Process Performance Improvement

An Industrial Case Study for Improving and Measuring the Outcome of Cost Reduction Projects

Master of Science Thesis in the Master Degree Programme Supply Chain Management

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Abstract

Due to hard price-pressure within the automotive industry, attention has been growing for cost-reduction projects. In order to achieve the full savings potential from these projects it is of importance both to work with the right projects and also to conduct the projects according to the plan. At the case study company there is although an experience of general problems with keeping the time-plans for the projects, which reveals lacks in how the process is currently carried out.

To be able to make recommendations for improvements of the current process the first step taken in this thesis is to map the current process in order to create knowledge about how the process is carried out in practice. With this as a baseline, the history if projects is analysed and categorised in order to distinguish which types of projects that historically has been unsuccessful. This then results in a mapping of the projects for a deeper investigation of the unsuccessful projects in order to find what parameters in the projects that are affecting the outcome.

This analysis showed that there are not a specific type of projects that more often is unsuccessful, instead there are parameters regarding how the process itself is conducted that affects the outcome. In order to improve the performance of the process, six different areas are identified as critical in this thesis. The six areas recommended to improve are *gate-requirements, time-plans, cross-functional work*, implementation of *additional goals for increased cooperation*, enhanced *knowledge transfer* and *measurement of time for activities*.

Key words: process mapping, project portfolio management, Stage-Gate process, project planning, performance measurement, knowledge transfer

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Hanna Axelsson and Charlotte Christiansson
Göteborg, 2013-05-23

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Abbreviations

CE – Cost Estimator

CMT - Cost Management Team

CO - Change Order

DPL - Deputy Project Leader

DRMS - Design Review Meeting Section

J1- Job 1

I&C- Interior and Climate

KPI - Key Performance Indicator

KRI - Key Results Indicator

KU - Task Leader

LS - Launch Start

MCEM- Material Cost Executive Meeting

PA – Project Approval

PCR – Project Cost Review

PI - Performance Indicator

PL - Project Leader

PS - Project Start

PSC - Project Strategy Confirmed

PTCC- Program Target Compatibility Checkpoint

RCD - Running Change Database

RCP - Running Changes Process

RI - Results Indicator

R&D - Research & Development Unit

VCC - Volvo Cars Corporation

SP - Support Plan

SU - System Leader

TARR - Time Adjusted Rate of Return

TVM - Total Value Management

VPC - Volvo Parts Concern

1 Introduction

Volvo Cars Corporation (VCC) is an automobile manufacturer that was founded in 1927 in Gothenburg, Sweden. The company has a long history of world known innovations within safety engineering, such as the 3-point safety belt, and is always striving to develop further. Today Volvo Cars is owned by the Chinese Zhejiang Geely Holding Group (Volvo Cars Corporation). The production of Volvo Cars is divided between Torslanda, Sweden and Gent, Belgium and in addition some minor parts are produced in Uddevalla, Sweden. Volvo Cars main office is located in Torslanda, which also is a place for other important units such as test centres, central warehouse and several different development departments (Volvo Cars Corporation).

The car industry is characterized by fierce competition, and in order to maintain customers and sales margins there is a need of price pressure on both components and in the own production. This has led to more focus on cost rationalizing activities within VCC. The cost rationalizing projects for components are carried out within the Research & Development unit (R&D). Within the R&D unit at Volvo Torslanda, a department called Interior & Climate Engineering (I&C) is located, which is responsible for the development of the interiors in Volvo cars and conducts several R&D projects every year. One of the tasks for this department is to develop cost rationalizing proposals, which is coordinated by the section Quality & Ratio Development[1]. The process for conducting the cost rationalizing projects, known as the ratio process, is the process on which this thesis will focus.

1.1 Background

Quality & Ratio Development is a section that performs ratio and quality improvement projects. The ratio projects concerns cars that are already in production, with the aim to lower the costs for existing components in the cars. Each department within the R&D unit performs their own ratio projects, which means that the ratio process within I&C only conducts projects that are connected to the components for which they are responsible.

Within the I&C department, between 100-200 projects are carried out each year. These projects are conducted by one of the five different sections located within the I&C department. The length and characteristics of the projects differ widely; some projects are performed in a time span of a couple of weeks while some may be on going for a couple of years. In the two following subchapters, a short description of the organization and the ratio process is given.

1.1.1 Organization

The ratio process at I&C is embedded in an organization in which the highest level is the R&D unit. The R&D unit reports directly to the CEO at VCC. The department

[1] Anders Sandberg, DPL Ratio & Quality Development, Volvo Cars Corporation, communication between January and May (2013)

that is responsible for ratio process within R&D is called Cost Management Team (CMT) and is located within a unit called Program Management. This is also the department that the project leader (PL) for the ratio projects is adherent to (Volvo BMS).

At the I&C department there are five different sections; interior trim, seats, cockpit & surface material, climate control systems and restraints. Each section is as mentioned responsible for a specific system in the car, and each section is structured into a varied number of groups. Each group is in turn responsible for the development of specific components or parts in the system. The project units at I&C are Strategy & Concept Development and Quality & Ratio Development (Volvo BMS).

The Quality & Ratio Development has one person employed that is working with ratio projects, which is the deputy project leader (DPL) who is responsible for organizing and following-up parts of the ratio process. The ratio projects are conducted by task leaders from the different sections, however other functional areas such as Design, Purchasing, Manufacturing and Finance are also involved. The number of employees that are working with ratio projects on a department level depends on the size of the budget that is allocated to Quality & Ratio Development from CMT. The number of employees dedicated for ratio projects in the different sections also differs dependent on how many employees the section manager wants to dedicate to ratio work, which often is dependent on the number of projects that are on-going at the section. The employees working with the projects are as mentioned named task leaders - component (KU). Most projects conducted at Volvo Cars use a project hierarchy with a project leader on top. The deputy project leader coordinates projects at department level and then reports to the project leader. The DPL has also a close relationship with the system leader (SU), which in turn coordinates the projects at section level and collects project information directly from the KU. The project hierarchy for the ratio process within I&C although differs a bit, instead of using SU the KUs reports directly to the DPL. The two different project hierarchies are shown in figure 1.

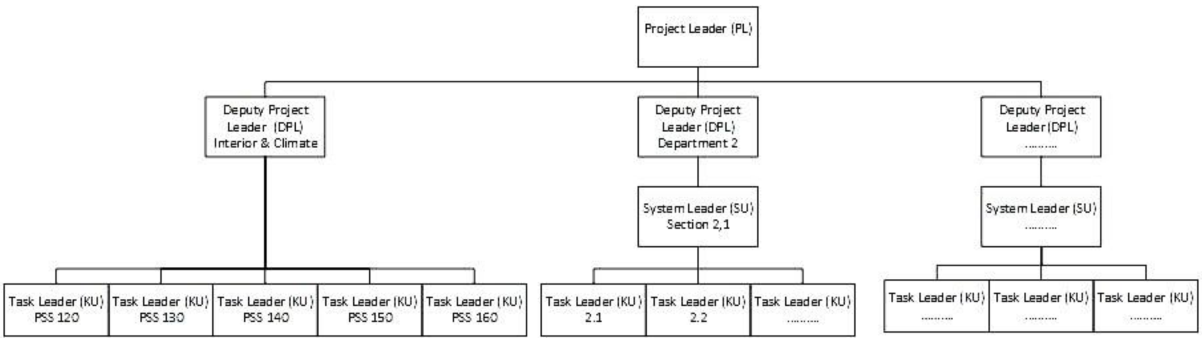

Figure 1: Project organization[2]

[2] Anders Sandberg, DPL Ratio & Quality Development, Volvo Cars Corporation, communication between January and May (2013)

1.1.2 The Ratio Process

The ratio projects performed by I&C can be divided into three phases; *idea generation, development phase* and *industrialisation phase*. The first phase conducted is in responsibility of the department Total Value Management (TVM) which in collaboration with Purchasing and I&C develops ideas for cost reduction projects. The development phase is conducted by the different sections within I&C under responsibility of CMT. During this phase there are three different gates which the project needs to pass in order to proceed in the process. In order to pass these gates, the developments and the estimated savings must be approved by the project leader. The CMT has expressed problems with gate-timing, which means that the ratio team have difficulties to keep deadlines. Phase three is called the Running Changes Process (RCP) and is also within the Quality & Ratio Development unit. During this phase the changes are implemented in production, but before the changes are permanently implemented, test series are conducted in order to make sure that no problems occur.

Today the ratio team has a process description for every part of the process, and uses a certain number of KPIs to measure the projects' performance. Although, the department experience problems with a wide variation range of project results and find it hard to predict the outcomes especially in the early stages of the project. Due to these problems the I&C department has expressed a wish for an analysis of their current project process.

1.2 Purpose and Research Questions

The initiation of this thesis was an expression from the I&C department at VCC to investigate the process for ratio developments. Reasons for the investigation was experienced problems with gate-timing, long project lead-times and lacks in resource efficiency. The scope further developed during the first meetings to also include recommendations for follow-up, mainly recommendations for how the project pace could be measured since it is experienced as a missing piece today. Based on the problems described above, the purpose of this thesis was defined as:

The purpose of this thesis is to suggest improvements for the ratio process. The proposed improvements should result in improved resource efficiency, reduced lead-time, improved precision for gate timing and possible KPIs for project pace.

Process descriptions for how the work should be carried out are today available at VCC. What although remains unclear is how the work is carried out in practice, since it is unsure to what extent these process descriptions are followed. Further on, in this thesis process mapping will be used as a support in order to improve the process. When using process mapping as a way to improve processes, the first step is to map the current process. This should be done in order to identify the critical points in the process (Kalman, 2002). Based on this the first step will be to map the current process and compare it with theoretical frameworks for product development in order to enable searching for lacks and improvement potential. This resulted in the first research question of this thesis:

RQ1: How does the current process look regarding persons involved, follow-up, activities carried out and how are they related to each other? Are there any differences between how the process is carried out at VCC and how it is advocated in theory?

When a picture of the current situation is achieved, lacks in the current process must be defined in order to see what could be improved. Since the number of projects carried out is high it would be time-consuming to look deep into all of them. An attempt will therefore be made to define what projects that are the problematic ones. It is also mentioned by Rother and Shook (2003) that it is too complicated to map everything that passes through the process. Therefore a selection must be made before conducting a deeper analysis. In order to find a category of projects that are problematic, the history of the projects that has been carried out must be investigated. These circumstances resulted in the second research question:

RQ2: What kinds of projects are carried out? Is it possible to find common characteristics for projects that are unsuccessful?

The wish of the second research question is to make an attempt to find common characteristics for the unsuccessful projects. If that is impossible, the wish is to define which projects that have been unsuccessful. When having made this definition, a deeper investigation of these projects will reveal what circumstances and actions during the process that has caused them to fail. In order to define what circumstances that has been the affecting ones, a comparison will be made with the projects that are considered successful. The goal is to define the differences that make projects unsuccessful, which is summarized in the third research question:

RQ3: What problems can be found in how unsuccessful projects have been conducted? Can differences be found between how the work has been performed in successful vs. unsuccessful projects?

The differences found will result in recommendations of the best way to conduct the ratio projects, and also in what ways the process can be followed up in order to ensure that the defined problems are avoided. The fourth research question in order to support this implementation and fulfil the purpose therefore is:

RQ4: How can the work in the process be conducted in order to avoid problems and through that improve performance? What follow-up is recommended to use in order to control the project pace?

1.3 Scope and Limitations

This thesis will cover the cost ratio process at the I&C department, within the R&D unit. Therefore limitations will be restrained to Volvo Cars Corporation and cost ratio projects executed by the specific department I&C.

The work will have a focus on the second phase of the process, the development phase, since that is the phase where the company has expressed an experience of problems. This limitation means that the other phases of the process will only be investigated regarding their connection with the development phase.

When looking at the history of the projects carried out and when selecting which projects to investigate more detailed, only the projects for one of the platforms will be taken into account. The reason for this is that the calculated savings are based on the lifetime of the cars it is implemented on. Since the other platforms are being phased out, it will create difficulties when comparing the result of the projects. Due to these circumstances, a limitation for this thesis is set to only include projects concerning only one of the platforms.

1.4 Structure of the Thesis

This thesis started with an *Introduction* that involves a background describing the company and the ratio process and its embedding, see figure 2 for a depiction of the whole process. After this, the purpose and research questions were presented followed by the scope and limitations of this thesis.

In the following chapter, *Method*, the research steps will be presented in detail. How the data collection has been performed will also be described. After this, the quality of the study will be discussed based on the information presented in the chapter.

The third chapter, *Theoretical framework*, will give the theoretical foundation for this thesis. The areas included will be project management, process mapping, performance measurement and knowledge transfer. In the end of each sub-chapter, a short summary of the information presented will also be given.

The next chapter is the *Empirical findings*. In this chapter, the project organization will first be described, followed by a description about the ratio process. Both the process in general will be described and how it is performed within the different sections at I&C. After this, a deeper investigation of chosen conducted projects will be presented. In the end of the empirical findings a short summary of the information presented will be included.

In the *Analysis* chapter, the theoretical and empirical findings will be discussed. In the end of the analysis, a summary of the information that will be the basis for the discussion and conclusion is given.

The following chapter, *Discussion*, will discuss the findings from the analysis and focus on how these findings contribute to answering the research questions. The *Conclusions* from the discussion will then be summarised and presented in the last chapter.

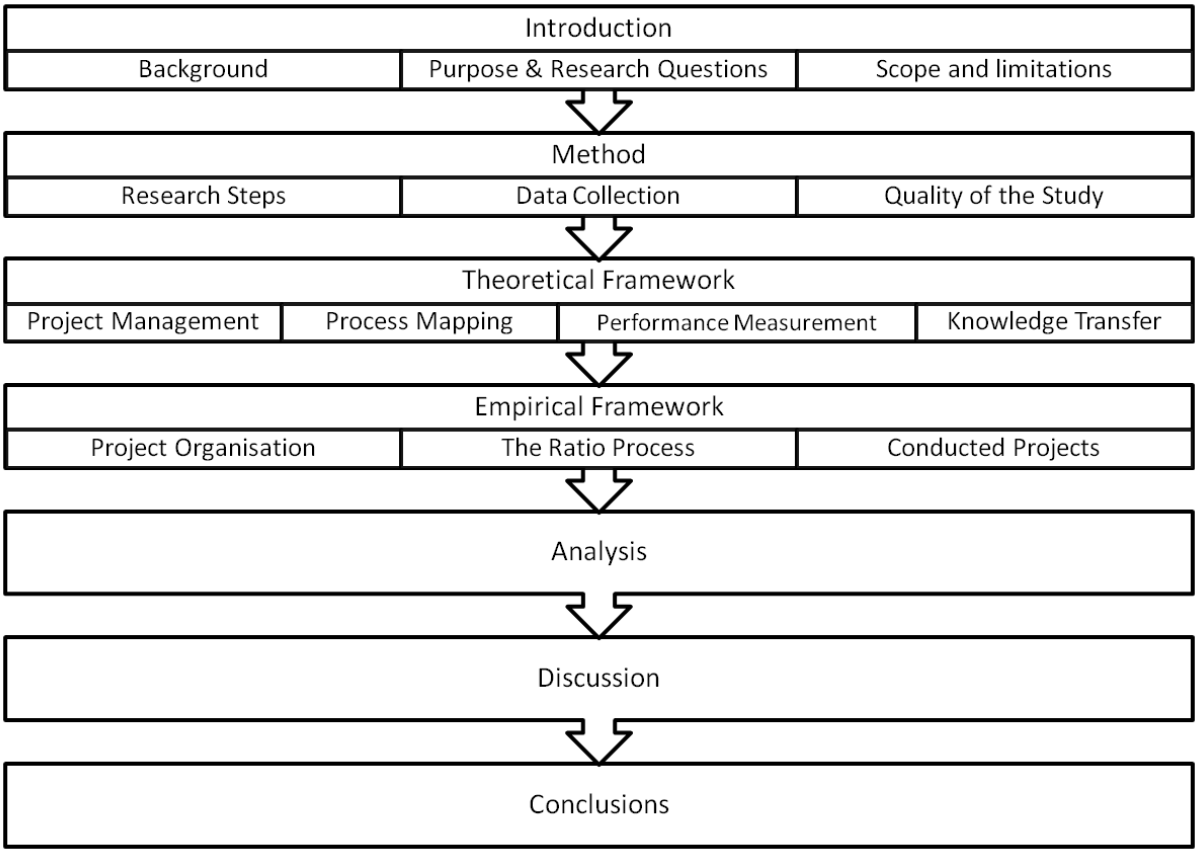

Figure 2: Structure of the thesis

2 Method

In this chapter the method used in this thesis will be discussed. This will be done by first presenting the research steps and the data collection and then finish with discussing implication regarding the quality of the study. A depiction of the method chapter is given in figure 3.

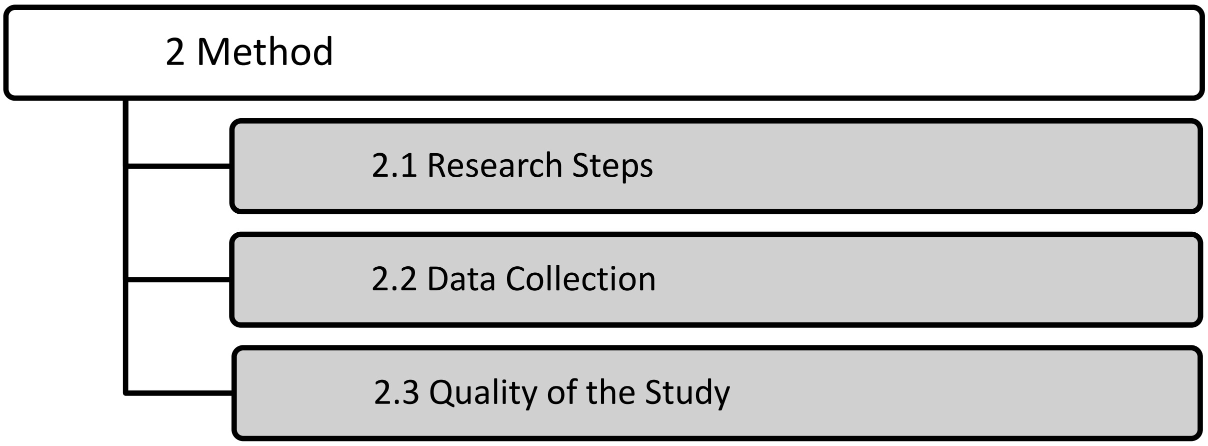

Figure 3: Structure of the Method

When performing research there exist five main research designs to choose from; experimental design, cross-sectional or social survey design, longitudinal design, case study design and comparative design (Bryman & Bell, 2011). The chosen research design provides a framework for how to collect and analyse data and the choice should be based on how different dimensions are prioritized. These dimensions include for example the importance of expressing causal relationship between variables or understanding behaviour in a specific social context. When performing a case study, a detailed analysis of a single case is conducted. Since a case study concerns the complexity and nature of the specific case and context it is suitable when investigating research questions that are connected to a certain case (Bryman & Bell, 2011). Based on this, a case study is considered to be suitable in order to fulfil the purpose of this thesis.

When linking theory and research there are several issues that must be considered, one of the main ones being whether data is collected to build theories or to test theories (Bryman & Bell, 2011). These approaches compose the two main strategies when performing research; deductive research and inductive research. When using a deductive approach, theory and hypothesis deduced from it comes first and then guides the collection of data. The data is then used in order to confirm or reject the hypothesis. A strength when using a deductive approach is that the research will be less affected by subjective perceptions of the persons performing it (Patel & Davidson, 2003). With an inductive approach, the theory is instead the outcome of observations or findings, which means that with an inductive approach the goal is to draw generalizable conclusions based on observations. Both these approaches although have weaknesses, the main weakness of the deductive approach is the lack of adapting and addressing to the empirical circumstances encountered (Polsa, 2013). This means that the research will be limited by the theories used and new discoveries may be missed. For the inductive approach, the weakness is that it may be hard to generalize the results since they are based in a certain empirical situation (Patel & Davidson, 2003).

According to Gillham (2010), one of the characteristics of a case study is that the starting point of the research is not theory. Instead the specific context is the starting point for what theories that will be most suitable to explain the case, which based on the explanation given above, would mean an inductive approach. Bryman and Bell (2011) although mentions the approach taken in a case study to be based on the characteristics of the research. If the case study is performed as a qualitative study, the approach taken tends to be inductive, while if the case study is a quantitative study the approach tends to be a deductive one. A third possible approach when conducting case studies is presented by Gadde and Dubois (2002); the abductive approach. The abductive approach means that the original theoretical framework is successively modified based on the empirical findings, which enables a deeper understanding of both theory and empirical phenomena. By using the logic of an abductive approach, drawbacks with the deductive and inductive can be avoided. Based on the facts that this is a case study with qualitative characteristics, the approach used will be an inductive one. However, by trying to use the logic of the abductive approach and iterate between the theoretical framework and the empirical data, some drawbacks with the inductive approach is hoped to be avoided.

2.1 Research Steps

The first step of the research is to perform an initial literature study (see figure 4 for a picture of the whole research process). Due to the fact that there is an uncertainty in how the process currently is carried out in practice, process mapping is evaluated to be a suitable tool for improving the process. Therefore the initial literature study focuses on process mapping, performance measurement and frameworks for product development processes with a focus on the Stage-Gate process. This is performed in order to understand the process that will be studied. Further on, research methodologies and interview techniques are also included at this first step in order to develop a basis for the research.

The research then continues with collecting empirical data about the case. This is done both in forms of interviews with persons involved and connected to the process and through documentation available at the company. The number of interviews conducted at this stage is 17. The persons chosen for the interviews are selected since they worked practically with the process, but the number of interviewees also increased during this phase based upon information found out during the initial interviews. A list of the interviews conducted in this phase can be found in appendix A. The combination of interviews and documentation means that both primary and secondary data was combined when collecting empirical data.

When both an initial theoretical framework and empirical findings had been created, the theoretical framework is extended in order to create a deeper insight into the studied case. This extension includes mainly project portfolio management, project planning and knowledge transfer. A deeper insight into the case is then successively built by iterating between the theoretical framework and the case. The empirical findings are during this stage extended to include also categorisation of conducted projects. The logic of the research at this step can therefore be seen as following the abductive approach.

The third step of the research is then to analyse the case, which is done with help of the theoretical framework and the empirical data. At this point the empirical data is extended and deepened through more interviews with personnel responsible for the selected projects. The number of chosen projects during this step is ten. These projects are chosen to represent every section within the department, and to minimise the chance of extreme cases two projects at each section is included. The chosen projects represent projects that are defined as unsuccessful, and to cover all aspects the chosen projects represent one implemented and one rejected from each section. However, due to high workload and personnel rotation within I&C the chosen projects have to be reduced to a number of eight, which lead to that eleven interviews is conducted at this point.

The analysis is performed with a focus on the stated purpose; reduce lead-time, improve gate timing and improve resource efficiency. In addition to the analysis based in theory, comparisons are made between how unsuccessful and successful projects had been handled within I&C. The analysis and in specific the comparison is extended by further investigate the successful projects. The selected successful projects are chosen to represent projects with a high fulfilment of the parameters that are considered to be the most important and in addition represent every section within I&C. As mentioned earlier, due to the lack of resources and high personnel rotation within the department the successful projects that are chosen for further investigation has to be reduced to a number of four, which results in six interviews. In total, during the third step, 17 interviews are conducted (see appendix B for interview persons).

The fourth and last step, the result and conclusions, is to propose improvements to the current process and in addition recommend how the project pace can be measured, as stated in the purpose of this thesis.

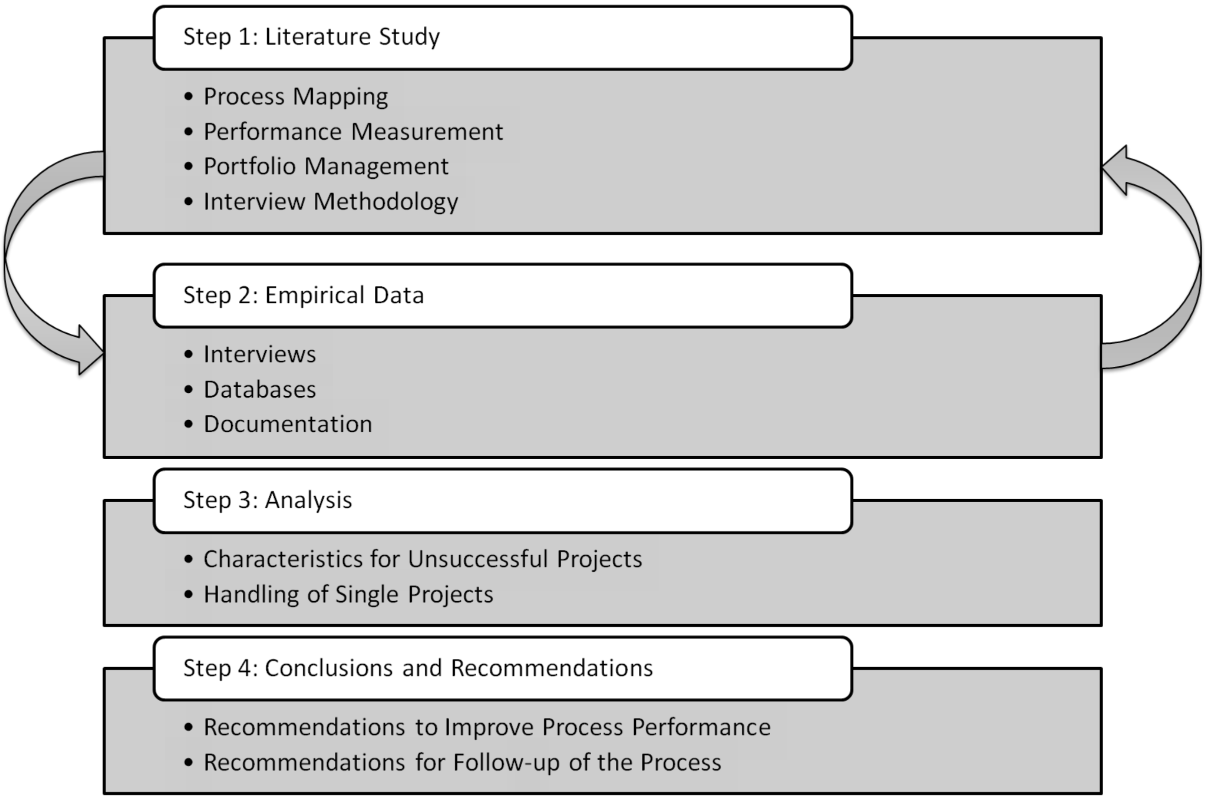

Figure 4: Picture of the Research Process

2.2 Data Collection

The data collection for both the theoretical and empirical findings will be investigated in this chapter. The main method for collection data during this thesis was through a literature study and through interviews, which also will be deeper examined. In addition other sources for data collection, such as the company's databases, process and function descriptions, are also considered in this chapter.

2.2.1 Literature study

The literature study carried out was performed in order to create a theoretical framework and was collected from books and articles. The literature search was conducted by using databases and libraries. When conducting the search in databases the key words used were: *process mapping, process improvement, performance measurement (R&D), project portfolio management, project management, project planning, knowledge transfer (R&D)* and S*tage-Gate process*. In addition the supervisor of this thesis supported with relevant literature.

2.2.2 Interviews

Interviews with personnel involved in the ratio process were the main source for empirical data regarding the process. Interviews were conducted in several steps during the research, the initial interview stage was performed in order to get a view of how the work in the process was carried out. Interviews performed later during the research had the purpose both to validate the identified issues, but also to look deeper into selected projects.

When performing interviews either a qualitative or quantitative approach can be used, the simplest distinction between the two being that quantitative data is measurable while the qualitative is not (Bryman & Bell, 2011). The qualitative research can be defined by having an understanding and deepen knowledge concerning the studied problem while quantitative research is about gathering information from statistics and numbers. In addition, Bryman and Bell (2011) also mentions that the quantitative approach aims to give a more general view while the qualitative provides knowledge and details about a specific topic.

In this thesis, the first step when collecting empirical data started with gathering information about the ratio process within the I&C department. This was done in order to understand and interpret the problem. The suitable approach therefore was to use a qualitative research. Lantz (2007) also mentions that if the information about the studied problem is inadequate it is uninteresting to quantify the collected data, which further supported the use of a qualitative approach when conducting interviews.

The qualitative interview approach tends to be less structured and more flexible than a quantitative approach which contributes to provide for a more general understanding of the problem (Bryman & Bell, 2003). A flexible and less structured interview approach was suitable for this work in order to be able to capture the interviewees' point of view and respond to in which direction the interview is proceeding. As opposed to quantitative interviewees the qualitative approach tends to lead to more than one interview (Bryman & Bell, 2011), which also was the case in this thesis.

When performing qualitative interviews, no set schedule of questions is followed. Instead the interviewer is following a guideline to various extents, depending on what type of interview that is performed (Trost, 2010). The two main types of interviews in qualitative research are called unstructured or semi-structured interviews (Bryman & Bell, 2003). The unstructured interview typically only consists of some bullet points or topic areas that the interviewer wants to cover and the interviewee then respond freely. Follow-up questions on topics that are considered to be of interest can also be asked. In a semi-structured interview, the interviewer has a list of rather specific topics that should be covered but the respondent has large freedom in how to answer the questions. This list of topics is called an interview guide. Further on, if topics of interest occur during the interview that is not part of the interview guide, they will also be included (Bryman & Bell, 2003). In this way the semi-structured interview is still flexible. It should also be flexible regarding the order of the questions in the guide, however the idea with a semi-structured interview is still to use similar questions for all interviewees.

The interviews performed during step one in this research were based on the above reasoning performed as semi-structured interviews, see appendix C for the interview guide. This was due to the fact that the focus of the interviews was made clear to be the ratio process and the way the work was carried out in that department. It also enabled the interviewers to use the knowledge about what the company has experienced as problematic and put more focus on these issues. For the interviews conducted in the later stage of the research, the subject was narrowed down to consider single projects. However, semi-structured interviews were still used since the knowledge about these projects was limited. What is of importance to consider is that the questions are not too narrow, in that case they may close the opportunity to detect issues that was missed when writing the interview guide (Ryan, 2004). In this specific research it meant that the questions did not only focus on the already known problems and reasons that they occur, since that may have meant that undetected problems were still remaining. By using questions that gives the interviewees freedom on how to response, an attempt to avoid this issue was done. The interview template developed for the second stage of interviews can be seen in appendix D.

2.2.3 Other sources

Other sources for collecting empirical data were both the company's business system, where process descriptions and functional descriptions could be found. Further on, documents from individuals working with the process and from the company's database E-tracker were also used. These documents included historical data about the performance of the process. In addition, data about the different projects performed was also collected from the database E-tracker. This data contained detailed information about the projects such as estimated time-plans, responsible persons, estimated savings and costs, and the outcome of the specific project.

2.3 Quality of the Study

The quality of the research will be discussed upon validity and reliability. In qualitative studies, the validity is discussed regarding the whole research process, which is done in order to interpret and understand situations and describe the findings that are made (Patel & Davidson, 2003). The reliability in qualitative research is close to validity, due to its important to capture the uniqueness situation and acknowledge the variation in the findings (Patel & Davidson, 2003).

The case study research is limited to the ratio process at the department I&C, which creates a discussion regarding the research's generalizability. According to Bryman & Bell (2011) there is not possible to generalise a single case study to be representative in order to draw any generalised conclusions. Instead, the research focus has been on this specific case and to gain deeper understanding of its specific complexity. This knowledge can however, contradictory to earlier statement, lead to generalisation but then only to other similar situations and contexts (Patel & Davidson, 2003).

The research is evaluated regarding its validity, which reflects on if the research actually measures what it is supposed to measure (Bryman & Bell, 2011). The data collection for the empirical study has been through triangulation (Patel & Davidson, 2003), and therefore been collected from different sources such as interviews, observations and previous documentation. This information is then used to create a whole picture, thus including both similarities and dissimilarities.

Additional triangulation, which validates the research further(Patel & Davidson, 2003), is that the interviews have been conducted with personnel with different responsibilities that work at different sections within the ratio process. This diversity has increased the validity of the research because the processes have been reviewed from several different perspectives. Every interview was recorded which gives the possibility to listen and repeat the given answer but during interviews there is always a possibility of misinterpretation, in both directions. It depends on how the interviewed person interprets the question but it also depends on how the interviewer interprets the answers.

All interviews have been conducted in a semi-structured way with the help of an interview guide. This interview approach gives each interview the possibility to go in different direction which can give inconsistence data and therefore affect the research validity. To avoid data inconsistence or to distinguish the differences the collected data was confirmed by asking additional questions afterwards and following up given answers.

3 Theoretical Framework

The theoretical framework is divided into four different parts, each of the parts ending in a summary. The structure can be seen in figure 5.

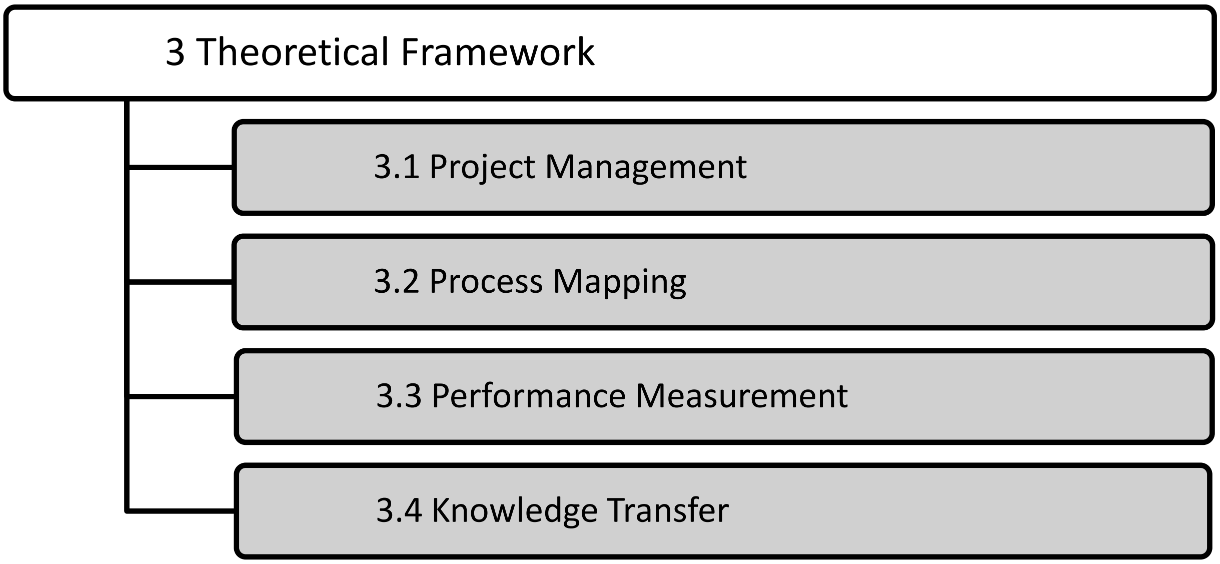

Figure 5: Structure of theoretical framework

3.1 Project Management

In this part an overview for how to conduct a product development project will be given. This includes frameworks for product development processes, with a focus on the Stage-Gate process, project portfolio management and selection of projects, and project planning.

3.1.1 Frameworks for New Product Development Processes

Three different frameworks for how to conduct new product development processes will be presented in this sub-chapter. These frameworks are based on linear, recursive and chaotic system perspectives, and therefore give different insights and descriptions about new product development processes (McCarthy et al., 2006).

Linear Framework

The linear framework for product development processes can be seen as a series of activities or stages which are orderly and conducted in sequence (McCarthy et al. 2006), see figure 6. A linear framework tends to explain the process in a logical way which eases the process complexity and the managerial challenges (Clift & Vandenbosch, 1999). The linear framework focuses on the process structure and describes how the process affects areas such as product quality, product development costs and execution of key tasks.

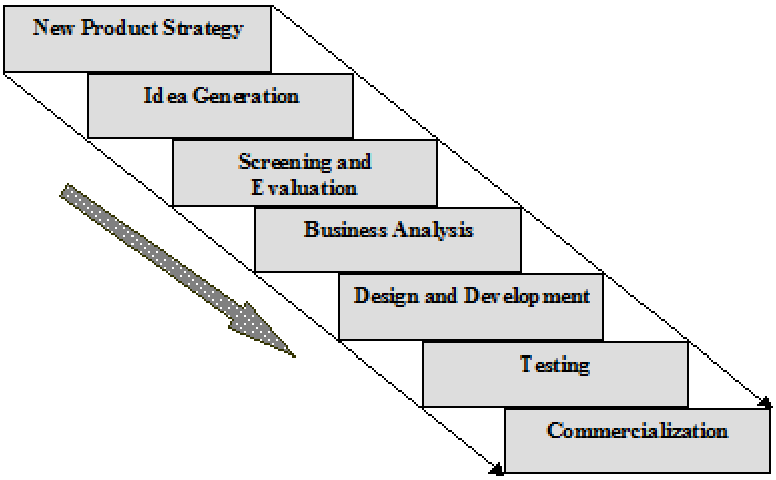

Figure 6: Linear framework for new product development process adapted from Booz et al., 1982

The linear framework is suitable when conducting incremental innovations and provides a simple and specific explanation regarding the logic in product development process (Adams, 2003). On the other hand one of the drawbacks regarding linear framework is that it tends to ignore different behaviours, such as complexity and iteration in the innovation process (Adams, 2003).

Recursive Framework

An alternative to the linear framework for product development is the recursive framework, which suggests that even though the process can be seen as consisting of different events or stages, it cannot always be described as a linear process (Adams, 2003). Instead, the different events can occur at any time during the innovation process and the recursive framework therefore suggests a more disorderly chain of events, where boundaries between events also are less clear.

One of the first recursive frameworks was presented by Kline and Rosenberg (1986); the "chain-link model". In the "chain-link model" there is not one major path of activities, instead there are five different paths of activities, which includes five different elements (see figure 7). Feed-back loops are also built into this model. For example, the first path of activities in this process begins with *Potential Market* needs, and then continues through the elements in the order as they are presented in path A to *Distribute and Market*. The second loops of activities are then a feed-back loop from perceived market needs back to design, path B.

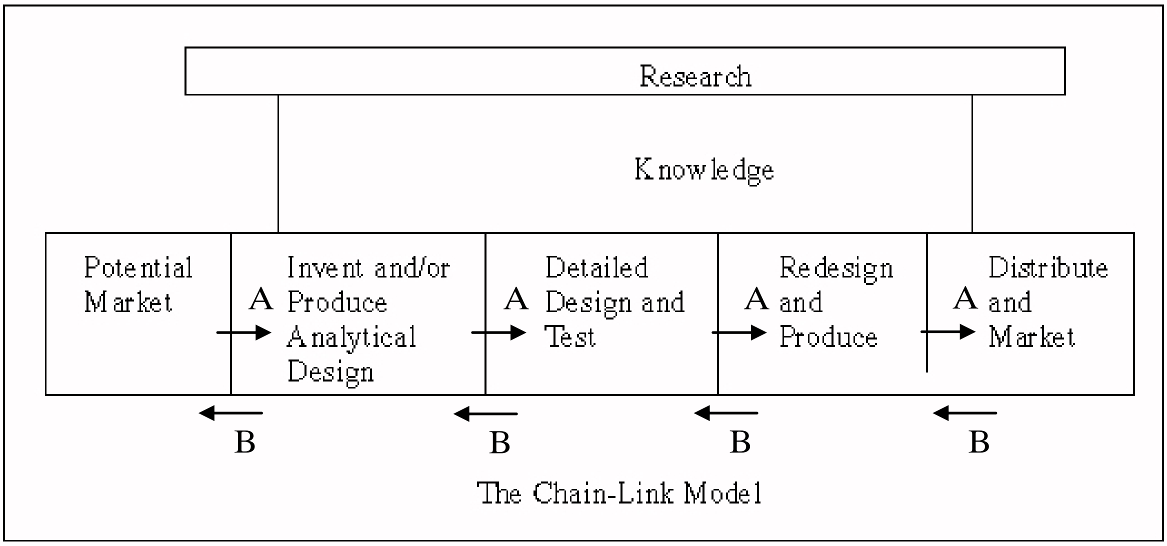

Figure 7: Recursive framework adapted from Kline and Rosenberg (1986)

Recursive frameworks contradict the orderly sequences in the innovation process, and are better suited to understand complex or radical innovations (Adams, 2003). According to McCarthy (2006), the recursive framework also better represents the dynamic nature in an innovation process. However, a drawback with this framework is that the recursive framework still assumes similar behaviour during the whole process.

Chaotic Framework

The chaotic framework describes the product development processes as nonlinear and random with chaotic characteristics and is developed from the recursive model (Koput, 1997). According to Cheng and Van de Ven (1996) product development processes have a chaotic behaviour in the beginning of the process while the later process phases have a more linear behaviour. Although, it is difficult to distinguish at which point the pattern changes from chaotic to linear.

The chaotic framework is appropriate to use when searching for radical innovations due to its ability to consider the different behaviours that can occur during the new product development process (McCarthy et al., 2006). The chaotic framework can be limited because it can be hard to implement and operationalize (Adams, 2003) and according to McCarthy et al. (2006), the framework focuses on differences between the process stages but still assumes that the process as a whole always is the same.

Choice of Framework in Product Development

The three frameworks presented above and its benefits and drawbacks are summarized in table 1. Since the linear framework is suitable for incremental changes, which the majority of the projects in the ratio process are, it is appropriate to examine this framework in more detail.

Table 1: Benefits and drawbacks with different frameworks in product development

Framework	Benefits	Drawbacks
Linear	Gives a simple and specific explanation of the process. Suitable for incremental changes.	Ignore different behaviours, such as complexity and iteration, in the innovation process.
Recursive	Better representation of the dynamics in the innovation process, especially for complex and radical innovation	Assumes similar behaviour during the whole process.
Chaotic	Consider different behaviour during the process, especially for radical innovations.	Hard to implement and operationalize. Assumes the process as a whole always is the same.

3.1.2 Stage-Gate Process

The most well-known linear framework is the Stage-Gate process presented by Cooper (McCarthy et al., 2006). The Stage-Gate process is a conceptual and operational model that can be used as a guide for a new product's process, from ideas and through all steps until it becomes a new product (Cooper, 2001). The Stage-Gate process gives an overview of the new product process and can be used as a help to manage, direct and accelerate the product development process and therefore improve both the process effectiveness and efficiency.

According to Cooper (1998) the Stage-Gate process can be divided into a certain amount of stages, each stage has specific activities that should be carried out. Each stage should be cross-functional; hence there are no stages where solely one department is involved. The reason for this is that it is critical activities during a development process may fall into several different functional areas. For the project to proceed in the process a gate has to be checked and approved before entering the next stage. The gates are decisions points for the project, and checks quality, prioritize and determine if the project should continue or not (Cooper, 1998). The group that decide if the projects should continue or not is called the gate-keepers. The gate-keepers must have the authority to allocate resources to the project, and further on they should represent different functional areas such as R&D, Marketing, Purchasing and Operations (Cooper, 2001).

At each gate the project should be able to deliver a set of required deliverables that is given for the specific gate and through that meet management requirement (Cooper, 2001). Every gate should also have predetermined criteria, which the proposed project needs to fulfil in order to proceed in the process. The decision at each gate should have a defined output in terms of to continue the project or not, or if the project should be put on hold. If the project is proceeding the output should also consist of an action plan (Cooper, 2001).

Every stage has activities that need to be done to be able to pass the gate and move further in the process (Cooper, 2001). The Stage-Gate process has usually four to six stages and can be divided in *discovery, scoping, building the business case, development, testing and validation* and *launch* (see figure 8). This is a typical model for the Stage-Gate process, which will be described in detail including both stages and gates.

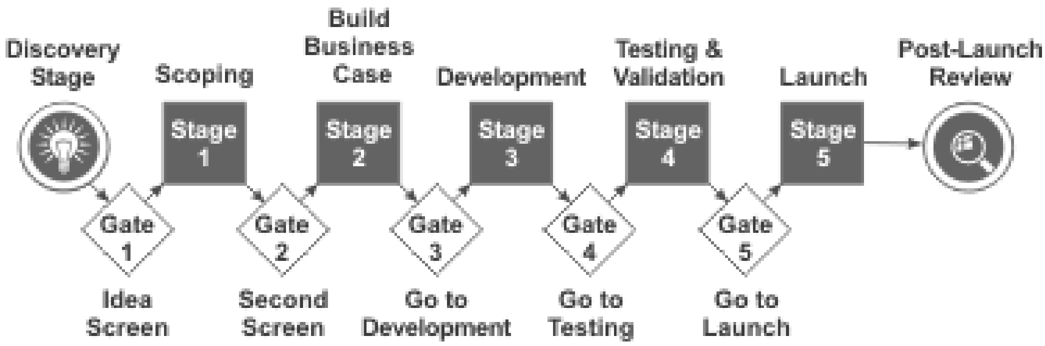

Figure 8: Example of the Stage-Gate process (Cooper, 2001)

Begin Stage: Discovery

Discovery is the first stage in the Stage-Gate process, and is dedicated to generate ideas and discover opportunities (Cooper, 2001). This activity is critical because it activates the whole process and is the input, it is therefore of importance for a company to generate many ideas. Due to the importance of new ideas, many companies have a formalized stage for this, which could include activities such as working with users to identify needs or exercises to identify gaps and opportunities in the market place.

Gate 1: Idea Screen

At the first gate, idea screen, decisions are taken regarding if the idea is worth investigating (Cooper, 2001). At this gate the criteria such as project's market opportunities, technical feasibility, and alignment with the company's strategy are considered. At this gate, the focus on the financial aspects is limited (Cooper, 1998). A check-list for what criteria that must or should be met can be used as a help to focus the discussion and rank the projects at this early gate in the process.

Stage 1: Scoping

Scoping is the second stage, which means a quick and relatively inexpensive investigation of generated ideas to see if the project is feasible (Cooper, 2001). This step involves desk research but no primary research. Due to the limited effort that is put in this stage, it can often be handled by a few persons, for example from a technical group and from marketing. The purpose of this stage is to estimate size, potential and acceptance on the affected market but also to create a preliminary technical assessment of the proposed project. In addition, a rough estimated financial analysis together with a risk assessment should be carried out (Cooper, 1998).

Gate 2: Second Screen

The second gate is more or less a repetition of the first gate, but the project is re-evaluated with a stricter consideration to the criteria (Cooper, 2001). Further on, information collected during the first stage may also have resulted in additional criteria that are weighed in at this point. Additional project information, gathered during the first stage, is reviewed and assessed to be able to decide if the project can continue or not. In similarity to gate 1, a check-list of must or should meet criteria can also be used here.

Stage 2: Build Business Case

According to Cooper (1998), building the Business Case is the first stage in the Stage-Gate process where the project becomes an actual business case, which needs to be done before any heavy spending. During this stage a detailed project investigation is conducted considering both market and technical aspects. Market research and market surveys could also be included in stage 2. The result should provide for a detailed product and project description and an additional project plan (Cooper, 1998). Compared to stage 1, stage 2 requires considerably more effort and also input from a variety of sources. Therefore, this stage should be handled by a cross-functional team. Cooper (2001) also mentions that this is the stage that is most often weakly handled.

Gate 3: Go to Development

At this gate, go to development, a final review of the project before allowing financial commitments is carried out (Cooper, 2001). Due to the fact that spending is substantial after this stage, the financial analysis is of uttermost importance. The business case review further evaluates the activities conducted during stage two. The project is approved to continue if the execution is satisfying and the results are positive. The project may also again be evaluated against the check-list of must-meet criteria at this point. A time-plan for development, operations and marketing are revised and approved at this gate. Furthermore, a cross-functional project team should be designated at this gate.

Stage 3: Development

During the Stage-Gate process third step, development, several activities are conducted. The technical development is an iterative process together with the market-analysis and customer-feedback (Cooper, 2001). A financial analysis for the project is updated with accurate information and at the same time the production and commercialization design are developed.

The development phase ensures that the proposed product meet requirements under controlled conditions, which could be done for example through in-house tests or lab tests. For long projects, milestones in the development plan could also be formed during this stage. The difference between the milestones and the gates is that while the gates makes kill- or go-decisions, the mile-stones is there to ensure that the project keeps on track regarding time. The output from the development stage is a lab-tested prototype of the product.

Gate 4: Go to Testing

According to Cooper (2001) gate 4, go to testing, controls the development of the project, which means that the project is reviewed in terms of expected outcome and progress considering both technical and financial aspects. A review of the project and market attractiveness is done here, as well as an updated financial analysis based on the more accurate data achieved at this stage. Further on, the product is checked in order to fulfil the specifications regarding time-plan for development, marketing and operations set up at gate 3.

Stage 4: Testing and Validation

During the stage, testing and validation, the project is verified and validated by testing the new product, its production process, market acceptance and financial aspects (Cooper, 2001). The product itself is tested in order to verify its quality and performance fulfilment both under controlled and actual use conditions. The market acceptance is tested to see customers' reaction on the new product, and determine expected market share and revenues from given project. Pilot production could be performed in order to find bugs in the production. All this tested and validated information will reflect the viability of the projects economics, and be the basis for a revised financial analysis (Cooper, 2001).

Gate 5: Go to Launch

If the project is approved at the final gate, go to launch, the next step would be to implement the new product (Cooper, 2001). Hence, this is the last gate when the project can be killed. This gate focuses on the quality of the results given by the testing and validation phase. The criteria for this gate have a focus on the project's financial aspects, both expected return and revenue.

Stage 6: Launch

This is the final stage in the Stage-Gate process, which involves implementation of the project (Cooper, 2001). Launching the new product involves full production together with marketing plan.

Post Implementation Review

The post implementation review is the last activity in the Stage-Gate process. This activity evaluates the implemented product and its performance, and provide for future lessons. This is done at a point approximately 6-19 months after the launch, when the new product can be seen as a "regular product" in the product line.

3.1.3 Project Portfolio Management and Selection of Projects

In order to generate profit from new product development it is of great importance to spot the profitable projects early in the process and to focus resources on the right projects (Cooper, 1998). In general, there are far more project opportunities than there exists resources to proceed with. If too many projects are conducted at the same time the result can be that projects take too long time, many projects are in a waiting queue and there is a lack of focus. In order to be able to narrow down the number of projects it is important that the gates are working. There are three main approaches to how the selection at the gates can be performed; benefit measurement techniques, economic models and portfolio management methods (Cooper, 1998).

Benefit measurement techniques excludes regular economic data, such as profit margins and costs, and instead puts focus on subjective assessment of strategic variables (Cooper, 1998). That could mean for example fit with corporate objectives. In order to make a relevant assessment a well-informed management group is required, that scores the project on several characteristics. The projects are then ranked according to these scores. Since benefit measurement techniques excludes economic data it is most suitable in the beginning of the product development process, since economic data is unknown at that stage.

Financial or economic models are similar to regular investment models; hence methods such as payback period and return on investment are used. It is recommended to use these methods but there must be an awareness of potential weaknesses of the methods (Cooper, 1998). The weaknesses stems in the lack of reliable financial data. In addition, the projects are with these methods treated as single projects, which can proceed if an economic limit is passed, and no consideration is taken to the overall resource allocation. Financial or economic models are in general the most popular ones, but due to lack of reliable data they may not be suitable to use, especially in early stages of the process. According to Cooper (1998), it is therefore recommended to use these methods, but not solely.

The third approach, portfolio management methods, considers the entire set of projects (Cooper, 1998). Portfolio management includes methods to maximize the total value of the portfolio, e.g. expected commercial value methods, methods to ensure the right balance of the portfolio, e.g. bubble diagrams, and methods to achieve a strategically aligned product portfolio, e.g. strategic buckets method. When using bubble diagrams, also known as portfolio maps, it is possible to achieve high decision effectiveness and also to achieve strategic alignment. On the downside are difficulties to deal with the number of projects and resource allocation.

In contrary to the earlier two approaches mentioned, portfolio management is not a method to evaluate single projects but instead a method for how to prioritize and allocate resources among a set of projects. According to Mors et al. (2010), portfolio management is commonly used in order to make a screening and selection of project proposals and to prioritize among running projects. However, it is less commonly used in order to track the realized benefits from already performed projects. By devoting time to follow-up the outcome of earlier projects, it is possible for companies to improve their screening and selection process.

Portfolio Management

When working with portfolio management there are three main objectives (Cooper, 1998). The first one is *value maximisation*, which means that the value of the whole portfolio should be optimized based on a certain objective, which for example could be return on investment. The common weakness with value maximisation methods are problems with obtaining data, reliability of data and overreliance of the data. In addition, value maximisation methods fail to show if the portfolio is strategically aligned and how balanced it is. Even though weaknesses with this method exist, value maximization is still a necessary part in portfolio management in order to make sure that the single projects included in the portfolio in fact are profitable ones (Cooper, 1998).

The second objective is to achieve *a balanced portfolio*, which means that the set of development projects should be balanced according to a set of defined parameters. In order to show the balance of the portfolio it is often preferable to use visual charts, for example bubble diagrams or pie charts (Cooper, 1998). The parameters chosen in order to achieve balance should be adapted to the specific company and is dependent upon the company's strategy (Dawidson, 2006). Examples of parameters that could be used are long-term projects vs. short-term projects, high-risk projects vs. low-risk projects, different markets etc. (Cooper, 2001).

Bubble diagrams are created by plotting projects in form of bubbles on a map (Mors et al., 2010). The axis that are used in a bubble diagram can as mentioned differ upon the business, for a list of the most frequently used see table 2.

Table 2: Most commonly used parameters, adapted from Cooper (1998)

Rank	Type of Chart	First Dimension	Second Dimension
1	Risk vs. Reward	Reward	Probability of Success
2	Newness	Technical Newness	Market Newness
3	Ease vs. Attractiveness	Technical Feasibility	Market Attractiveness
4	Strength vs. Attractiveness	Competitive Position	Attractiveness
5	Cost vs. Timing	Cost to Implement	Time to Implement
6	Strategic vs. Benefit	Strategic Focus or Fit	Business Intent
7	Cost vs. Benefit	Cumulative Reward	Cumulative Development Cost

The projects can then be categorized dependent upon which quadrant of the map they are located in (Mors et al., 2010).The size of the bubbles also tells information, which for example could be the amount of resources spent on the project (Cooper, 1998). According to Cooper (1998), the most common bubble diagram to use is a variant of a risk-return chart, which has reward on one axis and success probability on the other, see figure 9.

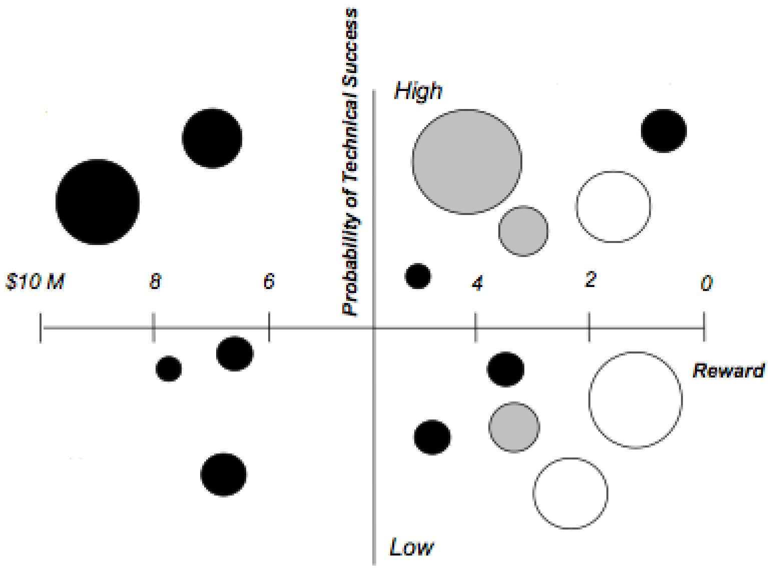

Figure 9: Example of a bubble diagram adapted from Cooper (1998)

Another way to visually present portfolio balance is to use pie charts (Cooper, 1998). Since the number of parameters for whom a company wants to achieve balance can vary endlessly, there is also a large variety of which pie charts that are used. Some of the most common parameters used are however timing, i.e. long-term and short-term projects, markets and type of projects (Cooper, 1998). An example of a pie chart representing balance regarding market segment can be seen in figure 10.

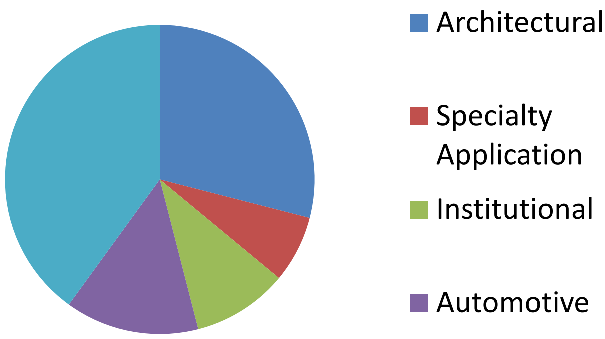

Figure 10: Pie Chart of Market Segments, adapted from Cooper (1998)

Building strategy into the portfolio is the third objective in portfolio management (Cooper, 1998). In order to achieve strategic alignment, both strategic fit and spending breakdown must be considered. Strategic fit means an inventory of the projects to see if they fit into the chosen strategy. Spending breakdown considers if the spent money reflects the chosen strategy, i.e. is the money spent on what is considered as strategic projects. Ensuring strategic alignment could be done either by building in strategic criteria in project selection or by already from the beginning setting aside money for what is considered as strategic projects.

3.1.4 Project Planning

When planning a project, time and cost are two important variables (Morris & Pinto, 2007). These variables are also interrelated, for example, exceeding a time-plan may result in reduced profitability due to later implementation and additional administrative costs. On the other hand, accelerating project can also lead to additional cost due to for example over-time work.

Scheduling Project Time

A project must in almost all cases meet a defined deadline (Morris & Pinto, 2007). This deadline can also, as described above, be important for the profitability of the project. In order to meet the deadline, a plan for what activities that needs to be carried out, how long time they require and when they should be finished is of importance. However, it is not an easy task to create a time schedule, which shows that risks of not fulfilling the time schedule in a project is the second most common risk identified when working in projects (Kendrick, 2009). There are three different categories of risks regarding not fulfilling the time-plan. The first one is delays, which can be defined as exceeding of schedule dependent on factors that are at least partly under control of the project. The second one is estimates, which means inadequate estimations of the duration of different activities. The third and last one is dependencies, which are defined as delays of the time-plan due to factors that are out of control of the project. An example of a dependency could be regulatory issues (Kendrick, 2009).

A project schedule needs to define the activities in a logical and interrelated way (Taylor, 2008). In order to achieve this, a break-down of the work that needs to be conducted should be carried out. If an activity is not identified in this break-down, it cannot be considered in the time-plan, so therefore this must be done carefully. Further on, when creating a project schedule, a distinction between activities and events could be made. An activity is a set of tasks that are in need of resources to be conducted, while an event is a point in time when an activity starts or ends (Morris & Pinto, 2007).

Several different methods for how to create a time-schedule are available, one commonly known being the Gantt-chart, which will be further described below. For complex and large projects, other useful methods include for example network representation (Morris & Pinto, 2007). However, a Gantt-chart may still be the best way to visualize the project for the different participants in the project since it is easily understood, and a mix of methods could therefore be used. For an example of a Gantt-chart, see figure 11.

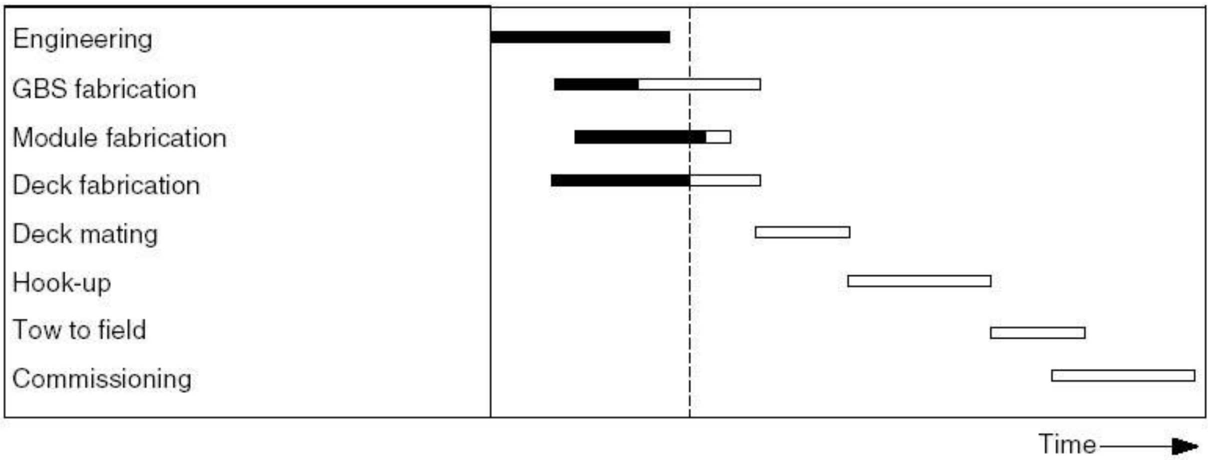

Figure 11: Example of Gantt-chart. As the activity progresses, the bar is filled. A dashed vertical line indicates the present day (Morris & Pinto, 2007)

A Gantt-chart presents the activities in a diagram with time on the x-axis and activities on the y-axis (see figure 11). Bars in the diagram shows when activities will start and for how long time they will proceed. The pros with a Gantt-chart are that it is easy to understand, hence a good communication tool. The drawback is however that no direct consideration is taken to resource constraints, which for example could affect the duration of an activity. In order to see how the duration of an activity is affected by resource constraints, both effort hours needed for conducting an activity and available working hours must be considered (Taylor, 2007).

Cost Estimation in Projects

In the beginning of a project, an estimation of the costs for different activities should be estimated. Even though these early estimation may be uncertain, these estimations can function as a basis for cost control during the project (Morris & Pinto, 2007).

Cost estimations can be done several times during a project. A distinction could therefore be made between estimations carried out in different phases of the project. This makes it possible to consider which documentation the estimation is based upon and hence which uncertainty it carries (Morris & Pinto, 2007). Cost estimations done can then be used during the project in order to control the costs (Morris & Pinto, 2007). When monitoring the costs, they should be compared to the estimations to see whether they over-run the estimations or not. By continuously updating the costs, an early awareness of too high costs is possible, and cost-consciousness can be established within the project team.

Taylor (2008) also mentions that cost estimations done early in a project are often inadequate. Some of the most common reasons for this are lack of historical project data, outdated estimating databases and reliance on intelligent guesses to estimate costs. These issues can result in guesses on costs being too low, and more effort than what should be necessary needs to be put into every cost estimating. According to Kendrick (2009), inadequate cost estimations may result in problems with funding, however it is not a common case. If problems with funding occurs it may although have great consequences, such as significantly stretch out the duration of the project, and also be a contributing cause to many other issues, such as staff turn-over which may result in lost knowledge.

3.1.5 Summary Project Management

In this chapter three different frameworks for product development processes were described; linear framework, recursive framework and chaotic framework. The different frameworks are appropriate for different settings. The linear framework is suitable for incremental changes and gives simple and specific explanation of the process, the drawback being that it ignores complexity and iteration in the process. However, due to the fact that the ratio process handles incremental changes, the linear framework is the most suitable one in this case. The most well-known linear framework is the Stage-Gate process presented by Cooper (McCarthy et al., 2006).

The Stage-Gate process is a conceptual and operational model that can be used in order to manage, direct and accelerate the new product development from idea to new product (Cooper, 2001). The process consists of a certain amount of stages, where each stage has activities that need to be carried out. For the project to proceed to the next stage, a gate must be passed. The gates are decision points for the projects, where it is decided if the project can proceed or not. Each gate should have a set of criteria that the project needs to fulfil in order to pass through the next gate. Further on, all stages and gates should be cross-functional, since critical activities during the process may concern several functional areas (Cooper, 2001).

In order to generate profit from new product development it is of great importance to spot the profitable projects early in the process and focus the resources on the right projects (Cooper, 1998). In order to narrow down the number of projects it is important that the gates in the Stage-Gate process are working. Three main approaches for how to make the selection at the gates are presented by Cooper (1998); benefit measurement technique, economic models and portfolio management methods. Benefit measurement techniques excludes regular economic data and instead put focus on subjective assessment of strategic variables. Due to the fact that benefit measurement techniques excludes financial data it is most suitable on the beginning of the process, since economic data is unknown at that stage. Economic models are similar to regular investment models, and focus on financial aspects such as return on investment. The weakness of this method is usually that there may be a lack of reliable financial data. The third approach, portfolio management has the goal to maximize the value of the portfolio in total. This includes objectives such as having a balance in the portfolio regarding defined parameters which is depending on the company's strategy. It could for example be to have a balance regarding risk of projects. Further on, portfolio management also considers whether or not the portfolio is aligned with the company's strategy. Mors et al. (2010) mention that even though portfolio management often is used to evaluate future and on-going projects, there is less use of the method to evaluate already conducted projects. However, if devoting time to follow-up of earlier projects, both screening and selection during the process can be improved.

When starting up a project, estimations regarding time and cost must in almost all cases be done. In order to make correct estimations and to meet a defined deadline Morris & Pinto (2007) pin-point the importance of having a logical time-plan. This time-plan should include necessary activities, duration, what resources that are required and when it should end. The most common type of time-plan, which also is easily understood by people working in the project, is the Gantt-chart. When making cost estimations during the project, the early ones tend to often be inadequate; therefore, a distinction should be made between the early ones and the ones done later during the process. The most common reasons for inadequate cost estimations are lack of historical data, outdated databases and reliance on guesses (Taylor, 2008).

3.2 Process Mapping

Process mapping is an analytical tool and technique to improve business performance by reducing errors and variance within a process (Conger, 2011). The main parts in process mapping consist of mapping existing process, analyse existing process, identify problems and its root causes, remap the process, develop a plan for implementation and finally implement the improved process (Kalman, 2002). Before the creation of the first process map it is however also necessary to decide which process that should be mapped (Keyte & Locher, 2004). When choosing a process, different service families can be identified within the company. A service family can be defined as a set of services that shares the same processing steps, and when making a process mapping it is necessary to find which one that needs to be improved and hence be the basis for creating the map.

The first step in process mapping is to map the process, which will provide for deeper understanding for the process and make it easier to identify work steps, roles and responsibilities for given process (Conger, 2011). A process map will show if the different activities work together or separately, and how the different activities and functions are related to each other (Kalman, 2002). When creating a process map, it must also be decided on which level of detail the process map should be and the scope. Keyte and Locher (2004) defines four levels of detail when creating a map; from a macro perspective, meaning a map for how all companies in the supply chain coordinates the work, to a micro perspective, which means a map of a certain task within a process.

One result of the mapping is that it will be possible to distinguish between how a process should be conducted and how it actually is carried out (Kalman, 2002). This will help identify the critical points and bottlenecks in existing process, which enable possibilities to analyse the process and determine the root causes for detected problems. The current state in that way can be seen as a baseline for designing a future state map (Keyte & Locher, 2004).

The next step in process mapping should be to make a new and improved process map, which should simplify the process work flow by change or even eliminate the earlier identified problems. This step, remapping together with analysis, can be done several times to not only identify the process common errors but to find significant process improvements (Kalman, 2002).

The process mapping final step is to implement the suggested changes, but before that it is appropriate to develop an action plan for how this implementation should be carried out (Kalman, 2002). Keyte and Locher (2004) suggests the use of a time-plan, which should include what should be done, how the success of the implementation can be measured, who is involved in the different steps and also check-points and deadlines for the different activities.

3.2.1 Different Types of Process Mapping Methodologies

There are several different ways to map your process for example flow charts, cross-functional process map, decision flow chart develop by the American National Standard Institute (ANSI) (Kalman, 2002). One more type of process mapping widely used in industry is value stream mapping, which is a tool developed within the lean methodology (Lasa et al., 2008).

A flow chart is defined as "a drawing that uses shapes and lines to show how the different stages in a process are connected to each other" (LDOCE). A flow chart can be visualized in a wide variety of ways, of which the ANSI standard and swim-lane charts are examples.

The American National Standard Institute (ANSI) standard flowchart is a way to map processes which identifies decisions steps and alternative paths the process can make (Kalman, 2002), see figure 12 for an example. The squares in the flow chart represents a decision, and the output from the decision can then result in alternative ways in the process.

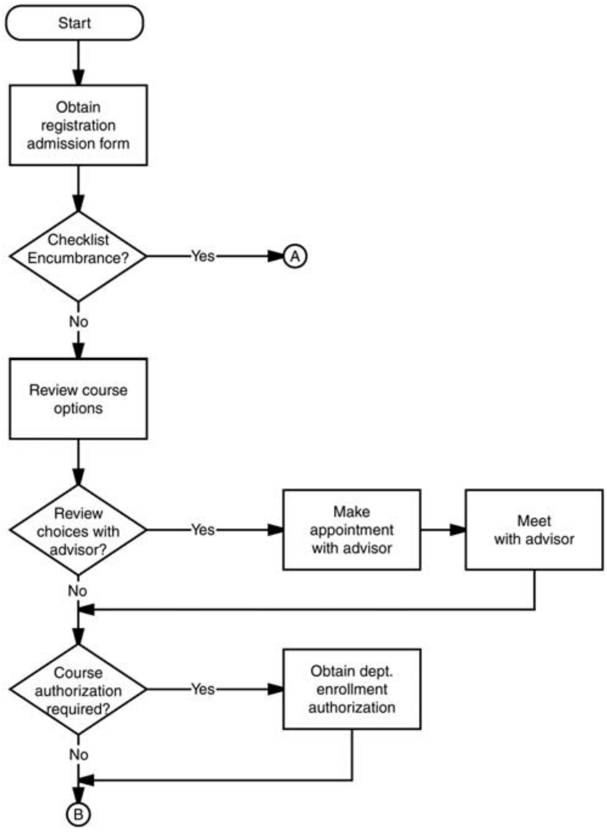

Figure 12 – Example of an ANSI, standard flowchart representing a registration process (Kalman, 2002)

Cross-functional process map, also known as a swim-lane flowchart, is another way of visualize a process and its work flow. This tool identifies the process activities but it also shows the interrelationship between the different departments (Kalman, 2002). The swim-lanes can also be representatives for different companies or roles, depending on the context (Conger, 2011). For an example of a swim-lane chart, see figure 13.

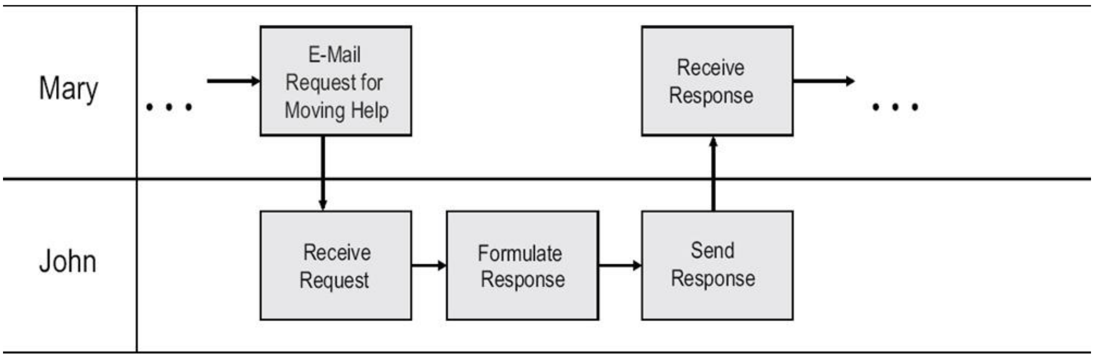

Figure 13: Example of a swim-lane chart, representing a handover between two persons (Conger, 2011)

VSM is another tool used for mapping processes which was developed within the lean methodology. When conducting a VSM, a special team should be designated to this work that will consist of five different steps; selection of a product family, current state mapping, future state mapping, defining a work-plan and achieve the work-plan. The goal with VSM is to adapt the production rate to the product demand (Lasa et al., 2008). When conducting a VSM there exists a set of icons that should be used (Tapping et al., 2002), some examples are seen in figure 14.

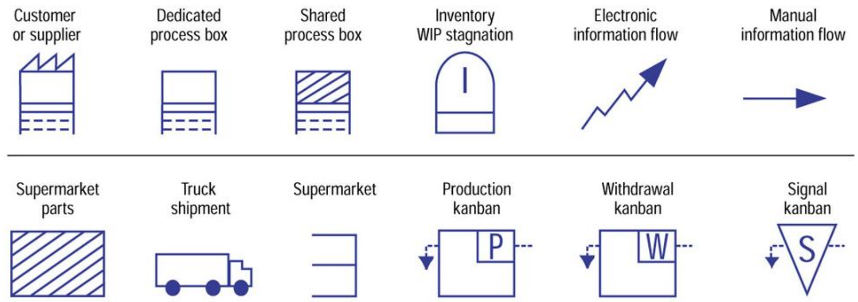

Figure 14: VSM icons (Tapping et al., 2002)

3.2.2 Adapting Process Mapping to Product Development Context

A product development process is an office process; hence it is not a physical flow of goods. Even though VSM and flow-charts was originally adopted for manufacturing processes, it is also suitable to use in office processes (Keyte & Locher, 2004). The challenge when adapting it to office processes is to find how it should be used in different parts of the company in order to generate benefits, this includes e.g. to identify what types of waste that can be found and on what level of details the mapping should be done. Examples of waste that may be found in an office process are unnecessary information or multiple sources for finding the information (McManus & Millard, 2002).

The same general working order when conducting a mapping of a product development process as of a manufacturing process is suggested to be used, which includes; choose which value stream to improve, map the current state, map the future state and implementation of the new process (McManus & Millard, 2002). McManus and Millard (2002) also include the mapping of an ideal state, which should be the long-term goal. Further on, the metrics that should be used in the mapping can vary dependent on the process characteristics, however, in a VSM process time and lead time should always be included (Keyte and Locher, 2004). Other metrics that could be used are for example number of people involved or information technology used.

Regarding the level of detail that should be used when mapping a product development process, McManus and Millard (2002) suggests that it is a good idea to start with a map on a high level in order to define the value stream and its context. When the process has been defined, a more detailed mapping of the concerned process should be done in order to ease the analysis. Keyte and Locher (2004) suggest the use of a cross-functional level for mapping, once the process has been identified. This means that the boundaries for the mapping should be within the company, but it stretches over several functions within the company, e.g. Purchasing and Design.

In a case study performed by McManus and Millard (2002), it was found that several tools for mapping product development processes was used in practice. However, no best practice to use in all cases could be found, instead the tools must be adapted to the specific scenario. If following the way of working which is recommended by McManus and Millard (2004), i.e. starting with a map on a high level, suitable tools are mentioned to be e.g. Gantt-charts in order to see the nature of the process. When moving on to a more detailed level, it can be hard to collect detailed data for all activities. The aspects that should be focused on should therefore be narrowed down to the input and output from each activity, capture metrics and characteristics of each activity and consider the value of each activity. The information collected should be found as close to the process as possible, e.g. from people working directly with it. In order to collect the information needed, a structured data collection sheet could be used. Other tools and considerations that are suitable on the detailed level analysis of a product development process are flow-chart mapping and categorization of value into different categories. This means that time spent in the process does not necessarily need to be considered as either waste or value-adding, instead activities can contribute with different kinds of value.

Some of the major problems with product development processes are mentioned by Keyte and Locher (2004) to be bad filters for initiating designs, resulting in poor choices. Further on, it is mentioned that there may be a problem with information sharing between different design errands, resulting in unnecessary iterative learning. In order to solve these problems, some questions to bear in mind when improving a product development process are:

- Would the quality and quantity of the design activity be improved by a better filter of projects?
- What wastes could be eliminated downstream if designs were not "thrown over the wall" to the next function (e.g., Purchasing, Production)?
- What wastes can you eliminate by using standardized work throughout the design process?
- What will be the effect on lead time if the appropriate design tools are made available to designers and engineers as well as fully utilized by them?

3.2.3 Summary Process Mapping

Process mapping is a tool to improve business performance by reducing errors and variance in a process (Conger, 2011). Process mapping consist of mapping the current process, analyse the process and identify problems and then redesign the process and create an action plan for how to reach the new state (Keyte & Locher, 2004). Several different methods for how a process mapping should be done are available, and even though they were originally adopted for manufacturing processes they are also suitable to use in office processes.

When adapting process mapping to a product development context, the same general order of working is recommended (McManus & Millard, 2002). However, the challenge when adapting it to office processes is to find how it should be used in order to gain most benefits. This includes what types of waste that can be found and also what level of details that should be included in the map. Recommended is to start with a high-level map and then move on to a more detailed mapping when the process and its context are defined. Further on, a cross-functional approach is often useable in product development context since many functional areas often are involved (Keyte & Locher, 2004). Regarding what tools to use, no best practice can be found; instead the tools must be adapted for the specific scenario (McManus & Millard, 2002). What also should be considered when mapping a product development process is to collect the information as close as possible to the process, i.e. from the people working with it.

3.3 Performance Measurement

The performance can be measured in several different ways, according to Parmenter (2010) there are four different performance measurements; key results indicator (KRI), results indicator (RI), performance indicator (PI) and key performance indicator (KPI).

The KRI indicate results from conducted activities and shows if you are on the right track or not. KRIs is the result of many different actions, e.g. customer satisfaction or return on capital employed (Parmenter, 2010). The time range for which a KRI is used is longer than for e.g. a KPI, which could mean that it is measured and reviewed quarterly or annually. A KRI is typically a measurement that is suitable for the board to review, rather than the people managing the process.

KPI is a nonfinancial measurement that shows what to do to be able to increase the performance for the organization most critical parameters (Parmenter, 2007). The time range for when a KPI should be reviewed or measured is shorter than for a KRI; daily or 24/7. KPI can never be a past measure; instead it is a future or current state measure, e.g. number of customer visits planned during the coming week. A suitable KPI should also be well understood, including an understanding of what correcting actions to take, and have a positive impact on all other performance measurements.

In between KPIs and KRIS are PI and RI. Performance indicators are a break-down of KPIs; even though they are of importance they are not key to the business (Parmenter, 2010). In line with KPI, a PI is also a non-financial measure that ensures that the work is aligned with organization's strategy. Examples of a PI are customer complaints from key customers or late deliveries to key customers. A RI is a break-down of a KRI, and all financial measures are RIs. To understand what to increase or decrease, result indicators could be used as a complement to KRIs. These could for example be net profit on specific product lines or sales made during a certain period of time.

Parmenter (2010) suggests that all types of measurements should be used within a business. However, the largest number of measurements should be PIs and RIs, which is suggested to correspond to 80% of the total number of measurements while KPIs and KRIs should correspond to 10% each. Further on, it is important that the measurement are aligned, hence a positive impact on one measurement should also result in positive effects on most of the other measurements used (Parmenter, 2010).

3.3.1 Performance Measurement in Projects

Performance measurement is necessary to be able to measure and give feedback concerning performance and resource utilization. It can be difficult to measure the performance of re-designing projects due to the process intangible output but despite this difficulty Stainer and Nixon (1997) means that it is important to measure and evaluate the projects performance in order to know in which direction the projects are heading.

To create a whole picture of the projects performance it can be suitable to measure the process itself, the outcome and the payoff (Stainer & Nixon, 1997). The aim for measuring the process itself is to be able to detect problems, keep the project on track and finally select those projects with potential to proceed (Stainer & Nixon, 1997).

When measuring and evaluating the process itself it can be suitable to use PI's such as quality of planning, clarity of technical objectives, effectiveness in tracking techniques and timeliness to meet milestones (Stainer & Nixon, 1997). In a survey performed by Goldense and Gilmore (2001), some of the most commonly used measurements for the process was percentage of milestones on time and percentage of phases on time (more measurements can be seen in table 3).

The projects payoff measures indicate the projects benefits or drawback. The KRI's for the payoff should indicate if the project has resulted in any cost reduction or increase in profitability (Stainer & Nixon, 1997). Examples of measurements for payoff are return-on-investment (ROI) and pay-back time (Goldense & Gilmore, 2001), for more examples see table 3.

The purpose of measuring the projects outcome is to see how well requirements is being meet, if there is any unexpected consequences and how well the time and cost plan is being met (Stainer & Nixon, 1997). The most suitable RI's should indicate target time and costs.

Table 3: What to measure in a process and examples of how it can be measured

What to Measure?	Areas to measure	Examples of measurements
Output	Fulfilment of cost and time-plan	Target cost, target price, fulfilment of project schedule
Process	Quality of Planning, Clarity of Technical Objectives, Effectiveness in tracking techniques and timeliness to meet milestones	Schedule slip rate, % of milestones on time, % of phases on time, % of documents on time
Pay-off	Profitability	Return-on-investment, pay-back time, total product contribution, lifetime sales volumes

As mentioned earlier, it can be difficult to measure project performance due to its intangible output. It is also a fact that little attention has been paid historically to measurement of product development and research processes (Kaplan & Norton, 1996). Different development processes within a company may differ greatly dependent upon the specific characteristics of the project, however some consistent patterns can often be found. For a process that follows a sequential framework, consisting of gates and stages, each stage can be characterized by different measures. For example, measurement such as yield (the number of projects that moves on to the next stage divided with the number of projects that entered the stage), cycle time (how long projects stay in the different stages) and cost in the different stages can be measured (Kaplan & Norton, 1996). By doing this, both cost and cycle-time can be focused on and improved.

3.3.2 Summary Performance Measurement

In order to be able to measure and give feedback regarding the project's performance and resource utilization, it is important to use performance measurement (Stainer & Nixon, 1997). According to Parmenter (2010), four different types of measurements should be used; key performance indicators (KPI), key result indicators (KRI), performance indicators (PI) and result indicators (RI). KRIs and RIs focus on the financial aspects, while KPIs focus on what that should be done in order to improve the performance. Hence, KRIs and RIs are past measurements while KPIs are future measurements. PIs are a break-down of the KPI, hence important for the performance but not key to the business. In a company there should be a balance of all these measurements. When measuring the performance of a project the outcome of the project, the project itself and the payoff of the project should be measured (Stainer & Nixon, 1997). The output could in short be said to include fulfilment of cost and time-plan, the process itself means events during the process, such as timeliness to meet milestones, while the payoff is the profitability of the project. For a project that follows a sequential framework, Kaplan and Norton (1996) advocates a break-down of the process into different stages and then implementation of measurement for the different stages.

3.4 Knowledge Transfer in Product Development

The product development is a complex process which creates both organizational and technical knowledge (Goffin & Koners, 2011). This new knowledge generation requires an approach to stimulate the transfer of knowledge in order to stay competitive with technological developments but also to avoid repeating old mistakes due to that knowledge is not shared across the organisation (Niedergassel & Leker, 2011).

Knowledge can be divided into two different types; explicit and tacit. Explicit knowledge is documented and possible to read which makes it easy to access and can be spread widely and transferred to other parts of the company (Goffin & Koners, 2001). On the other hand, explicit knowledge increases the chance of vulnerable information to spread outside the company (Sajjad et al., 2005). The other type is called tacit knowledge which is not documented and is difficult to express (Goffin & Koners, 2011). It however is hard to articulate the tacit knowledge, and therefore there is some controversy whether it is possible to make the knowledge explicit, otherwise the only way to learn tacit knowledge is by direct interaction or storytelling.

In a product development process a lot of tacit knowledge is generated regarding technical solutions, dealing with time schedules and coping with project budget (Goffin & Koners, 2001). It can be difficult to express how these kinds of issues have been solved and it is highly dependent on if the work is conducted individually or in teams, and in the latter case it depends on how the team is composed.

If the product development work has been conducted individually Goffin and Koners (2001) recommends that the employee keeps personal notes or work log to be able to share gained knowledge with other colleagues. Barker and Neailey (1999) continues with advantages with individuals logging conducted activities, for example it provides for a starting point in showing what the employee have learned, which then can continue with reflection and provide for a broader learning which is an important factor to enhance innovative ideas. The final stages in a product development have been shown to give best opportunities for individuals to learn and to transfer the gained knowledge to colleagues and other projects (Goffin & Koners, 2001).

The knowledge transfer within a team and between different teams is easiest through explicit material in form of written document but most advantages to gain is if the team members can communicate and reflect through conversation (Barker & Neailey, 1999). As mentioned earlier, the knowledge transfer in teams or between teams is highly dependent on the interactions between team members and other teams (Goffin & Koners, 2001). The team needs to include and allow every team member to contribute what they have learned both in informal and formal contacts (Barker & Neailey, 1999).

To capture and successfully transfer knowledge in a product development process, there are some formal tools that can be used. First of all, in order to gain knowledge about products it is appropriate to use a database to capture the lessons learnt while working with specific products (Goffin & Koners, 2001). Second, to be able to develop and improve, the process needs to be continuously updated with post-projects reviews and compile individuals experience into checklists which in turn can be integrated in the Stage-Gate process in terms of feedback loops. Hoppmann et al. (2011) also mentions the importance of transferring knowledge between projects as a way to increase the resource efficiency. This is due to the fact that if the knowledge gained during a project is not captured and transferred to other projects, it has to be continuously regenerated. In order to enable efficient transfer of knowledge it is important that the barriers to enter, retrieve and update information are as low as possible. Further on, Hoppmann et al (2011) also recommends clear guidelines for how to gather explicit documentation of lessons learnt or best practices gained during projects.

3.4.1 Summary Knowledge Transfer in Product Development

During a product development process both organizational and technical knowledge is created (Goffin & Koners, 2011). This knowledge can exist as either tacit or explicit knowledge. Explicit knowledge is documented and possible to read, which makes it possible to transfer to other parts of the company. Tacit knowledge on the other hand is not documented and difficult to express. In some cases the only way to express it may be through interaction.

In order to transfer knowledge gained during a product development process where the work has been conducted by an individual it is recommended to use tools such as a work log. When transferring knowledge within or between teams, explicit documentation as well as interaction is important (Goffin & Koners, 2011). To be able to improve the process, post-projects review should also be used as a basis for updating the process. Hoppmann et al. (2011) also advocates knowledge transfer to be a way to increase resource efficiency, since knowledge gained during a project does not have to be regenerated in the next one. Therefore, it is also recommended to have clear guidelines for how to gather explicit documentation of lessons learnt or best practices gained during projects.

4 Empirical Findings

This chapter will first give an overview of the organisation which the ratio process is a part of, in order to then describe the ratio process both in general and how the process is handled within the different sections. The last part will look deeper into what projects that has been conducted in the ratio process, how the result has been and what major issues that have caused delays in projects. For a depiction of the structure see figure 15.

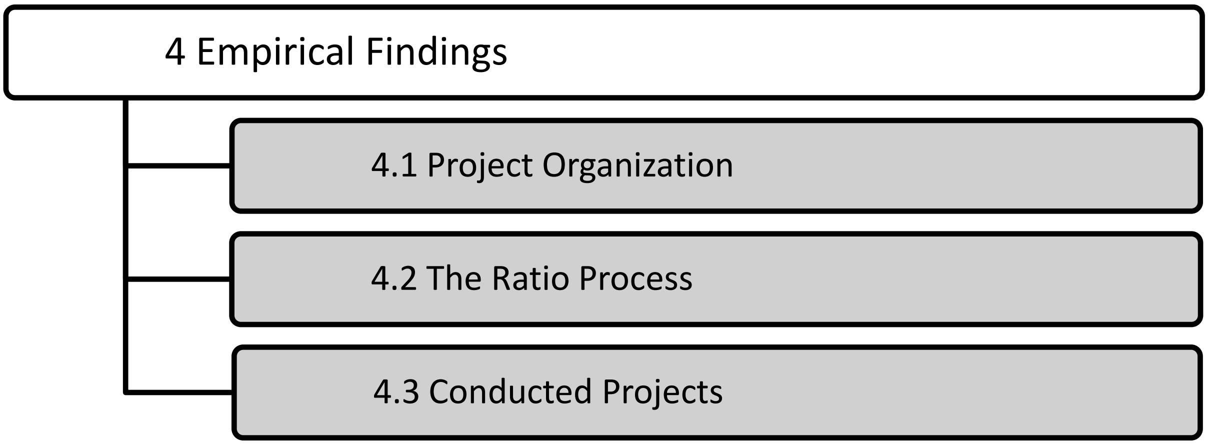

Figure 15: Structure of the Empirical Findings

4.1 Project Organization

The project organization at VCC can generally be described as having four levels; project leader (PL), deputy project leader (DPL), task leader – system (SU) and task leader – component (KU) (see figure 16).

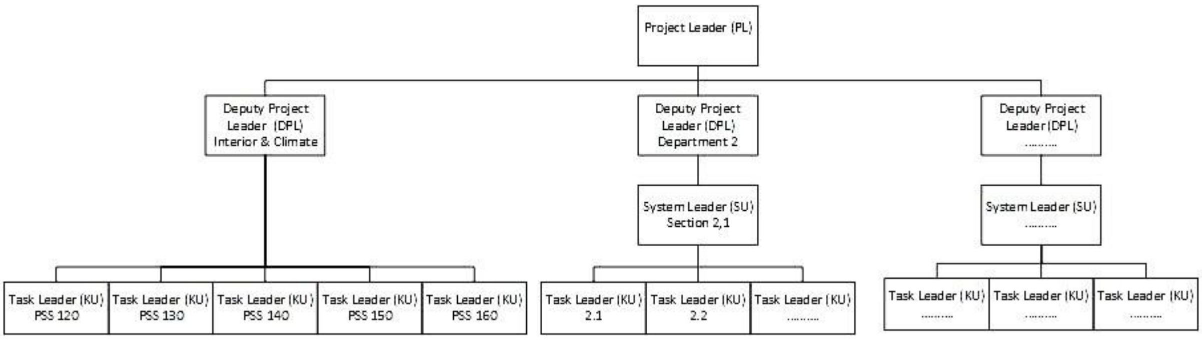

Figure 16: Project organization[3]

However, for R&D ratio projects at I&C the structure only has three levels since the SU-level is excluded, which also can be seen in figure 16.

As mentioned, the KUs in the different sections are responsible for carrying out the projects. The KU's reports to the DPL, which is responsible for following-up and

[3] Anders Sandberg, DPL Ratio & Quality Development, Volvo Cars Corporation, communication between January and May (2013)

coordinating the ratio projects within I&C. The DPL then reports to the PL ratio, which is responsible for coordinating the ratio projects at all departments within the R&D unit.

The different sections at I&C have different amount of resources, KU's, dedicated to carry out ratio projects. This amount is based on number of expected cases for the upcoming year. However, every section has at least one person that work 100% with the idea generation, and is called concept-KU. The concept-KU is always responsible for the first phase, idea generation, but every section has its own structure and decides when the project responsibility changes to another KU. The KU's that are responsible for the later parts of the projects is called running-KU. Table 4 present how the resources are divided between concept- and running-KU for each section.

Table 4: Resources dedicated for ratio projects within each section

Section	PSS 120	PSS 130	PSS 140	PSS 150	PSS 160
Concept-KU	100 %	100 %	100 %	100 %	100%
Running-KU	300 %	250 %	100 %	100 %	100 %
Total	**400%**	**350 %**	**200 %**	**200 %**	**200 %**

4.2 The Ratio Process

In previous sub-chapter, *Project Organisation,* the organization for the ratio process was described, in this sub-chapter the work carried out will be described, both in general and specifically for each section.

The ratio process can be divided into three phases; *idea generation, development and industrialisation,* see figure 17. The *idea generation* is the first stage in the ratio process, and TVM is responsible until the project is entering the development phase.

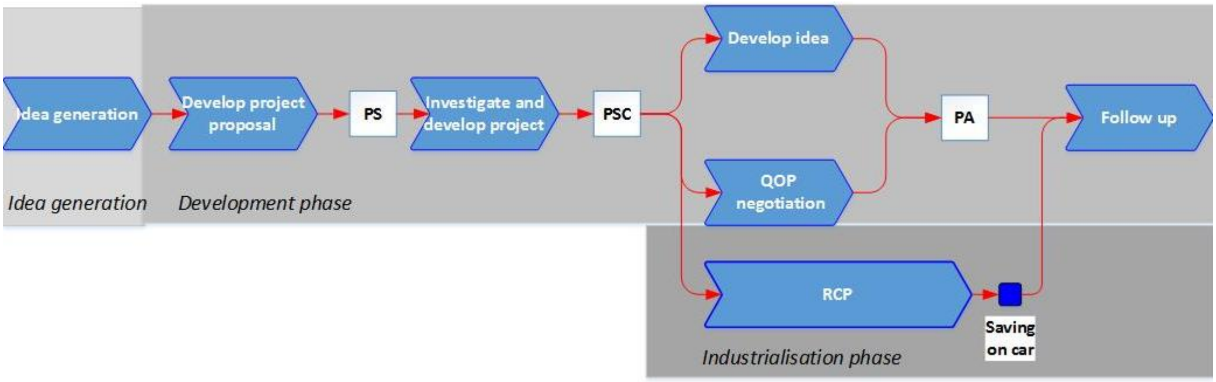

Figure 17: A process map showing the ratio process in general and its different phases

During the development phase, the ideas is developed and investigated before entering the first gate, project start (PS). After the PS-gate the idea is further investigated and a business case is built which then is presented at the second gate, project strategy confirmed (PSC). Further on, the project proceeds in the process by further development and negotiating the quote-one-page (QOP) in order to build a solid business case that can be presented at the third and final gate, project approval (PA).

The development phase consists of three development stages that are connected by three different gates where the project needs to be approved by CMT, who is responsible for the all the projects during the second phase. CMT reviews the projects at each gate and the projects need to fulfil different criteria and present a set of defined deliverables at each gate, see table 5.

Table 5: Deliverables for each gate in the ratio process

Gates	Criteria
PS	Intake-document, Time-plan
PSC	TARR-document, Time-plan
PA	Updated TARR-document, Negotiated QOP

The third phase in the ratio process is called *industrialisation*. During this phase the projects is ready to be implemented on cars and at this point the RCP is responsible for all activities.

After the last phase, the ratio process documents the final savings for every project that is conducted. Once again CMT is responsible and follows-up every project and its result.

4.2.1 Process Steps

Each stage in the ratio process will here be further explained.

Phase 1: Idea Generation

The ratio process starts with generating new ideas that can reduce the costs. The ideas can come from several different sources; the KUs themselves, other personnel within the section, different arranged activities such as tear-downs etc. The responsible person for collecting these ideas at each section is the concept-KUs in each section, and the department responsible for this activity is TVM. TVM is a bridge between Purchasing and R&D and is responsible for generating new ideas and to make sure that the ideas proceed in the process. This includes for example the responsibility for arranging idea-generating activities such as tear-downs. Within TVM a DPL is responsible for coordinating the ideas for the ratio process within I&C until the ideas are through the first gate.

The idea generation can be performed in several different ways within the sections, some examples are; through own experience and knowledge, ideas from co-workers, work-shops and cooperation with suppliers. The concept-KUs assemble the ideas and make a first sort-out of which ideas that can be viable. These ideas are then registered in a database called E-Tracker and given an ID-number.

Phase 2: Development

The ideas that the concept-KU judge as possible to become a business case, and therefore want to develop, are presented at a DPL follow-up meeting. At this meeting the DPL ratio and KUs in the sections are attending. The purpose is to see what ideas that are going to be presented at the Cost Management Team's (CMT) Intake-meeting, and when it should be done. In some sections, the idea has also been presented at the Design Review Meeting Section (DRMS) before presented to DPL. This is to anchor the idea within the section before proceeding.

The next step in order to proceed with the development of the idea is that the CMT needs to confirm that it is okay to allocate time to the errand. This is done at the CMT Intake-meeting, where the concept-KU presents the idea with an Intake-document, which includes estimated costs and time-plan for implementation. These costs are often based on judgment from the responsible KU, the section and other affected departments. In some cases the suppliers may also be asked for input before the CMT-meeting. If the CMT find the idea worth investigating, it passes the PS-gate and get the status "in process" in the database E-Tracker. At the meeting, KUs and DPLs from all departments within R&D are attending, and if an idea affects more than the responsible department it is anchored with the affected ones here. In some cases, no agreement can be made between the different parties at this point, or it is known that the change may affect other areas such as design. Even though that is the case, a decision needs to be taken before it can pass the PS-gate. The idea is therefore presented at pre-war room, where representatives from program strategy, vehicle line management and marketing and sales strategy are present and tries to reach a decision. If still no decision can be made, it is brought to the material cost executive meeting (MCEM) (see appendix E for details about meetings). At this stage, the idea either gets a confirmation to continue, or that it should be shut down or reworked and then brought back for confirmation.

When the idea has passed the PS-gate, the concept-KU can hand over to the running-KU that will be responsible for further development of the idea and industrialisation phase. In some cases this could also be done later, both depending on available resources and how different sections have divided the work.

After the PS-gate, the idea is further developed. This development should result in a better estimation of costs, time-plan and take rates, i.e. how large part of the total sales volume that are affected by the change. This data are the basis for a time adjusted rate of return (TARR)-calculation, which shows how large the savings will be and how long time it will take to get the investment back. A TARR-calculation is needed in order to get the next confirmation from the CMT. The estimated costs in the TARR-calculation can at this stage be done internally, with help from cost estimators (CE) at Purchasing, or with external help from suppliers. In some cases tests are also done at this stage in order to evaluate the solution.

In order to be able to continue, the TARR-calculation is presented at the CMT Milestones-meeting. If the TARR shows a good result and no other major issues come up, the project gets a confirmation to continue through the PSC-gate. This confirmation results in an allocated budget for external costs such as tests at the supplier.

When having passed the PSC-gate, the costs, technical solution and time-plan must be confirmed by the suppliers. In order to achieve this, a request for quotation, called QOP, is sent to the supplier. Since Purchasing officially is responsible for quotations, the QOP is sent through Purchasing. Purchasing is also responsible for the negotiations about the quotations, even though technical arguments might be provided from the KU that is responsible for conducting the project. According to KUs that are conducting ratio projects it often takes much longer time than expected to receive a QOP-answer from the suppliers. In many cases the negotiation about the QOP also lags in time.

When all possible consequences, including manufacturing issues and the TARR-calculation are set, the project is again presented at the CMT Milestones-meeting in order to get approval for implementation. If the TARR-calculation shows a solid business case, the project becomes approved to pass through the PA-gate. This means that CMT confirms that the process of implementing it into the manufacturing can start.

Phase 3: Industrialisation

When the CMT has approved implementation of the project, the Running Change Process is responsible. In most cases, the same KU follows the project also in this phase.

The first contact with RCP has been made earlier on in the process, after the PSC-gate. Phase two and three therefore runs in parallel, which also can be seen in the process map. The initial meeting with RCP is at the Program Target Compatibility Checkpoint (PTCC)-gate. At this stage a preliminary time, technical solution and cost are presented, however it do not exists a standard format for how this should be presented to RCP. The input from manufacturing can then also be evaluated when CMT makes the decision to implement the idea, i.e. confirm passage of the PA-gate. When the project has passed PTCC, it is also registered in the Running Change Database (RCD) and given a task number.

After the confirmation of PA from CMT, a PA-gate within the RCM process should also be passed. In order to get confirmation to continue the time, technical solution and costs needs to be set. When the project gets confirmed, the next step in the industrialization is to create a change order (CO). The CO contains information about what components that will be replaced and what part number the replacing component has. It also contains a bill-of-material, to show where the component is used. The CO needs to be reviewed and then released on a meeting called the red room, where the main decision makers in RCP are attending. The projects need to be brought to the red room eleven weeks before the planned production start.

After the release of CO, the Purchasing department order components to use in pre-series cars and also tools if needed. After this the material status needs to be checked in order to make sure that it fulfils demands to build the pre-series cars, which is the next step in the process. The gate where material status is checked and confirmed is called Launch Start (LS). After the pre-series cars are built, analysis is performed to ensure quality of the new cars. If the review of the cars can confirm that everything works, the Job1 (J1)-board approves the change to be implemented permanently in the production. The first production of cars with the implemented changes that are going to external customers can then take place, which is called J1.

When the change has been implemented in the manufacturing, CMT follows-up on the outcomes of the project. This follow-up concerns the result regarding saving on car.

4.2.2 Documentation

In this chapter an overview of which documentation that is used during the ratio process is given. This includes both databases and single documents that are used during the ratio process.

E-Tracker

The ratio process uses a database for follow-up their errands that is called E-Tracker. The errands are put into E-Tracker at different stages based on which section is responsible, however all errands are added before the PS-gate. When the errand is put into E-Tracker it also receives an ID-number. The errand in E-tracker is then continuously updated in E-tracker with gate approvals, estimated savings or other comments such as issues that comes up during the work. Further on, the documents presented at the CMT-meetings are also uploaded into E-Tracker. E-tracker then follows the errand all the way until the final saving can be documented. However, during the industrialisation phase E-Tracker is not used since the RCP has another database called Running Change Database (RCD).

When the errand is confirmed at the different gates in E-Tracker, the confidence of savings for the errand also changes based on the fact that certain requirements are fulfilled at the different gates. This confidence is used when calculating the savings forecasts. In figure 18, the different statuses and the confidence can be seen.

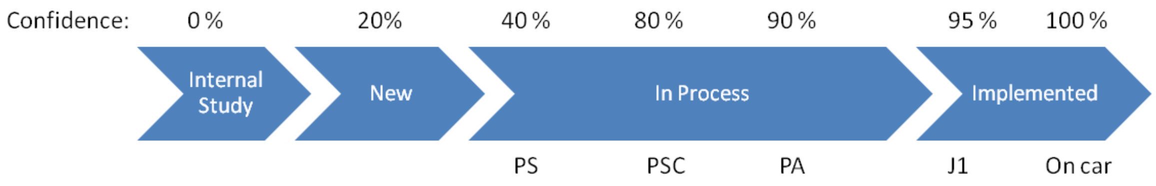

Figure 18: Different statuses in e-tracker and their adherent confidence

Running Changes Database

RCP's database is called Running Changes Database (RCD). The errands are registered in this system when they are presented at the PTCC-meeting, and the information from E-Tracker is then transferred into this database. When registered in RCD, the errand receives a task number. This is required in order to create a change order, which is needed in order to change the existing part number to a new one.

Volvo Parts Concern

Volvo Parts Concern (VPC) is a database which is used by all functional areas to a various extent. Assignments can be created in VPC which then is available to all personnel. In the database there exists boxes that can be checked when information is received or tasks finished. In the ratio process, a VPC assignment is created in order to send a QOP to the Purchasing department, which Purchasing then forwards to the supplier.

Intake-document

The Intake-document is presented in order to pass the PS-gate. The Intake-document includes the estimated savings, a time-plan for when the different gates should be passed and the estimated costs. Based on interviews with the different sections, the information on which the Intake-document is based can differ. It can either be done based on own estimations or in cooperation with actors such as suppliers and cost estimators.

TARR- document

The TARR-document is a calculation that results in a percentage. This percentage can in short be said to show how long the return-on-investment time is. The TARR-document includes information such as time needed, investment costs, take rates and savings. The document is presented in order to pass the PSC-gate. However, at this point the calculation is only needed to be based on estimations. Further on, for the projects to pass the PA-gate the estimations needs to be updated with sharp costs and savings based on information from suppliers.

Quote- One- Pager

Quote-one-pager is the name for the request quotation that is sent to suppliers. This quotation includes price information, estimation of costs for development work at the supplier and a support plan (SP) that shows when the different components can be delivered. The time in the process when the QOP is sent to the suppliers differs, but it should be negotiated before the PA-gate. The responsible for the QOP-negotiations is Purchasing.

4.2.3 Work at the Different Sections

In this sub-chapter the five different sections within I&C will be separately described regarding how they perform their work during the ratio process.

PSS 120

PSS 120 is a section that works with interior trim. This section has during 2011 and 2012 conducted 27 projects. This section has four KUs dedicated to the ratio process. One is working at the beginning as a concept-KU while the remaining three are running-KUs and they are responsible for developing a business case and for the industrialisation phase.

In the first phase of the process ideas are generated. In this particular section the idea generating is conducted through workshops, tear-downs and brainstorming together with co-workers within the section but also by cooperation with suppliers. Each new idea is documented in E-Tracker, and this section adds all the ideas in the database with the status "internal study".

The second step in the process is to sort out ideas with the highest potential, according to one of the KU's at PSS 120 this activity is done by the concept-KU together with running-KU and a technical expert within the section. The next step is to investigate and analyse ideas that have been chosen to proceed with to find out which ideas have potential to build a business case. This section analyse the projects through cost estimation, which is done together with cost estimators, and savings potential together with a technical specification that describe the changes that are being made. This information is the basis for the decision taken at the PS-gate, whether the project should continue or not.

Projects that involve other departments need to be presented and be accepted by affected departments. This section presents their case at Pre War Room if the departments do not agree on whether or not to continue the projects at PS.

If the project is approved at the PS-gate, the process continues, and at this point PSS 120 change KU, from concept- to running-KU. However, it is the concept-KU's responsibility to distribute the projects to the appropriate running-KU. Further on, the running-KU is now responsible to develop a business case, to see if the case is both financial and technical feasible. The running-KU at PSS 120, investigate the idea through presenting test materials and therefore be able to get closer to a real feeling for the project. The KU contacts the supplier and provide the first information about the upcoming projects and how it will affect them depending on the running-KU the first QOP-request can be sent at this point.

At the next gate, PSC, preliminary information regarding time, cost and technical solution should be presented and reviewed. The running-KU at PSS 120 works together with a cost estimator to estimate the projects' costs and savings. At this point, the running-KU also creates a time-plan for the project and sends the first QOP-request, if it is not done earlier, to the supplier via responsible purchaser.

Before the PA-gate, the KU perform test depending on the given projects and at the same time give the responsible purchaser support during the QOP-negotiation with the supplier.

PSS 130

PSS 130 is dedicated to seats, and during 2011 and 2012 this section conducted 25 projects that were approved at PA. This section has three KU that is 100% dedicated to the ratio process.

This section has one concept- KU that is dedicated to the first phase, idea generation. The ideas are generated through own knowledge, benchmarking, work-shops and through cooperation with the suppliers. PSS 130 prioritises those projects with savings potential for at least 2-3 SEK/average car so the administrative costs are covered. The concept-KU at PSS 130 adds all ideas in the E-tracker at this stage.

The next step is to sort out and prioritise the ideas. This step is carried out by the concept-KU together with the section and occasionally the supplier. Before PS, the concept-KU estimate what the project will cost and how long it will take to implement, usually the KU at this section have estimated a TARR and the necessary Intake-document together with a time-plan. The time-plan is estimated for all steps until J1, but it can be adjustments when receiving SP from supplier.

The project is raised at the Intake-meeting, and if the project is approved a QOP-request is sent, via group manager and Purchasing, to the supplier. PSS 130 usually change from concept-KU to running-KU between PS and PSC.

The section further decides if the idea is worth further investigation and if it can be seen as viable for implementation. If the case affects other departments the case will be raised at pre-war room, where it can be approved to continue. The running-KU conducts internal studies with different tests depending on the specific case to increase the confidence for the project. These activities are conducted either before or after PSC gate depending on the project.

The case will then be raised at the next CMT meeting, were the gathered information will be reviewed. At this stage the case should have a preliminary QOP from the supplier, and the estimated TARR should include both external and internal costs. According to the running-KU at PSS 130 it is time consuming to receive the QOP-answer from the supplier.

The next step in the process is to negotiate the QOP-request. Purchasing is responsible for this activity but the KU at this section provide argument and support to the responsible purchaser during the negotiation.

At the next gate, PA, the case should have a negotiated QOP together with a time-plan and a complete TARR-calculation. If the case is approved at this gate the case is transferred from CMT to RCP.

PSS 140

The section PSS 140 is working with the dashboard, the tunnel console and the control panel. This section divides ratio process in two parts, concept and implementation. They have one KU that works with the concept phase and further down in the process another KU takes over and handles the industrialisation phase. This section has one person that works 100% at the concept phase. They have also resources that are equal to one person 100% dedicated to the industrialisation phase but it is spread over several persons at the section.

The concept-KU at PSS 140 is dedicated to the first part of the process. The idea generation is carried out by brainstorming, teardowns, idea lists from suppliers and group activities within the section. At this point every idea is added into E-Tracker. The first investigation about the ideas then mainly concerns to an own estimation of whether or not it can be viable and also to ask other persons within VCC that may be involved. Based on this first investigation, an Intake-document is created and presented at the CMT-meeting in order to pass the PS-gate.

After PS, the case is developed and further investigated. The KU make layouts, calculations and anchor the idea at other departments such as Purchasing, Design and Marketing. The case can at this stage also be anchored at DRMS. The case can be presented at DRMS either before or after the PSC-gate. If departments cannot agree after PS regarding whether or not to continue the case, the case can at this stage also be taken to pre-war room and if there still is no agreement the case will have a decision at MCEM.

Based on the gathered information, an estimated TARR is created and presented at PSC, where a new decision is made based on the new information. Already at PSC, PSS 140 can also put the case into the running changes database and receive a KU-number.

When the case has been approved through PSC, the first QOP-request is sent to the supplier. The negotiation is then conducted by Purchasing and should be finished before the next CMT-meeting. According to PSS 140, the QOP should be finished so it does not change after having been approved at the PA-gate, even though it still may happen sometimes.

The case will be raised at PA, where decision is taken regarding the financial aspects for the case implementation, the QOP should at this point be negotiated. The case is then transferred from CMT to RCP. RCP then also has a PA-gate, where it is decided if the case is possible to implement or not, which also is the point where the cases at PSS 140 change KU, from concept-KU to running-KU.

PSS 150

There are two KUs dedicated to work full-time with ratio development at the climate section. During 2012, six projects were passed through the PA-gate. The same number for 2011 was seven. In the starting phase of the process, which is idea generation, the two KUs are working together in order to come up with new ideas. The ideas are generated through own knowledge, work-shops and through cooperation with the suppliers. The TVM section also supports the idea generation through different activities. In comparison to other sections within I&C, climate is working with more complex products since they purchase whole systems from their suppliers. This result in difficulties in finding savings potential for single components, and a more comprehensive cooperation with the suppliers are therefore needed. The suppliers are also responsible for all changes and drawings.

When ideas are found a first analysis of them are made within the section. The personnel responsible for the specifications are located within the section which eases this first analysis for the climate department. The section then decides if the idea is worth continuing with and if it can be seen as viable for implementation. Approximately after this the idea is documented in E-Tracker. According to the personnel at PSS 150, they generally investigate the ideas more than other sections before they document it in E-tracker. Once the section supports the idea, Purchasing and the suppliers are contacted in order to get a price indication and in some case a prototype to perform tests on. The development of the idea is handled by one of the KUs, but there is no sharp line where only one of them continues. However, the KU that continues to develop the idea will be responsible the whole way through the implementation.

When the idea has been developed it is presented at DRMS. This can be done either before or after the CMT-meeting. According to the KUs, they do not bring errands to DRMS or put them into E-Tracker unless they really believe they are viable for implementation. The idea is also presented at the CMT-meeting and the project is thereby in process, i.e. has passed through PS. Presented at this meeting is the Intake-document, which contains an estimated saving and time-plan. These figures can be estimated only within the section or together with the supplier. Other sections that will be affected by the change are also informed here so they can start up their work.

After PS and before PSC, the KU continues to develop the idea together with the supplier. At this point the QOP is also sent to the supplier. When PSC is passed through the cost, time and saving are better estimated. However, climate see the PSC-gate to be more of a meeting where the different sections involved in an errand can update each other of the progress. At approximately the same time, PSS 150 also presents the idea to the RCP process at the PTCC-meeting.

When the PSC-gate is passed, Purchasing is responsible for negotiating the QOP with the suppliers. Climate may support with arguments concerning technical issues at this point. In parallel with the negotiations, tests continue and the solution may still be amended together with the supplier.

PSS 160

At PSS 160 there are two KUs working with the ratio process. The work is divided so that one person works only as concept-KU and one work with projects during the industrialisation phase. The number of errands that was passed through the PA-gate during 2012 was one, the same figure for 2011 was nine.

The ratio process starts as usual with generating ideas. This is at PSS 160 done through input from employees at the section, own knowledge, work-shops, lessons from earlier projects and together with suppliers through e.g. line-walks, even though the cooperation with the suppliers is not working as well as wished.

Once the ideas are found the work with developing a business case starts. At this stage PSS 160 also makes a TARR-calculation and an Intake-document, even though the requirement to pass the PS-gate only is to have an Intake document. The calculation is made together with Purchasing, suppliers and Manufacturing. The supplier is at this stage part of both estimating costs and time-plan. When the TARR is made and the section feels like they have an idea that are viable, it is put into E-Tracker and presented together with the Intake-document at the Intake-meeting. At PSS 160, the goal is to anchor the idea both with the section and the supplier before bringing it to CMT. In many cases crash analysis is also giving input if the idea is viable.

When the project has passed the PS-gate, the idea is further developed through QOP-requests to suppliers. The consequences of an implementation is also deeper investigated together with other departments, e.g. manufacturing. When an updated TARR-calculation is made it is again presented to CMT in order to pass the PSC-gate.

After the PSC-gate, a budget for making tests is available. PSS 160 in general has to make more tests for their ideas than other sections since their projects most often affect safety issues. The tests has to make sure that the an implementation of a new idea does not affect legal requirements or VCCs internal requirements, which in general is more extensive than the legal requirements. In order to get an overview of the tests a test plan is created, in some cases this may also be done before the PSC-gate. In addition to the tests, crash analysis and other affected departments may also be further consulted. Purchasing is at this stage also involved through negotiations with the suppliers.

When the possible consequences, costs and time are established the idea is presented to CMT which confirms it can be implemented. At this stage the concept- KU at PSS 160 hands over to the KU responsible for the implementation and the idea is transferred to the RCP-process.

4.2.4 Follow-Up

Today ratio has an annual target concerning the amount of “saving on car” on the different platforms. Saving on car means the reduction in the component price that is achieved. The goal for savings on car concerns both Purchasing and ratio, however the goal is divided so ratio knows what their part to fulfil is. If a section fulfils their goal before the year is over, there is no pressure to continue to generate new ideas or implement changes, which according to personnel may lead to that possible projects are moved to future years. In some cases, it is also hard to estimate what the final saving will be for the ratio projects. The reason for this is that the savings on car are affected by many other aspects, such as other savings that has been negotiated with the suppliers outside the knowledge of the ratio process.

Every week, the economist calculates and creates a forecast, called Waterfall, for current year and three years ahead. This forecast shows the expected result from running projects regarding the savings on car and includes both the goals for Purchasing and ratio. The waterfall shows how much savings there is in total and in the different process stages. Additionally this report shows the number of ideas entering the process, number of cases in the different stages and its confidence. The same information as presented in the Waterfall is also compiled into a product cost review-report, called the PCR-report. The PCR- report is created by the financial controller monthly and is presented to the stakeholders. The PCR-report shows the actual savings that is implemented on car for the different platforms. The saving on each component is compared to the component price that was set in the beginning of the year. The PCR-report also presents the actual savings relative to forecast and target. When creating the PCR-report and the Waterfall it can however be difficult to find the actual savings derived from the ratio process.

Ratio’s common goal is divided on the different units, which in turn is within I&C shared equally on every section. Each section is then measured based on what saving on car they achieve. The cost needed to achieve these savings is not relevant when measuring the saving, instead the costs is taken into consideration when decision about whether or not to proceed are taken by CMT. This is due to the fact that CMT has a limited budget for ratio projects and need to prioritise the ones with the highest savings potential.

Regarding the project pace in the ratio process, there is a goal for “100% first time through” for all gates that is passed during the process. This means that the projects should pass all the gates on the times that they are estimated to do so. The estimation which this measure is based on is the time-plan for gate passage that is done when the gates pass through the PS-gate. The goal is followed up by the department manager, but the DPL within I&C also follows up the projects that are conducted within I&C.

4.2.5 Summary

The ratio process can be divided into three phases, idea generation, development and industrialisation. Every project needs to be approved at the three gates during the development phase to be able to go through the ratio process and become implemented on car. Between each gate the idea is developed to become a business case and further investigated in order to be checked at every gate and thereby be approved to proceed in the ratio process.

There are five sections within I&C that conducts different number of ratio projects but they have also different amount of KU resources that are dedicated to the ratio process. There are also some differences regarding the way of working with the process itself. During the first phase, idea generation, there are some variance between the sections regarding too what extent suppliers are involved in coming up with new ideas. There is also some variation in what stage the sections take the first contact with the supplier regarding a new idea. For example PSS 140 experiences difficulties to involve the suppliers in the idea generation while PSS 150 has a closer cooperation with the supplier because of their complex systems, which is due to the fact that they purchase whole systems from their suppliers.

All different sections experience various involvements from the Purchasing department. Although there are differences regarding at what point the different sections contact Purchasing for the first time when introducing a new project.

All sections except PSS 150 use a concept-KU that is responsible for the projects in the beginning of the process and then for the later part of the process the responsibility changes to a running-KU. However, there are some differences between the different sections regarding when the change of responsibility occurs. For example PSS 120 strives to have their change of responsibility between the PS-gate and the PSC-gate while PSS 160 changes responsible KU after the PA-gate.

All the generated ideas are documented in the database, E-tracker. Although at which point ideas are added in E-tracker depends on the section. Some sections add each idea in E-tracker from the beginning while other want to develop and investigate the idea before it is added in the database. During the whole ratio process the projects are documented in many different databases. Depending on which phase the project is in different databases are used and there are several different databases that need to be updated with project information during the ratio process.

However, even if the five different sections have their own way of working with the projects during the ratio process all projects need to be approved at every gate and fulfil the given criteria to be able to proceed in the process. Therefore the differences between the sections are judged in general rather insignificant.

Further on, the ratio process has yearly targets regarding the saving on car. This target is divided on the five different sections that work with the ratio process within I&C. The process is followed-up by a few different measures, i.e. one that shows how the process is fulfilling the yearly target and another that shows what the running projects expects to save when they become implemented.

4.3 Conducted Projects

The ratio process has during 2011 and 2012 conducted 87 projects that were approved at PA. During 2012, five projects were rejected while the remaining 26 were implemented, see figure 19 for further information. During 2011, 40 projects were implemented and 16 of the projects were rejected after approval at the PA-gate. The division can be seen in figure 19. The total result of all conducted projects during these two last years is that 66 become implemented while 21 were rejected after approval from CMT at PA.

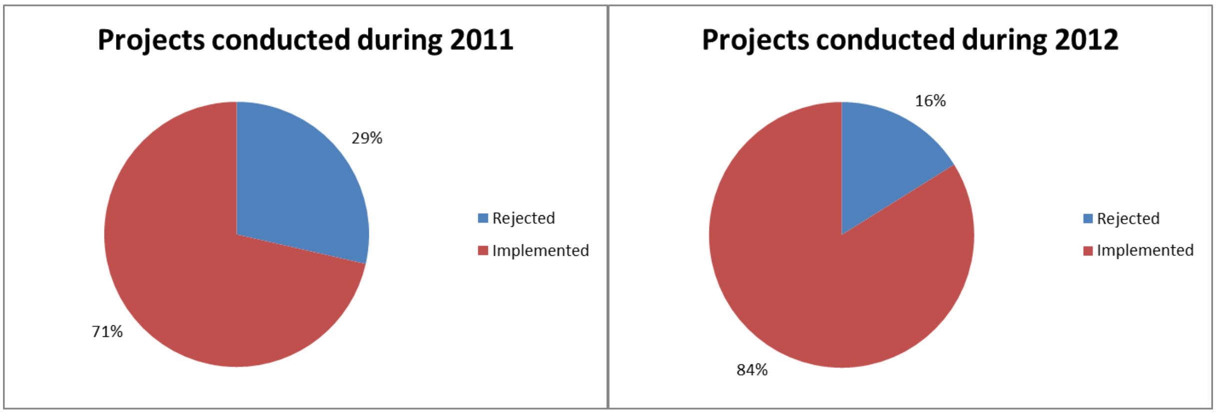

Figure 19: Conducted projects that were approved at PA during 2011 and 2012

The ratio projects conducted are divided between the five different sections. During 2011 a total number of 56 projects were approved at the PA-gate. Of these projects, the largest share was conducted by PSS 120, which performed a total number of 19 projects. The total number of projects that was implemented or rejected after approval at PA during 2012 was 31. The largest part was carried out by PSS130 while the smallest part by PSS160, see figure 20 for exact information regarding the division.

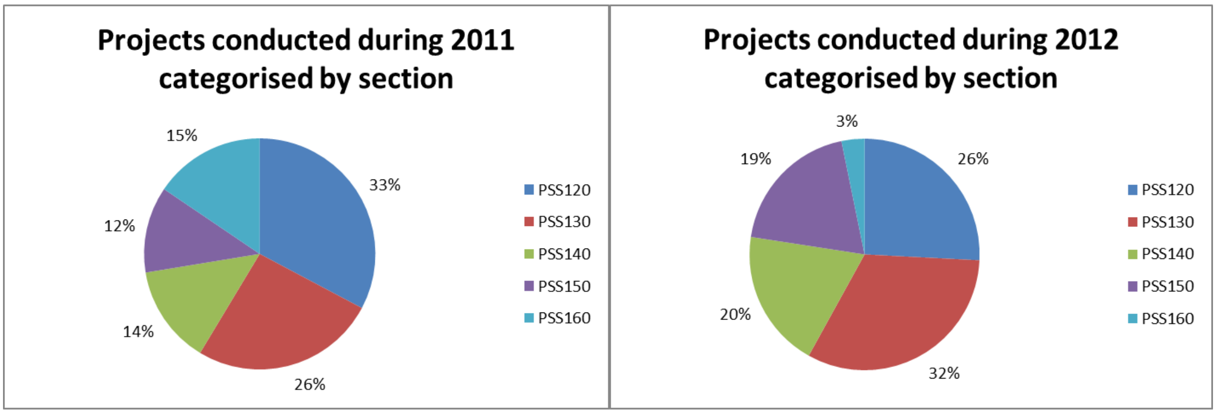

Figure 20: Conducted projects that were approved at PA during 2011 and 2012 categorised by section

The different projects conducted resulted in savings on three different platforms. Since the savings per car are calculated based on the lifetime of the platforms, and two of the platforms are expiring, a choice was made to only look at savings only for one platform. This choice was made since it enables a better comparison between the projects. The estimated savings are the savings defined before PS, and is calculated per average car of the chosen platform. Most of the projects (51%) during 2011 had an estimated savings below 5 SEK/average car, see figure 21. The estimated savings for the different projects during 2012 can be seen in figure 21. As seen in figure 21, a majority of the projects (35%) performed during 2012 was estimated to result in savings between 0 and 5 SEK/average car.

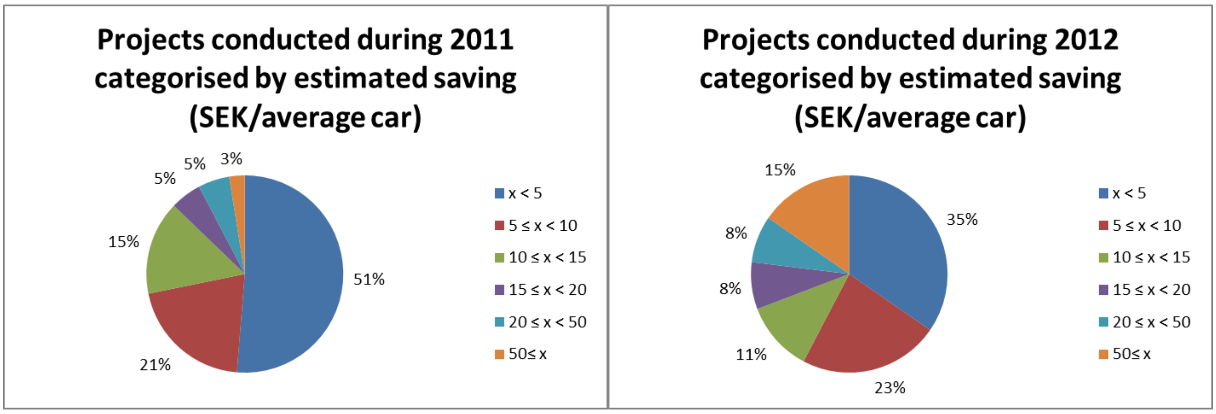

Figure 21: Conducted projects that were approved at PA during 2011 and 2012 categorized by estimated savings

In line with what was described above, only one platform was investigated when looking at the estimated costs. The estimated cost is the first cost presented in the project, in some cases it is presented at PS but it can also be done at PSC. In figure 22, the percentage of projects within the different cost ranges for 2011 and 2012 can be seen.

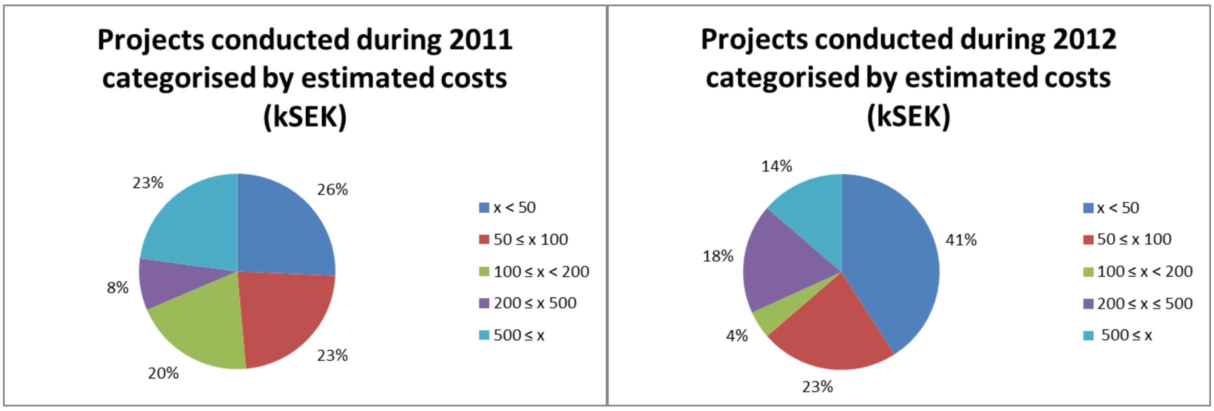

Figure 22: Conducted projects that were approved at PA during 2011 and 2012 categorised by estimated costs

For each project, a time-plan is presented at PS. This time-plan expresses when the different gates should be passed during the process. In figure 23, the estimated time between the presentation at PS and PA for the different projects conducted during 2011 and 2012 is presented.

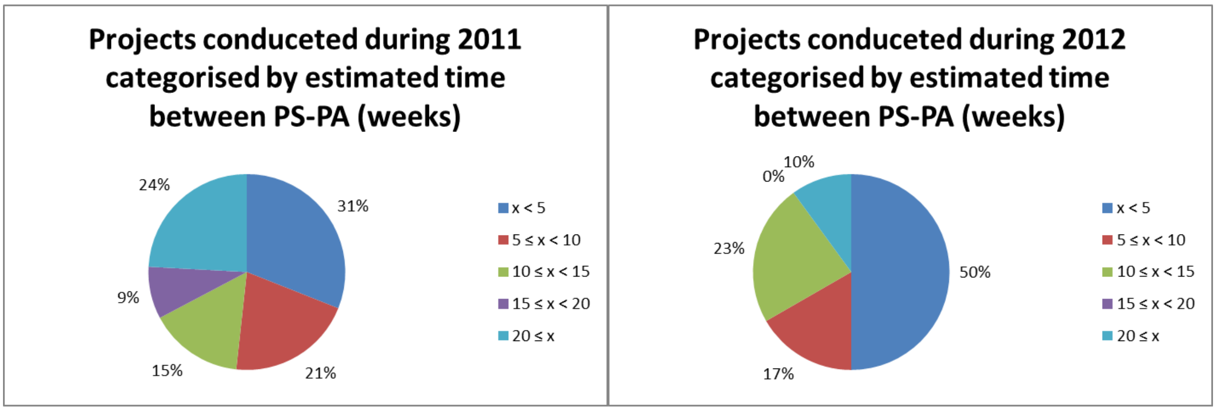

Figure 23: Conducted projects that were approved at PA during 2011 and 2012 categorized by estimated time between PS-PA

The projects conducted have been handled by a various number of KUs, in figure 24 the number of handovers for the different projects during 2011 and 2012 can be seen. As visualized, the majority of the projects during 2012 (87%) was conducted by either one or two KUs. The same was the case during 2011, when 96% of the projects were handled by either one or two KUs.

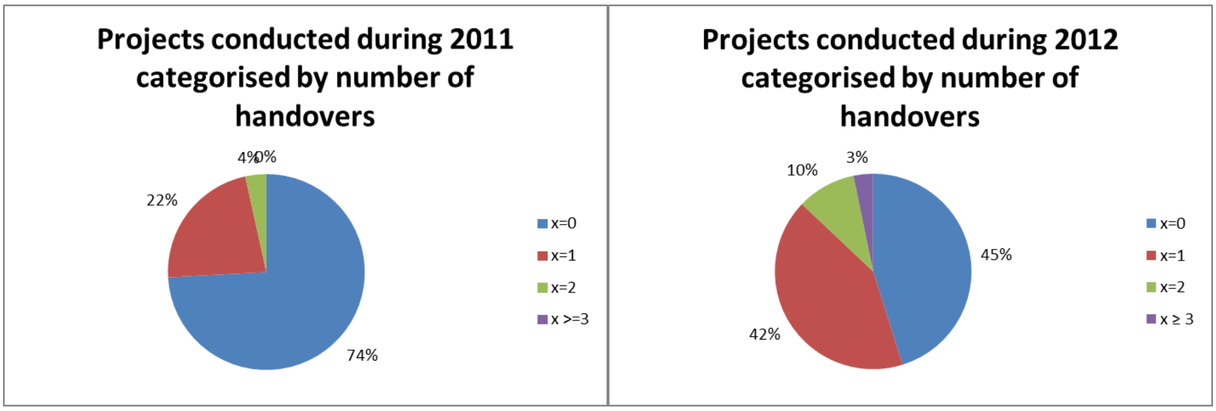

Figure 24: Conducted projects that were approved at PA during 2011 and 2012 categorised by number of handovers

The projects conducted by the ratio team can be categorised by type of projects, see figure 25. A large per cent of the conducted projects during 2011 and 2012 are change component. A small per cent of the conducted projects is regarding remove processing and that type of project was only carried out during 2011.

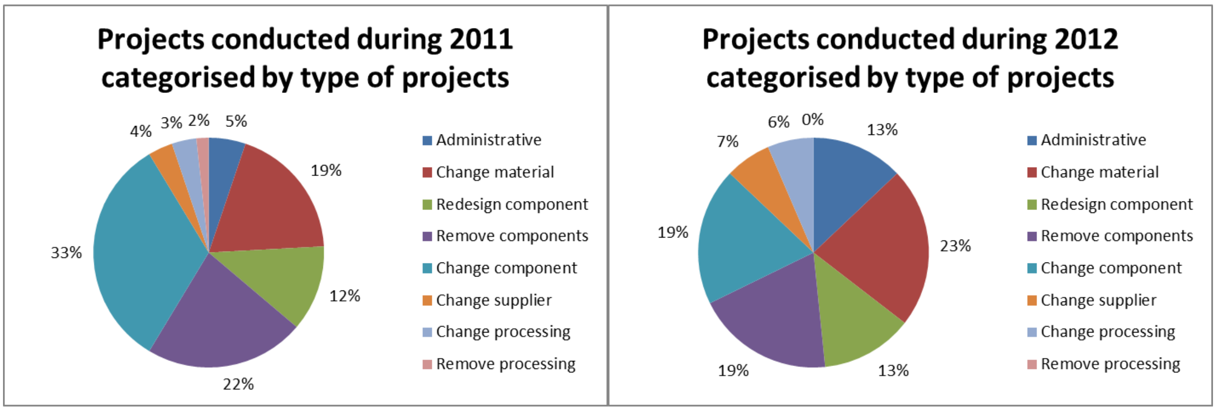

Figure 25: Conducted projects that were approved at PA during 2011 and 2012 categorised by type of projects

4.3.1 Results of Conducted Projects

As mentioned in the sub-chapter, *Purpose & Research Questions*, the ratio process has experienced problems with resource efficiency, gate timing and long lead-times which have given poor ratio results. The result can be seen in the ratio process yearly target, savings on car. The projects savings directly affects the ratio process results due to the yearly targets regarding the savings. The project time-plan, can indirectly affect projects saving, due to the longer time it takes to implement changes the fewer cars will be produced with the new cost effective solution.

Based on above, the ratio process two most critical aspects that affect the results are savings and time. A project has been less successful if the savings are small or results in up costs, or if the time-plan has been longer than expected. Although the ratio process has yearly targets regarding the savings and is therefore an important aspect, it may be difficult for the ratio team to actually affect this particular outcome due to other savings that has been negotiated with the suppliers while the projects have been ongoing. The second aspect is the time-plan for each project, which according to the DPL ratio within I&C is possible to affect to a higher degree.

Figure 26 and 27 shows how the conducted projects during 2012 and 2011 are spread regarding the fulfilment of estimated savings and estimated time. The x-axis presents the percentage of the difference between estimated and actual time relative to the estimated time, which can be seen as if the project have been delayed or not compared to the estimated time-plan. If the x-value is positive the project have taken longer time than estimated, this means that the less successful projects are plotted in the bottom right corner, which can be seen in figure 26 and 27 within the large circle.

The y-axis shows the percentage of the difference between estimated and final savings relative to the estimated savings, which thus means how well the projects fulfil or deviates from estimated savings. If a project is plotted with a negative y-value the actual savings is less than estimated and if the y-value becomes less than -100% the project has result in an up cost. If a project is located in origo, both time and savings is estimated correctly which is visualised by the small circle in figure 26 and 27.

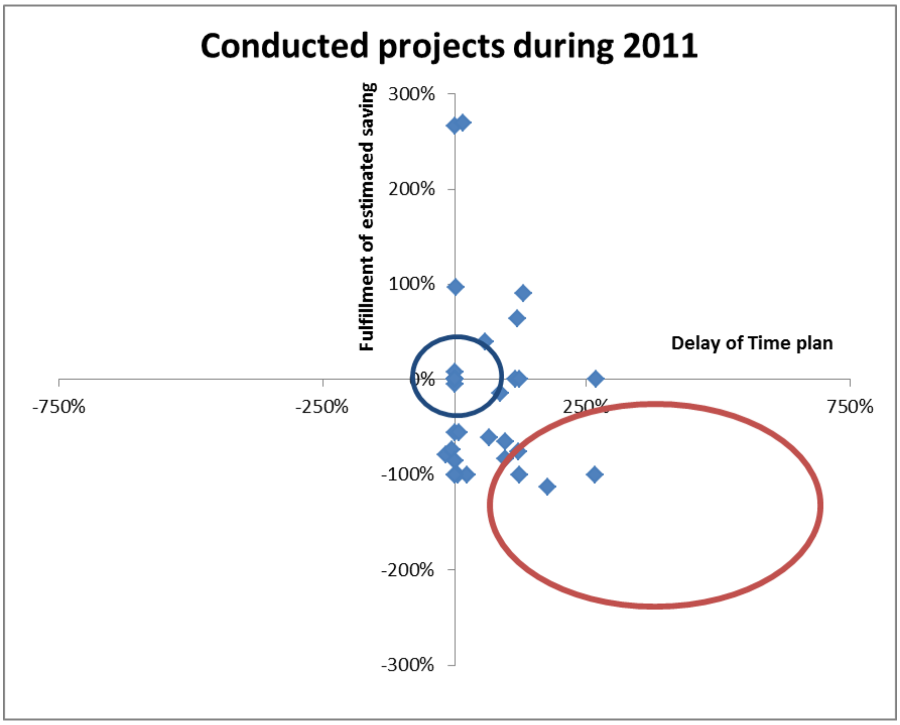

Figure 26: Total number of projects conducted that were approved at PA during 2011 and their performance regarding fulfillment of estimated time and savings (excluding rejected projects)

Figure 27 presents all the projects conducted during 2012, most of the projects have a negative y-axis value which means that the final savings become less than estimated.

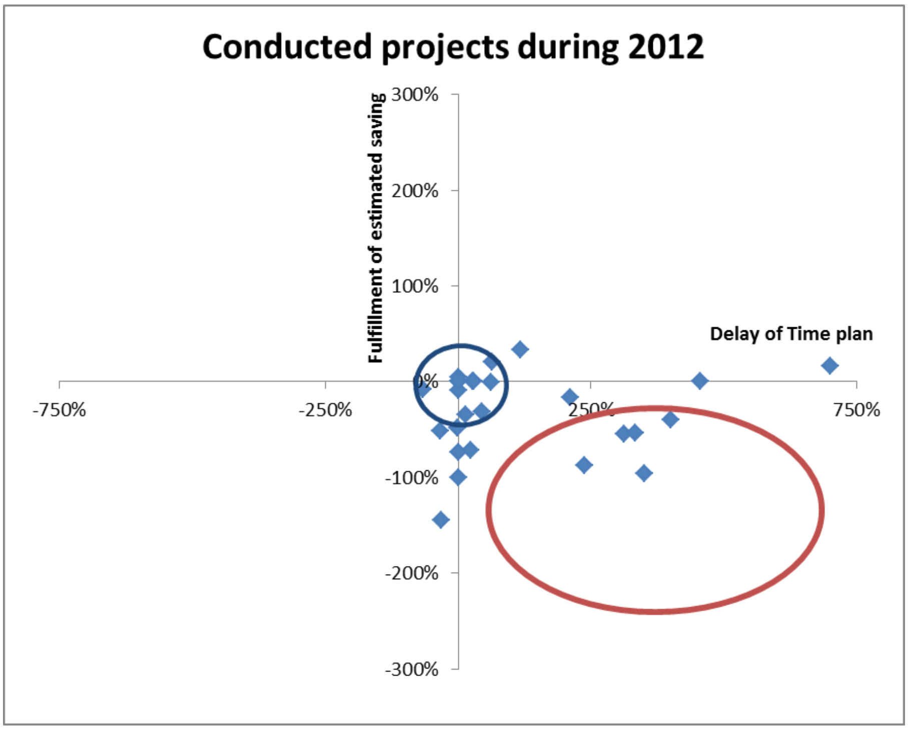

Figure 27: Total number of projects conducted that were approved at PA during 2012 and their performance regarding fulfillment of estimated time and savings (excluding rejected projects)

4.3.2 Handling of Projects

Based on the definition of unsuccessful projects made in previous chapter, projects with a low performance regarding fulfilment of time-plan and fulfilment of estimated savings were chosen for a deeper investigation. In addition, projects that succeeded the best in fulfilling the time-plan and the estimated saving were also chosen for deeper investigation in order to get a frame of reference when investigating what went wrong in the unsuccessful projects.

According to Cooper (2001), each stage in the Stage-Gate process should be cross-functional since critical activities often concern more functional areas than the R&D department. In the ratio process the dependency upon both the suppliers and the Purchasing department is significant since critical activities for the process is under their responsibility. Therefore, it is judged to be of interest to investigate how the different functions have been involved in the unsuccessful and successful projects in order to see if any differences exist. This is also of interest in order to answer one of the questions that can improve the product development process presented by Keyte and Locher (2004); what wastes could be eliminated downstream if designs were not thrown over the wall to the next function (e.g. Purchasing, manufacturing). Therefore, the first parameter that this investigation will look deeper into is:

- Involved functions: In what way and when were different functions involved?

Further on, Cooper (2001) also mentions that each stage should consist of certain activities that will result in fulfilment of defined criteria at the following gate. Since key activities in the ratio process has shown to be performed at different stages in the process, it is of interest to find out if there can be found any difference regarding when key activities has been conducted in successful versus unsuccessful projects. Further on, this will also show what the basis for the information presented at the different gates was, hence see if the standards for the information presented is the same in every project. This parameter is also important in order to answer the question presented by Keyte and Locher (2004); would the quality and quantity of the design be improved by a better filter of projects. Hence, the second parameter is:

- Key activities: At what time during the process was key activities carried out?

One of the major issues for the ratio process is an experienced problem with gate-timing. According to Morris and Pinto (2007) it is of importance to have a time-plan in order to be able to meet a defined deadline. Even though no data exist regarding time-plan for certain activities in the investigated projects, there is available data for planned gate-timing and the actual gate-timing. By investigating how the different estimated gate –timings were fulfilled in successful vs. unsuccessful projects, it can be seen if there are any difference when estimating how much time that should be spent in the different phases, hence if time-plans for successful projects are done in a more logical way. Cooper (2001) also mentions the fact that the stage concerning "build business case" is the one that is most often weakly handled, therefore it is also of interest to see if this stage is dedicated more time in the successful projects. This results in the third parameter:

- Time division: How large share of the total time was estimated to be spent in the different stages of the process, and what was the outcome?

Furthermore, by investigating how the projects had been conducted regarding these three parameters and see if there are difference in successful versus unsuccessful projects, best-practices can also be identified, which can contribute to answer the third question presented by Keyte and Locher (2004); what wastes can be eliminated by using standardized work throughout the design process.

When investigating the time division, ten unsuccessful and ten successful projects were included. The time division between the different gates for the unsuccessful projects (U1-U10) is shown in table 6. Both the time division that was planned before PS, time (est), and the resulting time division, time (final), is shown in the table. For example, for project U1; 13% of the total project time was estimated to be spent between PS and PSC, and the outcome was that 8% of the total project time was spent between PS and PSC. Same numbers then follows for the other phases; PSC-PA and PA-J1. Since no time-plan is made before the passage of the PS-gate, no time allocation is made to that phase. As can be seen in the table, the largest amount of time is in general spent between PA and J1. In average for the unsuccessful projects 13% of the total project time was spent between PS and PSC, 25% was spent between PSC and PA and 57% was spent between PA and J1.

Table 6: Time division in percentage for the defined unsuccessful projects conducted during 2011 and 2012

Project	Between PS - PSC		Between PSC - PA		Between PA - J1	
	Time (est)	Time (final)	Time (est)	Time (final)	Time (est)	Time (final)
U1-9256777	13%	8%	7%	4%	80%	Rejected
U2-9785649	5%	2%	27%	40%	68%	58%
U3-10063975	17%	22%	9%	48%	74%	30%
U4-1982406	4%	1%	19%	57%	78%	Rejected
U5-9505523	4%	0%	4%	8%	92%	Rejected
U6-10033547	25%	17%	21%	0%	54%	83%
U7-9524866	0%	31%	6%	8%	94%	62%
U8-1985807	13%	23%	50%	14%	38%	Rejected
U9-9239193	15%	19%	65%	33%	19%	48%
U10-10113820	5%	4%	26%	37%	68%	58%
Average	**10%**	**13%**	**23%**	**25%**	**67%**	**57%**

For the ten successful projects (S1-S10), the time division is shown in table 7. In average for the successful projects 12% of the total project time was spent between PS and PSC, 26% was spent between PSC and PA and 62% was spent between PA and J1.

Table 7: Time division for in percentage successful projects conducted during 2011 and 2012

Project	Between PS - PSC		Between PSC - PA		Between PA - J1	
	Time (est)	Time (final)	Time (est)	Time (final)	Time (est)	Time (final)
S1-10064178	0%	0%	29%	19%	71%	81%
S2-10134195	5%	4%	13%	27%	82%	69%
S3-10130367	6%	11%	19%	23%	75%	66%
S4-9114260	9%	13%	23%	4%	68%	83%
S5-10131030	9%	8%	0%	0%	91%	92%
S6-10181618	10%	10%	20%	30%	70%	60%
S7-10163208	12%	36%	18%	73%	71%	-9%
S8-9991384	14%	9%	14%	39%	71%	52%
S9-9506626	19%	0%	39%	12%	43%	88%
S10-9969175	41%	26%	15%	37%	44%	37%
Average	**12%**	**12%**	**19%**	**26%**	**69%**	**62%**

As can be seen when comparing the time division for unsuccessful and successful projects, the average time division is similar independent of the success of the project.

When investigating the key activities and the functions involved in the chosen projects, the focus is on when activities were carried out and at what point during the process other functions became involved. In order to visualize this, a process map was created for each of the chosen projects, an example can be seen in appendix F. Process maps were created for eight of the unsuccessful projects and four of the successful projects, the results are summarised in table 8 and 9. All activities that were carried out during the ratio process both for unsuccessful and successful projects are identified in relation to when they were conducted and who was involved, see table 8 and 9. It can be seen that during the process for the unsuccessful projects the majority of the activities are conducted after the PS-gate but before the PA-gate. During the successful projects the majority of the activities are carried out before the PS-gate and between the PSC-gate and PA-gate.

For the unsuccessful projects all tests have been carried out after the PS-gate and there are only in a few project processes other departments or support functions have been contacted, see table 8. When investigating the successful projects, it can be seen that the majority of tests are conducted before PS-gate and the contact with Purchasing and suppliers have also been done in early stages of the process.

Table 8: Activities and involved functions for the eight of the defined unsuccessful projects conducted during 2011 and 2012

	Before PS		Between PS - PSC		Between PSC - PA		Between PA - J1	
Project	Activities	Involved	Activities	Involved	Activities	Involved	Activities	Involved
U1-10063975			Send QOP, tests	Purchasing, DRMS	Neg. QOP, tests	Purchasing		
U2-1985807		Supplier, Crash	Send QOP	Purchasing, Crash	RCP	Crash, EL, Seats	Tests	
U3-9785649				CE	Send QOP, tests		Neg. QOP	Purchasing
U4-1982406					Tests	Supplier		
U5-9524866		Powertrain	Tests (int.)	Purchasing	Send QOP			
U6-10033547		CE	Neg. QOP, Tests (int.)	Purchasing, Crash			Re-neg. QOP, tests	
U8-9505523								
U10- 9256777		Crash	Send QOP	Purchasing		Purchasing, Supplier	Tests	Crash

Table 9: Activities and involved functions for four of the defined successful projects conducted during 2011 and 2012

	Before PS		Between PS - PSC		Between PSC - PA		Between PA - J1	
Project	Activities	Involved	Activities	Involved	Activities	Involved	Activities	Involved
S1-10064178	Send QOP, Neg. QOP	Purchasing, Supplier, DRMS					RCP	
S2-10134195	Tests (old), Tests				Send QOP, tests	CE, Purchasing	Tests, neg. QOP	Purchasing
S3-10130367	Tests (old)	Purchasing, Supplier		DRMS	Send QOP, Neg. QOP, tests	CE, Purchasing, Climate	Problem solving	
S9-9506626	Send QOP, Tests	Purchasing, Climate, El, Extrior, Crash, Supplier	Tests	Crash	Tests, RCP		RCP	

4.3.3 Identified Issues

When the process mapping for the chosen projects were conducted and all activities and functions involved were identified, four different issues were identified as a critical factors that cause projects to postpone in time. The four issues were identified to be *receive QOP-answer, negotiate QOP, delayed tests* and *technical problems after PA*, see table 10 for further information.

Table 10: Identified issues that caused delays for eight of the defined unsuccessful projects conducted during 2011 and 2012

E-Tracker no	Receive QOP-answer	Negotiate QOP	Delayed tests	Technical problems after PA
U1- 10063975	X	X		X
U2- 1985807			X	
U3- 9785649		X		
U4- 1982406		X		
U5- 9524866				
U6- 10033547		X		X
U8- 9505523			X	
U10- 9256777	X	X		

The first identified issue, *receive QOP-answer*, means that the estimated time-plan have exceeded because the project task leader had to wait for QOP-answer from the supplier to be able to proceed in the process. For example, the QOP-answer needs to be received in order to start the negotiation and in turn the negotiation has to be finalised before the project can be approved at PA. This activity is dependent on the supplier, although the quality of the answer can be dependent on the information sent in the QOP-request.

The second identified issue, *negotiate QOP*, is the most common problem that cause project delays, see table 10. This activity is dependent on the supplier and Purchasing, while the task leader support Purchasing with negotiation arguments. This activity can delay the project to proceed because this activity needs to be finalised before the project is approved at the PA-gate.

The third issue is *delayed tests during the project process*. This issue can delay the projects independently on which stage the project is in. This identified issue considers both external and internal tests, and if either of them is delayed the whole project will be postponed.

The fourth issue is identified as *technical problems after PA*, hence in order for a project to be approved at PA and able to proceed in the process the technical specification should be ready. If not, this can lead to rework of many activities, for example new tests and re-negotiation. For example, in one project an assembly problem was noticed first after PA. During the pre-production the personal detected that the new solution was not possible to assemble to fit the other parts, this lead to a re-construction, new tests, and re-negotiation for the modified solution which caused the project to exceed the estimated time.

4.3.4 Summary

During 2011 and 2012 the ratio process conducted 87 projects that were approved at the PA-gate. From these 87 projects it was 21 projects that become rejected even though they were approved at PA. The projects that are conducted at the ratio process are of various characteristics, hence the type of projects could be regarding remove component or change supplier. The projects have also various characteristics considering estimated savings, estimated costs, numbers of handover and estimated time. Projects can have an estimated saving below 5 SEK/average car but there are also projects with an estimated saving over 50 SEK/average car. The time between the PS-gate and PA-gate can be estimated to be between below five weeks and over 20 weeks.

Further on, the ratio process has two critical aspects, savings and time, which are important when considering the process's result. Considering these two aspects, the conducted projects during 2011 and 2012 have provided for a result that shows that the projects estimation at the PS-gate has been optimistic.

When investigating and comparing the successful and unsuccessful projects, there is no distinction to be found regarding the time division between the different gates. However, there is a difference when considering at what point different activities are conducted and who is involved at what stage during the process. For example, in the unsuccessful projects there are no tests conducted before the PS-gate while in the successful projects the majority of tests are conducted before PS.

A process mapping of the unsuccessful projects showed that there are four different issues that could be identified as possible problems that could create projects delays. The issues are identified as receive QOP-answer, negotiate QOP, delayed tests and technical problems after PA.

5 Analysis

In this chapter the ratio process will first be analysed in general, continuing with analysing the conducted projects in terms of fulfilment of estimated time and savings. The analysis will proceed with investigating the categorisation of unsuccessful projects. Even though the projects conducted at the ratio process are of various characteristics it was not possible to distinguish a specific category that affects the outcome of the projects. The categorisation of the projects showed that the conducted projects give a random distributed result independent on the projects characteristics. Therefore the later parts of the analysis will focus on a comparison between the projects defined as unsuccessful and successful. This comparison will consider how those projects have been handled. This means that projects will be examined in terms of which activities have been conducted, who is involved and how the time has been spent throughout the process for each project. The analysis will also consider how the process is controlled and followed-up. The structure of the analysis is depicted in figure 28.

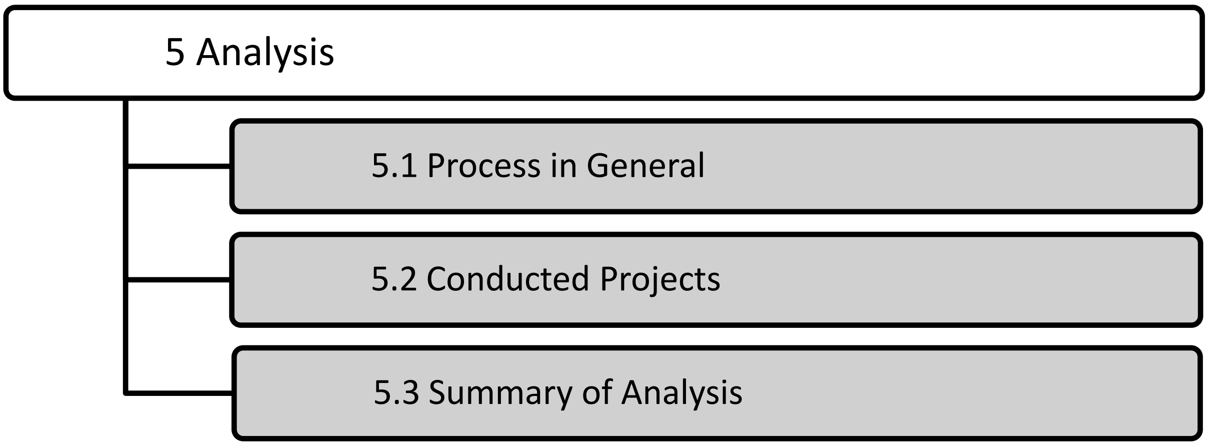

Figure 28: Structure of the Analysis

5.1 Process in General

The ratio process is similar to Cooper's (2001) guide for a new product's development process, the Stage-Gate process. The ratio process in line with the Stage-Gate process follows a certain amount of stages where activities are carried out and before the project proceed to the next stage it has to be approved at each gate. The weaknesses and strengths in the ratio process that will be analysed in this chapter are visualised in figure 29.

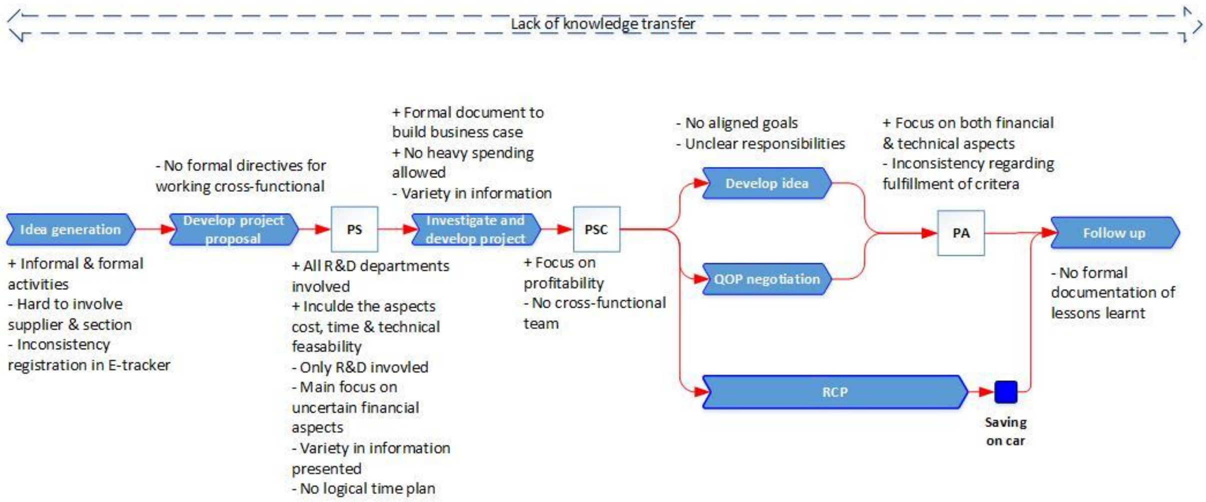

Figure 29: The ratio process with identified strengths and weaknesses

The first stage in the ratio process, idea generation is the same as Cooper's (2001) model, which highlights this activity's importance because it is the input to the process. The ratio process uses both informal and formal activities to support and generate new ideas, for example through workshops, tear-downs or brainstorming. According to Cooper (2001) this is common among other companies due to the criticality of this step. But even though the ratio process uses several different tools to create new ideas it is difficult to generate enough "good" ideas. One reason can be because the supplier has a deeper knowledge about a specific system or component, and are not willing to share knowledge and create new ideas. Further on, it can also be hard to get all persons within the section engaged in generating ideas, which means that much knowledge available within the section is not utilised.

The new ideas are added to the database, E-tracker, but at what time they are added to the system depends on the sections and its concept-KU. This affects the outcome of the follow-up when measuring the input flow of ideas, because the different sections have investigated the ideas for various amount of time. Some sections add the idea to E-tracker directly when they come up with them while other sections chose to investigate the idea before adding it to E-tracker. In addition it is possible for anyone to add ideas to the database, which also affects the follow-up when measuring input flow and also may create additional work for the KU that needs to sort out and prioritize the incoming ideas. When the idea is added to E-tracker by the responsible KU, the information registered is mainly a short description of the idea with some sentences. Hence the information that is made available to other personnel is at this point limited, and the majority of the information and knowledge about the idea can therefore be seen to be tacit knowledge. According to Niedergassel and Leker (2011), a risk with this may be that if an individual has been working alone with this idea the knowledge about the solution may be lost, for example in an occasion when an individual leaves ones job.

Before entering the first gate, PS, the task leader should investigate the idea further and then create an Intake-document to present estimated savings, estimated time-plan and technical description for the project. Cooper (1998) mentions that every stage should have input from different perspectives and departments, continuing to emphasise the importance to have a cross-functional team at every stage of the process. However, before the PS-gate the saving can either be estimated by the KU itself with old price lists or with the help of a cost estimator. It is however mentioned by Taylor (2008) that estimations regarding costs often are inadequate in early phases of the project due to lack of historical project data, outdated estimating databases and reliance on intelligent guesses to estimate costs, which also should be the case when estimating savings. Hence, the early estimations of savings in the projects are not fully reliable.

Further on, the project should have a rough estimated time-plan in order to enter the first gate which is something the KU estimate on their own and no requirement regarding input from other departments exists. The technical description that should be presented at PS-gate can be created by the KU together with a design engineer. Even though other departments are involved there are no formalized directives for what departments that should be involved. This may mean that in some cases several different departments are involved at this stage while other projects are carried out almost solely by the responsible KU. According to Cooper (1998), one of the reasons that several functional areas should be involved is that critical activities may concern several areas. Hence, if the KU works alone it may be harder to get support from other areas even though critical activities concern them.

At the first gate, PS, CMT decide whether the project should be further investigated or not and other affected departments become notified about possible effects from the new solution, and the idea can therefore be evaluated from several perspectives, which is in line with Cooper (1998) who stretches the importance to work cross-functional. However, at all gates during the process, it is only the different departments within the R&D unit which is involved in making the decisions. Therefore, input from other areas such as Purchasing, operations etc. is only presented by responsible KUs.

Further on, in line with Cooper (1998), the project is evaluated regarding costs, time and technical aspects. However Cooper (1998) also mentions that the main focus should be on criteria such as technical feasibility and alignment with company strategies, with limited focus on the financial aspects due to the uncertainty of financial measures which also is supported by Taylor (2008). In the ratio process the PS-gate has criteria that the project needs to fulfil in order to proceed, however projects are sometimes approved without fulfilment in every aspect. The focus is on the projects saving potential and time for J1, but due to the mentioned uncertainty regarding financial measures other aspects should be considered equally important when selecting which projects to work with.

During this first gate, CMT reviews a wide variations of information presented in the Intake-document, which can make it difficult to compare and prioritize which project that should approved for further investigation. The material can be different depending on how the estimation has been conducted, for example if the price estimation is based on old price lists there is a possibility that the estimated savings deviate from the start. Another issue is that the potential savings is presented in different formats which also make it difficult to compare projects. Cooper (2001) mentions the importance to have a defined set of deliverables and known criteria at each gate. Further on, the Intake-document contains limited information about the project, and the most knowledge at this point is tacit knowledge gained by the KU during the process. Similar to above, it is mentioned by Niedergassel and Leker (2011) to be a risk of losing the knowledge. Although, a lot of information at this step may also be hard and time-consuming to document, which according to Goffin and Koners (2001) only may be possible to solve through direct interaction.

It is of importance to present a plan for which activities that should be carried out in order to meet a defined deadline (Kendrick, 2009). At the PS-gate, CMT also reviews the project based on an estimated time-plan, but there is no requirement to present a logical time-plan[4] which should include the activities that needs to be carried out. Instead the main focus is to present a time for J1. The risk with not having a logical time-plan can be that certain activities are not considered (Taylor, 2008), hence the projects can be delayed. This could be avoided by creating a Gantt-chart for the project, which is an easy way to present the time-plan, hence also a good communication tool (Taylor, 2008).

The second stage is to investigate the project further, the KU continues to develop the idea, and provide a TARR-document to build a business case for the next gate. According to Cooper (1998) it is important to build a business case before heavy spending. The TARR-document at this stage depend on estimated parameters such as SOP, savings, tooling and resources which means that result from the calculation depends on who is involved making the estimation. During this stage it is allowed to conduct small tests and it is possible to conduct external tests. However, to be allowed to conduct external tests a solid business case is required and there must be a risk of missing the estimated J1 if the tests are not conducted. In line with Cooper (1998) no heavy spending is done before the business case is built. However at this point in the process input is needed from a variety of sources and the business case should therefore be handled by a cross-functional team (Cooper, 2001). Even though the TARR-calculation contains numbers that is based on a lot of information that the KU has gained during the work, the information only exists as numbers in the calculation and no requirements of making the information available to everyone within the organization in any other way exists in the ratio process at this stage.

[4] A logical time-plan is in this thesis defined as a time-plan that considers all activities that is needed to finalise the project including duration, start- and finish-time for all activities.

At the next gate, Cooper (2001) says that the project should be review in a similar way as in previous gate, although a re-evaluation should be conducted based on the new information. Due to the fact that heavier spending occurs after this gate in the ratio process, Cooper (2001) also mentions that financial analysis is of high importance. In line with this CMT evaluates the TARR-document with focus on the projects profitability. However it is only CMT that evaluates the business case, which by Cooper (1998) is advocated to be done in a cross-functional team.

After the project has passed the PSC-gate it should be initiated in the industrialisation phase, RCP. This process focuses on the technical solution and the time-plan, which complements the CMT process. Today the KU is working as the link between the two processes, and if the same KU is responsible when the project change process and database the information is being transfer without any problems. In those cases when the responsible KU changes from concept to running, the chance of losing information increases because there is no standard way to transfer knowledge between the different processes. In order to decrease the risk of losing information from work that has been conducted individually Goffin & Koners (2001) recommends that employees should keep a work log to be able to share the knowledge. Since no standard way for transferring the knowledge exist the deputy project leader at the industrialisation phase also experiences that the business case presentation varies in quality, which makes it difficult to receive correct information.

Before launching the project, the new solution should be verified with tests and revised financial analysis (Cooper, 2001). In the ratio process the KU further develops the business case by conducting tests, and send QOP-request to the supplier via Purchasing which then also should be negotiated by Purchasing before entering the next gate. In most cases an assignment in VPC is created before the QOP is sent to Purchasing, which makes it possible to keep track of whom that is currently working on the task. However, it is possible to send the QOP without using VPC, which may create uncertainty regarding whom that is responsible for delays etc. Further on, this is a critical stage for the ratio process, and the personnel experience difficulties to receive QOP-answer from the supplier. The supplier has nothing to gain from providing a quick QOP-answer because ratio projects often results in a reduced turnover. Furthermore, Purchasing has no interest in receiving QOP-answer because this is not in line with Purchasing's goals. Both these aspects contribute to that no one feels responsible for this activity which can cause delay in the project time-plan. This issue continues in negotiation of the quotation, where Purchasing is responsible and the KU should be a support function, although sometimes the area of responsibility becomes unclear and can create time consuming communication back and forth. This can result in that Purchasing feels that they are being chased instead of supported while the KU feels out of control.

At the last gate, Cooper (2001) mentions the importance of focusing on both the quality and financial aspects since this is the last gate where the project can be rejected.

The next gate, PA, in the ratio process reviews the project one last time in order to confirm that the solution is ready for implementation. The review is based on the updated TARR-document and the negotiated quotation including time-plan and the project should not be approved unless all parts are finalized. Some projects have been approved at this gate without having fulfilled all criteria, for example projects can be approved although the test resulted is not ready and if those result turn out poor the project can be rejected. Some tests are not possible to conduct before PA, which makes it difficult for CMT to consider the quality and financial aspects to full extent. However even if the project is rejected after PA, the costs will not change but this can give a misleading forecast for savings since the e-tracker confidence is the basis for the forecast. When the gates are approved the confidence increase, and therefore an approval without information that can ensure that no problems will occur may lead to a misleading forecast regarding savings.

After a project has been approved at PA, there is no requirement from CMT to further document the project. This means that a lot of the knowledge gained during the project only exists as tacit knowledge and not will become explicit, which do not enhance sharing of the knowledge within the organization and hence neither enhance learning from old mistakes (Niedergassel & Leker, 2011). It has also been expressed by KUs working within the organization that this is a problem, due to the fact that old ideas are sometimes investigated again even though they were not implemented the first time since information about what was the problem is missing out. Hence, time is spent on performing the same tasks in order to find the problem. In order avoid this problem and to make single employees' knowledge explicit, Goffin and Koners (2001) recommend the use of a work log or personal notes that are available to read. But even so, it may be hard to document all the information gained, and the only alternative could therefore be to share the knowledge by direct interaction or storytelling.

5.2 Conducted Projects

In this sub-chapter the chosen projects conducted during 2011 and 2012 will be further analysed. The focus will be on the result of the projects and if difference exists between how successful and unsuccessful projects have been handled.

5.2.1 Savings versus Time diagram

The most critical aspects concerning unsuccessful projects are as mentioned defined as savings and time. Based on these parameters ten unsuccessful projects from 2011 and 2012 were chosen for deeper investigation and ten successful projects from 2011 and 2012 were chosen as a frame of reference. In figure 30, the successful and unsuccessful projects from 2011 and 2012 are shown.

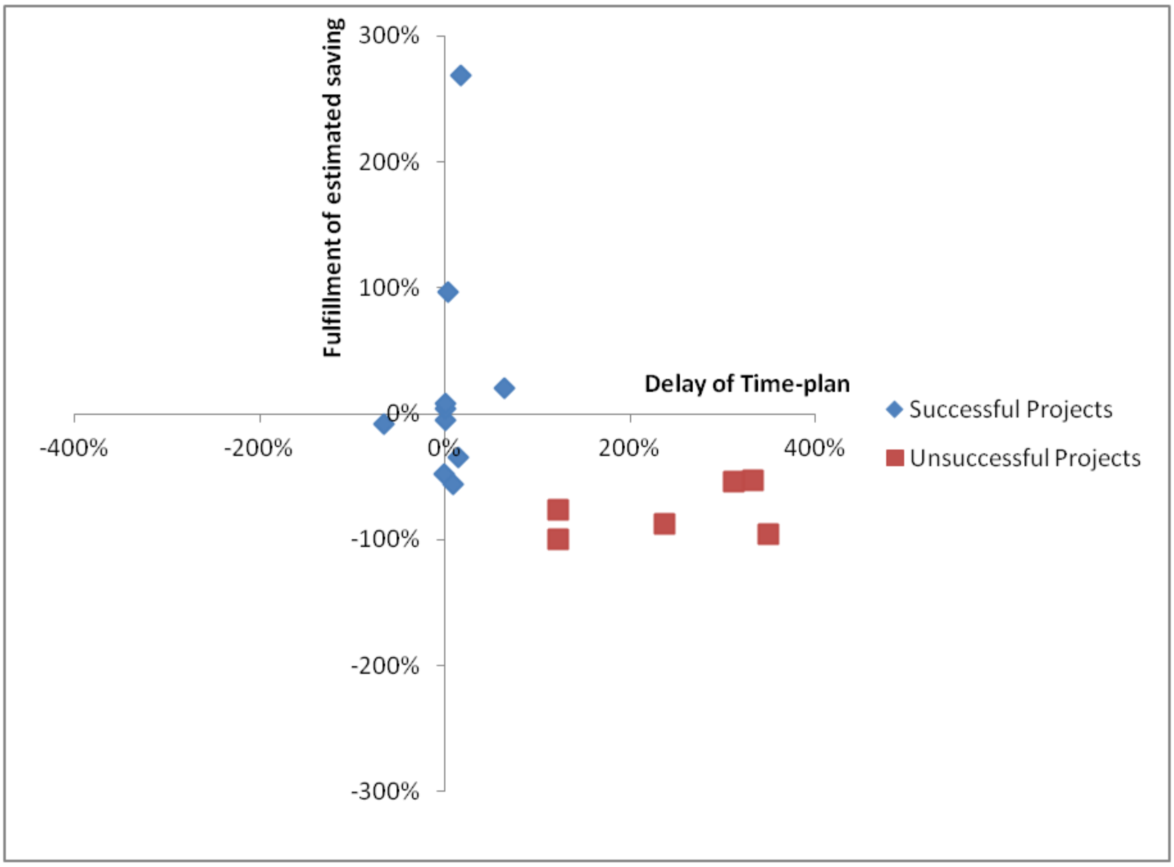

Figure 30: Scatter chart with unsuccessful and successful projects from 2011 and 2012 and how they have fulfilled the estimated time-plan and the estimated saving, excluding rejected projects

As seen in the scatter chart, also the successful projects have in a majority of the cases exceeded the time-plan, although to a much smaller extent. Therefore even though the successful projects have exceeded the time-plan, it is still interesting to investigate possible differences. However, the fact that also the successful projects have exceeded the time-plan indicates that there are problems with creating time-plans. According to Morris and Pinto (2007) a plan for what activities that needs to be carried out, how long time they require and when they should be finished is of importance in order to meet a defined deadline. This can also improve the possibility to avoid risk regarding estimates, presented by Kendrick (2009), since a more detailed estimation would take place, hence more effort put into the planning.

In the ratio process, there is a demand on presenting a time-plan, however, there is no requirement to present a break-down of the time-plan into single activities. By breaking down the time-plan into single activities it would also be possible to consider what activities that is dependent upon other departments. This could minimize the risk for delays due to factors that are partly out of control of the project, which is presented by Kendrick (2009) as one common risk and also acknowledged within the ratio process, where delays in cooperation with supplier and Purchasing are found to be common.

As mentioned there is no requirement to present a detailed time-plan in the beginning of the project, neither does it exist any standardized way of doing this. This results in that for some projects a time-plan is included in e-tracker, but in some cases it is only available for the KU itself. By having the time-plan in explicit form and available for everyone, the barriers to access the information is made lower, which enables more efficient knowledge transfer (Hoppmann et al., 2011).

The fulfilment of estimated savings is the second critical parameter. In similarity to the fulfilment of time-plan, it can be seen that in a majority of the cases the saving is not fulfilled, which indicates problems also when estimating the savings. This parameter is mentioned to be one that the ratio process itself has less influence over, due to the fact that the resulting saving can be affected by for example commercial savings that has occurred during the process. Therefore, the saving that is estimated in the beginning is mentioned hard to fulfil. When estimating costs in a project, Taylor (2008) mentions that the most common reasons for inadequate estimations are lack of historical project data, outdated estimating databases and reliance on intelligent guesses to estimate costs. In the ratio process the estimations is based on either cost-splits from the supplier or on communication with a cost-estimator from Purchasing. These cost-splits are in many cases outdated, and when commercial savings has been done they are not always updated. This results in inadequate estimations regarding savings, which then is in line with the issue about outdated databases mentioned by Taylor (2008). However, communication with a cost-estimator from Purchasing should result in a more adequate estimation and is also in line with what Cooper (1998) mentions, that work should be conducted in cross-functional teams.

5.2.2 Categorization of Unsuccessful Projects

The aim of dividing the projects into categories is to find common characteristics for the projects that were defined as unsuccessful. These categories are chosen based upon identified differences for the projects. When dividing the projects into different categories, the tool used is pie charts, complemented with bar diagram. Cooper (1998) describes pie charts as a way to see the balance in the portfolio, and by dividing the unsuccessful projects into the different categories, it can be seen how the balance of the portfolios should be. For example, by defining a certain category that more often is unsuccessful, the portfolio should be rebalanced so that a larger share of the projects is located in the other categories. Therefore, by finding less successful categories, it can help both when choosing what projects to work with and also what projects to control to a larger extent. Hence, if one category of projects is found to more often result in unsuccessful projects, this can be part of the evaluation when choosing what projects to continue with, but also be a warning-flag that these projects should be more carefully monitored and planned in order to avoid delays. This is also in line with what Mors et al. (2010) mentions; that portfolio management could be useful also for tracking realized benefits of already performed projects and use that information to improve screening and selection processes, which often is an aspect that is overlooked.

When placing the unsuccessful projects into the different categories, both the ones defined in the scatter chart and the rejected ones are included. The reason that also the rejected projects are included is that the process failed in the screening of these projects, since they were approved for implementation but still got rejected after this approval. However, the projects was from the beginning plotted with separate definitions in order to not miss any pattern that could be separately adherent to either one of the categories. For every identified category, a plot into the pie charts that represents the different categories of the projects is made. The example given here is the plot of the projects into different ranges of estimated savings (see figure 31). The savings which is the basis for the categorization is the ones estimated when passing the PS-gate, which is the first gate in the process and basis for forecasts both regarding savings and time for passage of the different gates.

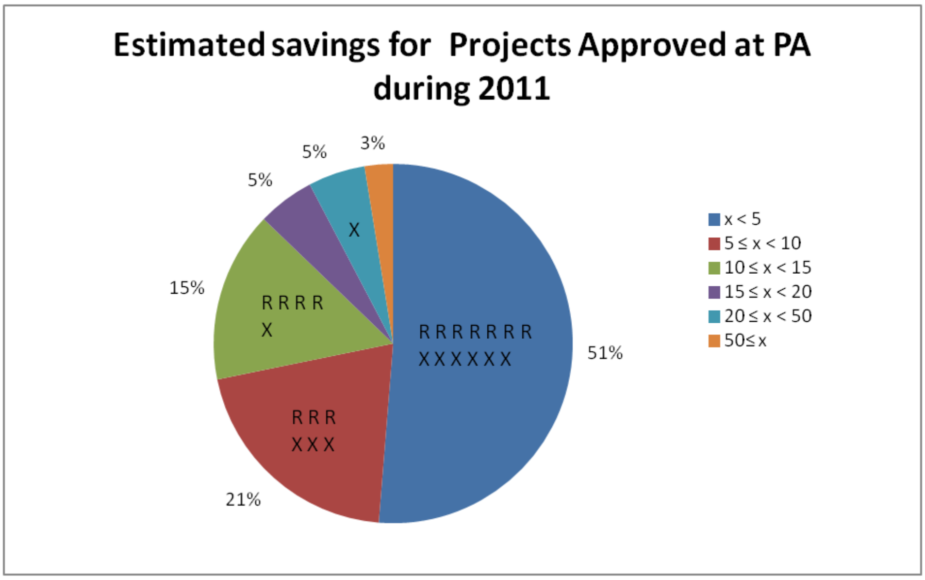

Figure 31: Categorisation for projects conducted and approved at PA during 2011 regarding estimated savings with the unsuccessful (X) and rejected (R) projects registered within the different savings ranges

The number of ranges of savings which are defined in the pie-charts is as seen in figure 31 six. The ranges for the low savings are shorter due to the larger number of projects conducted in the lower savings ranges. When having placed the different projects in the savings ranges, it can be seen in figure 31 that for projects conducted during 2011, the largest number of rejected and unsuccessful projects was located in the range of estimated savings between 0 and 5 SEK/average car. When looking at the same pie-chart for 2012, the largest number of unsuccessful and rejected projects was also located in the savings range between 0 and 5 SEK/average car (see figure 32).

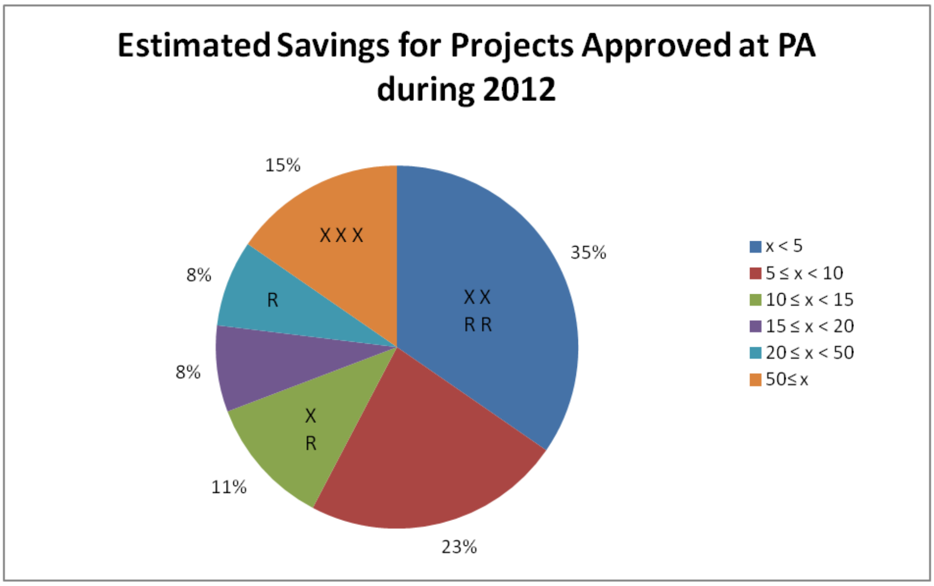

Figure 32: Categorisation for projects conducted and approved at PA during 2012 regarding estimated savings with the unsuccessful (X) and rejected (R) projects registered within the different savings ranges

When looking at only the number of projects that was plotted into the different savings ranges, it could be said that the largest number of unsuccessful and rejected projects was the ones with an estimated saving between 0 and 5 SEK/average car.

Therefore, when looking at only absolute numbers this could be seen as a category which needs to be more carefully monitored. However, what also needs to be considered is that the number of projects conducted within the different savings ranges differ. In order to also consider this, the pie-charts are complemented with bar diagrams. When looking at the percentage of unsuccessful projects, which is shown in the staple diagrams in figure 33, it can be seen that within the category of projects with an estimated saving between 0 and 5 SEK/average car, the unsuccessful and rejected projects are not overrepresented.

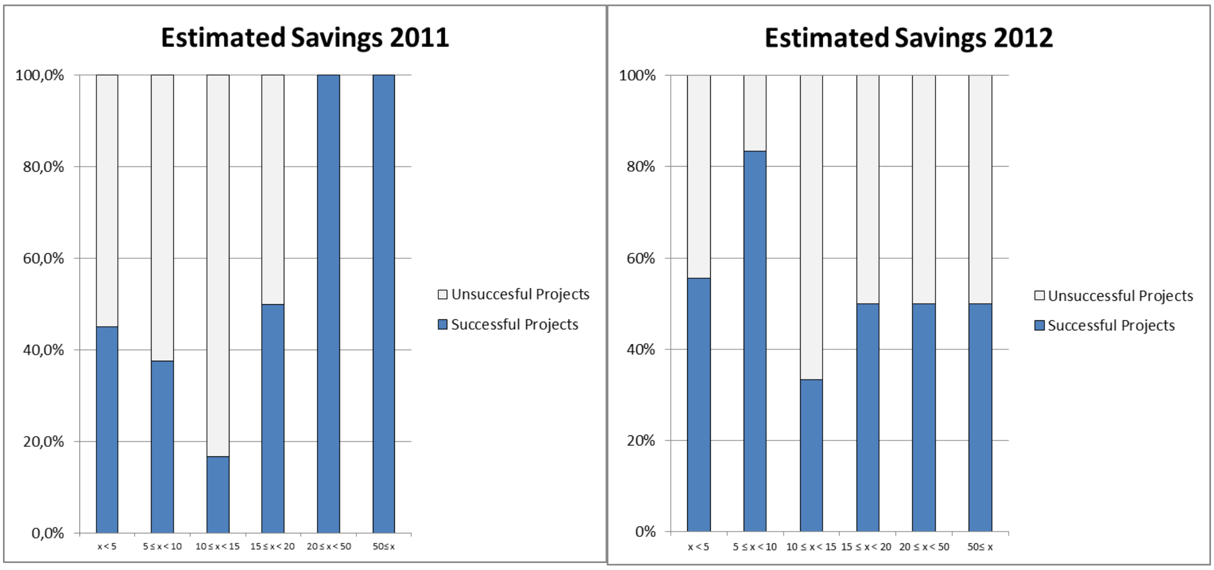

Figure 33: Percentage of unsuccessful projects within the different ranges of savings during 2011 and 2012

The bar diagram shows that the percentage of unsuccessful projects within the different categories during 2011 was the highest between 10 and 15 SEK/average car, which also was the case during 2012. However, while the percentage of unsuccessful project between 10 and 15 SEK/average car during 2011 was 83, 3%, it was 66, 7% during 2012. Further on, as can be seen in figure 33, the other ranges of savings varied between 2011 and 2012. For example, during 2012 the unsuccessful projects in ranges with a saving higher than 15 SEK/average car was almost as high between 10 and 15 SEK/average car, while this was not the case during 2011. Based on this it can be said that there is a large variance in percentage of unsuccessful projects within the categories between the two different years, which results in the fact that no conclusion can be drawn based on only this.

For all the categories identified the same analysis was made, hence both pie charts and bar diagrams was analysed. For each categorisation looked at, it could be seen that the categories containing the largest part of unsuccessful projects varied between years (see appendix G).

5.2.3 Handling of Projects

In this sub-chapter, the successful and unsuccessful projects will be analysed with focus on time-plans and when activities have been carried out.

Time-Plan

As mentioned by Morris and Pinto (2007), a time-plan for what activities that needs to be carried out and when is of importance in order to be able to meet a defined deadline. In the ratio process there has however been problems with fulfilling the time-plan for when different gates should be passed, and hence the deadlines estimated in the beginning of projects has also been delayed, as shown in the scatter charts presented earlier in this report.

As mentioned by Taylor (2008), a time-plan should present all activities that need to be carried out in a logical and interrelated way. However, in the ratio process there is no demand on presenting a logical time-plan. There must be an estimated time for when the different gates should be passed when passing the PS-gate, but no break-down into single activities. By breaking down the project into single activities, there is also a possibility to see what activities that are dependent upon external departments or may be affected by factors that are out of control of the department, which by Kendrick (2009) may be large risks that can cause a delay of the time-plan.

According to Cooper (2001), the beginning steps of the Stage-Gate process should be done relatively quick and inexpensive. When continuing with the step building the business case, there is although mentioned that this step most often is the one that is weakly handled, hence it is indicated that more time in many cases needs to be spent at that stage, which in the ratio process corresponds to the stage between PS and PSC. In order to see how the division of time between the different stages are in unsuccessful projects, and if any difference can be found between how the division is planned in unsuccessful and successful projects, a comparison is made between the percentages of the total project time that both has been planned and actually spent in the different phases.

In table 11, the average share of time spent and planned in the different phases for successful and unsuccessful projects is shown. Based on the percentages shown in the tables it can be said that when making time-plans for successful and unsuccessful projects, no large differences exists between the time to be spent in the different phases of the process. Hence, the time division is similar independent on whether or not the project has resulted to be successful or unsuccessful. Therefore, the success of the projects cannot be said to be directly correlated to the time planned or spent in the different phases of the process. However, since no data exists for when the projects started to be investigated, neither any data for how long time that was planned or spent investigating the idea before the PS-gate is available, and the effect on the outcome of the project from the investigation before the PS-gate can therefore not be evaluated.

Table 11: Average time planned and spent in different phases in successful projects and unsuccessful projects

	Between PS - PSC		Between PSC - PA		Between PA - J1	
	Time (est)	Time (final)	Time (est)	Time (final)	Time (est)	Time (final)
Unsuccessful Projects	12%	12%	19%	26%	69%	62%
Successful Projects	10%	13%	23%	25%	67%	57%

For both successful and unsuccessful projects it can in general be said that the least amount of time is spent between PS and PSC, where the outcome for unsuccessful projects is that 12% of the total project time is spent in average. For successful projects 13% of the total project time is spent between PS and PSC in average. The largest amount of time, both estimated and actually spent, is between PA and J1. As can be seen in table 11, the share of the total time spent between PA and J1 is in average estimated to be 69% for unsuccessful projects and 67% for successful projects. The result is that 62% for the unsuccessful projects and 57% for the successful projects of the total time in average is spent in that stage.

Activities

Based on the process mapping four different issues were identified as problems that cause delays in projects. The identified issues were receiving QOP, negotiating QOP, delayed tests and technical problems after PA. The process mapping also resulted in placing the key activities in the different projects according to between which gates they have been conducted. Based on this, it could in general be said that in successful projects both Purchasing and suppliers were involved to a higher degree earlier in the process, which also is in line with what Cooper (1998) advocates in form of cross-functional team. An example which is representative for the mapped projects is the comparison between project U10 and S3, see table 12. In project U10 Purchasing was involved first after PS, and the supplier was involved first after PSC. Further on, the tests were conducted after PA, which means that the project had already been approved for implementation. In project S3 both Purchasing and supplier were involved already before PS. In addition, there was available test data already when starting up the project, which not always is the case.

Table 12: Activities and involved functions during the process for project U10 and project S3

	Before PS		Between PS-PSC		Between PSC-PA		Between PA-J1	
Project	Activities	Involved	Activities	Involved	Activities	Involved	Activities	Involved
U10-9256777		Crash	Send QOP	Purchasing		Purchasing, Supplier	Tests	Crash
S3-10130367	Tests(old)	Purchasing, Supplier			Send QOP, Neg. QOP, tests	CE, Purchasing, Climate	Problem solving	

Receiving QOP-answer is one of the identified reasons for projects to become delayed. According to several KUs working at different section it is difficult to receive a QOP-answer within two weeks which is also confirmed in some of the unsuccessful projects that has been studied. These projects that have been delayed because the KU have had difficulties in receiving QOP-answer, has not been in contact with the supplier before the PS-gate, see table 12 for further information. Because this activity is dependent on the supplier, and a ratio project usually means a reduced turnover for the supplier, it is important to involve the supplier early in the process and to give them a responsibility for the project. Comparing handling of the unsuccessful projects to handling of successful projects, the supplier has been contacted early in the projects, which also can be seen in table 12.

The QOP-request is sent from the KU through Purchasing before the supplier receive it, and in those cases where the QOP-answer have caused the time-plan to exceed Purchasing have not been involved before sending the QOP-request to the supplier. According to Cooper (1998) the projects should be carried out by cross functional teams in order to include functional areas that are involved in critical activities, which then not has been the case in all of the unsuccessful projects.

The second identified reason for project to exceed the time-plan is negotiating QOP. According to several KUs this is one of the main reasons for projects to exceed the time-plan. This statement is also confirmed when examining the unsuccessful projects where negotiating QOP is the most common problem that causes delays. In all the unsuccessful projects, both the supplier and Purchasing have become involved later in the project while the successful projects have been in contacted with both parties before the first gate. This activity is dependent on both the supplier and Purchasing while the KU is having a support function. And as mentioned earlier the suppliers have no interest in ratio projects because it usually results in a reduced turnover. It is therefore important for the supplier to become involved in an early stage to feel responsible for the projects.

The Purchasing department has their own goals regarding the yearly savings, which means that they do not prioritize ratio projects because it does not influence their own goals. According to Parmenter (2010) it is important that the measurements are aligned, and a positive impact on measurement should also result in a positive effect on the other measurements that are being used. Although Purchasing and interior have ratio goals together, the division is between the two parties is resulting in sub-optimisation.

The third identified reason that causes the time-plan to exceed estimated time is delayed tests during the process. In the majority of all the successful projects it has either been old tests results available or crash analysis have been consulted early in the process. This is in line with Cooper (1998) who mentions the importance to work in cross-functional teams to be able to gain input from several perspectives and in this case create awareness regarding what tests that needs to be conducted throughout the projects process to be able to ensure the solution feasibility. Although, one of the unsuccessful projects has also been in contact with crash analysis early in the process, and even so the delayed tests resulted in exceeding the time-plan. This means that it can create unforeseen problems even though cross-functional consultation has been performed.

The fourth reason that could cause delays in projects is identified as technical problems after PA. In both those projects that have been delayed due to technical problems after PA, no contact have been made with crash analysis or any other department for consultation regarding possible tests that is necessary to conduct to be able to ensure if the solution is viable. Most of the successful projects have been in contact with other departments in early stages of the process which is in line with what Cooper (1998) points out, the importance to work in cross-functional teams to have different input from several perspectives.

After the PSC-gate but before the PA-gate, the projects are initiated in the RCP process at the PTCC meeting. At this meeting the focus is on the technical aspects and which critical factors that needs to be considered in order to avoid technical problems further on in the process. According to Niedergassel and Leker (2011) the knowledge transfer is a critical aspect to stay competitive with technological developments but also to avoid making the same mistake. The information between the RCP and CMT processes is not transferred in a standardised way and today the information from the two processes is only known for each project's responsible KU. This information can be seen as tacit knowledge which can be hard to spread though it is difficult to express and convert to explicit knowledge (Goffin & Koners, 2011). Goffin and Koners (2011) continues and recommends that individual work should be kept in work logs and through those be shared with other colleagues.

5.2.4 Performance Measurement

Parmenter (2010) mentions that it is of importance to include and have a balance between four types of measurements; KPI, KRI, PI and RI. KRIs and RIs are financial measurements, which should be included in order to see if the business is on the right track. When looking at the areas that are advocated by Stainer and Nixon (2007) to measure in a project, KRIs and RIs concern the projects' pay-off. For the ratio process at VCC, the financial results are followed up mainly in the PCR-report. Since this report shows the actual savings on car, both in relation to forecast and target, for the different platforms and in total, the financial aspect of the projects is considered.

Moreover, financial goals regarding achieved saving on car is also followed up, both for individual sections and overall for I&C. The common goal that I&C has is as mentioned divided evenly on the different sections. However, different sections have decided to allocate a varied number of resources to ratio, which makes it harder to reach the goals for the sections with less available resources. Further on, different sections also have different possibilities to reach the goals due to the fact that they work with different components in the car. For example, it was mentioned by PSS 150 that it does not affect them if an updated design of a car is introduced, since the systems that they work with are still the same. For other sections that work with parts that are changed when a new design is introduced it may on the other hand get easier to find new ratio ideas. By dividing the goals evenly over the sections, the managers for each section are encouraged to allocate resources to ratio, which is a positive outcome. However, if some sections easier achieve the goals dependent on the fact that many ideas are available for their specific components, it does not encourage them to work with every idea if they have already reached their goal. Instead, some ideas may even be postponed to the following year if the current year's goal already is achieved.

The overall ratio goal is divided into separate goals for Purchasing and R&D; one goal for commercial ratio, which Purchasing is responsible for, and one goal for technical ratio, which R&D is responsible for. These goals are followed up together in the Waterfall report. According to Parmenter (2010), it is of importance that the separate goals are aligned with each other, hence that a positive effect on one goal also has a positive effect on most other goals. However, two major problems are experienced with these separate goals. The first problem identified is that Purchasing negotiates with the suppliers in order to lower the price, the information that the parts price are lower than before are although in some cases not communicated to R&D. This enables a situation where the ratio team at R&D estimates savings based on old part prices, which makes the business case look better than it actually is. Sometimes, this information only comes up when the negotiations is about to start. Further on, in some cases when commercial savings has been done, the cost-split is not clarified, which makes it harder for the ratio team at R&D but also makes it possible for the supplier to hide what components actually cost. The second major problem identified with the separate goals for Purchasing and R&D is that Purchasing not prioritises the errands that come from the ratio team at R&D. The reason for this is that Purchasing is not measured in any way on how well they deliver regarding requests from the ratio team at R&D, and technical ratios may make it harder to achieve commercial ratios for the suppliers involved, since their margin becomes lower after technical ratios. Due to this conflict of interests, both QOP-answers as well as QOP-negotiations may take longer time.

In order to see what should be done to increase the performance, KPIs should also be used. These measures should be a non-financial measurement and a measurement that considers which future actions that should be taken (Parmenter, 2010). When looking at the follow-up done in the ratio process today, forecasts for how large the value of the projects in the different phases of the process will be in the future are included as well as the number of projects that are estimated to be in the different phases at certain points in time. This means that the ratio process today has a KPI that measures if the planned future actions can fulfil the overall goals.

One of the problematic areas described by VCC is although gate-timing during the projects. What is done today in order to control the project pace is that there is an overall goal to pass all the gates according the time-plan presented at the Intake-meeting, this is called “first time through”, and the goal is to have 100% of the gates passed the first time. This goal hence measures the performance for the projects to keep on track, not for individual projects but for the whole group of projects. When looking at the categories of performance measurement presented by Parmenter (2010), this measure can be categorised as a PI. This is based on the facts that it is a non-financial measurement and measures the outcome of the process, hence is a past measurement and can therefore not be categorised as a KPI.

Even though a variety of measurements are used today, and that all types of measurements advocated to use by Parmenter (2010) is included, the ratio process at I&C still experiences problems with keeping time-plans and meet milestones during the projects. Therefore, the wish is to find further measurements that can control and guide the process regarding these issues. When looking at the different areas that Stainer and Nixon (2007) presents as suitable to measure in a project, these measures would be focusing on measuring both the process itself and the output of the process. By implementing measurements that covers this area, the ratio process could therefore detect problems that occurs during the process, increase the ability to keep the projects on track and also monitor how well requirements of the process is being met.

5.3 Summary Analysis

The ratio process is similar to Cooper’s (2001) Stage-Gate process and can be divided into a certain amount of gates and stages. The development phase in the ratio process have three different gates were every project needs to be approved in order to proceed. During the stages activities are conducted to be able to fulfil the requested criteria at each gate.

In line with Cooper's (2001), all the gates have criteria and required deliverables that the projects need to fulfil in order to proceed and every project is reviewed regarding costs, time and technical aspects. Along with Cooper's (1998) Stage-Gate process, the ratio process also have criteria that have an increased focus on financial aspects and the project should present a solid business case in order to allow heavy spending. However, at the PS-gate CMT reviews the projects with a financial focus but Taylor (2008) mentions that financial estimations often are inadequate in early phases of the projects. Cooper (1998) continues with that the main focus early in the process should be on criteria such as technical feasibility and alignment with company strategies.

When CMT reviews the projects at the different gates every project has a set of deliverables that needs to be presented. However, there information is presented in various formats which can make it difficult to compare and prioritize the different projects. Some of the defined deliverables contains limited information about the projects and most of the knowledge is tacit knowledge gained by the KU. According to Niedergassel and Leker (2011) tacit knowledge is a risk of losing the knowledge.

Between the gates the project is developed and further investigated by a responsible KU. Since ratio projects is of a various characteristics the activities that are conducted during the process is carried out at different stages. The activities can also differ from projects to projects because of the projects variance in characteristics. Cooper (2001) highlights the importance to use cross-functional teams throughout the whole process in order to have input from several perspectives and ensure that all critical activities are considered. However, because of the ratio projects various characteristics the functions areas involved during the process depends on the specific project. The affected R&D departments are notified at the first gate otherwise it is the KU that is responsible to contact other function areas.

During the ratio process different databases are used to document projects. The databases are used differently depending on the user and some databases overlap which sometime can result in conflicting information. It is often the KU that is responsible for updating information, and work as a link between the different databases and processes. If it is the same KU during the whole process the information can be transferred without any problems. In those cases when the KU changes from concept to running, the chance of losing information increases because there is no standard way to transfer knowledge between the different processes and there is a risk of the knowledge only is known by the KU. Niedergassel and Leker (2011) mention the need to have an approach to stimulate the knowledge transfer in order to stay competitive with technological developments.

After a project has been approved at PA, there is no requirement from CMT to further document the project. This means that a lot of the knowledge gained during the project only exists as tacit knowledge and not will become explicit and hence is hard to learn from. It has also been expressed by KUs working within the organization that this is a problem, due to the fact that old ideas are sometimes investigated again even though they were not implemented the first time since information about what was the problem is missing out. This means that resources are spent on regenerating knowledge, which according to Hoppmann et al. (2011) should be avoided in order to increase resource efficiency in the process. Further on, learning from old projects is also a way to continuously improve the process (Goffin & Koners, 2001).

The most critical parameters for a project were defined as being fulfilment of savings and fulfilment of estimated time-plan. Based on this, the projects have been registered in a scatter chart and the unsuccessful and successful projects were identified. However, it could be seen that also the most successful projects in general was delayed compared to the estimated time-plan and did not fulfil estimated savings. Based on this, problems seem to exist regarding how the time-plan and savings are estimated. According to Morris and Pinto (2007) it is important to break down the project into activities in order to meet a defined deadline, which currently not is done in the ratio process since no demands exist for presenting this kind of time-plan. Further on, the savings in the project is hard to estimate, which partly depends on lack of communication between Purchasing and R&D but also on outdated information, which also is meant as one of the common reasons to inadequate estimation by Taylor (2008).

For the projects that were defined as unsuccessful an attempt was made to find if these projects could be adherent to a common category since Mors et al. (2010) mentions portfolio management as a way to improve the screening and selection of projects. However, any common characteristics for the unsuccessful projects could not be found and hence what kinds of projects that is unsuccessful varies randomly. Instead a detailed investigation was made for the unsuccessful projects regarding the parameters time division between different stages, involved functions and key activities, and how these parameters have affected the four identified issues that cause project delays.

The main causes found during the process that affected these issues were late involvement from other functional areas, such as Purchasing and suppliers, and goals that are not aligned between different functions, hence do not encourage cooperation. In addition, there was also expressed by Purchasing, that are involved in the projects to a large extent, that the division of responsibility sometimes are unclear, which creates additional communication regarding whom that solve certain issues. These problems is also supported by Cooper (1998) who mentions the importance of working cross-functional during the process, since critical activities often concern more than one functional area.

Even though the ratio process currently has a variety of measurements implemented they still experience problems with gate-timing during the process. In order to keep the projects on track and monitor how well the projects meet the requirements it could therefore be useable to consider the three areas that Stainer and Nixon (2007) presents as useful to measure during a process; the output, the process itself and the payoff. Further on it is important to consider whether or not all the measurements are aligned (Parmenter, 2010), which not is the case today and currently causes problems in the cooperation between Purchasing and R&D.

6 Discussion

In this chapter, the four research questions presented in the beginning of the report will be discussed based on what was presented in the analysis. The research questions will also be discussed regarding possible implications and solutions for the ratio process.

The first research question identified in this thesis was:

RQ1: How does the current process look regarding persons involved, follow-up, activities carried out and how are they related to each other? Are there any differences between how the process is carried out at VCC and how it is advocated in theory?

The ratio process follows the structure of the Stage-Gate process presented by Cooper (1998), where at each gate the project is reviewed by CMT. However, it is only CMT that reviews the project at the different gates and not cross-functional team as advocated in the Stage-Gate process. The different gates have requirements, but the basis for fulfilment of these requirements differs between projects since no formal requirements for what the information should be based on exist, which means that even though different projects has passed the gates they may still contain different degrees of uncertainty. In order to solve this, it is suggested that a cross-functional team should take part of evaluating and reviewing the projects. Top priority should be to include Purchasing in the cross-functional team and let them take part of confirming if the project should proceed or not. This is due to the fact that Purchasing is involved to a high degree in all projects and also that problems historically have occurred in the cooperation with Purchasing. Further on, having Purchasing involved in the cross-functional team could also help to evaluate the estimated savings which is done in the beginning, which without confirmation from Purchasing can be uncertain. This could be useful since there often occurs that the cost-splits which the estimations is based on is outdated and also that commercial ratios has been taking place during the projects has been carried out. Therefore, by involving Purchasing they can give this information during the project, and it also creates awareness within Purchasing about what ratio projects that will come up.

Further on, there is no formal requirement about a detailed time-plan for the projects during the early stages of the ratio process which according to Morris and Pinto (2007) is of importance to keep a defined deadline. This means that critical activities may stay unconsidered and therefore delay the projects, hence the deadline cannot be met, which also is one of the main issues that is described as a problem within the ratio process. Therefore, it is judged suitable to include a requirement of a logical time-plan for the projects in one of the early gates in the ratio process, which means either PS or PSC. By including a requirement of a logical time-plan early in the process it is also possible to see what other functions that will be involved and also let them confirm the time-plan, which should mean that they also feel a greater responsibility for fulfilling the time-plan. The way for how the time-plan should be presented is recommended to be in form of a Gantt-chart due to the fact that it is a simple way to present the time-plan, which also is easy to understand. By presenting a time-plan that is easy to understand it is also more likely to enhance knowledge transfer.

When it comes to measuring the number of gates that are passed in time, it should be based on this time-plan. This means that if the time-plan is presented at the PSC-gate, the number of gates passed in time should be measured from after PSC since that is when the functions involved has confirmed that they can fulfil the time-plan. However, today it is measured from PS. This means that if measuring the fulfilment of time-plan from PS it would also be needed to present a logical time-plan at PS, which requires more work before presenting the project to CMT. Therefore, it is a judgment to make if the time should be spent before PS or if the fulfilment of time-plan instead should be measured from PSC. In order to not spend too much time on the project before anchoring it with CMT, the suggestion is to present the time-plan at PSC, hence also measure the fulfilment of gate-passing from PSC.

Between the gates it is a KU that is responsible for the project, and no formal requirements exist for including other departments except for in single activities. According to Cooper (1998), each stage in the process should be cross-functional. However, by involving other functional areas when confirming projects, and also let them take responsibility for certain tasks should enhance cross-functional work. Therefore, it should not be necessary to have a formal cross-functional team dedicated to the project. This is also due to the fact that many projects are conducted at the same time, and often they are relatively small, and dedicating a cross-functional team to each project would therefore be too much work in relation to the benefits that could be achieved. However, since the KU alone is responsible for conducting the projects it means that lots of knowledge gained is only known by the KU itself, and may also be hard to transfer to other KUs and sections. Therefore it is important to enhance the transferring of knowledge from the projects. This should therefore be done during the process but also afterwards. How it should be done during the process should be standardized in form of what information that is judged necessary to document but also standards in form of what database that should contain which information, since three different databases are used in the process today. Further on, no formal lessons-learnt activities exists in the process today. Therefore, it is important to document lessons learnt from the projects and also make it available for everyone to find, and through that avoid e.g. investigating the same ideas again. However, it could also be suitable to complement this documentation with meetings between the KUs to share the lessons learnt, since some information might be hard to make explicit. These meetings should however not be too often due to time limits.

RQ2: What kinds of projects are carried out? Is it possible to find common characteristics for projects that are unsuccessful?

The projects conducted in the ratio process within I&C are carried out by five different sections. The projects are of different sizes regarding such as budget, estimated savings potential and estimated time-plan, hence the conducted projects at the ratio process are of various characteristics. The projects different characteristics do not affect the projects outcome instead the result is randomly distributed and it is not possible to find any common characteristics for projects that are defined as unsuccessful. Therefore it is not possible to distinguish any characteristics that would be more critical for the process, and it is therefore more important to focus on how the projects are prioritised and handled during the process. Further on, it is of interests to investigate how the process in general is handled and if there is any differences between how the work have been conducted in those projects that are defined as unsuccessful and those that are successful.

RQ3: What problems can be found in how unsuccessful projects have been conducted? Can differences be found between how the work has been performed in successful vs. unsuccessful projects?

There are four issues that are defined as problems and have caused delays in those projects that are defined as unsuccessful projects. These four issues are identified as; receive QOP, negotiate QOP, delayed tests and technical problems after PA. When comparing how the identified issues have been handled in unsuccessful versus successful projects one can see differences in when activities related to the identified issues are conducted and at what point other functions are involved during the process. In those projects that are considered as successful the critical activities have been conducted early in the process, which could have contributed to the successful results. There are no cross-functional teams during the ratio process, and those functions that are affected by a project are contacted for that specific project. It can be seen in the successful projects, that the functions related to the identified issues have been contacted early in the process. This could mean that by involving different functions in the beginning of a project it could give a positive result. Further on, the time spent in the different stages is the same whether or not the project has resulted as successful or not, hence the amount of time spent in the different stages do not affect the result.

RQ4: How can the work in the process be conducted in order to avoid problems and through that improve performance? What follow-up is recommended to use in order to control the project pace?

As discussed in relation to RQ3, there was seen that in the successful projects, other functional areas were involved earlier in the process. Hence, it appears that involving different functional areas earlier in the process has a positive effect on the performance of the project. Regarding the issues receive QOP-answer and QOP-negotiation, Purchasing and R&D today has contradicting goals which does not encourage cooperation between them. Therefore it is important that Purchasing becomes involved and feel responsibility also for receiving the QOP-answer. In order to enable this, Purchasing should be involved in confirming the time-plan for the project. Further on, both Purchasing and suppliers should be measured on how long time it takes to receive a QOP-answer in order to see a reason to improve the answering time.

By involving Purchasing in confirming both the time-plan and the estimated saving for the project, they should also feel responsibility for achieving these goals. It also enables Purchasing to give input to the time-plan, for example if they have lack of resources and knows that a negotiation will take two weeks longer than expected. This should encourage prioritisation of ratio projects and through that shorten the negotiation time, since Purchasing has approved the plan, and also been involved for providing a more accurate time-plan.

In addition, a clear division of responsibilities should be established between Purchasing and R&D. By having a clear division of responsibilities, the cooperation can be more resource efficient since no time-consuming communication back and forth is needed. Further on, the cooperation can be further improved if it is a clear communication between Purchasing and R&D about how R&D can support Purchasing in ratio errands, which would beneficial for both parties since it often are these activities that delays projects.

Regarding the last two issues, both of these issues should also be avoided by using cross-functional work. Since technical problems after PA often is a result of opinions that was not considered from the beginning, these opinions are more likely be acknowledged if the work is cross-functional through the process. Further on, delayed tests could also be avoided if it is known early in the process which tests that will be needed. Since this is something that needs to be confirmed by other functional areas, such as crash analysis, it is good if they are involved as early as possible in the process in order to be able to schedule tests. By involving these functional areas before establishing the time-plan, input from these functions can also be considered when creating the time-plan.

Since a large variety of projects is carried out within the ratio process it may be difficult to measure the performance of the process. This is also mentioned by Kaplan and Norton (1996) as a problem in product development processes, but a problem that can be solved by breaking down the measurements to focus on different stages in the process, which should be applicable in this case since the process is built based upon different phases and gates. However, the projects in the ratio process at I&C differ widely in characteristics, and certain key activities could be performed during different phases in the process. It could therefore be suitable in this case to break down the process even further and measure how well key activities stick to the time-plan. By implementing a measure that controls that key activities stick to the time-plan, for example average overdue time of key activities, also the overall gate timing can be improved. It is also easier to see what went wrong during the process, since a delay of a key activity is narrower than a delay of gate-timing, which will make it easier for the people conducting the projects to grasp what the problem is. Further on, by measuring which key activities that are delayed, data that supports in the planning of new projects can also be obtained. This will increase the quality when planning new projects, which also can improve the overall gate-timing. Based on this, a PI to control the average overdue time of key activities can be seen as complementary and supportive to the already existing PI for gate-timing and should therefore be used as a help to improve the gate-timing.

However, in order to measure the average overdue time of key activities, there must be an existing basis for how long key activities should proceed. Either, this could be set as a standard for certain activities, e.g. to receive a QOP-answer should take two weeks, or be decided when making the time-plan for the project, e.g. an individual test plan for a certain project.

7 Conclusion

In this chapter the conclusions regarding how the process can be improved in order to fulfil the stated purpose is presented. The purpose was defined as:

The purpose of this thesis is to suggest improvements for the cost ratio process. The proposed improvements should result in improved resource efficiency, reduced lead-time, improved precision for gate timing and possible KPIs for project pace.

In order to fulfil this purpose the following suggestions for improvements are made:

Gate requirements: Criteria regarding which functional areas that should confirm the project before each gate passing should be included. This is required in order to ensure that all projects approved at a gate contain the same level of confidence. Priority should be to include Purchasing. By making sure that the projects contains the same level of confidence at each gate it is also easier to make sure that every project fulfils the criteria that will be needed to pass the next gate in time. Hence the gate-timing will be improved.

Time-plan: Requirement of a logical time-plan before passing PSC-gate should be implemented. The format for the time-plan is recommended to be a Gantt-chart and it should include all required activities and should be confirmed by affected functional areas. Creating a time-plan that considers all activities can reduce waiting time between activities, hence improve both resource efficiency and lead-time. Further on, by considering what activities that will be needed the gate-timing will also be improved.

Cross-functional work should be enhanced in order to avoid the four identified issues that delays projects. Instead of dedicating cross-functional team this should be done by involving other functional areas in confirming the time-plan and approving projects at the gates. Since delays will be avoided both lead-time and gate-timing can be improved.

Additional goals to improve cooperation: The time it takes to receive a QOP-answer and negotiate the QOP should be measured in order to see a reason to improve the answering and negotiation time. However, it is also important that Purchasing and suppliers can give input to what the goal should be and how it can be reached in order to encourage cooperation. By decreasing the time for the key activities, receive QOP-answer and negotiate QOP, the lead-time can be improved.

Knowledge transfer should be enhanced by standardising what documents that should be available for everyone and in which database they should be documented. Lessons learnt should be documented after each project and shared between KUs in order to avoid making the same mistakes and to learn from each other's experiences. By avoiding making the same mistake and not have to regenerate knowledge the resource efficiency can be improved.

Measure project pace: The overdue time of key activities should be measured in order to detect where in the process the problems occur. By measuring this, the overall gate-timing can be improved and this measure therefore functions as a complement to the existing PI for gate-timing. The data from this measurement can also be used as support when creating a time-plan for a new project.

8 Future Research

During this study, issues in the ratio process was detected that could not be included in the scope of this thesis. Therefore, it is recommended to VCC to look further into the following areas in order to improve the performance of the ratio process:

Goals for saving on car: The goals for saving on car are divided between Purchasing and R&D and also divided upon the different sections. Even though Purchasing is part of fulfilling R&D's goal for saving on car, they also have their own goal regarding saving on car. These goals are experienced as contradicting and further research should therefore be put into investigating how these goals can be aligned. The goals are also divided evenly between the different sections even though different sections have different potential to achieve the goals. This means that for some sections the goal is unreachable, while for other sections it is easy to reach. This sometimes leads to that projects are postponed in time since the current year's goal already is reached. Therefore, in order to optimize the saving it is recommended to look into how the goal should be divided between the different sections.

How to involve suppliers in idea generation: It is expressed in the ratio process that it is hard to come up with enough of good ideas. Further on, even though the suppliers are the ones with most knowledge about the system it is hard to make them generate new ideas since they have nothing to gain from doing so. Therefore, the issue of hoe to involve suppliers in idea generation should be further investigated.

Enhance knowledge transfer: Lots of knowledge created during the process today only exists in the minds of the KUs. In addition, three different databases are used for documentation during the process, which makes it hard to know where the accurate version of the information is and where different documents can be found. Therefore, it is recommended to investigate what standards that should be implemented for documentation, and how the databases can be aligned in order to ease the search for information.

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10 Appendices

Appendix A: Interviews Conducted Step 1

Interior & Climate		
PSS 120	1 Concept-KU 2 KU	3 Interviews
PSS 130	1 Concept-KU 2 KU	3 Interviews
PSS 140	1 Concept-KU	1 Interview
PSS 150	2 concept and running KU 1 SU	3 Interviews
PSS 160	1 Concept -KU 2 KU	3 Interviews
	DPL Ratio	1 Interview
Program Management		
	Project Leader Ratio	1 Interview
Purchasing		
	Group Manager PSS140 and PSS150	1 Interview
RCP		
	DPL	1 Interview
Finance		
	Controller Ratio	1 Interview
Total Number of interviews:		**17**

Appendix B- Interviews step 2

Projects	PSS	Interviewees	No of Interviews
Unsuccessful Projects			
U1-10063975	150	2 concept-/running-KU	2 interviews
U2-1985807	160	1 concept-KU	1 interview
U3-9785649	120	1 running-KU	1 interview
U4-1982406	120	1 running-KU	1 interview
U5-9524866	150	2 concept-/running-KU	2 interviews
U6-10033547	140	1 concept-KU 1 running-KU	2 interviews
U8-9505523	120	1 running-KU	1 interview
U10-9256777	160	1 concept-KU	1 interview
Successful Projects			
S1-10064178	150	2 concept-/running-KU	2 interviews
S2-10134195	150	2 concept-/running-KU	2 interviews
S3-10130367	120	1 running-KU	1 interview
S9-9506626	160	1 concept-KU	1 interview
Total Number of Interviews			17

Appendix C: Interview Template step 1

Introduction

- Introduce yourself
- What are you doing at VCC?

The ratio-process

- Can you describe the ratio process?
- What are your tasks and responsibilities during the process?
- When is your work initiated and how?
- When is your work during the process finished and how does it end?
- Which persons and functions are you in contact with during the process?
- How is your work documented?
- From your experience; what works well and what works less well during the process?
- Are there tasks that you wished would be performed in any other way?
- Which are the most common problems that occur?
- Which reasons are according to you most often causing these problems?

Performance Measurement

- Do you use any performance measurement?
- Which measurements that are used during the ratio process are you aware of?
- Which measurement are you contact with in form of documenting, following-up etc.?

Appendix D: Interview Template step 2

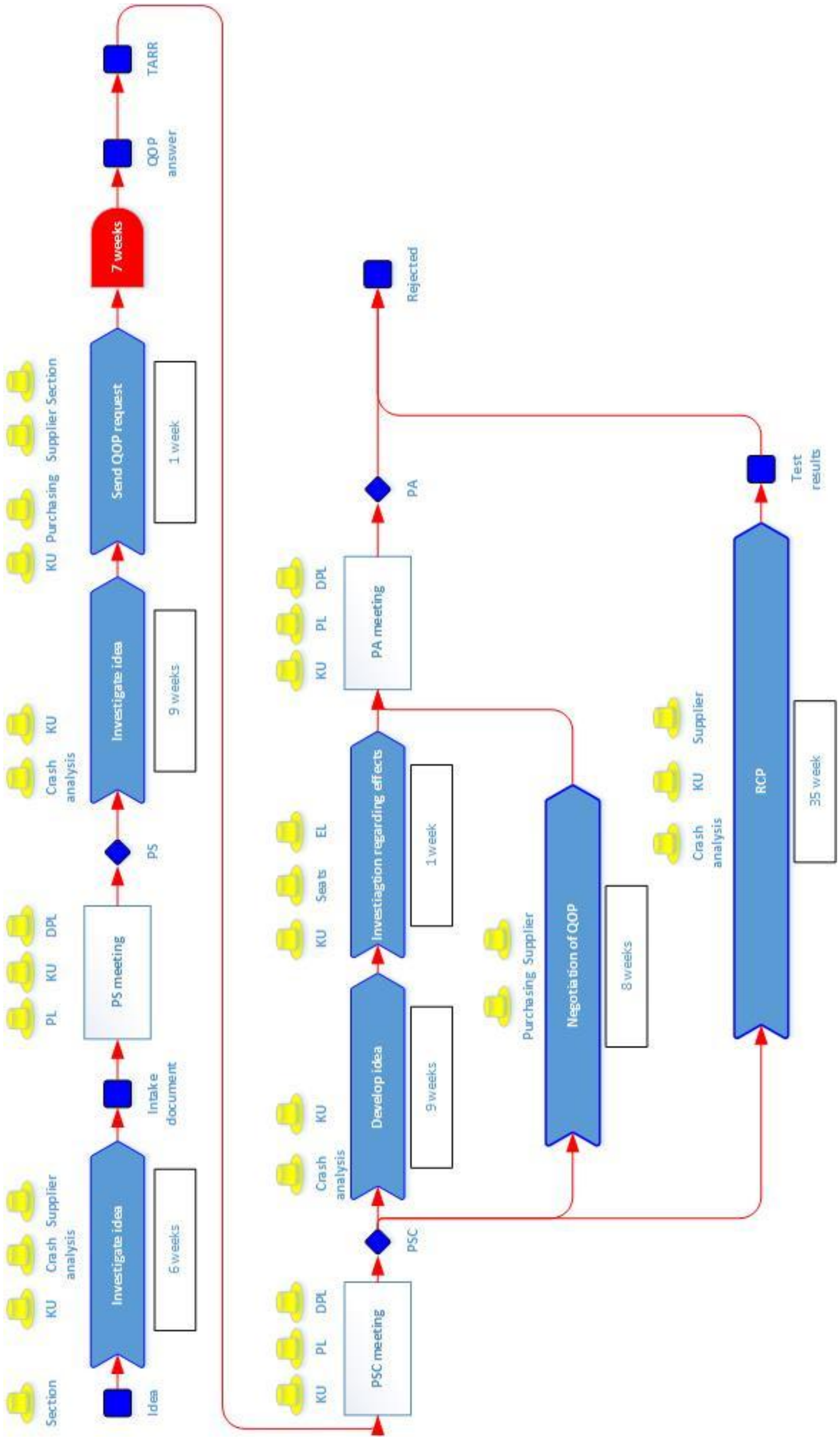
For each of the chosen projects:

- What activities were carried out?
- How much time was spent on these activities?
- Was there any waiting time between activities? Was any of this waiting time “necessary” waiting time?
- Which persons and functional areas are involved in each activity?
- Who was responsible for each activity?
- What was the input to and output from each activity?

Appendix E: Summary of Meetings

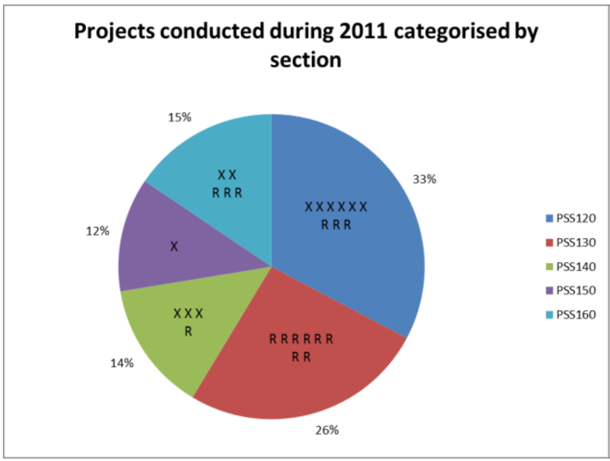
Meeting	Attending	Purpose	Frequency
CMT-Intake	PL Ratio DPL Ratio (for each department) KU Ratio Finance	Follow-up of errands in E-Tracker. Confirm intake of new ideas, and passage of gates.	Once/ week (Wednesday)
CMT-Milestones	PL Ratio DPL Ratio (for each department) KU Ratio Finance	Follow-up of errands in E-Tracker. Hotlist?	Once/ week (Friday)
DPL follow-up	DPL Ratio KU Ratio	Follow-up of errands for upcoming gate passage. Check if time plans are held or needs to be changed.	Once/week (Thursday)
DRMS-meeting	Section, incl. section manager, group manager and purchasing.	To anchor ideas within the section and get confirmation to continue.	Once/week
Pre war-room	Representatives from program strategy, vehicle line management and marketing and sales strategy	To agree on whether or not to continue with errands that affects several departments.	Once/week (Friday)
MCEM	Representatives from program strategy, vehicle line management and marketing and sales strategy	To decide if errands should be continued if no agreement was made at pre-war room.	Once/week (Thursday)
Meeting w. suppliers	KU, supplier	Anchor ides. Find new ideas. Follow-up on ongoing errands.	Varies

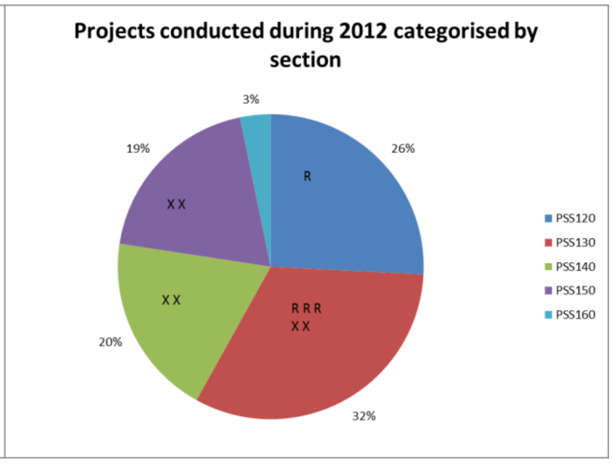
Appendix F: Example of process map for project U2



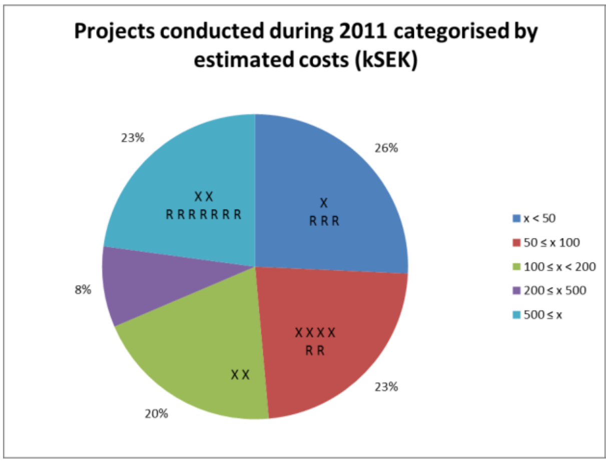
Appendix G: Pie charts and bar charts

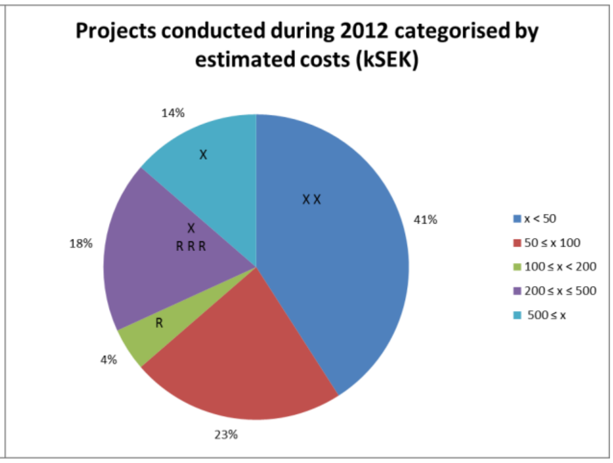
Projects categorised by section



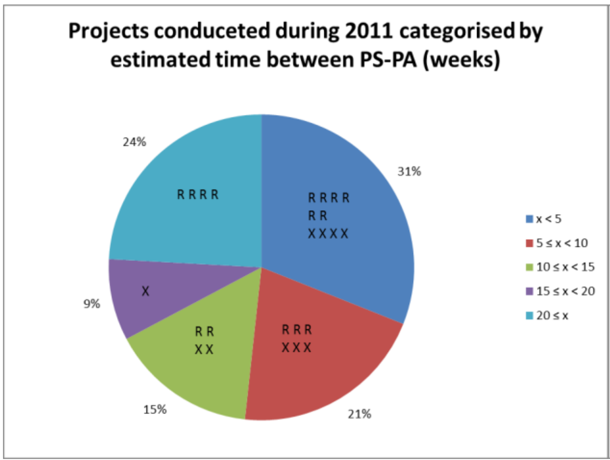


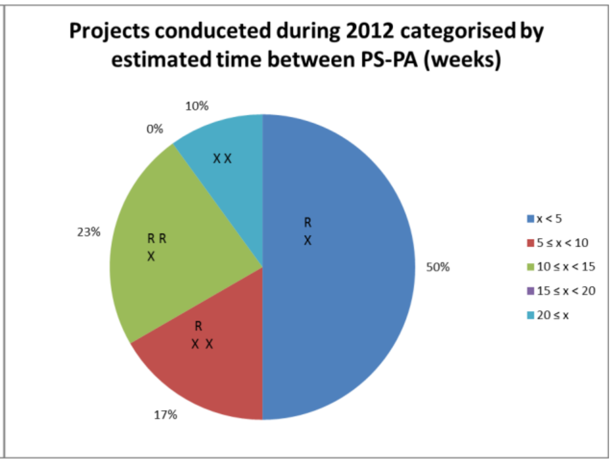
Projects categorised by costs



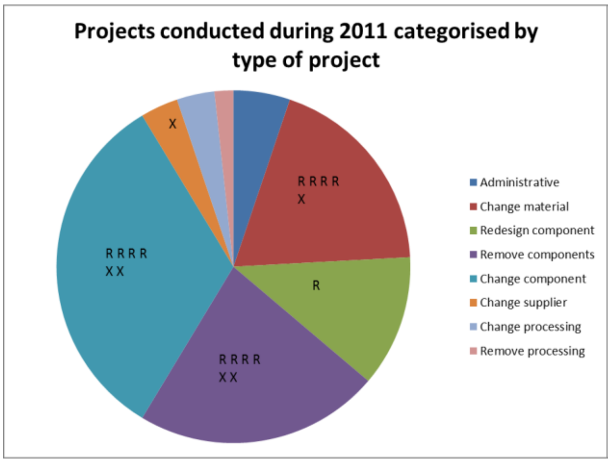


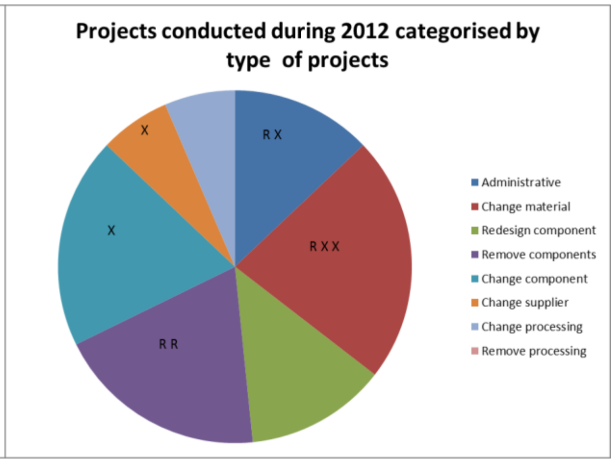
Projects categorised by estimated time between PS-PA



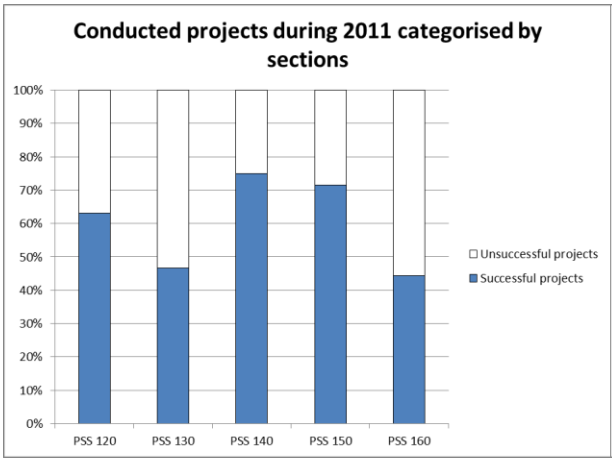


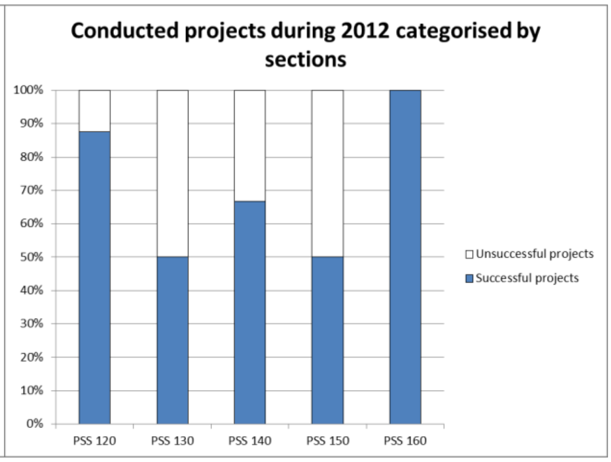
Projects categorised by type of project



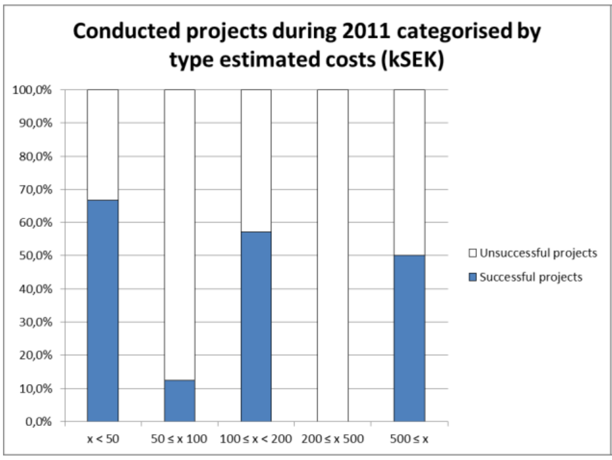


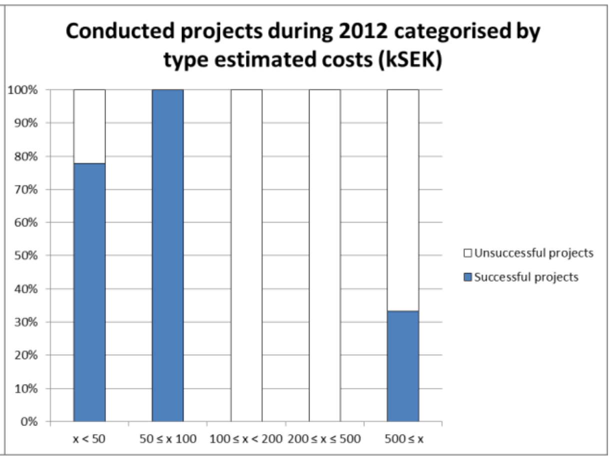
Percentage of unsuccessful projects categorized by sections



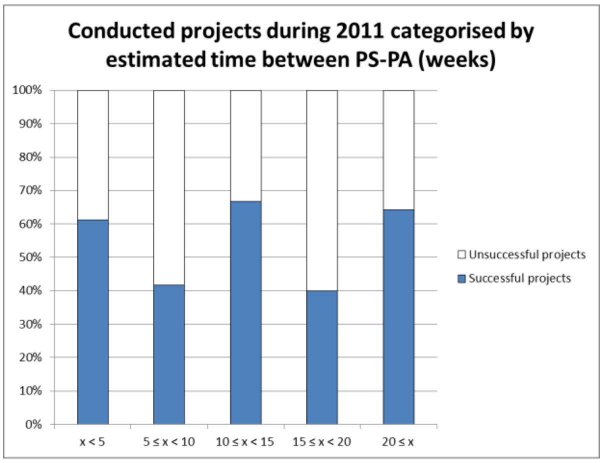


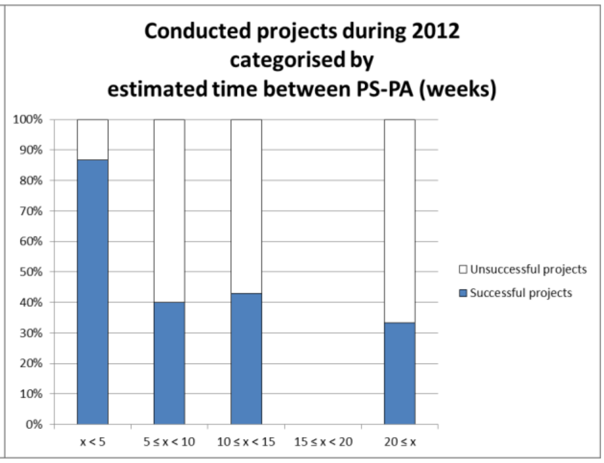
Percentage of unsuccessful projects categorized by estimated costs



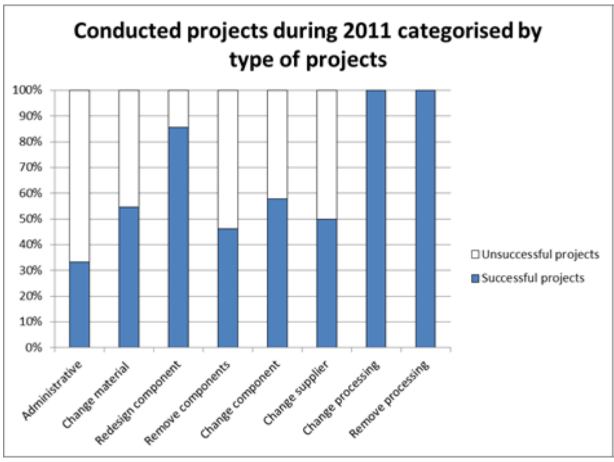


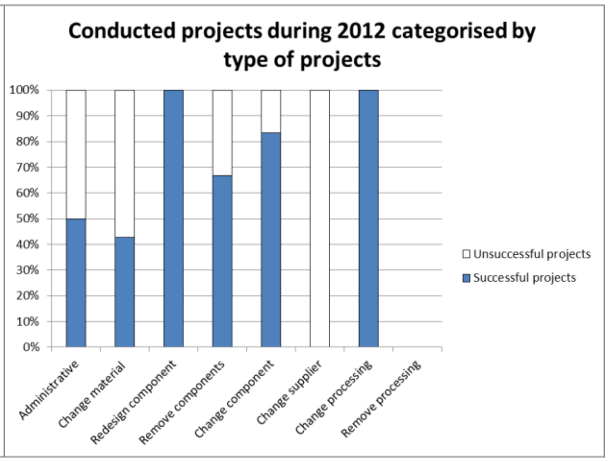
Percentage of unsuccessful projects categorized by estimated time between PS-PA





Percentage of unsuccessful projects categorized by type of project





Projects that was conducted during 2011 and 2012 and categorisation by number handovers is not including in this appendix since the majority of all conducted projects had the same responsible KU during the whole project