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A tool to forecast needed resources in product development projects at Scania's axle and gearbox assembly

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ABSTRACT

The increasing competition among companies compels them to introduce more attractive products and consequently force them to implement more effective processes. Forecasting models have become a widespread tool to assist company project management in structuring, planning, scheduling and controlling of projects. The purpose of this thesis is to facilitate the resource planning of local project managers at Scania's axle and gearbox assembly by constructing a forecasting model. It will also include the broader perspective of what the establishment of the model may imply. The study is emerging around observations and interviews mainly with local project managers at Scania's axle and gearbox assembly in order to identify their activities in projects, the time spent on those activities and how it varies, and what factors that affect the time variance. The findings in combination with a theoretical framework related to knowledge management, risk management and various forecasting approaches results in a forecasting model tailored to Scania's axle and gearbox assembly's needs and processes. One finding, in addition to the model, is that the local project managers work differently and holds diverse priorities in conducting their projects. The final results of the study shows a forecasting model, that will act as a first tool towards a more structured way to review the existing resource base of local project managers and allocate them to projects. The thesis includes recommendations for Scania's axle and gearbox assembly to clarify the activities and what they comprise to get the local project managers more consistent about what to do, as well as implementing a time log routine to keep control of how the time can vary between different types of projects. The thesis concludes with other implications a model of this kind can entail, which is considered important for the company to be aware of.

Key words: Forecasting methods, Estimation approaches, Knowledge management, Expert judgement, Constructive Cost Model

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Helena Hellerqvist & Mafalda Svensson de Brito

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ABBREVIATIONS

CAD: Computer Aided Design

CD-process: Concept development process

COCOMO: Constructive Cost Model

DT: Scania's transmission assembly unit

LPM: Local project manager at DT

OM: Object manager, a part of R&D

PEM: Production engineer manager, group leader of the LPM's

PD: Product Development

PD-process: Product development process

PD-project: Product development project

PM: Project manager, a part of YP

SLA: Scania Latin America

SPS: Scania production system

R&D: Research and Development

YP: Scania Project Office, a part of R&D

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1. INTRODUCTION

This master thesis starts with an introduction to introduce the reader to the topic under study as well as the assignment. The chapter provides a background to the case followed by the purpose, the research questions and scope of the thesis. It ends with an introduction to the company under study.

1.1 Background

Project management has for the last decades become a hot topic in today's society. It basically involves planning, scheduling and controlling of project activities, where a successful project finish according to pre-set specifications, within budget and not least, on time, using resources efficiently and effectively (Demuelemeester & Herroelen, 2002).

The increasing competition between companies compels them to introduce more attractive products and consequently force them to implement more effective processes (Rad & Anantatmula, 2005). Since organisational improvement to a great extent relies on its ability to learn, processes regarding knowledge capturing have become frequently implemented. Organisational learning is by Gould (1998) defined as: "…the capacity or processes within an organisation to maintain or improve performance based on experience". The majority of companies are approaching forecasting methods in the pursuit of awareness of the uncertain future.

Estimate and forecasting have been done ever since the first persons made long-term investments. A very basic forecast that has been made is that the way things have happened in the past will virtually reflect what will happen in the future (Porter et al., 2011). The objective of time estimations is to get the most accurate and realistic estimate as possible (Demuelemeester & Herroelen, 2002). Previous research within forecasting has produced major changes in recommendations of practise. Forecasting models, especially before the 1960's, have shown to have a detrimental effect on forecasting accuracy, and current research tend to recommend relatively simple models than those of a more complex nature, see for example forecastingprinciples.com (2014). Jain (2006) clarifies that there is no model that will work in every situation. To achieve a more correct forecasting model it should be adapted to capture a certain pattern from the data set in the specific situation.

1.2 Problem description

This master thesis will be executed at Scania's axle and gearbox assembly, DT, located in Södertälje. DT is facing many new product development projects in the near future. In order to execute these projects successfully, planning and efficient project management is essential. According to the assignment from Scania, one aspect of this is to be able to determine the time spent on projects by local project managers, LPMs, in order to decide the number of LPMs required within the organisation of DT. Scania continuously aims its practise towards standardised working methods. Currently it does not exist a standardised work method concerning resource planning of LPMs within product development projects, thus Scania requires a forecasting model to be introduced by the researchers.

The project engineering managers, as further on in the report will be referred to as PEM's, are currently planning the needed resources, in terms of LPMs, based on their knowledge and experience from earlier projects. However, this knowledge is not documented, nor accessible for other employees today. When the PEM is replaced by a new PEM, the organisation will lose the knowledge possessed by the leaving manager. Planning resources based on one person's knowledge increases the variation in resources between projects planned by different persons.

The problem Scania is facing, as the researchers interpret it, is a structural problem derived from a resource allocation problem. Today most of the work methods are standardised while the resource planning of LPMs is not. The researchers believe that by conducting the assignment of establishing a forecasting model, as required by Scania, existing knowledge within the organisation will be preserved to a larger extent than until today, and assist PEMs and LPMs using the model. Forecasting models of this kind may have the characteristics of acting like guidelines more than correct estimates of a possible future. Despite the complexity of the task, the interpretation of the problems formulated by the clients at Scania is that they want to reduce the uncertainty when planning for resources, LPMs, to be used in projects by structuring their work through a model. This model should be seen as a first attempt to structure the work method of the PEMs and to be continuously developed and improved in the future.

Seen from a broader perspective, getting more structure of operations and processes in an organisation in general with the aim of assisting PEM's and hopefully enhancing the success of the organisation, may according to Ruskin and Estes (1986) imply the opposite. As a manager of a project, it involves plenty of priorities to make. These priorities become relevant when to choose between what different activities to be made, but also they exist between different divisions or people of the organisation. Advantages that one decision of a manager can bring, may connote the adverse effect concerning another. Conflicts similar to those will be apparent in most of the organisations, which clearly should be taken into consideration by the management (Ruskin & Estes, 1986).

The success of a project not only relies on enhancing the planning of the project but also for the management to be aware of the possible impact a decision of that kind may bring. It may for example involve paid attention to interactions between projects to capture smaller problems before they become bigger problems (Ruskin & Estes, 1986). By understanding how the organisation affects projects, the manager will raise the chance to project control and consequently project success.

To conclude what just has been mentioned in the problem definition, the researchers suggest that the forecasting model called for by Scania, derived from a resource allocation problem, can be used as a tool to support the project engineer managers and LPMs in their decisions, which is consistent with Scania's general prevailing guidelines, and after seen from a broader perspective also highlighting the importance of the possible trade-offs to be.

1.3 Purpose

The purpose of this master thesis is to facilitate the resource planning of the LPM's at the DT department, by constructing a forecasting model, and communicate the broader perspective of what the establishment of the model may imply.

1.4 Research Questions

The clients at Scania have an operational production development process in which the LPMs are working, however they lack a tool to support them in allocating the resources of LPMs to the projects. Thus they require from the researchers of this study a forecasting model to predict the durations of projects. The purpose presented in the section above is broken up into four research questions, which under the study has been modified. These, in turn, fulfill separate entities of the purpose, thus require separate methods.

The first three research questions are designed with the aspect of the model construction in mind, to gather data and enable the construction of the forecasting model. In order to create a model the researchers determined it is essential to know what activities the LPMs perform, what factors they consider affecting the project size, and how these factors affect the activities. The first question was therefore determined to find out what activities the LPMs perform, and what time variance each activity has. The time variance is in this study defined as a variance between the minimum time required by the LPM of one activity and the maximum time required by the LPM of the same activity. The second question aimed to find out what factors the LPMs consider as important. With important factors the researchers mean factors that contribute to the time variance. The third question was defined as how, and to what extent the factors influence the time variance of the activities.

The different methods of how to, firstly, determine what model to select and what information it requires, and secondly, answer the three research questions, are further presented in the section of *3.3 Research method and data collection*.

The last research question is formulated to build in a broader perspective to what the construction of a model may imply. This question does not concern any data collection in order to be answered, thus will not be answered in chapter *3. Method*, but instead in chapter *7. Discussion*. This is due to the interpretive nature of the question seeking the researchers' own opinions after acquired experiences during this master thesis. The purpose of this research question is to provide the reader with how a model like the one constructed in this study might be useful for other practitioners, and whom these could be.
The four research questions can be seen in its final form below.

RQ1

What activities do the local project managers perform, and what time variance does each activity have?

RQ2

What factors do the local project managers consider as important?

RQ3

How, and to what extend do the factors influence the time variance of the activities?

RQ4

What prerequisites, in terms of tools and processes, have the researchers found important in constructing a forecasting model?

1.5 Delimitations

- Due to the time limitation of this master thesis, only the PD-projects executed at DT will be studied, and therefore neither project at DT nor in any of Scania's other departments will be considered as study objects. Only the work of LPMs in those projects will be investigated, work of other project participants will not be considered in this thesis.
- A model will be designed, established, and customised for the DT department, however it will not be tested to ensure its accuracy. No alternative solution/s to the problem will be presented, nor will alternative model/s.
- This model should be seen as a first step in a continuous process towards developing and establishing a more accurate future model, and will probably not provide accurate estimations.

1.6 Scania's Background

This section will in brief present Scania, all facts are taken from Scania.com unless another reference is referred to.

1.6.1 History

In 1891, in Södertälje, Sweden, Scania was founded, and at present time the head office is still located in Södertälje. Scania is one of the leading manufacturers in busses, and heavy trucks in the world today. Scania also manufacture Marine and Industrial Engines, a business area that is also very important for Scania. Scania is a successful company, with more than 1,400,000 produced trucks during its years, Scania has during each year for the last seven decades reported a profit, something Scania explain has been accomplished with good co-workers throughout the years.

There are over 38,600 employees working at Scania in more than 100 countries worldwide today. Scania has its largest production site in Södertälje. In addition to Södertälje, Scania has further production sites in Europe, Latin America, and South America (see figure 1 for production sites). Scania also has 10 plants only focusing on assembly. These ten sites are located in Africa, Asia and Europe. Distributors exist in approximately 100 countries, and there are more than 1600 service points worldwide.

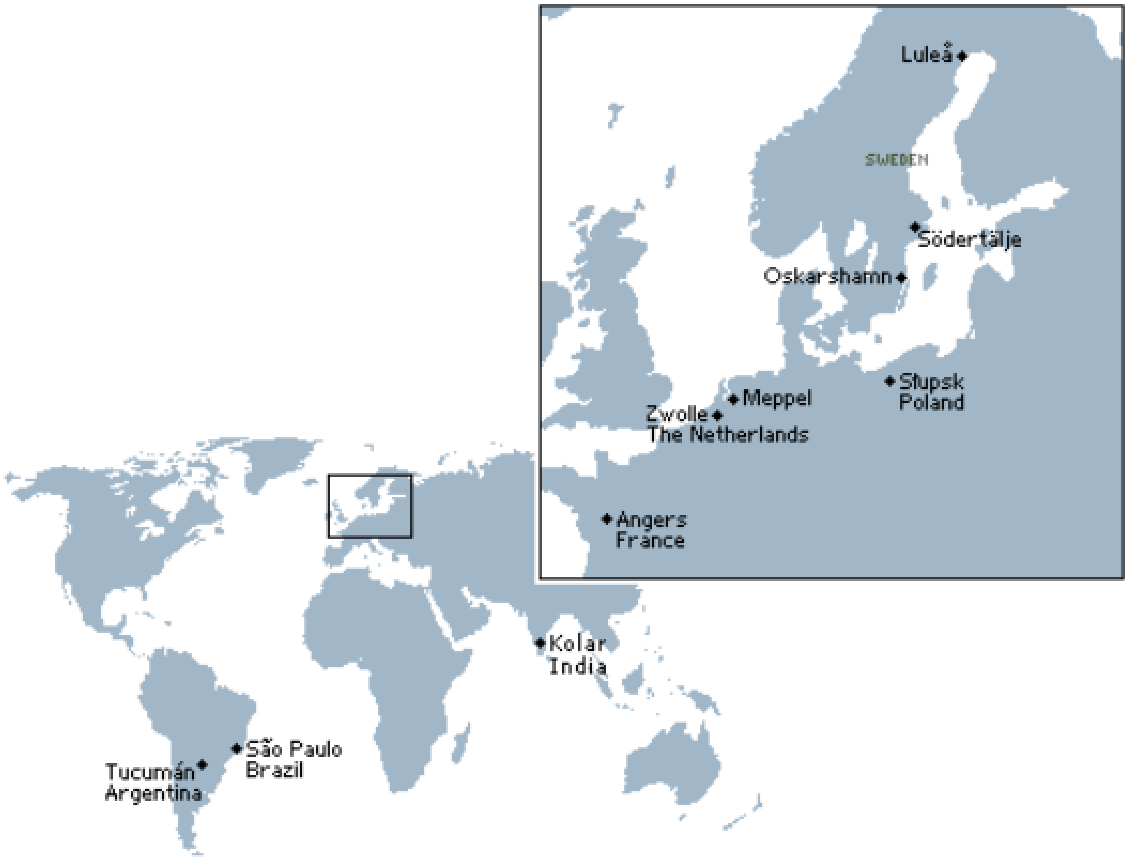

Figure 1: Production sites (scania.com)

1.6.2 Goals and values

Scania's vision is to provide its customers with high quality, and optimised busses and trucks. In order to do this, the company has decided upon three core values that are the fundamentals for all strategic business decisions throughout the organisation, worldwide.

In order to serve the customers, one must know about the customers' requirements and businesses according to Scania, This is the background for the first value; Customer first. By focusing on the employees, utilising their specific knowledge, and experience, will both make Scania an attractive employer as well as a company that functions, and perform well. This has set the base for the second core value: Respect for the individual. Finally, the third core value: Quality, which is based on Scania's vision of delivering quality products to the customers. The three values are all very closely linked together. Knowing what the customer expect and need is essential in order to develop and produce competitive products on the market. The products also have to have good standards which is delivered by high quality products, and in order to keep developing and producing high quality products that the customers wants, the company needs good employees and therefore stress the importance of taking good care of the employees and at the same time utilise them in a favourable way for both the company and the employee.

1.6.3 Scania Production System

Scania production system, SPS, has Scania's core values and principles as foundation: Customer first, Respect for the individual, and Elimination of waste. The SPS is Scania's common ground where the customers' needs, Scania's competitiveness, and profitability is in focus. In order to continuously develop and improve so that Scania maintain its competitiveness, Scania emphasise on the importance of having all employees understanding and striving towards Scania's values and principles. Good, and the right, leadership is important when motivating employees to strive forward and continuously improve themselves and the SPS according to Scania (Inline.scania.com). The SPS, or the Scania House as it is also referred to, can be seen in figure 2.

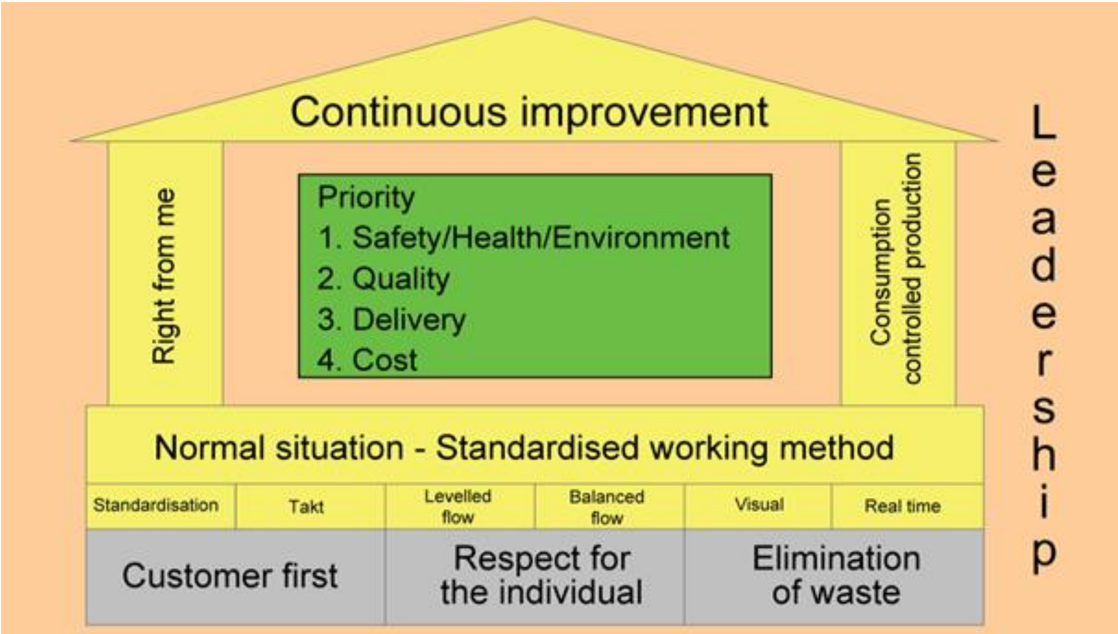

Figure 2: The Scania House, Inline.Scania.com

1.6.4 The Product Development process

Scania wants its customers and stakeholders to feel trust, pride and confidence when they are in contact with Scania or driving Scania's vehicles. In order to ensure this Scania is working continuous with improving its products and processes, and this work is done according to the Product Development Process, which further on in the report be referred to as the PD-process. This section will present the PD-process, its different stages, and also how the organisation is built around different type of projects.

The PD-process is Scania's process for the development of new products (Inline.scania.com). The process consists of three stages, the Concept Development stage, CD, the Product Development stage, PD, and finally the Product Follow-up stage. The three stages are also referred to as: yellow arrow, green arrow and red arrow, see figure 3 (Inline.scania.com). All projects begin in the yellow arrow, continue on in the green arrow and are followed up in the red arrow. However, a decision to either kill or freeze a project can only be made in the yellow arrow and green arrow.

Figure 3: The Product Development Process

The CD-process focuses on the predevelopment phase with emphasis on research, advanced engineering and concept development. The intended output in the CD phase is new knowledge that can be utilized in the advanced engineering stage and finally a concept ready to move into the next stage, the PD stage. When a project has entered the green arrow the focus has shifted towards the actual development of the product and the industrialisation of it. The dignity of different projects can differ a lot between different projects, as well as the time spent in each of them. The projects' life cycles can be anywhere between half a year up to ten years, and sometimes even longer. A project enters the last stage, the red arrow, when it has gone to production, is on the market and the end customer is utilising the product. The main focus in the red arrow is to update and maintain the existing product portfolio.

1.6.5 Hierarchical structure in different green arrow projects

This section will visualise the different hierarchical structures for different projects, Scania as a company and DT as a department. Due to confidentiality all the decision making organs in the PD process is not represented in the figures and text. All information is taken from Inline.scania.com unless another reference is referred to.

1.6.5.1 Scania

Depending on the dignity and size of a project, the hierarchy varies. The most common hierarchical structure can be found in figure 4 and is used in small, medium and large projects. The hierarchical structure shown in figure 5 represents the structure for very large projects, often with high dignity compared to other medium and large projects.

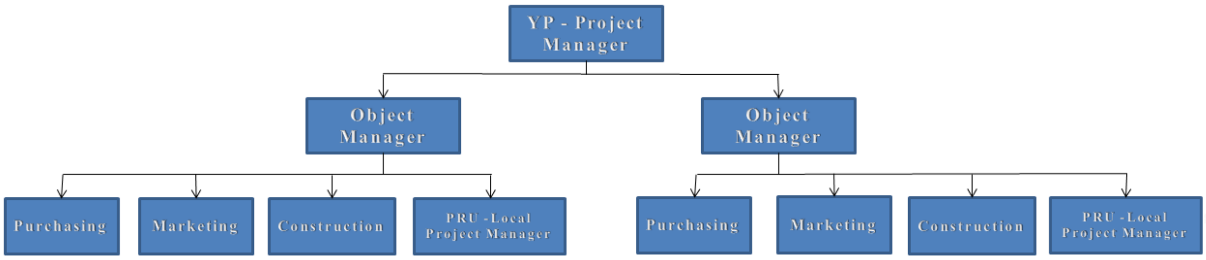

Figure 4: Most common hierarchical structure at Scania's project office.

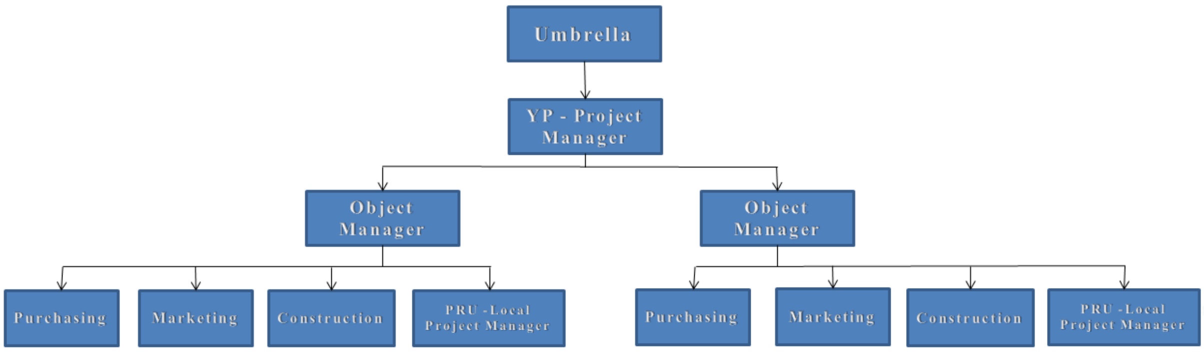

Figure 5: The hierarchy for high dignity projects at Scania's project office

1.6.5.2 DT

The hierarchical structure in the DT department is shown in figure 6 and is the same for all projects, independent of size and dignity.

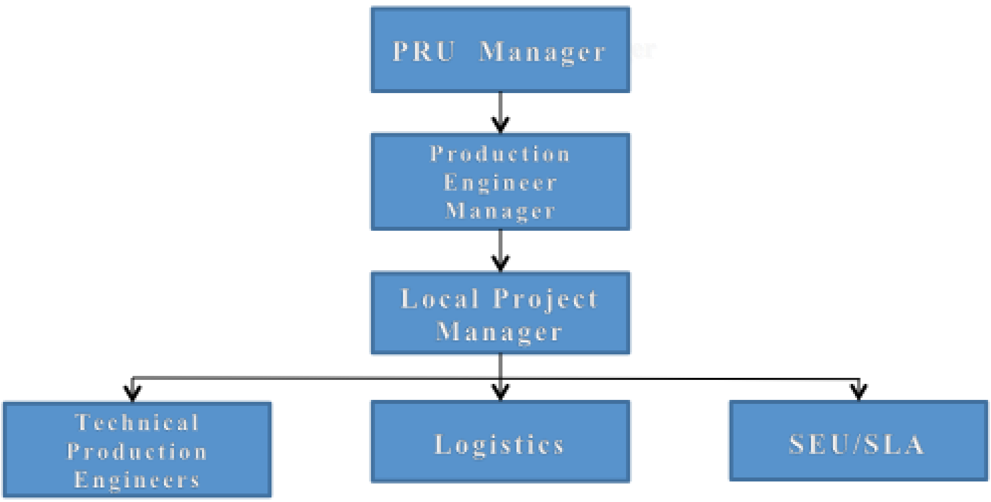

Figure 6: The hierarchy in all projects executed at DT.

1.7 Thesis Outline

This master thesis is divided into seven chapters, and each chapter are briefly summarised below for the reader to get an overview of the report structure. Similar briefs are also located in the beginning of each chapter to allow the reader to follow the report easier.

1. Introduction

The thesis starts with an introduction to introduce the reader to the topic under study and previous research, the assignment according to the problem description of the client and the corresponding interpretation of the researchers, the five research questions which culminated from the purpose and goal of the study, delimitations and risks, followed by a introduction of the company under study including the relevant processes. The four research questions will be answered in different locations in the report.

2. Theoretical framework

The theory in this thesis includes main areas of research, project management in relation to estimation and forecasting, knowledge management to emphasize the importance of capturing the knowledge throughout the study, risk management to raise the awareness of uncertainty in projects. In addition to these areas different estimation approaches of in what ways a model can be constructed and what to consider is also presented. It will be further described in later chapters how the theory has been used throughout the thesis.

3. Methodology

The third chapter presents how the research was conducted, the choice of research design, and what different types of data collection methods were used when answering the three first research questions, and finish with a discussion of the validity and reliability of the research.

4. Empirical findings

The empirical findings of the study includes a review of the current practise on the department of DT, listing of activities performed by the LPMs within the projects, a number of factors that the LPMs asserts to be contributing to the effort required to be put into a project. The relationship between the activities and the factors and to what extent they affect each other are also presented. Also the situation regarding documentation will be addressed. The first research question, RQ1, the second, RQ2, and the third, RQ3 can be deduced in this chapter.

5. Results

This chapter presents the constructed mathematical model by first displaying the equations on which all of its calculations are done. Secondly an illustrative data set of the model's interface, and its work sheet in Excel is displayed. It is in brief described how the user is indented to use the model, and an example of the outcome is also presented. Finally an example of how the calculations could be performed when using the model will be displayed.

6. Analysis

This chapter analyses the current practise at DT and evaluates how palpable the model will be for DT by comparing it with the theoretical framework earlier described. Characteristics of both potential improvements as well as accuracy of the model are brought up.

7. Discussion

This chapter discuss important considerations of the findings as well as the model constructed previously, and how the contribution of this study can be of relevance for other parties than Scania. The limitations of the study and prerequisites for further improvements of the model are also addressed. The fourth research question, RQ4, is answered in this chapter in addition to a more general discussion.

2. THEORETICAL FRAMEWORK

The theory in this thesis includes main areas of research, project management in relation to estimation and forecasting, knowledge management to emphasize the importance of capturing the knowledge throughout the study, risk management to raise the awareness of uncertainty in projects, together with different estimation approaches of in what ways a model can be constructed and what to consider. It will be further described in later chapters of how the theory has been used throughout the thesis.

2.1 Project management

A project manager implement activities of very different characteristics within a project, and these activities require a different amount of effort. To attain advantage of one activity, another one may be foregone. Time and energy needed to perform an activity compete with the time and energy for another activity, which repeatedly put the project manager in situation to prioritise between different trade-offs. By understanding how organisations affect projects as well as the project managers, the project managers can enhance the success of the project (Ruskin & Estes, 1986).

One common trade-off is the one between time and quality (Maylor, 2010). The more time you have access to in a project, the more time to spend on research and execution you have, which should result in a higher quality of the delivery. The less time spent on a project the less quality of the outcome (Maylor, 2010). The prioritisation of the trade-off should be made with the KPIs in mind (Parmenter, 2010), and reflect the stated objectives of the project (Maylor, 2010). Trade-offs will always exist in projects, and making the right prioritisation between them is one of many things that make the project management role a complex role (Maylor, 2010).

Maylor (2010) stress the importance of having the right resources in order for any project to function well and deliver the expected objectives. People with the right knowledge, the right control of deliveries, and financial resources are all resources that are crucial for any project (Maylor, 2010, and Pinto, 2013). Not having a top management sponsor that will assure the necessary resources can be devastating for a project according to Pinto (2013). Pinto (2013) continue on explaining that another just as important foundation for a successful project is trust, trust between the project managers and the top management. If the trust is not presence between these two parties the project will have a much more difficult time to survive, since the top management will probably not support the project and hence not provide the necessary guidance and resources (Pinto, 2013).

Baker et al (1988) through Pinto (2013, p.451) has compiled six factors that predict how successful a project will become.

1. Project coordination and relations among stakeholders
2. Adequacy of project structure and control
3. Project uniqueness, importance, and public exposure
4. Success criteria salience and consensus

5. Lack of budgetary pressure
6. Avoidance of initial over-optimism and conceptual difficulties

These success factors have been identified through the studies of both successful and unsuccessful projects. It was also found that successful projects have success drivers such as top management support, good leadership, support from the client, clear project objectives and motivated employees (Pinto, 2013). The importance of a good and updated project plan is also stressed; having a structured work method will help judge if objectives are met, consequently guiding the project members in the work.

There are several reasons for why projects overrun, according to Hill, Thomas & Allen (2000). The scope of the project was changed by the users, individuals' performance reviews not considering if their estimations were met or not, no ways of setting standard durations for when estimating more common tasks, together with the lack of reviewing the project afterwards to compare the estimates with the actual. Hill, Thomas and Allen (2000) advice management at companies to review the actual durations of the tasks that make up a project and to compare these with the estimations to find the relationship. Chen, Liu & Li (2010) claims there are many factors that affect the accuracy of project duration forecasting. Two of those aspects are the lack of relative information and the complexity of the project.

2.2 Principal-agent issue

The agency problem can occur when cooperating parties have different goals (Jensen & Meckling, 1976 through Eisenhardt, 1989). The theory assumes that humans possess self-interest, bounded rationality and risk aversion, in an organisation with efficiency as the effectiveness criterion. An agent can be motivated to any extent act in a principal's interest depending on how the principal can determine whether the agent has in fact taken the appropriate action. This can lead to a problematic situation since the agents goal sometimes is to act in its best interest rather than the principals, to maximise its own utility. Two problems that arises from such a situation are when the desires of the principal and the agent conflicts, and when it is difficult or expensive for the principal to monitor whether the agent act accordingly or not. The principal recommendation of Eisenhardt (1989) is to incorporate an agency perspective in problems having a cooperative structure.

2.3 Knowledge management

With the increasing competition in the current business environment of globalisation and free market philosophy, organisations are facing greater challenges to meet customer needs. Organisations need to review and get their product development processes improved to keep up with the prevailing competition (Rad & Anantatmula, 2005). This organisational renewal and transformation require the organisation to be more acquainted with organisational learning and its improvement (Gould, 1998). Gould (1998) defines organisational learning as the capacity or processes within an organization to maintain or improve performance based on experience. This phenomenon of learning stays on an organisational level even if the individuals within that organisation change. Gould (1998) asserts that most research within organisational learning study the acquisition of knowledge. The dissemination of knowledge, the process when the knowledge no longer is a property of individuals and becomes available for others, is however less known.

Knowledge and information are often used synonymous, however Rad & Anantatmula (2005) argues that the difference in-between the two concepts is significant within the area of knowledge management. Language, numbers, diagrams and pictures are examples of entities of information that allows us to communicate observations and perceptions, while knowledge also include the interpretation of that information as well as tacit knowledge of experienced people (Rad & Anantatmula, 2005).

Gould (1998) presents seven learning orientations where one claims that knowledge can be something that individuals possess by experience and education. This knowledge will get lost as soon as this individual, as an employee, leaves an organisation. Knowledge is not only something people possess. The most common form of knowledge can in addition to people be found in products and processes. Knowledge comes from experience, such as trial and error, other people with experience, training, manuals and hardwires into systems, processes and equipment. Knowledge management can enhance project management performance in fulfilling the goals within time, cost performance and customer satisfaction goals (Davenport & Prusak, 2002).

Learning can exist in at least three different appearances, according to Forman (2004). These are individual learning, team learning and organisational learning, which are all inter-related in one way or another. Organisations consist of teams, which in turn comprise individuals. Organisational learning is in comparison less understood and has gained more attention in business (Kim, 1998). The transfer process of how the individual learning is transferred to organisational learning should be clearly understood by the organisation before it can make this learning process consistent with its own vision.

2.4 Risk management

In all projects estimations are made throughout the project, and it is important to remember that estimations are guesses (Maylor, 2010). Maylor (2010) continue on explaining that estimations made later on in the project are often more accurate compared to estimations made in the early stages of a project since there is more data to base the estimations on. The closer you get to the end of the project the easier it is to make accurate estimations regarding the project’s cost and finish time (Maylor, 2010).

De Meyer et al (2002, pp. 60-61) explain uncertainty management, where the risks in a project are divided into four main areas: variation, foreseen uncertainty, unforeseen uncertainty and chaos. Variation is explained as small variances in the project, which the project manager easily can manage. Foreseen uncertainty are influences on the project that can be identified and understood, the possibility of these occurring is known by management but exactly how they will affect the project is not known. Unforeseen uncertainties are influences that project management cannot predict, and therefore have difficulties handling if they occur. The last area is chaos. Chaos is impossible to foreseen and will change the some of the vital parts of the project such as budget or objectives. Further it is discussed that by being aware of these different types of uncertainty and therefore create a plan on how to solve problems related to the uncertainties, it is easier to estimate the cost and time schedule for the project.

Risk Management should be adopted when you want to assure that the project's objectives are met, and in order to meet them minimize the disturbance in the project (Ramgopal, 2003).

Ramgopal (2003) argue that risk management should be adopted late in the project, since the perspective on the project at this stage is not as pessimistic as it will be if the risk have become a threat before adopting the risk management approach. They have divided potential risks into two categories: down-side risks, and up-side risks. The Down-side risks can be seen as risks where the consequence of an activity is not a welcomed consequence, the risk is a threat. On the contrary the up-side risks have consequences that are welcome, the risk is an opportunity. Ramgopal (2003) continue on explaining that the most common risks to focus on are the threats.

2.5 Estimation approaches

Porter et al. (2011) asserts that estimate and forecasting have been done ever since the first persons made long-term investments. A very basic forecast that has been made is that the way things have happened in the past will virtually reflect what will happen in the future. Forecasting the future can be difficult concerning lack of historical data and the complexity of the forces that will affect the forecast over time. Forecasting produces raw material in depicting a possible future. However, methods can be used to reduce the uncertainty.

Jain (2003), explain that since all markets today are changing dynamically and rapidly, it is important to revise and update the forecasting model as often as possible. He continue on explaining that the forecast will not only be more accurate with the changing market in mind, but by continuously, when needed, revising the forecasting model, problems with the model and its data and assumptions will be found and corrected, which also will conclude in a more accurate forecasting model. However, as continuous updates are important, updates of the model should not be conducted unless input data, or assumptions are no longer up to date. Even when working with what would be considered a good forecasting model, there is one essential aspect to this area to remember: "[...], forecasts are just forecasts" (Jain, 2003, p.13).

According to Porter et al. (2011) methods for forecasting can be classified into extrapolative or normative methods, depending on how they are applied. Extrapolative methods asks what the future may bring if the trends continue, while normative methods asks what actions and breakthroughs may be needed to shape the future. These two classifications can be used simultaneously. A qualification to make the forecast as suitable as possible for the project members is to early in the project determine what information is needed for the forecast, the degree of specificity required, and the amount of uncertainty that can be tolerated. The information needed to make the forecast has to be determined after the forecast has been bounded. Here it is vital to think through which factors will be considered and which will not.

It is necessary for the study to be bound early for the following work to get started, and should be set broad to remain flexible as long as possible. By doing this the significance of the factors can be recognised during the project.

Jorgensen and Shepperd (2007) address different approaches and research topics when making estimations within software projects. Some of them are mentioned below and can be taken into consideration in product development projects as well. Jain (2006) is presenting three types of forecasting models to be aware of when selecting the most proper model: Time series models including models that assume that past pattern will continue in the future, Cause-and-effect models which determine the average relationship between the dependent and the independent variables to project the future, and finally judgemental models where experts arrive to a forecast or when analogy is used. These types of estimation approaches will be addressed in different forms below.

2.5.1 Regression

One of the most widely used and accepted cost and effort estimation models is the constructive cost model, COCOMO, which is one form of a regression model used to help managers to estimate effort of a project. It was first published in 1981 by Barry Boehm and has since then been improved many times due to the fast development of software techniques. It is dependent upon the manager's ability to estimate size of software system early on in a project and is by Glinz and Mukhija (2002) divided into three sub-systems: Basic, Intermediate and Detailed.

The Basic COCOMO is a single valued model that is applicable on small to medium products developed in familiar in-house software development environment. It is a function of program size measured in delivered lines of codes and the class of the software project, as can be seen in equation (1). Using the Basic COCOMO enables early and quick estimates of software costs, however the accuracy of the Basic COCOMO is limited because of the lack other factors that may have significant influence on software cost, called effort drivers.

$$E_{basic} = a \cdot KDSI^{b} \tag{1}$$

E_{basic}= Effort applied using basic COCOMO
a= Development mode of project class
$KDSI$= Estimated number of thousands of delivered lines of code
b= Development mode of project class

The intermediate COCOMO include these effort drivers, unlike the Basic COCOMO, which is a subjective assessment of product, complexity, hardware, personnel and project characteristics. The effort drivers are rated on a six-point scale from very low to extra high and will return an effort multiplier for each of the points. An example of a project characteristics table can be seen in table 1.

Effort drivers	Effort multipliers					
	Very low	Low	Nominal	High	Very high	Extra high
Product attributes						
Required software reliability	0.75	0.88	1.00	1.15	1.40	NA
Size of application database	NA	0.94	1.00	1.08	1.16	NA
Complexity of the product	0.75	0.85	1.00	1.15	1.30	1.65
Hardware attributes						
Run-time performance constraints	NA	NA	1.00	1.11	1.30	1.66
Memory constraints	NA	NA	1.00	1.06	1.21	1.56
Volatility of virtual machine environment	NA	0.87	1.00	1.15	1.30	NA
Required turnaround time	NA	0.87	1.00	1.07	1.15	NA
Personnel attributes						
Analyst capability	1.46	1.19	1.00	0.86	0.71	NA
Software engineer capability	1.29	1.13	1.00	0.91	0.82	NA
Applications experience	1.42	1.17	1.00	0.86	0.70	NA
Virtual machine experience	1.21	1.10	1.00	0.90	NA	NA
Programming language experience	1.14	1.07	1.00	0.95	NA	NA
Project attributes						
Use of software tools	1.24	1.10	1.00	0.91	0.82	NA
Application of software engineering methods	1.24	1.10	1.00	0.91	0.83	NA
Required development schedule	1.23	1.08	1.00	1.04	1.10	NA

Table 1. Project characteristics table including effort drivers and effort multipliers (Chemuturi, 2009).

These effort multipliers will multiplied together calculate a total effort adjustment factor (EAF) and are in turn multiplied with the program size (KDSI) and project classification (a, b) to increase the accuracy of the estimate, as illustrated in the formula below:

$$E_{intermediate} = EAF \cdot a \cdot KDSI^{b} \quad (2)$$

$E_{intermediate}$= Effort applied using intermediate COCOMO
EAF= Effort adjustment factor

The Detailed COCOMO is using a phase-based approach to consolidate the estimate by weighing the effort drivers according to each phase of the software lifecycle. Barry Boehm divides these phases into requirement planning, product design, detailed design, code and unit test, and integration and test (Glinz & Mukhija, 2002). This means that the effort drivers are different, and are affecting the project differently, depending on which phase the project is currently in, thus the model gives an estimate for each phase before combined with the sub-systems generate in an overall project estimate. The detailed COCOMO will be the same as intermediate in equation (2) but the EAF will involve more effort multipliers than in intermediate. One effort multiplier for each phase in each effort driver.

The COCOMO is a transparent model and useful when the users want to see how it works and what happens in each step. By letting the users categorise a project into different predictor variables, it enables them to understand the impact of the different variables that affect the project (Glinz & Mukhija, 2002).

The development modes depending on the project class and the effort multipliers are calculated through regression. This can be hard in situations when historical data is not available (Glinz & Mukhija, 2002). It is important to point out that more staff put in the project does not mean proportionately less calendar time. A project that is estimated to 100 man months does not necessarily imply that by using a staff of hundred will finish the project in one month.

2.5.2 Expert judgement

This approach includes expert judgement-based estimation methods, and are most common used in situations when there are no historical data available, or when the historical data is no longer applicable. Estimation approaches based on expert judgement are by far the most common used approach by the software industry (Jorgensen & Shepperd, 2007).

Sometimes traditional forecasting methods are inadequate for a certain project due to subjective nature of the prediction domain, hence the use of an expert judgement-based forecasting approach may be the solution for the project at hand (Al-Tabtabai, 1997).

It is common that the estimations are based upon human judgement, and in turn often knowledgeable persons and experts, who are able to put good enough time estimates on the activities in projects (Demuelemeester & Herroelen, 2002). The estimates of experts can be very accurate according to experiments, and is considered as one of the most important factors on estimation accuracy (Morgenshtern, Raz & Dvir, 2007). The valuable knowledge gained when continuously observing and interact with project participants makes them an indispensable resource in making an efficient and successful completion of the project. This knowledge in combination with their experience from past projects facilitate evaluation of the project status (Al-Tabtabai, 1997). However these estimates do not provide an objective analysis of what factors that affect duration. The reliability of the estimates does also depend on the ability of the experts to see how the project correlates with previous projects (Hill, Thomas & Allen, 2000). Experiments have shown that the prediction of how long a task should take is likely to be underestimated along with the experience with the task. An expert who seems to be the most appropriate to predict the time is also the one who is most likely to be biased, even if the they are more consistently biased in their prediction than others (Roy & Christenfeld, 2007).

There are several causes of inaccurate time estimates when people are planning. They may base prediction on faulty memories from earlier completion times, they may fail to identify all subtasks of a multi-component task, they might be influenced by monetary incentives to finish the project early, and they might have the desire to please others when predicting the duration (Buehler, Peetz & Griffin, 2010). They also tend to adopt a singular perspective focusing on specific aspects of the current tasks and scenarios of how the tasks will be completed which is prone to error when they neglect the numerous ways on how their plans may go wrong, instead of adopting the distributional perspective based on previous tasks that were similar (Kruger & Evans, 2004).

Project managers have to compare expected performance in a project and compare with previous original baseline estimate in order to identify likely problems and solutions (Al-Tabtabai, 1997).

Expert judgement can be analysed in a framework, and requires that experts judge the same environmental criteria, have access to the same cues. Differences between judgements of experts can be reflected in four ways: Different organising principles, different weights, different function forms, and differences in bias. The reason for these differences may according to Mumpower and Stewart (1996) depend on four different groups of factors: Poor quality or missing feedback, poor quality or missing information, inability to learn about the quality of one's own judgement, and causal texture of the environment.

Missing or poor feedback: Much of existing research within organisational behaviour and human performance indicate that it is difficult to learn from experience when it originates from feedback concerning whether one's judgement was correct or not, and when this feedback holds error. Thus learning under uncertain circumstances is very difficult according to Brehmer (1976) referred to in Mumpower and Stewart (1996).

Missing or poor data: Experts do not always have access to the relevant data they would like, and instead rely and make use of proxy variables, which are more prone to exaggerate differences between the judgements of different experts.

Difficulty in evaluating the quality of one's own judgement: Experts may have difficulties to knowledge their own judgemental abilities, and when they believe that their judgements are better than they really are, the incentive for them to reconcile their judgement with those of others will decrease.

Causal texture of the environment: This occurs when experts agree on the same judgement when they actually have distinctly different judgement policies, and can be called a "false agreement". These differences may be unrecognised until the experts unexpectedly reach different judgements.

To get the experts making the same judgements they all need to have the same information available, share a similar problem structure, and employ the same type of organising principle (Mumpower and Stewart, 1996).

2.5.2 PERT

The performance evaluation review technique, abbreviated as PERT, is to analyse and represent tasks involved in a project, and especially the time needed to complete the tasks (Vanhoucke, 2012). It replaces random activity durations with estimates that are based on one single expert. The expert gives three different estimates, one pessimistic, one optimistic, and one most likely, which will stand as a base for the forecast. The estimates reflect the normal time to conduct the task, and not rushed. A range between the estimates is selected and will stand as an approximation of the mean of the assumed distribution, which is shown in the formula below.

$$T_e = \frac{O+4 \cdot M+P}{6} \tag{2}$$

Te = expected time
O = optimistic time estimate
P = pessimistic time estimate
M= most likely time estimate

The technique is commonly used in complex projects with high uncertainty of the durations of tasks. When implementing PERT it is first vital to determine the tasks that the project require for execution, and later decide the order of the task. The work breakdown structure is a common technique to determine the tasks. Some tasks may not be able to be carried through until other tasks are completed, and thus PERT is considering what tasks that are dependent on other tasks to facilitate the schedule process (Vanhoucke, 2012).

2.5.3 Analogy

Analogy estimation approaches makes according to Hill, Thomas and Allen (2000) use of previous actual time, an analog variable, and put it as estimates for the new task. An analogy approach requires a stable technological environment and accessibility of historical data, and will not be applicable when the previous projects do not match the new project. In those cases other expert judgement-based techniques will be needed.

2.5.4 Case-based reasoning

Case-based reasoning is one form of an artificial intelligence technique that is considered an important and widely applied problem solving technology. The idea of the technology is to exploit the experience from similar problems in the past, identify differences and what implications these have for the effort levels, and then apply them on the current situation. (Hüllermeier, 2007) This requires a memory base of cases that involves experiences and descriptions about the past situations, to further enable specifying the similarity between cases. The methodology behind a case-based reasoning system involves a number of phases, which are: Retrieve, reuse, revise, and retain. Case-based reasoning may advantageously be combined with other models, and rule-based reasoning is one interesting combination (Hüllermeier, 2007 & Hill, Thomas & Allen, 2000).

2.5.5 Activity decomposition

Concerning planning, people are often capable to list project activities in their head that has to be done within some smaller projects. However in that case, the plan will not be able to be communicated or analysed, and projects are often too complex to be planned and controlled effectively (Maylor, 2010). This can according to Demuelemeester and Herroelen (2002) be avoided if the projects are broken down into manageable portions. This can be done by an approach called Work Breakdown Structure, which defines project activities in relation to the project result. The identified activities the project manager will have to carry out within the project will serve as a base for when to later create different scenarios of how long the project might take. Dividing the project into smaller pieces will improve the estimations and reduce the errors (Raz & Globerson, 1998). Hill, Thomas & Allen (2000) argues for a strong relationship between time of the task and the number of subtasks involved in the task. A Work Break Down structure used to identify work tasks at lower levels would therefore be useful in order to attain a consistent management of the project and also to help experts out with estimating the times of the tasks better. Managers do all too often underestimate the effect that the number of subtasks has on the time of the tasks, where the tasks were poorly thought through. If they became more aware of the subtasks that make up a task at hand their approximations would be more accurate when estimating durations. Multifaceted tasks tend to take longer than people anticipate when the tasks are not unpacked into subtasks, according to experiments performed by Kruger and Evans (2004).

Demuelemeester and Herroelen (2002) present three steps in project management to achieve performance, cost and time objectives. These are planning, scheduling and control for project activities. Planning involves listing activities that has to be brought out to gradually complete the project. The scheduling step is about laying out activities in the correct order in which they have to be executed. Controlling the activities within a project implies to identify the difference between the planning and the actual performance once the project is up and running (Demuelemeester & Herroelen, 2002).

Milestones in a project can be a starting point when identifying activities in creating an activity breakdown structure. The activity breakdown structure will enable the project manager information to estimate the time for the different activities and consequently estimate the total time to be spent on the project (Jones, 2007; Demuelemeester & Herroelen, 2002). A project work breakdown structure can according to Miller (2009) be carried out in eight steps: Find the project deliverables, Build and review the initial product breakdown structure, Build down the product breakdown structure, Establishing the activities, Building the physical logical diagram, Assigning the resources, Estimate the durations, and finally verifying the project timeline.

2.5.6 Combination

Porter et al., (2011) describe five commonly used techniques in forecasting technology. These are Monitoring, Expert opinion, Trend analysis, Modelling and Scenarios. Forecasters should use as many forecasting techniques as practical within resource limitations. They should not be seen as separate methods where only one is selected to be appropriate but more as input to each other in making the estimates, depending on the statement of the problem and what resources are available.

Studies have shown that prediction of task time within software was more accurate if the person who was estimating could identify previous project of similar nature and determine the duration of those projects. Finding similar items to those currently being done will also save the estimator a lot of time (Causeway.com, 2013). This emphasises on keeping records of the time spent on tasks to facilitate future predictions (Roy & Christenfeld, 2007). Jorgensen & Shepperd (2007) advise to use prediction models in combination with expert estimates.

2.5.7 Choosing the right model

Selecting a proper method when estimating time depends according to Thomke and Reinertsen (2012) on the task characteristics and how experienced the estimator is. Choosing the wrong approach on the model the organisation may be unsuccessful. Product development projects for example characterises unique tasks and constantly changing requirements. Sometimes product development projects can be treated as if it were similar to manufacturing, which however possess tasks that are repetitive and activities that are reasonably predictable. Not understanding those differences may result in fallacies like undermining project execution and planning. Management seems eager to bring in the projects in budget and on time, and reach for more detailed plans.

When selecting and using a model for a specific situation it is necessary to be aware of the different models and the fundamental of models and modelling in order to use the right model. Jain (2006) is stating nine fundamentals of what to consider when selecting and using an estimation model for forecasting.

1. *Actual = Pattern + Error*: Different models capture different data pattern, and the more the model capture the pattern the less will be the error, thus a more correct estimate.

2. *100% accuracy is not necessary*: As stated above a model will always contain an error, more or less, and even though the aim of the model is to make it 100% accurate it will not be possible, neither necessary. The aim should be to minimise the error, and obviously different models manage to minimise the error in various degrees. Depending on the company or industry using the model and how the circumstances within can tolerate different amounts of error, the model should be selected thereafter.

3. *More data are not necessarily better*: Industries and companies act in a constantly changing environment, including market dynamics and renewals within procedures in the company. Thus it might not be necessary to gather data from a very long time ago for preparing a forecast. The company should decide with consideration of its own needs how far back in the history the data are relevant. The farther back in time bringing more historical data does not necessarily cause less error.

4. *Sophisticated models are not necessarily better*: Alleged sophisticated forecasting models do not necessarily better than simple non-sophisticated forecasting models. When introducing forecasting models one strategy should be to start with a simple model and gradually move towards more complex ones when the forecasting requirement is considered to be met. When the forecasting is considered requirement is met can depend on how large the forecasting error is. Using a simple model will also facilitate the introduction and description of how the model was derived towards the company management.

5. *There is no magic model*: Jain (2006) point out that there is no model that will work in every situation. Each data set forms a certain pattern and each model captures a certain pattern, thus it is unlikely to find a model that includes the best data pattern for different data sets.

6. *Models age with time*: As mentioned earlier, industries and companies continuously face changes. Data and requirements change along with this dynamic environment, and therefore the model needs to update as well. The model should be monitored regularly and when it indicates inefficiency, the model should be updated or replaced by another model.

7. *Each model has its own data requirement*: Different models require a different data set. Some models need less information to prepare a forecast while other need both dependent variables that is wanted to be forecasted, but also independent variables that drive the others.

8. *Statistical forecasts are nothing but baseline forecasts*: No model exist that are able to take into account everything. Judgemental forecasts do however overlay over baseline forecasts and tend to improve the quality of forecasts.

9. *Forecasts should not be prepared in isolation*. Since no one is sitting on all the information, when preparing forecasts researchers need input from various stakeholders on different positions to get a wider view.

3. METHODOLOGY

The chapter presents how the research was conducted, the choice of research design, and what different types of data collection methods were used when answering the three first research questions, and finish with a discussion of the validity and reliability of the research.

3.1 Research strategy

A research can be conducted using different approaches to social investigation. A research strategy can according to Bryman and Bell (2011) be used as a broader orientation to the conduct of business and management research. Two different approaches on how to conduct a business research will be presented, namely quantitative and qualitative research. The quantitative research comprise that the theory is described as something that precedes research, while the latter comprise the theory as something that emerges out of the research.

The quantitative approach has been the most dominant strategy when conducting research strategy. This distinct research strategy entails the collection of numerical data with an outcome that is presented through monetary or numerical terms. This approach may be useful when researchers aim to compile statistical generalisations from such numerical data in order to draw valid conclusions.

A qualitative research strategy usually emphasise words rather than quantification in the collection and analysis of data (Bryman & Bell, 2011). Krishnaswamy and Satyaprasad (2010) present the qualitative approach as one based on a subjective assessment of behaviour of people under study. This research depends on the definition of the meaning of words. However, quantitative and qualitative research should not be confused with quantitative and qualitative data. The qualitative research do not completely exclude numbers, nor being addressed as something that the quantitative research is not, which Bryman and Bell (2011) considers important to take into consideration when setting the research strategy. The quantitative approach is used regularly in different types of qualitative analysis, according to Krishnaswamy and Satyaprasad (2010).

3.1.1 Relationship between theory and research

The research of qualitative and quantitative strategy can be subdivided further depending on the relationship between theory and research. It can according to Bryman and Bell (2011) be viewed from two general approaches. The acquisition of new knowledge can be done with an inductive reasoning and a deductive reasoning. The inductive reasoning is a theory building process that commences with observations of specific instances and seeks to make generalisations about the phenomenon under investigation. The deductive reasoning is a theory testing process, which seeks to investigate if generalisations apply to specific instances (Hyde, 2000). Another approach is through abductive reasoning, which is a combination of the deductive and the inductive reasoning. It originates from observed data and builds hypotheses on these data. The hypotheses are then evaluated to find the best explanation that covers more of the given fact and contradicts a fewer of them. The research in this thesis will be conducted through an inductive reasoning. This is because the research will generate a contribution to theory through establishing a model adapted to the department under study. Bryman and Bell (2011, p.390) divides the inductive approach into six main steps: General research questions, Selecting relevant site(s) and subjects, Collection of relevant data, Interpretation of data, Conceptual and theoretical work and Writing up findings/conclusions. The fourth and fifth step are often iterative and consists of formulating tighter specification of the research questions, collecting further data and then iterate this as many times as necessary for the research (Bryman & Bell, 2011). This thesis will somewhat pursue this outline throughout the research because it exhibits fairly less codification of the research process than quantitative research.

3.2 Research design

A research design relates to the criteria that are employed when evaluating and planning for how to direct business research, and will serve as a framework on how to collect and analyse data (Bryman & Bell, 2011; Krishnaswamy & Satyaprasad, 2010). It will further give advice on how to make priorities in the research process. Yin (2003) explains the research design as a logical sequence that connect empirical data to a study's initial research questions and consequently to its conclusions. Bryman and Bell (2011) are presenting five different research designs: experimental design, cross-sectional design, longitudinal design, case study design and comparative design.

What research design to apply on a research depends on the nature of the problem and the aim of the research (Walliman, 2011). The research design chosen appropriate for this thesis is a case study, since it will successive contribute to the existing knowledge base on building a model adapted to the department of DT within Scania. This research design involves according to Eisenhardt and Graebner (2010) building theoretical constructs out of case studies, which are empirical descriptions of particular occurrences that in this research are contemporary descriptions of recent events. A case study is by Bryman and Bell (2011) characterised by a detailed and intensive analysis of a single case. Theory building from cases is popular since it is one of the best bridges between qualitative evidence and producing new theory, which makes this relevant design for the research in this thesis.

Case studies are common in not just group, social and political phenomena but also in industries where organisational and managerial processes are investigated. "The essence of a case study, the central tendency among all types of case study, is that it tries to illuminate a decision or set of decisions: why they were taken, how they were implemented, and with what result." (Schramm 1971 referred to in Yin, 2003, p.12)

The researchers must be well aware and prepared when designing case studies to overcome criticism of the research design (Yin, 2003). Yin (2003) presents four tests to check the quality case studies and also the tactics for how to deal with these tests. The four tests are construct validity, internal validity, external validity and reliability. Bryman and Bell (2011) is mentioning the same tests including ecological validity and replicability, however these are considered inappropriate in this thesis.

3.3 Research method and data collection

This section provides a general outline of the work throughout the study. The problem definition was defined and the scope of the research was set together in agreement with the clients at Scania based on a research proposal in the initial phase of the master thesis. The DT department was decided to be the unit under study. The general research questions were then formulated with regard to that problem definition. The data collection method was separated into three phases throughout the research: A pre-phase, an exploratory phase and an identification phase, which the section of *3.3 Research method and data collection* will be divided into. After the identification phase a model could be constructed using the data input from the earlier phases. A literature review was carried through simultaneously before any improvement recommendations could be accomplished.

When reading this master thesis report one must understand that it involves different types of methods. The result of this master thesis, a forecasting model, is a method, where the method is used to predict the future in either an exploratory method or in a normative method (Porter et al., 2011). The forecasting model constructed in this thesis is a forecasting method using the exploratory method. The study around constructing a model will per se implicate several methods. Four of those methods are illustrated in figure 7 and will further on in the thesis be referred to. This study emphasize on the first two of them. The method of how a forecasting approach was chosen is presented in *3.3.2 Exploratory phase*. The method of how the data required to use the chosen approach was collected and used is presented in *3.3.3 Identification phase*. The last two will be considered but not associate with an explanatory method in this chapter. It is mainly to apprise the company under study on how to use the model and make further improvement. The arrow between the last method and the third illustrates a loop of improvements. When using the model and detect a possible forecasting error the user need to reduce the error for the next time by changing the input.

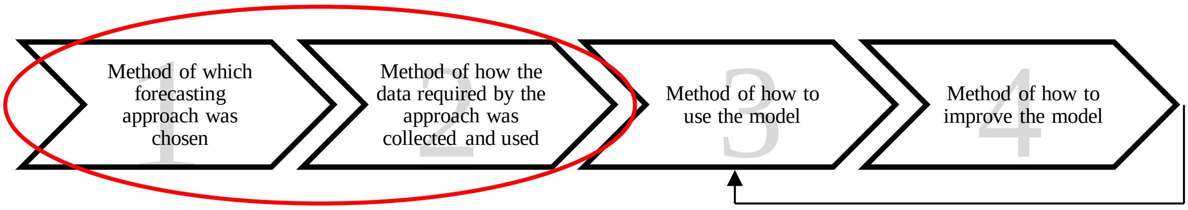

Figure 7. Four separate subsequent methods in model construction. The circled area illustrates the methods in which this study is emphasized on.

3.3.1 Pre-phase

During the pre-phase, identification and selection of the research problem were put through. Unstructured interviews with open questions were conducted with the clients on the company and a couple of experts for the purpose of getting to know the company as whole and gain a broad understanding of the processes in which the LPMs operated. The unstructured interviews involves just a single question where the interviewee can respond freely, thus get the interview similar to a conversation. Open questions have the advantage of giving the researcher knowledge about areas that he or she does not know much about in advance. Open questions also have the advantage of giving the interviewee the freedom to answer the questions in his or her own terms, which will provide information that might vary a lot from different interviewees, hence giving the researcher many different viewpoints (Bryman & Bell, 2011). Bryman and Bell (2011) also discuss the disadvantages with asking interviewees open questions, and emphasise that interpreting the data collected with open questions can be time consuming compared to interpreting data collected from asking interviewees closed questions. This will be further discussed in the section 3.4 about data analysis and validation. Along with this phase the researcher were able to iterate and finally set the problem definition that was presumed necessary before entering the exploratory phase. The collection mainly contained data of primary sources.

3.3.2 Exploratory phase

The exploratory phase included a pilot study with pre-testing questions together with unstructured observations of the LPMs. Unstructured observation does according to Bryman and Bell (2011) not make use of observation schedule but instead record the behaviour of the objects under study. The intention with this phase was for the researchers to gain knowledge within the daily routines of the LPMs by observing them a day at the time, and to consequently serve as a base when constructing the research questions prior the identification phase. The exploratory phase explains the method of which forecasting approach that was chosen, the first method of the four described in figure 7. Five LPMs were observed. A pilot study can be used to generate appropriate questions for semi-structured and structured interviews, and make the researchers more confident with the questions (Bryman & Bell, 2011).

The theory on which the forecasting model in this thesis was based upon was found in the exploratory phase, after the researchers found out what information was available among the LPMs. The regression model named COCOMO, a constructive cost model presented in more detail in section *2.5.1 Regression*, is the theory on which the constructed forecasting model has gotten its basics from. Following section describes the method of how the forecasting approach was chosen.

The studies in the exploratory phase indicated that documentation as historical effort data was missing to such an extent that the researchers could not make use of it. Therefore, an expert judgement method was considered the most suitable method when collecting data for the input of the model. It was found by the researchers that all information required by the COCOMO was not available to be collected by the LPMs. Hence the model was only partially constructed as the COCOMO. Bryman and Bell (2011) mentions the grounded theory that suggests that empirical research observations of the reality can act as the only source to knowledge. It was by the researchers considered that the information available to be collected at the company could be coded using open coding to categorise the information, in accordance with Strauss and Corbin (1990) presented in Bryman and Bell (2011), as the assignment and condition at Scania appeared to be of a particular nature where other information could not be used in order to conduct the study. Other forecasting models, presented in chapter *2. Theoretical framework*, have in addition to COCOMO influenced the construction of this model.

Bearing in mind that forecasting the future can be difficult (Porter et al., 2001) has made the researchers to carefully go through different types of estimation approaches in order to find a good combination for the model construction best suited for the department of DT. Using a combination of forecasting approaches, where one approach is input to another approach, can according to Porter et al., (2011) be preferable when constructing a model. Analogy and regression approaches require easy access of available existing historical data for the researcher to utilise, thus they will not be used as a foundation for this model construction. However, the analogy method suggests the utilisation of expert judgement to be beneficial, which has been used as a main source in this model construction. In addition to this and as mentioned earlier, the structure of intermediate COCOMO involves useful features, for example effort drivers that are different measures of the project and affect how much effort will be required, which were available to be identified at DT. The effort multipliers derived from the effort drivers are taken into consideration by the researchers. However, since the effort multipliers are derived out of a regression method using historical data, and the availability of enough historical data was not the case in this study, the effort multipliers are calculated differently. The effort drivers are in the model construction of this thesis named as *factors*, and the effort multipliers instead named *numerical factors* and are derived from expert judgement estimates. The method of detailed COCOMO was neither possible to utilize in full. The effort drivers, or factors, would in this study not be able to be weighed against each other within different phases of the project, partly due to the LPMs not possessing that kind of experience and partly due to the time consuming task. The class of the project, referred to in *2.5.1 Regression* as development modes of the project, are for the same reason just mentioned neither being used in the model construction. The framework of intermediate COCOMO was anyhow accounted as a fundamental idea in constructing this model. The model constructed in this thesis is described more in detail in chapter *5. Results.*

The research questions were, with the constraints and possibilities in mind, hereafter reformulated into more specific questions. Consequently the researchers entered the identification phase with the purpose to collect the data deduced by the research questions.

3.3.3 Identification phase

The identification phase describes the second method described in figure 7. The first step in the identification phase was to collect data regarding RQ1 and RQ2, which were done through semi-structured interviews with LPMs and the PEMs, as well as document reviews. Bryman and Bell (2011) describe the semi-structured interviews as interviews with a list of question, where the researchers can add additional questions that might occur during the interview, compared to structured interviews. Simultaneously as the researchers made their own notes, all of the interviews were audio recorded. This because of that the recording permits repeated and more thorough examinations of the interviewees' answers and helps when the memory or notes of the researchers lack. Recording may however entail problems regarding the subsequent data analysis, and this will be discussed in section 3.4 below.

The activities identified by the interviewees were easy to distinguish, and the interviewees all talked about the same activities. The researchers did however decide to combine some of the activities into other activities; this is further elaborated on in chapter *4. Empirical findings*. The factors identified during the interviews were not as clearly described in the same words by the interviewees. Some of the factors were described in the same way and with the same name by all of the interviewees, while other factors were described by all the interviewees, but described with different names. When all the interviews were conducted the researchers, in accordance to the grounded theory described in (Bryman & Bell, 2011), compiled all the answers and found twelve described factors. Some of the factors already had names, since the interviewees had all described them with the same name, but the factors that had been described in different names, the researchers named.

The interviewees were asked to describe in which way the factors affected the activities and in most cases the interviewees were uniformed, however there were two factors the interviewees had very diverse opinions about their affect on the activities, this is further elaborated upon in chapter *4. Empirical findings*. The two factors, which the interviewees had very diverse descriptions about how the factors influence the activities, the researchers chose to exclude from the model when it was constructed.

The data collected during the first set of interviews answered RQ2 and the first part of RQ1, which activities a LPM performs. However, RQ3 and the second part of RQ1, what each activity's time variance is, was not answered, therefore further data needed to be collected.

In order for the last part of RQ1 to be answered a second set with semi-structured interviews was conducted. Afterwards the researchers compiled the data and the result showed a variance in the minimum and maximum times asked about in the interviews. A meeting was held with the clients where the researchers presented a suggestion to use a mean of the times gathered during the interviews. The mean was suggested as a solution to the variance in answers since the interviewees were the ones with the required knowledge to answer the question and at that point in time they did not have any more precise answers. The clients agreed to the suggestion and it was discussed how the clients can revise the numbers in the future in order to make achieve more precise numbers and consequently improve the model's accuracy.

During the second set of semi-structured interviews it was also desired to answer RQ3. As the answers were compiled the researchers wanted to validate the answers and decided to do so with a questionnaire. The questionnaire showed an Excel document containing the compiled answers, the interviewees were asked to go through the document, and either validate the information in it, or suggest changes. The questionnaire method was chosen, as it would save time for both the researchers and the interviewees. The wished outcome was to receive an uniform answers since the researchers had drawn the conclusion that if all the interviewees had the same opinion about which factors that influence which activity, the constructed model would gain a better accuracy level compared to if the interviewees were not unanimous. The questionnaire was sent out by mail to each of the LPMs and the PEMs. Since it was a self-completion questionnaire, there was no interviewer to ask questions and the respondents read and answered the questions themselves. Bryman and Bell (2011) recommend using questions of closed nature, an easy-to-follow design of the form, and to keep the questionnaire short, which was applied in this research. This was to make it easier for the respondent to answer and to avoid confusion, as well as to enhance the respondent rate, and thus the quality of the answers.

Interestingly the reviewed Excel documents came back with many suggestions for changes in them. This was interesting since this was not the expected outcome, and with this information the researchers realized that in order to come to a final version of the answer to RQ3 it would be beneficial to gather the interviewees and let them discuss the question further. Therefore the researchers conducted two focus groups where the LPMs and PEMs were divided with the purpose to discuss the topic further to reach more consistent responds. The focus groups' division can be found in appendix C. Each focus group had two meeting where the first was 1 hour and the second one was 1,5 hours. Hutt (1979) through Bryman and Bell (2011) describe focus groups as to help individuals to define problems and together in a group find possible solutions. It also let the researchers of this thesis to understand why the interviewees respond the way they do. The two focus groups consisted of three LPMs and one PEM each, together with one researcher to act as a moderator. The role of the moderator was to open up a few topics whose opinions from previous interviews seemed to differ significantly among the LPMs. The moderator avoided being intrusive, and acted structured to enhance the participation of the focus group participants, still being able to refocus them as the discussion got to wide and off topic, which the dispensed time did not seemed to be enough for. Reticent or talkative participants can make, what seems as the view of the group, solely be based on one participants opinion, where it was extra vital for the moderator to make clear that every opinion of the participants was counted for.

The focus groups proved to be a good solution to the situation. The focus groups had long discussions about the topic in depth, and the result was two groups that had agreed on a final version of the answer to RQ3. Due to confidentiality the final version of which factors affect each activity cannot be shown. An illustrative description of the result can be seen in chapter *5. Results*.

Starting the pre-phase with unstructured interviews followed by unstructured observations in the exploratory phase, and in turn followed by semi-structured, structured interviews and a questionnaire during the identification phase, brings out an advantage. By gathering qualitative data in the beginning when the area under study still was fuzzy, a more specific set of questions could be investigated, according to Bryman and Bell (2011). At this stage closed questions were more likely to be used instead of open questions conducted when the researcher had incomplete knowledge about the research area. By using questions of a closed nature in the interviews, the researchers could more easily compare different interviewee's answers to each other, which facilitated the process of a correct analysis of different variables (Bryman & Bell, 2011). The document review was conducted in the latter part of the data collection phases also due to that the researchers knew what type of information to look for. Reviewing documentation of on-going projects as well as old and closed projects was done. These reviews helped the researchers to gain further knowledge in addition to the interviews about the type of projects that were being researched and consequently increased the reliability. Reviewing closed projects was something the researchers hoped would give useful insights on the execution of projects, from start to end. Unfortunately the existing documents were highly inadequate and no such information was available.

3.3.4 Model construction

When the amount of data collected during the three phases was decided to be enough, the researchers designed an estimation model based on that data. The model was constructed to fit the department of DT and its needs and was designed user friendly to reduce the risk of low utilization. The model was built on the opinions of the LPM's, what they believe and how they interpret the environment, thus they may express ambiguous responses, as described by both Buehler, Peetz and Griffin (2010) and Mumpower and Stewart (1996). This can imply difficulties in making valid results for the ones who will use the model, however this problem will be further discussed in chapter *7. Discussion*.

3.3.5 Literature review

A literature review was carried out simultaneously as these phases of data collection. By early recognising what other theories and concepts were already known in the area of study, the research methods and strategies could be identified in order to develop an existing framework further (Bryman & Bell, 2011). The found theory was then compared with the recent collected data during the phases. The theory on which the forecasting model in this thesis was based upon was found in the earlier stages of the thesis, in the exploratory phase. The COCOMO model, presented in section *2.5.1 Regression*, is the theory on which the constructed forecasting model has gotten most of it influences from. However, other forecasting models, presented in section *2.5 Estimation approaches*, have also influenced the construction of this model. The general research questions were reformulated into more specific questions since the researchers gained broader knowledge about the research area during the literature review. Different kinds of literature have been used, articles, journals and e-books from search engines and databases of Chalmers, and others.

3.3.6 Sample

The purpose and delimitation of this thesis declared earlier that this thesis will study the department of DT only. Consequently, the sample under study in this case study was each of the LPMs in the organisation of DT and their group leaders, the PEMs. To get a broader understanding of the process in which they act and also the project from a more comprehensive view, an expert and project managers for the big project were included in the sample. The LPMs were a force of seven men and women with different experiences. The length of their position as LPMs differed between one to three years. A couple of them had experience of project management since earlier, some of them came from other positions at Scania such as technical production engineers, while a few were recent graduates from universities. They all had implemented PD-projects during their position as a project manager, and all of them conducted on-going PD-projects in the writing of this thesis. The number of the current PD-projects each of them conducted differed from three to six, all in various forms and scopes of projects. The characteristics of the project managers differed in several ways, the way they structured their work, the way they followed the PD-process, and how they did their planning within the projects. A few of the project managers conducted PD-projects before the local PD-process was implemented at DT, while some of them took the position as project manager after the implementation. These different preconditions made, according to themselves as well as the observations, significant variation in how their daily work concerning the PD-projects were implemented and also how they made their priorities of project activities within the PD-process. Since it can take many years to conduct a project through the PD-process depending on the scope of the project, the project managers all worked in different phases and did not all have had the possibility to conduct each of the activities and phases in the process. This information can be viewed in context in chapter *4. Empirical findings*.

As mentioned above, the sample also consisted of two managers. Each inherited the position as the leader of half of the project manager force and was included in the process of project planning and which LPM to be assigned a project. The managers are henceforth this thesis termed production engineer managers, PEMs.

3.4 Data analysis

The research conducted within this thesis included interviews, observations and document reviews which yielded in an amount of qualitative data with rich descriptive information. The downside with this qualitative data is the difficulty to be interpreted and find a path through that richness (Bryman & Bell, 2011). Analysing data from a qualitative research are unlike the quantitative research, with its statistical methods, difficult to implement and is still in its early days (Walliman, 2011). Unstructured textual material is not straightforward to analyse, and specified and accepted rules of how the analysis should be carried out are few, according to Bryman and Bell (2011). Miles and Huberman (1994) propose three steps to follow when analysing qualitative data: Data reduction, Data display and Conclusion drawing/verification. Bryman and Bell (2011) are suggesting a general approach called Grounded theory which is the most prominent approach to qualitative data analysis. Since a central feature of this general approach is that the data collection and the analysis proceeded in parallel in an iterative process, this approach will be pursued in this research.

Bryman and Bell (2011) are giving some tools for achieving this type of analysis such as theoretical sampling, coding, theoretical saturation and constant comparison, which to a large extent have been conducted by the researchers of this thesis. They collected, coded and analysed their data and decided what and where to collect the data next in order to build theory, which was an on-going process. By coding, the researchers broke down the data into component parts and were treated as potential indicators, which were constantly compared. When extracting the factors affecting the project, the researchers used open coding of grounded theory. The general approach is however criticised by many researchers (Bulmer (1979) through Bryman and Bell (2011)) regarding whether theory-neutral observations are feasible or not, but will be used since it is useful capturing complexity of context in organisational research as in this study. Observations in research and what information that is seen in those observations are influenced by many factors. There is a risk of losing context of what people said and what was stated in the original data (Bryman & Bell, 2011).

Open questions conducted in the interviews in this research can imply further problems due to the possible variability in the coding process of the answers, which in turn may affect the measurement error (Bryman & Bell, 2011). However, this problem was partially avoided in this thesis and was considered internal reliable as well as inter-observer consistent, since the qualitative interviews were conducted with attendance of both authors. The external validity is also difficult to achieve in qualitative research since it may be considered hard to replicate the research. A higher level of external validity can however be achieved through adopting similar role as the researcher in this thesis, to make the observed data comparable (Bryman & Bell, 2011).

Analysing questionnaires was in this research timesaving to some extent, as the researchers did not have to meet every respondent further, as they were considered relatively busy. They instead let the respondent take their own time when they had the opportunity and return with the answers within a deadline a few days ahead. Bryman and Bell (2011) mention disadvantages with this method. The fact that the respondents do not have anyone to help them when they are having difficulties answering the questions. This was the case in this research but did not become a problem since the respondents were located in the same area as the researchers who offered their help, both by mail and in person.

Audio recording of interviews calls for transcription, which is a very time consuming process if not simplified. When simplified, the researchers will however impose their own interpretations and consequently bring distortions into the analysis. That is the reason why the researchers also chose to make notes simultaneously during the interviews and to use the notes as the primary recording method while the audio recording was used in case when the researchers missed out or suspected to misinterpret any information given in the interview. Due to the delimitation made by the client on the company that only the department of DT would be studied involved a limitation of number of project managers to include the sample. The amount of seven project managers working in the department of DT may according to Bryman and Bell (2011) be classified as a convenience sample, due to the restriction of how the interviewees were selected and also how many of them. The low representativeness in qualitative research, like in this study may, according to Bryman and Bell (2011), however not make such essential impact as it does in quantitative research. They assert that external validity represents a problem in qualitative research due to small samples and the nature of case studies, which are both present and applied in this study. Walliman (2011) claims that accurate generalisation about the population cannot be achieved by using a non-representative samples. The sample size has to be balanced against the resources of the research, which in this thesis mainly was restricted by the time. The external validity of getting the result of this study to be generalised beyond the specific research context, as mentioned by Bryman and Bell (2011), will therefore not be something the authors in this thesis will focus on achieving.

4. EMPIRICAL FINDINGS

The empirical findings of the study includes a review of the current practise on the department of DT, listing of activities performed by the LPM's within the projects, a number of factors that the LPMs asserts to be contributing to the effort required to be put into a project. The relationship between the activities and the factors and to what extent they affect each other is also presented. Also the situation regarding documentation will be addressed. The first research question, RQ1, the second, RQ2, and the third, RQ3 can be deduced in this chapter.

4.1 Current process

The current process of how the department of DT work is further investigated in the three following sections. The standardised product development process in which they follow, how the project hand-over are conducted, as well as the process in which the PEMs estimate the project effort are presented.

4.1.1 The Product Development Process

The general PD-process has been present at Scania for several years and has on DT been further developed to adapt to the local organisation. A process developer reconfigured the general PD-process in 2010 to fit the PD-projects at DT (Interview 1, 6). The PD-process is still under continuous improvement. Consequently a new department at Scania was established, the Scania General Milestone-group, SGM (Interview 6).

The process is visualised as a clear structure, where the activities in the process are mapped out and shown in the order they are supposed to be executed, where the process should be followed from start to finish (Interview 1). However, not all projects demand that every activity is executed, for example the DOL projects, which are very small projects, does not always demand that all activities should be performed (Interviews 5, 6, 8). Each project concern several people. At DT there are usually five groups in each PD-project. These groups are the PEMs, the LPM, logistics, technical production engineers and SLA, the projects that sometime do not include all groups are projects that are not going to be introduced in Brazil, SLA. Each of these groups has their own row in the process, where activities concerning that specific group is shown (Observations 1, 2, 3, 4, 5), see figure 8.

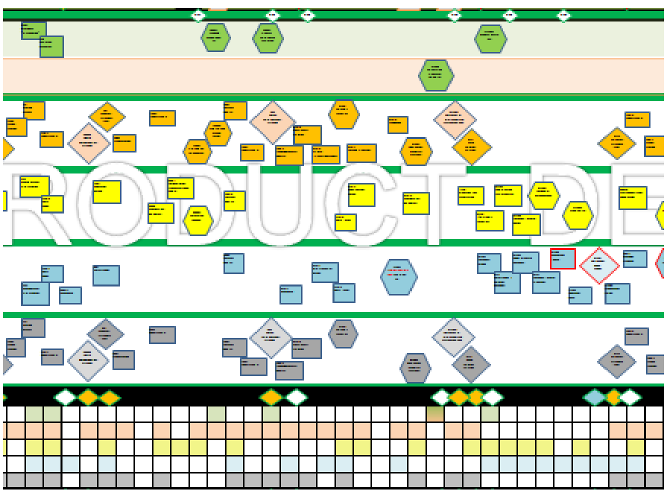

Figure 8: Part of the PD-process

All activities shown in the process are supposed to have a standard written for each of them, and the standard will inform what input is necessary to successfully execute the activity. The standard also describes what type of output is wanted (Interviews 1, 5, 6). Since the process is fairly new and there are many activities in it, not all activities have a written standard yet. Each Friday the LPMs are working together in an improvement group meeting to write these standards, in order to continuously improve the process (Interviews 5, 6). The LPMs review the written or updated standards together and suggest changes (Observation 4, Interview 9). Since the standards do not exist for all activities yet the LPMs all have differing thoughts and ideas of what should be included in an activity that does not have a standard written to it, and how it finally should be executed in order to deliver the necessary outputs.

The PD-projects conducted at DT are normally executed in between 2-5 years, and no project was in the start-up phase when the process was introduced. Combined with the fact that the PD-process has only been in use for about 4 years, no LPM has followed through the entire PD-process with one project (Interviews 5, 6). When the process was introduced at DT, the PD-projects that were already running at DT were applied into the new process. Therefore, some of the LPMs have worked in the initial phase of the process, while some have worked in the latter part of the process.

4.1.2 Project hand-over

The procedure on DT when the PEMs delegate projects in their early phases to LPMs are not a standardised process (Interview 2). At the moment the PEMs plan their resources at DT, in terms of LPMs, both in the concept development phase and product development phase of the project, or more specific, when they believe the project will be relevant for the DT department. How early this will be differs however between different projects and between the PEMs. The PEMs first become engaged in a new project during its start-up phase, where the project aims to get an early cross-functional establishment at involved organisations at Scania. Committed people, including PEM on DT, agree with the project management and the project planning work (Scania standards, 2007). As the project gather all affected organisations on the company, it is by now necessary for the PEMs to represent the DT department as to mediate what would be most profitable from DT:s point of view (Interview 2). Eventually a project description will be established by the project describing the project scope, what shall be done, by whom, when it shall be delivered and how follow-up of expected benefits should take place (Scania standards, 2007). Based on the project description documents the PEMs will in turn start to plan their resources local on DT (Interview 2).

The question of how to delegate the project and to whom is today an uncertain process. Since the project includes a date when the customer production starts, and where the project terminates and are handed over to the owner for continuous improvements, the PEMs need to consider the work effort required by a LPM until that date together with how busy they are with other projects at the moment (Interview 6). How this procedure is done is depending on the PEM and also differs projects in between. The decision of who will be assigned the project are today either made in accordance with other PEMs, the proposed LPM, the LPMs as a group, or other experienced people, but will in the end basically be the decision of the PEM itself (Interviews 2, 6). They may at times take the previous experience of the LPM into consideration, such as delegating similar projects to the same project manager to achieve synergies (Interview 9). Usually they do not make use of any methods or forecasts when estimating the effort, only using their "gut feeling" based on their previous experience, thus this process is far away from standardised (Interview 6). A lot of the PEMs effort today is therefore not put on making a thorough investigation on how much effort the project will require, but more on to manage the repercussions after a poor effort estimate (Interviews 2, 6). These repercussions include when the LPMs signal that they cannot reach the deadline or are working overtime, and this usually occurs before milestones, during the process verification, before summer vacation, during test assemblies or before the investment plan is frozen, according to different LPM (Interviews 6, 7, 11). Most of the LPMs are or have earlier been working overtime due to critical milestones in the project (Interviews 7, 8, 10, 11, 15).

4.1.3 Project effort estimation process

Some of the LPMs perceive they do not get any information on how comprehensive the project will be as they receive a project in its early phases from the PEM (Interview 8), while some discuss together with PEM what has happened in the project earlier together with information in the project AD, and based on that try to figure out the future effort. However, all projects do not have historical data on what has been done in the project earlier or how similar projects have been carried out previously (Interviews 2, 15).

During the close-down and when the project is handed over to the owner for continuous improvements the project leaders managing the project from R&D are supposed to compare the numbers and estimates of planned effort in the project description that was established in the start-up phase with the actual numbers at the end. The actual numbers of effort are by the project managers supposed to be measured in a time reporting system called SilberTime. According to project managers they measure the actual effort put by them every six months, or sometimes not until the project is completed, which can take two to six years or even more. Thus the measures are more of rough estimates of how much effort was put in total (Interviews 16, 18). Administrating and documentation of actual effort put in a project is not considered relevant in comparison to more project related tasks, thus are given lower priority by the project managers on a project level as well as the LPMs on a local level at DT (Interviews 7, 8, 16) It exists a standardised folder structure on the local network where to enter documentation on what has been done in the project, but may be unknown for some LPMs (Interviews 2, 4). The fact that there until today are no well established standards, or no standards at all, on why and how to carry out time reporting and documentation on actual effort also contribute to the lowered priorities in to actually executing them (Interviews 7, 8, 14, Observations 1, 4). Several LPMs do not have experience in project execution and what it entails (Interviews 3, 4, 10).

4.2 Activities

Interviews and observations of LPMs and their PEMs together with document reviews have brought a number of activities a LPM on DT performs. The activities below are fractionated and derived from the product development process in which they conduct their projects, continuous activities dependent as well as independent of the project, together with additional activities. The activities are summarised in table 1.

4.2.1 PD-process activities

The PD-process is the process in which the LPMs are conducting their projects, and the projects are divided into activities. Whether the project is considered small or big the LPMs follow the process either way. However, the activities visualised in the PD-process are not activities that have to be done in every project. Since the PD-process mediate activities for a complete project some of the activities might be removed, for example a project that not includes introduction of any new parts but only concerns new supplier. In these projects there will not be test assemblies to the same extent that in projects including new parts. The activities described can for the eye look like simple tasks, but when implementing them in reality they involve more preparation than expected and thus become more comprehensive (Interviews 1, 10).

Due to that the process is updated continuously the activities are not well defined and may change at hand. This makes it unclear for the LPM's to agree on what each activity includes and not includes, or even whether the activity is relevant for the process or at all. The LPMs do not always agree on what the activity involves (Interviews 2, 9, 10, 12, 14, Focus groups 1, 2). Neither in activities where there is a standard explaining what to do. Some of the actual work that a certain standard describes in an activity might be done by the LPM in another activity somewhere else. The LPM's can in some activities change their mind concerning what to do (Focus group 1, 2). When the activity at hand is unidentified it involves more time to catch up among other LPMs to gather information of what to do. The different activities are often linked together and the boundaries in between are flexible (Interviews 12, 15, 19, Focus group 1). Interviews clearly illustrate the difference in defining each activity and its subtasks. Most of the activities are executed under a longer period simultaneously as other activities in the process, and not often sequentially (Interview 19, Observations 1, 2, 3, 5). An activity can be repeated several times before it is assessed to be finished (Interview 19).

4.2.2 Continuous project independent activities

Continuous project independent activities are activities in addition to the PD-process and independent of the number of projects. They appear on regular basis, every day, every week or once every two weeks, and do not increase with the number of projects managed by the LPM (Interview 2).

The LPMs have together with their PEMs a meeting every morning to go through and plan the work of that day, called the *daily pulse meeting*. This meeting takes about 30 minutes. Twice a week after these meetings they will scour the working areas in which they store new products and make test assemblies, and identify what should and should not be sited in the area. They spend about 30 minutes a week doing this waste reduction (Observations 1, 2, 4)

90 minutes once every week the LPMs at DT meet up to discuss the product development process with the aim of improving it continuously. This meeting is called *improvement group meeting of the PD-process*. They write documents and standards on what and how to conduct a specific task in the PD-process (Interview 1, 2, Observations 1).

During the *reconciliation with SLA*, they require continuous updates from the DT department of what is happening in the projects in order to follow, thus the LPM dispense 30 minutes a week to inform and advice them (Interview 2, 5, 7, Observation 2).

The LPM meet up with the *PEM for reconciliation* 30 minutes every week to let the them know how the projects are doing and help getting priorities between the projects done (Interview 2, 5, 6, 15).

Once a week for the LPM's together with the technical production engineers under the same department meet up for an hour to get and to share information of what is going on at Scania in general, the status of the PD-projects and technical issues on the line. This is the *weekly meeting*.

During one hour every week the LPM's *pulse their PD-projects*. They update the status of their project against the physical PD-process as well as the CD-process, which are public (Interview 1, Observations 1).

4.2.3 Continuous project dependent activities

Continuous project dependent activities are further activities outside the PD-process that appears on regular basis. However these activities are unlike the project independent activities dependent on how many projects the LPM is dealing with. The activities are held for every project (Interviews 1, 7, 11, Observation 1, 2).

Every project has a *project meeting* once a week, which the LPM, among other committed project members, attends, and is held by the project manager. Each meeting takes one hour (Interview 7, 16, 18, Observations 2).

Since the project is fractioned into several objects described earlier, every object has similar to the project a meeting once a week. This *object meeting* is held by the object manager and takes one hour (Interview 22, Observations 1, 3).

All of these project dependent and independent activities are mandatory in general, however the LPM makes their own planning in what is prioritised at the moment, thus do not necessarily attend all of the meetings (Interview 7, 10, 16, Observations 1, 2, 3, 4, 5).

4.2.4 Additional activities

The activities mentioned above, such as PD-activities, continuous project independent and dependent activities are hardly all of the activities performed by the LPMs. Most of the additional activities are found to be subtasks of the activities in the PD-process but not formally established as standards. Depending on how the project was put through and managed in previous stages the LPM experience cases when a project encounters larger dilemmas than what is included in the PD-process, which causes additional meetings (Interview 8, 9, Observation 1).

Deviations in the concept or product construction can sometimes be detected along with the project. Concepts may sometimes not function as expected or that the parts break, and thus the concept has to be reconsidered. When these deviations are large the project manager or the LPM has to consider bringing together people from different organisations for a reconciliation and to solve the problem, which implies additional meetings focusing on the problem at hand. These meetings often occurs in the later phases of the project and are not included in the PD-process (Interview 3, 9, 10).

In projects that involve large investments, there will be a lot of additional *assessment meetings* concerning investments particular for that project that is not included as activities in the PD-process (Interview 2, 10, 11).

Before some of the test assemblies it is necessary to bring in extra meetings to *follow up the material* essential to carry through with the assembly. This does not necessarily apply on every project, but on those that comprises rare or complex material vital in the project (Interview 4, 8, 9, 11).

The object manager and the project manager have a high level of influence on how meetings will be proceeded in the project and to what extent (Interview 10, 11). The project manager may at times introduce supplementary continuous meetings when the project includes critical parts, and also when a project has to make retakes in the design there will be additional reconciliations. Projects affected by *high risks* include additional meetings other than the project meetings and object meetings, such as risk sessions (Interview 7). There is also a difference between the project managers and between the object managers in how they choose to follow up the timetable. Sometimes the timetable is not accessible for the LPMs, which makes the work and planning for the LPMs more difficult to manage, and thus time consuming (Interview 3, 11). The LPM judge whether the meeting called for is prioritised and necessary or not, and accordingly make the decision to join or not (Interview 7, 11).

In the early phases of projects, such in the CD-process, the activities and meetings are held more ad hoc because that process is not as developed as the PD- process (Interview 4). As a LPM, it is often necessary to bring in additional meetings due to that the PD-process is not completely developed and not always includes standardised work (Interview 4, 9, 10). Another reason is depending on to what extent the LPM choose to be involved in the product development process and whether to question the concept brought by the designers or not, which makes the LPM to include additional meetings with designers and other involved people (Interview 10, Observation 1).

Several LPMs regard themselves as time optimistic and are often surprised on how time consuming an activity can be. All too often they do not reckon with subtasks associated with an activity such as documentation and to firmly establish the activity. Along with this the already established *time plan has to be updated continuously* (Interview 10, 12). Late deliveries increase retakes in the project, which require additional effort of involved project members than it would have been if the project followed the schedule. Product development projects do obviously need to make retakes to retain the creativeness in the concept, but when the retakes are made in a later part of the project it will affect the work effort significantly (Interview 18).

The fact of *getting in touch with involved people*, in terms of telephone calls and sending email, turns out to be more time consuming than they thought from the beginning of the activity, and varies between projects. In many project activities the LPMs have to look for the designers involved in the project in order to get relevant information for the task at hand, which may take additional time. To schedule several different people for meetings can be more complicated than expected of that activity. Thus the more areas and people involved in that project the more time consuming for the LPM to coordinate, which was not expected prior the activity (Interview 3, 10, 14, Observation 1).

The changing preconditions prior test assemblies, verification of equipment, new acquisitions and deliveries make the earlier established time schedule irrelevant, thus the *time schedule has to be updated* constantly by the LPM, and is regarded as a very time consuming task to arrange outside the PD-process (Interview 4, 10).

The project managers on YP are located in another area than the LPMs on DT, and many of the meetings related to the projects on a higher level will be held in that area. Thus the LPMs have to allocate time for *transport* to and from those meetings (Interview 2, 5, 9, Observation 1, 2, 3).

Type of activities	Activities
PD-process activities	All of the activities according to standards
Continuous project independent activities	Daily pulse meeting
	Improvement group meeting PD-process
	Reconciliation SLA
	Reconciliation PEM
	Weekly meeting

	Pulse PD-projects
Continuous project dependent activities	Project meeting
	Object meeting
Additional activities	Extra meetings due to deviations
	Assessment meetings due to investments
	Material monitoring prior test assemblies due to complex material
	Risk sessions due to critical parts
	Further documentation to establish completion of activity
	Revise time plan
	Getting in touch with involved People
	Transportation

Table 2. Activities conducted by the LPM

4.3 Factors

This section will present the factors influencing the identified activities. The size of these factors will determine how much time the project will take out of a LPM:s work time. During the first round of interviews the interviewees were asked to identify factors that, in their opinion, influence the time scope of a project. The factors presented in this section was all mentioned by several of the interviewees. However, everyone did not refer to each factor by the name it has now been given, but the significance of the factor was the same as one of the factors now presented.

4.3.1 Identified factors

The most frequent identified factor is *Number of Parts* (Interviews 3, 4, 5, 7, 8, 9, 10). The *Number of Parts* refer to the number of part numbers that is affecting a project, this means that part numbers that are being phased out when the new product is introduced, as well as the part numbers that are being introduced with the project, are to be considered. During the interviews it became clear that the *Number of Parts* is of high significance to the projects' time scope. For example, the time a LPM spends on reviewing and revision of CAD drawings become greater with an expanding *Number of Parts* (Interviews 12, 15).

Interviews (15, 17, 19) state the second factor, *Similar Parts*. *Similar Parts* refers to parts that are of the same type, but not exactly the same. For example, a project can involve several cogwheels, which are not exactly the same, but since they are cogwheels the time a LPM spend on reviewing and understanding the cogwheels does not expand linear with the number of cogwheels (Interview 15).

Variant Matrix is the third identified factor (Interviews 8, 12, 17, 20). The *Variant Matrix* will provide information about how many variants in production that will be affected by the new project. When the number of affected variants is high the time the LPM has to spend on preparing and conducting test assemblies will increase because it is desired to test as many new variants as possible (Interviews 17, 20). Interviewee (17) also explains that with an increasing *Variant Matrix,* meetings with line areas and documentation from meetings tend to take more time.

The fourth identified factor is *Number of Investments* and is referring to how many investments that will have to be done during the project. As the *Number of Investments* become greater the time spent on finance estimates and follow-up will become greater (Interviews 4, 5, 6, 7, 9, 11). More investments also mean more time talking to other organisations in order to coordinate the investments, and it also means that the LPM has to get more invoices granted, sorted and documented (Interviews 17, 20).

The *Investment Size* is another factor identified during the interviews. Each investment that will be made during a project has to be approved by a manager. The size of the investment determines how high up in the hierarchy a LPM has to go to have the investment approved (Interview 5, 10). The higher in the hierarchy the LPM has to go, the time spent on meetings increase. The smaller investments can be approved by the manager closest to the LPM, and can be done in a few minutes while the bigger investments demand longer meetings with higher managers in order to be approved.

The outcome of a project, the new product or improvement of an already existing product, will not affect all produced products. Therefore, the *Frequency* of produced products that the project will affect is a factor (Interviews 3, 7, 8, 11). If the *Frequency* is low, the LPM will not have to spend as much time on verifying the assembly process, as when the *Frequency* is high (Interview 8).

The PD-projects can vary from updates and improvements on existing products to completely new products the factor *Technical Novelty* is of importance to many of the activities the LPM perform (Interviews 2, 4, 8, 9, 10). The factor indicates if the technology in the project has been used before, which often is the case in updates of products compared to completely new products where most of the technology often is new. When the *Technical Novelty* in a project is high, understanding parts and the assembly of parts will take more time for the LPM (Interviews 2, 3).

Interviews (2, 3, 6, 9, 10) state *New Equipment* as a factor. The factor *New Equipment* provide information regarding how much equipment the project has to buy in order for the project to proceed, an example is test equipment. It also refers to equipment that has to be bought in order for production to function in the future. Buying new equipment means that the LPM has to go through the requirement specification for each equipment that will be bought, and it is also important to understand the technology of the equipment. Therefore an increasing number of *New Equipment* requires more working hours from the LPM (Interview 15).

The *Number of Affected Areas* is a factor that refers to how many areas on line that are going to be affected by the project (Interviews 2, 3, 6, 7, 8, 10). Interviewee (6) explain that the more areas on line that is affected, the more meetings will have to take place in order for the employees working on line to understand the new product. Preparing education for these employees will also take time from the LPM (Interview 9).

In the project as a whole, which include the projects under study, many different organisation within Scania is involved. For example, the large project involves YP, Objects and PRU:s, and all of these organisations meet and have contact on at least a weekly basis (Interviews 3, 4, 5, 7, 8, 9, 10). Therefore the *Number of Involved Organisations* is a factor. The LPM has to attend more meetings. However meetings are not all to often held with all involved organisations, but there is a constant contact and follow up with many of the organisations involved. If the product in the project concern more different departments within for example R&D, there will be more meetings to attend (Interviews 4, 5, 10, 18).

Another factor that all interviewees have mentioned is *The Person*, which refers to the LPM. This factor takes the different traits of people into consideration, such as effectiveness, the ability to adjust focus between different projects, and also the different experiences people hold. Interviewee (3) explain that with experience one learn to prioritise and focus on the activities that are of most value for the project in the future, and therefore become more effective. On the contrary to this interviewee (7) had experienced the opposite, that with experience one often tend to perform activities with more accuracy since one knows what is important, which takes more time. Some persons have the ability to easily switch focus between two different projects, and a person with that ability can be assigned projects with very separate contents (Interview 4, 5, 6). However it has been asserted that similar projects should be assigned to one LPM since deeper knowledge regarding one type of projects is beneficial and contributes with synergies (Interviews 5, 6, 9, 10). All the LPMs have different ways of working, interviewees (4, 14) find it important to be organised and have clear structures in the manner to store for example folders in the computer. Interviewees (6, 7, 8) on the other hand had experience in focusing too much on structure and planning would issue in too less time for the actual work, describing it as a trade-off between available time and quality of the requested objectives. Spending time on creating more structure in the work would as soon as the plans were changing get superfluous (Interviews 6, 7, 8). Thus they preferred more of a “ad hoc” approach. However, it is difficult to decide which work method that can be seen as a best practice since every individual is different (Interviews 8, 9).

The last identified factor is *New Directives* (Interviews 3, 4, 10, 11). All projects have to follow the directives that are coming from managers higher in the project’s hierarchy or from a more central part of Scania. Directives regarding changes in either the time plan or the budget are changes that affect the LPM’s work load in many different aspects, for example, the LPM has to notify all project members at DT and plan for the changes (Interviews 3, 4, 5, 9). The different directives coming from project managers, their managers and the steering group varies depending on who the person is and what traits that person possess. If the project manager is organised and plan with a long term perspective, the LPM can receive some warnings that a significant change in the project probably will come soon, and therefore the LPM can plan for that change in advance and not be completely surprised (Interviews 3, 6, 20). Additional weekly meetings can also be ordered by the PM or OM, and hence increase the workload for the LPM (Interviews 3, 10, 11). All factors can be seen below in table 2, with a brief definition.

Factors	Description
Number of Parts	The number of parts that affect a project. Both part numbers that will be introduced to Scania, as well as part numbers that will be phased out.
Similar Parts	Parts that are similar to each other, but not exactly the same. For example different types of screws.
Variant Matrix	The number of different variants of a product that will be affected by the project.
New Equipment	How much new equipment that has to be bought in in order for the project to proceed. For example new equipment for the production line, and new testing equipment.
Number of Investments	The number of investments that will be done during the project.
Investment Size	The size of each investment.
Frequency	The frequency in production, how many vehicles will be produced?
Technical Novelty	To which extent is the technology new to Scania?
Number of Affected Areas	The number of areas on line that will be affected by the project.
Number of Involved Organisations	The number of organisations that are involved in the project.
The Person	Different levels of experience, and the different traits a person beholds.
New Directives	Sudden changes in the project that comes from higher up in the hierarchy. Can be changes in the budget or the time plan.

Table 3: The factors

4.4 Time variance

The factors mentioned in the section above do influence the activities a LPM performs during a project, such as the continuous project activities (both project dependent and independent), activities stated in the PD-process, and additional activities, in a way that requires more time spent by the LPM. These factors do however not all together affect all of the activities. Some activities will not expand in time under the influence of certain factors.

4.4.1 Continuous project activities

The continuous project dependent and independent activities described earlier are activities with a predetermined set of time for the LPM to deposit, and are set as a standard at DT. It does not matter whether the project is affected by any factors, the time spent by the LPM should be the same in any of the projects. The time scopes of these activities are presented in the table below (Interview 1, 5).

4.4.2 PD-process

The activities defined in the PD-process do not have a determined time scope and are instead a general tool to facilitate correct deliveries by the LPM to a central level of Scania. The LPM use the PD-process as a guide as well as updating the underlying documents of expected input and output of the activities and when it should be done until deadline. The amount of time required by the LPM is however not expressed (Interview 1). In this thesis the time scopes of the activities in the PD-process are being estimated and expressed by the LPMs. The time scopes present one minimum time, which represents the time of an activity influenced by the involved factors to a low extent, and a maximum time, if the same activity was influenced by the involved factors to a large extent. These activities are never put through requiring the same amount of time, but will basically always be situated within this time scope depending on how many factors are involved in the activity and to what extent these factors affect the project (Interviews 12, 13, 14, 15, 17, 19, 20, 21).

Each activity may take various amount of time for the LPM depending on what factors influencing the activities and to what extent those factors influence the project in whole. All of the activities are not affected by the same factors. The time scopes of an activity will also vary between which project that is referred to as well as what LPM who is estimating the time.

The different factors mentioned in the section above includes *Number of Parts* in a project, *Similar Parts, Variant Matrix, New Equipment, Number of Investments, Investments Size, Frequency, Technical Novelty, Number of Affected Areas, Number of Involved Organisations, The Person*, and *New Directives* will have an influence of how much time the LPM will spend on the project.

The *Number of Involved Organisations* affect activities when the LPMs have to contact and gather involved people of different concerned organisations and departments. These activities will expand in time for the LPM when the project concerns a larger number of organisations and departments. When writing the project report the LPMs include and describe all of the involved project organisations and also inform the involved. *Number of affected areas* is another similar factor that affects activities that require the LPM to involve each of the areas the affected by the change the project brings. They might have to communicate with each technical production engineer or production leader of the areas. The number of areas influence test assemblies when the LPM have to verify the new product with each of the areas on line and their particular assemblers (Interviews 10, 12, Focus group 1).

The activities will grow as the number of articles increase in a project. When there is more articles to coordinate in test assemblies, the LPM has to order home and ensure that all of the articles are in place, which can make the time spent on similar activities escalate as the number of articles increases. The *Number of Parts* and number of *Similar Parts* in a project will also affect activities that are sensitive to deviations, since a larger amount of articles increase the risk of errors. Making risk analysis and when updating the risk analysis may take longer time in projects with a larger amount of articles. Activities involving reviewing of drawings or documents of articles, and preparations prior a milestone, also tend to increase the time spent by the LPM. These two factors are present in the larger part of the activities in the PD-process (Interviews 1, 5, 6, 12, 19).

Another highly present factor in the PD-process is *variant matrix,* which affects the LPM when preparing and processing activities. The more variants a project holds, the higher the risk of future deviations, thus by making more test assemblies the LPMs can assure a more or less flawless future assembly which accordingly make the LPMs spend more time of that PD-activity (Interview 12). When the LPMs preparing test needs and engage in test assemblies the different variants need to be considered.

The time spent in activities regarding decision making whether to buy or make in-house are influenced by the *Number of Investments* the project possess as well as how large the investments in the project are, namely *Investment Size*. The same applies for most of the activities regarding financials and equipment acquisitions when the LPMs need to consider each of the investments in order to conduct the activity. The LPMs do not necessarily make the investments but act as administrators, which still may be time consuming for the LPM (Interview 17). In project containing larger investments the LPM have to pass by further approvals from a more central organisation of Scania. Investments can be made without buying new equipment, thus they act as two different factors possible to affect a project.

Product development projects have a plan at DT for how the introduction of the product to the line should follow through. From the first test assembly to full production of the product the LPMs have to arrange a plan depending on how frequently the product will appear on the line and the date of when the full production is scheduled for. In cases when a new product replaces an old one there has to be a plan for the phase out as well. The higher the frequency of the product when fully introduced, the more time the LPMs are required to spend on the planning.

The *Technical Novelty* of the product affects activities such as risk analysis since all of the probable risks are identified thoroughly by the LPMs (Interviews 10, 14, 19). Planning for what resources will be required in a project, together with the test demand of the product, calls for a more careful review of the product when the technique never has been reviewed at

DT earlier. These projects challenge the current equipment on the line and thus make some activities more complex to handle. Usually when a project contains complex technique the existing line needs to be updated in order to handle the new product. The LPMs are supposed to make a plan for acquiring any new equipment and will require more time as the technique increases in novelty and in turn complexity. Test assemblies will take longer due to more inexperienced situations. Projects containing purchase of *New Equipment* will add up to a thorough risk analysis and also extended test assemblies when verifying them together with the product, thus more time consuming for the LPM. New equipment will also extend some activities concerning compiling finances. A project that not requires unique equipment is not as time-consuming (Interview 8, 10, 17, 19, 21).

Some activities in the PD-process are not affected by any factors at all, and the time remains the same regardless what project is at hand. These activities has no time variance, in other words the min and max time are the same.

Another reason that the time scopes of the activities in the PD-process differ is due to the insufficient information about the activity and what to do. When deciding the time scope of the activities the standards available for how to carry through the activity can be necessary to have in mind. These standards are lacking information of what to do, and they are biased in a way that the LPMs can interpret the tasks differently. For instance, a meeting prior to a test assembly can be organised in many ways. Either the LPM gather all of the involved members to the meeting or the LPM sets up a meeting with each individual area, which consequently generates in more time engaged by the LPM. Whether to conduct a single meeting with every organisation or to gather them at the same differs between the LPMs (Focus groups 1, 2) Thus letting the LPMs to put a definite time scope on the activity result in a variance of responses between them, as well as between which project that is referred to. In situations when the LPMs together are able to discuss what an activity really imply and define the subtasks, the time scopes are shown to coincide more than when the LPMs individually makes the estimates.

4.4.3 Additional activities

Additional activities appear several times during the PD-process, as mentioned earlier. These activities, and the time spent by the LPMs on these activities, have been included in the appropriate activities of the PD-process expressed by the LPM.

4.5 Documentation of historical effort data

During the interviews the interviewees have been discussing project reports from closed projects. For instance, when asked for time variances of the activities the interviewees have discussed that this type of information should exists in project reports (Interviews 14, 15, 17, 19), something that also have been discussed in interviews (5, 6).

When searching for the project reports from closed projects, the authors have searched internal databases and found 40 project reports from closed projects. The researches hoped to foremost find information regarding estimated and actual times in old projects in order to draw conclusions, which could then be utilised in this thesis. Secondly it was wished to find general information about projects and the process in which the LPMs work in, this to gain a better understanding of the whole process at DT.

The found project reports have very varying levels of information in them, some of the reports had many pages and the project were well documented with information regarding new equipment, financials, and deviations during the project. However, there were not many of these reports and they did not include any time schedules, estimated or actual times for the projects. Other reports only consisted of a short, one page, description of the project, its intended output and the actual output.

Only one of the project reports presented any type time estimation of the project. This was a report of a large project with an 8-year duration. Because of the length of the project, the same LPM did not carry it through. Also due to the length, the PD-process did not exist when the project started, but the project was phased into the process when it was introduced. The first LPM is no longer an employee at DT, and the researchers were therefore not able to contact that person. The time estimation of the project included the time all of the organisations at DT would spend in total in that project. Interview (5) explains that the first local project manger did the time estimations based on experience and did probably not follow them up during the project.

The second LPM took over the project when the project was in the final stages. In interview (14) the LPM was asked how the handover of this project was handled, the questions were asked with focus on the handover of the time planning. The interviewee explained that when the project was handed over there were several meetings with the first LPM, as well as working along each other at first. However, it was never fully discussed how the time planning had been executed in the initial phase of the project. This was not discussed since neither of the LPMs found it important at this stage of the project (Interview 14).

When the project entered the final stages the actual time spent by all organisations involved in the project had to be reported. In order to do this the second LPM asked all organisations involved how much time they had spent in the project, none of the organisations had documented the exact time spent but did instead make estimations of what seemed realistic. The lack of documentation of historical effort data was probably due to the fact that it has never been required to document the time spent in a project on a regular basis (Interview 5, 14). Because of the length of the project, not many of the people had been working in it throughout the project, which was another reason for the lack of documentation (Interview 14).

The estimated times gathered from all involved organisations was compiled and later included in the project report. The number of hours concluded in the end of the project was much smaller than the initially estimated hours done by the first LPM (Interview 14).

During interviews (16, 18, 22, 23) the interviewees were asked if and how they document the time they spend in different projects. Interviewees (16, 18) are both project managers, working at Scania's central project office, YP, which belongs to R&D, and described a program they use to document the time they spend in each of their projects, the employees at R&D use this program. The program has been developed internally by Scania to fit the needs of the company.

The purpose of the program is to document the time spent in different projects in order to see the actual time spent and update time plans with this information. Another purpose concerns finances, whether the project follow the plan of used resources. The project managers are supposed to log the time after each workday. The program is designed so that each project has its own code, and then different types of activities for the project has different codes. The project manager enters the code for the project, or project that has been the day's work focus, the conducted activities for each project is logged together with the time spent on each activity.

Interviewees (16, 18, 22, 23) are all using the program. However, only one of the interviewees (22) uses it as it is intended. Interviewee (22) is a consultant and the information that is logged in the program is the basis for what the consultancy firm charge Scania, therefore interviewee (22) stressed the importance of logging the hours worked each day. The rest of the interviewees (16, 18, 23) do not log their worked hours on a regular basis. Interviewee (16) says that logging is done once a month, and sometimes after several months.

The interviewees (16, 18, 23) all explain that documentation has low priority since their managers do not focus on these reports. Interviewee (18) thinks that if the program was used correctly it would benefit not only by its intended outputs, but it would also benefit future projects, and especially the planning of future projects. When the logging is done infrequently and inconsequent by users, the outcome of the documentation is not very useful today (Interviews 16, 18, 23).

5. RESULTS

This chapter presents the constructed model by first displaying the equations on which all of its calculations are done. Secondly an illustrative data set of the written programme's interface, and its work sheet in Excel is displayed. It is in brief described how the user is indented to use the programme, and an example of the outcome is also presented. Finally an example of how the calculations could be performed when using the programme will be displayed.

5.1 Model construction

The model makes use of the activities and factors defined in previous chapters. Each activity is connected to the time scopes. The time scope, consisting of one minimum and one maximum time are recalculated to three different times, adding one mean time (see equation 1). Depending on how many different factors that are affecting the activity, further explained in the section of time scopes, a so called numerical factor is calculated for each of the three times (minimum, mean, and maximum), which is illustrated in equation 2-4 below.

$$Mean\ time\ = \frac{(Minimum\ time + Maximum\ time)}{2} \tag{1}$$

$$Minimum\ numerical\ factor = \frac{Minimum\ time}{Number\ of\ affecting\ factors} \tag{2}$$

$$Mean\ numerical\ factor = \frac{Mean\ time}{Number\ of\ affecting\ factors} \tag{3}$$

$$Maximum\ numerical\ factor = \frac{Maximum\ time}{Number\ of\ affecting\ factors} \tag{4}$$

These three numerical factors are then connected to the three assesses within the factors. The different numerical factors will work as building blocks that will add up to a total time of the activity, depending on:

-The number of factors that affect the activity, and

-Which factor categories that have been chosen as relevant for the specific project.

The sum of these building blocks, representing the time of each specific activity, will in turn add up, together with the time of the other specific activities, to a final summation, representing the overall time of the project. This number will only represent the activities presented in the PD-process. Continuous project dependent activities, which are occurring every week, will be added to the overall time depending on the number of weeks until deadline. Every project has a deadline and the user has the opportunity to fill in the number of weeks until that deadline in order to recalculate the overall time of the project into a percentage of the LPMs total workload. An ordinarily week for the LPMs are defined as eight hours, five days a week. The number of available hours can therefore be calculated by using equation 5.

$$Available\ hours\ = Working\ hours\ per\ week\ \cdot Number\ of\ weeks\ until\ deadline \tag{5}$$

The total calculated hours of the PD-activities together with the continuous project dependent activities are then distributed on the amount available hours to get a percentage of to how large extent this specific project will engage the LPM of the daily work.

$$Percentage\ of\ work\ required\ = \frac{(Total\ hours\ PD-activities)+(Total\ hours\ weekly\ activities)}{Available\ hours} \quad (6)$$

The percentage shows the approximate proportion of how much time the project at hand will require by the LPM. Important to notice is that continuous independent activities which occur every week for the LPM independently of the number of project the LPM is managing is not included in the percentage since the model only cope with one single project. If the user requires seeing how several projects will affect the effort it has to use the programme for each project to consequently adding together each project's percentage together with the fixed hours the continuous independent activities includes.

5.2 Illustrative data set of the programme

The constructed programme is currently a physical model in Excel with an interface in Visual Basics, and will be used by the PEMs together with the LPMs at Scania. Due to confidentiality the figures shown in this section are illustrative data sets, and do not represent the actual data used in the model.

The user will initially be countered by an interface with the ten factors identified during this study, as can be seen in figure 9. The figure shows a calculated example. Each factor presents three different assesses the factor can be weighed into, and the user will need to assess a weight most in accordance with the project at hand for each factor. The different weights are in figure 9 illustrated as "Alternative 1", "Alternative 2", and Alternative 3", and represent an ordinal scale in which the factors can be weighed. "Alternative 1" can be viewed as the alternative with the lowest number of for example *Number of Parts*, "Alternative 2" can be viewed as the medium alternative, and finally "Alternative 3" is the largest alternative. Depending on when the project will be finalised, the user enter the number of weeks until deadline in a box. The excel programme is now fed with the input required and calculates three different entities presented in three different boxes. First, the total amount of hours all the activities in the current project will require, depending on which factor assess have been chosen in the initial phase, is presented. The second box presents the available hours for a full time job during the number of weeks, which have been entered. Finally, the last box present the percentage of a full time job that the intended LPM should devote to the project according to the model.

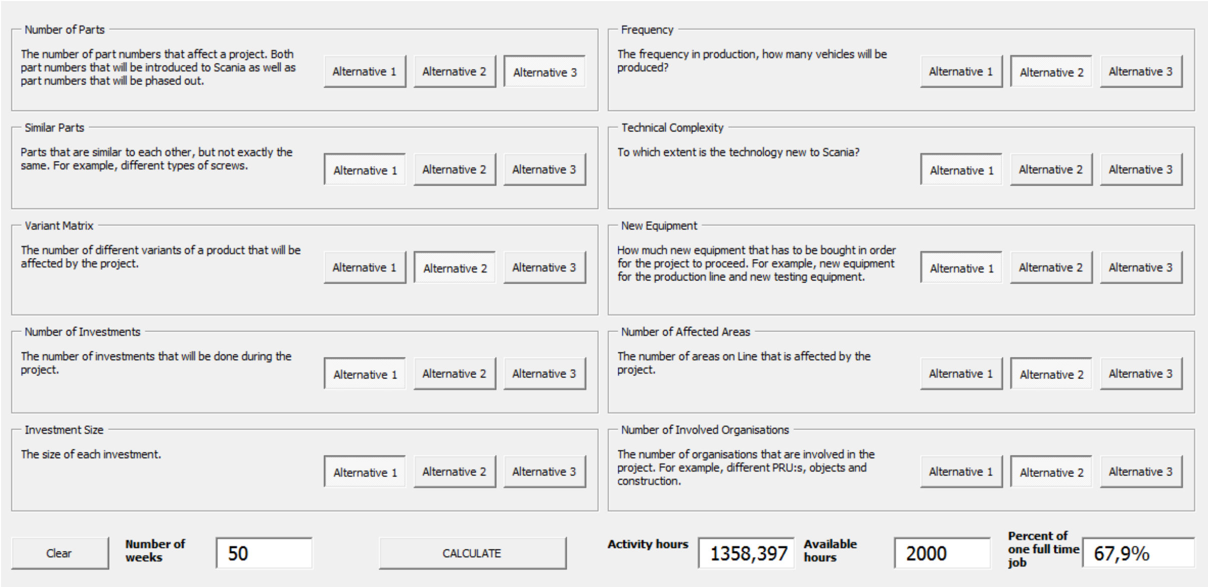

Figure 9: Example of the interface of the programme

The Excel sheets behind the Visual Basics interface contain the activities and factors identified during this study. The different activities are piled in a column to the left and are illustrated in figure 10. Beside the activities is the time variance of each activity, measured in hours. In the same Excel sheet the factors' influence on the activities are shown. All factors do not influence all activities, the factors influencing an activity is marked with a grey box in the row of the concerned activity. Some activities are only affected by one, or a few, factors, while other activities are influenced by all factors. Another scenario is when none of the factors influence the activity, which means that the activity does in all different projects require the same amount of time to be performed by the LPM. When this is the case none of the factors are marked grey in the concerned row, see activity 4 and activity 8P.

	Time Frame		Factors				
Activity	Min	Max	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Activity 1	1	25					
Activity 2	0,5	10					
Activity 3	20	100					
Activity 4	5	5					
Activity 5	2	30					
Activity 6	30	400					
Activity 7	15	60					
Activity 8	8	8					
Activity 9	5	20					
Activity 10	1	20					

Figure 10: Example of the work sheet in Excel

The programme is constructed as a first version and the intention is to have it continuously revised and updated. The time variances, as well as the factors' influence on the activities are easy to change for the user in order to update the model. However, this is not something recommended to do every time the model is used, but rather when the existing PD-process is updated. Therefore, the only sheet the user has to operate when using the model is the interface shown in figure 9.

5.3 Calculation example

An example of how the model calculates a project is demonstrated in this section. This imaginary project consists of only two activities and only five factors. Due to confidentiality the names and numbers used to illustrate a calculation in the model are not consistent with the names and numbers in the real model.

Figure 11 is the basis for this example and it can be seen that the first activity: Project Schedule has a minimum time of 3 hours, and a maximum time of 15 hours. The activity is affected by factors 1, 2, 4, and 5. The second activity: CAD drawing has a minimum time of 10 hours and a maximum time of 30 hours. This activity is affected by the factors 1, 2 and 3.

	Time frame		Factors				
Activity	Min	Max	Number of Parts	Similar Parts	Technical Novelty	Number of Affected Areas	Number of Involved Organisations
Project Schedule	3	15					
CAD Drawing	10	30					

Figure 11: Example of the programme

When utilising the model the user is instructed to decide upon one classification for each factor, as can be seen in figure 9. There are three classifications per factor to choose from. The user is also instructed to enter the number of weeks the project is running. In this example the following information can be assumed chosen:

Number of Parts: Alternative 2
Similar Parts: Alternative 1
Technical Novelty: Alternative 2
Number of Affected Areas: Alternative 2
Number of Involved Organisations: Alternative 3
Number of Weeks: 4

The model has now calculated a mean time for each activity by using equation (1).

$$Mean\ for\ Project\ Schedule = \frac{3+15}{2} = 9$$

$$Mean\ for\ CAD\ drawing = \frac{10+30}{2} = 20$$

Each of the factors is then converted into numerical factors. The numerical factors are calculated separately for each activity by using equations (2), (3), and (4).

The Project Schedule activity's numerical factors:

$$Minimum\ numerical\ factor = \frac{3}{4} = 0{,}75$$
$$Mean\ numerical\ factor = \frac{9}{4} = 2{,}25$$
$$Maximum\ numerical\ factor = \frac{15}{4} = 3{,}75$$

The CAD drawing activity's numerical factors:

$$Minimum\ numerical\ factor = \frac{10}{3} = 3{,}33$$
$$Mean\ numerical\ factor = \frac{20}{3} = 6{,}67$$
$$Maximum\ numerical\ factor = \frac{30}{3} = 10$$

The model now calculates how many available hours there are during the project's duration by using equation (5).

$$Available\ hours = 40 \cdot 4 = 160$$

The total hours the activities will take, depending on what factors affect them, and what classification has been chosen for each factor is then calculated. In this example the activity Project Schedule is affected by three factors, which all have been given an assess, the chosen assesses in this example can be seen above. When a factor is given the Alternative 1-assess the Minimum numerical factor is chosen, the Mean numerical factors is chosen for the Alternative 2-assess, and for the Alternative 3-assess the Maximum numerical factor is chosen.

The Project Schedule activity:

$$Total\ hours\ Project\ Schedule\ activity = 2{,}25 + \ 0{,}75 + 2{,}25 + 3{,}75 = 9$$

The CAD drawing activity:

$$Total\ hours\ CAD\ drawing\ activity = 6{,}67 + 3{,}33 + 6{,}67 = 16{,}67$$

The project's hours:

$$Total\ hours\ PD - activities = 9 + 16{,}67 = 25{,}67$$

Finally the percentage of a full time job that this project will demand in resources during its duration time is calculated with equation (6):

$$Percentage\ of\ work\ required = \frac{25{,}67}{160} = 0{,}160 = 16\ \%$$

This example project would require 16 % of an LPM's work time during the 4 week in which the project will run.

6. ANALYSIS

This chapter analyses the current practise at DT and evaluates how palpable the model will be for DT by comparing with the theoretical framework earlier described. Characteristics of both potential improvements as well as accuracy of the model are brought up.

6.1 The current process of project estimation

The current processes at DT described in chapter 4 will here be compared to theory, and the reader will gain a better understanding of the benefits of creating a model.

6.1.1 Project delegation

The department of DT clearly possess an applicable process of how to handle product development projects. The procedure of how to delegate the projects between the LPMs is however still unstructured and dependable of the PEMs who mainly make decisions of that kind. A main vision of DT, and Scania, is to implement a more standardised approach to all the operations. According to Gould (1998) conducting processes within an organisation to improve performance based on experience will enhance the organisational learning. Pinto (2013) list success factors identified in successful projects. Two of these success factors are structured work methods, and updated project plans, which consequently lead to met objectives. By gathering knowledge from experienced LPM's in order to function as a foundation for a model, which will assist PEMs, the researchers can expect the model as a factor to successful projects.

The current process when the PEMs provide the LPMs with new projects is based on poorly supported estimates of how much time the project will require by the LPM. This process differs between different projects, and is also depending on who is delegating the project. The work method of delegating new projects to LPMs is, as stated, not structured, which is proven by the LPMs working overtime due to a too high work load. Creating a standardised and structured way of delegating projects at DT should result in a more accurate estimation of future work load, and consequently result in a more even work load for the LPMs and less overtime.

6.1.2 Work breakdown structure

DT can be assessed to partially fulfil the three steps presented by Demuelemeester and Herroelen's (2002) of planning, scheduling and controlling. The PD-process listed activities of the project and also put them in the order in which they should be executed. The order in which the activities should be executed is however not always followed according to the LPMs, which leads to disagreements of what to do and when. Further, the activities have on DT shown to be out-dated and needs to get reviewed so that everyone agree on what activities should be conducted. Controlling the activities, which according to Demuelemeester and Herroelen's (2002) implies to identify the difference between the planning and actual performance, is not a current procedure at DT, thus the chance to reach performance, cost, and time objectives is reduced. The LPMs does however continuously work with updating the process and its standards every week, unfortunately this process is slow and should probably have more focus if DT want to improve on the outcomes of a structured process described by Demuelemeester and Herroelen (2002).

6.1.3 Knowledge management

Today the clients, and in some cases together with the LPMs, are making estimations regarding the needed resources based on experience, their own knowledge, from earlier projects. However, the expert judgement method can be uncertain if the person making the judgement is not the person being biased by the prediction (Roy & Christenfeld, 2007). At DT the clients make the judgements about how much time a LPM have to spend on a new project, which mean that the client is not directly affected by the judgement. However, indirect a very wrong judgement regarding the time will bias the client, since if a project overrun the estimated time so much that other projects are affected the client have to relocate resources, or ask for more resources. The fact that the LPM is the person affected foremost from the judgement, will with the argument from Roy and Christenfeld (2007) implicate that the LPM is a suitable expert, if that person possess the required knowledge, to help make the expert judgement alongside with the clients. As knowledgeable persons have been wanted by the researchers during the study, the expert knowledge about the work the LPM conduct have been collected through several interviews with each of the accessible LPMs. At DT, as mentioned above, the LPM sometime assists the clients when estimating a new project's time consumption of the LPMs' workload, which is preferable with the recent stated argument. By compiling the knowledge of the LPMs and the clients into a model, the intention is to utilise everyone's knowledge at the same time.

The conducted interviews would have been unnecessary if the interviewees did not possess the necessary knowledge required from the researchers in order for them to construct the model. Therefore it is important to interview the right people, and have access to them. The persons that the researches have interviewed have all had more than two years of experience in the project management field within DT, something that was proven to have given them a good insight in the work. Some forecasting models are based completely on experts' knowledge, more information can be found in chapter 2, section 2.4 Estimation approaches. According to Jorgensen and Shepperd (2007) expert judgement is the most common forecasting model used in the software industry, something that has been proven to be the case at DT as well.

The knowledge the clients and the LPMs have reached during their earlier experiences and during their period as PEMs and LPMs will go lost, due to the lack of documentation, when they decide to move on with their careers and are replaced by new individuals. Rad and Anantanula (2005) and Gould (1998) express the significance with organisational learning, which is to maintain and improve performance based on experiences. Adopting this philosophy of organisational learning would result in that the knowledge the PEMs and LPMs possesses will stay on an organisational level even if they are replaced. The process of getting individual learning to organisational learning should be clearly understood by the organisation of DT to make it consistent with its own vision of enhanced standardisation, and to consequently keep up with prevailing competition in the current business environment, a theory presented by (Rad & Anantanula, 2005). At present time, DT has no structured, or unstructured, way of containing and sharing the expert knowledge these people posses regarding this subject. The constructed model is a first attempt to contain this knowledge and share it within the organisation.

6.2 The model

The method of how the model was chosen was described in chapter 3.3 Research method and data collection, and the resulting model arrived by the researchers was described in chapter 5. Results. This section will further analyse the implication of the model in terms of relevant theory.

6.2.1Model deficiencies

The construction of the model contained constrains in making the model more accurate. Three deficiencies were observed, lack of documentation, inaccurate time scope estimations, and changed directives, whose significations will be presented in this section.

6.2.1.1 Lack of documentation regarding historical project effort data

The lack of structured, or even at all, documented closed projects have been an obstacle when constructing the model. Both the regression model, described by Jorgensen (2007) in section *2.4.1 Regression*, and the Analogy estimation approaches described by (Hill, Thomas & Allen, 2000) chapter 2, section *2.4.3 Analogy*, are based on previous data, which require documentation to access the information in the future. The case-based reasoning described in chapter 2, section *2.4.4 Case-based reasoning*, also have its foundation in previous, similar, projects, which require some documentation of old projects. Since the researchers have not been able to review documentation of old projects, the model have been based solely on estimation made by experts at DT. This has made it difficult to test and confirm the accuracy of the model, since there is no data to compare the model's output with. Documentation would not only have helped the researchers in testing the model, but would also have provided some comfort and help to the interviewees as they were to answer questions about time limits and activities. Since historical data is an essential part in many forecasting models, and will help the LPM have control over how much time they spend in different projects, it would definitely be preferable to start documenting time spent in the projects. If proper documentation was introduced and correctly performed, the model constructed in this thesis, would be much easier to revise and update with actual time limits, hence the model's output would be more accurate than it is today.

Hill, Thomas and Allen (2000) and Chen, Liu and Li (2010) both discuss that when there are poorly or no documentation of earlier projects it is difficult to make accurate forecasts. When forecasting it is desired to compare actuals with earlier made estimation in order to draw conclusions on which the forecast later is based on. At DT the fact that historical data holds very little, or as in most cases, non existing information regarding closed projects have made it difficult for the clients and the LPMs to remember, and control their memories from earlier projects when asked for estimations regarding time scopes. The LPMs have all estimated earlier time spent in activities, but without being able to compare their memories with previously executed activities the estimations have less accuracy than they would have together with documentation of historical actuals. Therefore the model would have been more accurate with available documentation of historical data.

6.2.1.2 Inaccurate time variance estimations

Using expert judgement data as a main input may in addition to the positive effects, mentioned later in the analysis, also imply difficulties that should be taken into consideration. Buehler and Griffin (2003) explain that when estimating time scopes for future prediction it is possible that the prediction will be based on faulty memories from earlier completion times. The PD-process is not yet a standardised process, in that manner that it does not have written standards to all of its included activities, which sometimes cause confusion regarding the meaning of an activity. During the interviews the interviewees has described different sub activities in some of the activities in the PD-process, and a consequent of this is that the interviewees have estimated differently when it comes to the time it takes to perform these activities. If written standards had existed for these activities the time estimations made about the activities by the LPMs should have been more alike. However, the lack of standards has resulted in the interviewees performing different sub activities and therefore remembering different times for the same activity.

In addition to estimating time variances differently due to the lack of standards, the interviewees also prioritise differently both between different activities as well as to what extend they perform the activities. Parmenter (2010) express the importance of being able to make the right prioritisations in order to be a successful project manager. Knowing what is expected will make it easier to prioritise right. When there is a lack of standards for activities, it enhances the difficulty in making a prioritisation, since the intended outcome of the activity is unclear. Maylor (2010) discuss the matter, and also express the importance of knowing what to prioritise, this in order to satisfy as many stakeholders as possible. If one does not know what is expected, knowing what is the most important expectation and therefore should be prioritised is very difficult. Today the LPMs prioritise differently between the activities as a result of not knowing exactly what the intended outcome of the activities are, and this is consequently shown in the different times the LPMs have estimated it takes to perform different activities. Therefore it would be beneficial to have written standards to all activities, which is something DT is continuously working on achieving.

In addition to the diversity in prioritisation between the LPMs just presented, Mumpower and Stewart (1996) explain four different conditions prior the judgements that makes them differentiate between the respondents. The possibility of the respondents making judgements about earlier experiences when the experiences holds error or missing, can make the judgement process ambiguous. Also the fact that respondents may misdiagnose the quality of their own judgements, or that the respondents happen to come to the same judgement but base them on different information, may possibly affect the responses from the LPMs at DT.

When the researchers conducted interviews with the LPMs the responses differed between them as mentioned earlier. The principal-agent issue by Eisenhardt (1989) can be one unconscious cause of that difference. The LPMs are aware of that their responses will act as a basis for a research with the aim of getting a more structured process to work within, and to set time scopes on the activities within their daily work. Somehow this awareness, whether what scenarios the time scopes may induce, can influence the LPMs way of act in response, in situations described by Eisenhardt (1989). Depending on the desire of the LPM the responses of time scopes may therefore vary.

To conclude, different time variance estimations have been done, with several different explanations. However, the fact that the estimations differ will be shown in the model since the researchers have used a mean of the stated estimations.

6.2.1.3 Changed directives

The projects running at DT are sub projects to bigger projects at Scania, the hierarchical structure can be seen in figure 2. This fact means that the projects running at DT often gets affected by changing directives from a central part of Scania. Unfortunately this is impossible to overcome since companies continuously faces changes from the society, government, and customers, which requires strategic decisions. Ramgopal (2003) describes two types of risks, down-side and up-side risks, where the down-side risk can be seen as a threat. Further they state that the down-side risk is the one most managers focus on. This is positive since it might give the LPM an early warning that something is about to happen, and thereby prepare them for some uncertainties.

However, De Meyer et al (2002) discuss four areas of uncertainty management, where one is managing unforeseen uncertainties. As the new and changed directives coming from a central part of Scania, and cannot be predicted it is very difficult for the LPM to plan for these changes, even if they are trying to manage them by being aware that they might happen, according to the theory presented by Ramgopal (2003). When the changes coming from a central part of Scania are major changes, the changes can be compared to the chaos described by De Meyer et al (2002). These changes can, as the describes state chaos, completely change the projects objectives, time plan, or budget. When this happens, the outcome of the project will change, or at least the prerequisites for meeting the original intended outcome. This will denote in that the first forecast made by the model in an early stage of the project will be inaccurate, and the forecast will have to be done once again with the new prerequisites.

6.2.2 Model consistency

Although deficiencies are mentioned in the section above the model is still regarded as consistent and useful according to theory, which are evaluated in the sections below.

6.2.2.1 The utilisation of expert judgement

Since there was lack of historical data available when constructing the model, the researchers used data from the expertise of the LPMs that according to Morgenshtern (2006) will enhance the estimation accuracy. Since expert judgement according to Jorgensen and Shepperd (2007) is the most common used approach within the software industry, it should in this model construction work nearly as good since the respondents in this research are hold knowledge from experiences in combination with earlier project executions concerning to put time estimates on the activities in the projects. By the researchers to continuously interact with the LPM's and capture their valuable knowledge, it contributes to a more efficient and successful research and make it an indispensible resource, according to Al-Tabtabai (1997).

6.2.2.2 The utilisation of existing WBS

The fact that DT works according to the PD-process, and that the process divide the project into sub-activities, makes it according to Raz & Globerson (1998) easier to create scenarios of how long the project might take. Having the project structure already broken down into distinct activities, the PD-process, is a so-called Work Breakdown Structure, thus improve the time estimations of the activities, and thereby reduce the errors in the model constructed by the researchers.

6.2.2.3 Engaging use of the model

The transparent characteristics of the model constructed, with influence of the constructive cost model, COCOMO, indicates that the user whenever are able to see what happens in each step and understand the impact of the different variables that affect the project, as described by (Glinz & Mukhija, 2002). Users as well as involved members can follow the procedure of using the model, which enables them to understand the effect of the factors and also act and discuss around what it implies for the estimation. This goes in line with the continuous understanding of their processes that the clients wish to obtain in establishing a forecasting model at DT, and to further be able to develop the model in the future.

6.2.2.4 Support from top management

The fact that the managers are the ones who allocates the resources for all projects (Pinto, 2013, Maylor, 2010) means that having the support of managers are crucial for any project. When managers assure that a project have access to both the right people, and more importantly, to their time the project will have a fair chance of succeeding (Pinto, 2013). This master thesis, the constructing of a forecasting model, has its foundation in data collection from interviews. Interviews are time consuming, which made it important to have the support of the managers, in this case, the PEMs, whom are the clients, in order for them to allow the researchers to occupy the needed time from the LPMs to attain the needed data. The time to interview interesting employees has been provided from the clients. The fact that the researchers have had the opportunity to do as many interviews as they have had certainly had a positive impact of the accuracy of the constructed model. However, as in many cases, more time with the interviewees would have been beneficial for the researchers, a trade-off between time and accuracy of the forecasting model was made.

7. DISCUSSION

This chapter discuss important considerations of the findings as well as the model constructed previously, and answers the second and the fourth research questions, RQ2 and RQ4. The limitations of the study and prerequisites for future constructions of forecasting models are also addressed. In addition to this, it discusses how the contribution of this study can be of relevance for other parties than of Scania.

7.1 Peoples' diverse perceptions

One interesting thing noticed while conducting the interviews is that on one hand the LPMs have similar opinions about which factors they have discussed, but on the other hand they have separated opinions regarding the factors' meaning, especially one factor, *The Person,* that will be further discussed below.

Factors such as *Number of Parts*, *Technical Novelty*, and *Number of Affected Areas*, each of the interviewees agreed on and described in the same way. Other factors such as *New Equipment* and *Similar Parts* only some of the interviewees did mention, however all of the interviewees have agreed on them when introduced for, sometime after some explanation and discussion, but nevertheless agreed on.

The factor *New Directives* has also been one of the factors mentioned by many, but with contradictory explanations concerning whether extent it affects them. The discussion returned to the fact of the relationship between the LPM and the project manager from YP. If the relationship was comprehended as a good one including regular communication, the interviewee seldom had any problems with the factor and the LPM was therefore prepared for upcoming changes. As in opposite cases when the relationship was not as good, changes came unpredictably, which resulted in more work for the LPM. What the researchers found to be an interesting aspect is that the new directives perceived by one depends on the individuals in that relationship, which is related to the factor most distinguished from the LPM's, *The Person*.

The Person is the factor that all of the interviewees mentioned, but had very different opinions regarding its significance. The experience a person possesses was important and separated them from each other. However, the interviewees had very different perceptions regarding how the different level of experience affected them. *The Person* confirmed that people think very differently regarding what is important and efficient and how it affects the time spent on activities. It confirms the fact that all people are different, acting, thinking, and behave in different ways even when situated in the same situation within the same qualifications. One way or another can be preferable, but claim that one way is always the correct way will not hold true, as everyone have different definition of what is correct.

To conclude this, the fact that all people work differently due to that everyone is unique, makes the factors that affect each of the LPM's when being compiled into a common view, resulting in a more general model less accurate that however will satisfy a wider user base.

Since the model is based on activities performed by humans, which we just concluded, that act and prioritise differently, the time estimated by the model will never be fully accurate for all people intended to work according to the outcome of the model, since the model is depending of the performance of the individuals.

7.2 Beneficial prerequisites when constructing a forecast model

There are many prerequisites that are beneficial when constructing a forecasting model, the researchers will now present the ones found most beneficial during this study.

Knowing what the client is seeking to forecast, and what type of outcome is expected is essential in order to find a suitable method to create a model, which will provide the right type of outcome. Having a clear goal towards the desired outcome is important, but knowing when the outcome is “good enough” according to the client is just as important. A forecasting model is just a method to make somewhat qualified guesses with some kind of data as a basis, in this study the data has been defined by experts’ knowledge, and having a clear goal to when the guess is considered “good enough” is important when collecting data. If the “good enough” limit is not clear the data collection can go on for a very long time, since the more data you use as a basis should provide a more precise and accurate guess. Having recurring meetings with the client in order to both update the client on the progression as well as to assure that the purpose is the same as defined in the beginning is also beneficial, and should prevent an unsatisfied client and confused researchers, consultants or employees, depending on who is constructing the forecasting model. Therefore, having a clear and well defined purpose has been considered very important throughout the data collection and construction of this model, as well as keeping all involved parties updated on the progression.

A crucial prerequisite when constructing a forecasting model is knowing what type of forecasting model that will be used. Conducting in-depth literature studies regarding different forecasting models is important to gain knowledge about existing ones, and thereby gaining knowledge regarding what type of data each forecasting type will need. The data available will probably not change much during the time in which the forecasting model is constructed, and it is therefore beneficial to know what type of data that is accessible. Knowing this will be crucial when determining which forecasting type to use since forecasting models are based upon different type of data. For example, choosing a forecasting model using regression will demand access to historical data, hence available historical data must exist in order to utilise a regression model.

Creating a forecasting model from scratch is a very time consuming process, and consequently an expensive process. Identifying and utilising existing processes on which the forecast can have its foundation is also beneficial when collecting data and later constructing a forecasting model. During this study it has proven to be very useful to have a process to use as a foundation. If no clear process exists the researchers would have to as an initial phase create a process on which the model could have its foundation, something that would be very time consuming, and sine the process of constructing a forecasting model is time consuming in itself it is definitely desired to identify an existing process. An existing work process will assist both the ones constructing the model as well as interviewees.

Finally, the support of top management is essential when constructing a forecasting model. As stated above, creating a forecasting model from scratch demands many and much resources, and top management allocate resources. Having the ability to discuss and elaborate ideas with management has also been proven beneficial during this study since management often consist of very knowledgeable persons who can provide both pointers and data. Another important aspect of having the support of top management is that the management are the ones making the final decision on which tools to utilise within the organisation. Therefore, assuring top management and keeping them updated about the progress will provide them with information regarding the benefits with the constructed model, which consequently should make the management eager to implement and use the constructed model.

7.3 The presence of trade-off

Making a more or less bold reasoning, one can imagine the PEMs as resource allocators whose interest is to man project development projects and plan their resources, LPMs, as efficiently as possible to facilitate their own work in order to satisfy other involved members in a more central part of Scania. The PEMs goal could be to enhance the predictability by confide in a forecasting model. The LPMs on the other hand can be seen as resources having a mission of implementing product development projects at DT on time, within budget and according to pre-set specifications. Bearing in mind that projects are of uncertain nature and often unpredictable one can envision that a project manager needs to be adaptable to bring in impulsive actions outside an ordinary process to achieve those goals. To conclude this bold reasoning, assuming that the PEMs can be seen as resource allocators requiring predictability, while the LPMs can be seen as the resource are striving for adaptability, it can indicate on a conflict of interest, a so called trade-off.

However, as the researchers have noticed during the study is that the PEMs and the LPMs seem to have a tight collaboration with a common vision dealing with product development projects. They do not solely request the model to facilitate the work of the PEMs, but instead to be utilised both as a tool to support the PEMs in the work of allocating resources, as well as raising infrequent occurrences to the surface that do not follow the normal process, to continuously improve the daily work.

The study of theoretical frameworks in this thesis indicates that present research is teeming with all kinds of forecasting models able to, more or less, get established in business organisations. The, what it may seem, simplicity of adopting a model may according to the researchers delude practitioners. The accuracy of forecasting models depends on how specific the model is constructed towards the area of use and of the available resources. Using a general model suitable for more users may reduce the accuracy, simultaneously as a model constructed for a specific area of use will not be directly applicable by other practitioners.

The model will act as a tool to help Scania to predict the future, and the tool is based on factors and time variances identified by the LPMs. Since the identifications by the LPMs sometimes contained diverse views, the definitive selection of factors and time variances were by the researchers decided out of an appropriate reasoning of the average responds, thus the estimates will contain inaccuracy. In the current situation at Scania it was not enough judgemental knowledge to, for example, weight the predictor variables according to COCOMO. However it was considered, by using expert judgement in combination with fundamentals of other forecasting models, and in line with the grounded theory (Bryman & Bell, 2011), that the observations of the LPMs would stand as the knowledge used to construct the model specific for the department under study, as required by the company.

A trade-off should be recognised by each involved party, together with the purpose of the decision, to keep awareness of possible future situations, and to find a level of compromise. The researchers believe that trade-offs in many cases can be beneficial for an organisation in obtaining insight of its processes and for future development.

Trade-offs will continue to exist every now and then within projects as well as in organisations, and two illustrative example of this can be drawn from the making of the model in this thesis. In these two cases the trade-off between time and accuracy was present.

First, one can theoretically construct a model with the vision of being the most accurate model of them all, however it comes at a price, which in the case of this study has been the availability of time. Demanding one thing always comes at the expense of another. To construct a model, as illustrated in figure 7 as the first and second phase, under a more limited amount of time will hence lower the accuracy, and would it be more time for the researchers to utilise in those phases, the model could be elaborated further to practically get more accurate. However, the improvement loop can still be used in order to get the model more accurate, which are further elaborated in the section below.

Secondly, pushing aside the aspect of the researchers' time in making the model, the time spent by the users also affect the accuracy. This phase is illustrated as the third phase in figure 7. In order to utilise the model, the user is required to decide what ten factor categories are relevant for the project at hand, which is a relatively fast execution and makes the third phase in figure 7 shorter. Demanding a more accurate model, the time spent by the user in phase three would probably increase. Incumbent more advanced forecasting models often require more parameters as input. The process to actually use the model is far more complex, more information and decisions need to be interpret, thus the user must dedicate more time each occasion using the model, as well as improve the model further in phase four.

Bearing this trade-off in mind, the researchers assessed a reasonable level concerning the accuracy of the model contra the time, both available for the researchers as well as the users, in compliance with the client to attain satisfaction from both.

7.4 Other areas of practice

Despite the statement mentioned in the chapter of Research Method that the model in this thesis is constructed for the DT department of Scania in particular, and adapted to fit its prevailing processes and condition, the researchers believe that other departments on Scania or other companies do request forecasting models of similar nature and possess similar prerequisites. Therefore, in case when others review the model construction with the purpose of potential use, the researchers would recommend the model to a target group with certain type of requirements. Departments and companies that do not emphasize excessively on model accuracy but instead require a more structured working approach on a relatively short definite amount of time, can exert this model construction as a first tool towards a more structured way to, for example, review existing resource base of project managers and allocate them to projects. Thereafter the practitioners can enhance the accuracy of the model when they understand what prerequisites are essential in order to continue collect accurate data.

As a practitioner, the researchers recommend one to bear in mind that the trade-offs mentioned earlier are present with each decision. A constrained availability of time in a company may challenge the model accuracy, an increased predictability for resource allocators can result in a reduced adaptability for the resources, and a model constructed for a specific department will not be directly applicable by other practitioners in other areas.

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Appendix A

Information regarding the interviewees.

Interview	Position	Interview Questionnaire	Type of Interview	Work Location of the Interviewee
1	Process developer	1	Unstructured	DT
2	Production engineer manager	2	Semi-structured	DT
3	Local project manager	3	Semi-structured	DT
4	Local project manager	3	Semi-structured	DT
5	Production engineer manager	4	Semi-structured	DT
6	Production engineer manager	4	Semi-structured	DT
7	Local project manager	3	Semi-structured	DT
8	Local project manager	3	Semi-structured	DT
9	Local project manager	3	Semi-structured	DT
10	Local project manager	3	Semi-structured	DT
11	Local project manager	3	Semi-structured	DT
12	Local project manager	5	Semi-structured	DT
13	Process developer	6	Semi-structured	DT
14	Local project manager	5	Semi-structured	DT
15	Local project manager	5	Semi-structured	DT
16	Project manager	7	Semi-structured	R&D/YP
17	Local project manager	5	Semi-structured	DT
18	Project manager	7	Semi-structured	R&D/YP
19	Local project manager	5	Semi-structured	DT
20	Local project manager	5	Semi-structured	DT
21	Local project manager	5	Semi-structured	DT
22	Object manager	8	Semi-structured	R&D

23	Object manager	8	Semi-structured	R&D
24	Senior Development Engineer/Service	9	Unstructured	Service

Appendix B

Information regarding the observations.

Observation	Position
1	Local project manager
2	Local project manager
3	Local project manager
4	Local project manager
5	Local project manager

Appendix C

Information regarding the focus groups.

Focus group	Involved Persons	Position
1	A,B,C	A,B,C,D,E,F are Local project managers
2	D,E,F,G	G are a production engineer manager
3	D,E,F	
4	A,B	

Appendix D

Questionnaire 1

Intervjufrågor till processutvecklaren

1. Kan du beskriva hur arbetet med PD-processen startade?
2. Kan du beskriva PD-processen, dessa användning och syfte?

Translation

1. Could you describe the initial phases of constructing the PD-process?
2. Can you describe the PD-process, its areas of use, and its purpose?

Appendix E

Questionnaire 2

Intervjufrågor AD in i grön pil

1. Vad i ADt är det du kollar på först när du ska bestämma en projektledare till projektet?
2. Skiljer det sig ofta hur mycket info ni får i ADt?
    a. Vad är det som skiljer sig åt dem emellan?
3. Är du med och skriver ADt i de fall då du är med ända från gul pil?
4. Vad önskar du att du hade mer information om i ADt?
5. Brukar du prata med någon annan när du kollar igenom detta och ska ta beslut om vilken projektledare som ska ta projektet?
    a. Vilken typ av input brukar den personen komma med?
6. Letar du ofta efter mer data på annat håll än enbart det som finns i ADt när du bestämmer vem som ska bli projektledare?
7. Vad är det du baserar dina timestimeringar på?
    a. Erfarenhet eller bara ren gissning?
    b. Hur ofta gissar du rätt? Och hur ofta måste du/projektledaren planera för mer eller mindre tid?
8. Är det projektledaren som sedan bestämmer hur mycket tid hen väljer att sätta på ett projekt, eller är du med och bestämmer det?
    a. Typ sätter stopp för hur mycket hen får lägga i fortsättningen eller säger till att öka timmarna.
9. De gånger det ändras, är det de gånger LPL själva har satt sin arbetstid eller är det när du har satt det? Och om det är när LPL har satt det, blir det ofta ändrat till vad du estimerade från början?

Translation

1. What is the first thing you check in the AD when you are to choose a LPM for the new project?
2. Does the information in the AD's often differ?
    a. What is it that differs?
3. Do you help to write the AD in the projects where you are already involved in the project from the yellow arrow?
4. What information do you think is missing in the AD?
5. Do you normally consult someone else before assigning a new project to a LPM?
    a. What type of input does that person/s normally bring?
6. Do you normally search for more information than the one provided by the AD before you assign a LPM a new project?
7. What do you base your time estimations on?
    a. How often are your estimations correct?
8. Is it the LPM personally that decides how much time he or she wants to spend in a project?
    a. If so, do you sometime disagree?

9. The times when the estimation for a project proves to be wrongly estimated, is it normally you or the LPM who did the estimation?
    a. If it was the LPM, are the actuals then more alike what you estimated or not?

Appendix F

Questionnaire 3

Intervjufrågor till första intervjun

1. Hur länge har du jobbat som en projektledare?
    a. Har du bara jobbat på Scania som det, eller på något annat företag?
    b. Har du jobbar på någon annan avdelning på Scania som projektledare?
    c. Hur många projekt har du haft under din karriär som projektledare?
        i. Har alla projekt varit av samma typ?
2. Hur många projekt har du fullföljt?
    a. Varit med från start till slut?
    b. Endast varit med och startat projektet med inte avslutat det?
    c. Kommit in efter att ett projekt har påbörjats och avslutat det?
    d. När är det vanligast att du kommer in i ett projekt?
3. Vilka projekt har du hand om? Förklara gärna lite kort vad de handlar om.
4. Vad har du för fasta grejer du ska göra varje vecka som är projektoberoende?
5. Vilka ”fasta” möten/rutiner/arbetsbördor är desamma för varje projekt?
6. Har du några möten/aktiviteter som endast sker för vissa projekt?
    a. Är dessa återkommande i dessa projekt?
    b. Vilka projekt har såna här aktiviteter?
    c. Varför hålls dessa möten?
7. Hur går det till när du får ett nytt projekt tilldelat dig?
8. Skulle du känna att du kan klassificera projekt? (T.ex. stora, mellan, små el. ny produkt, uppdatering osv.)
9. Vad anser du är största orsaken till att din arbetsbörda i ett projekt blir förändrad?
10. Finns det gånger då projekt ökar mycket, men ditt jobb inte påverkas så mycket? Och tvärtom?
    a. Är det speciella typer av projekt som detta händer i?
11. Hur ofta jobbar ni över?
    a. Varför får ni jobba över?
    b. Märker ni att det är vissa projekt som gör att ni behöver jobba över?
        i. Vad är det i dem som då gör att ni måste jobba över?
12. Skulle du kunna klara av att ha fler projekt än vad du har idag?
    a. (Om ja): Varför har du inte full beläggning?
        i. Ditt beslut eller Christer/Magnus beslut?
13. Har du fler projekt idag än vad du känner att du borde ha?
    a. Varför har du det?
    b. Ditt beslut eller Christer/Magnus beslut?
14. Kan du se skillnad på hur mycket tid samma typ av jobb tar för olika projektledare? (inga namn behövs, vi är ej ute efter att sätta dit folk utan vi vill veta om det är skillnad på erfarenhet, kön, ålder eller vad det nu skulle kunna vara)
    a. Varför tror du att det tar så olika lång tid för olika personer?
15. Hur dokumenterar du ett färdigt projekt?

   a. Är detta en process som fortlöper under hela projektet, eller är det något som sammanställs i slutet av projektet?

Translation

1. For how long have you been working as a project manager?
   a. Have you been working at other companies than Scania as a project manager?
   b. Have you been working as a project manager in a different department at Scania?
   c. How many projects have you managed during your career?
      i. Have all the projects been of the same type?
2. How many projects have you completed during your career?
   a. How many projects have you started up but not closed?
   b. How many projects have you closed but not started up?
   c. What have been the most common phase of the projects that they have been assigned to you in?
3. Which projects are you responsible for today? Explain briefly.
4. What activities are set for each week that you as a project manager have to perform that are directly related to a project?
5. Which activities/meetings are the same for all projects?
6. Do you have any activities/meeting that are set for some projects but does not occur in others?
   a. Which projects have these activities/meetings?
   b. Why do you have these activities/meetings?
7. What is the procedure when you are assigned a new project?
8. Do you think you can classify projects according to small, medium and large projects?
9. What do you think is the most common reason for a change in work load in a project?
10. Are there times when the project get bigger but it doesn't affect your work load? And the opposite situation?
    a. What type of projects do this happen in?
11. How often do you work overtime?
    a. Why do you have to work overtime?
    b. Are there specific projects that demands the overtime?
       i. What is it in the projects that demands that you work overtime?
12. Could you manage more projects than the ones you already have today?
    a. Yes: Why do you not have a full work load planned for you?
       i. Is this your decision or is it your group leaders'?
13. Do you have more projects assigned to you today than you feel you can manage?
    a. Yes: Why do you have that?
    b. Your decision or the group leaders?
14. Can you see any difference in how much time the project managers at DT spend on the same type of activity?
    a. Why do you think it takes different amount of working hours for different persons?
15. How do you document a closed project?

a. Is this a process that is present during the entire project or is it just compiled at the end of the project?

Appendix G

Questionnaire 4

Intervjufrågor till första intervjun med Magnus och Christer

Stort projekt = Scanias projekt, projektet = DTs del av det stora projektet

1. Hur länge har du haft din position här på DT?
2. Vad jobbade du med innan du började jobba med det här?
   a. Har du någon gång arbetat som projektledare själv?
3. Är den modell som du och Magnus/Christer visade oss uppdaterad?
   a. Är dem individuella mötena med varje projektledare medräknade i er modell som ni började med?
   b. Hur ofta har ni dessa möten?
4. Berätta om processen när det kommer ett nytt projekt till dig?
   a. Vem får du projektet av?
5. När du får ett nytt projekt, som ska delges en projektledare, vilken information får du då av YP(?) ?
   a. Får du någon annan information utöver den du precis sa?
   b. Vilken information av den du har fått använder du dig av när du estimerar beläggningen för projektledaren?
6. Brukar du ofta försöka föreställa dig hur projektet kommer se ut i framtiden för att på så sätt estimera tidsåtgången? Ifall projektet troligtvis kommer ha mycket osäkerhet, andra risker eller att det är relativt klart hur projektet kommer utspela sig, etc.?
   a. Vad är det du brukar basera dessa ”föreställningar” på?
7. När du får AD och ska dela ut projektet till en projektledare, brukar du enbart estimera hur stort projektet blir för DT eller brukar du även försöka estimera enbart projektledarens beläggning i projektet?
8. Hur många projekt har du fått lämna över till en projektledare under din tid här?
9. Tycker du att du är bra på att estimera tiden som det är idag?
   a. (om nej): Vad är det som brister tycker du?
      i. Vilken information är det du tycker att du saknar?
   b. (om ja): Vad är dets om gör dina estimeringar bra?
10. Vilka projekt tycker du är svårast att estimera för?
    a. Varför är dessa svåra?
11. Hur skulle det kunna bli lättare att estimera dem?
12. Hur kategoriserar du projekten? (Jag antar att du måste göra något typ av kvalificerad bedömning på om detta kommer bli ett stort eller ett mindre projekt ur LPL synvinkel för att kunna bestämma vem som har tid för det nya projektet)
13. Vad anser du vara ett stort/litet projekt?
    a. Vilken information i AD tyder på ett stort/litet projekt?
14. Använder du dig idag av olika metoder för att försöka bena ut osäkerheter? T.ex. WBS, TBS, Critical Chain method, Risk Management.
    a. (om nej): Varför inte?
    b. (om ja): Vilken/vilka brukar du använda?
       i. Tycker du att den/dem hjälper?

15. Ser du någon skillnad i hur du och din kollega estimerar tid?
    a. Varför tror du att ni tänker olika? Grundorsaken? (Inte bara att ni tänker olika)
    b. Är det i alla projekt ni estimerar olika, eller kan du se att det är i vissa typer av projekt?
    c. Tar ni hjälp av varandra ibland?
        i. (om ja): Hur ofta?
            1. I vilka typer av projekt brukar detta vara?
        ii. (Om nej): Varför inte?
16. Tar du hänsyn till hur duktig/effetkiv/erfaren en LPL är när du delger den ett projekt?
17. Är det någon gång du har sett att det har blivit för mycket jobb för en LPL och då tagit bort projekt från hen?
    a. (om ja): Var det något du hade förutspått skulle ske eller blev du förvånad?
    b. Vad var det med projektet/en som gjorde att du visste att det skulle bli för mycket?
18. Brukar du ge någon hänvisning till LPL om hur mycket av dennes tid det nya projektet kommer/borde ta?
19. Är det projektledaren som sedan bestämmer hur mycket tid hen väljer att sätta på ett projekt, eller är du med och bestämmer det?
    a. Typ sätter stopp för hur mycket hen får lägga i fortsättningen eller säger till att öka timmarna.
20. Tenderar dina estimeringar över projektledarens beläggning att under- eller överskridas?
    a. Hur har det framgått?
21. De gånger det ändras, är det de gånger LPL själva har satt sin arbetstid eller är det när du har satt det?
    a. Och om det är när LPL har satt det, blir det ofta ändrat till vad du estimerade från början?
22. Kan du se att beläggningen på projektledaren följer storleken på det stora projektet om du bortser från hur stort projektet blir lokalt på DT?
23. Ser du att en projektledares beläggning ökar ”linjärt” med hur ett projekt ökar i omfattning hos DT?
    a. Baserar du dina estimeringar på enbart hur stort du tror projektet i helhet blir, eller tar du till hänsyn till hur stort projektet kommer att bli för projektledaren och inte projektet i sin helhet?
        i. Hur kan du veta att projektledarens beläggning kanske inte blir lika stor det stora projektet?
24. Har du någon gång gjort en utvärdering på just detta efter ett projekt? (Alltså frågat LPL om hur mycket tid detta har tagit av den personens tid för att på så sätt kunna underlätta för dig i framtiden eftersom du i såna fall kommer ha fått veta om du gjort en bra estimering)
25. Är det du eller projektledaren som tar beslut om när det blir en vit plupp i PD-processen?
    a. När tas det beslutet?

Translation

1. How long have you had your position at DT?
2. Where did you work before you started here?
    a. Have you ever worked as a project manager?
3. Is the model with estimated times you showed us before up to date?
    a. Are the individual meetings with all project managers accounted for in your estimations?
    b. How often do you have these meetings?
4. What does the process look like when a new project is assigned DT?
    a. Who assign the project to DT?
5. What information do you get from YP (?) when you are about to delegate a new project to a project manager?
    a. Do you receive any other information apart from the one you just explained?
    b. What information do you use when you make the time estimations for a new project?
6. Do you normally imagine how big the project will become in the future? The amount of uncertainties it contains?
    a. What do you base the imagination on?
7. When you receive the AD and are about to estimate the time the project will demand, do you only estimate the time for the entire project or do you also estimate the time the LPM will spend in the project?
8. How many projects have you assigned to LPMs during your current job position?
9. Do you think you are good at estimating time?
    a. No: Why not?
        i. What information do you think you lack?
    b. Yes: What makes your estimations good?
10. Which projects are the most difficult to estimate the time for?
    a. Why are these difficult?
11. How could one make it easier to estimate the time for these projects?
12. How do you categorise the projects? (small, medium, large)
13. What do you think define a small/large project?
    a. What information in the AD implies this?
14. Do you use any known methods to handle uncertainties?
    a. No: Why not?
    b. Yes: Which one do you use?
        i. Do you think they help?
15. Do you see any difference in the way you and your colleague estimate time in the same way?
    a. Yes: Why do you think it differs between the two of you?
    b. Do you make different estimations in all types of projects?
    c. Do you ask each other for help?
        i. Yes: How often?
            1. In what type of projects do you ask for help?
        ii. No: Why not?
16. Do you take the LPMs experience into consideration when you assign them a new project?
17. Have you during your time here noticed that a LPM had too high work load so that you had to assign one of their projects to someone else?
    a. Yes: were you surprised or did you see it coming?

   b. What was it in the project that made you realise it was/would become too big?
18. Do you normally give a indication to the LPM on how much time they should spend on a new project?
19. Is it the LPM who by its on decide how much time he or she should spend in the project?
    a. Do you ever tell them to prioritise something?
20. Do you see if your estimations tend to be too small or too big compared to actuals?
    a. How have you noticed this?
21. The times when the estimated time is not correct, is it in projects where you have estimated the time or where the LPM have done the estimation?
    a. If the LPM did the estimation, does the actuals often prove to be more alike your estimation?
22. Can you see any correlation between the size the project on DT have compared to the size of the same project at YP?
23. Does the LPMs work load increase linearly with how the work load at YP increases for the same project?
    a. Do you take the hole project into consideration when you estimate the time LPM have to spend in it or do you just estimate the time LPM spend and don't think of the others involved?
       i. How do you know if the LPMs work load is smaller or bigger than the project at YPs work load?
24. Have you ever evaluated the estimates against the actuals after a project has been closed?
25. Is it your decision or it is the LPMs' decision to make one of the activities in the PD-process a "white dot"?
    a. When is this decided?

Appendix H

Questionnaire 5
Intervjufrågor om PD-processen
Allmänt

1. Är alla punkter som står under projektledaren i PD-processen alltid med i alla projekt?
   a. Om nej: Varför inte?
      i. Är det ditt beslut att inte ta med dem?
      ii. Varför anses den punkten inte nödvändig?
2. Behöver du göra något i någon punkt som inte står på din rad? T.ex. göra någon punkt hos Logistiken.
   a. Är detta vanligt?
   b. Vad tar det i tid i såna fall?
3. Hur mycket nytt gör ni under konfigureringsfasen? Och hur mycket tas från ADt från gul pil?
4. Vad gör du i ett projekt utöver de punkter som står i PD-processen? T.ex. Projekt/objekt-möten.
   a. Hur ofta har du dessa?
   b. Hur mycket tid tar dem? Antingen i timmar totalt under ett projekt, eller timmar i månaden, eller timmar i veckan.
5. Finns det någon del av processen som du aldrig har jobbat med?

Specifikt för punkterna

1. Vad är arbetsuppgifterna i denna punkt?
2. Hur mycket tid lägger du på denna punkt?
   a. Är det olika för olika projekt?
   b. Vad är det som skiljer sig i tidsåtgång i punkten mellan projekten?
   c. Varför tror du att det skiljer sig mellan olika projekt?
3. Uppstår det ofta problem med denna punkten?
   a. Kan man förutse dessa problem eller är det olika varje gång?
4. Är denna punkt alltid med i alla projekt?
   a. Vilka är den inte med i?
   b. Kan du veta det från början eller är det något du märker under projektets gång?
5. Hur många gånger har du utfört denna punkt? (Alltså hur många projekt har du gjort den i)
6. Om denna punkt blir stor och tar lång tid, medför det då att en eller flera punkter längre fram också ändrar storlek?
7. Det du utför i denna punkten, i vilken byggnad utför du detta?

Translation
General

1. Are all activities presented in the PD-process, under the LPM's responsibility, always included in all projects?
   a. No: Why not?

    i. Is it your decision not to include them?
    ii. Why is the activity not considered important?

2. Do you ever perform an activity that is in the process, but not under your areas of responsibilities?
    a. Yes: Is this common?
    b. How much time do you spend on this?
3. How much do you do under the configuration part of the project? How much of this information is taken from the AD?
4. What activities do you perform in a project that is not stated in the PD-process?
    a. How often do you perform these other activities?
    b. How much time do you spend on these activities?
5. Is there any part of the process in which you have not been working?

Specific for the activities

1. What are the work tasks in this activity?
2. How much time do you spend in this activity?
    a. Does it differ between projects?
    b. What is that makes the time spent in the activity differ between projects?
    c. Why do you think it differs?
3. Does problems often occur while working in this activity?
    a. Is there any chance to predict these problems or are they different every time?
4. Is this activity always part of every project?
    a. No: In which projects does it not occur?
    b. Do you know from the start of the project that this activity won't be a part of the project?
5. How many times have you performed this activity? (in how many projects)
6. If this activity tend to be big and take a lot of time, does that imply that other activities also will be big?
7. The sub activities you perform in this activity, which of the Scania buildings do you perform them in?

Appendix I

Questionnaire 6

Frågor till processutvecklaren

1. Hur har PD-processen mottagits av DT, samt Scania?
2. Hur ofta uppdateras processen?
3. Hur går implementeringarna av processen på andra delar av Scania?

Translation

1. Was the process welcomed at DT, and at Scania?
2. How often is the process updated?
3. How have the implementations of the process been at Scania?

Appendix J

Questionnaire 7

Intervjufrågor till Projekt Ledare på YP

1. Hur många projekt har du idag?
2. Hur tidsplanerar planerar du projekt?
3. Hur tidplanerar du din egen arbetstid?
4. Vilka olika faktorer kan du se påverkar hur din planerade beläggning förändras?
5. Vad anser du utmärker små, mellan och stora projekt?
6. Hur använder ni ert tidsloggningsprogram?
    a. Vad är för- och nackdelarna med att ha det?

Translation

1. How many proejcts do you manage today?
2. How do you make the time plan for these?
3. How do you plan your own work hours?
4. Which factors does, in your opinion, change the original time plan?
5. What do you think define a small, medium and large project?
6. How do you use your program for documenting time?
    a. What are the pros and cons with using it?

Appendix K

Questionnaire 8

Intervjufrågor Objektledare:

1. Vad har du för projekt?
2. Vad anser du utgöra ett stort projekt?
3. Hur tänker du när du gör en tidsplan för ett projekt?
4. Hur planerar du din egna arbetstid?
5. Finns det standarder för hur många möten och hur ofta du ska ha möten med ditt objekt?
    a. Om ja: Följer du dem?
    b. Om nej: Hur tänker du när du planerar in möten?
6. Skiljer sig ditt arbetssätt från andra objektledare?
7. Har du olika många stående möten för olika projekt?
8. Dokumenterar du din arbetstid?
    a. Hur gör du detta?

Translation

1. Which project are you responsible for?
2. What in your opinion is a large project?
3. What do you take into consideration when you establish a time plan for a project?
4. How do you plan your own work hours?
5. Are there any standard (recommended) amount of meetings you should hold with your object?
    a. Yes: Do you follow these standards?
    b. No: How do you reason when you plan the meetings?
6. Is your work method different compared to other object managers?
7. Do you have a different number of set meetings for different projects?
8. Do you document your work hours?
    a. How do you document your time?

Appendix L

Questionnaire 9

Frågor till senior utvecklingsingenjör

1. Kan du berätta lite om ditt arbete?
2. Vilka verktyg använder ni för att beräkna tiderna på servicemarknaden?

Translation

1. Could you describe your work?
2. Which tools do you use in the service market to calculate the service times?