Process mapping and improvement in a Prototype Build Organization
- Enhancing process performance of material supply

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Preface

This Master Thesis was conducted during 2011/2012 and represents the final part of our master’s degree in Mechanical Engineering at Lund University, Faculty of Engineering. The thesis was initiated by Volvo Bus Corporation in order to get a third party view and a fresh set of eyes to conduct a review of their organization for Prototype Build and Test and to map and improve their core process material supply. Process management, process orientation and process improvements are starting to get a central role in today’s businesses and it has been truly interesting for us to participate in a global company’s work with these matters. It has been an evolving, challenging and fun experience and we would like to express our gratitude to the people who have enabled us to conduct this study and provided us with support.

We would like to thank all the people at Volvo Bus who have been there for us and supported us. We would especially like to thank the employees of the Prototype Build and Test department and our supervisor Catarina Wass, many thanks to you all for your pleasant and helpful attitude. Thank you Kostas Selviaridis, supervisor at Lund University, Faculty of Engineering for your time, support, excellent guidance and meaningful advice. We believe your comments and perseverance influenced our work and contributed to a better outcome.

Marcus Berg

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Lund, May 2012
Abstract

Title: Process mapping and improvement in a Prototype Build Organization - Enhancing the process performance of the material supply

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Product development in the automotive industry is characterized by a high demand on short lead times and efficient use of resources. This is no different for Volvo Bus Corporation, the second largest manufacturer of buses and bus chassis in the world, whose global product development organization is under pressure to find new ways to meet an increased amount of projects along with requirements on shorter lead times. For the Prototype Build and Test department, one actor in the product development process, this means that gains in process efficiency and effectiveness is needed to meet future demands.

The purpose of this thesis is to map and analyze Volvo Buses’ Prototype Build and Test process, with a specific focus on the material supply process within the Prototype Build and Test department, in order to identify areas of potential improvement and suggest appropriate actions. Suggestion of a number of key performance indicators to measure the improvement of the process is also a goal for the study.

The study uses a systems approach to provide a holistic view of the studied organization and to properly capture the complex interrelations within the system. The study is conducted through a case study where the bulk of the data is gathered using qualitative data collection methods, consisting of semi-structured interviews with representatives from all parts of the studied process. The data is analyzed through a theoretical frame of reference, developed by means of a literature study, based on the areas of process understanding, process mapping, process analysis, process improvement, process measurement and organizational structure.

The analysis results in a set of process maps describing the core processes of Prototype Build and Test as well as its relation and connections to the rest of the product development process. The analysis identifies a number of issues; Insufficient process orientation, poor communication, lacking control over the material flow, unrealistic time and resource planning and unclear definitions of roles and responsibilities, all of which limits the process’ efficiency. The authors suggest a set of recommendation for how Prototype Build and Test, and the product development organization as a whole, should act to address these issues and increase the efficiency of the process. The recommendation to Prototype Build and Test are:

- To start actively working with process orientation efforts
• To regain control of the material flow by implementing improved delivery control, goods receiving and warehousing routines
• To create clearly defined descriptions of roles and responsibilities
• To initiate an evaluation of the time and resource planning routines
• To start implementing a continuous improvement program

To measure improvements in the material supply process KPI’s measuring delivery performance, goods reception and standstills in the prototype builds are suggested.

**Keywords:** Process mapping, process management, process improvement, process-based organizational structure
Glossary and Acronyms

**GDP**
The Global Development Process is a framework for product development, developed and used by Volvo Group.

**PBT**
Prototype Build and Test is a department within product development with the purpose to build and provide a test object for verification usage.

**CPM**
Chief Project Manager manages the project until the final project termination.

**TPM**
Technical Project Manager is responsible for leading, coordinating and planning the technical work of the projects in his/her area.

**PVM**
Project Vehicle Manager is responsible for the prototype build activities.

**Kola**
A construction data system used by Design Engineers to create the material specifications. These specifications specify the material needed for the designs and subsequently creates the Bill of Material.

**PROTUS**
Is the prototype follow up data system used to keep an updated status of the test object. In this system all the data concerning the test object i.e. the vehicle, and the status of this should be stored, updated and retrievable at all time.

**BOM**
Bill of Material is a list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, components, parts and the quantities of each needed to manufacture an end product.

**SAP**
The business system the material coordinators uses to place purchase requisitions in. A SAP system is also used in the warehouse to help administrate.

**GPS**
The system purchasers work in, to which the purchase requisitions are transferred. In this system the purchasers place the order towards the supplier.
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1 Introduction

In this chapter a background for the master thesis will be presented. The chapter starts by giving the reader an introduction to the studied company, followed by the problem description, purpose, research questions and the delimitations which shaped this study. The chapter is concluded by a discussion regarding the thesis’ target group and a short reader’s-guide to the disposition of the thesis.

1.1 Volvo Buses

“The Volvo Group is one of the world’s leading providers of commercial transport solutions, providing such products as trucks, buses, construction equipment, engines and drive systems for boats and industrial applications, as well as aircraft engine components” (About us: Volvo Group Global, 2012). In 2010 the Volvo Group reported a total net sale of 264.7 billion SEK, with an operating income of 18 billion SEK and the organization had over 90 000 employees worldwide. (Annual Reports: Volvo Group Global, 2012).

One of the business units within the Volvo Group is Volvo Buses, which is the second largest manufacturer of buses and bus chassis in the world. The products comprised in Volvo Buses’ product program are city buses, intercity buses and tourist coaches. It also provides services within areas of financing, vehicle diagnostics, traffic information systems and aftermarket services such as servicing and spare parts distribution. For the time being Volvo Buses is operating in Europe, North and South America, Asia and Africa and employs approximately 7900 people (About us: Volvo Buses, 2011). In 2010 Volvo Buses reported a total net sale of 20.5 billion SEK, with an operating income of 0.8 billion SEK and thus accounted for 8% of the Volvo Groups total sales (Annual Reports: Volvo Group Global, 2012). Volvo Buses financial results for 2010 can be seen in Figure 1.

![Figure 1. Net sales and operating income for Volvo Buses 2010. (Annual Reports: Volvo Group Global, 2012)](image)

The head office of Volvo Buses is located in Gothenburg, Sweden and while production is carried out all around the world, product planning and product development is mainly concentrated at the head office. The department for product development is called Global Product Development and Purchasing, G2P, which is responsible for developing and maintaining both vehicles and related services. Global Engineering is a department within G2P with responsibility for development of powertrain, body, chassi and electrics as well as prototype building and testing. This master thesis has mainly been carried out on behalf of the department Prototype Build and Test. Figure 2 shows
the overall organizational structure of Volvo Buses and highlights how the Prototype Build and Test department is related to the rest of the organization.

![Organizational chart showing PBT’s place in the Volvo Bus organization. Adapted from (Volvo Bus intranet, 2012)](image)

1.1.1 Prototype Build and Test

As long as Volvo has worked with constructing vehicles they have more or less worked with prototype building. The purpose of Prototype Build and Test, PBT, is to build prototypes used as test objects. The test objects are used to validate the functionality, the constructability and the quality of the product. The management of PBT is situated in Gothenburg but it operates globally with facilities in Poland, Mexico, Brazil, India and China. To create a unified production process the PBT department in Gothenburg communicates the issues and solutions found, when creating the test objects, to the PBT sites world-wide. An organizational chart for the PBT department in Gothenburg can be seen in Figure 3.

The objective for introducing a process based view at PBT is to create a holistic view in order to enable continuous improvements. Due to the increasing globality of PBT it is of importance to increase standardization in their work process. Volvo Buses experience a high demand on the reduction of lead time and an increased amount of projects, which creates a great need for efficiency gains within PBT.

In order for these optimizations to be implemented it is crucial to have a clear picture of the “as-is” situation. Today PBT lacks the necessary process mapping and documentation needed to make informed decisions about organizational changes.
1.2 Problem description
Due to the reduced lead times and increased amount of projects a high demand is put on the efficiency of the prototype build organization and their processes. The organization of PBT is today built on the knowledge and skills of the employees. The functioning of the organization is entirely depending on their ability to stay flexible and solve emerging problems hands on. The organization has no structural working approach and lacks documentation. The organization is functional oriented and is at the moment putting a lot of investment on attempts of getting more process oriented. The projects PBT are running today often suffer from delay due these issues. PBT also suffers from delays due to issues with material supply and lack of accuracy in stock levels. For the projects PBT are running, a finalized build plan is often lacking and due to continuous changes in the build plan throughout the working process the projects are often put back even more.

1.3 Purpose and research questions
The project aims to provide a better understanding and create a holistic view of the organization for PBT. The purpose is to provide Volvo Buses with a process map reflecting the situation today. The process that PBT intend to work along today is then to be revised and a process that will allow for continuous improvements will be created. The goal is to create a more efficient organizational structure and to obtain a process suitable for global use with clear focus on future needs.

By means of these premises the following research questions can be formulated:

- How can the process be mapped to expose problem areas?
- How can the process be improved to enhance the efficiency?
- How can stagnation in build and delays in projects be prevented?
- Why are the material deliveries unreliable and how can the reliability of material supply be enhanced?
- How can the organizational structure be changed to facilitate efficiency gains in the process?

1.4 Delimitation
One of the original goals for this study was to create a new global process for PBT. To do this would, however, mean that the scope of the study would be quite expansive. Data collection would have
needed to be done on a global scale and it would have been difficult to perform a detailed study. For this reason it have been decided early on to exclude the other, global, PBT-sites from the scope and limit the study to performing a more profound analysis of the site in Gothenburg. The results of this study can then, possibly, be used as a basis for creating a well-functioning global PBT-process.

At the first stage of the research focus will be put on creating an accurate process map of the as-is situation of the product development process. Once this have been successfully made, a general study of PBT’s core processes, material supply and prototype build, will be conducted. The scope of analyzing the core processes is vast and the authors will delimit the study to make a profound analysis and optimization of one core or sub process in vital need of revising. In the initial phase of the study the core process in greatest need of revising was considered to be material supply. An early contemplation was therefore to make an in-depth analysis of this department and create a template for how the analysis and improvements of a core process can be conducted.

1.5 Target group
The main target group of this report is the management and employees of PBT at Volvo Buses in Gothenburg. In addition to the PBT organization the report is also intended for the Faculty of Engineering and in particular the Division of Engineering Logistics, scholars in the field of process mapping and improvement, students majoring in logistics as well as those who possess a profound interest in the subject matter.

1.6 Disposition
To facilitate for the reader when going through the report the disposition of the report will be stated and illustrated. Additionally each chapter will be initiated with a very brief review of what will be discussed in that chapter in particular.

The report starts with an Introduction were the surroundings and general facts underlying the study are presented. In the introduction the research question formulation, the purpose of the study and the deliberately made delimitations is clearly stated as well. The introduction is followed by the Methodology were the study approach and the research method is planned with consideration to activity and time parameters. The body of the report consists of three main chapters Theory, Empirical study and Analysis. In the Theory chapter a brief study of theories perceived relevant are presented and a frame of reference for the study is created. Subsequently a more in-depth presentation of the theories selected for the study is carried out. Empirical study starts with a company description followed by a presentation and discussion of the empirical findings. In the Analysis chapter the empirical findings are analyzed using the theoretical frame of reference as a basis. Problem areas are identified and possible solutions to these problems are presented. The thesis is concluded by a Conclusion and discussion chapter where the authors present the results of the study in the form of a set of recommendations, what these recommendations are based on and what the probable consequences will be. Finally the authors make some closing remarks by reconciling the result and the goal, discussing trustworthiness and authenticity, the generalization ability of the result and providing recommendations for future research in the area of process development.
2 Methodology

This chapter enlightens the reader about existing research approaches and methods. It presents the methodology that is used throughout the study and justifies the choices of each method or approach respectively. The chapter also includes a discussion of trustworthiness and authenticity and ends with a section of source criticism.

2.1 Scientific approach

When conducting a scientific study every researcher approaches its studied area with a set of predetermined assumptions. These assumptions will influence which methods are chosen to study and understand the area which in turn will influence the results of the study. It is therefore essential that every researcher, before performing the study, reflects on and clearly defines its own scientific and methodological approach. This will establish a frame of reference for the study and ensures that the study can be understood in its proper context (Arbnor & Bjerke, 1997).

According to Arbnor and Bjerke (1997) there are currently three methodological approaches to business research, each with its own defining characteristics. These approaches are the Analytical Approach, the Systems Approach, and the Actors Approach. An overview of the characteristics of each approach is presented in Table 1 and the approaches are discussed in further detail below.

Table 1. Characteristics of the Scientific Approaches. (Gammelgaard, 2004)

<table>
<thead>
<tr>
<th></th>
<th>Analytical approach</th>
<th>Systems approach</th>
<th>Actors approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory type</td>
<td>Determining cause-effect relations. Explanations, predictions. Universal, time and value free laws</td>
<td>Recommendations, normative aspects. Knowledge about concrete systems</td>
<td>Interpretations, understanding. Contextual knowledge</td>
</tr>
<tr>
<td>Preferred method</td>
<td>Quantitative (qualitative research only for validation)</td>
<td>Case studies (qualitative and quantitative)</td>
<td>Qualitative</td>
</tr>
<tr>
<td>Unit of analysis</td>
<td>Concepts and their relations</td>
<td>Systems: links, feedback mechanisms and boundaries</td>
<td>People - and their interaction</td>
</tr>
<tr>
<td>Data analysis</td>
<td>Description, hypothesis testing</td>
<td>Mapping, modelling</td>
<td>Interpretation</td>
</tr>
<tr>
<td>Position of the researcher</td>
<td>Outside</td>
<td>Preferably outside</td>
<td>Inside - as part of the process</td>
</tr>
</tbody>
</table>

2.1.1 Analytical approach

The analytical approach is positivistic in nature and proposes that reality can be described by breaking it down into its smallest elements and identifying universal cause-effect relations between them. The goal is to create rules that can be generalized and ultimately be used to predict future behavior. Reality is seen as summative i.e. the whole is the sum of its parts (Arbnor & Bjerke, 1997).
The analytical approach is heavily linked with quantitative research methods and the researcher must avoid any interaction with or influence on the research object. Qualitative research methods can be used to validate an analytical study (Gammelgaard, 2004).

2.1.2 Systems approach
Significant for the systems approach is the use of a holistic point of view. The idea is that to fully understand any given phenomenon, one must view it as a system composed of linked parts. The system as a whole is heavily dependent on the interactions and dependencies between these parts. Therefore any attempts to analyze it must also view the system as a whole. To simply decompose the system into its smallest elements and analyze them individually will not yield a complete and accurate understanding of the system (Gammelgaard, 2004). Reality is not seen as summative, but as synergetic i.e. the whole differs from the sum of its parts (Arnbor & Bjerke, 1997).

The systems approach is a more pragmatic and practically oriented research approach than the analytical. It focuses on practical solutions to real world problems and the solutions are case specific rather than universal (Gammelgaard, 2004).

Due to its case specific nature a natural way to analyze problems with the systems approach is the use of case studies. Both qualitative and quantitative research methods are applicable (Gammelgaard, 2004).

2.1.3 Actors approach
The actors approach employs a more abstract point of view in which reality is a social construction that can only be understood through analysis of human interactions and intentions. Because of its contextual nature any research must be performed through qualitative studies and the researcher must be highly involved in the studied object (Gammelgaard, 2004).

The actors approach has yet to become commonly used in the field of logistics research, although attempts have been made to use the approach in the fields of operations management and supply chain management (Gammelgaard, 2004).

2.1.4 Scientific approach chosen for this study
The purpose of this study is outset to map and improve the process for Prototype Build and Test, but it became clear early on in the study that the process with most deficiencies and thereby the most improvement potential was the material supply. Therefore the study will have a strong emphasis on the process for material supply and this is the process that will be mapped, analyzed and improved. However, the process for material supply is affected by the activities that come off in the process for Prototype Build and Test as well as product development and vice versa. Figure 4 illustrates how the process and its sub processes affect each other.

![Diagram](image-url)
For example, if the designs that are created in the process for product development are incorrect this will affect the process for material supply due to errors in the material specifications. On that account, to avoid local optimization the process for material supply will be studied in depth, complemented by a cursory analysis of the entire process for product development and the organization of PBT. How much emphasis placed on the different detail levels of are illustrated in Figure 5.

![Figure 5: Baseline levels of focus](image)

In order to achieve the right result, the processes need to be studied using a holistic view. The input, output and activities of the processes, as well as the employees, resources and information are all components affecting the performance of the processes and the organization of PBT. These are all interconnected, constantly affecting each other and needs to be examined as a system. For example, if an employee working within the process perform their own activities in an excellent manner but neglect to share information about errors occurring when they performed their activity or potential future problems that might occur as a result of a previous activities, the process will not perform in its full capacity. The result if the components of the process are not studied as a system is for this specific example that errors occur and are first discovered in a succeeding activity, when it actually was generated much earlier. Due to the holistic and process based nature of the study as well as the focus on customized solutions it is the authors’ opinion that the systems approach is most suitably employed. To clarify; the system being studied is the process of Prototype Build and Test, with a focus on material supply, consisting of the components; input, output, activities, employees, resources and information. Figure 6 shows how the performance of a process is dependent on the performance of all of its components.
2.2 Research methods

There are many different ways to gather and analyze data when performing a scientific study and as previously mentioned the selected method will have a profound impact on the result. It is important to be aware of the strengths, weaknesses and implications of these different methods. In this section a number of alternative methods are presented and discussed.

2.2.1 Explorative, descriptive, explanatory and normative

Throughout any study the abstraction level often varies due to the different aims of each part of the study. This is due to the varying levels of previous knowledge in any area.

If there is little known about a specific area of research one must first conduct an explorative study to acquire a basic understanding. The next level of abstraction means performing a descriptive study. This is conducted in order to describe the studied area without attempting to explain its inner functions and relations. An explanatory study is conducted when attempting to thoroughly explain and create a higher level of understanding for the studied area. The normative study is a further step in abstraction level and attempts to prescribe changes and improvements to the studied area (Björklund & Paulsson, 2003).

2.2.2 Inductive, deductive & abductive reasoning

The chosen method of logical reasoning will fundamentally influence the way in which any study is conducted. There are three principle kinds of logical reasoning, namely inductive, deductive, and abductive.

Inductive reasoning means that conclusions are drawn from real world observations. Theories and models are constructed based on empirical data and no review of previous literature or existing theories are necessary before conducting the data collection. Inductive reasoning is contrasted with deductive reasoning in which theories are used to draw conclusions and predict the outcome of empirical data. These conclusions and predictions are then validated by conducting an empirical study (Björklund & Paulsson, 2003).

Abductive reasoning means that conclusions evolve through movement back and forth between theory and empirics, induction and deduction (Björklund & Paulsson, 2003).
2.2.3 Qualitative vs. quantitative
There are two distinct methods for gathering and analyzing data, namely through qualitative or quantitative studies. Different studies are suited for different methods and it is mainly the purpose of the study and the assumptions made regarding epistemology that defines whether it is going to be qualitative or quantitative in nature (Björklund & Paulsson, 2003).

Starrin and Svensson (1994) argues that the distinction between qualitative and quantitative lies in the goal of the analysis. Quantitative analysis aims at investigating the distribution of certain phenomenon as well as determining causal relations between different phenomena. Qualitative analysis aims at identifying and describing different phenomena. The outcome of this distinction is that the two methods are suited for answering different types of questions and generally apply different methods of analysis. Quantitative analysis is heavily oriented towards statistical analysis due to its largely numerical data, whereas qualitative analysis incorporates a variety of different methods in order to interpret and describe a studied phenomenon. It is also of importance to state that data should not be seen as either qualitative or quantitative and that most types of data can be used for either method of analysis (Starrin & Svensson, 1994).

2.2.4 Research methods used in this study
The abstraction level of this study will start out at an exploratory level. When the understanding of the as-is situation is satisfactory the study will pass thorough the explanatory level in order to provide in depth understanding for the target group of this thesis and finally enter into the final phase where the level of ambition will be more normative.

For this study the process for Prototype Build and Test will be observed, focusing on the process for material supply. Empirical data collected through semi-structured interviews and observations will underlie the mapping, analyzing and the conclusions drawn. In order to map and analyze the process and consequently suggest potential improvements a literature review on process mapping, process analysis and process improvements will be made. For this study an abductive approach will be the method used for the logical reasoning.

Most of the data will be collected through qualitative data techniques such as interviews and observations using a flexible structure, resulting in the main part of the data being qualitative.

2.3 Research strategies
A variety of different research strategies exists. A research strategy helps the researcher to relate adequate techniques of collecting and analyzing empirical material to the study (Yin, 2003). A research design is a form of logic for how the research should be done, a plan of how to get from ‘here’ to ‘there’. It provides a way of connecting theories to inquiry strategies and empirical data collection techniques. When designing the research, focus is put on the research question, the study purpose, “what information most appropriately will answer specific research questions, and which strategies are most effective for obtaining it” (LeCompte & Preissle, 1993 cited in Denzin & Lincoln, 1998, p. 28).

Yin (2003) presents three different situations that can be used to allow a characterization of the strategies. The three situations and how these are related to the different research strategies are presented in Table 2.
When a qualitative study is conducted, and the analysis will be on descriptive and subjective data, the importance of a well adapted research design is of crucial importance. A research design will help validate the study and lets the researcher come to terms with issues regarding representation and legitimation (Denzin & Lincoln, 1998).

### 2.3.1 Research strategies chosen for this study

When it comes to designing the research strategy let us apply the idea by LeCompte and Preissle (1993) i.e. return to the research questions. The research aims to answer research questions in the form of ‘how’ and ‘why’ and focuses on contemporary events without any required control of behavioral. When these aspects are considered and in accordance to the distinction made by Yin (2003) a case study strategy is chosen for this study. This study is also, as can be seen in Table 1, preferred in the systems approach which further validates the choice of it.

For this study qualitative methods of collecting and analyzing material will primarily be used, such as interviewing, observing and documentation analysis. For case studies these are commonly used collection and analysis methods and the case study research strategy validates the use of a qualitative method for the study (Denzin & Lincoln, 1998).

### 2.3.2 Case Studies

A case study is a strategy that can be used when doing a social science research with the aspiration to understand the complexity of a real-life phenomenon. For case studies a pre-defined strategy for collecting and analyzing data exists. The strategy, which is visualized in Figure 7, consists of the 5 steps that follow.

![Figure 7. The steps to follow when conducting a case study. Adapted from (Yin, 2003).](image)

**Step 1. Designing the case study**

When designing the research, five steps have been designated as particularly important for case studies. The purpose of the first step, **the study questions**, is to provide a view of which research strategies that are most appropriate. Questions of ‘how’ and ‘why’ character makes the case study...
suitable. In the second step, study propositions, attention is directed to what should be studied and helps steering the data collection in the right direction. The definition of ‘what the case is’, is the problem related to the third step, units of analysis, in this study a process is the case being studied. Linking data to the propositions and criteria for interpreting the findings are the fourth and fifth steps and these help provide a foundation for the data analysis (Yin, 2003).

When it comes to case studies, four different kinds of designs exist. First one has to define if a single-case study is to be made or if one will make multiple-case studies. The researcher must also reflect on how many units of analysis one study consist of. One unit of analysis or more than one unit is called holistic and embedded case study respectively. In Figure 8 the four types of designs are illustrated in a 2 x 2 matrix and these will now be further explained.

The single-case study is suitable when testing existing theory, when analyzing an extreme or unique case or for typical cases such as an everyday situation. Another suitable situation is when a first time opportunity to analyze the phenomenon exists or when studying the same single case at different points in time. The single-case study resembles a single experiment and many of the characteristics for a single experiment can be used to define single-case studies. Within the single case study one unit of analysis or more than one unit of analysis may be observed. Holistic case study, TYPE 1, is used when the intention is to only observe one unit, this could be for instance when the global nature of an organizations is examined. Embedded case study, TYPE 2, is the design used when more than one unit of analysis exists and occurs when one or more subunits are considered within a single case (Yin, 2003).
A problem when using the holistic design is that the nature of the case study may shift during the course of time the study is conducted. Due to this, the research questions will evolve and possibly new ones will be created. The risk now is that the research question and the implemented research design no longer match. A possible way of redressing this problem is to also analyze a set of subunits, thus using the embedded design (Yin, 2003).

When the same study contains more than one case object, all replications of one another, the multiple-case design will be applied. In such a study each case object is subject of an individual study but they all must serve the purpose of the whole study. For multiple-case studies the terms of holistic, TYPE 3, and embedded, TYPE 4, studies exists as well (Yin, 2003).

In this study a single case will be conducted, which rules out TYPE 3 and 4. The single case comprises the mapping, analyzing and improvements of the processes at Volvo Bus. As already mentioned in section 2.1.4 the authors accentuate the importance of examining the process and its components as a system and to use a holistic view. The research design used for this research will therefore be TYPE 1, the process for Prototype Build and Test the single-unit of analysis.

**Step 2. Preparing for data collection**

Preparing for data collection is a complex and difficult task. Nevertheless it is necessary in order to be well prepared for a case study. One way of preparing is to develop a list of requirements that desirably should be met when the preparation is done. Yin (2003) lists the following requirements as particularly important. To possess desired skills, by the means of a skilled investigator who ask good questions, incorporate a technique for listening that enables the intake of large amounts of new information without bias, is adaptive and flexible and has a contextual understanding. Training and preparation for the specific case study is another crucial step, preferably followed by the developing of a case study protocol. The protocol is an overview of the case study project and contains the rules and procedures that are to be followed. It should also serve as a guide throughout the investigation and contain the case study questions as a constant reminder. The screening of candidate case studies is a necessary step in those situations when many case study candidates exist. In this step, the final selection of cases or the single case should be selected. The final step concerns the conducting of a case study pilot. The pilot will help develop the questions, clarify the research design and refine the data collection plan.

**Step 3. Collecting the data**

Generally when conducting a case study the data is collected from the following sources: Documents, archival records, interviews, direct observation, participant observation and physical artifacts. When it comes to documents one has to keep in mind that these are not always accurate and that they may include bias. Therefore it is important to use them with a sense of caution. A fitting purpose is to use them to verify primary data. Archival records refer to organizational charts, maps, lists, service records etc and are for a case study fitting to use in combination with other sources. Interviews are of utmost importance for case studies and emphasis will be placed on describing techniques for this data collection method later. Direct observations can be achieved by making a filed visit to the case study site and participant observations are engendered when the researcher is participating in the actual events studied. At a field visit the researcher may recognize the possibility of gathering a physical artifact, such as a tool or instrument, that may be studied to give a contribution to the case study (Yin, 2003).
In order to get the most out of the six sources of data three principals are recommended by Yin (2003) to be followed. Use multiple sources of evidence, create a case study database by documenting the collected data, and maintain a chain of evidence by presenting the collected data throughout the report.

**Step 4. Analyzing the data**

Analyzing data is a way to recombine qualitative and quantitative data to address the initial postulation of a study. It is essential for every case study to have a general analytical strategy to clearly define what to analyze, why and the priorities of analyzing. A general strategy is relying on theoretical propositions, which is the most preferred strategy and that implicates to follow the theoretical propositions that led to your case (Yin, 2003). Our analysis will be driven by our frame of reference, which can be found in Figure 9.

**Step 5. Reporting the case study**

The writing of the report is when the result and findings are brought to closure. Before writing the report the audience of the report must be identified, the report should be given a clear structure and data should be thoroughly reviewed.

### 2.4 Data collection and analysis

When a research project is being executed one has to perform a structured data collection. Data appears in many different forms and it is important to be able to distinguish these different types.

#### 2.4.1 Primary & secondary data

Data can be characterized as two different categories, primary data and secondary data. **Primary data** is defined as original data collected by the researchers themselves, at the original source. This kind of data is often encountered when the research is physically executed at the actual site for the event or problem underlying investigation and typical collected by the use of surveys, interviews, experiments (Collis & Hussey, 2009) or direct observations (Arbnor & Bjerke, 1997). **Secondary data** on the other hand, is not collected from the original source by the researcher. This is data that has already been collected and subsequently published by someone else. When the researcher has no ability to get to the original data source, a need for secondary data will emerge. Secondary data can be collected from publications, databases or internal records (Collis & Hussey, 2009).

Secondary data is often easily accessible and found in abundance but it is also associated with a few problematic issues. The first issue is compatibility. Data which has previously been collected may have been collected for a different purpose and may therefore not be compatible with the current research. This is especially true when using the systems approach due to the view of reality as complex systems of case specific nature. Secondary data should therefore be used with caution to avoid using irrelevant data and drawing faulty conclusions. The second issue revolves around trustworthiness of secondary data due to uncertainty regarding the accuracy of previously collected data. As a result of this source criticism is important when using secondary data (Arbnor & Bjerke, 1997).

#### 2.4.2 Literature review

The literature review is preceded by a literature search, which refers to a systematic process of identifying existing body of knowledge within the field of the research. The literature, in this context, is a typical source of secondary data. Once a comprehensive literature search has been conducted
the literature review is written. The literature review is a crucial step in the data collection where the researcher critically evaluates the existing body of knowledge. This will guide the research and provide a validation of the study by demonstrating that relevant literature has been located and analyzed (Collis & Hussey, 2009).

2.4.3 Research interview

Interviews are as mentioned a way of collecting primary data. Under an interpretative paradigm interviews are used to explore data on understanding, opinions, attitudes and feelings. Under a positivist paradigm all interviews are structured and based on questions and approaches planned ahead (Collis & Hussey, 2009).

In unstructured interviews the questions are open and allows for the interviewee to respond in his own way with his own words. The questions that are to be asked evolve during the interview and are not set or even prepared beforehand. When conducting many unstructured interviews different aspects of the topic is revealed in each interview, which can broaden the scope of the data collected. A complication with unstructured interviews is the difficulty to control the interview topics, which makes it time-consuming and complicates the analysis of the collected data (Collis & Hussey, 2009).

In semi-structured interviews some questions are prepared beforehand but there is room for the interviewer to add questions to further explore a certain area (Collis & Hussey, 2009).

Unstructured and semi-structured interviews are suitable to seize the interviewees’ opinion about the situation, to evolve a basic understanding, to grasp the step-by-step logic of a situation or when the data is sensitive or confidential. To get the greatest possible understanding of the issue, when performing these two types of interviews, it is crucial to probe the interviewee. A probe is a question the interviewer asks in response to the interviewee’s answer, in order to make him elaborate their statement (Collis & Hussey, 2009).

Structured interviews are often based on closed questions in the form of a questionnaire or an interview schedule; these questions each have a predetermined answer. Some open questions may be used to initiate for the interviewee to answer in his own words. Structured interviews are advantageous when there is a need to compare the answers of different interviewees. These interviews are also suitable when there is a desire to avoid bias (Collis & Hussey, 2009).

2.4.4 Observation

Observation is another common way of collecting primary data in case studies (Yin, 2003). The observation can be conducted in a laboratory setting or in a natural setting which refers to a “research environment that would have existed had researchers never studied it” (Vogt, 1993 cited in Collis & Hussey, 2009, p.154). Observations can also be categorized into direct observations, collecting primary data and indirect observations collecting secondary data (Arbnor & Bjerke, 1997). The form of observation that Yin (2003) refers to as direct observation, will from now on be referred to as non-participant observation in this report, because the authors find that this more accurately contrast the participant observation. Direct observations will refer to all observations that are conducted face-to-face, i.e. cover both participant and non-participant observations.

Non-participant observation, is the most frequently conducted type of observation and imply that the researcher collect data by observing and recording what people say or do without being involved
in the events studied (Collis & Hussey, 2009). The people subject of the research may more or less be aware of being observed or even non-aware (Arbnor & Bjerke, 1997).

When a participant-observation is conducted the researcher is fully involved in the events being studies and with the participants (Collis & Hussey, 2009).

2.4.5 Data analysis
Collis and Hussey (2009) suggest a series of non-quantifying methods for analyzing qualitative data. No matter which methods you choose or how you go about analyzing your qualitative data one has to start with reducing the data, “a form of analysis that sharpens, sorts, focuses, discards and reorganizes data in such a way that ‘final’ conclusions can be drawn and verified” (Miles & Huberman, 1994 cited in Collis & Hussey, 2009, p.167). Focus should here be placed on reducing the amount of data and removing irrelevant information, making further analysis possible. The data reduction can be done either continuously, by compiling the data which appears interesting and relevant and discarding other data, or anticipatory, which means that data is deemed relevant or not based on a predetermined theoretical framework. When the data has been reduced a good way of making it easier to analyze further is to restructure the data. This means contextualizing the data by placing it in an appropriate category (Collis & Hussey, 2009). Miles and Huberman (1994) suggest the use of analysis tables to categorize the data and help bring order to it.

2.4.6 Data collection and analysis in this study
Exploratory study
In order to gain a basic understanding of the studied organization an exploratory study was conducted at an early stage of the project. The study was mainly composed of unstructured interviews with employees selected to represent a cross-section of the organization. During this interview session people from each functional group within Prototype Build and Test were interviewed. The format of unstructured interviews was chosen as it was well suited for obtaining the desired outcome of a step-by-step description of the process. It is also a well suited interview technique for collecting the sensitive data that may be encountered in a prototype building workshop.

In conjunction to the interviews non-participant observations of the organization was conducted to visualize the process and get an idea of how communication between employees come to pass and how information is exchanged.

The authors had an ambition of corroborating the information gathered from the interviews and observations by reviewing documentation and archival records in the form of role descriptions and organizational charts, but due to these documents being rather insufficient this couldn’t happen in the extent hoped for. Role descriptions covering some of the roles could be found and these where reviewed as well as some very non detailed organizational charts.

Literature review
To create a theoretical framework, as a basis for understanding the studied field, an extensive literature review was conducted. This literature review covered previously collected data, i.e. secondary data and creates a summary of these. This data collection method was advantageous for this study due to it enabling the gathering of a great share of data during a small time frame and with limited resources at hand.
To ensure the authors would encounter all relevant literature within the existing body of knowledge the research was carried out on a keyword-basis at online databases, online libraries and scientific journals. The keywords used in the research were thoroughly compiled in order to aim the literature outcome to match the field studied in an accurate way. Concepts within process management were reviewed and the keywords for which theories, methods and models were sought was process mapping, process analysis, process improvement, process measuring and organizational structure. The information was mainly collected from literature with an educational purpose of the field and articles. When the authors had encountered all relevant literature it was possible to identify what was current state of knowledge and recognized knowledge within the field.

The main search engine when conducting the research was LibHub, a tool that among others integrates metadata from publishers, databases and the library catalogue. Via this tool the researcher could access and search the following journals, *Business Process Management Journal*, *Journal of Product Innovation Management*, *International Journal of Operations and Production Management* and *Journal of Operations Management* and get access to scientific articles within the field of research. To find relevant books on the subject the researchers preferred to use online library catalogues, such as Libris, rather than LibHub due to the simplification of the loaning process.

**Interviews**

After the literature review when the authors had gathered background knowledge in the scientific field a new round of interviews were conducted to better grasp the problems and issues at the company. Approximately 25 people were interviewed one or several times in semi-structured interviews. This covered at least one employee of each functional unit within the department, to find out the issues they experienced. Each interview lasted for approximately one hour. A list of the interviewees can be found in Appendix A. The interview consisted of somewhat closed questions to enable the comparison of the employees’ answers in conjunction with some open question that would ask for the interviewees’ own rendering of the situation. To provide the interviews with a certain degree of structure an interview guide was made, this can be found in Appendix B. This interview guide was used when conducting the semi-structured interviews. When interviewing Chief Project Manager, Technical Project Manager, Project Vehicle Manager and group managers all of the questions were reviewed and discussed. When interviewing people within the different units, such as build, warehouse and material supply the interviews to a great extent revolved around questions relevant for that specific unit. The interview guide would also help the interviewers to keep and secure the connection back to the theoretical frame of reference throughout the interview. All the interviews were transcribed and the main issue and problems were communicated to the interviewees for verification.

**Second round literature review**

When all the interviews had been conducted a new round of literature review took place. The purpose of this session was to fill out the gaps engendered after the previous round as well as to better adjust some areas of the frame of reference to the needs of Volvos Prototype Build and Test. In the preceded session the authors wanted to acquire a basic knowledge for the field studied and books were generally reviewed. In this round more focus were put on specific articles in the field to acquire an in-depth knowledge of process development. This literature review included, except for the ones mentioned above, keywords connected to prototype building, but with few and
Unfortunately non-applicable findings. Keywords used for this literature review were; prototype build, prototyping and product development combined with auto industry and automotive.

**Data analysis**

In order to analyze the data collected throughout this study a number of different methods of analysis were implemented, most of which were qualitative in nature. The bulk of the data was collected through interviews and literature, and the analysis of this data largely followed Collis and Hussey’s (2009) non-quantifying methods for analyzing qualitative data. For all analysis sessions focus was put on continuous reduction of the amount of data and removing of irrelevant information, in order to make further analysis possible.

As an example of how the data analysis was conducted in this study the general procedure for analyzing an interview will now be outlined. After an interview was conducted the content was transcribed and reviewed, relevant information was identified and subsequently categorized. The categories in broad terms being; data connected to and needed for process mapping, data emphasizing eventual problems and data emphasizing potential areas of improvement. This was followed by a session of brainstorming, to bring forward ideas and problems identified through the interview. Time was then taken to reflect on the problems or the new information that had been detected and to relate the problems and issues to the frame of reference in order to provide a foundation for a better analysis.

**2.5 Trustworthiness & authenticity**

The methods and approaches that are used when conducting a study can have an effect on the trustworthiness of the study. Trustworthiness can be evaluated through three criteria: validity, reliability and objectivity (Björklund & Paulsson, 2003).

Validity is concerned with how well a study is measuring what it is supposed to measure. In other words, do the results of the study align with the purpose and the stated research questions? One way of increasing validity is to study the same object using multiple methods. This way you can view the studied object from different perspectives. This method is often referred to as triangulation (Björklund & Paulsson, 2003).

Reliability describes the accuracy of a measurement and is closely linked to repeatability. Reliability can be increased by use of triangulation or by exploring the same area more than once in an interview or a survey (Björklund & Paulsson, 2003).

Objectivity is a measure of the extent in which personal values and interpretations influence the study. In order to ensure the objectivity of a study it is important that the authors clearly motivate their choices and their reasoning throughout the study (Björklund & Paulsson, 2003).

**2.5.1 Quality of research design**

Several methods of judging the quality of a study exists. Yin (2003) presents one way to judge the quality of empirical social research studies. On the grounds that the case study is an empirical study he argues that these tests are equally applicable for case studies. These tests are based on the concepts validity and reliability which are further elaborated above. Table 3, lists the tests, the rationale of testing and its recommended tactics respectively. It also presents a cross reference stating in what phase of the research the tactic is used (Yin, 2003).
2.6 Criticism of the sources

Source criticism is an important aspect of scientific studies. If a study is to be considered as trustworthy then so must its sources. Forsberg (2009) outlines a procedure for evaluating the sources. In order to ensure credibility one should first ask the question, is the information relevant to the subject? This question is answered through previous knowledge of the subject matter. If the information is relevant the next step is to ask, is the information trustworthy?

Trustworthiness of the sources can be determined by asking the following five questions. Who wrote the text? Is the author a scientist, journalist or neither? Does the author possess any knowledge in the field? This information about the author is crucial in the assessment of trustworthiness. Where is the text published? If the text is published in a renowned scientific journal or by a well-known publishing company it is more likely to have been reviewed and fact-checked by trusted subject specialists. When was the text written? The relevance of the text is sometimes heavily dependent on how old it is. What is the purpose of the text? Objectivity in sources must always be considered and will ultimately affect the way in which a certain source is used in the study. Can the information be found in other sources? Double-checking information with other sources will strengthen the trustworthiness of the text (Forsberg, 2009).

Source criticism has been a constant focus during this study. The used literature has been a combination of books and articles recommended by subject specialists as well as literature found through keyword-based searches in LibHub, Libris and Lovisa. All the literature has been critically assessed and relevant sections have been chosen.

<table>
<thead>
<tr>
<th>Tests</th>
<th>Test rationale</th>
<th>Case study tactic</th>
<th>Phase of research in which tactic occurs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construct validity</td>
<td>establishing correct operational measures</td>
<td>- Use multiple sources of evidence</td>
<td>data collection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Establish chain of evidence</td>
<td>data collection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Have key informant review draft study report</td>
<td>composition</td>
</tr>
<tr>
<td>Internal validity</td>
<td>establishing a casual relationship</td>
<td>- Do pattern-matching</td>
<td>data analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Do explanation building</td>
<td>data analysis</td>
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<tr>
<td></td>
<td></td>
<td>- Address rival explanations</td>
<td>data analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Use logic models</td>
<td>data analysis</td>
</tr>
<tr>
<td>External validity</td>
<td>establishing the domain to which a study’s findings can be generalized</td>
<td>- Use theory in single-case studies</td>
<td>research design</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Use replication logic in multi-case studies</td>
<td>research design</td>
</tr>
<tr>
<td>Reliability</td>
<td>demonstrating that the operations of a study can be repeated with the same results</td>
<td>- Use case study protocol</td>
<td>data collection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Develop case study database</td>
<td>data collection</td>
</tr>
</tbody>
</table>

Table 3. Case Study Tactics for Four Design Tests. Adapted from (Yin, 2003).
3 Theory

This chapter is a summary of the relevant literature studied for the thesis, covering the underlying key concepts and ideas. Foremost the chapter contains methods for process mapping, analysis and improvement, but also descriptive sections about process management and orientation as well as sections covering organizational structure and performance measurement.

The purpose of the thesis is to find a more efficient way to organize the PBT department and to create a clear and structured process. Before one can start working with process development an understanding of the process concept is crucial. For that reason, the theory chapter starts with a section dedicated to introducing the reader to the process concept and its key components. In order to enhance the performance of a process and make improvements, the process needs to be mapped. Therefore, to study process mapping, analysis and improvement was a given. However, it is also a necessity to have an organization that allows for process enhancement work and the pursuit of such improvements, hence, the study of a variety of existing organizational structures was also included. Figure 9 illustrates how the topics of this theory chapter together form our frame of reference.

![Figure 9. A theoretical framework for process mapping and improvement.](image)

3.1 Process understanding and process management

It is generally known that the functioning of an organization is represented by its business processes. Companies consist of processes, not the products or services they offer. This is why extensive literature highlights the importance of process management. Managing a business means managing its processes (Skrinjar, Stemberger, & Hernaus, 2007). As stated before it is, however, essential that you have a clear understanding of the process concept before you attempt to work according to it. Before you can manage your business processes, you must know what a process is and what the overall process concept is about.

3.1.1 Defining process

Up to this point a lot of emphasis has been put on processes in this report and a proper definition is in order. One must take some time to reflect over what a process really is. Once an understanding for what a process is has formed, knowledge concerning how to develop it can be obtained. Many different definitions of a process exist for the time being. A definition by Ljungberg and Larsson (2001) reads:

“A process is a repetitively used network of in order linked activities using information and resources to transform ‘object in’ to ‘object out’, from identification to satisfaction of the customer’s need.” (Ljungberg & Larsson, 2001, p. 44)
This definition is considered to, in a broad sense; describe the contents of a process and how it relates to its surroundings. It also highlights the importance of adding information and resources, to an otherwise empty process, in order to create value (Ljungberg & Larsson, 2001). This definition of a process links well to the definition of the system being studied, presented on pp. 5-6.

For a more refined definition, a distinction can be made between the word process in general and business processes.

“A process is a completely closed, timely and logical sequence of activities which are required to work on a process-oriented business object...for example an invoice, a purchase order or a specimen.” (Becker, Kugeler, & Rosemann, 2003, p. 4)

“A business process is a special process that is directed by the business objectives of a company and by the business environment. Essential features of a business process are interfaces to the business partners of the company (e.g. customers, suppliers). Examples of business processes are the order processing in a factory, the routing business of a retailer or the credit assignment of a bank.” (Becker, Kugeler, & Rosemann, 2003, p. 4)

To find one complete and concise definition of a process is not an easy task. The fact is that all of the different definitions tend to miss some part of the whole, which makes up the process concept. In reality the best way to find a complete definition is somewhere in the combination of short definitions like the ones presented above. If one takes the time to read and reflect on definitions like these it is possible to create a good understanding of what a process truly is.

3.1.2 Process orientation
A company that has gone through process orientation possesses a process-based view. However, process orientation is not equivalent with a process based organizational structure. Process orientation represents an understanding of the business flow and is only the first step towards a process based organizational structure (Skrinjar, Stemberger, & Hernaus, 2007). Process orientation is the adaptation towards a new paradigm, a process paradigm Figure 10. It aims at changing the perception of the organization, systems and structures as well as attitudes, values and cultures and stresses the importance of a holistic view. As a company becomes fully process oriented it accepts and embraces the process concept and takes on a process-based view (Ljungberg & Larsson, 2001).

For an organization that is fully process oriented the business processes are the central point of the corporate design (Becker, Kugeler, & Rosemann, 2003). In other words the processes are the basis for how the organization plans and runs its operations (Ljungberg & Larsson, 2001). All the internal and external factors that affect the processes, therefore, need to be identified. A reason for using a process-based view is to enable process efficiency enhancing work (Kiraka & Manning, 2005). When a
company wishes to enhance its overall performance, focus must lie on the cross-functional business processes (Becker, Kugeler, & Rosemann, 2003). Due to its holistic view of the organization, a process-based view can be useful for identifying good management practices (Kiraka & Manning, 2005; Skrinjar, Stemberger, & Hernaus, 2007).

Some of the benefits with a process-based view are the holistic view, employees’ buy-in, providing a sense of pride and that it is customer driven. When analyzing the performance of a business the analysis of processes and activities is often done in a vacuum, without considering how these processes interrelate. This may create conflicting results by improving the performance of one activity while degrading another. The process-based view provides a holistic approach for such analysis (Jacka & Keller, 2002). It combines individual tasks and activities in an organization and provides an opportunity to make a transitional analysis, making sure that the execution of real work is linked to the organization’s overall functioning (Kiraka & Manning, 2005). The analyst will get an understanding of how the processes’ objectives interrelate with the company’s overall objective (Jacka & Keller, 2002). A process-based view also shows that tasks and activities often are part of a single sequence by highlighting links between activities (Kiraka & Manning, 2005).

*Employees’ buy-in* to the completed product refers to employees’ ability to, when the process maps are being developed, see what is being recorded, affect the course of action and provide input. The third benefit is related to how well the processes illustrate the work being done. The benefits that it provides a sense of pride is related to how well the processes illustrate the work being done. The employees are fed with an understanding of how their work adds value and this endows them with a sense of pride. With a process-based view, focus is put on the customers and how to create value for them. A process with no customer concern may create an output that nobody wants (Jacka & Keller, 2002). One must understand that the benefits of having a process based view can only be enjoyed to its full extent when the organization has undergone total process orientation (Ljungberg & Larsson, 2001).

A factor that can be challenging to handle for a business leader when becoming more process oriented is to mediate functional objectives that often may be contradictory and conflicting, in order to facilitate for existing and new activities to be integrated in processes. Another challenge treated when becoming more process oriented is to find a balance between function and process (Braganza & Korac-Kakabadse, 2000). In order to accomplish the organization’s overall goals, the organization should be designed to provide both vertical and horizontal information flows (Skrinjar, Stemberger, & Hernaus, 2007). The leader must be able to create a balance between function and process in order for them to co-exist. Business leaders are now also required to think and act across value chains in addition to the functional and cross-functional dimensions that existed before (Braganza & Korac-Kakabadse, 2000).

### 3.1.3 Process identification

In order to manage and develop the business’s processes it is crucial to be able to identify and understand them. When a company is being described by its processes three types of processes are of particular importance; these are core processes, support processes and management processes (Ljungberg & Larsson, 2001).
Core process

Unfortunately one univocal definition of core processes does not exist, but many supplementary descriptions can be used to fully grasp what a core process is. In Ljungberg and Larsson (2001, p.82-83) four definitions are featured and each of them are insufficient if presented individually. Due to their inadequacy Ljungberg and Larsson (2001) chooses to refer to them as descriptions even though they are initially presented as definitions. The descriptions read as follows:

“Those processes, whose activities refine products or services to external customers.”

“Processes that realize the business idea.”

“Processes that together form a system that creates the foundation for the business. If one is removed the business falls apart.”

“Processes of particular importance to the business.”

The first description accentuates the role of the customer but it fails to include processes with internal customer, such as product development, that nevertheless may count as a core process for some businesses. The second description accentuates the significant role the core processes has in order for a business idea to be realized which is decisive for the success of a business. From a customer perspective they form the core of the organization. The third is a version of the second and is based on systems thinking as well. The third description will however include processes that might not realize the business idea but still are needed for the business not to fall apart, like invoicing customers. That leads up to the fourth and final description needed to define what a core process is (Ljungberg & Larsson, 2001).

To summarize the descriptions of a core process provided by Ljungberg and Larsson (2001) the following description can be used:

“Core processes, the value-added activities that support and facilitate the customer life cycle, represent the foundation of most businesses and the value that customers pay for and the essence of most businesses.” (McCormack & Rauseo, 2005, p. 66)

A significant difference between this description and the ones by Ljungberg and Larsson (2001) is that this description purposefully excludes the internal customer and chooses to distinguish processes aiming at internal and external customers. The processes aiming at external customers are the core processes and the processes aiming at internal customers are, according to McCormack and Rauseo (2005), defined as sustaining processes.

In this study a core process is understood to include processes of importance for the business with both possible internal and external customers.

Support process

To make the core processes function as good as possible and to ensure the performance of the entire organization, support processes are needed. The support processes are not value adding processes per se, but are valued after how well they support the core processes. The amount of support processes in an organization can be vast and to enable efficient and structured work with improvements, each organization needs to identify which support processes are crucial for it and focus on making these more efficient (Ljungberg & Larsson, 2001).
According to Becker et al. (2003, p. 5) “Support processes are processes whose activities do not create value from the customer’s point of view, but are necessary in order to execute a core process.”

Management process

*Management processes* are needed to manage and coordinate the core and support processes as well as the organization as a whole. In many organizations the management has trouble with identifying their own work in terms of a process and not much, if any at all, emphasis is put on actually managing and coordinating the processes of an organization. (Ljungberg & Larsson, 2001).

Level of detail & components of the process

All processes are related to other processes. These could be superior, subordinated or on the same level. *Sub processes* are subordinated to core processes, they are the processes that a core processes is built up of. The number of levels with sub processes can vary and depends on the size of the business. The final level of sub processes is in turn built up of *activities*. An illustration of a process can be seen in Figure 11 (Ljungberg & Larsson, 2001).

![Figure 11. A process and its different levels of detail. Adapted from (Ljungberg & Larsson, 2001).](image)

The components that are associated to the process’ fundamental characteristic are *object in*, *activity*, *resources*, *information* and *object out*. How they are related to the process is illustrated in Figure 12 and a description of them is presented in Table 4.
3.2 Process documentation

It is a common fact that to be able to manage a process it must be understood. A documentation of a process provides the degree of understanding needed in order to manage it. A process document is a graphical representation of a process showing how the product or service is created (Damij, 2007). The techniques used for the modeling can be diagrammatic or tabular (Grad & Damij, 2006). The reason for properly documenting a process is to be able to describe the process to others. This will make it easier for people involved to understand the process. It will also enable for standardization, improvement and reengineering (Ungan, 2006). The purpose of using a modeled process when working with process performance enhancement is to analyze and improve the model instead of the real business process (Grad & Damij, 2006). This report contains a short notation of the classic organizational chart and a tabular modeling technique represented by the activity table. Flowcharts and process maps, two different kinds of diagrammatic techniques (Damij, 2007) serving the same purpose (Ungan, 2006), will be further elaborated.
3.2.1 Organizational chart
Traditionally the classic organizational chart is used when describing an organization. Such a chart mainly provides information about how the resources are organized, who reports to whom and the hierarchical structure. The focus is on management and control and not value creation. An organizational chart lacks two things necessary to enable a focus on value creation. These are to show what is done as well as showing the connection between operations and customers (Ljungberg & Larsson, 2001). An example of a classic organizational chart can be seen in Figure 2 and Figure 3 in the introduction chapter.

3.2.2 Activity table
The activity table is a tabular process model, representing the as-is model of a process and illustrating the flow. It allows for an analysis of the table as a whole as well as for each work process separately. Depending on requirements on the process model and the complexity of the process an activity table can be developed to represent one or more processes. The activity table is organized as follows: It contains a column for the business process, a column showing sub processes of the process and a column for the activities of the sub processes. The remaining columns of the table contain the entities, which is a user or a group of users. The activities are then linked horizontally and vertically. The horizontal links connects the activities to entities. Each activity is usually connected with two entities, the one starting the activity and the one receiving the output of the activity. The vertical links shows the order in which the activities are performed. To help describe the activities in detail a property table is developed containing a row with information about each activity (Grad & Damij, 2006). Figure 13 shows an example of how an activity table can be structured for a sales-claim process.

![Figure 13. Example of an activity table (Damij, 2007)](image-url)
3.2.3 Flowchart
The flowchart provides a graphical representation of an algorithm or a process. Each part of the solution to the problem or step of the process is represented by an annotated geometric figure and each of those is connected by flow lines. Various geometric figures are used to represent operations, data, flow, equipment and other desired steps of the process or algorithm. The main benefits with the flowchart are that it provides the reader with an as-is snapshot of the business processes, provides an understanding of the complexity of the business process, gives easy access to visualization of the flow (Damij, 2007) and it can be documented at various levels of detail (Ungan, 2006). It may as well be used to mitigate risks when making process improvement by creating what-if flowcharts visualizing risks involved in the improvement operations (Grad & Damij, 2006).

However, with a high focus on flow, the flowchart is deficient in focus on value creation. It lacks in modeling interactions between activities and it doesn’t assign attribute data such as input and output to each process step. This is a serious shortcoming due to the interactions often being significant areas for improvement efforts. Other shortcomings of the flowchart are; its limited vocabulary, vagueness about the details of sequence and simultaneity, the activity list only contain the activities that occur if everything functions perfectly, no disclosure of unproductive labor due to errors and omissions (Ungan, 2006). According to Damij (2006) the flowchart is good for modeling small processes but it becomes unclear in large processes. Another major disadvantage with flowcharts is that many of the techniques used for process flowcharting requires the use of complex notational conventions that can be difficult to use effectively if not properly educated (Ungan, 2006). An example of a very basic flow chart describing an everyday situation can be seen in Figure 14.

![Figure 14. An example of a flow chart.](image)

3.2.4 Process mapping
The process maps of a business may have different level of detail and abstraction. A core process map has the highest level of abstraction and is “an illustration of the organization’s core processes” (Ljungberg & Larsson, 2001, p. 81). The core process map focuses on showing what is done, providing a comprehensive understanding of the organization and helping to describe the organization from both the internal and the external customer’s perspective. It mediates what is important for the organization (Ljungberg & Larsson, 2001) as well as illustrating connections and relations both internally and externally for activities, personnel, information and the objectives (Ungan, 2006). A core process map is preferably used complemented by the classic organizational chart (Ljungberg & Larsson, 2001). An example of a core process map can be seen in Figure 11.
**Why map?**

A process map provides an *up-to-date description of the business processes*, comprehensive enough to show what is done and by whom. The process maps can be used by employees to provide them with a better understanding of the organization and their work tasks. The process maps are more transparent than the classic organizational chart in order to communicate the processes more efficiently (Becker, Kugeler, & Rosemann, 2003). According to Ungan (2006) the process map was developed to overcome all the shortcomings, mentioned above, associated with the flowchart.

When a company is process oriented the business process maps enables the *analysis of the organization as a whole* and helps management to identify soft spots in the processes affecting the entire organization (Becker, Kugeler, & Rosemann, 2003). Essentially the mapping is done to enable for improvements to be done. The map provides a way to easier detect value adding and non-value-adding activities and simplifying work processes (Ungan, 2006).

Process orientation is succeeded by *continuous process management*. This includes long-term planning, execution and control of processes. The process maps allows for continuous improvement by continuously comparing the maps with the actual process execution to ensure that the process maps are adequate and then analyzing and improving the maps to make sure that the process execution is performed as efficient and effective as possible (Becker, Kugeler, & Rosemann, 2003).

These benefits of mapping your processes are substantial for most companies. A lot more benefits exist that may vary in importance. Such a benefit can be that the possession of a process map provides the ability to *benchmark processes*, in terms of both structure and their performance. Another benefit is that *integrated software solutions* are available to support the processes, such as Enterprise Resource Planning systems (Becker, Kugeler, & Rosemann, 2003).

### 3.3 Enhancing process performance

When one has established a profound understanding for what a process is and understands the importance of process-based view, the desire is to enhance the performance of the process by improving the *efficiency* and the *effectiveness* of the process (Ljungberg & Larsson, 2001). Efficiency refers to how well a task is performed internally and with what amount of resources; it is quantifiable as the ratio between input and output. Effectiveness refers to the capability of producing the desired result, which is what the customer asks for. Efficiency and effectiveness can in brief be expressed as: ‘doing things right’ and ‘doing the right things’ respectively (Näslund, 2010).

By documenting the process, problem areas can easier be identified and the efficiency of the process can be improved. Examples of problems that can be detected by the help of documentation are: processes that are more complicated than they have to be or not clear enough, processes that create defective or incorrect output; unnecessary transportation or movements of products or resources; unnecessary waiting, buffering or inspection; duplication and unnecessary record keeping and data collection (Ungan, 2006). Before the efficiency can be enhanced it is important that the process is effective. To avoid duplication of work one must do the right things before enhancing the performance of the things you do. In order to do the right things people managing the process must know their customer (Ljungberg & Larsson, 2001).
3.3.1 A General Methodology for Enhancing Process Performance

In order to evaluate if the process is efficient and effective one needs to be able to identify the process and possess knowledge of how the process uses resources. A variety of methods for efficiency enhancement exists; Ljungberg and Larsson (2001) present a general method consisting of five steps for how the development work can be carried out.

- Identify and map the processes
- Analyze and reconstruct
- Implement new or changed processes
- Measure the processes
- Continuous improvement of the processes

All of these steps will now be given a brief presentation, followed by a more in-depth description of the first step i.e. the process of process mapping.

A lot of emphasis will be put on the first step, identify and map the processes. In this step the processes will be identified and mapped – from customer need to customer satisfaction – in doing so describing the structure of the process. The tools used for mapping will be provided with an in depth description in section 3.4. Once this is done one can start analyzing how efficient and effective the process is. In this next step, analyze and reconstruct, the researcher can pose the questions ‘how well are the processes working?’ As well as ‘can they be designed in a better way?’ The analysis and reconstructing in this step is conducted on a conceptual level focusing on identifying activities that are creating value and those that are not. It should identify possible improvements of activities that will enhance performance of the entire process. It may also identify possible new activities and improved sequencing of the activities (Ljungberg & Larsson, 2001).

After the mapping and analysis of the as-is situation it is time to implement the improvements identified in the previous step and get the actual efficiency improvements. The third step, implement new or changed processes, takes the reconstruction to a concrete level. In order for the implementation to be successful the commitment of employees is crucial. The people working with the process must believe in it and participate in the implementation of change. The forth step is presented to help structure the improvement work by measuring the processes and the results. ‘Was there any improvement?’ and ‘what is the next step?’ are questions to pose. The final step, continuous improvement of the processes, is necessary to maintain an efficient process (Ljungberg & Larsson, 2001).

3.3.2 The Process of Process Mapping

Jacka and Keller (2002) present a process mapping system similar to Ljungberg and Larsson (2001) for enhancing the performance of a process, they call it ‘the process of process mapping. The steps of this process are:

- Process identification
- Data gathering
- Interviewing and map generation
- Analyzing the data
- Presentation
In the first step the process reviewer must identify the start and end point of the process as well as the triggers initiating the process. The reviewer must talk to people working with the process in order to understand what is done, by whom and why. Once this is done the reviewer can identify core and support processes and name them. Jacka and Keller (2002) accentuate the importance of taking the customers’ view of the process into consideration. When the reviewer has attained an overall understanding of the process a deeper investigation is in place and the reviewer starts gathering all the relevant data. This could include statistical information, finding out important key persons to talk to, and information needed to fully understand what the process does. Data must be gathered to make it possible to identify and describe all processes and to identify process owners. With all the right facts at hand the reviewer will avoid focusing on unimportant things. It will provide the reviewer with knowledge to easier understand the information the map will provide later on. The gathering of information will most importantly provide the reviewer with credibility (Jacka & Keller, 2002).

With the basic understanding of the process and the gathered information at hand the reviewer can start creating the map. The map is created in interaction with further information gathering in the form of interviews. The course of action when creating the map concurrently with the conducting of interviews is explained in detail in section 3.4.2. Throughout the process of process mapping, analysis of data is made simultaneously. All discussions, information gathering and map generations should provide opportunities for analysis. It is at the end, with the whole picture at hand, that the full effect can be seen. Bottlenecks, delays and significant sources of problem can be identified and the effectiveness and efficiency of the entire process can be determined. When putting together the identified processes and activities, the gathered data, the interviews, the generated map and the analysis this contains the result that was requested by the management (Jacka & Keller, 2002).

The method for development work presented by Ljungberg and Larsson (2001) and the process of process mapping presented by Jacka and Keller (2002) have many similarities but they put their focus on different levels of detail. Ljungberg and Larsson (2001) attend to the entire process for performance enhancement and deal with both the conceptual phase and the concrete phase with a low level of detail. If used as a tool for mapping, it needs to be perfected by their process mapping tool. Jacka and Keller (2002) have a narrower focus comprising only the conceptual phase, comparable with the first two steps in Ljungberg and Larsson’s model, but with a higher level of detail. According to their method the task ends once the map is generated and analyzed, leaving the implementation, measurements, and continuous improvements unfulfilled.

### 3.4 Process mapping tools

Ljungberg and Larsson (2001) presents a method for process mapping with a purpose of making the mapping work more efficient and to avoid common pitfalls, like piling activities one after the other without considering the relations between them or too much focus on details. This method is not a standard model but contains contributions from a lot of different standard mapping models. The mapping methodology is preceded by some preparatory steps followed by a detailed mapping methodology in eight steps (Ljungberg & Larsson, 2001).

The preparations involve defining suitable symbols and connections for the map. Different standards for these symbols exist and the important thing is to be consistent when using them. Another rule of thumb is to use as few symbols as possible in order for the map to stay clear. The next preparation is
to consider the *naming of the processes and activities*. To avoid getting locked in to the traditional organizational chart the names should not be associated with functions and not relate to what happens in the current department. The process name should reflect the purpose of the process, how value is created or why, instead of what is done or how it is done.

The third and most important preparation is the collecting of information. Three approaches for collecting the information needed for the process map is presented. *Walk through, virtual walk through and mapping team.* In the *Walk through* approach a person/the persons in charge of making the map conduct interviews of people in descending order throughout the process. This approach needs few resources and creates a map with a homogeneous character a drawback is that the employees might feel unengaged and there is a risk of bias. An alternative to the walk through is the *virtual walk through*, where representatives from the entire process are gathered to describe their own section. A mapping manager leads the meeting and conduct open interviews by asking questions. The benefits and advantages are similar to the ones of the walk through approach. A more thorough but resource consuming method is to create and educate a process *mapping team* consistent of representatives from the entire process.

### 3.4.1 Eight step mapping methodology

Ljungberg and Larsson (2001) suggest a mapping methodology, consisting of 8 steps, which is presented below:

1. Define the purpose of the process and its start and ending point.
   “The better understanding one has of the process before the mapping begins, the smoother the mapping work will go” (Ljungberg & Larsson, 2001, p. 207).
2. Conduct a brainstorming session. All possible activities of the process are defined as the result of brainstorming and written on post-its. The purpose of the brainstorming session and the post-its are to quickly and easily get started.
3. Arranging the activities in the right order by moving the post-its around until a unanimous description of the process is found. Yet another advantage of using the post-its is that they can easily be moved around.
4. Merge and add activities. Activities that are duplicates of one another are merged and missing activities are added.
5. Define object in and out for each activity, this will connect the activities and form a process with a unanimous purpose.
6. Make sure that all activities are linked together by the objects. In this step it will be very clear if any activity is missing, if not each activity’s object out will be the next activity’s object in.
7. Make sure all activities have a common level of detail and accurate names.
8. Make amendments until a satisfactorily description of the process is obtained.

Another method for process mapping is presented by Jacka and Keller (2002) in the third step of their process of process mapping. In contrast to Ljungberg and Larsson (2001) the information gathering is carried out simultaneously with the map generation. Similarly it is preceded by a preparatory step.

Before the interviews and the map generation Jacka and Keller (2002) accentuates the need to understand a few ground rules.
• The mapping project needs buy-in from the top management.
• Another aspect of importance is setting aside adequate time for the interviews and the entire project respectively. It could be necessary to compromise, by having either more interviews with less information or fewer interviews with more information sharing, if the interviews are being too time consuming and starts to take time away from the project.
• Be sure to secure a private interview area. Even though performing an interview at the interviewees own desk could provide the interviewee with comfort and some sense of self-assurance the risk of interruption and people listening in is a greater reason for using a private area.
• Set a friendly tone when conducting the interviews.
• Actively listen and do not pose the questions as if using a preset script. Make use of the time, set aside for interviewing, well; by listening to the answers and adjust the next question to the response obtained from the preceding questions.
• Select the right people to perform the interviews.
• The sticky-note revolution, will be used when creating the draft of the map. This is the idea of using sticky-notes to document actions and to generate sticky-note process maps concurrently with the interviews. This provides a fast and easy method to document results.
• Jacka and Keller (2002) present some basic rules for the process of the interviews. From the ground rules the importance of being consistent when creating the sticky-note maps is concluded.

3.4.2 Alternate method for process mapping
Jacka and Keller’s (2002) method for process mapping is, in broad terms, divided into two steps which are presented below:

• The method starts by conducting the interviews. An appropriate way to set off the interviews is by interviewing a supervisor or manager. They can provide an overview due to their knowledge of several major aspects of the process. These people should help provide information concerning the tasks, names of individuals and starting and ending points for the tasks. When these interviews have been conducted the remaining interviews are probably made randomly. To be able to compile the interviews in the right sequence record them and make the connections with the entire picture at hand. Start the interviews by asking about the basic sequence of events and add on to the appropriate map throughout the interviews, make sure to document delays. At the end of the interview a significant step is to walk the interviewee through the map and ask if there is anything to add or change.
• The creation of a final map should be done when all interviews are completed. This is the part when the sticky-notes are moved around, added or removed and finalized into a finalized and permanent map. Jacka and Keller (2002) suggest a technique that implicates the making of one overview map and several drill down maps. Jacka and Keller (2002) suggest starting out with a high-level map. This should work as a table of content for the process map. For each area of the map the detailed drill down map is created. With the drill down maps as aids the overview map is created. This technique helps avoiding too much detail on the map but still provides a way to freely explore and area in depth.
3.4.3  As-is and To-be Modeling

Becker et al. (2003) presents an alternative to the previously reviewed process mapping techniques, which consists of first mapping the as-is situation and then the to-be situation.

3.4.3.1 Objectives of As-is and To-be modeling

When attempting to enhance the performance of a process the general initial steps are to; first identify the core processes of the organization, then collect data interrelated to these processes followed by an analysis of these currently existing processes. The information generated when making these steps can then be used to identify weaknesses of the processes, show activities in need of improvements and opportunities for improvement (Becker, Kugeler, & Rosemann, 2003).

To facilitate the analysis and enhance the prospect for good data mining, the making of an as-is model can be adequate. The modeling is the basis for identifying shortcomings. The knowledge needed for creating the as-is model is necessary to possess when developing new processes and the modeling is a good way of ensuring that this knowledge is available in the organization. The model provides people in the reorganization project as well as other employees with a pedagogic overview of the current situation. When conducting the as-is modeling, the project members will be introduced to tools and trained in modeling techniques. This will facilitate the future to-be modeling. Another thing facilitating the to-be modeling, is that the as-is model can be used as main input (Becker, Kugeler, & Rosemann, 2003).

A risk when conducting the as-is modeling is that employees lack enough creativity and that the as-is modeling creates constraints. Another risk is that the old processes are retained without them being questioned. A factor working against the as-is modeling is that it is very time consuming and expensive (Becker, Kugeler, & Rosemann, 2003). The final factor makes the authors draw the conclusion that when an as-is modeling is to be done it must be done thoroughly and accurately, otherwise it is a waste of time and money.

Based on the as-is model and the weaknesses and potential improvement identified during the analysis of it, the to-be modeling is conducted. It is hard to state how a company will benefit from the to-be modeling, because this depends on what weaknesses the as-is modeling identified and in which areas of the organization changes are prioritized. Instead of listing the potential benefits of the to-be modeling, two lists of internal and external expectations a company may have are presented (Becker, Kugeler, & Rosemann, 2003).

The internal expectation may be; increase in profit, cost savings, streamlining of processes, lead time and idle time reduction, updated view of the organization and better communication (Becker, Kugeler, & Rosemann, 2003).

The external expectations may be; higher product quality, increased customer orientation and higher process transparency towards the customer (Becker, Kugeler, & Rosemann, 2003).

3.4.3.2 Procedure of As-is and To-be modeling

For the as-is modeling Becker et al. (2003) recommend the procedure presented below. The techniques that are used for the actual modeling in Becker et al. (2003) all require software based modeling tools. The procedures for as-is and to-be modeling therefore contains steps that allows for, or prepares for, a software modeling execution.
• Preparation of as-is modeling
• Identification and prioritizing of problem areas
• Collection and documentation of as-is models
• Consolidation of as-is models

The preparation includes determining the level of detail, what modeling techniques that will be used and which description views of the organization that are to be modeled. The description views that can be modeled are the process view, a data view, a functional view, an organizational view and an output view. These views are different ways of describing the organization and they are all interconnected. In Becker et al. (2003) these views are all integrated in a framework. Another preparation is identifying relevant sources of information, e.g. organizational charts, documentation and people familiar with the company (Becker, Kugeler, & Rosemann, 2003).

Problem areas need to be identified in order to be able to prioritize those in the modeling. Domains with problems can then be split down into partial areas while considering the core processes identified. A distinction is done between function-oriented and object-oriented and it should correspond with the organizational structure of the company. Figure 15 shows an object-oriented and function-oriented splitting of a problem domain. (Becker, Kugeler, & Rosemann, 2003).

Prior to the modeling an elementary pre-collection of processes should be conducted. For each process the basic features should be collected, such as name, objective and other characteristics of the process. These collected processes can be used as a basis for identifying weaknesses. Whether the pre-collected processes will be a part of the as-is model can be determined after they have been characterized. Not all areas are important for the as-is map. For the as-is modeling, areas of importance representing core processes should be included as well as cost-consuming areas in support processes that are executed frequently (Becker, Kugeler, & Rosemann, 2003).

The next step is the collection and documentation phase and the list of prioritized areas generated when identifying weaknesses should be used as the input. The collection and modeling is preferably conducted in a few workshops. The modeling is conducted successively throughout the workshops and when the workshops are done the conducted models are edited and ultimately approved, when found satisfactory in detail and coherence exist. Finally the models created in the workshops are consolidated (Becker, Kugeler, & Rosemann, 2003).
For the to-be modeling Becker et al. (2003) recommends the following procedure. The to-be modeling is, as for the as-is modeling, designed with software based modeling tools in mind:

- Preparation of to-be modeling
- Collection and documentation of to-be models
- Consolidation and editing of to-be models

The preparations for the to-be modeling has a different focus than the preparation for the as-is modeling. As for the as-is modeling the modeling view and the level of detailed needs to be determined. Another important preparation for the to-be modeling is a mapping of the corporate strategy and project goals for single purposes (Becker, Kugeler, & Rosemann, 2003).

In the next step, collection and documentation of to-be models, a rough draft of the processes and their structures should be created. This is preceded by an identification of the relationships between core and support processes. Such a relationship could, for example, be a ‘request for material’ between the core process ‘render services’ and the support process ‘provide resources’. Now the to-be models are created for each process or problem domain, identified in the as-is modeling, respectively. These models are then evaluated based on the criteria created for as-is modeling. As for the as-is modeling the models are now consolidated. The separate models can preferably be maintained for further use. The to-be model can be regarded as a short- and mid-term objective (Becker, Kugeler, & Rosemann, 2003).

The main difference between the method proposed by Becker et al. (2003) and the ones suggested by Ljungberg and Larsson (2001) and Jacka and Keller (2002) is that Becker’s et al. (2003) focuses on weak spots and problem areas when creating the as-is map. The other two methods are simply methodologies for how to create a process map and then analyze and improve it. In this method, on the other hand, the weaknesses and problem areas need to be identified and understood before the as-is map is created in order for the map to put focus on these only. That is preferable when the problems in an organization is well known and the issue is how to make the most suitable improvements. However, for a general process performance enhancement effort, the authors find Ljungberg and Larsson’s (2001) and Jacka and Keller’s (2002) methods to be more appropriate.

### 3.5 Process analysis and improvements

Process mapping will provide you with invaluable information about what your process looks like and process measurement will tell you how it is performing. These are prerequisites for being able to improve your process, but in order to improve you must first analyze all components of the process to know where the problems truly lie and how best to solve them. In this section a number of methods that can be useful when working with process analysis and process improvements will be presented

#### 3.5.1 Process audit

The purpose of a process audit is to evaluate how far along in the process based business development an organization is, or as Hammer (2007) describes it; how mature the process is, and help assess and prioritize how to proceed with further process orientation or process improvement. Through the process audit a general view of a process and its environment is gained with the aim of singling out problems and possibilities. The process audit is carried out by asking a set of questions
related not only to the specific process being audited, but also to the organization itself (Ljungberg & Larsson, 2001; Hammer, 2007).

While both Hammer’s (2007) and Ljungberg and Larsson’s (2001) process audit methods share some common features, Hammer’s (2007) is more directed towards process redesign and Ljungberg and Larsson(2001) presents a more general process audit which will now be further explained. The types of yes/no questions that can be used for a general process audit are presented in Ljungberg and Larsson (2001, p.275) and should be of the following nature:

- Has the business identified its core processes?
- Have the core processes been mapped?
- Have the most important customers and their demands and expectations been identified?
- Has the organization been adapted to focus on the processes?

These questions are simple to answer, but can be very helpful in revealing how well, if at all, the process-based business development is being carried out. The audit can easily be applied on both a high level, to audit the entire organization, or on a specific process, with an emphasis not just on the process itself but also on the environment in which it operates. If the predominant answer to the audit questions is yes, then the organization is most likely far along in its process-based development and emphasis can be put on more in depth analysis and improvement work. If the answer is predominantly no, then the organization should focus on further process orientation (Ljungberg & Larsson, 2001).

With the process audit as a basis, strategies and programs for going forward with process improvements can be formulated. It is also a helpful tool for identifying existing problems, not previously known to the organization. Many times, organizations are not aware of the issues and problems they are actually struggling with. This highlights the need for process auditing, as it sheds a light on how the organization is actually doing rather than how the organization thinks it is doing (Ljungberg & Larsson, 2001).

3.5.2 Process analysis

Process analysis is a more thorough evaluation of a process than the aforementioned process audit. The aim of the process analysis is to identify and solve specific problems with a given process or to find ways of improving a working process. There is not one general way in which to perform a process analysis. The number of methods and tools able to be used for the analysis is virtually unlimited and which ones are chosen is highly dependent on the nature of the process and the problem being analyzed (Ljungberg & Larsson, 2001).

In the following section a number of common and useful process analysis tools will be presented.

Bottleneck analysis

The bottleneck analysis aims at identifying the parts of the process that are acting as bottlenecks and thus limits the performance or outcome of the process as a whole. The main advantage of this method of analysis is that the analyst can identify the limiting factors of a process or an organization from a holistic point of view and start the improvement work where it is most needed and yields the greatest return. This is in a sense a logical approach to process analysis and improvement as it is
important to improve the right parts of the process first. If done differently, then you run the risk of actually creating more problems (Ljungberg & Larsson, 2001).

**Root cause analysis**

The goal of the root cause analysis is, as implied by its name, to identify root causes to problems that have been identified in the process. Many times large or small problems with far reaching consequences on the process performance can be attributed to a number of different causes. These causes can often be broken down into a set of underlying causes, and so forth. In the end a set of root causes can be identified. These root causes for the visible problem are often hard to identify when they occur as they may in themselves seem like insignificant events. However, if these minor events can be prevented to start with the entire costly problem can be avoided. It is for this reason that the root cause analysis can be an extremely helpful way to improve processes (Moore, 2006).

Root cause analysis is often carried out by means of a number of standardized tools such as Pareto charts, Ishikawa diagram, also known as fishbone diagram, or the 5 why method. Examples of a Pareto chart and an Ishikawa diagram can be seen in Figure 16 below. The Pareto chart is a simple way of listing the potential causes to a problem in a bar chart to visualize which factors contribute the most to causing the problem. The method utilizes the Pareto principle, or the 80/20-rule, which states that 80% of the effects can often be attributed to 20% of the causes, and these are then the root causes to focus improvement efforts on. The Ishikawa diagram is a way of visualizing the relationship between different causes and a problem. The 5 why method, originally developed in the Toyota Production System, is an easy-to-use technique to identifying the true root causes of a problem by asking yourself why a problem has occurred at least 5 times. This way you make sure that you are not simply fixing the symptoms of a problem, but instead you are truly dealing with all of the causes of the problem and can then improve the process. There are of course many more methods for working with root cause analysis and many of them may be used just as well as the examples brought up in this section (Moore, 2006; Ståhl, 2011).

![Figure 16. Examples of the structure of an Ishikawa diagram and a Pareto chart. Adapted from (Moore, 2006)](image)

The main benefits of the root cause analysis is that it is a time- and cost efficient way to tackle problem solving. Because a standard set of tools are used, anyone with sufficient training is able to perform the analysis near where the problem occurred and it does not need to take a large amount of time. This is in other words an efficient use of resources. It is also a way to make sure that you are actually fixing the cause of problems instead of the symptoms. This way you can eliminate future problems and the gains will therefore be multiplied greatly. Another positive aspect of the root cause analysis is that, if applied correctly, it can increase communication and the level of participation of the users of the process as they work together to identify areas of improvement (Moore, 2006).
**Value analysis**

The general idea of the value analysis is to identify and divide each activity and sub-process into one of the three categories, value adding, non-value adding and waste. Depending on which category each activity is assigned to, a specific strategy for process improvement can be determined.

The first category is *value adding activities*. Activities in this category directly add value to the customer. It is not always easy to determine if an activity is directly beneficial to the customer and it is important to put a lot of effort into the work of determining which activities are value adding and which are non-value adding. Once the value adding activities have been identified the strategy is to continuously develop these activities (Ljungberg & Larsson, 2001).

The second category is *non-value adding activities*. Here we find activities that do not add direct value to the customer, but are necessary for the functioning of a specific process or the organization. It could also be an activity that is of importance to other stakeholders. Examples of common non-value adding activities are storage, control and handling of goods. The strategy for process improvement in this category is to minimize the amount of non-value adding activities without negatively affecting the performance of the process (Ljungberg & Larsson, 2001).

The third and final category is *waste*. Waste activities are characterized by not adding any value to either customer, the own organization or other stakeholders. These activities are often relatively easy to identify, because they are basically redundant activities such as redoing work from previous activities. The strategy for handling waste activities is to eliminate them (Ljungberg & Larsson, 2001).

**PDCA-analysis**

PDCA, or Plan-Do-Check-Act, is originally a model for quality improvement developed by William Edwards Deming (Bergman & Klefsjö, 2007). The PDCA-cycle is described in more detail in the section on continuous improvement below and here focus will be put on how PDCA can be used as an analysis tool.

Ljungberg and Larsson (2001) describe how the PDCA-cycle can be adopted into an analysis model for processes and process improvement, referred to as PDCA-analysis. The general idea of the PDCA-analysis is that every well-functioning process should contain activities characterized by each of the four categories, plan-do-check-act. The analysis as such is performed through classifying each activity or sub-process as pertaining to one of the four categories. After the activities and sub-processes have been categorized it is possible to assess how well the process actually works according to the plan-do-check-act philosophy. This analysis can then be used as a basis for determining where and in what way efforts should be made in order to improve the performance of the process. If the analysis, for example, shows a lack of checking activities or planning activities it is possible to draw conclusions on how the process can be changed to better address the issues and problems with the current process performance (Ljungberg & Larsson, 2001).

All of the presented methods for analyzing processes have their own relative strengths and areas of usefulness. The bottleneck analysis can be used to identify areas in the process limiting the performance in order to attack the right areas first. The root cause analysis can be used to identify the true causes of problems in the process so that you can eliminate the problems instead of fighting symptoms. The value analysis is useful for categorizing the activities of the process so that waste can be eliminated and efficiency can be increased. The PDCA-analysis can be used to identify areas of
weakness in the process so that it is possible to identify what kind of activities might be added to the process to increase efficiency. The best solution to improving process performance is of course to use a combination of different analysis methods and make use of their different strengths.

3.5.3 Continuous improvement

Once a balanced and strategy-aligned performance measurement system, which is discussed in section 3.6, has been successfully implemented it is possible to actually assess how well the business is performing, but this does not mean that everything is well and all work is done. It is now that one truly has the prerequisites for improving business performance. There are principally two different approaches to improvement; either you perform big radical improvement projects or you employ an incremental long-term process of continuous improvements. While radical improvement in the form of technological breakthroughs and restructuring of entire organizations can be highly beneficial, and sometimes absolutely necessary, they can also be quite disruptive and require large investments. This is one of the reasons why continuous improvements have gained a lot of attention from businesses (Slack, Chambers, & Johnston, 2007).

Continuous improvement is certainly not a new concept. While originally developed in the US, it was the adaptation and development, and success, of the concept in the Japanese industry that really made it catch on in western industries as well. Today continuous improvement programs and tools are very commonly implemented in all kinds of businesses as a means of becoming more competitive. The concept has however not yielded the same successful results in western industry as it has in Japan. This is most likely due to the fact that successful implementation is often hard to achieve, as it requires commitment from management and employees, a change in the mentality of everyone involved as well as long-term continuous work. Despite the fact that continuous improvement is not an easily achieved quick-fix, the benefits of a successful implementation are substantial and it is for this reason that continuous improvement is, and should continue to be, a focus of business performance improvement programs (Nilsson-Witell, Antoni, & Dahlgaard, 2005; Bergman & Klefsjö, 2007).

A few examples of commonly used tools associated with continuous improvements are presented below with a short description of the basic idea behind it:

- **PDCA**
  The PDCA-cycle, or Plan-Do-Check-Act-cycle, is a systematic way to achieve continuous improvement. This is accomplished by following the four steps of the cycle. When a problem has been identified the first step is to plan how this problem is going to be solved. When the appropriate measures have been decided on, the next step is to implement, do, these measures. After implementation it is important to thoroughly investigate, check, whether the desired effects have been acquired. The fourth step is to act according to the results of the previous investigation (Bergman & Klefsjö, 2007). This tool is a very useful one as it is well known, easy to understand and clearly shows the cyclical nature that needs to be affiliated with continuous improvements. It is also easy to create your own customized improvement-cycle following the Plan-Do-Check-Act formula.

- **5 Why**
  The 5 Why concept, previously presented in section 3.5.2, is a simple but effective concept for identifying the true causes of a problem. It is one of the classic tools used for practical
continuous improvement work, as it is easy to employ in any part of an organization and can be conducted by anyone, at any time. (Ståhl, 2011; Moore, 2006).

- Ishikawa diagram
  The Ishikawa diagram, or fishbone diagram, previously presented in section 3.5.2, is a simple method for finding the root causes to problems in a process. This is also a very effective tool for practical implementation of continuous improvement efforts (Ståhl, 2011).

- SMED
  SMED stands for Single Minute Exchange of Die, and is a continuous improvement tool which is specifically designed for a manufacturing process where the goal is to reduce the setup time for a machine to less than ten minutes. The general idea, to locate areas within the process which can be streamlined to improve the overall efficiency, can however be applied to any kind of business (Ståhl, 2011).

- 5S
  The name 5S comes from five Japanese words beginning with the letter s. The five words tell us to organize, tidy up and get rid of all unnecessary equipment, create standardized ways of working and show discipline to maintain this way of working. The general idea of the concept is to create a good working environment which will make work more efficient (Ståhl, 2011).

All of these tools differ slightly in focus, but they all share the same common philosophy which is what continuous improvements are all about. The idea is simply to identify and visualize problems, find the root causes to these problems and subsequently solve them. This is how you achieve improvements in your process and the most important thing is not what tools you use, since there are already many available and more are still being developed. What is important is that, based on the specific process, a suitable combination of tools can be chosen to achieve continuous improvements in any organization.

### 3.6 Performance measurement

Performance measurement is an important aspect in the operation, evaluation and improvement of businesses. Before an organization can improve its operations it must know how well it is currently performing. Only then will you know which parts of your operations should be prioritized for improvement. Needless to say is that a means of measuring your performance is absolutely essential for any business (Slack, Chambers, & Johnston, 2007).

Historically, business performance measurements have been heavily focused on a financial perspective. These traditional measurement systems, which date back to the late 19th century, were developed, based on accounting systems and revolved around measures such as profit, return on investment and return on equity. However, in the late 1970s and through the 1980s a lot of things changed in the field of performance measurement. A large number of scientific papers were published, criticizing the traditional performance measurements for their many flaws and identifying why they were not appropriate for effectively managing a modern business. It was stated that traditional financial performance measurements encouraged short-termism and local optimization as well as lacking relation to strategy and counteracting work with continuous improvements. As a result of this criticism a variety of new, more “balanced”, performance measurement systems were proposed which utilized a combination of different measures both financial and non-financial in nature. This new philosophy in performance measurement system design aims at offering managers a more holistic view of the organization and the environment in which it acts. Some famous
examples of these new measurement systems are “the balanced scorecard” and “activity based costing” (Bourne, Mills, Wilcox, Neely, & Platts, 2000; Ghalayini & Noble, 1996; Taticchi, Tonelli, & Cagnazzo, 2010).

The need for a balanced performance measurement system is, as mentioned, well documented. But how does one design such a system? How many measures should be used and how does one identify which measures to be used? There is a lot of literature available, where different methods for answering these questions are presented and there is of course no one best way to design a performance measurement system. It is however generally agreed upon that “measures should be derived from strategy” (Bourne et al., 2000, p.757), and the importance of having alignment between an organization’s performance measurement system and corporate strategy has become a core aspect of performance measurement methodologies. “A performance measurement system aims to support the implementation and monitoring of strategic initiatives. The definition of performance measures and the setting of targets for these measures are concrete formulations of the firm’s strategic choices.” (Wouters & Sportel, 2005 cited in Johnston & Pongatichat, 2008, p.943). This of course also means that, when implemented, it is important to regularly review the measurement system and its alignment to strategy. If shift in strategic focus is not followed by revision or changes of the performance measurement system alignment is lost and measurements lose their meaning. In fact; if alignment is lost measuring can even become counterproductive as conflicts arise between following measures or strategy and a whole new set of problems have to be dealt with (Johnston & Pongatichat, 2008; Bourne, Mills, Wilcox, Neely, & Platts, 2000).

Another challenge one faces when designing a performance measurement system is the selection of different measures that have been identified as relevant to measure. These measures will vary from very detailed, such as rejection rate for a specific machine, to more high level measures, such as overall performance of the production unit. The solution to this challenge is to create a balanced performance measurement system containing a few key performance indicators, or KPIs, clearly related to operational strategy as well as a number of more detailed measurements which will allow for a richer, more nuanced picture of the different aspects of an operations performance (Slack, Chambers, & Johnston, 2007).

The approach when measuring processes is very much the same as when it comes to general performance measurement. What is needed is a balanced measurement system and, as always when it comes to processes, a holistic view when designing, implementing and evaluating this measurement system. When measuring processes it is of the utmost importance that a process-based view is the foundation for all work with the measurement system. In other words you need to have a structured, process-based, method for developing and using a process performance measurement system if you wish to make full use of its potential (Ljungberg & Larsson, 2001).

3.7 Organizational structure

The importance of having an organizational structure which is aligned with the way the organization operates is immense. If the organization is not structured in a way that allows it to achieve its purpose it has no chance to succeed. One must therefore carefully consider how to organize a company in order to allow for the company to perform in a desired manner (Ljungberg & Larsson, 2001). In this section a number of ways to structure an organization will be briefly presented and discussed in order to explain how organizational structure relates to, and is suited for, different ways
in which businesses operate. This includes whether the organization is small or large, local or global, deals with mass production of single products or unique projects and if the organization employs the concept of business processes or not. First a set of functional-based organizational structures will be described in a simplified form and then more emphasis will be put on explaining the process-based organizational structure and what sets it apart from the other organizational structures.

3.7.1 Functional-based organization

The traditional way to structure a company has its roots in the industrialization of the 18th and 19th century and is referred to as the functional-based, or hierarchical, organization. This form of organizational structure focuses on a clearly defined hierarchical structure as well as a clear definition, and division, of responsibilities. The purpose of this structure is to create an easily manageable organization where each function is responsible for its own area of operation. This specialization and focus within each function provides an environment where expertise is allowed to develop. Due to the clearly defined duties and responsibilities of each function, the organization is also less dependent on individuals. The separation of the organization’s different functions can unfortunately also lead to an inflexible and sluggish organization where sub-optimization can often occur, especially when the organization grows larger (Ljungberg & Larsson, 2001; Becker, Kugeler, & Rosemann, 2003; Johnson, Scholes, & Whittington, 2009).

Figure 17. Schematic representation of a purely functional-based organizational structure. (Johnson, Scholes, & Whittington, 2009)

This, most basic, way of structuring an organization according to its functions is visualized in Figure 17 and is most often found in, and is most suited for, smaller companies operating on a single site. The purely functional-based structure is not a suitable choice when the organization is large in scale or diverse in its markets and product ranges. Because of this, similar ways of dividing organizations based on attributes such as geographical location, type of product or type of customer have been devised. This type of structure is called a divisional organization and can be seen in Figure 18 (Campbell & Craig, 2005; Johnson, Scholes, & Whittington, 2009).

The divisional organization is a way to structure larger organizations which often operate globally and within several different business areas. Essentially it is a functional-based organization on a larger scale where each business unit, or division, works as a largely independent organization. The different divisions are connected mainly through the common administrative functions and it is relatively easy to remove or add new divisions. Each division can, in turn, employ a functional-based structure or be composed of its own subdivisions. The strength of the divisional structure is that each division can be customized to fit a certain market or business area, thus increasing the customer focus, and it is easy to assess every division’s performance individually. In addition, the divisional organization can result in decentralized decision-making, higher flexibility and reduced bureaucracy.
as well as reduced costs for coordinating different business functions. Just as it did in the functional-based organization, the separation of the divisions can also lead to sub-optimization due to lack of communication, cooperation, sharing of knowledge and focus on common goals (Ljungberg & Larsson, 2001; Becker, Kugeler, & Rosemann, 2003; Johnson, Scholes, & Whittington, 2009).

Partial divisionalization is sometimes employed as a means of restructuring when a completely divisional organization is not possible to achieve. This way the organization can still benefit from the advantages of the divisional organization even though some common functions still exist (Ljungberg & Larsson, 2001).

The matrix organization, Figure 19, can be seen as a mix of a functional-based, or divisional, and a project-based organization. The functions of the organization still operate separately, but cross-functional project teams, task forces, or different product groups work horizontally across all of the different functions. A matrix organization can be structured in different ways, with emphasis being placed on either the functional or the project aspect (Slack, Chambers, & Johnston, 2007; Ljungberg & Larsson, 2001). This form of organizational structure is one way of better utilizing the resources within a functional or divisional organization. It helps to promote cooperation and communication within the organization and allows the employees to be flexible and make good use of their competence. A matrix structure is also adaptable to suit an organization’s specific needs over time. Negative aspects of the matrix organization are that confusion regarding responsibility and accountability can occur and that the number of managers will increase which can create conflicts and frustration (Ljungberg & Larsson, 2001; Campbell & Craig, 2005).

Figure 18. Schematic representation of a divisional organizational structure. (Johnson, Scholes, & Whittington, 2009)
The project-based organization is a highly flexible organizational structure where employees with different specialties are allocated to project groups. Each project group is responsible for its specific project for its entire duration and all members of the group report to a project manager rather than several different functional managers. The purely project-based organization is assembled in order to solve a specific task or project and is therefore, most commonly, a temporary structure. If the organization handles similar and recurring projects, and becomes more permanent, it will often drift towards the matrix structure described above. Benefits of the project-based organizations are focus on value adding activities, flexibility and customer satisfaction. Two common negative aspects are difficulties in working with continuous improvements and transferring knowledge from project to project due to the temporary nature of working with projects (Ljungberg & Larsson, 2001) (Slack, Chambers, & Johnston, 2007).

In the process-based organizational structure processes are the basis for all things pertaining to the organization. Every facet of how the organization is structured, managed, developed and viewed is tied to the process-based view. The process-based structure is generally a less hierarchical structure than the traditional function-based. There is of course still a need for some level of hierarchy and defined chain of report, but overall the number of managing positions is reduced and more responsibility is put on the remaining staff. This means that the operational work in the process-based organization increases in complexity and magnitude and high demand is put on the competence of the employees. This demand in competence along with a desire for good communication, a holistic view and synergetic effects are all reasons why the operational work in the process-based structure is team-based. Operating in cross-functional teams ensures that many different areas of expertise are combined and every complex task can be managed. Another effect of this horizontal approach is that customer focus is increased (Ljungberg & Larsson, 2001).

### 3.7.2 The process-based organization

The process-based organization is more than just an organization structured in a certain way. It is an organization built around the process-based view. The business is thought to be composed of a network of processes and focus is put on horizontal, cross-functional, value creation rather than vertical, functional or hierarchical, division of responsibilities. The process-based organization is
customer focused; the aim of the process is to turn customer need into customer satisfaction (Ljungberg & Larsson, 2001).

The process-based organization also demands a different kind of leadership structure than what is predominantly used in organizations today. Ljungberg and Larsson (2001) describe three different managerial areas of responsibility that has traditionally been different aspects of every manager’s work. In the process-based organization these areas correspond with three different leadership roles, namely the process owner, the resource owner and the team leader.

The main responsibility of the process owner is to develop and improve the process. This is no small task and it is of high importance that the process owner is a process expert and has a holistic view. Each improvement or change in any process must be designed so as not to favor the performance of any single process, but constantly looking to increase the performance of the system as a whole. The process owner must also maintain the process and make sure that everything is running smoothly. To summarize, the process owner can be seen as operating largely on a strategic level, responsible for ensuring long-term effectiveness and efficiency of the process as a whole (Ljungberg & Larsson, 2001).

The resource owner is responsible for providing the process with the required resources. This also means that the resource owner needs to look at future resource needs for the process as well as develop and maintain the resources currently possessed. Resources refer to the personnel, machinery and equipment of the organization, but also very importantly to the competence of the personnel. An important aspect of the resource owner’s role is to acquire new competence by hiring new personnel and continuously developing the existing personnel. Due to the many different kinds of resources needed for a process to function there is a need for several different resource owners in any larger process-based organization. Each resource owner has its unique qualities and is suited for handling different kinds of resources all of which are of critical importance for the performance of the processes (Ljungberg & Larsson, 2001).

Team leaders are responsible for leading, coordinating and supporting the resources allocated to a specific process in the operational work. The team leader has a close relationship to the personnel and acts as a line of communication between the personnel and the management. It is the team leader’s responsibility to convey the process goals and visions to each individual and make sure that the process view is present in all areas of the process. An important part of the team leader’s role is to make sure that the team develops over time and functions as a team and not just a group of people working in the same place (Ljungberg & Larsson, 2001).

As stated earlier in this section, it is important that an organization is structured in a way that is aligned with the overall business idea and corporate culture. When an organization has decided to work with the process concept it is therefore important that the organizational structure is aligned with this, instead of being an obstacle to overcome. Because of the vast differences in general philosophy, a functional organizational structure is not suited for a process based organization. A structure more along the lines of the matrix organization or the project based organization is more suited due to their orientations towards cross-functionality. What these organizational structures lack is the holistic approach to working with processes which is found in, what Ljungberg and Larsson (2001), refers to as the process-based organization. This organizational form is designed with processes in mind and deals not only with pure organizational structure, but also with the corporate
culture and mentality which is needed to successfully work with processes. Because of the complete solution, containing both a cross-functional structure and a focus on enabling a process-based view, the project-based organization is the most suitable organizational structure for a company which is trying to be process-based (Ljungberg & Larsson, 2001).

The topics discussed in this chapter forms the basis of the theoretical frame of reference, visualized in Figure 9. The next chapter will present the empirical study that was carried out at Volvo Buses. Here the Product Development process will be presented along with descriptions of the roles of the users of the process. The findings of the empirical study and the theoretical frame of reference together found the basis of the analysis in this study.
4 Empirical Study

In this chapter the Volvo Global Development Process will be presented along with the roles of people and groups acting within this process. Next the process of Prototype Build and Test is presented and finally an in depth description of the process for material supply is given, as this is where the focus of the study is put.

4.1 The problems Prototype Build and Test are facing

Volvo Bus is an organization that is working according to a process based view and possesses a company-wide process, stretching through the entire company with various levels of detail. For the Global Development Process mapping exists and PBT is a part of this process. However, when reaching the high level of detail needed to view PBT, the process map gets extremely insufficient and not detailed enough to include the process of PBT. In fact, when the study was conducted, no mapping of the PBT process existed on Volvos intranet at all. This leads to lack of structure in the department for PBT and results in their way of working not being in line with Volvo Buses process based view.

PBT is aware of their lack of process mapping and structure and with reduced lead times and increasing amount of projects a high demand is put on the organization being more efficient. PBT needs to develop a process map and change the way they work to be more in line with the rest of Volvo Bus. The incentive for Volvo to initiate this thesis was the possibility of receiving an improved process and organizational set up for PBT. At an early stage of the study it became clear that the main issue at PBT, an issue that eventually all interviewees in some level raised, is delayed and lost material. The core business for PBT is to build and provide a test object. Material constantly being delayed or lost in the adjacent buildings causes stagnation in build and delays entire projects. On that account, for PBT the most crucial process to map and improve in order to become more structured, hence efficient, is the process for material supply.

4.2 Empirical study in this thesis

The problems PBT are facing, in combination with the scientific approach for the study, forms the basis of which the empirical study is built upon. The empirical study is needed in order to investigate and analyze these problems and subsequently solve them. The scientific approach used for the thesis is the systems approach. The idea of the systems approach is that in order to understand any given phenomenon, it must be viewed as a system; hence one needs to use a holistic point of view. For this thesis this meant taking a step back to look at the department for product development which PBT is a part of. In any organization it is essential to have a common objective and goal regarding the process. Furthermore it is also essential to have a general and common view of roles and responsibilities within the organization. Therefore when collecting the empirical data the focus was to some extent put on ensuring that a common objective and view of the process and roles existed. Due to the identification of material supply as a key process to improve, much of the emphasis when making the empirical study was put on material supply.

The empirical study was structured to first gather, through interviews and observations, the data needed to understand the organization PBT, its purpose, input, output and the roles of the people acting within the process. After this the authors took the step back to retrieve the data needed in order to understand the entire process for product development, how PBT was situated in that
process, how it affects and is affected by PBT as well as the roles of the people acting within this process and interacting with the people of PBT. Finally the authors returned to PBT and, through additional interviews, retrieved all the necessary data to make a detailed mapping and analysis of the process for material supply.

The description of the Global Development Process, GDP, is largely based on documentation from Volvos intranet. The description of roles, the process of PBT as well as the process for material supply is based on data from interviews and observations. With respect to the anonymity of the interviewees no direct referencing will be used in the empirical chapter, but a list with names of all the interviewees can be found in Appendix A.

4.3 Volvo Global Development Process

The Volvo Global Development Process, GDP, is a product development framework developed for the Volvo group, based on past experience of product development and best practice processes gathered from all business units within the Volvo Group. The GDP is the basis for all development projects in all business areas and business units within the Volvo Group, and offers a structured way to plan and execute any development project. This common, structured, way to execute projects is essential for the success of Volvo’s product development. Not only is the GDP designed to assure effective product development and reduced lead times in single projects, but it also allows for effective cooperation and communication in shared projects between different business areas or business units. Yet another positive aspect of the GDP is that it drives improvements through sharing of experience, knowledge and best practice processes which can easily be adopted by all the organizations utilizing the framework.

The Volvo Corporate GDP is, what is referred to as, a maximum model. This means that it is developed to work for every project in every business unit or business area within the Volvo Group. In reality this means that the model needs to be applied differently to different situations and every business unit has a unique adaptation of the GDP which is tailored to fit the specific needs of that unit. While all these adaptations share the same common structure, they also add additional processes and different decision structures as well as case-specific information. The visual representation of the GDP can be seen in Figure 20.
4.3.1 Phases, gates and decision points of the Global Development Process

When studying the GDP overview in Figure 20 the overall structure is easy to understand, but the figure contains a lot of information which now will be explain in further detail. The GDP is split into six phases, where each phase indicates a different project focus. During the pre-study phase focus is put on establishing prerequisites and developing different concepts in order to define the projects scope. When the project moves on to the concept study phase the different concepts are analyzed and a concept is chosen for development. The detailed development phase is focused around defining and consequently approving the solutions for the chosen concept. In the final development phase the previously approved solutions are built, verified, validated and refined into a product ready to go into production. The industrialization and commercialization phase is focused on preparing for the actual production of the product. The final phase of the GDP is the follow-up phase where a follow-up of the project is conducted in order to assess whether targets were met and requirements were fulfilled. Experience from the project is used to improve future projects as the line-organization takes over product responsibilities and the project is ultimately closed.

Along the six phases of the GDP there are a number of gates and decision points. Each phase starts and ends with a project gate. These project gates act as checkpoints along the project and in order for a project to pass through a gate a certain set of predetermined generic as well as case-specific criteria must be met. Decisions on whether to open gates or not are made by the Steering Committee. When the decision is made to move forward through a gate the project should already have made preparations for the next gate and updated the project documentation accordingly.

The project decision points are another type of checkpoints on the GDP where projects are evaluated from a number of different perspectives, such as corporate, strategic and profitability, to determine whether or not to continue with the project and green-light additional funding. This evaluation process is carried out by the project’s Decision Body. For decision points directly following project gates, the Steering Committee is responsible for preparing a recommended decision to the Decision Body before opening the gate.
4.3.2 Project organization
When describing the GDP we have already mentioned the Steering Committee and the project’s Decision Body, but we have yet to discuss how the project organization associated with a GDP project actually looks. The actual project organization will vary depending on the size and nature of the project, but it is generally comprised of four parts; the Decision Body, the Steering Committee, the Project Management Team and the Line Organization, as seen in Figure 21. The project is led jointly by the Project Management Team and the Steering Committee. The Project Management Team consists of a number of Project Managers led by a Chief Project Manager. The Project Management Team is responsible for running the project from start to finish. The Steering Committee is responsible for steering and supporting the project. They are also responsible for approving the appointment of the Project Management Team as well as its responsibilities, authorities and directions. As mentioned above the Steering Committee is also responsible for gate opening decisions. The Line Organization provides the resources and technical know-how needed to carry out the project and the Decision Body is responsible for deciding whether or not to continue funding projects and move forward.

4.3.3 Product development cycle
The development of parts in the GDP is done by moving through a number of stages of maturity. The relation between these stages of maturity and the phases of the GDP can be seen in Figure 20. The four stages of maturity are A, B, C and P where stage A is the creation stage, B is the verification stage, C is the tooling stage and P is the production stage. Before passing through the gates between different phases in the GDP all parts must have the right maturity level and all documentation must be updated accordingly.

4.3.4 Project time plan
Proper planning of time and resources is an important part of the GDP. Without a long- and short-term project time plan it is hard to efficiently run any project and in an environment when resources need to be shared between many different projects and lead times need to be kept short it is near impossible. There are several different levels of time plans, each with a different focus and level of
detail and an example of the relationship between the different levels of time plans can be seen in Figure 22. The level 1 time plan, or project main time plan, is the highest level and is created at a very early stage of the project by the Project Management Team. The main time plan is aimed at identifying the most important milestones and activities of the project in order to get a view of the project as a whole. This way you can identify the critical path of the project and it is possible to plan ahead. The level 2 time plan is a more detailed plan, typically identifying when activities need to be carried out in the line organization in order to meet the requirements of the main time plan. A level 3 time plan is an even more detailed plan highlighting when and in what order a specific function or team within the line organization needs to carry out its activities to meet the requirements of the level 2 time plan. The level 3 time plans should be used as input when creating the level 2 time plan, thereby making the requirements of the level 2 time plan originate from the level 3 time plan. How the time plan is broken down in a specific project is heavily dependent on the size and scope of the project as well as the organization within the project. All time plans are continuously updated throughout the project and because of the relation between the different levels of time plans it is important to be aware of how changes in the time plan will affect other plans. The steering committee is ultimately responsible for the approval of the project time plans.

![Figure 22. Example of the hierarchical relation between different levels of time plans. (Volvo Bus intranet, 2012)](image)

4.4 Roles within the process for Prototype Build and Test
In this section each functional group or role within PBT or that is interacting with PBT will be described on the basis of the information collected through interviews and observations. The description of each role is based on interviews of at least one employee occupying that role and the data retrieved from interviewees working closely with and constantly interacting with people in that role.
**Chief Project Manager – CPM**

In product development several projects are active at once. For each project a Chief Project Manager, CPM, is accountable. The role of the CPM is to manage a project from the very beginning, in the pre-study when the project is started by a pre requisition, throughout the whole project until the final project termination. The responsibilities of the CPM is to run the project according to the project documentation, with a certain budget, time frame and requirements on quality. The CPM is also responsible for making sure the project is run according to the GDP process, following instructions, standards and other system guidelines and processes. Product development is just a small part of the duties of the CPM. The CPM works with and has responsibility towards purchasing, quality, the market, the production and certifications as well.

The CPM is responsible for the main time plan. In this plan the needs of each function group involved is considered on a rough level to meet the scope of the project. The CPM is not in charge of the specific time plan for each project. The main time plan is subsequently refined to include the components, systems and the tests that are to be made on the test objects. With this information as input the TPM can with help from the Test Leader create the level 2 time plan and subsequently provide the information about needed number of test objects.

**Technical Project Manager – TPM**

The Technical Project Manager, TPM, is responsible of leading coordinating and planning the technical projects i.e. is responsible for the technical development part of all deliveries from product development, with the exceptions of quality, homologation and certifications. The TPM is involved in the product development process all the way from the pre-study until the product goes into production. The TPM is the manager of a group, composed of Design Engineers, Test Engineers and Component Responsible, which works with a certain project within product development. In collaboration with the Design Engineers and the Test Engineers the TPM defines the test object, within the scope of what it is and what should be included. The Design Engineers define what needs to be tested and a Test Leader connects all test requirements and help determine what kind of test object is needed and how many.

Another task the TPM is responsible for is to break down the main time plan into a more detailed level 2 time plan covering when a test object or part is needed and when activities need to be carried out in the line organization. When setting the time plan a dialog is held with Construction Group Managers, the Workshop Manager and the Purchasing Project Manager in order for the time plan to on a rough level comprehend the scope of activities.

**Design Engineer**

The Design Engineer’s role is to design components and to specify material and keep material specifications updated. The Design Engineers are involved in a new project from early on, in the pre-study. In this phase the Design Engineers are mainly involved on a virtual idea stage. Once the project gets fully started the Design Engineers are involved in determining what should be developed, what components should be included and what needs to be tested. This is done and a concept is developed. A certain Design Engineer is often dedicated to one or a number of specific projects and specializes on specific components. The main responsibility of the Design Engineers is to design the components and to specify the articles in Kola. Kola is a construction data system that the Design Engineers use to create material specifications in for all the projects. Component responsible Design Engineers have the responsibility to compile a Bill of Material, BOM, for each functional group. This is
done via Kola, which transfers the data to a system where the Material Coordinators can retrieve it. Eventual changes in the specifications are done in Kola and should be noted in PROTUS. PROTUS is the prototype follow up data system where all the prototype data and the status of buses should be updated and retrievable at all time. Responsible for this is the component responsible Design Engineer.

When the specification is finalized the component is either ordered from a supplier or built in the workshop. The involvement of Design Engineers in the construction work varies and no clear structure for this exists. Since the Design Engineer possesses all the requirements on what should be tested they are also somewhat involved in the testing process. Finally the components go into production, still with a responsibility on Design Engineers to make any eventual adjustments or updates needed.

**Purchaser**

Each project has a Purchasing Project Manager, PPM. This person is a representative for the purchasers in this project and is responsible for all activities surrounding purchasing, such as sourcing, supplier selection, ordering and making sure that the right things get delivered. The PPM is involved already in the pre-study to make estimations regarding lead time and costs. The PPM is also involved when making the time plan and contributes with knowledge about lead time.

The purchaser’s role is to select suppliers, order prototype parts, standard articles and tools. They get involved in a project when it is time to order the stage B maturity prototypes and are then often needed throughout the whole project to order new parts or tools. The responsibility of the purchaser is to place the order with enough margins for it to be delivered according to the time plan. The purchaser’s responsibility ends once the order is placed according to the time restrictions and the responsibility is moved on to the Delivery Coordinator. If an order is delayed for more than a week the purchaser will contact the supplier.

**Management Team of Prototype Build and Test**

At PBT a group of four people compose the management team. The team consists of the head of the PBT department, her assistant, the workshop group manager and one of the Project Vehicle Managers. In this group one person from Material Supply and the manager of Measuring and Testing Technology are somewhat involved as well.

The head of the department has the ultimate responsibility for PBT and her role is to make sure that the objectives of the management are fulfilled and to make the budget for projects within PBT. The assistant of the head of the department is mainly responsible for IT and administrative work tasks. The role of the workshop manager and the role of the PVM will be explained in detail below.

**Project Vehicle Manager – PVM**

Project Vehicle Manager, PVM, is a relatively new role and there are currently a handful of them at PBT. The main role of a PVM is to act as a project manager and coordinator in projects and to make sure that the constructions of prototypes proceed. The PVM has an overall responsibility for the construction process of the prototype buses and all the prototype build activities from definition of test object until the test object is ready and prepared for testing. The PVM is responsible for coordinating design releases, material supply, resources and test objects to ensure that they are all in place and on time. The coordinating of information and resources in the process is done in order to
facilitate the construction process and to make sure that the time plan is followed. The other actors of the process within PBT are responsible for sub-areas while PVM should make it all work. To summarize, the PVM is responsible of having a proper bus available for the projects.

The PVM becomes involved in the pre-study when the planning of the project starts and is involved in planning all the activities related to construction. The responsibility of the PVM does not start until the designs enter stage B maturity. The PVM start planning the construction when the detail is designed and it is known what should be tested. In this phase the PVM will develop the time plan on a more detailed level. A responsibility that is unclear to whom it belongs to is the responsibility for updating PROTUS. However, at the moment the overall responsibility for keeping PROTUS updated and maintaining a documented view throughout the entire project lies on the PVM. The PVMs responsibility ends when stage C has been validated.

Each PVM is assigned to one or several projects and each project can have one or several PVMs assigned to it. Due to the organization being a product development organization each project is unique and the work tasks and the work method change among the PVMs.

**Material Coordinators**

At PBT two Material Coordinators work in the material supply process with placing the purchase requisitions to the purchasing department. A Material Coordinator is involved at the beginning of a project and advices on the order the Design Engineers should design the parts, based on lead times. Their work starts with the first purchase requisition of a project and continues throughout the entire project as new requisitions constantly needs to be placed. Material lists of parts to be requisitioned are retrieved from PROTUS and subsequently the Material Coordinator places the requisition in SAP. To keep track of the status of the material the Material Coordinators create sheets in excel and use color codes; yellow – sent requisition, green – delivered material, red – delayed material. Throughout the project the Material Coordinator is participating in construction meetings to keep updated on what material should be purchased.

**Delivery Coordinator**

The Delivery Coordinators role is to monitor the deliveries. One person is responsible for delivery control of the prototype material and another for standard material. When the purchaser places an order to a supplier, the order will be sent to both the supplier and the delivery coordinator. After the suppliers get the order they make the order acknowledgement and the goods should subsequently get delivered. On the expected delivery date the Material Coordinator color codes each material based on whether the material was delivered or not.

The delivery coordinator’s responsibility is to retrieve the lists of delayed goods, i.e. material with red color code, from SAP. Then the delivery coordinator will look for the order in her e-mail inbox and control the order acknowledgement. The supplier is then contacted to find out if the material has been sent and when. If the material has not been sent the supplier is asked to confirm a new delivery date. If the material has been sent from the supplier the material coordinator must try to find out what happened with the material and where it could be. The delivery coordinator is also responsible for informing about the delay.
**Warehouse Personnel**
The role of the people working in the warehouse is goods receiving and warehousing. Their responsibility is to take care of delivered goods i.e. receiving and put-away and make sure it gets stored in the right storage location. To facilitate the warehousing a SAP system is used to confirm the receiving of goods and keep track of storage locations. When the goods are reported in the SAP system an auto email is sent to the Material Coordinator who placed the requisition, to make it possible for them to put a green color code on the delivered material. The responsibilities the warehouse personnel have for the material end when the goods are received and put-away on the right place. Another work task the warehouse personnel perform is to pick articles when needed in construction, but this is not done exclusively by the warehouse personnel.

**Workshop Mechanics**
The workshop consists of 22 workshop mechanics with different areas of expertise and a Group Manager. The Group Manager is a participant of the Management Team of PBT and he is responsible for the resources and the equipment in the workshop. The Group Manager assigns appropriate mechanics to construction work and employs new personnel. He is also responsible for ensuring that the workshop possesses the right equipment and instruments and is in charge of purchasing new equipment.

The Group Manager is the person who makes the level 3 time plan for the construction work in the workshop and provides the PVM with information concerning the resources and time needed for the construction work. The Group Manager also communicates and exchanges knowledge with other actors of the development process and especially the Design Engineers.

**Measuring and Testing Technology**
Measuring and Testing Technology is a small group of two full time employees. The group has a supporting role and provides support for ongoing tests and is responsible for storing, tracing, maintaining and procuring measuring equipment.

The group provides support concerning tests mainly to the Test Engineers, but also to Design Engineers and Workshop Mechanics. Before the testing they support the Test Engineers and Design Engineers by providing knowledge on what measures to do, if measures are possible to do, how to measure things, how to use the equipment and if it has been done before. During the mounting of tests they support the Workshop Mechanics. During and after the test they support the Test Engineers by contributing with knowledge helpful in the analysis. This guidance is only on a verbal level and not performed in a structured way.

The group stores the equipment with full traceability and has information regarding who used the instruments and when. They send the measuring equipment for calibration to ensure the quality of the measurements in tests and are responsible for tracing potential faulty measurements if the equipment was not reliable when the tests were performed. The people of the group are experts on the measuring equipment and also develop some equipment on their own. The equipment they develop on their own is often aimed to facilitate repeatability in the testing i.e. support equipment and adaptable equipment.
Test Vehicle Support

Test Vehicle Support is a group of three people whose role is to answer for and provide the test objects, i.e. the vehicles. They serve all of Volvo with buses and transports. The test vehicle support group is responsible for administering tax, insurance and logistical issues concerning the existing buses as well as the purchasing of new buses. They retrieve and deliver the buses from and to tests and other sites.

4.5 The process for Prototype Build and Test

In this section the process for PBT will be presented with an emphasis on where different players become involved in the process. The PBT process should however not be seen as an isolated process, but rather as an integrated part in the bigger process of product development within Volvo Buses. To describe the PBT process one should therefore start at the beginning of the entire process. It is also important to note that the different product development projects carried out at Volvo Buses vary greatly in size and scope which affects how the project is carried out in more detail. The following process description should therefore be seen as a general process description which will work somewhat differently in different projects.

The product development process starts with advanced engineering or a customer coming up with a new idea or a demand from the market which creates a need for a new project. This takes place before the start of the GDP. If the decision is made to initiate a new project, the project starts up according to the GDP with a pre study. Here a Pre-study Leader, a CPM and one or more TPMs are assigned to the project. At this early stage of the project the Pre-Study Leader is mainly responsible while the CPM assumes full responsibility of the project when it passes into the concept study phase. During the pre-study phase the CPM starts working with the projects main time plan identifying the main activities and milestones of the project. When the pre-study is done the project moves on to the concept study and real development of parts, with stage A maturity, begins. The main time plan gets further developed and once it has been properly defined work also starts with breaking it down into a level 2 time plan, where the activities along the project can be planned in more detail. The creation of the level 2 time plan is performed by the TPM with input from the persons responsible for the different functions within the line organization. Throughout this early time planning PBT is naturally involved in order to plan its own activities and advice on the estimated time it will take to perform stated activities. Within PBT a more detailed time plan is also created and it is the responsibility of the PVM to coordinate and ensure that all the different level 3 time plans are provided for the level 2 time plan and synchronized and updated in order to create the overall time plan of PBT.

When parts reach a maturity level where validation through prototype building and subsequent testing is needed the Design Engineers need to update and finalize the material specification in Kola and synchronize it with PROTUS. It is at this point that PBT become directly involved in the process. During this phase of the project many parallel activities, involving all of the functional teams within PBT, are carried out. These activities involve the ordering and subsequent receiving and handling of parts, planning and execution of the actual prototype build in the workshop, development and preparation and subsequent installation of measurement equipment for the tests. The task of coordinating all these activities falls on the PVM.
When the material specification is finalized in Kola and a part is ready to be ordered the material coordinator retrieve the associated bill of material, BOM, from PROTUS and subsequently creates a purchase requisition in SAP where it is accessible for the purchaser. The material coordinator also creates lists of the materials associated with certain builds in a certain project and this list is used to keep track of the status of these parts. When the purchase requisition reaches the purchaser the process of placing the order is initiated, the purchase system used by the purchaser for ordering is called GPS. When the order has been confirmed by the supplier all that is done is waiting for materials. When the ordered parts arrive at PBT they are handled by the warehouse team. The parts are goods received and put into storage or are taken directly into an ongoing build if the parts are needed directly. If the material is not delivered in time the Delivery Coordinator takes over the responsibility of the ordered parts.

The building process is initiated by a work order in which it is stated what is to be done and in what time frame. The building process starts at the start date of the order when the right bus and material is received. The first step in the process is often to make preparatory work on the chassis that are to be used for the prototype, in anticipating of material. The preparatory work involves removing all old parts, such as engines, consoles and other parts, which are to be built and tested in the specific project. When the preparatory work is completed the bus chassis is ready for the actual build. At this point the ordered building material should have arrived and other parts that are made by the workshop mechanics themselves should be ready and the prototype building can commence. The first step is generally to adjust and complete the frame as well as constructing new consoles. When this is done the new electrical system and new software is installed. After this the remaining parts are installed. Throughout the process of building measurement equipment is continuously prepared and installed on the desired parts before the parts are built into the bus.

When the tests are all mounted, the construction of a bus is completed and it is presumed ready for testing the PVM, TPM and Test Leader hold a sign-off meeting to assure that the bus meets the project requirements and prerequisites. When the sign-off is completed and the bus leaves for testing PVM is still accountable for the bus, but the direct involvement of PBT ends. It is common that workshop mechanics are involved in the testing in case anything should break.

4.5.1 The process for material supply
The process for material supply is first initiated when the constructor has finalized the material specification in Kola and the associated BOM consequently is retrievable for the Material Coordinator from SAP. With the BOM as input the material coordinator create material lists, consisting of the material that are to be purchased, considering the lead times for all the material. With this list as input the material coordinator can then put the purchase requisitions on the right time in SAP where it is transferred into GPS, the system used by purchasers who subsequently place the order to the supplier.

The material coordinator also creates lists of the materials associated with certain builds in a certain project and these lists are used to keep track of the status of these parts. After the order has been placed, the material coordinator updates the material lists and put a yellow color code on all the ordered material. Next an order acknowledgement is received from the supplier saying that the material will be delivered on time or not. If not, the supplier proposes a new delivery date and the delivery date on the material lists is manually updated by the material coordinator. When the order

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acknowledgement has been received nothing happens in the material supply process until the day the material should be delivered.

The ordered parts can be delivered to the warehouse and handled by the warehouse personnel who goods receives the material and puts it into storage. Alternatively, material will bypass goods receiving and be taken directly into an ongoing build if the parts are needed directly. Very often the material will, however, bypass the warehouse completely and get delivered directly to a design engineer, meaning that the material will not be properly goods received. As the material gets goods received an e-mail informing that the part is delivered is automatically sent to the material coordinators. This triggers the activity of updating the material lists executed by the Material Coordinators. The material lists are updated and a green color code is put on received material whilst a red color code is put on materials that are not goods received on its delivery date. The output of the material supply process is the material and the material lists that are subsequently presented to build.

The materials that obtain a red color code and consequently are not goods received on time will get handled by the delivery control. The delivery control starts when the material has obtained a red color code and is already late. The delivery coordinator extracts the lists of red color coded material manually and therefore it can take up to two weeks until the delivery control of delayed material is initiated. Then the delivery coordinator will look for the order in her e-mail inbox and control the order acknowledgement. The supplier is then contacted to find out if the material has been sent and when. If the material on the other hand has not been sent and remains with the supplier a new delivery date is decided. In those cases when the material has been sent from the supplier the material coordinator must try to find out what happened with the material and where it could be. Three possible scenarios now exist. The first scenario is that the material never got delivered to PBT and got lost somewhere in the distribution process. The second possibility is that the material has been delivered to PBT but was taken directly into build. The third one is that the material was delivered to PBT but to some other location than the warehouse, hence was not goods received. Among these three alternatives the two latter ones are the most commonly occurring.

This chapter described the processes and users of the processes that were studied in this thesis. The data obtained from the empirical study is now to be used to make an adapted map of the GDP, to map the core processes, material supply and build. After the processes have been mapped, the process for material supply, the roles of the people working within it as well as the effects the material supply process has on the build process will be analyzed. Subsequently improvements will be made on the material supply process and the effects of the improvements on both core processes will be discussed and visualized in process maps. In addition the data not directly related to the material supply will be analyzed and problems and improvement proposals for the entire process will be presented.
5 Analysis

This chapter analyzes Prototype Build and Test’s current situation, with emphasis on the process for material supply. The analysis is based on the empirical data presented in chapter 4 and the frame of reference in chapter 3. The analysis of each problem area is presented through process mapping, where applicable, and analysis of the current situation followed by improvement suggestions.

In order to improve the process of PBT it must be understood what it looks like at the moment, what the issues and problems of the organization are and then finding a solution to these problems. When working with processes one must first of all understand and have acceptance for process thinking and process orientation. Therefore the authors chose to start the analysis by investigating to what extent PBT was process oriented and what actions were needed to be taken in order for the organization to become more process oriented.

The purpose of the thesis is to map the process for material supply, analyze it and suggest improvements. Due to the importance of having a holistic view when working with process development, it was of great importance to understand the whole process of product development in order to take well informed decisions and to avoid local optimization of the material supply process. Therefore the whole product development process was mapped and analyzed first, even though the focal point of the thesis was the material supply. After this, the core processes at PBT were mapped on a more detailed level and analyzed. The core processes at PBT are material supply and build. In order to highlight the main area of focus for this study the authors chose to present the analysis and suggestions on how to solve the problems of the PBT core processes first. This was done with a clear focus on material supply and the effects material supply has on the build process. Finally the problems found in the entire Product Development process and the organizational structure was analyzed and solutions to the problems were suggested.

5.1 Process orientation at Prototype Build and Test

For an organization to get the most out of working with processes, it is most important that the organization and its employees are process oriented. If the process is simply a concept which is enforced without full understanding or commitment by the employees it will most likely not yield the desired results. Volvo, as a company, has the ambition to be a process-based organization. The company has made big efforts to develop and implement business processes, like the Volvo Corporate GDP, and most of the company’s processes have been thoroughly mapped. On this level Volvo is process oriented, but process orientation is not all about having well designed business processes. For an organization to be fully process oriented it also requires employees who are process oriented and are committed to working with processes. Employees need to understand the process-based view and see the potential of working this way. Only then can the true benefits of the process-based organization be achieved.

5.1.1 Analyzing PBT process orientation

In theory for a process oriented organization the business processes are the basis for how the organization plans and runs its operation. But as mentioned above having structured and documented business processes does not make an organization process oriented. A process oriented staff is also needed and it is in this area that PBT and Volvo Buses have the most work left to do. In terms of theory, this is referred to as employees’ buy-in which is lacking in Volvo Buses. There are
still some organizational structure issues to deal with as the PBT organization is still very functional oriented, but a bigger issue is the fact that a large part of its employees are not process oriented at all. This becomes obvious as you interview the employees regarding their work and their view on the process. Most of the interviewees know of the GDP, but in many cases this is as far as their knowledge goes. Only on a few rare occasions did an interviewee actually try to explain their work by referring to the process. Furthermore it is clear that the general philosophy behind process thinking has not been properly communicated to the employees. There is an apparent lack of a holistic view and communication is also far from where it should be in a process based organization. When talking to the interviewees about what problems they can identify in the process they were often willing to share and highlight multiple problems. However, they most often only consider things are not their own responsibility and they show no real commitment or take on any responsibility to participate in solving these problems. This is a clear problem for an organization striving to be process oriented. While the employees have difficulty seeing how problems are their responsibility, they neither understand his or her value-add to the process which is crucial for the employees to possess a sense of pride. The employees need to understand their effect on the entire process in order to possess a process-based view.

An organization possessing a process-based view should also be customer driven. For PBT the direct customer is Volvo itself, thus, an internal customer. Due to this the communication with the customer is immediate, without detours and therefore satisfactory and better than for most companies with external customers. But one can always improve and for PBT to excel it is important to become more process oriented and for everyone working in the process to keep a customer orientation.

It is quite revealing that while the rest of the product development process is well documented, through process maps available on the Volvo Bus intranet, PBT has not been mapped at all leaving a gap in Volvos process documentations and this part of the process is inadequately defined. This is likely due to the fact that at the moment there is a lack of clearly defined process ownership. Without someone to drive process orientation and process improvement projects very little will get done.

In all fairness, some work towards becoming more process oriented has already been done and there are definitely employees within the organization who are onboard with the process-based way of working. The initiative for starting this thesis can definitely be seen as an attempt to become more process oriented. There is, however, still a long way to go before PBT can consider themselves fully process oriented.

5.1.2 Improving PBT process orientation
Derived from the analysis of the empirical data and the theory it is clear that in order to become more process oriented, PBT will have to undertake a long-term project. According to the theory on process orientation it is absolutely necessary to develop both the process and the process users, and not focus on one or the other. PBT should assemble their own process group who are responsible for structuring and driving this process orientation project. It is essential that everyone who is leading this project possesses a process based view and it is likely that education and process orientation work must start already at this point. The people leading the project must manage to mediate functional objectives to facilitate for new or existing activities to be integrated in the process. To be
able to conduct a project like this it is highly recommended that PBT enlist the help of process experts from within Volvo, who are used to conducting this type of work and are well acquainted with Volvo-specific process training, methods and other issues. This will most likely be the best way to ensure that the process orientation work will get done in the right way, with the best possible prerequisites.

The main target for the process orientation project should be to infuse a process based view into the whole of the PBT organization. According to theoretical evidence for process orientation the work should start by establishing clear process ownership. It must be clear who is responsible for developing and maintaining the process as well as who is responsible for developing and maintaining the personnel working within the process. On the process user side it is of great importance to inspire the employees to commit and actively take part in shaping, following and improving the process, by means of that getting employees’ buy-in. The only way to attain a fully process oriented organization is to have process users who realize what part their activities, actions and information exchanges play in the big picture. In other words; you need to have employees who see the system and not just their own functional silo and endow them with a sense of pride.

5.2 Process mapping
The GDP was mapped to provide the authors with a better understanding of the organization and subsequently the core processes of PBT, material supply and build, were mapped using the tools in theory section 3.4.

5.2.1 Mapping the Global Development Process
For the process of product development at Volvo, the GDP, a process map already existed. Therefore the mapping of the GDP was not conducted with the actual map as the desired outcome, but merely to create an understanding of the process and to provide the authors with the data and information required for the analysis. The mapping of the process was based on data extracted from the existing process map as well as interviews with the GDP Manager, CPM, TPM and PVM to obtain a deeper understanding. A list of these people can be found in Appendix A. An overview of the resulting process map can be found in Appendix C and three cropped versions of this map in Figure 23, Figure 24 and Figure 25.

The process starts in the pre-study when a new idea or a demand from the market triggers the process. In the pre-study the prerequisites for the project are created and translated into requirements. In the pre-study the test leader also starts to develop the verification methods that will be needed and defines the test object.
After the pre-study the process enters into the concept study, in which the final concept is chosen and developed and the time plans for the project starts to get developed.

The last process in our process map is the development phase which symbolizes the detailed and final development phases in the GDP. This is when the actual designing of parts start and the Bill of Material is created. The tests are specified with the designs as input and the test plan is developed and almost finalized, although changes can be made in the test plan if new needs of testing comes up during build. It is in the development that PBT becomes directly involved starting up by setting a final time plan and project plan for PBT. In this map only the core processes of PBT are visualized which are the material supply and build.
Using the data obtained from the interviews and by analyzing the final map the authors could detect problem areas within the organization. One of these problems can be located and visualized in the process map and concerns the creation of the time plans. The GDP manager, CPM and TPM communicated the importance of using the level 3 time plans as input when creating the level 2 time plan but the PVM and the different group managers communicated a different scenario and expressed that the level 3 time plans often had to be scheduled to fit the level 2 time plans. This misconception of the creation of the time plans is one of the things causing a vast problem with unrealistic time plans.

“The line organization should meet the level 2 time plan, when this is created the level 3 time plans must be done...The creation of the level 3 time plans should not be taken lightly, these should be realistic and used as input when creating the level 3 time plan.” (GDP Manager, 2012)

“The main time plan and the level 2 time plans are roughly created when I and the other group managers create the level 3 time plans. Therefore we need to make the level 3 time plans to fit into the overall project plan and have to adjust it and compromise the real time required.” (Workshop Manager, 2012)

Other problem areas that could be identified when analyzing the whole process and the data retrieved from the interviews regarded the role descriptions, lack of communication and information exchange, lack of documentation and uncontrolled design changes and changes of measuring points. These problems will be described in more detail in section 5.5 and be attended to in terms of solutions and recommendations.
5.2.2 Mapping the core processes at PBT

The actual process mapping work started when it was time to map the core processes of PBT. No process maps existed within PBT whatsoever when this work was about to start. The need of a good mapping tool was crucial in order to not let anything pass the reviewers. Therefore the mapping methodology was based on existing theories and tools.

In this study a combination of the mapping methodologies reviewed in the theory chapter were used when creating and analyzing the map. More specifically, the techniques suggested by Becker, Kugeler and Rosemann (2003), the methodology by Ljungberg and Larsson (2001) and the process of process mapping by Jacka and Keller (2002) were all used.

The development of the process maps at PBT followed four steps:

- **Identification and prioritizing of problem areas.** Prior to the mapping a bottleneck analysis based on empirical data was conducted in order to identify and prioritize problem areas. In this analysis material supply was identified as a bottleneck.
- **Interviewing and map generation, create as-is map.** The interviews were conducted using the walk through approach. Continuously the map was generated using the 8 step methodology presented in the theory chapter.
- **Analyze the data.** The map and the empirical data was analyzed following the methodology presented in the theory chapter by Ljungberg and Larsson (2001) and Jacka and Keller (2003).
- **Create to-be map.** Finally the to-be map was created, taking all the improvements suggestions into consideration.

The technique by Becker, Kugeler and Rosemann (2003) consisted of mapping first the as-is and then the to-be situation and it was utilized to the extent that both an as-is and a to-be map were created of the core processes at PBT. We also adopted the idea of identifying problem areas prior to the modeling, by making a function-oriented splitting of the problem domains, and by performing a bottleneck analysis identifying material supply as the function most crucial to map and analyze, see Figure 26.

![Figure 26. Problem Domain Splitting.](image)

Apart from making this problem identification prior to the mapping and creating both an as-is and a to-be map the mapping methodology used followed the two very similar methodologies by Ljungberg and Larsson (2001) and Jacka and Keller (2003) with a focus on the conceptual phase. These methods
were used because: a) they are both methodologies of general nature that can be applied to map the process in an industrial company, b) none of them express a vital need for software based modeling tools which were not accessible at the company, c) they are both meeting the requirement to be easy to understand which is crucial in an organization with no experience or previous work with processes.

When it comes to the actual map generation the 8 step mapping tool by Ljungberg and Larsson (2001) was followed to the point. This was done due to it being structural, easy to follow and it contained all the steps of the other tools but with more details, making it very pedagogic and allowing detailed mapping.

The as-is maps of the material supply and build can be found in Appendix D. Cropped versions of these two maps will be presented in Figure 27, Figure 28, Figure 29, Figure 30 and Figure 31 complemented by brief explanations of them below.

**The process for material supply**

The process for material supply is first initiated when the constructors have created and finalized the BOM. With the BOM as input the material coordinator creates material lists, considering the lead times for all the material. To create a list considering lead times is a valuable activity, because this allows for each purchase requisition to be placed in a timely manner which in turn improves the conditions for the material to be delivered on time. To be able to take lead times into account in this way, experience regarding lead times for materials is needed. Alternatively, good communication and information exchange with purchasers, who are the interface to the suppliers, and possess this information, is needed. With the material list as input the material coordinator can then put the purchase requisitions at the right time in SAP where it is transferred into GPS, the system used by purchasers who subsequently place the order to the supplier.

![Figure 27. The process of material supply from the updating of the BOM until the purchase requisition is placed in SAP.](image)

After the order has been placed, the material coordinator updates the material lists and put a yellow color code on all the ordered material. Next an order acknowledgement is received from the supplier saying that the material will be delivered on time or not. If not, the supplier proposes a new delivery date and the delivery date on the material list is manually updated by the material coordinator. However, this new delivery date is not communicated to build immediately. This has negative consequences on build, causing unnecessary stagnation in the build process when they later on experience that the material is late. This could easily be prevented if the information about the new delivery date was shared immediately. When the order acknowledgement has been received nothing
happens in the material supply process until the day the material should be delivered. The next activity in the material supply process is to receive the material, but no routine for goods receiving exists and all the material is not goods received. The material lists are updated and a green color code is put on goods received material whilst a red color code is put on materials that are not goods received. The output of the material supply process is the material and the material lists that are subsequently presented to the build unit.

**Figure 28. The process of material supply from purchasing to delivered material.**

Material that is not goods received on time will obtain a red color code on the material lists and will subsequently be handled by the delivery coordinator. The delivery control process is initiated only when a material has obtained a red color code and is already late. These lists are extracted manually and therefore it can take up to two weeks until the delivery control of delayed material is initiated. This faulty delivery control makes it impossible to prevent delayed deliveries. Delayed material is one of the things causing the greatest bottlenecks in the build process.

**Figure 29. The process of material supply covering delivery control.**

**The process for build**

The process for build starts with the workshop manager creating a detailed build plan and coordinating the work schedule for the workshop mechanics. This is followed by some preparatory work on the bus, preparing the bus for the mounting of materials and measurements, in anticipating for the work order and the material. The work order is subsequently created with the material lists and build plan as input and as soon as the work order is finished and the material is received the building can start. However, the build is today further postponed due to the workshop mechanics’ need to start by searching for and picking the material needed in build.
When the material has been picked it can be mounted, prepared with measuring equipment and then the build is finalized. Finally a sign-off of the bus is made and the output is an approved test object. The problems within the build process are delayed and lost material which causes stagnation in the build process and the searching and time consuming picking of material.

### 5.3 Analyzing the material supply process

As already stated, prior to the mapping of the core processes a bottleneck analysis based on empirical data was conducted in order to identify and prioritize problem areas. In this analysis material supply was identified as a bottleneck and for that reason subsequently mapped. The build process was merely mapped in order to show what effects material supply had on this process and how these could be remedied.

The focus when analyzing the core process map was put on material supply and how the problems within this process affect the process of build. The greatest bottleneck of the organization had been identified as the material supply process. More specifically, the bottleneck is delayed and lost material. A root cause analysis was conducted to identify the root causes to the bottleneck. Four major problems within the process for material supply where identified, which in conjunction cause the bottleneck of delayed and lost material. These problems are:

1. The delivery control
2. The goods receiving
3. The inventory control system
4. The suppliers

Generally it became clear during the interviews that the importance of material within the prototype building process cannot be underestimated. Several interviewees have mentioned that material is one of the most critical parts of the process. If the right material is delivered on time and accessible when needed, the building of the prototypes will progress according to plan.
“Three things are of utterly importance when building test vehicles, that is; material, material and material. If you have the material you need you can build anything.” (Chief Project Manager, 2011)

“If you gain control of material that puts you in control of the build process” (Project Vehicle Manager, 2011)

In order to assure that ordered material will arrive on time and will be accessible when needed, PBT has to solve the identified problems within material supply. These problems will now all be further explained and analyzed. The activities have been analyzed on the basis of analysis tools in the theory chapter section 3.5.2 and mainly the value analysis tool.

5.3.1 Delivery control

The problem with the current delivery control is that, when the study was conducted, it was a reactive processes rather than proactive. There is no current checkup of incoming material and whether it will arrive on time. Delivery control starts looking for material that has not been goods received after it is supposed to have been delivered.

“The design engineer turn to the material coordinator with the BOM, the material coordinator accepts the material list and put the purchase requisition to purchasing, purchasing place the order and then there is a black hole!” (Technical Project Manager, 2011)

The process of finding the lost material is, to add to it all, highly inefficient and time consuming which leads to even more delays. The process goes as follows. Delivery control is informed that the material is late by looking at the material lists, in specific excel-sheets, where material that is apparently late is color-coded as red. Once these red materials are identified it is up to delivery control to start searching through an email inbox for the corresponding purchase order, to ensure that is has been ordered and to find information about the supplier. The supplier is then contacted to clarify if and when the material was sent and when it will be delivered. On top of this it often turns out that the missing material has actually been delivered but not goods received; meaning that all the time spent looking for the material has been wasted and resulted in even more delays of the project.

5.3.2 Goods receiving

As stated before it is of the utmost importance to keep track of incoming material, as one cannot build if there is no material to build with. An important aspect of keeping track of the material is to goods receive all incoming material. If all the material is not goods received it is impossible to know whether or not material was actually delivered, who received the material and where it was allocated. During the interviews it became obvious that there was a big problem with the routines, or lack thereof, for how material was to be goods received. It was not uncommon that material bypassed goods receiving entirely and was delivered directly to, for instance, a design engineer or brought directly into build.

“It is common that the goods receiving is neglected…often material does not enter PBT via the warehouse to be goods received…often material are sent directly to a design engineers or taken directly into build due to the urgent need” (Delivery Coordinator, 2011)
This problem rebounds on delivery control and makes the process of finding delivered material tedious and sometimes impossible. In addition it can cause problems regarding invoicing seeing that the supplier sends an invoice for materials that according to PBT have not been delivered as there is no goods receipt.

5.3.3 Inventory control system
At the time when this thesis was conducted PBT were in the process of rebuilding their warehouse and all warehousing activities were conducted in a temporary warehouse. This of course caused some problems as there was limited storage space, a lack of storage racks and it was difficult to keep track of stored goods. It was, however, found out through interviews with warehouse personnel and workshop mechanics, that not all of these problems were new ones caused by the temporary warehouse move. Instead it was found that warehousing had been suffering with problems even before the move.

The major problem is the inventory control system which is very limited in its current form. The current system is not suited for this kind of business, with that intended, a prototype organization where new material is constantly introduced and very few fixed storage locations are used. One big issue is that the system currently is not able to represent storage locations in an adequate way. All the material stored in every pallet on every shelf of a specific rack will share the same storage location. For example, a part stored in compartment 4 in a pallet located on shelf 3 of rack 5 will only have the storage location rack 5 in the inventory control system. The result of this limited representation of storage locations is that the process of locating stored material becomes tedious and time-consuming.

The problem with the storage location representation is made even worse by the fact that picks are not registered in the system. Because of this there is no way of checking whether the material you are looking for is even in stock and the time-consuming search might end up being fruitless.

Another problem with the current warehouse is that the workshop mechanics are often the ones searching for and picking material. This means that a lot of the time that could have been used for building is instead spent in the warehouse searching for material and the mechanics, being one of the greatest resources of the company, is not fully utilized. Another side effect of this is that a lot of different people are operating in the warehouse and it is difficult to ensure that everyone is working in the same structured way.

5.3.4 Suppliers
During the interviews some issues concerning the procurement of materials were identified which involved the suppliers. The main issue appears to be a lack of communication between Volvo Buses and the suppliers which leads to uncertainty concerning deliveries. It was also found that the order acknowledgement placed by the supplier could be very unreliable due to the suppliers not reading the orders carefully enough and not taking the delivery date properly into account when placing the order acknowledgement.

5.4 Improving the material supply process
In this section the improvement suggestions for each problem within material supply will be presented. Some of the improvements are based on ideas arising during interviews and then developed further by the authors. These ideas from interviewees will be clearly cited in the
improvement suggestions below. Yet, most of the suggestions are developed by the authors and have then been vented with people at PBT.

5.4.1 Delivery control

“After the order has been placed, it is crucial to perform proactive delivery control and to monitor the material flow.” (Technical Project Manager, 2011)

A clear focus going forward should be to implement a proactive delivery control system. When the order for a material has been accepted by the supplier and a delivery date has been set, delivery control must become directly involved. All expected deliveries should be entered into some form of database or spreadsheet where information regarding every material should be available. If there is a clear and structured way to view all the material that is supposed to be delivered, delivery control is already in a good position to perform its task. As mentioned above it is, besides having a structured way to view all ordered material, of the utmost importance to start working proactively. A status check of all expected deliveries should be performed at least once before the expected delivery date. The checks should be performed at such a time that, if it is found out that a supplier will not be able to deliver on time, actions can be made to either speed up the delivery, by using an alternative distribution solution, or change the construction plans so that the workshop will not be standing still waiting for building material. Preferably these status checks should be carried out several times but this might require more resources than is currently available within delivery control. However, the more effort that is put into structuring and automating this work the more efficient the process will become. This will ultimately lead to a better utilization of existing resources and increase the performance of delivery control.

5.4.2 Goods receiving

It is essential to introduce clear routines for goods receiving on a global scale as well as introducing education on these routines in order to retain control over the incoming material flow. Every single piece of material needs to be goods received; no matter whom the recipient of the material is and even though it appears as it will create a costly delay or an unnecessary expenditure of time. The new routines need to contain clear guidelines on how e.g. the design engineers should act if a part is needed urgently and they wish to have it delivered directly to them. Preferably, all material should pass directly through goods receiving and consequently be distributed to its final destination. It is, however, possible to allow material to be delivered directly to other parties if there is a clear and structured way for them to properly register the reception of goods, but this is only possible if everyone follows the new routines.

5.4.3 Inventory control system

Some of the issues discussed above are currently being looked at and some forms of actions to improve the situation are being performed when the warehouse moves into its new location. It is, however, still of importance to point out some changes that need to be implemented in order to make the warehousing process more dependable.

First and foremost the warehouse personnel must receive proper training and education in the inventory control system to ensure that they are familiar with all the functions of the system. During the interviews it was clear that the personnel lacked sufficient training at the moment, this causing the default registration of picks. The personnel pointed out another insufficiency with the system, being the inability to search for material.
“It is possible that the system can handle more than I know of, if so I don’t have the right education in it. “ (Workshop personnel, 2011)

When venting these problems with people from the management group it was confirmed that the system in fact could register picks. When the personnel are properly educated new clear routines for registering everything that is placed into the warehouse as well as everything that is picked from the warehouse must be introduced.

It is equally important that the inventory control system is adapted to fit a prototype workshop. This can be done by revising and expanding it to allow for a more structured way to store and handle goods in the warehouse and provide a more accurate way of representing storage locations. It also needs to allow for simple and effective ways to register the movement of all material within the warehouse.

Another recommendation for the improved inventory control system is enhanced searching abilities to quickly find material along with information concerning storage locations and quantity. If it is easier to track material in the warehouse significant efficiency gains can be achieved. If it is not possible to make the needed adjustments in the existing system an alternative system must be implemented.

A final recommendation is that a limited group of relevant people, in preferential manner the warehouse personnel extended with a selected group of workshop mechanics to ease the workload, are allowed to operate in the warehouse. This would create a unanimous mode of operation and establish and maintain the order in the warehouse.

5.4.4 Suppliers
When the order for a material is placed and consequently accepted it is very important to confirm that the desired delivery date stated in the order can be met and if this is not the case a new delivery date must be determined. It is important that both parties, thus also the supplier, feel responsible for keeping the delivery date and understand the importance of keeping it. To ensure that the suppliers keep their part of the deal the contracts may need to be revised and one way could be to include some sort of penalty clause for delayed goods. Better communication and a closer relationship with the suppliers is also recommended in order to improve the reliability of the material supply. Working with these issues should preferably be a task for the purchasing department, as they are the ones who handle the contact with the suppliers. For PBT it is important to make sure that these issues are actively being handled by the purchasing department.

5.4.5 Applying the improvements on the material supply process
One of the expected deliveries for this thesis was the creation of an improved process. To achieve this for the people the report is targeted towards, a to-be map was created. An overview of the to-be map can be found in Appendix E and once again cropped version will be presented in the text in Figure 32 and Figure 33.

The improvements derived when attending to the identified problems presented in section 5.3 are all related to the material supply process but not all of them can be clearly visualized in the to-be process. A minor visual change but with significant impact is the activity of receiving goods. Previously no routines for goods receiving existed and the material where simply enough delivered but not goods received in any structured way. In the to-be process map all material must be goods
received in the warehouse by employees educated in the goods receiving routine. The obvious
difference of the as-is and the to-be map is the changes of the actions for delivery control, these are
now triggered directly after the order acknowledgement is received from the supplier to make it
proactive.

![Figure 32. The part of the material supply process showing how all material are goods received. The map also shows the new process for delivery control.](image)

Since the activities performed in the warehouse not are a part of the core process for material supply
these are not included in the map. However, the effect the new warehouse routines will have on the
build process is visualized in an activity in the build process. The workshop mechanics no longer
searches for material in order to pick it. The material can now be picked directly without any tedious
searching. Furthermore this activity is only performed by the selected people allowed to act inside
the warehouse.

![Figure 33. In the to-be process for build no searching for material will be necessary and this action is now comprised of picking the material.](image)

5.5 Analyzing the product development organization
During the data analysis a number of issues that are not directly related to PBT’s core processes, but
still affect PBT, were identified. In this section problems concerning design changes, changes of
measurement specifications, time- and resource planning and documentation will be presented. All
of these problems involve large parts of the product development organization and ultimately end up
affecting both PBT and the overall process performance.
5.5.1 Design changes
One problem that was identified is that drawings and material specifications are often released prematurely and then changes are made to the designs. This means that material which is ordered or constructed in the workshop is obsolete when it is finished and instead of going into the prototype build it is simply thrown away. Alternatively the parts can still be used in the prototype build, but they were not final, up to date, versions and unnecessary time was spent on making non-critical parts perfect. Both cases represent a huge waste which costs both time and money. Through interviews it was made clear that many of these late changes to designs were seen as more or less a natural and necessary part of the development process. This was particularly communicated by design engineers but more or less confirmed by managers, project managers and people in material supply, purchasing and build.

"This is a development process, loops are constantly occurring, changes need to be made due to activities effecting each other, eventually you should get a good product but this will require changes to be made over time." (Design Engineer, 2011)

Material will always need to be continuously changing and evolving. It was, however, also found that in many cases the design engineers knew that a specific part was not finished and would need further changes, but in order to meet a deadline the drawing was released anyway and construction of the part began in the workshop only to be thrown away later on. This kind of waste activities needs to be reduced.

5.5.2 Measurements specification changes
Another problem identified in the workshop was that the build was delayed due to changed requirements on the number of measurement points or changed specifications on how the measurements are to be made. Such measurements could be flow sensors, pressure sensors or temperature sensors. The requests for changes come from many different stakeholders in different parts of the product development organization. One of the major contributors to measurement specification changes has been identified, by many interviewees, as Volvo Powertrain. An example of a measurement specification change could be Volvo Power Train requesting 50 new measures on the engine of flow, pressure or temperature.

It has been made clear that measurement specifications do not need to be a problem if it is clearly defined what is supposed to be measured, and how, before the prototype is assembled. However, if new requirements keep getting continuously introduced during the build, this will result in a need of removing and installing the engine or the entire powertrain over and over again in order to add and adjust measurement points. This causes a large amount of waste activities in the build. This could ultimately mean that one or several of the current builds end up being delayed. If you can reduce the number of times that changes have to be made after installation, a lot of waste activity can be eliminated, efficiency can be increased and cost can be reduced.

5.5.3 Time- and resource planning
The goal of the product development process is to get the right product to the market in the shortest time possible with the highest quality possible. If you do not have realistic time- and resource planning the product will either be delayed or lack in quality; possibly even both. Therefore it is essential that the process of developing these plans is evaluated.
A recurring issue that was brought up during interviews with representatives from many parts of the product development process is that the project time plan is always very tight. Many delays within the PBT-process can, in one way or another, be ascribed to the time plan not being realistically possible to meet with the allocated resources. Unrealistic planning will either result in delays or important steps in the process being rushed, improperly executed or skipped completely. What was found through the interviews was that this is exactly what is happening today. In order to meet deadlines many deviations from how the GDP states that a project is to be conducted are made. This only reduces the value of working according to a structured process and introduces large risks into the project. If a part is moved into the next stage in development before it has been validated through tests, then the value of running the test is heavily reduced. If it is found that something must be changed it is already too late and large costs will follow.

One possible reason for the time plans being set unrealistically is that, as explained earlier, the higher level time plans, level 1 and 2, are set first according to a deadline set in an early stage of the project. When the level 3 time plans are to be made, detailing exactly how long all activities will take and when they can be done, they are forced to fit into the higher level time plan regardless of the feasibility. With a set amount of resources for each project it is not possible to speed up activities to fit the schedule and delays or shortcuts will likely be the result.

5.5.4 Documentation
As the distribution of responsibilities look today, basically all documentation in Volvo Buses prototype follow-up system PROTUS is conducted by the PVM. This is not in any way strange because one of the main reasons for the introduction of the PVM-role was to improve the PROTUS-documentation work, which covers keeping the status of the test vehicle updated. Through the interviews it has, however, become apparent that all this documentation work can easily become overwhelming and it has been remarked by several interviewees that problems occur due to insufficient PROTUS-documentation. Most often the problem is that PROTUS-data is not up to date which means that it becomes impossible to see previous work that has been done to the test vehicle or get an accurate description of which parts are currently installed. This inaccurate PROTUS-documentation leads to uncertainty which causes delays and unnecessary work. One reason for inaccuracies is that the documentation is sometimes carried out by the PVM even though the test vehicle is in a different location, e.g. when the vehicle is running tests off-site test engineers make changes and then send back a report which the PVM is supposed to enter into PROTUS.

5.6 Improvements in the product development organization
In this section the improvement suggestions for each problem, not directly related to PBT’s core processes, but still affecting PBT, will be presented. The improvements in this section have come about by the authors developing ideas and then venting them with relevant people at PBT. This resulted in valuable input which was used to further develop the improvement suggestions.

5.6.1 Design changes
Late changes in designs will likely always occur in a product development process and the best way to go about solving the problems that they create is not to try and stop the changing of designs. The solution is quite simply to create detailed routines for how one should go about making these late changes to reduce the number of problems that are caused. Such routines are not easy to develop, in order for them not to complicate the work for the design engineers vastly, but nevertheless crucial to
provide structure to an organization. The authors will now suggest how Volvo Bus should go about to develop such routines.

These routines need to be created with input from all affected parties and it is important to address issues like pressure to meet deadlines which causes design engineers to, knowingly, release unfinished material. Pressure to produce, and release material, must not take precedence over quality. The next step is to enforce these routines so that everyone abides by them. Routines that are not followed are about as useful as no routines at all. Finally, and maybe most importantly, the late changes that are made must be communicated to whoever is affected by them. Sometimes it is not a problem that a part is released before it is finalized. Perhaps it is not a critical part for a specific test and it can be mounted and used as a reserve. If this is communicated to the workshop they know that they should not spend any extra time making the part perfect and can spend it on more important things instead. If all these steps are taken, late changes will not cause nearly as much waste as it does in the current situation.

5.6.2 Measurement specification changes
To solve the issue of measurement specification changes all parties who, in some way, are involved in determining measurement points and number of measures will need to work together to establish routines for how this process is supposed to work. This includes when, and to what extent, changes are allowed to be made. The purpose of these routines is to force everyone to make sure that measurement requirements are final when the components are built into the vehicle. By making sure that there are clear rules on how this process should be done, it will be harder for anyone to break the rules. It will also be very important to enforce these new routines after they have been agreed upon, as they will only work as long as everyone follows them. As always, communication is key. If someone knows that the measurement specification will be changed it needs to be communicated so that no unnecessary work is performed.

5.6.3 Time- and resource planning
To evaluate how time- and resource plans are developed is a big, but necessary, task. This will most likely require a big evaluation project with many actors involved. The most important objective will initially be to assess whether or not the current process is actually working as it is supposed to. Senior management said, on several occasions during interviews, that the level 3 time plans shape the higher level time plans, but the ones responsible for creating the level 3 time plans felt that they are more or less bound by the higher level time plans. This must be evaluated to see what is actually true. The next part of the evaluation will be to look at how deadlines and resource allocation is done in the start-up of the projects. It is understandable that time-to-market is a very important factor when establishing time plans. Laws and regulations on e.g. emission levels will naturally force very strict, and sometimes short, lead times for projects. However, this does not mean that unrealistic time- and resource plans for the projects should be set. There are essentially two ways to meet a project plan that is not realistic; allocate more resources or postpone the deadline. This issue needs to be brought up for discussion in order to become more efficient and effective in the future.

It is worth noting that these recommendations do not mean that Volvo buses should stop trying to reduce the amount of resources used in projects or trying to shorten lead times. It simply means that all time- and resource plans that are developed should be realistically possible to follow.
5.6.4 Documentation
A relatively simple way to increase the accuracy of the PROTUS-documentation is to rearrange the responsibilities. This does not mean that PROTUS-documentation should be split equally between all parties involved but rather that the responsibility should lie with the person who is responsible for making the changes, e.g. if the test engineer makes some changes to the prototype during testing it is only logical that the test engineer updates PROTUS. If one handles all PROTUS-documentation this way you will reduce the risks associated with handovers of responsibility where the one handling the documentation does not know what has actually been done to the prototype. It will also increase the traceability in PROTUS because the one who updated is also the one who made the changes and will be better equipped to answer any questions than someone who just entered someone else’s information into the system.

5.7 Analyzing Organizational structure
In order for an organization to effectively work with processes the organizational structure and the employees need to allow for the process to work. During the analysis of the product development process some issues related to organizational structure were identified. These issues concern the structured way of working in the process and have been categorized as, role descriptions and information exchange and communication. If solved, these issues can contribute to a more structured way of working which will result in a more effective utilization of the process.

5.7.1 Role descriptions
One of the major issues identified within the product development process, and especially within PBT, is a lack of clearly defined roles and responsibilities. This is evident in many different parts of the organization and is the cause of a lot of problems. Today most of the actors in the process of PBT work in different ways and each project will be conducted in a different way depending on who is involved in the project.

“The people working within the department of PBT, that is people working with build, Material Coordination and the PVMs have no clear role description or division of who does what.” (Technical Project Manager, 2011)

“Each PVM has their own way of working in projects.” (Project Vehicle Manager, 2011)

This method of working does not correspond well with the overall process-thinking that is supposed to be a fundamental part of how all Volvo companies operate, as outlined by The Volvo Way and the Volvo Corporate GDP. The GDP is designed to be a project template which offers a well-structured and repeatable way to conduct a project. The idea is to create an efficient way to conduct a project where everyone knows from the start what needs to be done and in what order. This does, however, rely on the fact that the users of the process also have a clear picture of their own as well as other actors’ roles and responsibilities. This is where the problem lies today. Many interviewees have expressed a need for clear descriptions on division of responsibilities as well as clear role descriptions to avoid all the uncertainty that occurs in projects today.

The problem with unclear role descriptions is especially evident for the PVM-role. As the PVM plays an important part in the building phase of the projects it is not hard to see that this has the potential to cause big problems. It is also an issue because the PVM-role is quite new and there are a lot of PVMs who are currently trying to learn the role. Without proper documentation and a common,
structured, role- and responsibility description this is no easy task and the result will most likely be a large number of individually crafted roles. One can already see the evidence of this development of personalized roles when talking to the TPMs and PVMs. During the interviews they consistently spoke in terms similar to “my PVM does this” or “my Material Coordinator usually works this way”. If this development continues it will become more and more difficult to establish responsibilities when starting a new project as it will largely depend on who is part of the project.

The material coordinator role is also one that is in need of a common, structured and documented way of working. Today there are two material coordinators who work in two completely different ways with very little cooperation. It is also hard for anyone on the outside to get a good view of how the material coordinators work which means that all of the knowledge of the material coordinators work is held exclusively by them. This is not a good way to work in a process based organization and the transparency must be improved.

5.7.2 Information exchange & communication

During the interviews it was discovered that many problems within the product development process can be attributed to a lack of communication and information exchange. Well-functioning communication and information exchange is an important part of successfully working in a process-based organization, as discussed in section 3.1. The conclusion is that big problems could actually be avoided if the different actors of the process would simply communicate and share information with each other. Instead, a lot of problems arise because people do not think to share information to other actors and parts of the process.

On example of neglected information exchange has already been raised. This concerned the supplier not being able to keep the delivery date and informing this already in their order acknowledgement. This information is not shared directly with build, which will experience the problem later on when the material should be mounted and is missing. This causes stagnation in build and delays the entire projects. If this information had been shared, build would have been able to rearrange modify the build plan.

Other examples are:

- Neglecting to share information about design not being finalized when they are presented to build. This results in parts being constructed and later on thrown away or mounted just to be ripped out and replaced.
- Neglecting to share information to purchasing about up-coming high seasons. This results in purchasing not being able to place orders on time which causes late material deliveries that causes stagnation in the build.

5.7.3 Volvo Bus organizational structure

By the means of analyzing these problems the authors would say that PBTs organizational structure best resemble a project based organizational structure with some similarities to the matrix organization. PBT are today working with projects in a highly flexible environment where each employee has their own way of working and each project has a special project manager assigned to it. Confusion regarding responsibilities is unfortunately more the rule than the exception, which is a common negative aspect of the matrix organization. Due to the highly dynamic nature of projects, PBT have difficulties in working with continuous improvements and transferring knowledge.
It is our direct suggestion and in Volvo Bus’ and PBT’s best interest to strive for a more process-based organizational structure. In order for PBT to get an organizational structure that is more process-based it needs more structure and management tied to the process-based view, which is presented in detail in the theory chapter. By adopting the entire process concept create clear role-descriptions, share information and knowledge up and down the process, demolish individual opinions and the culture of “I do my tasks and nothing else” and focus on process flow. By starting with addressing these problems they will be on the right way for this to happen.

5.8 Improvements in organizational structure

In this section the improvement suggestions for each problem that are related to the organizational structure will be presented. Most of the improvements in this section have come about by the authors developing ideas and then venting them with relevant people at PBT which gave input for further development. Some of the improvements are based on ideas arising during interviews and then developed further by the authors. These ideas from interviewees will be clearly cited in the improvement suggestions below.

5.8.1 Role descriptions

“I request a structured way of working, where everyone works in the same way and share their knowledge. The downside of it not being customized for each different project is worth taking.” (Project Vehicle Manager, 2011)

It is very important that PBT, but also Global Engineering, starts to address the issues regarding unclear routines, roles and responsibilities. A unified structured role description for each individual role in the process must be established and documented. It is very important that the work of defining these roles and responsibilities involves representatives from all areas of the process. Since all roles are interconnected it is important to include this holistic view into each role description. A recommended way to go about creating these role descriptions is to first gather all the employees with the same role. They must, together, think about and define how they view their own role, which responsibilities should be included and also how they view the roles of the actors they are directly involved with in the process. When all the groups have defined their take on the process and the roles within it, it is time for a workshop where all roles and groups meet to discuss their different views. The outcome of this workshop should be the beginning of a mutually agreed upon distribution of responsibilities as well as clear role descriptions and information channels. All this information then needs to be documented in such a way that both new and current users of the process can identify how they should work. Also a set of checklists should be designed and included in the documentation. These checklists should be used as a tool for assuring that nothing is missed during the project and that everything is carried out at the right time and in the right order. It is easier to coordinate projects if there are clearly defined checklists for each step describing what should be done before the project can move forward.

It is important to know that the work is not done after these new role descriptions have been defined and documented. Follow-ups are needed as there are bound to be areas where this new way of working does not quite work. This is natural and the role- and responsibility descriptions should be living documents that are revised continuously with regular workshops to evaluate how everyone feels that the process is working.
5.8.2 Information & communication

In order to come to terms with the lacking communication and information exchange there has to be a shift in mentality among the employees at Volvo Buses. This goes hand-in-hand with the work to become more process oriented and is exactly what is suggested in process theory, as discussed in section 3.1. It is not easy to accomplish this shift in attitude, but it is absolutely necessary to tear down the walls between the different groups and functions within the organization. It is hard to force people to communicate; instead communication is dependent on personal commitment and a sense of responsibility for more than just the activities closest to oneself. The employees need to see the worth of sharing information. If they realize that sharing information to someone downstream in the process can help avoid problems for the entire project they are more likely to start communicating. An important step in introducing more communication is to create opportunities for employees who do not usually meet, but are connected through the process, to get together and discuss how information from the other party can help them in their work.

5.9 Key Performance Indicators

One of the main goals of this thesis was to evaluate PBT’s core processes and propose KPIs to measure the processes. PBT currently have no KPIs to measure their performance. Needless to say, it is important to establish one or more measurements to be able to evaluate the process and hopefully improve. As discussed in section 3.6 the development of KPIs is no small task and it is of great importance that it is done correctly. The KPIs should ideally be developed by a group of people who are familiar with both the process and corporate strategy as this should be the basis of all KPIs.

The KPIs presented in this thesis should therefore be seen as a guideline for what type of measures PBT should use and actual KPIs should be further developed.

5.9.1 Suggested Key Performance Indicators

- Delivery Performance.

PBT needs to keep track of incoming material and make sure that material is delivered on time by the suppliers. For this purpose delivery performance is a good performance measurement. The goal of this KPI is to measure the percentage of orders that are delivered on time, given that the delay was not caused by Volvo earlier in the process.

- Goods Reception.

The purpose of this KPI is to measure how many of the ordered parts are actually, goods received when they arrive at PBT. This means that the material has to be received and signed for by authorized personnel and registered in the system. The number of material logged as received in the system is then compared to the number of materials that have been ordered and are expected to have been delivered. The authors suggest that the target values for a measure of this kind should be very high, probably around 99-100%, which will force a proper registration of incoming goods. This also reflects the intentions of PBT who demands that all material must be goods received in the future. By introducing a KPI that follows this activity it is probably going to be easier to make sure that no material bypasses goods receiving. This measure could also be used to evaluate the effect that proper registration of parts will have on the work load of delivery control.

- Standstill in Prototype Build
This measurement is designed to measure the utilization of the workshop personnel. By measuring the number and duration of standstills in the builds, as well as categorizing the root causes of these standstills, it is possible to analyze what is causing the biggest waste of build time and where effort need to be placed to better utilize the workshop personnel.

### 5.9.2 Implementation of Key Performance Indicators

When it comes to the implementation of the suggested KPIs it is important that a lot of work goes in to making the measurements measure the right things in the right way before you actually start to measure. Thorough groundwork is essential when designing new measurements. If the data which the measurements are based on is not right, or is gathered in the wrong way, then the value of the entire measurement is reduced. Therefore PBT needs to evaluate currently available data versus the data that is needed to perform the suggested measurements and revise their data collection structure.

When the measurements are in place data should continuously be captured and stored in the system. It is highly recommended that a KPI-responsible person is appointed, or that the follow-up and reporting of specific KPIs are distributed to a number of specific employees. This way you will establish ownership of the KPIs which will assure that monitoring and evaluation is not neglected. This is, as discussed in section 3.6, a very important aspect of successfully working with performance measurement. It is also important to perform follow-ups with the right frequency. Some measures like delivery performance is important to follow up very frequently whereas a measure like standstill in prototype build may be more suited to evaluate after a longer period of time. PBT is recommended to follow up and report the KPIs at least every quarter, but preferably even more frequently such as on a monthly basis.

One important aspect to keep in mind is also to follow up measurements during the right time. Preferably performance measurements should always be followed up on a continuous basis, but sometimes companies might not prioritize measurement follow-ups during highly intensive periods. However, if you only follow up your KPIs when there is not as much to do you will not have the opportunity to affect your performance or your situation during high intensive periods which is when it is crucial that everything works as the margins for error are very small. Therefore KPI follow up must be seen as one of the primary activities and not something that can wait until there is more time. The measurements should, as stated in section 3.6, be used as a basis for future process improvement.

### 5.10 Continuous improvements

A crucial part of becoming a well-functioning process based organization is to embrace, implement and drive process-wide initiatives for continuous improvements. To strive to always get better is part of the process-based view. It is important to realize that there are always areas to improve and you can always become better. The concept behind continuous improvements is simple but highly effective if it becomes a part of the organizational culture. At the moment there is a lack of initiative from PBT’s side to encourage the employees to take part in the work of improving the process. Here lies a great untapped potential for improvements within PBT. If PBT takes the initiative to introduce continuous improvement work into the everyday routines of every employee, much can be gained. Each group and employee only needs to set aside a few minutes a day, or week, to reflect on what is working and what is not and try to come up with ways to make the process more efficient. It is also
worth noting that the implementation of KPI’s, such as the ones suggested above, can be a good first step in working with continuous improvement. This is because it will allow for constant evaluation of performance, which presents opportunities to improve the process.

What needs to be done from PBT’s management is to assemble a common methodology and provide the employees with the proper tools to carry out the continuous improvement work. The authors suggest that one way for PBT to start their continuous improvement work is by implementing root cause identification through the 5 why and Ishikawa diagram techniques as well as the PDCA-cycle to track and facilitate the continuous improvement work. As discussed in section 3.5 the amount of good available tools is vast and many other techniques could be chosen instead, yielding the same or perhaps even better result. The important thing is not which specific tools you use, but how you use them.

It is also strongly recommended that PBT carries out regular audits of the own organization and all of its processes to get a feel for how they are performing and what the need to do differently. These audits are preferably carried out both by an internal audit group and a group of external auditors who can see the organization and process with fresh eyes.

With both larger scale audits and everyday continuous improvement work conducted by the employees PBT will likely be seeing big improvements both in efficiency and effectiveness, but also in terms of employee satisfaction.
6 Discussion and Conclusion

This final chapter concludes the master thesis. In this chapter the results and findings will be presented in the form of an action plan. In a discussion the results and findings will be connected back to the purpose and objectives of thesis and the trustworthiness and authenticity of the thesis will be discussed. Finally recommendations and suggestions for future work will be presented.

6.1 Meeting the objectives

The purpose of the thesis was to find a more efficient way to organize prototype build and to propose a process with a clear focus on future needs. The study was however delimited to mapping, analyzing and improving the process for material supply whilst investigating how the material supply affected the process of build. To fulfill this purpose five research question were formulated. Let us now return to the posed research questions.

The first two research question was formulated:

How can the process be mapped to expose problem areas?
How can the process be improved to enhance its efficiency?

To meet the objectives and to answer the research questions the authors studied relevant literature on process mapping and a method for process mapping was outlined. In order to retain a holistic view and perform the study in accordance with the preset methodology, where the systems approach was chosen, the process for the entire product development was mapped. By doing so, the authors gained a deeper understanding of how PBT affected and was affected by the product development process as a whole. With the increased and broadened knowledge of the product development process and PBT’s involvement in it, the authors could map the process of PBT in further detail in order to expose problem areas. This was done by mapping PBT’s core processes, material supply and build. Material supply because it became clear early on in the study that this was the area in most need of revising and build because this is an important core process which to a large extent is affected by the performance of material supply. Another reason for choosing to map the as-is build process was for the authors to see the effects of the improved, to-be, material supply process on the, to-be, build process, this to ensure the trustworthiness of the study. The problems identified through the process mapping were mainly related to the material supply process and these issues, and the solutions to them, are discussed together with the fourth research question. One problem area, not directly related to material supply, which was identified through the process mapping was the creation of the project time plans. In the current set-up a lot of problems could be attributed to the time plan not being realistically possible to meet with the allocated resources. The authors suggest that the solution to this problem is to change the way that the time plans are created. The lower level time plans should always be used as input for the creation of the higher level time plans. This way you make sure that the high level time plans are realistically possible to meet. If it is still needed to shorten the lead times, more resources must be allocated to the project. By making the suggested changes to the process it is possible to enhance its efficiency.

How can we prevent stagnation in build and prevent delays in projects?

During the study it became clear that the stagnation in the prototype builds were evidently related to delayed or lost material. These two factors can each be related to the process for material supply.
Hence, the stagnation could be prevented by enhancing the reliability of material supply which will lead us to the fourth research question.

**Why are the material deliveries unreliable and how can the reliability of material supply be enhanced?**

When interviewing the employees and mapping the process for material supply the authors could identify four main problems with the material supply process. These issues were insufficient delivery control, inadequate goods receiving routines, inadequate inventory control system and poor supplier relations. Each problem was analyzed and the authors suggest the following course of actions to increase the reliability of the material supply process. PBT needs to start performing proactive delivery control and work closer with their suppliers to avoid problems with late material at an early stage. When the material reaches PBT new goods receiving routines must be implemented so that all material gets goods received and entered into the inventory control system. The current inventory control system must also be improved, and warehouse personnel must be better educated in using it, so that it is easy to keep track of the building material. If these actions are taken the reliability of the material supply process can be increased dramatically and as a result stagnation in the prototype builds can also be prevented.

**How can the organizational structure be changed to facilitate efficiency gains of the process?**

By analyzing data from interviews and the map of the entire product development process the authors could find problems related the organizational structure, impairing PBT’s ability to use a process-based view. These issues involved unclear role descriptions and division of responsibility as well as poor communication and information exchange. These issues caused a lot of uncertainty in the process and meant that unnecessary activities had to be carried out. The authors suggest that all involved parties need to collectively formulate a new set of role descriptions and responsibilities. This common work approach will result in a more efficient use of the process with clear communication interfaces. The suggested changes do not directly change the physical structure of PBT, as this is already much like a process-based organization should be structured. What it does attempt to change is the overall mentality and the way that PBT works. This will allow for continued process orientation which is what is needed to acquire a truly process-based organizational structure.

Hence the purpose of the thesis is fulfilled and the research questions have been answered.

### 6.2 Recommendations

**Action plan**

This action plan contains recommended actions which PBT should use as a basis for the development of the organization. The recommendations are categorized into 5 fields and are arranged in the action plan in the order they should be attended to. Most of the recommended actions are directed especially at PBT, but there are also issues that need to be addressed on a larger scale. All recommendations are explained in further detail in the analysis chapter.

**R1. Process orientation**

- Actively work with introducing process thinking throughout the organization
PBT has a long way to go when it comes to being fully process oriented and are at the moment closer to a functional paradigm than a process paradigm. In order for PBT to work according to a process based view, it is important that the employees are onboard with these ideas and that they actively partake in developing the process. While there are definitely employees who have taken to the process way of working, there are still those who do not see the purpose or the possible gains of a process based view. For a successful process-based organization, however, it is essential that everyone is pulling in the same direction. PBT should employ the help of process experts within the Volvo Group and design a program for how the process based view can be better infused into the organization and its employees. In order to assure that continued process development will take place, process ownership must be established. It is the responsibility of the process owner to drive process improvement work and make sure that the process is working as it is supposed to.

**R2. Regain control of material flow**
- Implement proactive delivery control
- Develop and implement new routines for goods receiving
- Implement improved inventory control system and warehousing routines

Delayed and missing building material is the biggest cause of delays for the prototype building process. If PBT can regain control of the inbound material flow and increase the delivery performance much will be gained. This can be achieved by implementing proactive delivery control, along with a closer cooperation with the suppliers, to detect problems before it is too late to act. By creating a robust set of routines for goods receiving no material will get lost when it is being delivered and combined with an improved inventory control system it will be easy to keep track of material and have it ready and waiting when the building is to commence. This way the amount of wasted resources linked to the material flow can be heavily decreased.

**R3. Define roles and responsibilities**
- Define, document and implement a common structured way to work within the process

To find a more efficient way of working within the product development projects it will require some effort from all involved parties. The recommendation for how to develop this new structured way of working is divided into a few steps. First each team or group with the same or similar roles needs to sit down together and create a common view of what this role means, which responsibilities that are connected to the role and how a common working method should look. After this a bigger workshop, with representatives from all parts of the process, needs to be carried out where the different views of roles and responsibilities within the process are discussed. The aim of this workshop is to create a process-wide definition of what each role means and how responsibilities are distributed. The result of the workshop should be a process where all the actors have collectively agreed on how they are supposed to work within the process. This should provide good prerequisites for a standardized process with an easily repeatable way of working which in its self makes it much easier to continuously improve the process. It is very important that, throughout this process, everyone keeps in mind how the new working methods and responsibilities of each role will affect all of the other roles and activities in the process. The goal is to create a process that is optimized for the greater good and not a single role. It is also important to follow up on this workshop, as the result of such a big task is rarely perfect from the start.
R4. Process measurement

- Establish process measurement, implement measurements and evaluate them

When a process-based view permeates the organization and the process is commonly known and used by the employees, the work still does not end. There is a need to develop an improvement system for the process and a pre-requisite for continuous improvements are measurements. The suggestion is to use the KPIs that have been developed by the authors and have primarily focus on the process of material supply by and complement these with KPIs for the other processes and activities. The three KPIs are:

- Delivery Performance
- Goods Reception
- Standstill in Prototype Build

The data needed for the measurements should be collected continuously throughout the year. The evaluation and follow up of the measures are very important and should be done on a regular basis. To assure that the process measurements are accomplished a selected relevant person should be responsible for the measures. This is usually the process owner.

R5. Continuous improvements

- Implement and drive process-wide initiatives for continuous improvement work

Continuous improvement is an important aspect of working in a process-based organization. The best way to achieve a better working, more efficient, process is to learn from past experience. It is essential that PBT works at implementing continuous improvement as a part of the everyday work. Every part and every function within the organization can gain much by simply having a routine consisting of evaluating how the latest project or step in the project has gone and to use this knowledge to be even better in future work. Audits of the organization should be conducted on a regular basis to highlight how everyone is doing and where the biggest improvement efforts are needed.

R6. Evaluate time plan

- Evaluate how project time plans can be set with a more realistic time frame

The entire product development organization needs to collectively evaluate how the time plans are set. Today many parts of the process are being rushed, carried out in a less than desirable manner or even loses its value when the project tries to find ways to make up time and meet the overall time plan. It is understandable that new laws or emission regulations will mean that some deadlines are non-negotiable and sometimes have a very short time frame, but this does not mean that the time plans, set early on in the project, can be unrealistic from the start. This will only lead to quality deficiencies in the finished product which costs vast amounts of time and money to correct as well as lead to customer dissatisfaction. In short we recommend that Volvo Buses should investigate how the process of determining project time frames can be revised in order to reach more realistic levels. Perhaps it is not always best to focus entirely on time-to-market, if the unrealistic time plan means that the project will not be able to be carried out in the desired manner and the quality of the finished product will suffer.
6.3 Trustworthiness and authenticity

To ensure the trustworthiness and the authenticity of the study the authors worked according to the described methodology in chapter 2. As mentioned, in the section 6.1 above, the authors managed to retain a holistic view throughout the study which reaffirms the trustworthiness of the result. The authors moreover, chose to visualize the results by creating to-be maps illustrating the effect of the improvements on both material supply and the related build process.

To ensure the validity and reliability of the study the criteria and design tests by Yin (2003) presented in the methodology chapter, section 2.5.1, will be used. Now, the tactics that have been considered in this study and how they were taken into account will be presented.

To ensure construct validity, multiple sources of evidence were used. This triangulation of data was achieved by combining interviews, observations and data from Volvo’s intranet. The authors have performed interviews in two predetermined sessions and complemented these with follow up interview sessions. All the data used in the thesis is based on data retrieved from more than one interviewee. However, at one stage in the study the authors encountered difficulties regarding interviewees due to one employee’s refusal to participate in the interviews. This employee was directly related to the material supply process, and only one other employee occupying the same role existed. For this reason a lot of data had to be based on the interview of only one person. The information from this interview could however be verified by employees working closely with this employee or with similar tasks. A chain of evidence was maintained throughout the study by keeping the link between the initial case study questions and the case study and by storing actual evidence to enable continuous checkups. The data used in the study is confirmed by key informants and during the development of the process maps these were continuously overlooked by people in the organization.

To ensure the internal validity of the data analysis pattern matching was done by comparing empirical data with expected outcomes, explanation building was done at an early stage of the study and rival explanations were addressed by retaining a holistic view throughout the study contemplating the effects of previous activities and by assuming that the presence of certain explanations should exclude the presence of others. Finally to keep the data collection reliable, a case study database and an interview guide was developed. The authors are confident in managing to keep the study align with the purpose and the stated research questions.

Throughout the study the authors have kept an open mind and put personal opinions aside. To ensure the objectivity the authors have clearly motivated their choices and their reasoning. However, when using the Systems approach in combination with a qualitative research it is inevitable for the results not to be somewhat subjective. The authors still feel that the chosen methodology was correct for the study and emphasize that when working with process development in a social environment a subjective view and knowledge of the employees can be advantageous when enhancing the performance and efficiency of an organization.

To ensure the external validity of the study the authors evaluated the possibility of generalization of the findings. What can be said is that, this study covers a unique case and the findings and recommendations are specifically related to the organization of PBT and the processes within. The stressed problems and the recommendations are however important to work with and need to be functioning in any prototype building organization. The authors express that material availability is of
great importance for any similar industrial business, with a high pressure on reduced lead times or increased amount of projects. The recommendations regarding the organizational strategy can be applied to any company working with process orientation. One should, however, keep in mind the delimitations that were set for this thesis in the beginning of the study. The delimitations being to only cover the local site in Gothenburg in spite of this being a global process, as well as the choice to focus on the process for material supply when performing the analysis. As long as the prerequisites for this thesis are understood others can assimilate the findings of this thesis, which implies a degree of external validity.

6.4 Future work at Volvo Bus

The thesis was delimited to analyze the material supply process. Throughout the thesis the authors encountered problems lying outside of this delimited area. These are presented and analyzed on a rough conceptual level, but some of them were too vast to attend to in a sufficient way in this thesis and yet too important to let them pass through. These will be presented below and are our suggestions for future studies.

6.4.1 Streamline the work in the workshop

For this study the process for build was mapped and the affects the material supply had on the build process were considered and analyzed. However, no extensive analysis of the build process was done. In this thesis it is stated that the main issues in the build processes today are directly related to the availability of material. When the problems identified through this thesis, that are affecting the build process, has been handled extensively, less issues with delayed and lost material will occur. Then it could be time to make an equivalent study of the build process. Our suggestion is to perform a detailed study mapping all the activities of the build process to be able to efficient the work in build and produce a structured operation mode. In doing so the organization of PBT can overcome the dependencies there is today on the knowledge and skills of the employees.

6.4.2 Create proper process mapping for all the processes at PBT

The purpose of the thesis was to begin with to propose a process map for all of PBT. However, this purpose was delimited to only cover the core processes and foremost the material supply. PBT still lacks proper process mapping of all of its processes and a need exists of getting them all mapped to create structure within the organization, this also to be in line with the level of process orientation at Volvo Buses in general as well as the Volvo way and the GDP.

6.4.3 Implement the changes

The analysis in this study has been on a conceptual level and none of the recommendations to restructure the material supply process or to make the changes of the organizational structure have yet been implemented. Our suggestion for future work, which may advantageously be suggestions for future theses, is to implement the improvement suggestions of this thesis and taking them to a concrete level. An example could be to develop the new role descriptions. Another one to follow up this thesis by measuring the performance of the material supply process on the developed KPIs and evaluate the transformation over 6 months.

Our final recommendation and hope is that Prototype Build and Test sees the potential in the suggested improvements, implements these and continues to develop their business. Process orientation and the changes towards a new process paradigm is a long-term project that never ends demanding continuous process improvement work.
6.5 Future academic research
When this study was conducted the authors had difficulty finding theory on prototype organizations and not a lot of research and literature in this area exists. While this study aims at filling some of the gaps in this area there is still much unexplored territory. A proposal for future academic research would therefore be to perform a case study on prototype organizations focusing on material supply and build, on the grounds of these being the core processes. A study of this type could benefit from having a multiple-case design and a benchmarking between multiple prototype organizations. This would provide a better understanding of the field and emphasize generalization possibilities of the findings. For such a study the findings, analysis and recommendations stated in this study will come to excellent use and could help build the foundation for the analysis of that study.
7 List of References


http://mittkursbibl.lub.lu.se/get_doc.cgi/V%6E4rdera_feb_2010.pdf?document_id=16991


# Appendices

## Appendix A. List of interviewees

<table>
<thead>
<tr>
<th>Role</th>
<th>Location</th>
<th>Dates</th>
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<td><strong>GDP Manager</strong>, Volvo Bus</td>
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<td><strong>Project Vehicle Manager</strong>, Volvo Bus</td>
<td>Göteborg</td>
<td>13 September 2011</td>
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<td><strong>Manager of PBT Department</strong>, Volvo Bus</td>
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<td>several occasions</td>
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8.2 Appendix B. Interview guide

8.2.1 Background questions
Name, position, role

What is the purpose of your role?
What are the tasks and activities for your role?
Define when your work starts and ends?
What problems do you see within the organization today?
Why do you think these problems occur?
How would you solve these problems? Potential solutions?

8.2.2 PBT
What is the purpose of PBT?
What is the end product of PBT?
How is the purpose of PBT and your business idea realized?
What activities are of special importance for PBT?
What is the core competence of PBT?

8.2.3 Customer focus
What are the customers’ expectations and need?
Tell us about the project specification and how changes are made in it during a project?
How do you interact and cooperate with the customer?

8.2.4 Project planning and the PVM role
What are the responsibilities for a PVM?
How is everything tied together?
Are the designs final when build begins? If not when are they finalized?
How do you interact with other people within the organization? And what people do you cooperate most with and share information with?
Tell us about the project planning and the work with time plans, main, level 2 and level 3.
How is the BOM and the material specifications created?

8.2.5 Material Supply
Tell us about the ordering procedure.
Who is responsible for the material to be delivered on time?

How are problems with delayed or missing material tackled/dealt with?

How is information shared when material is delayed or lost?

How is information shared when material has been delivered?

How is it registered where material in the warehouse can be found?

How do you interact, communicate and share information with other units, mainly the workshop and purchasing?

How is this done and what information do you share?

8.2.6 Build

Tell us about the process for build.

Who do you interact with most and share information with?

How is this done and what information do you share?

What cause stagnation in build?

What cause delays in build and the entire project?

What are the most time consuming activities?

Could you identify unnecessary activities, so called waste?
8.3 Appendix C. The Global Development Process
Appendix E. To-Be process map of core process at PBT