. Ulrich (2001). "Product Development Decisions: A Review of the Literature." Management Science **47**(1): 1-21.

Loch, C. H. and U. A. S. Tapper (2002). "Implementing a strategy-driven performance measurement system for an applied research group." The Journal of Product Innovation Management **19**(3): 185-198.

Marxt, C. and F. Hacklin (2005). "Design, product development, innovation: all the same in the end? A short discussion on terminology." Journal of Engineering Design **16**(4): 413-422.

McGrath, M. E. and M. N. Romeri (1994). "FROM EXPERIENCE The R&D Effectiveness Index: A Metric for Product Development Performance." Journal of Product Innovation Management **11**(3): 213-220.

Neely, A. (2007). Business performance measurement. Cambridge, Cambridge University Press.

Neely, A., M. Gregory, et al. (2005). "Performance measurement system design: A literature review and research agenda." International Journal of Operations & Production Management **25**(12): 1228-1263.

Neely, A., J. Mills, et al. (2000). "Performance measurement system design: developing and testing a process-based approach." International Journal of Operations & Production Management **20**(10): 1119-1145.

Neely, A. and M. A. Najjar (2006). "Management Learning Not Management Control: The true role of performance measurent?" California Management Review **48**(3): 101-114.

Nixon, B. (1997). "Conference report: Performance measurements for R&D." R & D Management **27**(1): 87-90.

O'Donnell, F. J. and A. H. B. Duffy (2002). "Modelling design development performance." International Journal of Operations & Production Management **22**(11): 1198-1221.

O'Donnell, F. J. and A. H. B. Duffy (2005). Design Performance. London, UK, Springer Verlag.

Paranjape, B., M. Rossiter, et al. (2006). "Performance measurement systems: successes, failures and future - a review." Measuring Business Excellence **10**(3): 12.

Pun, K. F. and A. S. White (2005). "A performance measurement paradigm for integrating strategy formulation: A review of systems and frameworks." International Journal of Management Reviews **7**(1): 22.

Rubinstein, A. H. (2004). "50 Years of Engineering and Technology Management." IEEE Transactions on Engineering Management **51**(4): 407-408.

Senge, P. M. (1990). The Fifth Discipline, the Art & Practice of Learning Organizations. New York, Currency Doubleday.

Sink, D. S. and T. C. Tuttle (1989). Planning and Measurement in your Organization of the Future. Norcross, GA, Industrial Engineering and Management Press.

Syamil, A., J. Doll William, et al. (2004). "Process performance in product development: measure and impacts." European Journal of Innovation Management **7**(3): 205-217.

Szakonyi, R. (1994). "Measuring R&D effectiveness - I." Research Technology Management **37**(2): 27-33.

Tang, V., B. Liu, et al. (2005). Enabling factors in successful product development. International conference on engineering design. Melbourne, Australia.

Ulrich, K. T. and S. D. Eppinger (2003). Product design and development Singapore, McGraw-Hill Education.

Yin, R. K. (2003). Case Study Research: Design and Methods. Thousands Oaks, California, Sage Publications.