Master thesis

Process for preparing work instructions
- A multiple case study at
Volvo Group Trucks Operations

by

Frida Delin & Sofie Jansson

2015-06-04
Master thesis

Process for preparing work instructions
- A multiple case study at Volvo Group Trucks Operations

by

Frida Delin & Sofie Jansson

LIU-IEI-TEK-A--15/02266--SE

2015-06-04

Supervisor: Bozena Poksinska
Examiner: Peter Cronemyr
Acknowledgment

There are so many people that have helped us during our master thesis who deserves recognition. At first we would like to send our sincerest gratitude to our supervisors Pierre Johansson and Lena Moestam at Volvo GTO. Thanks for your confidence in us to carry out this thesis. Your support and guidance have enabled many interesting discussions and the possibility to finish our thesis.

Secondly, we would like to thank our supervisor Bozena Poksinska at Linköping’s University for your commitment and time spent to help us throughout this thesis. Your feedback has been very valuable and guided us in the right direction. We would also like to thank our examiner Peter Cronemyr for valuable feedback to improve our thesis. Our opponents Pontus Unroth and David Jakobsson also deserve recognition for their time spent on giving us feedback.

This thesis would not have been able to execute without the engagement from people we have contacted. The time you spent on helping us through interviews, study visits, and email contact have enabled us to carry out this thesis and given us a learning experience.

Lastly we would like to thank the people at our department who have contributed to an enjoyable time at the office.

Gothenburg, May 2015
Frida Delin & Sofie Jansson
Abstract

A study made by Johansson, Fast-Berglund and Moestam (in press) shows that diversity regarding how information is used exists in global production networks. To be closer to markets, organizations have chosen to globalize their business which is one reason for why diversity arises. This because product types and brands historically have been different. One company that is currently working with improving consistency among processes is Volvo Group Trucks Operations (GTO). The company wants to evaluate how the process for preparing assembly work instructions looks like at different sites within their production network. This enables Volvo GTO to start their work towards a standardized process and uniformity.

A starting point for this is to make a current state analysis of the process for preparing assembly work instructions when producing Volvo trucks, engines and transmissions in Sweden. The purpose is to identify key activities within the process and important factors to consider when standardizing the process. This is done on three sites, one for each area.

Volvo GTO is the part of the Volvo Group that covers all production of engines and transmissions as well as the production of Volvo, Renault, Mack, and UD trucks. In 2012 the group choose to reorganize from brand based where each brand was an own organization to joint units, for example center of development, operations etc. This has led to a greater need of one common process for preparing assembly work instructions in order to create uniformity among the brands Volvo, Renault, Mack, and UD trucks.

The result of the current state analysis shows that the process for preparing assembly work instructions is differently performed depending on the site studied. Despite this, some activities in each process are similar. These were found to be: design, review, time setting, time analysis, balancing, station marking, create assembly work instructions, and share information. Since some activities actually are similar, it would be possible to standardize the process for preparing assembly work instructions in the future. Important to consider when standardizing a process is to create awareness and involvement among employees. It is also important to have the management committed as well as uniformity among IT systems used when performing a process. One last thing to consider is that the process needs to be adaptable because sites are located all over the world and have different culture and regulations.
Sammanfattning

En studie gjord av Johansson, Fast-Berglund och Moestam (i tryck) visar variation i hur information hanteras i globala produktionsnätverk. För att komma närmre marknader har organisationer valt att globalisera sin verksamhet, vilket är en anledning till varför variation uppstår. Detta eftersom produkttyper och märken historiskt har varit annorlunda. Ett företag som för närvarande arbetar med att förbättra enhetligheten mellan processer är Volvo Group Trucks Operations (GTO). De vill utvärdera hur processen för framställning av monteringsarbetsinstruktioner ser ut på olika siter inom produktionsnätverket. Detta gör det möjligt för Volvo GTO att starta sitt arbete mot en standardiserad process och enhetlighet mellan siter.

En början i detta arbete är att göra en nulägesanalys av processen för framställning av monteringsarbetsinstruktioner vid produktion av Volvo lastvagnar, motorer och växellådor i Sverige. Syftet är att identifiera nyckelaktiviteter inom processen och viktiga faktorer att tänka på när man standardisera processen. Detta sker på tre siter, en inom varje område.

Volvo GTO är den del av Volvokoncernen som omfattar all tillverkning av motorer och växellådor samt produktion av Volvo lastvagnar, motorer och UD lastvagnar. År 2012 valde Volvokoncernen att omorganisera från varumärkesbaserad till organisatoriska enheter, till exempel utveckling, tillverkning etc. Detta har lett till ett ökat behov av en gemensam process för framställning av monteringsarbetsinstruktioner för att skapa enhetlighet mellan varumärkena.

Resultatet av denna nulägesanalys visar att processen för framställning av monteringsarbetsinstruktioner utförs annorlunda beroende på siten som studerats. Trots detta är vissa aktiviteter i varje process liknande. Dessa visade sig vara: design, granskning, tidsättning, tidsanalys, balansering, stationsmärkning, skapa monteringsarbetsinstruktioner och dela information. Eftersom vissa aktiviteter faktiskt är lika skulle det vara möjligt att standardisera processen för framställning av monteringsarbetsinstruktioner i framtiden. Viktigt är att tänka på när man standardisera en process är att skapa medvetenhet och engagemang bland medarbetarna. Det är också viktigt att ha ledningens engagement och stöd samt enhetlighet mellan IT system som används för att utföra processen. En sista sak att tänka på är att processen måste kunna anpassas då siter är placerade över hela världen och har olika kultur och lagar.
## Abbreviations & Definitions

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexibility</td>
<td>The ability of adapting a process in a late stage in order to avoid an entirely new process</td>
</tr>
<tr>
<td>Preparation process</td>
<td>The process for preparing assembly work instructions</td>
</tr>
<tr>
<td>Master structure</td>
<td>The structure that represents in what sequence the assembly should be performed on a global level</td>
</tr>
<tr>
<td>Target structure</td>
<td>The structure that represents the actual assembly sequence on a local level</td>
</tr>
<tr>
<td>PCR</td>
<td>Product Change Request from Design to sites</td>
</tr>
<tr>
<td>DCN</td>
<td>Design Change Note from Design to sites</td>
</tr>
</tbody>
</table>
Contents

1 Introduction ........................................................................................................... 1
  1.1 Background ..................................................................................................... 1
  1.2 Problem formulation .................................................................................... 2
  1.3 Purpose .......................................................................................................... 2
  1.4 Research questions ..................................................................................... 2
  1.5 Delimitations ............................................................................................... 2

2 Methodology ......................................................................................................... 3
  2.1 Research method ......................................................................................... 3
  2.2 Research perspective ................................................................................. 3
  2.3 Stages of the study ..................................................................................... 4
    2.3.1 Planning phase ....................................................................................... 4
    2.3.2 Data collection phase .......................................................................... 4
    2.3.3 Analysis phase ..................................................................................... 5
    2.3.4 Final phase .......................................................................................... 5
  2.4 Literature study ........................................................................................... 5
  2.5 Data collection methods ............................................................................. 6
    2.5.1 Interviews ............................................................................................. 7
    2.5.2 Documentation study ........................................................................... 7
  2.6 Analysis methods ......................................................................................... 8
  2.7 Process mapping ........................................................................................ 8
  2.8 Evaluation of the study ............................................................................. 11
    2.8.1 Validity .................................................................................................. 11
    2.8.2 Reliability ............................................................................................. 11
  2.9 Summary of methodology ......................................................................... 11

3 Theoretical framework ......................................................................................... 13
  3.1 Process ......................................................................................................... 13
  3.2 Process mapping ........................................................................................ 13
  3.3 Preparation process ................................................................................. 15
  3.4 Standardization .......................................................................................... 16
  3.5 Previous research ....................................................................................... 18

4 Results ................................................................................................................ 21
  4.1 Company description ............................................................................... 21
4.2 Volvo Group Trucks Operations .................................................................................. 22
4.3 Current state of the process at Volvo GTO Cab & Vehicle assembly ...................... 22
4.4 Current state of the process at Volvo GTO Powertrain Production ......................... 26
  4.4.1 Transmissions .................................................................................................. 27
  4.4.2 Engines .......................................................................................................... 29
4.5 Process for preparing assembly work instructions according to interviewees ......... 30
5 Analysis ..................................................................................................................... 33
  5.1 Process map with key activities .......................................................................... 33
    5.1.1 Identified key activities ................................................................................. 33
    5.1.2 Differences in current processes for preparing assembly work instructions .... 35
  5.2 Standardization .................................................................................................... 37
6 Discussion .................................................................................................................. 39
  6.1 Process map with key activities .......................................................................... 39
  6.2 Differences in current process for preparing assembly work instructions .......... 39
  6.3 Preparation process ............................................................................................. 41
  6.4 Standardization .................................................................................................... 41
  6.5 Method discussion ............................................................................................... 42
  6.6 Contribution of this study ..................................................................................... 43
7 Conclusion .................................................................................................................. 45
  7.1 Theoretical contribution ....................................................................................... 47
  7.2 Recommendations to case company ..................................................................... 47
  7.3 Future research ..................................................................................................... 47

Appendix 1: Interview questions with people inside the process
Appendix 2: Interview questions with people outside the process
Appendix 3: Interviewees and their title
Appendix 4: Other contact persons
Appendix 5: Assembly work instruction – Cab and Vehicle Assembly
Appendix 6: Assembly work instruction 1 – Powertrain Production, Sweden
Appendix 7: Assembly work instruction 2 – Powertrain Production, Sweden
Appendix 8: Assembly work instruction 3 – Powertrain Production, Sweden
List of Figures

Figure 1: Symbols for process mapping .................................................................................................................. 9
Figure 2: Our method for data collection and analysis of processes ................................................................. 10
Figure 3: Summary of methodology .......................................................................................................................... 12
Figure 4: Main processes in manufacturing organizations (source from Scallan, 2003) ...... 15
Figure 5: The process planning linkages (source from Scallan, 2003) .............................................. 16
Figure 6: Relationship and purpose of standards (adapted from Liker & Meier, 2006)........ 17
Figure 7: The Volvo Way (Volvo Group, 2014) ................................................................................................. 21
Figure 8: Volvo GTO in the world (Volvo Group, 2014) ...................................................................................... 22
Figure 9: Level 0 - Process for preparing assembly work instructions and its surroundings ... 23
Figure 10: Level 1 - Process for preparing assembly work instructions at Cab and Vehicle ... 23
Figure 11: Level 2 - Product design at Cab and Vehicle ....................................................................................... 24
Figure 12: Level 2 - Introduction preparation at Cab and Vehicle ............................................................... 25
Figure 13: Level 2 - Instructions development at Cab and Vehicle ............................................................... 25
Figure 14: Level 2 - Local adaption at Cab and Vehicle ....................................................................................... 26
Figure 15: Level 1 - Process for preparing assembly work instructions at Powertrain .............. 27
Figure 16: Level 2 - Product design at Powertrain Transmissions ....................................................................... 27
Figure 17: Level 2 - Introduction preparation at Powertrain Transmissions, Sweden .......... 27
Figure 18: Level 2 - Instruction development at Powertrain Transmissions, Sweden .............. 28
Figure 19: Level 2 - Product design at Powertrain Engines ........................................................................... 29
Figure 20: Level 2 - Introduction preparation at Powertrain Engines, Sweden ...................... 30
Figure 21: Level 2 - Instruction development at Powertrain Engines, Sweden ...................... 30
Figure 22: The preparation process at Cab and Vehicle according to interviewee A .......... 31
Figure 23: The preparation process at Cab and Vehicle according to interviewee B .......... 31
Figure 24: The preparation process at Cab and Vehicle according to interviewee C .......... 32
Figure 25: The preparation process at Cab and Vehicle according to interviewee D .......... 32
Figure 26: Key activities of the process for preparing assembly work instructions .......... 35
Figure 27: The process for preparing assembly work instruction around the globe ........... 38
Figure 28: Answer research question 1 ........................................................................................................... 45

List of Tables

Table 1: Research perspectives .......................................................................................................................... 4
Table 2: Literature search .................................................................................................................................. 6
Table 3: Approaches to break down a process ................................................................................................. 14
Table 4: Summary of systems at Cab & Vehicle .............................................................................................. 26
Table 5: Summary of systems at Powertrain ................................................................................................. 29
Table 6: Key activities of the process for preparing assembly work instructions ....................... 34
Table 7: Comparison of systems at the different sites ..................................................................................... 36
1 Introduction

In the introduction a background to the problem is presented, which is narrowed down into a problem formulation. Based on the problem formulation, two research questions are stated together with a purpose of the study and its delimitations.

1.1 Background

A recently made study at a global company investigates how information is treated at different sites within the same production network. The study shows that there exists diversity both between production sites but also within one production site (Johansson, Fast-Berglund & Moestam, in press). This global study is a continuation of a study made at national level by Fast-Berglund et al. (2014) where they investigate national information strategies at three global companies. During the recent years, organizations have chosen to go abroad with parts of their business as well as acquire companies to be closer to markets (Hitt, Ireland & Hoskisson, 2009). This globalization is one of the reasons diversity arises because companies have “hard times creating global standards when product types and brands historically have been different” (Johansson, Fast-Berglund & Moestam, in press, p.6).

Globalization is when products, services, and markets around the world are drawn together (Gilani & Razeghi, 2010). Globalization is defined by Gilani and Razeghi (2010, p.103) as a “process by which a given firm begins a journey of becoming global... in order to achieve competitiveness”. There exist different forces for organizations towards globalization, which are described by Kotler (1986) as: the extent of customer requirements in different countries, resources and buying behavior in different countries, and environmental factors. HermanMiller (2010) describes three other drivers for globalization: technology, labor costs and global talent pool, and trade agreements.

Problems can be faced when broadening a business worldwide because of different organizational cultures, approaches, and local regulations. As a result the processes are often performed in different ways (Gilani & Razeghi, 2010). This can be solved by standardizing processes such that everyone within the company has the same work approach for the same kind of process. Standardization also generates benefits such as increased efficiency, possibility for continuous improvements, and quality increments (Liker & Meier, 2006). All these benefits in turn lead to increased profitability which is one of the main targets for companies to survive on today’s market as well as developing their businesses and increase the customer base (Spangenberg, 2005). Even if there is a need to standardize processes in order to reach efficiency (Liker & Meier, 2006), parts of the processes still needs to be flexible for variety to maintain efficiency (Rentzhog, 1998). Another aspect of flexibility is the ability to provide customized products based on different customer requirements (Chou et al., 2009). Flexibility is required in order to handle variations as well as allow local plants to realize their own needs (Chou, Teo & Zheng, 2008; Tushman & O’Reilly, 1996). By allowing a process to be flexible, the main part of the process can still be standardized but with an ability to handle local adaptions. This is strengthened by Ljungberg and Larsson (2012) who states that creating an entirely new process can be avoided by adapting a part of the process in a late stage.
1.2 Problem formulation
During the last decades companies has started to expand their businesses by company acquisitions and offshore production (Hitt, Ireland & Hoskisson, 2009). This has led to differences when performing processes because of, among other, previous procedures (Gilani & Razeghi, 2010). To reduce the risk of performing procedures differently, a standardized process can be used. A standardized process should be designed to cover key activities such that it becomes flexible (Rentzhog, 1998). In a wide spread organization, it can be hard to standardize processes and still maintain high flexibility (Kotter, 1995).

One company that is currently working with improving consistency among processes is Volvo Group Trucks Operations (GTO). Volvo Group has, during the recent years, acquired several different brands such as Renault trucks, Mack trucks, UD trucks etc. These investments have led to differences in the process for preparing assembly work instructions (in this study, preparation process). Differences exist because all brands work according to previous procedures, as they were doing before the acquisition. All these different approaches lead to confusion among employees involved in the process due to different terminology and systems. To eliminate these problems, Volvo GTO wants to evaluate how the preparation process looks like.

1.3 Purpose
The purpose is to investigate a preparation process in a global company in order to define the process, identify key activities, and suggest how this process can be standardized.

1.4 Research questions
- Which key activities can be identified within the process for preparing assembly work instructions?
- How can a process for preparing assembly work instructions be standardized to fit a global company?

1.5 Delimitations
This study only focus on the process for preparing assembly work instructions when producing trucks, engines and transmissions within Volvo GTO. The study captures the key activities of such a process by performing a current state analysis at three sites, one for each area, within Volvo GTO in Sweden. Sweden is the starting point since the main development is made here for the Volvo brand. By using this starting point, it is possible to get an understanding of how the production network looks like. Therefore this study is limited to only investigating the Volvo brand and not the brands acquired.
2 Methodology

The methodology to conduct this study is presented in this chapter. It includes methodologies, perspectives, stages of the study, and finally a summary of methods used.

2.1 Research method

There exist two main research methods, the qualitative and the quantitative. A qualitative research is a methodology that provides an in-depth understanding of one specific area (Hennink, Hutter, & Bailey, 2011). The characteristics of a qualitative research method are, according to Christensen et al. (2010), words, text, symbols, and actions. This approach emphasizes words and understanding of social interaction between individuals (Bryman & Bell, 2011). A study that focuses on measuring, counting, and quantifying data is called a quantitative research approach (Bryman & Bell, 2011). This method covers a broad population to understand relationships in data gathered from a large sample size (Hennink, Hutter, & Bailey, 2011).

This study uses a qualitative research method because it focuses on one specific area where the data gathered provides a detailed understanding of the area in focus. The data contains information in text rather than numbers which supports the choice of research approach. According to Hennink, Hutter, and Bailey (2011, p.9) a qualitative study “is an approach that allows you to examine people’s experiences in detail”, this by using methods such as interviews, focus group discussions, observations, and content analysis. Answering the research questions in this study requires an understanding and interpretation of the current situation where it is necessary to identify processes and explain experiences (Patel & Davidson, 1994; Bryman & Bell, 2011).

One way to perform a qualitative research is by applying a case study approach. A case study is appropriate when gathering in-depth information to get a comprehensive overview about a specific area (Patel & Davidson, 1994). This can be done by investigating a small group such as individual, group of individuals, an organization or a situation (Bryman & Bell, 2011; Patel & Davidson, 1994).

We chose to use a case study approach because we wanted to investigate a process within an organization. This is consistent with Patel and Davidson (1994) who states that this approach is appropriate for such a purpose. A case study also gave us an in-depth understanding about the stated problem.

2.2 Research perspective

When conducting a research, several different perspectives exists, see Table 1. The research perspective sets the base of which approaches to be used in the study. A perspective is a framework that defines how to see and understand reality. (Hennink, Hutter, & Bailey, 2011)
Table 1: Research perspectives

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positivism</td>
<td>Importance of natural science and logic</td>
</tr>
<tr>
<td>Realism</td>
<td>Combination of natural science and reality</td>
</tr>
<tr>
<td>Interpretivism (Hermeneutics)</td>
<td>Explanation and understanding of social interactions</td>
</tr>
<tr>
<td>Objectivism</td>
<td>Reality exists independently of social actors</td>
</tr>
<tr>
<td>Constructionism</td>
<td>Social actors learn effectively by accomplishments and continuous revisions</td>
</tr>
</tbody>
</table>

(Charmaz, 2006)

We choose a hermeneutic perspective because it is according to Bryman and Bell (2011) closely connected to a qualitative study. Hermeneutics can be called the learning of interpretation where the researchers study, interpret, and trying to understand the study object (Patel & Davidson, 1994). The data collection mainly came from interviews and therefore required an understanding of people. In order to understand the meaning of the results from the interviews, the information was interpreted. This is in accordance with the hermeneutic perspective which therefore was used in this study.

2.3 Stages of the study

We chose to divide the study into four stages: planning phase, data collection phase, analysis phase, and final phase. This was done to provide a framework of how to execute this study and to ensure that risks connected to case studies were minimized. One example is that necessary information is not provided. We created this framework with inspiration from Christensen et al. (2010), who states that a model is necessary to develop in an early stage to get a good overview of what to include in the study. Björklund and Paulsson (2012) describe the importance of dividing a research into phases where they suggest three phases; idea phase, knowledge phase, and deepening phase. These phases were the foundation for the framework developed for this study.

2.3.1 Planning phase

The study started with a planning phase where we gathered information through a literature study to get enough knowledge about the stated problem. This by firstly define the background of the problem and why the problem exist, which later came down to a problem formulation. A discussion with the supervisors at the case company was held to get additional information about their problem that was not clearly stated in the initial problem description. When the problem was clearly defined, a purpose was formulated in such a way that it directed the study to answer the research questions. To narrow down the study into an appropriate size, limitations were developed. During the planning phase, the methodology used in this study was developed to address the problem.

2.3.2 Data collection phase

Additional theoretical information was gathered from literature and articles in order to build a frame of references to support the study. Other data regarding the study target was collected by performing interviews with key persons and study of documents connected to
the process. This information was necessary to be able to answer the research questions. To decide which data that needed to be collected, we used our purpose as a starting point. The data collection methods used in this study is more described in chapter 2.4 and 2.5.

2.3.3 Analysis phase

Data collected during the previous phase was processed and compiled, and compared to the frame of references. The data was also analyzed according to the methodologies described in chapter 2.6, in order to interpret and understand the data accurately. The purpose of the analysis phase was to distinguish relevant data to solve the stated problem.

2.3.4 Final phase

Lastly, the findings were presented based on the analysis performed. From this the result was discussed with a critical point of view and conclusions were drawn. Suggestions regarding future work were presented to the case company as well as other authors.

2.4 Literature study

When searching for knowledge within a specific area or trying to find gaps in science, a literature study is performed (Machi & McEvoy, 2009). According to Machi and McEvoy (2009, p.4) literature can be defined as “a written document that presents a logically argued case founded on a comprehensive understanding of the current state of knowledge”. When performing a research it is important that the researcher has good knowledge within the specific problem area. A literature study is appropriate for such a purpose (Machi & McEvoy, 2009).

The theoretical information was gathered through books, articles and other scientific publications, which was critically evaluated to ensure reliability. The information was used to create a common understanding of the stated problem. We also studied the literature to find gaps in previous research in order to contribute scientifically within the specific area as well as solving our stated problems. We used recommended articles received from our supervisors at the university and the case company. We also used literature gathered in previous courses covering part of the theoretical framework.

Additional searches were made on subjects regarding processes, globalization, standardization, preparation process to find academic journals, see Table 2. Since these searches gave us very many hits we chose to combine each subject with key words such as manufacturing, flexibility, work instructions etc. to narrow down the number of hits. When searching for information regarding “preparation process”, a limited amount of information was found. We could not find any clear definition of this process and it appeared that the process is named differently e.g. process planning, preparation process. The most important articles that we found appropriate are:

2.5 Data collection methods
To gather data that answer the research questions, several different options to choose from within the qualitative method exist. Some common approaches are interviews, observations,
2.5.1 Interviews

Interviews are an approach where information is gathered by asking questions (Patel & Davidson, 1994). There are different types of interviews; personal interview, group interview, and telephone interview where these can be structured, semi-structured or unstructured (Christensen et al., 2010). The level of structure decides in what extent the questions allow the interviewee to answer (Patel & Davidson, 1994), e.g. a structured interview consists of closed question where the questions are pre-decided (Christensen et al., 2010).

The stated problem for this study concerns a process that is performed by human beings and therefore interviews was considered to be appropriate in order to gather information. The data gathered from interviews can be defined as primary data, meaning “new” data that has not previously been collected (Christensen et al., 2010). The interviews in this case were mainly unstructured due to lack of knowledge about the specific process steps. But also to allow the interviewee to thoroughly explain what he/she is doing. When knowledge about the process was achieved, semi-structured interviews were held to get more specific information. The interviews were held during the data collection phase with employees from each process step at the different sites to receive necessary information. Most of the interviews were performed by going to each site having personal meetings, additional interviews were held over internet (Lync) and email. In connection to some of the interviews, we were given a guided tour in the assembly line to get understanding of where the assembly work instructions are used.

We started to interview one person per site that has an overall knowledge about the preparation process to receive a comprehensive overview as well as contact persons from each step. To get a more detailed view of the process we contacted suggested persons and booked interviews. During these interviews, additional people were suggested to interview in order to get even more knowledge. In total we had contact with 27 people where 18 of these were interviewed. Each interview was approximately one hour long. Questions were asked regarding their daily work and how they contribute to the process for preparing assembly work instructions, see Appendix 1.

We wanted to get the perspectives of standardization and globalization within the organization and therefore we interviewed four people outside the process. These people works with development of processes for assembly, global introductions, and IT-systems. We asked questions regarding what to consider when standardizing and globalizing processes at Volvo GTO. Each interview was approximately one hour long and the questions can be seen in Appendix 2. A summary of the people we interviewed together with their title are presented in Appendix 3, and additional contact persons are presented in Appendix 4.

2.5.2 Documentation study

Document study is when gathering information that has already been collected for another purpose by another researcher (Christensen et al., 2010). According to Bryman and Bell
(2011), documents can be in form of: personal, public, organizational, commercial, and virtual. This is a good complement to the literature study where a basic knowledge and understanding of the study target can be received. Information gathered from documents is said to be secondary data, meaning that the data already exist and has been collected by another person (Christensen et al., 2010).

We studied documents in form of work instructions and organizational charts to see relations between the process and output. The documents provided valuable data but were not the main source of information in this study and therefore this was a rather small part of the data collection phase.

2.6 Analysis methods
Analysis of data is done to highlight underlying patterns and important information to answer the research questions (Christensen et al., 2010; Björklund & Paulsson, 2012). The analysis methods depend on whether it is a quantitative or qualitative research method. Qualitative data requires time due to that data consist of word, text, and symbols. The qualitative analysis focuses on an overall picture and understanding of the context. Another objective of qualitative analysis is that data is collected and analyzed at the same time, called procedural analysis (Christensen et al., 2010).

During the interviews, notes were taken by both of us and, if allowed, the interview was recorded. Answers from these were compared to find the most relevant information for the study target. This information was divided and grouped into key activities which were the basis for the process map. To understand the gathered information from the interviews, content analysis was applied. Content analysis is a “research technique for making replicable and valid inferences from texts to the contexts of their use” (Krippendorff, 2004, p.18). Bryman and Bell (2011) defines content analysis as an approach of analyzing texts and documents systematically. They also describe two approaches of content analysis, semiotics and ethnographic. The semiotic approach is when understanding the deeper meaning of phenomena and signs. A more useful approach for qualitative studies is ethnographic where understanding the meaning of content is significant. We used an ethnographic approach because of the data’s qualitative nature. This analysis method was applied when the results from the interviews were analyzed in order to understand the meaning and be able to distinguish relevant information.

2.7 Process mapping
To structure and visualize the information regarding the preparation processes at the different sites, process maps were developed. These were analyzed in order to identify key activities within the processes. Based on this analysis a new process map was developed. A process map is helpful when identifying improvement opportunities and when creating awareness about the activities in the process (Hellström & Eriksson, 2008).

The symbols used in our process maps either represent processes, activities or documents. The symbols are presented in Figure 1. In this report, the processes and activities evaluated is colored with blue. To clearly distinguish the output, we chose to color the document box grey.
We developed a method that was used to make a current state analysis of the process for preparing assembly work instructions. The method was developed through brainstorming where we identified important steps to follow. It is divided into seven steps where some are recurrent. Our method is presented in Figure 2.
<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Comprehensive process view</td>
</tr>
<tr>
<td></td>
<td>Identify a contact person within the area to interview in order to get a comprehensive overview of the process to study.</td>
</tr>
<tr>
<td>2</td>
<td>Identify key persons</td>
</tr>
<tr>
<td></td>
<td>Find persons working in each step of the process.</td>
</tr>
<tr>
<td>3</td>
<td>Interviews</td>
</tr>
<tr>
<td></td>
<td>Perform semi-structured interviews with each identified person to get as much information as possible.</td>
</tr>
<tr>
<td>4</td>
<td>Analyze information and create process maps</td>
</tr>
<tr>
<td></td>
<td>Analyze the information gathered and create drafts of process maps. One for each step as well as one for the entire process.</td>
</tr>
<tr>
<td>5</td>
<td>Additional interviews</td>
</tr>
<tr>
<td></td>
<td>Perform additional interviews to collect more information if necessary. Additional interviews are also made to verify process maps.</td>
</tr>
<tr>
<td>6</td>
<td>Analyze process maps</td>
</tr>
<tr>
<td></td>
<td>Review the created process maps and identify key activities.</td>
</tr>
<tr>
<td>7</td>
<td>Map process with key activities</td>
</tr>
<tr>
<td></td>
<td>Suggest a new process map based on the key activities.</td>
</tr>
</tbody>
</table>

Figure 2: Our method for data collection and analysis of processes
2.8 Evaluation of the study

To ensure that the study result is useful, it must be evaluated against reliability and validity (Christensen et al., 2010). Validity is that the data gathered reflects what it is intended to display (Rosengren & Arvidson, 2002; Björklund & Paulsson, 2012). Reliability of a study demonstrates the ability to perform a similar study once more and get similar results (Bryman & Bell, 2011; Christensen et al., 2010; Björklund & Paulsson, 2012).

2.8.1 Validity

There are two main types of validity, internal and external (Bryman & Bell, 2011; Christensen et al., 2010). Internal validity can be defined as the level of conformity between results and reality, external validity is based on the level of generalizability (Christensen et al., 2010). According to Bryman and Bell (2011), one way to ensure internal validity is by letting external people revise the study. By performing a multiple case study, the result becomes more generable which enhance external validity (Bryman & Bell, 2011; Christensen et al., 2010). Following a pre-determined methodology minimizes the risk that data are processed and compiled inappropriately (Christensen et al., 2010). According to Christensen et al. (2010), openness regarding data collection method, as well as engagement in the study is important in order to increase its validity.

To strengthen the internal validity of this study we used multiple sources for information to prevent that conclusions were drawn in an early stage. Our findings were evaluated by several other people such as examiner, supervisor (from university and case company), and opponents who gave us feedback which also enhance internal validity. The external validity was strengthened by performing a multiple case study where three sites at the case company were studied. We developed a methodology for this study to ensure that information was analyzed properly.

2.8.2 Reliability

When performing a qualitative study, reliability can be hard to achieve according to Christensen et al. (2010) due to that reality is a constantly changing environment. Although there are some approaches that can increase reliability. According to Bryman and Bell (2011) and Patel and Davidson (1994), the reliability is strengthened by having more than one researcher taking notes in parallel during interviews. To ensure that information is correctly perceived, records of interviews can be taken so that the information is available afterwards as a complement to notes (Patel & Davidson, 1994; Ryen, 2004). During the interviews, we both took notes separately and, if allowed, recorded the interview to avoid information losses.

2.9 Summary of methodology

A summary of the methodologies that are applied in this study is presented in Figure 3.
<table>
<thead>
<tr>
<th>Research method</th>
<th>Research perspectives</th>
<th>Stages of the study</th>
<th>Data collection</th>
<th>Analysis methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Qualitative</td>
<td>• Hermeneutics</td>
<td>• Planning phase</td>
<td>• Literature study</td>
<td>• Content analysis</td>
</tr>
<tr>
<td>• Case study</td>
<td></td>
<td>• Data collection phase</td>
<td>• Interviews</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Analysis phase</td>
<td>• Documentation study</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Final phase</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 3: Summary of methodology**
3 Theoretical framework

This chapter presents the theoretical framework that is used to get more knowledge about the stated problem and to get a foundation towards answering the research questions. The subjects addressed in this chapter are process, standardization, flexibility, and lastly a discussion regarding previous research within the area.

3.1 Process

A process is the chain of activities that transform an input to output such as a product or service (Bergman & Klefsjö, 2012; Rentzhog, 1998; Ljungberg & Larsson, 2012). There are several definitions of a process, Harrington (1991 cited in Rentzhog, 1998, p.29) defines a process as “An activity or group of activities who takes an input, add value to it, and provide an internal or external customer with a result”. Rentzhog (1998, p.30) himself defines a process as “a chain of activities that in a recurrent flow creates value for the customer”. A process can be divided into three different categories; main process, support process, and management process (Rentzhog, 1998). The main process is the core of the business, meaning an organizations primary value creator for external customers. The support process’s main objective is to support the main process, meaning that the customers are internal (Bergman & Klefsjö, 2012). This kind of process is therefore vital in the success of the main process because without support, the main process cannot be executed (Rentzhog, 1998). The management processes decide upon business goals and strategies but also manage improvement work. This kind of process also has internal customers (Bergman & Klefsjö, 2012).

Processes can be divided into different groups depending on their nature and level of detail (Rentzhog, 1998). Ljungberg & Larsson (2012) describes three groups: process, sub process, and activities, while Rentzhog (1998) adds an additional group: task. A task is a distinguishable operation which together with other tasks forms an activity. Several activities forms a sub process (Rentzhog, 1998). By categorizing processes, the communication and mapping can be facilitated (Rentzhog, 1998; Ljungberg & Larsson, 2012). By focusing on processes, benefits such as increased transparency, higher efficiency, higher quality, and improved customer orientation can be achieved (Ljungberg & Larsson, 2012).

3.2 Process mapping

Organizations should, according to Ishikawa (1985), Deming (1988), and Juran (1989) cited in Hellström and Eriksson (2008, p.167), “be viewed as a system of processes that should be mapped, improved, and under control”. This process orientation can generate efficiency, improvement, and an integration of the entire organization. It contains a set of tools used to improve processes. One of these tools is process mapping, which can be used to describe a process figuratively (Hellström & Eriksson, 2008). Process mapping is a tool within process management that is used to understand the process by documenting the work flow. This is an important part when trying to improve the process, which is a necessity in order to stay competitive. Therefore it is crucial to systematically identify each activity within the process and present it in a flow chart. A flow chart generates a picture of today’s practices and provides valuable information that can be used for improvement work (Bergman & Klefsjö, 2012; Ljungberg & Larsson, 2012; Rentzhog, 1998).
The purpose of developing a process map, according to Rentzhog (1998), is to provide employees with a comprehensive picture of how their work contributes to the value created for the customer. Ljungberg and Larsson (2012) describe an eight step methodology that can be used when developing a process map:

1. Define the purpose of the process
2. Identify the process activities
3. Arrange activities in the right order
4. Merge and add activities
5. Define input and output of each activity
6. Connect all activities with input and output
7. Control that all activities are equally detailed
8. Make small corrections

According to Rentzhog (1998), it is necessary to break down the process into sub processes when developing a process map. This can be done in four different ways, described in Table 3.

Table 3: Approaches to break down a process

<table>
<thead>
<tr>
<th>Approach</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical</td>
<td>The process is shredded vertical into sequential chains of sub processes with activities. One sub process is defined at a time.</td>
</tr>
<tr>
<td>Phase</td>
<td>Similar to the vertical approach but the sub processes is divided into phases instead of activities.</td>
</tr>
<tr>
<td>Horizontal</td>
<td>Unlike the vertical approach, all the sub processes are firstly defined and then broken down into activities.</td>
</tr>
<tr>
<td>Pareto</td>
<td>Evaluates the process to find which part that is most important to focus upon.</td>
</tr>
</tbody>
</table>

To which extent the process is divided depends on the complexity of the process, but it is still important to keep the map as simple as possible and not make it too detailed (Rentzhog, 1998; Ljungberg & Larsson, 2012; Fransson, 2008). To clarify the process map, Ljungberg and Larsson (2012) states that it is important to be consistent with symbols etc. They present four simple rules to follow when creating a process map:

1. Input arrive to activity from left
2. Output leave activity to the right
3. Information connects to the activity from above
4. Resources connects to the activity from below

To ensure the quality of the process map, it is important to be honest and clearly display the actual process with connected inputs and outputs. According to Bergman and Klefsjö (2012), an input can be material, resources, equipment, or information. They also describe an output as a product, service, or information. The map must be logical with right amount of details in order to facilitate the understanding, which is an important objective of a process map (Ljungberg & Larsson, 2012). Fransson (2008) discusses the importance of commitment and engagement among the employees when creating process maps. To be able to capture
all parts of the processes, key persons from each process step must be involved in order to get a strong empirical foundation for the process map. Management support is a prerequisite to increase motivation and participation among employees (Fransson, 2008).

3.3 Preparation process
A manufacturing organization usually consists of three functions; marketing and sales, design, and manufacturing (Scallan, 2003). Within the manufacturing organization, each function is responsible for performing several tasks, presented in Figure 4. Marketing and sales assess current market for development of new and current products. Design works with creating detailed specifications of the product including drawings and bill of materials. Manufacturing is the last function where product and process requirements from earlier steps are used as an input. Based on these, detailed work instructions are prepared and then passed on for manufacturing (Scallan, 2003).

Figure 4: Main processes in manufacturing organizations (source from Scallan, 2003)
As can be seen in Figure 4, the design and manufacturing functions are separated but as Figure 5 shows they are linked together. This link is generated by process planning (Scallan, 2003). Scallan (2003) describes process planning as the transformation of raw material to finished components, including selection and sequencing of needed operations. He also states that it is (p.38) "the act of preparing detailed work instructions to produce a component". Activities within this preparation except the selection of manufacturing operations are to choose appropriate production equipment and tools. Before choosing manufacturing operation, prototypes are built, tested, and lastly evaluated to ensure manufacturability and ergonomics (Coletta, 2012). The preparation process starts already in the design phase in order to ensure that the product is possible to manufacture (Engren & Karlsson, 1957).

Figure 5: The process planning linkages (source from Scallan, 2003)

During the design of a product many adjustments might be necessary which therefore makes linkages between functions vital. Such adjustments can depend on various reasons, for example feedback from the user (Kidd & Thompson, 2000). Kidd and Thompson (2000) also discuss the importance of thoroughly reviewing design change proposals before accepting or rejecting them. Design changes are common to occur in the beginning of a product life-cycle to reach product maturity, which corresponds to linkages described by Scallan (2003). It is important to involve employees affected by the design change to get their feedback so no major problems occur during the implementation (Kidd & Thompson, 2000).

The main output from the preparation described by Scallan (2003) is two types of documents, routing sheets and operations list. The routing sheet describes how the material should go through the manufacturing area. It includes which equipment and tools to be used. The operation list describes each operation in detail and is often prepared for each work station.

3.4 Standardization
Standardization can be described as an agreement to ensure that processes, products, and/or services are performed such that it does what it is intended to do (Medina & Duffy,
1998). It is also a requirement for continuous improvements (Liker & Meier, 2006; Bergman & Klefsjö 2012). Buzzel (1968, cited in Medina & Duffy, 1998, p.229) states that standardization is “the offering of identical product lines at identical prices, through identical distribution systems, supported by identical promotional programs, in several different countries”. Decreased variations and reduced waste are some of the outcomes from standardized processes. It is an approach to develop “best practices” of processes such that it requires as few resources as possible (Liker & Meier, 2006). Medina & Duffy (1998, p.230) summarize standardization as “a process that involves the creation of a standard to be applied rather than the creation of a standard to be achieved”.

The most common tool towards standardizing processes is standardized work documents together with other Lean tools such as training, visual controls, 5S etc. (Liker & Meier, 2006). According to Liker and Meier (2006) there are some strategies that can be used to facilitate standardization; repeatable work method, clearly defined expectations, and processes that ensures consistency among resources. Standardization is, according to Gilani and Razeghi (2010), affected by five factors: target market, market position, nature of product, environment, and organization factors. To be able to standardize work, there are other areas within the organization that must be standardized. This is visualized in Figure 6.

![Figure 6: Relationship and purpose of standards (adapted from Liker & Meier, 2006)](image)

- **Quality, Safety and Environmental standards** – These standards are often connected to external requirements and expectations. The quality represents customer requirements of the product, such as appearance, surface quality, deformities etc. Safety and environmental standards are commonly required by the state and federal regulations to ensure that organizations follow laws.
- **Standard Specification** – The specifications stands for the technical information when producing a product and is internally developed. These specifications can include tolerances, equipment information, methods etc.
• **Standard procedures** – These are also internally developed and are used to define rules in the different operations. These rules can be regarding material flow routes, organized work areas, color coding etc.

(Liker & Meier, 2006)

There are both benefits and disadvantages with standardized work. According to Liker and Meier (2006), standardized work can generate waste reduction, efficiency, increased quality, and enable operators to quickly detect abnormalities. Standardization generates simplicity among employees because activities become better coordinated and there is only one way to perform an activity, which also is close to the “best practice” (Brunsson & Jacobsson, 2002). Although, challenges and disadvantages when standardizing work exist. There is a large risk that people performing the process becomes resistant if they are not involved when creating the standard. Employees can see standardization as unwelcome, unnecessary, harmful, and has a difficult time understanding why it is beneficial. The opportunity for innovativeness among people decreases because procedures must be performed in one way (Brunsson & Jacobsson, 2002). This can in turn decrease employees’ motivation and the process can become inefficient even if it is standardized. Gilani and Razeghi, (2010) says that standardization can reduce the focus on customer needs because it is often more focus on products. To lower the risk of resistance among employees it is important that the management is committed and encourage the standardization (Liker & Meier, 2006).

There are several other aspects to take into account regarding standardization. One is that it can be influenced when globalizing a business. This because globalization creates a need of standards due to different norms, conditions, and rules. Important to consider when standardizing processes, especially within a global environment, is that the standard must be concrete such that it can only be interpreted in one way. Too abstract standards might cause misinterpretations which in turn lead to variations when using those. To facilitate uniformity among sites within an organization in a global environment, standardization is a good start. It provides one similar way of doing things no matter where the employee is located in the world (Brunsson & Jacobsson, 2002).

Even if there is a need to standardize processes in order to reach efficiency (Liker & Meier, 2006), processes still needs to be flexible for variety to maintain efficiency (Rentzhog, 1998). According to Rentzhog (1998), flexibility is when a process is adjusted based on changes in preconditions. This can be connected to Bergman and Klefsjö’s (2012) description of flexibility as the ability to handle variations and special demands. It also enables processes to maintain efficiency even if demands are fluctuating (Rentzhog, 1998). It is not always necessary to standardize an entire process but neither necessary to make the whole process flexible. Flexibility can be referred to as the ability of adapting a process in a late stage in order to avoid an entirely new process depending on customer requirements (Ljungberg & Larsson, 2012).

### 3.5 Previous research

Through our literature search, see Table 2, we found that limited research has been performed about our stated problem. Previous research regarding preparation processes
exist but we could not find much information covering assembly. Another problem was that no clear definition of a preparation process could be identified. Although, the research that was found concerned operational matters, for example how to prepare for casting and was not suitable for this study. The preparation process in this study is more abstract and hard to map because no clear definition exist.

Standardizing work has historically been more difficult within the truck manufacturing business due to highly complex products. This complexity has arisen from mass customization where products are more or less customized for the customer (Johansson et al., 2013). Johansson et al. (2013) has analyzed the current state of standardized work in the automotive industry. They suggest that future work should be done with focus on standardizing work within an entire organization. The standardization should capture cultural and geographical differences having a less focus on local plants.

A study recently made by Johansson, Fasth-Berglund and Moestam (in press) investigate if diversity exist when creating and using assembly information in a global company. The study shows that diversity exists when creating assembly instructions. This can lead to inefficient sharing of knowledge and experiences between the different sites. Diverse processes make it hard to get a comprehensive overview of the overall production performance. They emphasize the need for future work in standardizing the process for preparing work instructions for assembly.
4 Results

Description of the case company is presented in this chapter, including both general information about the organization and also more detailed descriptions of the current state of the process for preparing assembly work instructions.

4.1 Company description

The Volvo Group is one of the world’s leading manufacturers of trucks, buses, construction equipment, marine, and industrial engines. The Volvo Group has since 2012 been organized in Trucks sales, Trucks operations, Trucks technology, Construction equipment, Business areas, and Financial services. The Volvo Group has English as their corporate language and they own several different brands. These are: Volvo, Penta, UD Trucks, SDLG, Renault Trucks, Prevost, Nova Bus, and Mack which are distributed in different industry segments.

Volvo was founded in 1927 by Assar Gabrielsson and Gustaf Larsson in Gothenburg. Already in year 1928, the first truck was produced, this only one year after the first passenger car was manufactured. Volvo grew during the following decades and is now spread all over the world in various industry segments to strengthen the company.

The Volvo Group bases their organization on the Lean philosophy, which is the fundamental of the Volvo Production System (VPS). The VPS is the framework for their manufacturing operations and is a collection of tools and methods that originates from Six Sigma and Lean. The production system starts with “The Volvo way” and ends with the customers. The way from Volvo to the customer is set by five principles: Team work, Process stability, Built-in quality, continuous improvements, and Just-In-Time, see Figure 7.

![Figure 7: The Volvo Way (Volvo Group, 2014)](image)

The corporate core values of Volvo Group are quality, safety, and environmental care, which can strongly be identified in the VPS. From these core values together with customer focus and employee empowerment, the Volvo Group strives to become the world leader in sustainable transport solutions.
4.2 Volvo Group Trucks Operations
Volvo GTO is the part of the Volvo Group that covers all production of engines and transmissions as well as the production of Volvo, Renault, Mack, and UD trucks. They provide the customer with spare parts and also support the VPS and Operational Development within the entire group. Volvo GTO has 45 plants worldwide and during 2013 they delivered approximately 200 000 trucks. Approximately one third of the 110,000 employees in the Volvo Group work within GTO and are distributed in 36 countries, where their location is shown in Figure 8. Volvo GTO is built of eight business units categorized into five categories:

- Cab & Vehicle Assembly: responsible for the manufacturing and assembly of highly customized trucks for different markets and brands.
- Powertrain Production: manufactures diesel engines and transmission systems for commercial vehicles.
- Logistics Services: designs, handles, and optimize supply chains within the Volvo Group.
- Knock-Down Assembly: assembles trucks from kits.
- Remanufacturing: responsible for remanufacturing of products.

![Figure 8: Volvo GTO in the world (Volvo Group, 2014)](image)

4.3 Current state of the process at Volvo GTO Cab & Vehicle assembly
To be able to make a current state analysis of the process for preparing assembly work instructions, it is important to know where this process occurs. The process with its surroundings is presented in Figure 9 at the highest level 0. It starts with an order which comes from a customer demand where the customer has requirements on the final product. These requirements together with other specifications such as product improvements and quality requirements triggers the process for preparing assembly work instructions to start.
The output from this step is the assembly work instruction which is used as input in the actual production.

Figure 9: Level 0 - Process for preparing assembly work instructions and its surroundings

The Cab and Vehicle assembly have sites located in different countries. The sites in Sweden, Russia, Belgium, Brazil and Australia have a strong relation due to similar production processes. These five sites produce the Volvo brand and have a similar process for preparing assembly work instructions. An overview of the process is shown in Figure 10, displaying the sub-processes at level 1, which is further described.

Figure 10: Level 1 - Process for preparing assembly work instructions at Cab and Vehicle

The process for preparing assembly work instructions starts in Sweden where the center of development is placed for the entire Volvo Group. Here almost all components connected to the Volvo brand are designed based on customer requirements, product improvements, and quality requirements. Anyone of these can trigger the preparation process to start, shown as inputs in Figure 10 and 11. The process starts by assigning a project where employees from both trucks technology and trucks operations are involved. A project start-up meeting is normally held for an entirely new product or if an extensive change of components is required. During this meeting information regarding the final product and components is shared. Next step is designing the product, here the different involved departments can forward requirements such that the product is possible to manufacture and designed for assembly. When designing a product there is a high focus on the time perspective, leading to requirements on shortening lead times.

A new designed product generates an internal message called Design Change Note (DCN) which connects the components to different product variants in the product data system. During the design work, prototypes are built and tested to secure that the product is possible to manufacture. In some cases when there is an extensive change of components, the final product is test assembled in a pilot plant located in Sweden. When everything is designed and tested, it is reviewed by several different parties. If one of these not approves the design, the DCN is not allowed to move forward. Instead it goes back to the design department for adjustments. In parallel with this project, when an entirely new article is
designed, there are in some cases an equipment based project going on to ensure that right equipment are available in time for assembly.

Figure 11: Level 2 - Product design at Cab and Vehicle

When the design and testing is finished, the DCN is released such that the introduction of the changes can be decided. The center of development sends the DCN’s forward to sites in Europe, Australia, and Brazil. The process for Europe and Australia continues in Sweden but Brazil takes over and handles their own preparation process. During the interviews it was revealed that the preparation process performed in Brazil is similar to the one in Sweden where they also perform DCN-analysis, time setting, and time analysis etc. From this phase and forward, all parties involved in the preparation process works within the organizational unit trucks operations. Here there is more focus on quality to ensure high qualitative products.

The time setting is made by a technical preparation engineer who starts by making a volume calculation for the components in the DCN, as can be seen in Figure 12. The volume calculation is based on forecasts from previous purchases. This calculation is sent to the purchasing department who answers with a lead time for how long it will take to get the material. Before the new components can be ordered, the closest project manager must approve the order. Besides the order of new components, a cancelation of old components must be sent to the purchasing department. The last step is to add the introduction week to the DCN in a time setting system. When the new components should be introduced is decided early in the project. It is done in accordance with an existing introblock calendar that describes when introductions should be made. When the time setting is made, the DCN is automatically sent to a system where work instructions are created for assembly in Sweden, Russia, Belgium, and the knock-down site in Australia. A knock-down site assembles modules of the truck where these modules are produced at other sites. Each DCN must be activated in the system where the work instructions are created. This is done in Sweden for the three assembly sites. The knock-down site activates the DCN´s concerning their assembly process by themselves.
When the DCN is activated it is possible to start developing instructions, presented in Figure 13. This is done in Sweden by several introduction engineers who are responsible for all sites that assemble Volvo trucks in Europe. The introduction engineers are responsible for different functional areas of the truck (e.g. fuel). The introduction engineer starts by getting more knowledge regarding the DCN to identify which components that has been exchanged. They delete the old components and replace them with the new ones in the master structure level in the system. The new components has to be connected to its specific station, this is done in the station marking system. After this they create instructions for the new components in a system for creating work instructions. They mainly work with creating core instructions, but when the assembly work is more complex, more detailed assembly instructions are needed.

The work instruction is created in two variants, the core instruction includes component numbers, and the assembly instruction includes more detailed descriptions, pictures, and/or time analysis. The actual assembly instruction provided to the operators is called “assembly lowest level” and is a combination of the core instruction and the assembly instruction created in Figure 13, see Appendix 5. This instruction is broken down for each assembly position in the production line.

When these instructions are finalized, information regarding the DCN is shared to a local level for each site. Here the production engineers have the opportunity to locally adapt instructions if necessary, see Figure 14. Depending on if the instruction is new or old, the production engineer works differently. If it is an old instruction, the instruction only needs to be verified. If it is new, the including components must be connected to the target structure in the system and the time analysis must be adapted to fit the local process. The production engineer also balances the components in a balancing system to find where it fits the production line. This means that they evaluate where the changed components are most appropriate to assemble. The next step for the production engineer is to make two article lists, one including all components and one including only new components. The lists with
new components must be verified by the logistics department to make sure that material is available when needed. In some cases, when the documentation is not good enough, the production engineer creates additional illustrations for the operator in order to facilitate the assembly.

Continuous communication is held between production engineers in Sweden, Russia, and Belgium to solve and prevent problems and learn from each other. Before the production, the production engineers have an information session with the operators where the changes are presented together with instructions. In time for production all assembly instructions are printed out and put at the right station so they are available for the operator.

Figure 14: Level 2 - Local adaption at Cab and Vehicle

A summary of all systems used for the different tasks at Cab and Vehicle assembly is presented in Table 4.

Table 4: Summary of systems at Cab & Vehicle

<table>
<thead>
<tr>
<th>System</th>
<th>Cab &amp; Vehicle assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product data system</td>
<td>KOLA</td>
</tr>
<tr>
<td>Time setting system</td>
<td>DIS</td>
</tr>
<tr>
<td>Balancing system</td>
<td>Excel</td>
</tr>
<tr>
<td>Station marking system</td>
<td>Sprint</td>
</tr>
<tr>
<td>System for creating work instructions</td>
<td>Sprint</td>
</tr>
<tr>
<td>Visualization system</td>
<td>Do not exist</td>
</tr>
</tbody>
</table>

4.4 Current state of the process at Volvo GTO Powertrain Production

The highest level for both Powertrain Production sites and Cab and Vehicle assembly are identical, see Figure 9.

Volvo GTO Powertrain Production is divided into two different areas, Transmissions and Engines. Both of these areas have one site each located in Sweden. Powertrain Production has come far in their work towards a standardized process for preparing assembly work instructions. This has led to that, independent of which area, the sub-processes are the same and performed in same sequence. Since the activities differs depending on area, each is
further describes in chapter 4.4.1 and 4.4.2. A comprehensive view of the preparation process is shown in Figure 15.

**Figure 15: Level 1 - Process for preparing assembly work instructions at Powertrain**

### 4.4.1 Transmissions

The preparation process at Powertrain Transmission starts at the center of development located in Sweden. As mentioned earlier, all design is made here based on customer requirements, product improvements, and quality requirements. During the design work, a Product Change Request (PCR) is sent to the site where it is analyzed to ensure manufacturability and evaluated against costs, presented in Figure 16. If the PCR affects several sites globally (Japan, Brazil, and USA), they all come together with an answer that is sent back to Design. If it is approved a DCN is created otherwise the PCR must be changed. From now, each site is responsible for their own process for preparing assembly work instructions.

**Figure 16: Level 2 - Product design at Powertrain Transmissions**

When the status is changed, a product preparation engineer is assigned to perform a DCN-analysis including trial assembly and tests. In the DCN-analysis a production engineer thoroughly reviews the DCN to decide how to implement it. When this is done and approved, the DCN receives an introduction week in a time setting system. If the DCN is not okay, the product preparation engineer contacts design and the process start over until it is approved. These activities can be seen in Figure 17.

**Figure 17: Level 2 - Introduction preparation at Powertrain Transmissions, Sweden**
When the time setting has been made the DCN is sent to a production engineer at the site, based on their functional area. The first step of creating the actual assembly work instruction is to balance the components, in a balancing system, so it fits the production line. This means that a time analysis is performed and they evaluate where the changed components are most appropriate to assemble. In this system, two types of assembly work instructions are made, one consisting of descriptive pictures (assembly instruction 1 in Figure 18, picture in Appendix 6) and one with details regarding time for operations (assembly instruction 2 in Figure 18, picture in Appendix 7). These instructions are not normally used at the line but they are available and used for an educational purpose. Next step is, based on the balancing, to assign the right station for each article in a station marking system.

The assembly work instructions used in the production line (assembly instruction 3 in Figure 18, picture in Appendix 8) are made in a system for creating work instructions. In this system, the production engineer sort the operations in the correct sequence, add text descriptions, connects the right equipment, and add pictures if necessary. It is crucial that this work is correct because the operator follows these instructions through a visualization system. This system presents in what sequence operations should be performed in where the operator must confirm when the operation is done.

Figure 18: Level 2 - Instruction development at Powertrain Transmissions, Sweden

A summary of all systems used for the different tasks at Powertrain Production is presented in Table 5.
### Table 5: Summary of systems at Powertrain

<table>
<thead>
<tr>
<th>System</th>
<th>Powertrain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product data system</td>
<td>KOLA</td>
</tr>
<tr>
<td>Reviewing system</td>
<td>PDM-link</td>
</tr>
<tr>
<td>Time setting system</td>
<td>MOMS/DIS</td>
</tr>
<tr>
<td>Balancing system</td>
<td>AviX</td>
</tr>
<tr>
<td>Station marking system</td>
<td>STAM</td>
</tr>
<tr>
<td>System for creating work instructions</td>
<td>BEMS</td>
</tr>
<tr>
<td>Visualization system</td>
<td>AAS</td>
</tr>
</tbody>
</table>

#### 4.4.2 Engines

The first step, design, in the sub-process “product design” is the same for Engines as Transmissions, see Figure 19. In the second step there exist some differences when performing the PCR-analysis at the different sites. The PCR-analysis is conducted to ensure manufacturability and to evaluate costs, by inter alia performing a trial assembly. The trial assembly is performed by product preparers, production engineers together with operators and its team leaders. When the PCR is approved by all affected sites (Japan, Brazil, USA, and France), it is converted into a DCN. During the PCR-analysis also a preliminary time analysis of assembly is performed in order to get an estimated total time.

![Diagram: Level 2 - Product design at Powertrain Engines](image)

The DCN is sent to the site where it is analyzed by a product preparation engineer. The DCN is compared to earlier specifications in the PCR. This to ensure that nothing has been added or removed. They also check the structure for belonging components in a reviewing system. Similar to Powertrain Transmission the DCN must be okay before it can receive an introduction week. These activities can be seen in Figure 20.
The last process step is also similar to Transmissions, see Figure 21. The DCN’s is appointed to production engineers based on products. At Engines, the assembly instruction 1 (Appendix 6) is created after the station marking. After the station marking also sequencing, text descriptions, equipment, and pictures are added. This generates assembly instruction 3 (Appendix 8). When the production engineer has created all instructions, information is shared to material controllers, team leaders, shift leaders, and technical leaders. After the DCN has been introduced, the production engineer reports this to the product preparation engineer who adds a breaking date in the time setting system. Engines and Transmissions use the same systems and these can be seen in Table 5.

4.5 Process for preparing assembly work instructions according to interviewees

During the interviews at Cab & Vehicle assembly the interviewees got the opportunity to describe the process for preparing assembly work instructions according to how they perceive the process. Figure 22-25 represents the view of the process from the different persons. By doing this it is possible to see if employees perceive the process similar independent of where in the process they work. Interviewee A-D described the process for preparing assembly work instructions based on departments rather than activities. The interviewees came from different departments involved in the preparation process and have different amount of knowledge regarding what happens before and after their work.
The different departments mentioned and their responsibilities are:

- **Product design** – the department where the products are designed and the DCN is created.
- **Technical preparation** – the department where time setting are made. They are also responsible for communication between design and manufacturing to ensure manufacturability.
- **Purchasing** – the department responsible for buying material.
- **Logistics** – the department where material is handled.
- **Logistics engineering** – the department who make sure that there is place for new material.
- **Introduction engineering** – the department who is responsible for creating assembly work instructions.
- **Production engineering** – the department where local adoptions are made.

*Interviewee A (Logistics)*

![Diagram](image1)

Figure 22: The preparation process at Cab and Vehicle according to interviewee A

*Interviewee B (Introduction engineering)*

![Diagram](image2)

Figure 23: The preparation process at Cab and Vehicle according to interviewee B
**Interviewee C (Technical preparation)**

![Diagram](image)

**Figure 24**: The preparation process at Cab and Vehicle according to interviewee C

**Interviewee D (Production engineering)**

![Diagram](image)

**Figure 25**: The preparation process at Cab and Vehicle according to interviewee D
5 Analysis

This chapter presents the analysis where the results of this study are compared with the theoretical information. The suggested key activities identified are shown in a process map together with a brief description.

5.1 Process map with key activities

The steps within the process for preparing assembly work instructions, in the results chapter, are presented as sub-processes. These sub-processes are broken down into activities in accordance with the horizontal approach described by Rentzhog (1998). There is additionally one more group called task, where more detailed information regarding how to perform the activity is described. As can be seen in the results, the tasks are not included. This is because the tasks are people dependent and also complex due to all IT systems involved. Rentzhog (1998) together with Ljungberg and Larsson (2012) states that by grouping process related information into sub-processes and activities, the process mapping can be facilitated.

The process maps are created based on information from key persons from each process step in order to get as correct process maps as possible. As Fransson (2008) discusses, the quality of process maps can be improved if key persons from each process step are involved. The process maps presented in the results chapter do not include many details and has a consistency among process map symbols. This is in line with Rentzhog (1998), Ljungberg and Larsson (2012), and Fransson (2008) who states that it facilitates the understanding and usage for employees. The process maps are created following the eight step methodology that Ljungberg and Larsson (2012) describes.

5.1.1 Identified key activities

By comparing the process maps from the sites studied, presented in the results chapter, some common activities can be identified. These can be seen as key activities in the process for preparing assembly work instructions. The key activities identified are: design, review, time setting, time analysis, balancing, station marking, create assembly work instructions, and share information. These are described further in Table 6 and presented in Figure 26. The inputs that trigger the process to start are customer requirements, quality requirements, and product improvements. These can be compared to “information”, which is one type of input described by Bergman and Klefsjö (2012).
Table 6: Key activities of the process for preparing assembly work instructions

<table>
<thead>
<tr>
<th>Key activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>Design the components according to specifications and requirements, such that the product is possible to assemble ergonomically.</td>
</tr>
<tr>
<td>Review</td>
<td>Review the design to ensure that it fulfills requirements and to minimize risks that might occur during the assembly. Build and test prototypes to ensure manufacturability. If the review is approved the process continues, otherwise it goes back to the design stage.</td>
</tr>
<tr>
<td>Time setting</td>
<td>Add an introduction week to the design change note according to the introblock calendar.</td>
</tr>
<tr>
<td>Time analysis</td>
<td>Perform a time analysis to estimate how long time a specific operation requires.</td>
</tr>
<tr>
<td>Balancing</td>
<td>Identify where it is possible to assemble the exchanged components.</td>
</tr>
<tr>
<td>Station marking</td>
<td>Assign each component to a specific station based on the balancing.</td>
</tr>
<tr>
<td>Create assembly work instructions</td>
<td>Based on the exchanged components, add text descriptions, pictures, equipment, and sort operations in the right sequence.</td>
</tr>
<tr>
<td>Share information</td>
<td>Inform affected parties and managers about the changes. Distribute the assembly work instructions to the stations.</td>
</tr>
</tbody>
</table>

The process starts with design where components are designed. When this is done, a DCN/PCR is created which must be reviewed to ensure manufacturability. The review is supported by Kidd and Thompson (2000) and Coletta (2012), who emphasize the importance of reviewing designs before accepting them in order to reduce the risk of problems during the implementation. When the review is approved, the DCN receives an introduction week. Then it is possible to perform time analysis, balancing, and station marking for components. This in turn enables the creation of assembly work instructions which are shared to affected parties. The main output, the assembly work instructions, is similar to the input and can be referred to as “information” described by Bergman and Klefsjö (2012). It is also in accordance with the main outcome from process planning, the operations list, that Scallan (2003) defines.
The process map of the process for preparing assembly work instructions was suggested, covering key activities identified during the interviews. These steps were taken from the process maps in the results chapter because they were commonly used by all sites. It was created to be comprehensive and simple covering the most important steps. The process was mapped in a general manner to create understanding among involved employees, which is strengthened by Bergman and Klefsjö (2012), Ljungberg and Larsson (2012), and Rentzhog (1998).

The key activities are those activities that must be performed in order to be able to generate assembly instructions for the operator. How these activities are completed can differ depending on product, country, site etc. For example the different engine variants are only assembled at one site each meanwhile truck variants can be assembled at several sites. When creating work instructions in these cases the assembly instructions for trucks must be adaptable for all affected sites. The instructions to assemble engines only needs to consider one site, leading to that the activity “create work instructions” in this case becomes less complex.

5.1.2 Differences in current processes for preparing assembly work instructions
At the Powertrain production sites it can be seen that the preparation processes at Transmissions and Engines are very similar. This can be connected to previous organizational structure within the Volvo group, where Powertrain production already had an outspoken ambition to globalize their organization.

When comparing the process for preparing assembly work instructions between Powertrain production and Cab and Vehicle assembly some differences exist. One large difference between these units is that Powertrain perform a PCR-analysis before the DCN is created. The PCR-analysis is performed to find out if the change is possible to implement at each affected site. At Cab and Vehicle assembly instead, a design review is performed before the
DCN is approved. This review only takes drawings and documentation into account regarding the change.

A second difference identified is that several systems are used for performing the same activities. Within Powertrain Production, both Transmissions and Engines use same systems when performing their activities. The only difference is that Transmissions use AviX in a broader context, for example when they create assembly instruction 2, Appendix 7, which Engines do not have. At the Cab and Vehicle assembly site, they use other systems than Powertrain Production except from KOLA and DIS. At the Cab and Vehicle assembly DIS is used as a tool for time setting meanwhile Powertrain Production only use DIS as a visualization tool in order to show other sites that the time setting has been made. Powertrain Production use MOMS as their tool for time setting. A comparison of the systems is presented in Table 7.

Table 7: Comparison of systems at the different sites

<table>
<thead>
<tr>
<th>System</th>
<th>Cab &amp; Vehicle assembly</th>
<th>Powertrain Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product data system</td>
<td>KOLA</td>
<td>KOLA</td>
</tr>
<tr>
<td>Reviewing system</td>
<td>Do not exist</td>
<td>PDM-link</td>
</tr>
<tr>
<td>Time setting system</td>
<td>DIS</td>
<td>MOMS/DIS</td>
</tr>
<tr>
<td>Balancing system</td>
<td>Excel</td>
<td>AviX</td>
</tr>
<tr>
<td>Station marking system</td>
<td>Sprint</td>
<td>STAM</td>
</tr>
<tr>
<td>System for creating work instructions</td>
<td>Sprint</td>
<td>BEMS</td>
</tr>
<tr>
<td>Visualization system</td>
<td>Do not exist</td>
<td>AAS</td>
</tr>
</tbody>
</table>

At Powertrain production each site makes their own instructions, meaning that they only consider their own production line at a local level. Cab and Vehicle assembly creates instructions on a master level for three sites, not only located in Sweden. These instructions might need minor changes to fit the local production line at each site, for example connecting components to the right station (target structure). The station can differ at each site depending on the local assembly sequence.

Based on the results from the interviews, another difference is the number and type of instructions that are made. There exists a minor difference between the two Powertrain production sites. Transmissions have three variants, one main and two educational, Engines only have two variants, one main and one educational. When it comes to Cab and Vehicle assembly the operator only have one main instruction. The reason for the diversity of work instructions is not known. The main instruction at both Powertrain production sites are provided through a visualization system, meanwhile Cab and Vehicle site print the main instruction and deliver it to the right station.

It is not only differences in how performing the process for preparing assembly work instructions, but also how people perceive the process. In Figure 23-26 in the results chapter it is clear that the process for preparing assembly work instructions, at Cab and Vehicle assembly is differently perceived depending on the interviewee. It is also obvious that the
interviewees describe the processes based on departments rather than activities. The four interviewees (A-D) agree upon that the process starts at the Product design department but what happens after is described differently. For example, three out of four includes Technical preparation in their process description, and only one mention the Purchasing department. It can clearly be seen that the last step in the process is differently described depending on position of the interviewee.

5.2 Standardization

When looking at the process maps presented in the results, it can easily be seen that the process deviates in different stages, at some sites already in the beginning. By firstly identifying key activities of a process, future work towards a standardized process is facilitated. As Brunsson and Jacobsson (2002) discusses, this can generate uniformity among sites. This is because each site will have the same starting point but with a possibility to perform each step such that it fits local abilities. Meaning that the activities must be done but the tasks inside the activities can be executed in different sequences depending on the employee performing them. One example is that some people might prefer to add picture before text when creating the assembly work instructions. By letting people perform tasks as they prefer, Brunsson and Jacobsson (2002) argues that resistance regarding the standardization of a process can decrease and innovativeness can be maintained.

As can be seen in the results chapter, Figure 22-25, there are many different views of the process for preparing assembly work instructions. By standardizing the process, it is possible to reduce the risk of people perceiving the process differently, if it is communicated to the employees involved. As Brunsson and Jacobsson (2002) discusses, the process becomes better coordinated due to transparency and awareness of what happens within the process. Another important factor they discuss is that the process must be concrete in order to avoid several interpretations of the same things.

Another aspect of having a more general preparation process is that some steps are not possible to perform for all sites at once. For example, balancing must be done but since the production lines at the sites looks different it is not possible to make a common balancing for all sites. Instead each site must handle its own balancing. This approach enhances the flexibility of the process, which can be justified by Ljungberg and Larsson (2012). They describes that it is possible to have part of the process flexible so local adaptions can be made.

When looking at the figures of the process for preparing assembly work instructions in the results, it can be seen that the process deviates at different stages. An overview of all deviations and where they occur is presented in Figure 27. The dashed lines are sites that have not been the focus of this study, although some information regarding Brazil was given during the interviews. Independent of where the process is performed it always starts with the inputs: customer requirements, product improvements, or quality requirements. The output from each process is assembly instructions. In Figure 27, Powertrain sites deviates directly after the product design stage where each site have their own process for preparing assembly work instructions. At Cab and Vehicle the process deviates differently. Brazil deviates at the same point as the Powertrain sites, meanwhile Australia deviates after the
time setting. Russia, Belgium, and Sweden share the same process until the end where it is locally adapted.

Figure 27: The process for preparing assembly work instruction around the globe
6 Discussion

In this chapter the analysis is discussed to highlight potential benefits and problems. The methodology of this study is also critically evaluated.

6.1 Process map with key activities
According to Hellström and Eriksson (2008), process orientation is necessary to integrate an organization and leads to increased efficiency. As Ishikawa (1985), Deming (1988), and Juran (1989) cited in Hellström and Eriksson (2008, p.167) states an organization should, “be viewed as a system of processes that should be mapped, improved, and under control”.

During this study it has been found that employees explains the process for preparing assembly work instructions from a departmental aspect instead of actual activities. This departmental thinking can generate a lack of knowledge regarding the process steps outside the interviewees’ own department. At this stage they do not know how they contribute to the final output of the process for preparing assembly work instructions. The lack of knowledge regarding the process can also depend on that no comprehensive process map is available for the employees involved. By creating process maps, Rentzhog (1998) states that the employees receive a good picture of how their work contributes to the end customer, which in this case are internal.

The process map presenting the key activities, Figure 26, is very general and comprehensive with few details. This because it should be possible to adapt the process based on local needs. This is also one reason for not including tasks in the process maps. The tasks performed are dependent on the employee and is therefore hard to standardize. This is one example of why flexibility is required in the preparation process. Since the case company is spread all over the world, the process must be structured such that it handles cultural differences. One example is language barriers, the corporate language is English but some countries do not use this language. Therefore the process must be described in such a way that the main content cannot be perceived differently when translating the instructions into the native language.

As mentioned, the Volvo group has acquired several different brands where each brand has their own process for preparing assembly work instructions. In 2012 the group choose to reorganize the organization from brand based to organizational units, for example center of development, operations etc. This has led to a greater need of one common preparation process in order to create uniformity among the brands. By having one common process it is possible to share knowledge more efficient between sites. Even if the process should be common, it is important to take into account that different countries have different rules and regulations. For example, in some countries the operator is not allowed to do heavy lifts and therefore it might be necessary to purchase extra equipment. Therefore it is not possible to perform all tasks equally around the globe, leading to that part of the process for preparing assembly work instructions must be locally adaptable.

6.2 Differences in current process for preparing assembly work instructions
As mentioned in the analysis all key activities should be performed, but how they are executed can differ depending on site. As it is today, some steps that can be standardized
are design, time setting and to some extent time analysis. Activities such as balancing, station marking, create assembly work instructions, and share information are site dependent based on structure of the production line and the systems used. Therefore, these activities are difficult to standardize in today’s situation.

In the future it would be possible to standardize the entire process for preparing assembly work instructions on a master level, only allowing local adoptions in the end. This creates uniformity and strengthens collaboration among sites around the world. If the process is standardized, it could be performed in one place and spread to affected sites that then make local adoptions, e.g. time analysis. A starting point towards standardization is to create awareness about the process. This would facilitate the future work towards a standardized preparation process.

When the interviewees got the opportunity to describe the process for preparing assembly work instruction, each answer were different from each other. It is obvious that the interpretation of the process is connected to where the interviewee works. The interviewees include their own department as well as the one before and after but have limited knowledge regarding the other parts of the process. This can be linked to a lack of transparency regarding the preparation process within the organization.

When comparing the process descriptions from the sites one big difference is that Powertrain Production performs a PCR-analysis before the DCN is created. This to decide, in an early stage, whether it is possible or not to introduce the changes. This is strengthened by Kidd and Thompson (2000) who states that it is important to review design changes before accepting them. By doing this the risk of mistakes can be decreased. Cab and Vehicles equivalence to this is that representatives from the Technical preparation department are involved already in the design stage where they ensure manufacturability from an operational perspective. Therefore it is not critical for Cab and Vehicle to perform a PCR-analysis. There is a risk that the DCN is not evaluated with the same depth which can lead to quality differences in the execution.

Another big difference regarding assembly work instructions between Cab and Vehicle and Powertrain Production is that the main instructions are presented in different ways. At Cab and Vehicle, the instructions are provided to the operator in paper form in time for production. Since Cab and Vehicle works with mass customization, some new instructions come with each truck leading to that new instructions has to be printed out. This extra work is avoided at Powertrain Production where assembly work instructions are presented in a visualization system. As mentioned in the results, this system guides the operator throughout the assembly. This system makes it easier to monitor the assembly as well as implementing continuous quality controls.

One risk that can occur when working on master/target level is that information is not shared within the production network. One example can be seen in Figure 14 where the production engineer sometimes creates additional illustrations for the operator on a target level. These illustrations are created if documentation is missing or insufficient. If one production site has problems with the documentation, the other sites may have the same
problem. If additional illustrations are made on a local level, it is not connected to the master structure, meaning that other sites cannot reach that information.

6.3 Preparation process

A support process as described by Bergman and Klefsjö (2012) can closely be connected to the process for preparing assembly work instructions. This because the preparation process studied has only internal customers. Without a preparation process, it is not possible to assemble the final product due to lack of work instructions. This process concerns more than the actual work instructions, it also enables changes in the design of components to be introduced. If changes are made at the design stage and the preparation process is not performed, the operator will not receive the information and the final product is unchanged. This can in a broader context lead to unsatisfied customers who will not receive the product ordered.

The process planning described by Scallan (2003) can be compared to the process for preparing assembly work instructions at Volvo GTO. This is because both processes start already in a design stage and is the link between design and manufacturing. Scallan (2003) also states that process planning includes selection and sequencing of operations, which in the end results in detailed work instructions. From this, the process for preparing assembly work instructions, can be referred to as process planning because it has similar characteristics. This process is used to enable the production to start, without it, design changes are not possible to implement. This can be strengthened by Kidd and Thompson (2000) who says that the linkage between design and manufacturing is essential when introducing design changes.

During the interviews it appeared that the interviewees visualize the preparation process based on departments rather than activities. This lack of process orientation can generate several losses. Ljungberg and Larsson (2012) argue that increased transparency, higher efficiency, higher quality, and improved customer orientation is some of the outcomes from having a process oriented organization.

6.4 Standardization

Today, the process for preparing assembly work instructions for same components are in some cases performed at different sites. Figure 27 clearly displays that the process for preparing assembly work instructions are different depending on area and country. As earlier mentioned, the Cab and Vehicle site in Brazil deviates rather early from the process even though the process performed there is similar to the one in Sweden. The reason for this is not known by the interviewees, which indicates a lack of transparency within the organization. It might also be connected to the re-organization made in 2012 because now the process for preparing assembly work instructions involves several of the organizational units. During the interviews it emerged that the organizational units work towards different goals, one towards low lead times, and the other towards high quality. These goals contradict each other where low lead times can affect the quality negatively. One example can be that the design of a product becomes accelerated to reach lead time goals. This can lead to that quality requirement are not highly prioritized. When the product later comes to
production problems might occur due to this. By standardizing the preparation process it is possible to avoid deviations such that only local adaptations are the part of the process that differs but also to cooperate towards the same goals.

A standardized process would enable one site to prepare the instructions for several sites, leading to time savings. Although, each site might need to adapt the instruction so it fits their production line. Meaning that time spent on creating entirely new instructions can be avoided. This approach generates a more centralized organization but can lead to difficulties when communicating with employees involved in the process at a local level due to the distance and language barriers. This can lead to that design changes for example are not possible to manufacture everywhere or that the time setting cannot be fulfilled. Currently, many sites are decentralized because of previous organizational structure, which is beneficial when preparing assembly work instructions in the manner of fast communication. This generates diversity in the process for preparing assembly work instructions and it impedes the collaboration among sites in the production network.

Standardization of a process does not only consider the actual activities but also the systems used when performing them. As can be seen in table 7, the three sites studied within Volvo GTO use several different systems for the same purpose. This can lead to difficulties when sharing information. Since Volvo GTO covers other brands than Volvo, it can be assumed that even more systems exist for the same purpose.

6.5 Method discussion

This study is of qualitative nature, meaning that all data gathered was interpreted. This can lead to that the study becomes subjective. Although the study was conducted by two people and if the data is equally interpreted it likely reflects the actual situation at the case company. The information has also been reviewed by the interviewees to reduce the risk of misinterpretations. The data was mainly primary and therefore required much time to gather and also much unnecessary, but interesting, information outside the scope of this thesis was received. Interviews were the main data collection method, where the information was interviewee dependent. This means that the interviewees perceive the importance of telling certain information differently.

If the data is misinterpreted it might not reflect what it is intended to do and in turn decrease the validity of the study. An approach that increased both the validity and reliability of this study was the usage of a predefined methodology, Figure 2. This methodology describes how to proceed when making a current state analysis of a process for preparing assembly work instructions.

One problem that occurred when performing the literature study was that limited research was found within this area. This led to that the literature gathered is, in some cases, rather old and parallels from other areas had to be made. Though this is an indication of that more research should be conducted.
6.6 Contribution of this study
This study provides an overview of how the process for preparing assembly work instructions for the Volvo brand looks today at three sites within Volvo GTO in Sweden. It is a starting point for a continuous work towards a standardized preparation process. The study reflects on what has to be considered when developing a standardized process with ability for local adaptations. By interviewing people along the preparation process, we believe that the interest regarding how the process actually looks like has increased.
7 Conclusion

In this chapter the authors answer the research questions stated in the introduction. Recommendations to the case company are given together with suggestions for future research.

RQ1: Which key activities can be identified within the process for preparing assembly work instructions?

The suggested key activities of the process for preparing assembly work instructions identified are: design, review, time setting, time analysis, balancing, station marking, create assembly work instruction(s), and share information. These are presented in a process map, see Figure 28 and further described in Table 7 in the analysis chapter.

Figure 28: Answer research question 1

When suggesting the key activities, the common activities performed at all sites were included. There exist some differences between the preparation processes at the Cab and Vehicle assembly and Powertrain Productions sites studied. Although they have the same main activities but these are performed in different extent. As earlier discussed the interviewees view of the process is very different from the process suggested, where their descriptions focused more on departmental responsibilities rather than actual activities. The descriptions received from interviewee A-D were different from each other. Therefore a conclusion is drawn that there is a lack of holistic thinking and transparency regarding the process for preparing assembly work instructions.

There may be some difficulties when standardizing this process if there is an outspoken standard for the existing preparation process at sites. The case study shows that such outspoken standards exist, leading to that even if it is possible to standardize the process in the future, it will require much effort.
RQ2: How can a process for preparing assembly work instructions be standardized to fit a global company?

Based on the information regarding the preparation process and theory there are some factors that need to be considered when standardizing the process.

*Process steps that must be standardized:*

**Design** – This process step must be standardized because it often affect several sites where all these must be considered when creating a new design. By having a standardized design work, all designs are constructed in the same way including same type of information making it easier for the sites to prepare for new introductions.

**Review** – To make sure that high-qualitative components reach the production, the designs must be reviewed and tested. This is important in order to avoid problems that can occur during the assembly. Standardizing the review ensures that all designs are investigated against same criterion. This leads to that all sites will have the same prerequisites when introducing new components as well as working towards common goals.

The other activities: time analysis, balancing, station marking, creating work instruction, and share information must be adaptable because they are site(s) dependent. Although these activities must be performed in order to reach the final output, the work instruction.

*Systems that must be standardized:*

**Product data system** – To easy share information among sites regarding products, they must use the same product data system. If only having one product data system, information only needs to be inserted ones and it is easier to keep it updated.

**Time setting system** – It is important that all sites get knowledge about when the introductions are planned and therefore same time setting system should be used. By having a common time setting system, communication between sites is facilitated leading to a better collaboration opportunity.

**System for creating work instructions** – Because several sites can be affected by one design change it must be possible to share work instructions. This can be done if all sites use the same system for creating work instructions. This will also facilitate the communication between sites and create uniformity because all uses the same type of instruction.

**Visualization system** – Because the visualization system is closely connected to the system for creating work instructions it must also be standardized. Having the same visualization system makes it is easier for employees to work at different sites and still understand the work instructions.

Some general factors to consider during standardization are that employees must be aware of how they contribute to the process and final output. Employees must have the opportunity to participate in the standardization where the management must be committed and motivating. Since a global company have sites in different countries it is
important that the process takes local cultures and regulations of each country into account. This is also the reason that some activities must have room for local adaptions.

7.1 Theoretical contribution
This study provides a definition of what a process for preparing assembly work instructions is and where in the organization it occurs. This definition includes activities that should be performed in the preparation process. The study suggests factors to consider when standardizing a process for preparing assembly work instructions in a global company.

7.2 Recommendations to case company
During the study, it was found that the process deviates at different stages where no clear reason for this was known. We suggest Volvo GTO to investigate why these deviations occur in order to get an understanding of how the process is spread.

To continue the work towards a common process for preparing assembly work instructions within Volvo GTO, we recommend that more sites are studied starting with the Volvo brand. Later it is necessary to investigate remaining brands such as Renault trucks, Mack trucks and UD trucks. When mapping all processes it is important to observe which systems that are used at the different sites. This to see in what extent the processes differs from each other.

This study did not take the knock-down sites into consideration but during interviews it appeared that difficulties occurred when instructions from different brands was going to be used in the same factory. Volvo GTO should evaluate how the knock-down sites are affected by a non-standardized preparation process with different outputs.

We believe that our methodology can be helpful when mapping the preparation processes and therefore suggest Volvo GTO to use it as a starting point when investigating remaining sites and brands.

7.3 Future research
Since limited research was found within this subject we recommend other researchers to investigate preparation processes for assembly work instructions at other organizations. This should be done in order to conceptualize what a preparation process is and what it should cover.

This study only discusses what should be considered when standardizing a preparation process, but not how to create or implement such a process in a global environment. Therefore we recommend other researchers to investigate how to proceed with this matter.

Another aspect that should be investigated regarding the standardization of a preparation process is what risks that can occur. This study is limited to sites in Sweden and therefore research should be done to identify risks for foreign sites.
References

Books:


Conference materials:


Dissertations:


E-books:


Journals:


Websites:


Appendix 1: Interview questions with people inside the process

1. Vad gör du i ditt dagliga arbete?
2. Vad behöver du för att utföra ditt arbete (input)?
3. Vad ser du för förbättringsmöjligheter?
4. Om du själv skulle förklara processen för att skapa arbetsinstruktioner från KOLA till arbetsinstruktion, hur skulle du då förklara den övergripande?
5. Vilka olika avdelningar är involverade i processen?
6. Finns beredningsprocessen dokumenterad?
7. Vad är resultatet av ditt arbete?
8. Arbetar du mot några mål?
9. Ser du några svårigheter med det du gör?
10. Vilka länder jobbar du mot?

Questions in English (during the interviews the Swedish questions was used)

1. What do you do in your daily work?
2. What do you need in order to perform your work tasks?
3. What improvement opportunities can you identify?
4. How would you describe the preparation process?
5. Which departments are involved in the process?
6. Is the preparation process documented?
7. What is the result from your work?
8. Which goals are you working towards?
9. Can you see any difficulties in your daily work?
10. Which countries do you cooperate with?
Appendix 2: Interview questions with people outside the process

1. Vad är viktigt att tänka på när man skapar en masterprocess?
2. Finns det någon masterprocess för processen för att skapa arbetsinstruktioner?
3. Hur går ni tillväga när ni skapar en masterprocess?
4. Har man sett skillnader i utförande mellan varumärken?
5. Finns det ett stort behov av masterprocesser generellt?

Questions in English (during the interviews the Swedish questions was used)

1. What is important to consider when creating master processes?
2. Does a master process exist for the preparation process?
3. How does one proceed when creating master processes?
4. Has any differences between brands been identified?
5. Is there a great need for master processes?
## Appendix 3: Interviewees and their title

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Function</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Engineering Intro PE FA Coordinator</td>
<td>Cab &amp; Vehicle</td>
</tr>
<tr>
<td>2</td>
<td>Quality Journal, PROTUS</td>
<td>Development center</td>
</tr>
<tr>
<td>3</td>
<td>Technical Preparation Engineer</td>
<td>Development center</td>
</tr>
<tr>
<td>4</td>
<td>Logistic Engineer</td>
<td>Cab &amp; Vehicle</td>
</tr>
<tr>
<td>5</td>
<td>Intro Engineer</td>
<td>Cab &amp; Vehicle</td>
</tr>
<tr>
<td>6</td>
<td>Production Engineer 1</td>
<td>Cab &amp; Vehicle</td>
</tr>
<tr>
<td>7</td>
<td>SL Execution Control System</td>
<td>Powertrain Transmissions</td>
</tr>
<tr>
<td>8</td>
<td>Production Engineer 2</td>
<td>Powertrain Transmissions</td>
</tr>
<tr>
<td>9</td>
<td>Product Engineer 1</td>
<td>Powertrain Engines</td>
</tr>
<tr>
<td>10</td>
<td>Design Engineer 1</td>
<td>Development center</td>
</tr>
<tr>
<td>11</td>
<td>Design Engineer 2</td>
<td>Development center</td>
</tr>
<tr>
<td>12</td>
<td>Process Owner</td>
<td>Development center</td>
</tr>
<tr>
<td>13</td>
<td>Project Manager</td>
<td>Powertrain Transmissions</td>
</tr>
<tr>
<td>14</td>
<td>Product Engineer 2</td>
<td>Powertrain Transmissions</td>
</tr>
<tr>
<td>15</td>
<td>Product Preparation Engineer</td>
<td>Powertrain Transmissions</td>
</tr>
<tr>
<td>16</td>
<td>GTO Project Manager</td>
<td>Development center</td>
</tr>
<tr>
<td>17</td>
<td>Production Engineer 3</td>
<td>Powertrain Engines</td>
</tr>
<tr>
<td>18</td>
<td>Virtual Manufacturing</td>
<td>Powertrain Engines</td>
</tr>
</tbody>
</table>
Appendix 4: Other contact persons

<table>
<thead>
<tr>
<th>Person</th>
<th>Function</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Logistic Preparation Engineer</td>
<td>Cab &amp; Vehicle</td>
</tr>
<tr>
<td>2</td>
<td>Director Technical Preparation 1</td>
<td>Development center</td>
</tr>
<tr>
<td>3</td>
<td>Manager Chassi &amp; Final Assembly</td>
<td>Development center</td>
</tr>
<tr>
<td>4</td>
<td>MTM Engineering System Powertrain</td>
<td>Powertrain Transmissions</td>
</tr>
<tr>
<td>5</td>
<td>Manager Engineering</td>
<td>Cab &amp; Vehicle</td>
</tr>
<tr>
<td>6</td>
<td>Group Manager</td>
<td>Development center</td>
</tr>
<tr>
<td>7</td>
<td>Manager Engineering Assembly</td>
<td>Powertrain Engines</td>
</tr>
<tr>
<td>8</td>
<td>Intro coordinator maintenance</td>
<td>Cab &amp; Vehicle</td>
</tr>
<tr>
<td>9</td>
<td>Director Technical Preparation 2</td>
<td>Development center</td>
</tr>
</tbody>
</table>
Appendix 5: Assembly work instruction - Cab and Vehicle Assembly

Assembly Instruction

<table>
<thead>
<tr>
<th>ALL</th>
<th>Montör 1 Avlastning</th>
<th>AAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chassis Number</td>
<td>Sequence Number</td>
<td>Serial Number</td>
</tr>
<tr>
<td>X</td>
<td>XXXX</td>
<td>XX-XX-X.XXX</td>
</tr>
</tbody>
</table>

Hämta telfer
Kalla på lorför chassilyft.

Roipaket

<table>
<thead>
<tr>
<th>Part</th>
<th>Qty Description</th>
<th>C1</th>
<th>C2</th>
<th>Comment</th>
<th>Emb</th>
<th>UP</th>
</tr>
</thead>
<tbody>
<tr>
<td>XXXXXXX</td>
<td>1 RÖR CAB HEATER</td>
<td></td>
<td></td>
<td>Drag ej. Monteras på lösen, UTSIDA RAM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XXXXXXX</td>
<td>2 FLÄNSSKRUVA M8’25</td>
<td></td>
<td></td>
<td></td>
<td>P3</td>
<td>XXXXX</td>
</tr>
<tr>
<td>XXXXXXX</td>
<td>2 FLÄNLSMUTTER</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>XXXXX</td>
</tr>
</tbody>
</table>

Montera plugg till vattenrör (UEAS/EAS-S0)

<table>
<thead>
<tr>
<th>Part</th>
<th>Qty Description</th>
<th>C1</th>
<th>C2</th>
<th>Comment</th>
<th>Emb</th>
<th>UP</th>
</tr>
</thead>
<tbody>
<tr>
<td>XXXXXXX</td>
<td>1 ANGLUTNING</td>
<td></td>
<td></td>
<td>Monteras till pip på vattenrör</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Avklamning höger ramsida
Klamma av befintliga klammor till ledningsmatta. Klamppunkten framför motorfäste till ändbalk.

Framför motorfäste skall kabelmattan placeras så nära insida ram som möjligt. Detta för att undvika skav från startmotor.

Klamma av sidomarkiringskablage, fram och fram-mitten, höger sida. Klamma av höger klammar på tonsol växellådsbak.

Klamma av sidomarkirings-kablage, bak (MARKL-SR).

Klamma av sidomarkirings-kablage, överhäng (MARKL-SR).

Avlastning chassis, koppla lyftöglor.
Se Handhavandeinstruktion Chassilyft, vändare

CI | XXXXX |
Appendix 7: Assembly work instruction 2 - Powertrain Production

### OIS Operator Instruction Sheet

<table>
<thead>
<tr>
<th>Arbetssområde</th>
<th>nr.</th>
<th>Steg</th>
<th>Tempo</th>
<th>Tid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arbetsmoment 1</td>
<td>1</td>
<td></td>
<td></td>
<td>14.5</td>
</tr>
<tr>
<td>Arbetsmoment 2</td>
<td>2</td>
<td></td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>Arbetsmoment 3</td>
<td>3</td>
<td></td>
<td></td>
<td>2.4</td>
</tr>
<tr>
<td>Arbetsmoment 4</td>
<td>4</td>
<td></td>
<td></td>
<td>8.9</td>
</tr>
<tr>
<td>Arbetsmoment 5</td>
<td>5</td>
<td></td>
<td></td>
<td>11.1</td>
</tr>
<tr>
<td>Arbetsmoment 6</td>
<td>6</td>
<td></td>
<td></td>
<td>3.2</td>
</tr>
<tr>
<td>Arbetsmoment 7</td>
<td>7</td>
<td></td>
<td></td>
<td>0.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vaktilesande</th>
<th>Notvändig</th>
<th>Vanlig</th>
<th>Fortids</th>
<th>Varsa</th>
<th>Totalt Antal Steg</th>
<th>Totaltid</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2</td>
<td>24.5</td>
<td>14.5</td>
<td>22.2</td>
<td>0.0</td>
<td>2</td>
<td>74.4</td>
</tr>
</tbody>
</table>

Takt: 89.0 | Beläggning: 83.64% | Tidsenhet: 5
Appendix 8: Assembly work instruction 3 - Powertrain Production

<table>
<thead>
<tr>
<th>Header</th>
<th>Qty</th>
<th>Instruction text</th>
<th>Cfm.</th>
<th>Bar.</th>
</tr>
</thead>
<tbody>
<tr>
<td>VERIFY CU GASKET FOR INLET MANIFOLD</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GASKET, 16*22</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOLLOW SCREW, M14<em>1.5</em>26</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GASKET, M14*14</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FLANGE SCREW, M8*16</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASSEMBLE ECU</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FLANGE SCREW, M8 *40</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FITTING, ELBOW 90 DEGREE</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

STATION COMPLETED