CHALMERS

The impact on the aftermarket supply chain with increased pre-planned service activities

A case study at Volvo Group

Master´s thesis in Supply Chain Management

AUDUR ÝR BJARNADÓTTIR

HULDA HALLDÓRSDÓTTIR

Department of Technology Management and Economics
Division of Logistics and Transportation
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2015
Report No. E2015:065

REPORT NO. E2015:065

The impact on the aftermarket supply chain with increased pre-planned service activities

A case study at Volvo Group

AUDUR YR BJARNADOTTIR

HULDA HALLDORSDOTTIR

Examiner: Patrik Jonsson

Supervisor at Volvo Group: Jonas Jern

Department of Technology Management and Economics

CHALMERS UNIVERSITY OF TECHNOLOGY

Gothenburg, Sweden, 2015

The impact on the aftermarket supply chain with increased pre-planned service activities

A case study at Volvo Group

AUDUR ÝR BJARNADÓTTIR

HULDA HALLDÓRSDÓTTIR

Technical report no. E2015:065
Department of Technology Management and Economics
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone: + 46 (0)31-772 1000

Chalmers Reproservice

Gothenburg, Sweden, 2015

Abstract

Aftermarket services in the automotive industry bring profitable advantages to manufacturing firms and are a major enabler to secure customer loyalty by providing value-adding services through the product life-cycle. High uptime of vehicles is one of the key performance indicators as it increases customer satisfaction which is the fundamentals for long-term relationship with the end-customer. Demand for spare parts is difficult to monitor as breakdown services can occur at an unpredictable time. Therefore, it is challenging for many OEM's to contribute to high availability of spare parts in a cost efficient way. Today there is data available from connected vehicle technology to facilitate pre-planned services activities and to avoid breakdown situations. The Volvo Group has implemented pre-planning to their aftermarket supply chain but as the amount of pre-planned service activities is not performed in a high degree the company is uncertain about the impact from this concept. The purpose of this thesis was formulated to investigate the impact from higher degree of pre-planned service activities on the aftermarket supply chain in order to identify future performance potential.

The thesis was conducted as a case study at the Volvo Group. Three research questions were stated in order to identify scenarios where pre-planning has impact on the spare part control; 1) identify the effect from current spare part control practices and performance in the aftermarket supply chain, 2) identify how pre-planned service activities affect the current spare part control, and 3) identify the opportunities and obstacles for future performance potential on different spare part control scenarios. The current aftermarket supply chain at the Volvo Group was investigated and analysed to find the practices and performance indicators that are affected by the current spare part control and their relevance to higher uptime and decreased lead time, transportation cost and tied-up inventory was evaluated. Characteristics of pre-planning were conducted from literature and benchmarking study from the automotive industry was made to estimate effects from pre-planned service activities on the current spare part control. Historical sales data from two dealers was analysed in order to understand current behaviour from the dealer side. Furthermore, potential pre-planning scenarios and their effects were identified to visualize direct impact from higher degree of pre-planned service activities.

The results from this thesis give a clear description on how pre-planned service activities impact the current spare part control. It has the potential to contribute to higher uptime of the vehicle with reduction of inventory levels at dealers and supporting warehouses, and total transportation cost. Furthermore, it identifies potential planning scenarios where pre-planning will have different impact from different segments of parts. The greatest impact are from faster moving segments of spare parts, that represent the majority of sold parts, and supports the potentials of reduction of total inventory cost, transportation cost, and higher turnover rate at dealers' stocks.

Keywords: Pre-planning, aftermarket supply chain, automotive industry, spare part management, performance indicators.

Acknowledgements

This master thesis was conducted the spring 2015 at Chalmers University of Technology as a part of the M.Sc. program Supply Chain Management. The master thesis was done in collaboration with Volvo Group Logistics Services located in Arendal, Gothenburg where the case study was conducted.

This master thesis was supervised by Patrik Jonsson at Chalmers University of Technology, and Jonas Jern at Volvo Group, and to them we are especially thankful. Their experience, support and inspiration were highly valuable in the thesis process.

Furthermore, we would like to thank the many employees at the Volvo Group Logistics Services for their advice and support during the thesis project and especially the company representatives for the interviews and information sharing. In addition, we would like to thank all the representatives from Volvo Group Truck Sales for valuable input and help as well as the VCS representative for broadening our vision and providing an interesting aspect of the topic.

A special thank you goes to Ulrik Lork at UL3 for guiding us towards our goals during the thesis process.

We are grateful for the opportunity provided to apply our theoretical knowledge gained from the Supply Chain Management program in real life setting of a topic of interest at the Volvo Group.

Audur Ýr Bjarnadóttir and Hulda Halldórsdóttir

Gothenburg, June 2015

Index

Figure Index

Table Index

Abbreviations

ASC	Aftermarket Supply Chain
CDC	Central Distribution Centre
DC	Distribution Centre
DIM	Dealer Inventory Management
GTO	Group Trucks Operations
ICT	Information and communication technology
KPI	Key Performance Indicator
MM	Materials Management
OEM	Original Equipment Manufacturer
PI	Performance Indicator
RDC	Regional Distribution Centre
SDC	Support Distribution Centre
VCS	Volvo Cars Sverige AB

1 Introduction

This chapter provides a brief description of the challenges and opportunities in the field of aftermarket services which serves as the background for the thesis. The purpose of the master thesis is discussed as well as the aim and research questions are stated and the scope defined. Lastly the structure of the thesis is presented and content of each section briefly described.

This master thesis was done for Volvo Group, more specifically the Material Management (MM) Development department located in Arendal, Gothenburg. This master thesis investigates the impact a higher degree of pre-planning has on the company's aftermarket supply chain (ASC).

1.1 Background

Aftermarket services have had increasing interest within manufacturing firms as it brings advantages in profitability, customer loyalty, and is seen as a great source of revenue. The aftermarket is found to be much larger than the new product market, and the turnover of the new product can be tripled with aftermarket services (Bundschuh and Dezvane, 2003, Gaiardelli et al., 2006, Saccani et al., 2007). Companies within the aftermarket can therefore not consider the aftermarket as an afterthought (Cohen et al., 2006). Original equipment manufacturers (OEMs) need to focus on enhancing the value of the core product where value-adding services need to be provided to customer through the product life-cycle to gain a long-term relationship and competitive advantages (Cavalieri et al., 2007). These customer offers require operational excellence in securing availability of spare parts at different locations around the world.

A key step in achieving this is the design and management of an effective distribution structure in the ASC. The challenges companies in the automotive industry are facing include a huge number of stock keeping units (SKU's) and uncertainty in demand for spare parts (Cohen et al., 2006, Jouni et al., 2011). Understanding what kind of supply and distribution networks are required to operate in and deliver to the promising and growing but also complex area of aftermarket services (Saccani et al., 2007) is necessary as the OEM takes on an increased responsibility of the customer's own processes. The shape of the distribution network determines the flow of spare parts from the supplier base to multiple clients (including service stations, dealers, truck owners/users, and OEM's internal customer). OEM's must understand how to upgrade and transform their supply and distribution network in order to seize the promising opportunity of the aftermarket, and to deal with the complexity of the task.

Capabilities for efficient and effective monitoring of the service, through planning and control of spare part inventories are challenges for many OEMs (Jouni et al., 2011). Today there is data available to facilitate pre-planning of maintenance service occasions and to avoid breakdown situations. According to Oxford Dictionaries online, to pre-plan is to plan in advance and in relation to the purpose of this thesis pre-planned service activities refers to planning customer service visits at dealers in advance as well as the spare parts required to perform the service. Effective pre-planning of spare parts requires that the spare parts are available at the right time and provided at the right cost. This possibility creates new opportunities and challenges for the ASC. Moreover, standards regarding digital requirements are increasing and a higher service level is becoming necessary (Robinson, 2014). Therefore it is important that companies in the automotive industry use available technology in order be competitive in the automotive aftermarket. Information and communications technology (ICT) and connected vehicles allows for direct monitoring of the vehicle, both its usage and condition. There is an increase in sales of connected vehicles that presents new opportunities for the automotive aftermarket. With increased use of connected vehicles the value for the customer will also increases as there are opportunities to provide interactive maintenance and remote diagnostics (Frowein et al., 2014).

Today there are more than 300,000 connected commercial vehicles from the Volvo Group as telematics solutions are now a standard in new vehicles where diagnostics support the performance of pre-planned service activities at dealers. It increases the opportunities to perform proactive maintenance and avoid breakdown situations, or reactive maintenance, where breakdown services require fast response and high costs to deliver parts to the dealers. This will provide a more efficient way to support the uptime of Volvo Group´s end-customer vehicles. A higher degree of pre-planned service activities at the dealers will present challenges in the ASC and the impact needs to be investigated in order for the aftermarket to be cost efficient and effective to ensure end-customer loyalty in the long term. Volvo Group sees the opportunity with pre-planning to better meet the customer demand with lower cost in the overall ASC.

The goal of Volvo Group´s ASC is to: "...ensures the global availability of aftermarket parts to dealers and end customers at the right time, the right place and at the right cost" (Volvo Group, 2015d). The current planning environment aims at fulfilling this goal and increasing the degree of pre-planned services activities still aims at fulfilling the goal. However, the challenge presented in this thesis is enhancing the knowledge of how pre-planned service activities will affect the ASC. Identifying the possible impact on the ASC can also present the possible benefits from changing the planning environment and processes.

1.1.1 Problem Identification

The focus of the ASC at Volvo Group is to provide the end-customer with maximum uptime of their vehicles. In order to provide the desired level of uptime the management of materials, warehousing and distribution has to ensure the availability of spare parts at the dealers and to do so at the right time, right place and at the right cost. To meet the end-customer´s goal, to have maximum uptime of their vehicles, dealers need to focus on providing the service they require while Volvo Group develops logistics systems and maintains competence by balancing the availability and cost of spare parts (Volvo Group, 2015d). Ensuring that this is done in the optimum way there needs to be a balance in the spare part flow between improving the uptime of vehicles and reducing logistics cost, tied-up capital, and lead time. Demand of spare parts is usually unpredictable and requires high levels of inventory at dealers and distribution centres or responsive high cost transportation to ensure the availability of parts required.

1.2 Purpose

The purpose of this master thesis is to investigate the impact from higher degree of pre-planned service activities on the aftermarket supply chain in order to identify future performance potential.

1.3 Problem Analysis

Performance in the ASC can be described as how well the spare part control manages to meet the customer requirement in a cost efficient way with optimum stock levels; in other words the balance between cost, cash and service. The purpose of the thesis aims at investigating the future performance potential with a higher degree of pre-planning with a balance between cost, cash and service factors; uptime of vehicles, logistics cost, tied-up capital, and lead time. In order to investigate how a higher degree of pre-planned service activities can affect Volvo Group´s ASC there needs to be a thorough understanding of how the current ASC and services within work, how the current spare part flow is controlled and how it performs. Furthermore, the concept of pre-planning at the company needs to be explained.

The purpose of the first research question is to understand Volvo Group´s ASC and how the current distribution of spare parts affects the control and performance. This was done in order to identify important parameters that need to be taken into consideration to understand how the impact will be compared to the current planning. The second research question aims at identify how pre-planned service activities affect the current spare part control. This includes the behaviour at dealers and the impact their ordering behaviour has downstream in the ASC. The last research question provides the foundation for potential performance improvement with a higher degree of pre-planning. Parameters were evaluated and assessed in different planning scenarios in order to identify the impact on the ASC by higher degree of pre-planned service activities.

The purpose of this master thesis will be fulfilled by answering following research questions:

RQ1: How does the current spare part control affect practices and performance within the aftermarket supply chain?

RQ2: How do pre-planned service activities affect the current spare part control?

RQ3: What are the opportunities and obstacles for planning performance for different spare part control scenarios?

1.4 Scope

This thesis investigated the current spare part control at the Volvo Group and is used to identify the future performance potential with a higher degree of pre-planned service activities. The thesis is limited to the Volvo Trucks brand and conditions in the Nordic market. The study focuses on the Nordic market due to the importance for the Volvo Trucks brand, the size of the market and the current pre-planning activities in the market which contributes to the possibility to estimate higher degree scenarios of pre-planning. The current state was investigated at the aftermarket services department, in Arendal, Gothenburg where the authors were located. This resulted in data gathered through observations and field notes that are not a formal evidence material. The system that was studied is the ASC, from Central Distribution Centres (CDCs) to dealers, and more specifically a study of two dependent dealers in the Swedish market was made. Historical data of activities regarding orders and management of spare parts in the Global Dealer System (GDS), dating one year back in time (2014.03.20 - 2015.03.24) from the chosen dealers, was studied and analysed to support qualitative assessment of scenarios identified in RQ3.

The results from the thesis are used as recommendations on how the ASC will be impacted and not as directly as an implementation plan or prerequisite for higher degree of pre-planning. The system that was studied is the ASC and included in the system boundaries are dealers and the distribution centres that provide dealers with spare parts and the links between. Excluded are supplier nodes and the link between them and the CDCs. The opportunities with the new set up require the use of data available from ICT and in order to reach a high degree of pre-planning that is a prerequisite.

1.5 Thesis Structure

This section provides the structure of the thesis and brief description of what each chapter includes.

1. ***Introduction***

This chapter presents the introduction to this thesis. It aims at giving an understanding of main thesis topics from theory and how it connects to the background of Volvo Group. It provides a problem analysis that discusses the importance of the thesis topic and why this thesis was conducted. The purpose is stated as well as the research questions that aim to answer the purpose, and the scope.

2. ***Methodology***

This chapter presents the methodology of the thesis. It gives a description of the research strategy, design and methods to address research questions and approach the study. A model of analysis is stated, and reliability and validity of the study is discussed.

3. ***Literature Review***

This chapter presents a theoretical framework relevant to the main topics that provides understanding of the ASC. The literature review includes a brief introduction of spare part and ASC, their characteristics, and main challenges within this field. Literature on inventory management, performance indicators, and distribution structures are reviewed in order to understand challenges and comprehend the fundamental terms of this field.

4. ***Empirical Findings***

This chapter presents a description of the current ASC at Volvo Group. This includes description of the current spare part control practices and performance within the ASC. Data collected from interviews and observations concerning the analysis are presented as well as the outcome from a benchmarking study is stated. The benchmarking study gives and understanding on how pre-planned service activities work in real life where benefits, challenges, and prerequisites are stated.

5. Analysis and Discussion: Part I

This chapter presents analysis of empirical findings and theoretical framework, and provides answers to the first two research questions. It gives a description of the current state at Volvo Group Trucks Operations (Volvo GTO), how the current control of spare parts contributes to Volvo Group's goals and how it impacts control practices and performance of the ASC. Pre-planned service activities are analysed in order to see how it affect dealer's behaviour.

6. Analysis and Discussion: Part II

This chapter presents a case study of two dealers and their characteristics, practices, and performance. The pre-planning potential is identified and the possible impact a higher degree of pre-planning for different planning scenarios is discussed.

7. Results

This chapter summarizes main results from the analysis and identifies focus areas with regards to higher degree of pre-planning. It states obstacles to with regards to performance measurements and what changes are required before higher degree of pre-planning can be gained.

8. Conclusion

This chapter presents conclusions based on the major findings from the thesis. Theoretical and practical implications are discussed and fields for further studies are proposed.

2 Methodology

This chapter presents the research strategy, design and methods used to approach the study. First a general description of the appropriate methodology used for the project is presented as well as an introduction to the empirical and theoretical evidence used to support the findings in the study. The process and methods used for specifically for the aim and each research question is then described in details. Lastly the reliability and validity of the study is discussed.

2.1 Research Strategy and Design

Research strategies can both be quantitative and qualitative (Bryman and Bell, 2011). The main difference between the two strategies is that quantitative research is based on measurements or collection and analysis of data where qualitative research is based on interpretation of perspectives. There is also a difference between the two strategies when it comes to relationship between theory and research. The relationship can either be deducted; when theory is tested or inductive; when theory is generated. For quantitative research a deductive approach is more common and an inductive approach is used for qualitative projects (Bryman and Bell, 2011). A mixed method research also exists as a possibility, where qualitative and quantitative research is done for one study (Bryman and Bell, 2011). These type of research mixes methods used to gather data, where there can be five distinctive reasons to using mixed methods; for triangulation purposes, to be complementary for the other method, to develop the other method, to initiate a new perspective of a study or to expand a study by using different methods for different purposes (Bryman, 2006). This research is a mixed method, prioritizing qualitative research and is done using a qualitative assessment to support findings as quantitative evidence was used in order to triangulate and compliment the qualitative findings. The reason for using mixed method can then be said to be complementary. The proper research design must also be assigned as it provides the framework on how data will be collected and analysed. The right research design reflecting the most important factors of the research process should be chosen. A case study presents an analysis of a specific situation in a detailed and thorough manner whether it regards a single organization, a single location, a person, or an event (Bryman and Bell, 2011). A single case study provides an in-depth analysis of the chosen condition or process in a specific situation. In order for a case study to provide trustworthy and high quality there are several factors that need to be kept in mind (Baxter and Jack, 2008). The research questions need to be correctly formulated with clear purpose and definition, the design of the research should be appropriate, the method for gathering data should be appropriate for the study as well as it should be collected in a systematic way. Lastly, the data should be analysed correctly.

For this thesis a case study researching a contemporary phenomenon is appropriate as the study will be on a specific situation within a process at a company. The research method contains multiple sources of evidence that will be used; including a literature study of relevant theory and empirical data gathered from relevant sources.

2.2 Research Methods

Empirical and literature evidence is required to fulfil the aim of the study and answer the research questions. The evidence gathered will provide foundation of the analysis and will be crucial for the results of. This chapter includes a general description of the evidence gathered and the purpose they serve to fulfil the aim. In section 2.3, it will be further described how the evidence supports each specific research question.

2.2.1 Primary Evidence

Primary data is evidence that is collected directly from first-hand experience. The primary data that was collected for this study includes qualitative and quantitative evidence with the prime purpose of describing the current practices and performance and how it relates to pre-planning.

Interviews

Two types of interview structures were used to gather information; unstructured and semi-structured interviews, the list of interviews can be found in, Appendix I. According to Bryman and Bell (2011) a qualitative interview is structured in a way that reliability and validity are maximized, giving the interviewee an opportunity to express their own opinion with limited influence and objectivity from the interviewer. Unstructured interviews include a specific topic but there is no specific amount or order of questions where the interviewer has the ability to follow up on topics pointed out while the interview takes place. This form of interviews is often quite similar to a conversation (Bryman and Bell, 2011). The gathering of primary evidence started with introductions to how processes within the ASC at the company work. These introductions can be identified as unstructured interviews where there is a specific topic to be discussed but no limit to the range of what will be covered within the topic. They were held to gain understanding of both how their respective process works and what the main characteristics are. It provided knowledge about the purpose of pre-planned activities and expected results from the company by increasing pre-planning in the ASC. These introductions were held in companion with other thesis students that share a number of common topic areas at the company. They were held with process owners and managers and laid the foundation to establish further contacts in order to gain access to primary data. These introductory interviews were in the form of a presentation followed with questions regarding interesting points from the participants. As the content of the presentations were pre-determined and organized by the supervisors at the company there was no involvement of the students of what the pre-determined outcome should be. The students had the opportunity to schedule follow up interviews if a more detailed description or further information were needed.

The other form of interviews used in this study is the one of semi-structured interviews that consist of questions that cover a specific topic but not a direct guide of what the answer is (Bryman and Bell, 2011). The use of this type of interviews was found to be the most useful one as the topic of the interview was pre-determined but as the different subjects had different influences on the topic there needed to be availability for the openness to investigate follow up points relevant to the study. When introductory presentations had been held a broad overview could be made of what process was relevant to investigate further for the purpose of this thesis. For this mainly semi-structured interviews and open discussions were held for processes and sub-processes that were of special interest in order to gain relevant information for the purpose of the thesis. The interview guide that served as the semi-structure interview structure is presented in Appendix II. The main purpose of the interviews was threefold; to identify the current situation at the company and how they work with pre-planning today, to understand the current practices, performance and processes in the aftermarket, and to identify parameters and their impact on both practices and performance. These interviews were held with employees from Volvo GTO to understand the ASC perspective and with employees from Volvo Group Trucks Sales to understand the dealer or customer perspective. This supports identifying the impact on both ends of the ASC. Two open discussions were held with logistics development managers in order to further increase the understanding of pre-planning and to validate findings. A benchmark study with a company in the automotive industry was included as a way to measure the quality of the findings and to compare standard and similar measurements in a different setting than the case subject. A company in the automotive industry working with pre-planning was the subject of the benchmark study that provided a measurement to compare parameters and their impact on different ASC within the same industry.

Notes were taken in all interviews and a handful was recorded and transcribed. The reason why not all interviews were transcribed was due to the setting of the interviews, they were held over the internet in software that doesn't allow recording. In these cases secondary evidence from internal documents presented in the interviews were used to assist the process of the interview. Members that were interviewed were decided in agreement with the supervisor at the company as well as thorough contacts with interviewees.

Study visit

A key in understanding how current pre-planning activities work in practice and what probable scenarios could be identified was a visit to a dealership. The visit was a form of an observation where members of the dealer process at the company visited the dealer to understand their processes. This provided the authors the opportunity to participate in the discussions and to broaden the perspective of what key members thought of the dealer practices. Furthermore, a questionnaire was sent to the person responsible for the dealers to get the information regarding pre-planning activities from the case subjects' perspective. The visit together with the questionnaire was important to understand the historical data which was used to identify and support scenarios as they required an understanding of what different order lines in the data represented and an understanding of the procedures of practices and reason for the behaviour at the dealership.

2.2.2 Secondary Evidence

Secondary data is published evidence or evidence that has been collected in the past and is not specific for the research. The secondary data used in this study was derived from a literature study and through documents published on the internal Volvo GTO web places.

Literature study

Literature is defined as a source of secondary data as it is written for other purposes that this specific research. A literature review will be performed in the field of ASC and material management. This will provide better knowledge of the main topics in this project and overall knowledge in this field of study. The literature review will also be used to investigate if research project with similar purpose have been performed before and if there is experiences or knowledge that can be gained from such project. Furthermore, it will be used in order to understand possible opportunities within ASC, and support the improvements of the current performance at Volvo GTO. Understanding the main topics is necessary before starting gathering primary data and will provide more effective interviews results about specific topics.

The literature study began with a search in the domain of the study, by searching through combinations of keywords within specific topics in relevant to the thesis. Appendix III presents the topics and keywords relevant in order to fulfil the aim and the research questions of the thesis. A domain based search provides relevant sources and in the long-term it can be less time consuming than other methods. When relevant literature had been identified with the domain based search, a search through trusted sources was conducted. Academic journals commonly cited from articles in the domain based search were reviewed as well as backtracking through articles found important was done. The second study of literature provided a confirmation that the scope of relevant literature had been found as well as other literature, on a more detailed level, was found. The literature studied mainly includes journal articles, magazine articles and books. The area of publication and the field of study determined the validity of the literature; the investigation was done in parallel to the literature study as trusted sources were identified. For the literature framework to be relevant and up to date literature written in the last decade was chosen. Literature that provides descriptions and definition of commonly used theory date longer back in time. Electronic sources were mainly sought after using Chalmers Library search function Summon as well as the database Scopus was used.

Internal documents

Another form of secondary evidence gathered were internal documents from the company internal web places used both to gain a deeper understanding of the topics discussed and to support assertions stated in the performed interviews. The internal documents used were gathered from the web places from relevant departments at Volvo Group and from general information, such as annual reports and news segments. The quantitative evidence that was gathered was used to support the description and findings on the current state as well as providing supportive evidence of the various scenarios. It will thus be used to analyse the possible scenarios of a higher degree of pre-planning that will provide the foundation for a future potential performance. The internal documents used were in the form of presentations provided by interviewees, informative material on the web place, and process descriptions.

Historical sales data

The use of real historical data provided the opportunity to identify different ordering scenarios and the impact downstream the supply chain. The data used was extracted from GDS, the system dealers' use for all service and sales activities, for a one year period. In addition to the data from the dealers correspondent data from the CDC was extracted, providing all activities from the CDC to the dealers.

2.3 Fulfilling the Aim

The aim of the master thesis was fulfilled by answering the research questions stated in section 1.3. The first research question gives an understanding and description of the current

ASC and identifies which influencing factors have impact on the spare part control practice and performance. The second research question identifies the main characteristics of pre-planning and how it affects dealers behaviour and upstream the ASC. The third research question provides qualitative assessment of quantitative examples with higher degree of pre-planning and how it affects the ASC. It also provides possible opportunities within the spare part control practice and performance. The method is described in Figure 1.

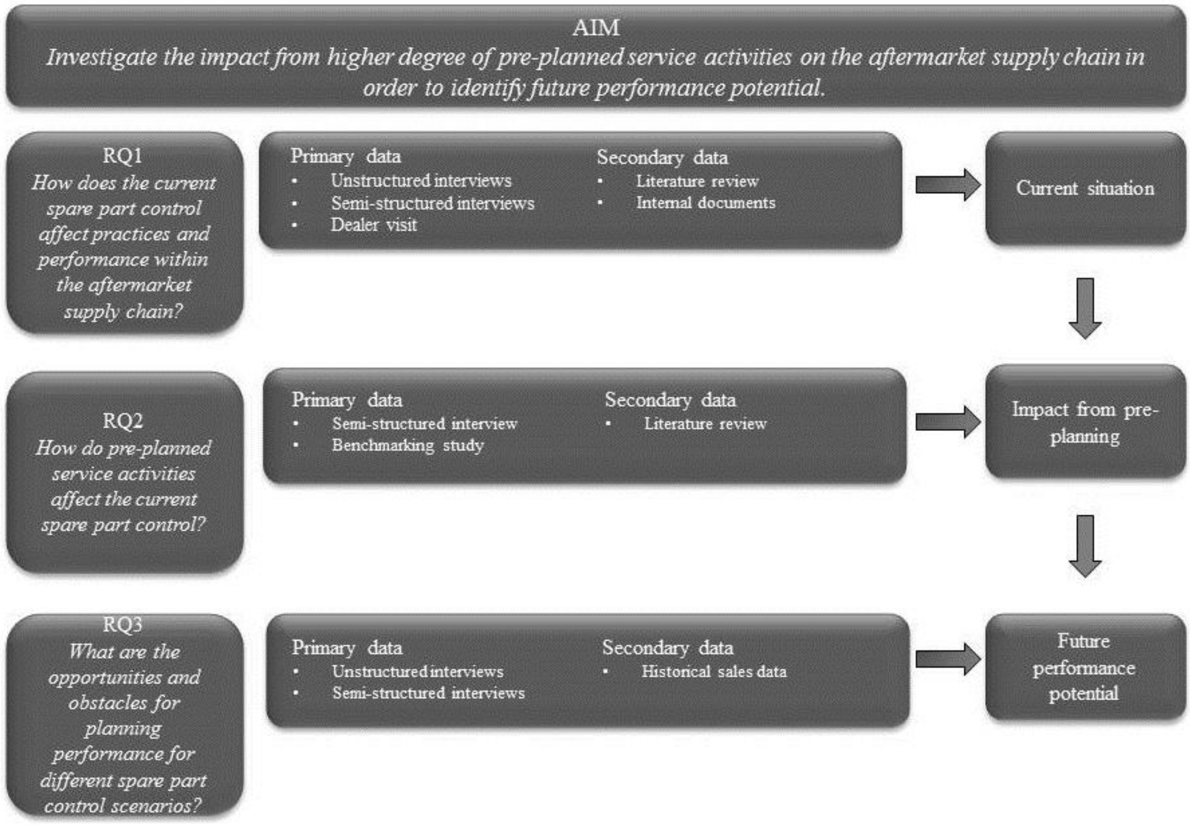

Figure 1: The methodology process.

2.3.1 Research Question 1

The current processes related to material management were investigated at Volvo GTO where the main focus included topics related to the control of spare parts. Qualitative assessment of the present performance was performed, where KPI's and other qualitative evidences regarding the spare part control was gathered to understand the current practices and performance of the ASC. Theory about challenges in the aftermarket industry was analysed in the literature review to support the outcome of research question one and see how Volvo GTO is performing compared to theory. The first research question;

"How does the current spare part control affect practices and performance within the aftermarket supply chain?"

Was stated to provide understanding of how the current spare parts control affects the practice and performance within the ASC. Processes related to material management were investigated to estimate how they affect the overall performance of the ASC. Performance indicators were selected and research of how they are affected by the spare part control and other performance indicators was made. Literature review was conducted in order to understand the performance indicators and evaluate how important they are in theory. Furthermore, it was conducted to understand the main challenges in the aftermarket industry and what is required for efficient distribution control. The process to reach the expected outcome of the first research question was done through four steps.

Interviews

Two types of interviews were used as a material to answer the first research question. Unstructured interviews were done in order to get a general knowledge of the company and departments that are related to the aftermarket services. This process was mainly set-up with presentations about certain processes and flows within the distribution network of the ASC. It gave a good understanding of conditions and main factors within this network and was also used to scope the project and find relevant contacts with regards to relevant information to contribute to the understanding and description of general information of the current situation at the company. Semi-structured interviews were held with employees within Volvo GTO to get detailed information about the current spare part control both regarding practice and performance. Information of the practice was mainly gathered from process managers and process owners to understand how the ASC really works in practice. Interviews with regards to performance was also gathered from these interviews as some of the process owners had figures of how each process was performing, but also more detailed interviews about performance indicators was made. The majority of the interviews were not very formal as the purpose was to get brief introduction to each process, have a discussion and questions about specific processes and performance indicators. Therefore the main information from the interviews were merged together to understand the overall picture of the current spare part control practice and performance.

Preliminary literature review

A preliminary literature review was conducted to gain general information about main topics needed for this thesis. This literature review was also done in order to see if similar studies have been done before within this field. The domain of the literature was regarding the ASC concept and topics that were connected to the outcome of the interviews, such as performance measurements and processes within automotive industry.

Internal documents

Internal documents from the company were gathered from internal web places. They were used to gain a better understanding of each process and prepare specific interviews questions. The process descriptions provided a detailed description and understanding of how the Volvo GTO works and how different practices and processes are linked together.

Dealer visit

A dealer visit provided a great understanding of dealers' behaviour. The visit was a form of observation since a group from Volvo GTO went for the visit and therefore the question asked was not always related to the topic of the thesis. The visit also influenced the interview questions specifically made for an interview with a representative of the two studied dealers.

2.3.2 Research Question 2

The second research question;

"How do pre-planned service activities affect the current spare part control?"

Was stated in order to see how pre-planned service activities at dealers affect the spare part control both in relation to practice and performance. This was done by investigating how current dealers' behaviour affects the ASC. Next step was to investigate how pre-planning would affect dealers' behaviours and how that affected the upstream ASC. The process to reach the expected outcome of the second research question was done through two main steps.

Literature review
A literature review was conducted in order to identify main parameters that are affected by the characteristics of pre-planning. This was done in order to see how this concept has been developing in recent years and to see how this works in this industry. The main purpose of the literature review was to find in a detailed level how factors that influence pre-planning will affect both the dealer and upstream the ASC.

Benchmarking study
The benchmarking study was done to gain a better understanding of how other actors in the industry, outside of the Volvo Group, are performing pre-planning activities. Volvo Cars Sverige AB currently works with a high degree of pre-planning and their input was valuable in order to understand how pre-planning of parts works in a similar industry parts and how it affects the logistics and planning in the supply chain in order to see how different parameters affect the ASC. The information from Volvo Cars Sverige AB was conducted through an interview with a project manager which holds a great knowledge of dealers' processes and performance, as well as understanding the pre-planning concept at Volvo Cars Sverige AB. The information gathered from the interview was used to see how they are performing, which parameters are affected and/or have been improved with a high degree of pre-planning. The benchmarking study was not used to compare the possible future state at the Volvo Group, but only to understand how higher degree of pre-planning affects certain parameters in the ASC and evaluate which parameters are important to consider when making a quantitative assessment.

2.3.3 Research Question 3

The third research question;

"What are the opportunities and obstacles for planning performance for different spare part control scenarios?"

Was stated in order to find different scenarios with regards to a higher degree of pre-planning, where real historical sales data were used to make a quantitative assessment of the future performance potential. Case study was made to understand the behaviour of two dealers and see how they perform with regards to performance indicators and set goals. This was done in order to compare the current to the possible future spare part control practice and performance. The process to reach the expected outcome of the third research question was done through three main steps.

Gathering quantitative data
Quantitative data was gathered to get a clearer picture of the current situation at Volvo GTO and to be able to compare it with potential planning scenarios. Important parameters were

identified from a literature study and interviews and from that it was decided which quantitative data was needed. The quantitative data provided information of the current spare part control performance and how it is related to the practice.

Evaluation and analysis quantitative historical sales data
Historical sales data from two dealers was evaluated and used as frame of reference in order to investigate how dealers are performing today. It was also used to identify specific scenarios and calculate possible effects if these orders would have been pre-planned. Different scenarios were analysed in order to find different impacts from different examples of dealers' practices.

2.4 Reliability and Validity of the Study

There are factors that play an important role for the evaluation of a research, these factors are crucial when determining the quality of the outcome of the research. Reliability and validity are terms commonly used for quantitative research that can be adapted for qualitative research (Bryman and Bell, 2011). Others debate that another criteria should be used for qualitative research but as the strategy for this case study is mixed method reliability and validity will be used to evaluate the quality of the outcome of this study.

Reliability can be described as the credibility of the method used to conduct the study or possibly the dependability of the findings. For qualitative research is can be divided into internal and external reliability where internal reliability refers to the consistency and agreeableness of the findings and external reliability determines if there is a chance for other studies to mimic the study. Reliability requires a thorough documentation of procedures (Bryman and Bell, 2011). When interviews are held there is always a possibility that if the research would be conducted by others different follow up points would be brought to light or that the correspondent would answer them differently. With regards to this implication, external reliability can be difficult to achieve even with clear interview guides.

Validity is defined by Bryman and Bell (2011) to be either internal; how relevant the findings are with the concept that is developed or external; how findings can be generalized for other research. A session was held with supervisors from the Volvo GTO and Chalmers and with other students to provide an update of what had been done in the process and in which way it would be possible to proceed with study at the given time. This provided an outside perspective of the method of the study as well as criticisms and feedback of findings to improve the internal validation. A seminar with the other thesis students was held to validate findings of the current state as the other thesis contains a description of the current state at the company supported from the same or similar sources. Comparison of statements and facts of the current situation was done to improve the internal validation. Furthermore, two seminars presenting the findings of the thesis were held with company representatives to validate findings. Additionally, as the research focused on one company and the processes within that company, validity was supported by comparing the evidence gathered and findings by benchmarking with another company in the automotive aftermarket industry. Triangulation of evidence plays an important role supporting the reliability and validity as if more than one source of evidence is used to support findings. As multiple sources of evidence was used to support findings and provide validation of the results.

3 Literature Review

The theoretical framework provides a review of literature relevant to the main topics that can provide understanding of the ASC. This includes a brief introduction of spare part and ASC, their characteristics and main challenges within that field. In addition, general literature on material and inventory management will be reviewed in order to comprehend the fundamental terms of this field.

3.1 The Aftermarket Concept

Actors in the automotive industry can no longer consider the purchase of the final product as an ending of the business. There is a need for a long term relationship with the final customer through the whole product life-cycle by providing value-adding customer service of the product (Cavalieri et al., 2007). The aftermarket industry has been increasing and is today much larger than the market for new products (Bundschuh and Dezvane, 2003, Saccani et al., 2007). In manufacturing industries it is a great source of revenue, profit, and creates competitive benefits (Bundschuh and Dezvane, 2003). This is further supported with Wagner and Lindemann (2008) which state that spare part business is one of the most profitable sources of organizations. Also, aftermarket business creates more turnover of the original purchase during the product life-cycle (Wise and Baumgartner, 1999).

One important part that supports profitable benefits are customer returns as there is a less need for marketing and improvements of customer satisfaction (Alexander et al., 2002). Reaching high customer satisfaction in the aftermarket plays also a critical role for companies when introducing new products (Goffin, 1999, Goffin and New, 2001).

Cohen et al. (2006) state that many companies do not know how to provide efficient aftermarket service, although in the automotive industry the aftermarket is much bigger than the equipment business. The aftermarket needs to support all the products that are available in the industry and because of different vendors and development between generations the aftermarket needs to hold about 20 times amount of SKUs that the manufacturing holds in stock (Cohen et al., 2006). It is thus important for companies to adapt their supply chain management to the aftermarket business to gain profitable benefits (Wagner and Lindemann, 2008).

3.1.1 The Aftermarket Supply Chain

Supply chain management is highly important for organizations within the aftermarket industry to be competitive (de Leeuw and Beekman, 2008). The overall goal with any supply chain is to fulfil the customers' needs while maximizing the surplus of the whole supply chain (Chopra and Meindl, 2013). Both set-ups of the manufacturing and ASCs are of similar nature with regards to the flow of material, finance, information and there exist fundamental differences between them that results in different methods to manage them in the best way possible. The ASC requires a different approach than manufacturing supply chains as it is driven by a different characteristics stated by Cohen et al. (2006) presented in Table 1.

Table 1: The difference between manufacturing and aftermarket supply chains (Cohen et al., 2006, p. 132).

Parameter	Manufacturing Supply Chain	After-sales Services Supply Chain
Nature of demand	Predictable, can be forecast	Always unpredictable, sporadic
Required response	Standard, can be scheduled	ASAP (same day or next day)
Number of SKUs	Limited	15 to 20 times more
Product portfolio	Largely homogeneous	Always heterogeneous
Delivery network	Depends on nature of product; multiple networks necessary	Single network, capable of delivering different service products
Inventory management aim	Maximize velocity of resources	Pre-position resources
Reverse logistics	Doesn´t handle	Handles return, repair, and disposal of failed components
Performance metric	Fill rate	Product availability (uptime)
Inventory turns (the more the better)	Six to 50 a year	One to four a year

The complexity of spare part control lays in controlling the nature of demand; unpredictable and sporadic demand of spare parts requiring responsive actions, high variety of products; large product portfolio with a high number of SKUs (Cohen et al., 2006, Jouni et al., 2011). This is in line with the findings from Huiskonen (2001) which points out that main challenges in spare part control are affected by difficulty in forecasting, price differences of individual parts, and high service requirements as stock-outs can have great financial effects. These challenges increases the importance of the contribution within the ASC but not only the structure of the supply chain causes complexity for spare part control, other factors such as inventory control, supplier performance, demand patterns and customer behaviour influence the impact on the spare part control (Jouni et al., 2011). These factors need to contribute to the ASC and secure that spare parts are available for the whole lifecycle of the primary product (Fortuin and Martin, 1999).

3.2 Spare Part Characteristics

The critical factor of ASCs is the availability of the spare parts needed (Cohen et al., 2006). Additionally, minimising the total inventory cost and order cost of spare parts as well as managing stock-outs is the aim of spare part management (Lawrenson, 1986). Backorder recovery is an important factor to manage as quickly as possible to guarantee the highest uptime possible of the vehicles. Managing spare parts for the automotive industry is an important task due to the high range of parts needed in stock to respond to the necessary availability (Boylan and Syntetos, 2008). There are three factors needed to effectively manage spare part inventories; spare part classification, demand forecasting, and inventory control (Cavalieri et al., 2008, Wahba et al., 2012), where the former have presented a framework with two additional factors; part coding and policy test and validation.

Spare parts have three phases in their lifecycle according to Fortuin and Martin (1999); the initial phase when the spare part is introduced and the demand is unknown, the normal phase where the demand pattern are foreseeable for some parts, and the final phase where the primary product is no longer produced but the spare parts are still needed (Fortuin and Martin, 1999).

Lawrenson (1986), Kennedy et al., (2002), Romeijnders et al, (2012) and more have made a distinction to the type of maintenances services. For spare parts in the automotive industry there are two types of service of interest; i) planned preventive maintenance or corrective maintenance and ii) unplanned emergency/breakdown maintenance. Preventive maintenance is done to prevent failures and can either be done based on a fixed time intervals were wear-and-tear follow certain behaviour or based on the condition of the part. For parts needed for preventive maintenance there is a possibility to predict the demand and deliver parts with efficiency. The more common the intervals or wear-and-tear the higher the demand, furthermore there is higher use of low priced spare parts and lower use of higher priced insurance spare parts. Corrective maintenance is done for scheduled repairs of parts that have failed or are close to failure. This maintenance is planned as the actions needed to respond to the failure is known and is done so in a cost efficient way. Breakdown maintenance is conducted when parts have failed and need to be fixed. Spare parts for both corrective and breakdown maintenance is hard to predict as the failures often occur randomly, as severe failure often requires higher priced spare parts, re-order levels and quantities must be limited.

3.2.1 Classification of Spare Parts

Spare part classification is a way to reduce the complexity in the ASC as it provides different categories that can be managed as a whole in a more effective way instead of managing the spare parts on a part number level (Jouni et al., 2011). Classifying spare parts aids in determining the service requirements of the parts, how much should be stocked, and the forecasting approach and methods appropriate for the parts (Boylan and Syntetos, 2008). Categorizing items according to the Pareto-principle based on price and volume is widespread and very commonly used but for spare parts with other important characteristics using more criteria for classification can be useful (Huiskonen, 2001). Cohen et al., (2006) argue that in order to have high customer satisfaction in the aftermarket sale there needs to be a match between the ASC strategy and the criticality of the customer's need for the spare part. Determining the service level of spare parts that vary a lot can be based on their classification as stated by Boylan and Syntetos (2008) by three means; criticality, by total volume or total volume of sales, or cost.

Categorization of spare parts is useful when applying the appropriate control method on an item level. The criterion to use depends on factors that are appropriate and relevant to each organization's assortment of spare parts. Fortuin and Martin (1999) identify elements including; reparability, demand intensity, purchasing lead times, price of the service part and the cost of stock keeping in order to apply the appropriate reordering method.

Huiskonen (2001) among others (Fortuin and Martin, 1999, Jouni et al., 2011) has defined some of the main factors and categories used for classifying spare parts. For the purpose of this thesis Huiskonen (2001) classification factors will be taken into consideration, applying four control related characteristics in order to categorize spare parts; criticality, value of spare parts, specificity, and demand pattern and the affect the characteristics have on elements in the logistic network and control principles.

Criticality of a spare part relates to the consequences for the process and the possible responses to control the situation should the part not be readily available when it is required. The more severe consequences if a failure occurs in the primary product the more critical the part is. Determine the criticality can be based upon several aspects, such as cost of lost uptime or the time required to respond to the failure. Control criticality is determined by factors such as the predictability of a failure occurring, the availability of spare parts, lead times. Spare parts with low criticality require no special attention but parts with high or medium criticality require fast responsive; respectively immediate or some lead time. The level of inventory can then be determined by the criticality of the part; high critical parts need higher safety stock to secure availability (Huiskonen, 2001).

Specificity of spare parts indicates whether it is a standard part or a customer-specific part. Standard spare parts are used by a wide range of customer and have high availability, shorter lead times and are stocked in many levels of the supply chain. Suppliers are often willing to cooperate with their customers as volumes are high and support economy of scale. Customer-specific parts have low volume which results in low stock levels, low support from suppliers where the customer is responsible for the availability of the parts. They are often made to order and have long lead times. High price, low volume and sporadic demand are other characteristics. The main goal is to reduce lead times and secure the control of replenishment (Huiskonen, 2001).

Demand pattern of spare parts covers the volume and predictability of the part. Spare parts often have a large number of parts that have low and irregular demand which is harder to control than parts with high volume of demand where economies of scale can be used. Low volumes of parts are not favoured by suppliers as it is often difficult to receive spare parts in low volumes at irregular times, and require a high number of safety stock to cover the volatility of the demand and the availability should be the end-customers responsibility. The predictability of demand of the spare part can be divided into two categories, parts with random failures of predictable wearing. Possibilities to predict how failure will occur can than predict the demand of certain spare parts (Huiskonen, 2001).

Value of the spare parts has an impact on the desire to stock the parts; high value parts cause actors in the supply chain rather to look for other solutions than stocking the parts. Stocking high value parts is favoured downstream in the supply chain but they are still often required to be stocked to secure availability. Low value parts have to have efficient procedure so other costs don´t exceed the cost of the spare parts (Huiskonen, 2001).

When these factors are combined the control of spare parts becomes difficult to manage as the parts require different methods and attention. The relevant control characteristics and their importance need to be identified and implemented according to each situation (Fortuin and Martin, 1999, Huiskonen, 2001).

3.3 Forecasting Demand for Spare Parts

The main characteristically differences between manufacturing supply chain and an ASC is the nature of demand; manufacturing supply chains tend to have more predictable demand that can be forecasted while ASCs have less predictable demand that is sporadic (Jones, 2001, Cohen et al., 2006), intermittent (Martin et al., 2010, Wang and Syntetos, 2011, Romeijnders et al., 2012) and often lumpy as well as when there is demand the amount can vary a lot (Martin et al., 2010, Wang and Syntetos, 2011, Romeijnders et al., 2012). This is further investigated by Martin et al. (2010) which argues that one of the main challenges in spare parts control is the demand pattern and the methods used to respond to the demand. The demand arises when parts are needed due to the need to be replaced or requires replacement (Martin et al., 2010, Romeijnders et al., 2012). Some parts have low demand, they tend to be expensive, critical and not instantly available so these parts are very difficult to control, and required a high stock investment. As the demand is uncertain, quantitative forecasting methods can be hard to manage and thus there is a need for a holistic view of the supply chain where information flow between actors are essential to gain effective planning decisions (Jones, 2001, Martin et al., 2010). Martin et al. (2010) explains that it compensates the variations in demand and risk of unavailability with high stock levels and high reordering points and quantities. The most common methods for forecasting spare parts are time series demand forecasting, such as moving average or single exponential smoothing. A common problem is that mean level of intermittent demand gets overestimated, if applied exponentially weighted after a demand occurrence (Bacchetti and Saccani, 2012).

The underlying cause of the demand is the service that is needed to be performed (Romeijnders et al., 2012). Both Wang and Syntetos (2011) and Romeijnders et al. (2012) discuss the difference in demand patterns for different type of services; preventive maintenance where arrival in time of the demand is deterministic and demand quantity is stochastic and vice versa for corrective maintenance, as the quantity of spare parts needed for corrective maintenance is most often one item. But regardless of the service type the demand for spare parts is intermittent and lumpy (Wang and Syntetos, 2011, Romeijnders et al., 2012), intermittent demand patterns significances that there are variations of time of demand occurring, the intervals and the quantity of demand; varying from none to a large size. When predicting the demand for services, a part of the demand can be certain as preventive maintenance has a stochastic demand for spare parts. For maintenance services that is unplanned there are significant consequences when stock-outs occur as the vehicle uptime is compromised with high cost in return to provide the spare parts (Wang and Syntetos, 2011).

Forecasting demand is very difficult in spare part management due to the intermittency and lumpiness of the demand (Romeijnders et al., 2012). For spare part inventories were expensive parts had to be stocked to meet instant availability forecasting the demand becomes a very important issue. By having more accurate forecasting methods it is possible to reduce safety stock levels and the cost of having parts in inventory without reducing the availability (Romeijnders et al., 2012).

Furthermore, Romeijnders et al. (2012) point out that reduction of demand of spare parts is due to either the primary product not being used anymore or that new ways of maintaining the primary product is being done instead of replacing the spare part.

Many models and tools can be used for inventory management but when controlling spare parts these methods can lose their applicability (Fortuin and Martin, 1999). Different methods are used for different products and supply chains, and the quality of forecasting can also differ. When forecasting demand for spare parts there is a need for more historical demand figures and they might be invalid or unavailable for spare parts with a certain demand patterns. It is hard to get valid historical demand of slow moving parts, and from parts that have a very short life cycle (Fortuin and Martin, 1999). What forecasting method is used, few things are always correct about forecasting; estimation of future demand will never be 100% correct, it is more difficult to forecast demand for individual products than for product sold in different packages within the supply chain, and it is more accurate to forecast for short-term than long-term time period (Christou, 2012).

3.4 Inventory Management

Supply chain inventory management focuses on the planning and control of inventory among the network as a whole. It aims to meet customer demand, improve customer service, increase product variety, and reduce costs (Giannoccaro and Pontrandolfo, 2002). A balance between high inventory cost and a cost of stock-out is important for the supply chain and inventory management focuses on avoiding the high cost associated with stock-outs, but still reducing carrying inventory cost by minimizing inventory levels (Cardamone, 1996). Meeting customer demand is also a challenge as smooth material flow and minimized cost is required. In order to overcome this challenge actors among the supply chain need to coordinate with inventory policies (Giannoccaro and Pontrandolfo, 2002)

Bacchetti and Saccani (2012) point out that some companies seem to overlook the aftermarket services and in some cases the management technique is the same as for the finished products or components used in production. Kennedy et al., (2002) argue that there are two fundamental differences with spare part and manufacturing inventories; as spare part inventories only consist of products to be directly sold to the customer there is no buffer to respond to irregularities in the production or product flow, both in terms of work-in-process and final products. Additionally, spare part inventory levels depends on the usage and maintenance of the primary product whereas manufacturing inventories aim at utilizing resources in the optimum way (Kennedy et al., 2002, Cohen et al., 2006).

Spare part inventories have the purpose to provide spare parts to keep the primary product running (Kennedy et al., 2002). As stated in section 3.2, there are two different types of services that require different measurements. Inventory levels for spare parts used for planned services are possible to schedule to be available at the time it is needed, not requiring it to be stocked in large amounts. For spare parts used for unplanned services, stock-outs are significant as it reduces the uptime of the primary product and requires quick and responsive measurements. Thus they require a safety stock level based on factors such as general management policies and obsolescence (Kennedy et al., 2002). Cardamone (1996) argues that one of the most difficult tasks faced by managers is to find the optimal inventory level of spare parts for unplanned services. It is a challenging task due to the intermittent and unpredictable demand of these spare parts.

Keeping stock that secures instant availability is essential for those who carry out services and what is kept in stock should be based on the demand forecast for the different types of spare parts (Romeijnders et al., 2012)To be able to provide aftermarket services in a responsive manner, spare parts inventories need to be available within the supply chain due to short lead times. High number of parts managed, presence of intermittent patterns, high responsiveness required due to downtime cost for by customer, and the risk of stock obsolescence makes it complex for supply chains to manage spare part inventories as summarized by Bacchetti and Saccani (2012). Having spare parts instantly available requires that low volume and expensive parts to contribute to high inventory costs (Cavalieri et al., 2008). Bacchetti and Saccani (2012) state that for slow moving spare parts small improvements in the inventory control can have significant savings in cost. The high variety of parts creates high costs in the distribution structure, costs such as tied-up capital, warehousing and stock-out costs (Jouni et al., 2011).

Fortuin and Martin (1999) identified that different control methods are used in practice for reordering of spare parts, depending on nature of the demand. For slow-moving items historical demand figures are often unavailable that can make forecasting the demand for spare parts invalid. This is also affected by the difference in number of SKUs as ASCs require approximately 15 to 20 times more than manufacturing supply chains (Cohen et al., 2006)The SKU's do not all have the same demand so categorization of the different spare parts is necessary to optimize the balance between availability and cost in the ASC. Categorization of spare parts is useful in order to apply the appropriate control method on an item level. The criteria to use depends on factors that are appropriate and relevant to each organization's' assortment of spare parts. Fortuin and Martin (1999) identify elements including; reparability, demand intensity, purchasing lead times, price of the service part and the cost of stock keeping in order to apply the appropriate reordering method.

3.5 Distribution Networks in the Aftermarket Supply Chain

As the aftermarket performs a major role within the automotive industry, the design of the ASC is highly valued. The design of the ASC is depending on crucial factors such as; product characteristics, aftermarket strategy, service characteristics, and the distribution supply chain (Saccani et al., 2007). Aftermarket services can be described as a network of repairs and inventory facilities that serve local and regional customer demand (Cohen and Lee, 1990). Cohen and Lee (1990) conclude that there are five main management policies that should be included for effective spare parts management: Network Stocking Policies which manage what part should be kept where, Implications for the Design of the Logistics System with regards to fixed cost at facilities and responsiveness of inventories, Service Management which includes segmentation of parts, Data and Parameter Analysis that concerns forecasting, and Control System Implementation which contributes to data and information systems.

3.5.1 Responsive Spare Part Management

Management of an organization needs to build their strategy based on how they can respond to the demand of their products, thus product life-cycle, variety of the products, demand predictability, and standards for lead time and service are crucial (Fisher, 1997). Fisher (1997) argues that there is often a mismatch between products and their supply chain. Products can be categorized in two ways with regards to demand; functional products and innovative products.

If a product is innovative with unpredictable demand there is a need for responsive supply chain, but if a product is functional with a predictable demand it should belong to efficient supply chain (Fisher, 1997). For functional products with a predictable demand the gap between demand and supply can be really small. Ordering, production, and delivery of supplies can be planned in a very efficient way with employ manufacturing-resource-planning software and usually results in low inventory and high production efficiency (Fisher, 1997). This is not how it works for innovative products with unpredictable demand. It is important for these products to use new historical data when forecasting to be able to react quickly to the customer demand with regards to the product short life-cycle (Fisher, 1997). Information flow is thus crucial for responsive supply chains, not only between actors within the supply chain but also from customers. de Leeuw and Beekman (2008) argue that spare part supply chains can be characterized as responsive supply chains as the main focus is on high availability, and effective and responsive actions to customer demand. Fisher (1997) describes ways to manage uncertainty in demand, such as; reduce uncertainty or avoid uncertainty. Reducing uncertainty can be done with new technology and data system that can serve as leading indicator in order to gain more predictable demand. Avoiding uncertainty often includes reduction of lead time and higher flexibility in order to have the parts near the customer.

3.5.2 Distribution Structure

There are different structures of supply chains. Saccani et al. (2007) describe centralization activities where the most common is to centralize inventories or warehouses. There can be many reasons why companies decide to have warehouses centralized but the main reasons is cost savings, by reducing numbers of locations and reducing inventory stocks. Direct deliveries from a central warehouse to customers will result in higher customer service and reduction of distribution cost (Abrahamsson, 1993). Location of warehouses are mainly decided by three factors; distribution cost, road transportation connection, and proximity of assembly and manufacturing units (Hilmola and Lorentz, 2011). Warehouses should therefore be located where the profit can be maximized and where it can react rapidly to customers demand. Abrahamsson (1993) argues that numbers and locations of warehouses are mainly related to materials flow, and the total cost of physical distribution, including inventory cost, warehousing cost, transportation cost and the cost of lost sales. Furthermore, the location should be depending on customers need. If the location of warehouses are too far away from the customer, it might increase the amount of lost sales, thus the lead time is essential to respond quickly to customer demand.

Cohen et al. (2000) point out that companies can align their service strategy based on the criticality of their spare parts. Criticality of part is defined as how urgent it is for the customer to get the part. If the criticality of parts is high the company should have decentralized supply chains but when the needs for parts are usually not urgent it is more efficient to have centralized supply chains. It is very important for companies to understand the criticality of their parts in order to increase the uptime of the product and increase customer satisfaction (Cohen et al., 2000). Centralized distribution structure results in comparable low inventory and warehousing cost, high transportation cost, and high cost of lost sales (Abrahamsson, 1993). However, Abrahamsson (1993) compared three different companies and the impact on their performance by centralizing their distribution centres. With centralization the companies were able to reduce their inventory level, tied-up capital cost, distribution cost, average lead time to customers, number of operators in warehouses, and increased their delivery performance. It was expected that transportation cost would increase in line with reduction of warehouses, but it did not appear in these three cases.

Lead times within supply chains are important to measure for the organization to set goals and a great source for competitive benefits as it affects the customer satisfaction (Cohen et al., 2006). Reducing lead times is challenging for supply chains and there are different opinions on how to reduce it. Abrahamsson (1993) argues that by providing direct distribution from central warehouses instead of decentralized companies can gain shorter and more reliable lead times as it provides higher availability, and smoother and efficient material handling. However, as Abrahamsson (1993) states that if customers require low lead time it is beneficial to have decentralized distribution which is located near to the customer.

3.6 Performance Measurements

Supply chain management is important for organizations and the management of the performance of the supply chain is as important (Bhagwat and Sharma, 2007, de Leeuw and Beekman, 2008). It gives information about how well the supply chain is performing according to internal goals, such as meeting customer expectations and other strategic objectives (Chan, 2003). de Leeuw and Beekman (2008) argue that there is not enough to qualitatively evaluate how well the supply chain is performing but a quantitative measurements are necessary. Measurements should include a balanced approach between all levels within the supply chain, as well as the measurements goals. The measurements give feedback on where in the supply chain there are areas with unacceptable performance and thus give information about potential improvements (Bhagwat and Sharma, 2007, Chae, 2009). Effective performance measurements enable organizations to identify their current practice to benchmark with future goals (Anand and Grover, 2015). Anand and Grover (2015) state main reasons for measuring the performance of a supply chain, such as growing competition among supply chains, various development incentives, shifting organizational responsibilities, and fluctuating external demand.

Many actors are involved within a supply chain and the performance of one actor can affect the performance of another. When selecting performance measurements for a supply chain it is important to focus on the supply chain as a whole (de Leeuw and Beekman, 2008). The most important factor is to implement performance measurement by identify key performance indicators (KPIs). KPIs provide a visual approach of the supply chain and make it easier to evaluate supply and demand forecast, and sales plan. It is also crucial in order to analyse and confess the viability towards realization of objectives and improvement of SC strategies (Anand and Grover, 2015).

3.6.1 Important KPI´s

It is a challenge for many companies to choose reasonable KPIs and numbers of KPIs, but high numbers of KPIs is not always beneficial. It is preferred to have fewer numbers of KPIs in a hierarchical organization and performance indicators (PIs) to support them (Chae, 2009). In responsive supply chain the main goal is to have the right products at the right place on the right time. KPIs for responsive supply chains are thus not necessarily the same as for effective supply chains (Anand and Grover, 2015). The ASCs are examples of responsive supply chains (de Leeuw and Beekman, 2008). In the aftermarket the customers' need can vary, Cohen et al. (2006) argue that they key behind having a high performance in the aftermarket is to have a supply strategy that matches the urgency, or criticality, of the customers need. It is as important to have the same strategy throughout the supply chain and a tight coordination between every actor. de Leeuw and Beekman (2008) state that in an automotive spare parts supply chains non-financial performance measures are crucial. Common KPIs within responsive supply chain are the following:

Sources within the supply chain play important role when it comes to supply chain performance. Supply chains need to work on optimizing the total cost and make sure that they have the right set of workforce (Anand and Grover, 2015). The performance of the sources in the upstream of the supply chain is even more important than for those in the downstream because there is increasing demand for more customer-oriented supply chain (Chae, 2009). KPIs related to suppliers are often important for the supply chain as a whole. It concerns the suppliers lead time and fill rate which affects the availability and overall lead time of the supply chain. The material quality is also important as it relates to the quality of the final product.

Transport is also an important parameter that concerns the supply chain performance. Reliable deliveries are a key aspect with regards to customer satisfaction (de Leeuw and Beekman, 2008, Chae, 2009). Anand and Grover (2015) argue that more PIs with regards to transport affect customer satisfaction such as delivery speed, delivery dependability, and delivery flexibility. This is challenging for global supply chains since deliveries cover a long destination, it is thus very important to have PIs to support KPIs deliveries (Chae, 2009). The transport KPI can be supported with other PIs, with regards to time related, frequency related, and capacity related. Transportation is an important KPI when it comes to integrating actors among the supply chain as the transportation is usually performed between actors (Anand and Grover, 2015).

Inventory is essential for supply chain performance and this applies to every location of an inventory within the supply chain. Indicators within inventories can be related to cost, time, quantity, and service (Anand and Grover, 2015). These can be further supported with behaviour, inventory turnover, the number of inventory days, and the forecasting quality. Inventory turn rate, cycle time, and stock-outs are also important performance indicators that concerns the inventory (de Leeuw and Beekman, 2008)

Availability is a crucial performance indicator for a responsive supply chain and very important for customer satisfaction (Cohen et al., 2006, de Leeuw and Beekman, 2008). The main characteristic of ASCs in the automotive industry is a short turnaround time of service activities. Therefore the availability is even more crucial KPI, both for off-the-shelf availability, and transport. Cohen et al. (2006) points out that within a supply chain where actors share responsibility, such as manufacturer and retailer, it is important to have a performance measures that supports rights behaviour and decisions. One PI is off-the-shelf part availability which is measured at the retailer but is used as a performance metric for service delivery. The main supporting indicators for availability are forecasting quality, ordering quality, replenishment quality, and the availability at supporting distribution centre (Corsten and Gruen, 2003). High availability of spare parts increases customer satisfaction (Cohen et al., 2006). Furthermore, Corsten and Gruen (2003) argue that if a part is not available for the end customer it will result in lost a sale. It is thus important in the automotive industry to have spare parts on stock when it is needed for service and that the product is repaired correctly the first time (Corsten and Gruen, 2003).

3.7 Preventive Service Activities

As the aftermarket has been increasing and becoming equal or more important as the physical products, services within the aftermarket provide competitive advantages for manufacturing industries (Brax and Jonsson, 2009). Maintenance services are important aftermarket solution in the automotive industry and can be divided in four categories (Tsang, 2002); run-to failure, preventive maintenance, condition-based maintenance, and design improvement. The latter two focus on cost-effective activities as it is depending on “just in time” instead of “just in case” (Brax and Jonsson, 2009). These categories use technologies to optimize the preventive activities instead of using direct information from customer for predictive maintenance. In the automotive industry it is challenging to plan predictive maintenance as the vehicles brake down and need services at unpredictable times. Thus the change from predictive to preventive activities in order to plan the maintenance service and have all parts needed for the service available.

Supply chains have been focusing mostly on supply-focused approach which pushes products downstream the supply chain based on forecast instead of making the customer demand pull it (Christopher and Ryals, 2014). Christopher and Ryals (2014) argue that there is a need for demand chain management that provides lower inventory levels and faster customer response. Demand chains provides reduction both in waste and obsolescence (Christopher and Ryals, 2014) and competitiveness can be enhanced since the focus is more on the customer value at lower cost and higher responsibility (Hilletofth, 2011)Within demand supply chains, organizations only produce when there is a demand, but a prerequisite are organizational competences, IT support, great information flow and collaboration among the supply chain (Hilletofth, 2011, Christopher and Ryals, 2014). This is a difficult task within industries that have unpredictable demand, but new technology such as remote diagnostics is a competitive solution as it gives signal when a product needs a service (Brax and Jonsson, 2009).

There are different flows within a supply chain and they can be divided in pull and push based supply chains. When products have a product schedule they are often pushed through the supply chain where there is often a need for high inventory levels. Product flow can also be pulled based on a customer demand. In this kinds of supply chains there is a need for flexibility and responses to customer demand changes (Lambert and Cooper, 2000).

4 Empirical Findings

This chapter is dedicated to give a description of the current situation at Volvo Group. First an introduction of Volvo Group's organization is provided to enhance the understanding of the nature of the studies system. An explanation of the ASC set-up is provided to create an understanding of the current situation of the spare part control; this includes a description of actors and the links between them as well as the general control practices within them. The current planning practices and conditions will be presented. Lastly a description of the practices and performance of the company used for the benchmarking study is provided.

Material in this chapter has been gathered through interviews, observations, informal discussions, and internal documentation from Volvo Group's intranet homepage unless otherwise stated.

4.1 Introduction to the Volvo Group

Volvo Group is one of the world´s leading manufacturers of commercial vehicles and engines (Volvo Group, 2015a). Volvo Group is a part of AB Volvo founded in 1927 as a subsidiary of AB SKF, the Swedish ball bearing manufacturer. The company started as a car manufacturer but over the years it developed into the Volvo Group now known through mergers and acquisitions as well as joint ventures. Today Volvo Group includes various brands of heavy-duty commercial vehicles and engines as well as the company offers financial services for their customers. The core products of the company is Volvo Group Trucks which encompasses besides the Volvo brand; Renault, UD, Mack and joint ventures with Eicher and recently Dongfeng. Majority of the company's revenue is generated from Volvo Group Trucks (Volvo Group, 2015b). A part from trucks the product range from Volvo Group includes busses, construction equipment and engines from Volvo Penta, a complete list of brands within the Volvo Group is presented in Figure 2 . Included in the product range are services, aftermarket and extended offers.

Figure 2: The Volvo Groups' brands.

Volvo Group´s organizational structure reflects the focus on the core product, as truck operations present two-thirds of the company's turnover it is organized accordingly (Volvo Group, 2015b, Volvo Group, 2015e). There are five divisions generated by truck operations and three divisions covering other business areas, for the aftermarket all brands and business areas are covered by the Group Truck Operations division, Figure 3.

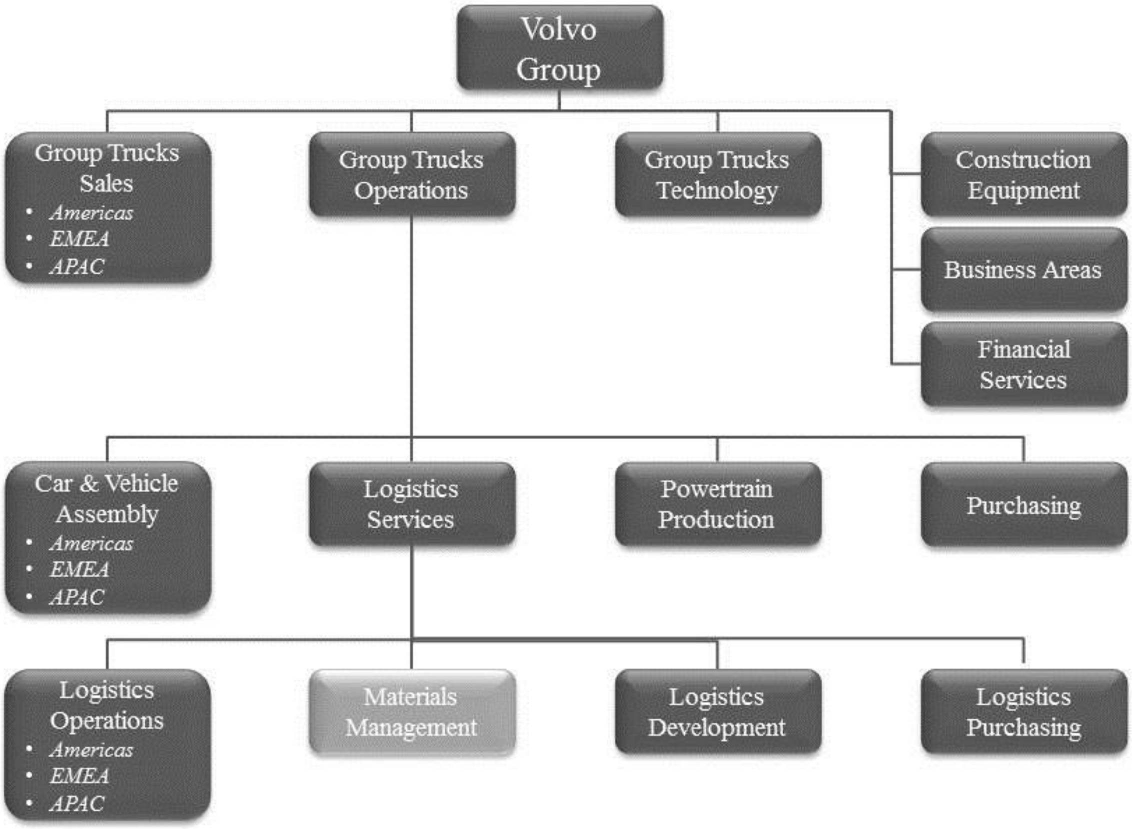

Figure 3: Simplified version of the division of departments in Volvo Group.

Group Trucks Sales has the global responsibility for sales and marketing activities for all truck brands as well as the joint venture relationship between the Volvo Group and Eicher Motors Limited. The responsibility for sales and marketing is organized into three geographical regions, each considered as their own division; Americas, EMEA (Europe, Middle East and Africa), and APAC (Asia and the Pacific region). This is the pattern throughout the organization.

Group Trucks Technology is responsible for research and product development of complete vehicles, powertrain, components and service offering.

Construction Equipment manufactures a number of different types of equipment for construction applications and related industries under the brands Volvo and SDLG.

Business Areas encompasses Volvo Penta; engines and drive systems for leisure and commercial boats and industrial applications, Busses; city and intercity buses, coaches and chassis, and Governmental Sales; sales to government agencies and organizations.

Financial Services that delivers competitive financial solutions which strengthen long-term relationships with Volvo Group dealers and customers.

Group Trucks Operations is responsible for truck manufacturing within Volvo Group. It includes all production of Volvo, Renault, Mack and UD trucks as well as engines and transmissions for Volvo Group. Volvo GTO also includes logistics and aftermarket supplies to the Group´s customers. Group Trucks Operations is also responsible for purchasing.

Aftermarket control belongs to Logistics Services (LS) within Volvo GTO, LS is responsible of the design, handle, and optimization of the supply chain network. Materials Management (MM), which is a part of LS, manages all Volvo Group brands aftermarket from suppliers to dealers via the warehouse structure to ensure that the right customer service is balanced with inventory and cost levels. MM contributes to Volvo Group´s vision; "to become the world leader in sustainable transport solutions" (Volvo Group, 2015c), by focusing on operational activities that improve uptime of vehicles and reduce logistics cost, tied-up capital, and lead time.

4.2 Current State of the Aftermarket Supply Chain

The Volvo Group is a process oriented company that sees process management as a tool to govern and continuously improve the business by designing and developing common processes within the company. All flows within the ASC follow certain processes and all employees are trained according to processes in how to efficiently add maximum value in their daily work. Process management aims at a better structure of how the work is done, strong culture of customer satisfaction, and teamwork. In order to manage the processes, Volvo Group is driven by Process Manager and Process Forums, and decisions are taken by the Process Owners. On the first level are the main processes that cover all divisions at Volvo Group; Develop product and aftermarket product, Market and sell total offer, Produce and distribute products (PDR), and deliver and develop customer loyalty (DCL) and their supporting and sub-processes. The ASC control belongs to a sub-process of PDR, Plan Material Parts; that supports parts availability at dealers to fulfil customer needs in a cost-cash-availability balance. Thus the study is directly conducted from PDR processes to support the outcome of DCL. The Plan Material process consists of five main processes; Demand Planning and Life Cycle Management that deals with various parameters to control planning and its optimization, Dealer Inventory Management that handles orders from dealers, Refill Management that replenishes orders within the distribution centres, Backorder Handling that manages day orders from distribution centres to dealers, and Supply Planning that manages replenishment of parts to distribution centres from suppliers.

The ASC is a network from suppliers of spare parts and to the dealers, who service the end-customers, through the distribution structure in between, Figure 4. In the global network for the Volvo Group there are approximately 5000 suppliers in the network, 80 distribution centres and 3000 dealers, both independent and dependent. The studied system includes distribution centres and dealers.

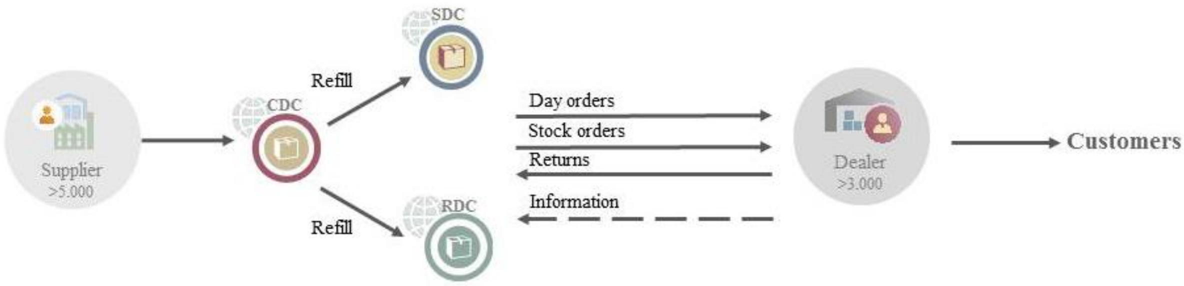

Figure 4: The aftermarket supply chain at the Volvo Group.

The flows between actors in the ASC are to replenishment the orders and the information to manage replenishment orders. The material flow mainly goes upstream from suppliers, through the distribution structure and dealers, to the end-customers, but also downstream from dealers to distribution centres in the case of returns of parts. The information flow used is real historical sales data from dealers to the management of material in warehouses to the suppliers. The scope of the thesis includes the CDCs and the dealers with the flows between. As there are no regional distribution centres in the Nordic market they are excluded from the studied system.

Distribution structure and flow between distribution centres and dealers

The distribution centres (DCs) in the ASC are in a decentralized distribution structure. Placement of the DCs are based on optimization of cost and lead time; including the cost of each warehouse, cost of inbound and outbound transport, distance from dealers and other DCs and the current and forecasted sales from dealers. There are six central distribution centres (CDC) located around the world. The CDCs offer full range of parts as they receive products from suppliers and act as a link between suppliers, the other types of distribution centres and dealers. All CDCs get the spare parts from suppliers and the CDCs refill the two other types of DCs; regional distribution centres (RDC) and support distribution centres (SDC). The RDCs are located in areas where there CDCs have a longer lead time than required to deliver spare parts and in some geographical areas they even take the role of a CDC. The role of RDCs is to supply dealers with orders to refill their stock as well as providing parts that are not available at the stock. SDCs have the sole purpose of supplying dealers with parts that have to be delivered due to not being available at the dealer stock; these supplies are defined as day-orders. There are two processes that manage flow within the distribution structure and the balance in performance for the distribution structure.

Refill Management manages the flow of material within the distribution centre network with focus on lowering transportation costs and shortens lead time to end-customer. Refill orders are mainly between CDCs and RDCs or SDCs.

Demand Planning and Life Cycle Management plans the overall material flow of spare parts from CDCs to dealers. Planning the overall material flow is important to achieve the right customer service with the right amount of inventory and cost. Furthermore it prepares the ASC for changes in demand pattern, by using historical sales data from and long term forecast to predict the demand. Inventory levels are optimized on a high level where the safety stock and EOQ are balanced with availability and stocking destocking parameters. Every part is optimized according to current stock holding policy at the DC. Usage of SAP is widespread in stock level control, the program uses various forecasting methods to predict demand of a spare part and the method that is most suitable is chosen.

4.2.1 Inventory Management at DCs

The inventory control principles at the DCs are based upon segmentation of parts according to the price of the spare part and order frequency, i.e. how often a certain spare part is requested by the end-customer. In principle it means that the lower the price of a part and the higher frequency the higher service level and inventory level the part has. Inventory management is therefore optimized based on the spare part characteristics. In some DCs the control is also based on a life cycle approach and the segmented stock holding policy also differentiates the stock in inventory depending on where the product is in the life cycle, Figure 5. Some brands within Volvo Group´s ASC have the same theory of stocking policies but different parameters for segmentation are used depending on the characteristics of the brand.

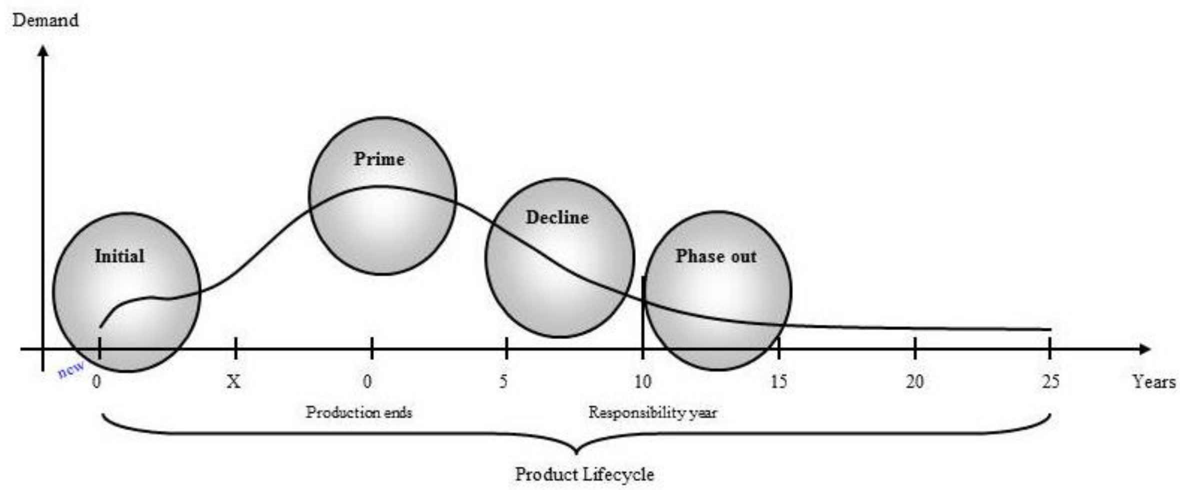

Figure 5: Four phases in a life cycle of a products, based on demand and years.

In the segmented stock holding policy the demand for spare parts is analysed and depending on in which phase of the life cycle the main product is, each phase representing different place in time. This optimizes the control of inventory over the whole lifecycle and supports reduction of inventory where applicable. The four phases are; initial phase where a part is born and introduced, prime phase where the part has a steady turnover, the decline phase where demand is dropping and a phase out where the part has exceeded the responsibility year (RY). Combining the life cycle approach with the basic control practices provides a segmented stock holding policy, Figure 6

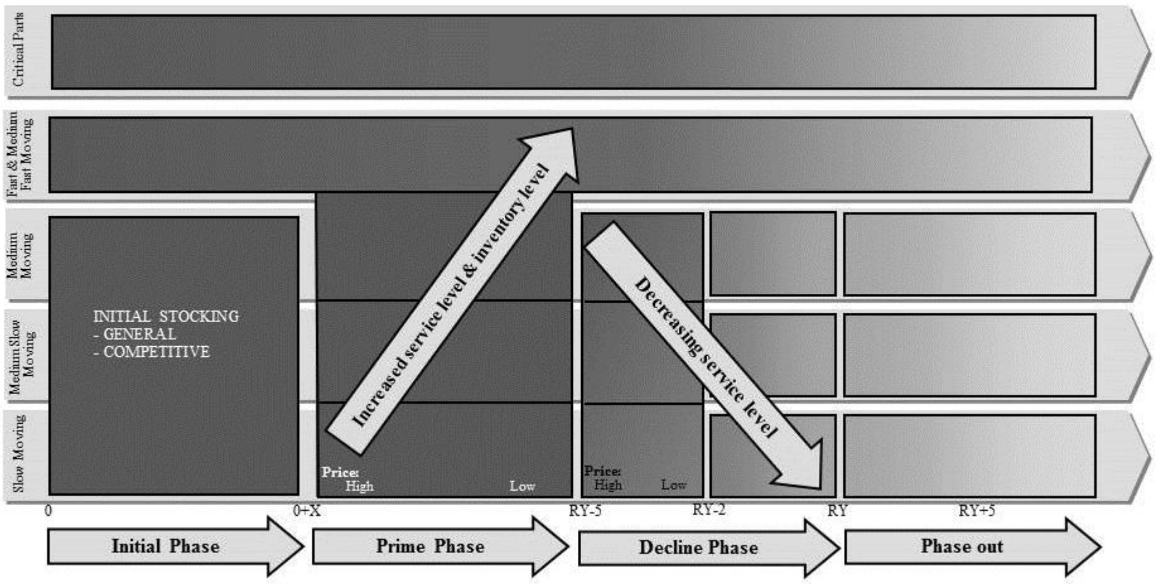

Figure 6: Segmented stock holding policy of spare parts.

The initial phase of a spare part is when a new primary product is launched on the market. In this phase the initial stocking process is central. In the initial phase, fast and medium fast moving spare parts are kept on stock in a high level. For medium to slow moving parts there is an initial stocking where level of stock of the parts is dependent if it is a general item or a competitive item. In the initial phase the part criticality is determined according to certain qualitative assessment, or general knowledge of the criticality of the parts. Critical parts follow a specific stock holding policy that differs from the other policy as it is not mainly based on price and frequency. There are different levels of criticality that are set.

The prime phase is the phase where the demand of spare parts is at the highest and end of production activities are often included in the prime phase. The demand increases after the initial phase due to the primary products being well established and requiring maintenance services. In this phase high service levels are critical. In the prime phase and into the decline phase the stock holding policies for all spare parts excluding critical parts are dependent both on the price and frequency. The prime phase has an increased service level and inventory level dependent on the price and frequency of ordering of the spare part, basically the lower the price of a part and the higher frequency the higher availability target is set.

When demand drops there is a *decline phase* of the spare parts. The focus is shifted from high availability and service levels to reduction of inventory levels, due to costs and the risk of parts becoming obsolete. The reduction of inventory levels includes the consolidation of spare parts towards the CDC. In the declining phase, the fast and medium fast parts keep the same service levels and inventory levels as in the prime phase but for medium to slow moving parts there are a decreasing service level. In the RY-5 until RY-2 the stock holding levels are dependent on price but after RY-2 there is no difference made between an expensive or inexpensive part.

The phase out phase occurs when the part has past the RY and doesn't have to be available through regular means. There is a reduction in inventory and service levels of the parts. Parts are consolidated to CDC or are available through a make to order process. In the phase out period, after the responsibility years there is a significant decrease in service levels and possibly no service for slow moving parts.

Depending on the order frequency a part is stocked or not after the RY of the part. Fast moving parts are stocked the whole life cycle but service and availability level depends on the price of the part. For medium and slow moving parts the reduction in service level and inventory occurs after the prime phase and in the phase out phase those parts do not have a set availability target.

Within each phase there are several segments, Table 2. The segments are categories by how frequent they are needed, except for spare parts in the initial phase and critical spare parts that are based on other criteria. The price of the spare parts also determine the segment, the higher the number within the order frequency the higher the price; as an example in segments EA-EE, EA has the lowest price and EE the highest price of spare parts.

Table 2: The categorization of spare parts segments.

Segments	Initial phase	Prime phase	Decline phase	Phase out phase
Initial parts	0C			
Critical parts	AA-AI	AA-AI	AJ-AK	AL
	BA-BI	BA-BI	BJ-BK	BL
	CA-CI	CA-CI	CK-CK	CL
	DA-DI	DA-DI	DJ-DK	DL
Fast Moving		EA-EE	EA-EE	EA-EE
Medium-Fast Moving		EF-EJ	EF-EJ	EF-EJ
Medium Moving		EK-EO	FA-FC	GA
			FM	GX
Medium-Slow Moving		EP-ET	FD-FF	GB
			FN	GX
Slow Moving		EU-EZ	FG-FI	GC
			FO	GX

4.2.2 Dealers and the Flow from Distribution Centres

Inventory levels at dealers and DCs differ both in the amount of part numbers as well as the required availability, both in general and for each part number. At the dealers the most common spare parts are kept in stock, mainly fast and medium fast moving spare parts as well as critical spare part segments, supporting the majority of the spare part required from the end-customer. The availability of spare parts needs to be high as instant availability is required by the end-customer. Downstream, at the DCs the amount of spare parts increases and at CDCs almost a full range of spare part is kept on stock. The further downstream the ASC the less amount of parts is available to instantly deliver the spare parts to dealers, but in order to be able to deliver spare parts next day the availability of the parts has to be relatively high or a backorder needs to be created.

Dealer Inventory Management (DIM) is a process that secures local availability at dealers, the aftermarket business, and supports customer satisfaction and uptime. The process makes sure that the supply chain is fed with high degree of accurate sales data that results in low administration and workload, and high profitability on all levels. It secures availability of spare parts and thus gives business possibilities. The process monitors the end-customer demand in order to supply parts in the most cost efficient way and keep high service level at the same time. The process is mainly divided in three corner stones:

Customer service: Each individual dealer has an agreement with the Volvo Group, where the responsibility of each actor is stated. Furthermore, they have regular buybacks where the buybacks of obsolete stock are performed for each dealer to secure a healthy stock, and dead stock is exchanged to more saleable parts.

Distribution costs: DIM offers automatic refill to their dealer’s stock. That means that parts are automatically filled based on forecast from each dealer’s individual sales history. It ensures that needed parts are in correct quantity at the right time in dealer’s warehouse. Moreover, stock holding policy and refill parameters are set to secure a high customer service, balancing distribution and capital cost.

Capital costs: Performance indicators such as service index, turnover rate, healthy stock, and automatic share of stock are followed by DIM for each dealer. Performance is then secured both by optimized parameter setting and by extensive dealer coaching in each market.

Backorder Recovery is the process that aims at recovering customer orders that have not been fulfilled by alternative ways than through the DIM process. There are three types of backorders; *regular backorders* that are ordered to replenish the stock at the dealer as a stock order, *urgent backorders* that are either stock replenishment orders or day orders placed by dealers, and *emergency backorders* that are orders of critical parts necessary for the function and usage of the customers vehicle that need to be available at the dealer as soon as possible. There are various reasons for parts being backordered, where the most common ones include; missing purchasing orders, late deliveries, poor forecast accuracy, or that the parts is no longer supplied.

4.2.3 The Part Flow between Volvo GTO and Dealers

The flow of spare parts to dealers can be divided into two categories; stock orders and day orders. Stock orders are orders that replenish the stock at dealer warehouses according to re-order points and safety stock levels. Day orders are orders made for parts that are not available at the dealer stock when the end-customer requires them. There are several distinguishing characteristics of the two order types. Parts are ordered as stock orders to ensure availability at the dealers in a cost efficient way. Volvo GTO manages dealers’ inventories with the dealer inventory management (DIM) concept. The majority of dealers in the Volvo Group’s network are a part of the DIM concept which includes an agreement stating the responsibilities of each party. By analysing the flow from dealers to end-customers it is possible for DIM to use real historical sales data in order to manage the flows between distribution centres to the dealer inventory. With this type of an agreement the stock orders can be automatically ordered when the stock level at the dealer for a spare part is below the re-order point. The parts are thus automatically refilled based upon each dealer's sales history and provided in the correct quantity at the right time at the optimum cost to the dealer stock. The stock holding policy and refill parameters are set to secure a high customer service, with a balance between distribution and capital cost. Some parts have to be manually ordered. All stock orders from dealers are based on forecasted demand and are replenished from CDCs and in some occasions from RDCs. For stock orders the critical factor is to ensure the lowest possible logistics cost for Volvo GTO to get the spare parts to the dealer.

Stock orders are delivered to dealers from CDC via supporting warehouse. Full truckloads containing stock orders and refill orders to SDCs depart every day from the CDC. The SDC is also used to consolidate parts and orders, for all deliveries from the CDC to the Nordic market. Pick and pack at the CDC is around 3-4 days, transport lead time from the CDC to the SDC in the Nordic market is one day, resulting in a lead time of approximately 10 days for stock orders. From the SDC to the dealers spare parts are delivered by truck but for dealers located very far away air transport is used. When a part is not in stock in the dealer warehouse when the customer requests it, the part can be ordered as a day order which is done manually by the dealers. Day orders are sent to dealers from any one of the three types of distribution centres, depending on the availability in the distribution centre and the delivery lead time, which is the main criterion for day orders. Day orders from the CDC are delivered by air but occasionally shipments are put on truck transport if their condition (e.g. weight) is not suitable for air freight. This is only a very small fraction of the total supply of spare parts to the dealers but accounts for half of the total transportation cost.

4.3 Current Planning at Dealers

The current aftermarket demand is mainly planned with planning methods such as forecasting to predict customer demand. The common spare part planning process is presented in Figure 7.

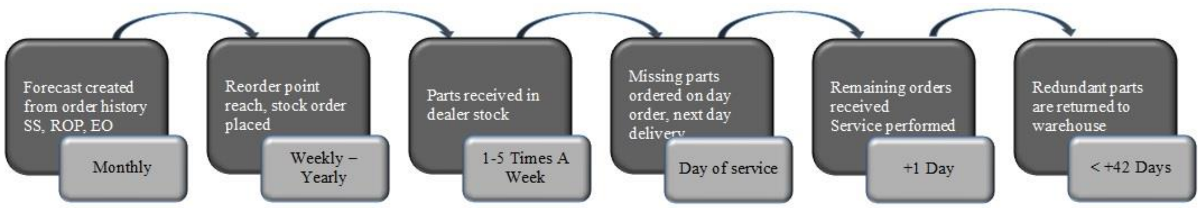

Figure 7: Current spare part process at dealers.

Forecasts are created from order history where safety stock, reorder point and economical order quantity is calculated monthly. Stock orders, orders to replenish the dealer stock according to reorder points, can be placed daily and are delivered from CDCs to the dealers 1-5 times per week depending on the dealer. Day orders are made when certain parts are not available at the dealers' stocks and are needed for a service. Day orders can be ordered every day by the dealers, the cut off time is before closing time where the part is delivered the next morning and for some dealers there is another one before lunch with a delivery of the parts in the afternoon depending on the location of the dealer. For the dealers there is no difference in cost for parts ordered via stock orders or day orders but for Volvo GTO day orders are comparable expensive, since they are sent from the DCs with an estimated delivery within 24 hours. After the service has taken place the customer is invoiced and within 42 days any excess parts can be returned to the CDCs.

Pre-planning is another planning method for spare parts requirement where an order for spare part for a scheduled service is placed at least 14 days in advance. Pre-planning requires the dealer to plan services activities for the customer in order to have spare parts available that are needed when a service takes place. The pre-planning ordering method is illustrated in Figure 8.

Figure 8: Pre-planning process at dealers.

Maintenance or a repair service is scheduled by a maintenance schedule that determines the part needed for the service two weeks in advance. This is initiated either by the dealer who sends an invitation to the customer to show up within two weeks for a service or by the customer requiring services. The distribution channels differ as the transportation time is not the same from DCs to each dealer. Due to that, the minimum time that is needed for the distribution centres is 14 days' notice from the dealers to a CDC regarding when a particular spare part is requested. Ten working days before the service date, spare parts are reserved at the stock and if a part is not available it can be ordered and delivered before the customer comes in for a service. If the needed spare parts are not available on stock, GDS creates and sends an order for outstanding parts. When the dealer has initiated the service the customer is contacted a few days in advance from the scheduled service visit to gain information for any additional work that needs to be done for the truck so that any additional spare parts can be ordered as well. Within one and three days before the planned service date the parts are pre-picked to ensure that the dealer has the right parts for the service. When the customer comes for service, on the planned service date, spare parts that are needed are available at the workshop. After the service an invoice is made and sent to the customer.

The purpose of the planning processes is to support pre-planned activities. At the dealers there are three different workshop processes, where two processes are used when planning service visits; workshop initiated maintenance offer and customer initiated maintenance/repair, and the third one; customer initiated parts request.

Effective pre-planning is a foundation for detailed workshop planning and will increase the uptime of the trucks. It increases both the possibilities of repairing right at the first time, workshop capacity, and the availability of spare parts.

4.4 Performance Indicators in the Aftermarket Supply Chain

MM influences and supports the company's goals by measuring and following the performance of the processes within the aftermarket spare part flow. The KPIs that MM has full responsibility over cover availability and cost aspects in the ASC. The KPIs are placed in different nodes in the ASC and are supported by PIs and other parameters. KPIs are measured at suppliers, distribution centres, and at dealers. PIs and other supporting factors are also related to transportation and the end customer. The KPIs and supporting indicators are following:

Aftermarket Supplier Delivery Precision measures the capability of the suppliers to deliver parts the right way and on the right time. The main parameters that drive the Supplier Delivery Performance are production-, transport-, and inbound-lead-time, right amount of parts, and forecast accuracy.

Aftermarket Parts Backorder Recovery takes place at the distribution centres. It measures the capacity of logistics services to solve backorders at CDC, RDC, and SDC, when a part is not available at dealers. There are two KPIs that support the Aftermarket Parts Backorder Recovery; these are Supplier delivery Precision, and Parts Availability. Other drivers are forecast accuracy, and lead time performance of; transportation, production and inbound the distribution centres.

Aftermarket Parts Availability takes place at the distribution centres. It measures the capacity of logistics services to fulfil the customer (dealer) demand, both in CDC, RDC, and SDC. There are the same indicators that drive the Parts Availability and the Parts Backorder Recovery, including a planning factor that drives the transport lead-time performance

Aftermarket Dealer Service Index (DSI) takes place at the dealer. It measures dealer's stock capacity to serve parts to the end-customer according to weekly forecast of sales. The higher the service index, the higher delivery capacity there is to the customers. DSI is supported by parts availability, behaviour, and lead-time performance indicators.

4.5 Pre-planning concept at Volvo Cars Sverige AB

Pre-planning spare parts in the automotive industry is an established strategy and has shown to have increased the performance of the ASC at Volvo Cars Sverige AB (VCS). Around 1990 VCS started working with Local Distribution Centre (LDC) concept. By implementing the LDC concept the company has changed work processes and increased performance with:

- More favourable business conditions for dealers.
- Optimized work processes.
- Integrated system solutions.
- More frequent deliveries to the dealers.
- Full right of return, with some exceptions.
- Lower inventory value at the dealer as the stock is shifted downstream the supply chain.
- Higher availability of spare parts.
- Less environmental impact with less direct transport.
- Less obsolescence as all spare parts are assigned to a specific order.
- Stock/handling cost moved from the dealer to VCSs, giving the dealer the chance to increase sales through better services, higher availability of spare parts, more efficient work processes and reduced personnel.

Description of the spare part control practices

The increasing amount and variety of models as well as more options arriving in the market resulted in a need for a new way to manage spare parts. This increase in variety of spare parts, more expensive parts, and more demanding customers resulted in high tied-up capital cost at dealers. VCS needed to decide if they were going to; i) keep high stock level at dealers that would need great financial investment of parts and creating more risk of obsolete parts and increased handling of parts, ii) do nothing and likely decrease customer satisfaction, iii) or implement a concept that could respond to the changing spare part environment. The LDC concept is based on the idea that all dealers have a LDC that provides spare parts for the dealers and manages refill of the dealers' stock.

The process of the dealers' spare part requirements and replenishments is that work orders are produced, where pre-planned workshop orders receive spare parts automatically from the LDC but emergency workshop orders and over the counter sales have the spare parts either delivered from the LDC (rush orders for emergency workshop orders) or taken from the dealer warehouse if it is available on stock. It is up to the dealers to decide whether the spare parts are ordered as a pre-planned orders or rush orders. If the part is not available in the LDC it is ordered at the CDC, delivered overnight to the LDC and then shipped to the dealer to perform the service, Figure 9.

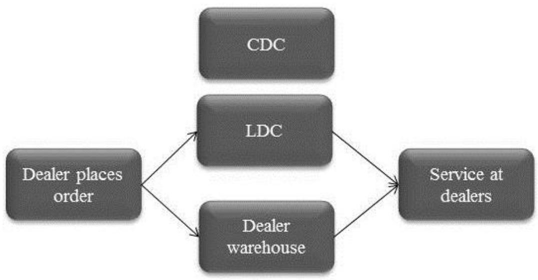

Figure 9: Spare part flow to dealers at VCS.

In order to get the part supplied from an LDC one day is required but for orders that have to be supplied from the CDC a minimum of two days pre-planning in advance is needed. The stock at the dealer warehouse is automatically refilled, and the dealer only places pre-planned orders and rush orders. Deliveries are made to the dealer two or three times per day; morning, afternoon, and night, depending on the distance to the LDC. It is also possible to get rush orders, then the order is sent at the next available cut off time. Rush orders are day orders; e.g. if a car needs something extra done for it than was determined before with pre-planning. For VOR (vehicle of road) there can be other means of delivery in order to get the part as soon as possible to the dealer. All spare parts are ordered via the LDCs. This applies both for workshop orders and over the counter sales and whether it being a pre-planned order or rush order. The LDC and CDC work with traditional planning and forecasts and as the dealers orders are automatic they only pick and pack at the larger warehouses.

In Sweden the distribution structure consists of one CDC and five LDCs that support all most all dealers in the market. All dealers in the market within the geographical area are a part of the LDC concept and actively pre-plan their spare part requirements. All dealers are located within 3 hours driving distance from their respective LDC, with a few exceptions. The dealers and VCSs have a closed agreement which includes that the dealers have to pre-plan their spare parts and are not able to order a part unless they have an order in their own system. The dealers work a lot with first customer contact, the aim is to have personal service technicians that book their own jobs, repair the car and create the invoice. The importance is for the technician to ask the customer what is needed to repair and giving the technicians the confidence to know exactly what parts are needed for these types of services. Spare parts are not segmented but they are classified according to frequency of order and price of the parts. Although the dealers manage their own stock and which parts are kept at their site, VCSs advises which parts should not be stocked based on historical data. When an order is received in the LDC the latest cut off time is half an hour, that means that by that time the part needs to be picked, packed, and loaded into a truck. This requires approximately 10-15 people in each LDC handling the picking and packing of orders. Inventory at the dealer counts around 1.000 part numbers and every LDC in Sweden has approximately 17.000-20.000 part numbers in store. If the part has demand that is more than twice per 6 months period it is stored in LDC, otherwise it is stored in CDC in Gothenburg which supplies the whole part assortment, around 100.000 part numbers. The LDCs are replenished by the CDC every night and deliveries are made to dealers in milk rounds three times per day. Only parts that are used are invoiced and the rest is returned free of charge.

VCS controls the system and educates the dealers regarding the system and the spare part control. They train the dealers how to use the system in order to avoid returns and extra handling cost. The system is designed so that it is not possible to order a part unless there is an existing work order in the dealer system. The system also books the scheduled time for the repair so that technicians will benefit from having their parts ready when the repair comes. They try to deliver parts three times per day and aim at the technician to be able to finish using all those parts in that day.

Description of the spare part control performance

The performance is measured on a dealer level; including the amount of pre-planning and rush orders. VCS aims at having 65% of all spare part use pre-planned and this applies in all areas within the market. Last year the pre-planning level was 72 % for the Swedish market, around 80% for workshop orders and 68% for counter sales. There are some dealers that manage to have up to 92% pre-planning but there is a limit to how much can be pre-planned as VCS expects that is pre-planning is pushed too hard it can affect the end-customer satisfaction level negatively and it would increase the amount of rush orders for instant availability. For new cars the average is 89% of pre-planning and it is easier to determine when the service is needed as the delivery times of cars are known. With the concept the availability of spare parts at the dealers is at 99,6 % of pre-planned orders and 97 % for rush orders. Return from dealers to warehouse is aimed at maximum 5 % of all ordered spare parts and currently the level is at 4,3 %. Technically it is possible for the dealers to order almost any part that they want to order and then send unused parts back to VCS without any extra cost for the dealers. This creates cost in the whole supply chain and dealers are aware that this does not benefit them as it only means more parts in their own work wagons. The most returns are for orders that are rush orders.

Turnover rate in the dealer warehouse is currently around 30, this includes parts that are pre-planned. If pre-planned spare parts are not included the turnover rate is somewhere around 8 - 10 which is normal for this industry for the last 15 years. There has been a major reduction of inventory values at dealers that uses the system. Cutting the cost for the dealer in the stock level makes them accept a little bit higher price for the parts, which includes the support from VCSs. When the concept is initiated at a dealer everything that is obsolete is taken back to VCS so that there are no old parts in the dealer stock that makes the data accurate regarding improvements in the inventory value.

Spare part characteristics

The classification of spare parts is kept as simple as possible. There are 9 “blocking codes” determining the dealers what to stock and what not to stock. Most common critical parts are available at the dealer warehouse. Critical vehicles, e.g. ambulances and police vehicles have almost all parts in store. Body parts and accessories are not stored at the dealer level; this is due to the uniqueness of every repair although there is an exception for the most commonly ordered accessories that are available for display for the end-customer. Parameters at the inventory at dealers are dependent on price and number of picks and are recalculated every day. The lower the price and the more frequent the order/picking the higher service level is at the dealers’ stocks. Parts that are stocked at the dealers but not sold after 20 weeks are automatically bought back. There is a safety stock of average 1-2 weeks of spare part requirement depending on the price and frequency, which is 10 % of the total spare parts that the dealer needs. For high frequent parts EOQ and reorder points are calculated automatically in the purchasing system. Other parts have a very low frequency of orders so they go down to 0 in stock before they are ordered.

Identified parameters

Pre-planning can work with different parameters or with different values on the parameters still having the same opportunities for the performance. The most important thing is to keep balance between the parameters and determine with the dealers on how to manage the spare part flow.

- *Availability* - Availability of the spare parts at the dealers at the time of customer request.
- *Lead Time* - Lead time to dealers, from LDC or CDC.
- *Inventory value* – The amount of inventory and tied-up capital at dealer level.
- *Turnover rate* - How healthy the inventory at dealers is.
- *Transport parameters* - One of the most important factors to take into consideration when pre-planning to the extent that VCSs does is the transport in terms of availability, distance, cost, and lead time. Location of LDC is determined with the contracted transport providers hubs in mind as there needs to be a certain cut off time for the dealers to order parts and that cut off time needs to be as low as possible. The transport providers need to be able to deliver parts between the LDC and the dealers within 3 hours and to provide deliveries three times per day. If the dealer orders require more than one truckload the transport provider needs to be able to deliver more than once for each assigned delivery. Delivering the orders to dealers with milk rounds

from one warehouse instead of an individual delivery to all dealers has a lower environmental impact and is a key feature for the company that focuses on sustainability.

Benefits

By implementing the LDC concept VCS has managed to respond to the increased amount of spare parts and the increased amount of models as well as decreased inventory level in the supply chain (mostly at dealers), increased service intervals from 15.000 km to 30.000 km, and in some cases improved the product quality. At the dealers there are less obsolete spare parts than before due to the low inventory amount and return policies. With the introduction of LDC there has been a dramatic change in the healthiness of the dealer stock, as some dealers that had a significant stock before had up to 50 % obsolete parts. There has been an increase in the turnover rate for parts at the dealer inventory for parts that used to have very low turnover rate.

VCS can see a lot of benefits by pre-planning service activities at dealers, both for their own company as well as for the dealers. They believe that by pre-planning and keeping historical information about their customers' services there is a reduction of breakdown services, meaning fewer VOR and less emergency deliveries to the dealers of unpredictable spare part use. VCS goal is to make the ordering and distribution of parts simple and ensure high availability for dealers. It has shown that they sell more and are able to keep lower inventory level at dealers' stocks. From dealers perspective they have more structure for their work when they plan their services and work more efficiently when they have needed spare parts available for a service with a higher flow of cars in the workshop. It also secures that the dealers get their parts so they can perform the service as quickly as possible. Since pre-planning was introduced the waiting time for a service has been reduced in some cases due to more structure in the schedules for technicians because spare parts are available when they are required.

Challenges

There is a difference in the level of pre-planning possible when comparing workshop and counter sales with spare parts. It is more difficult to manage the customer behaviour for counter sales as they are used to dealers having all parts in stock. Pre-planning also requires a thorough dialog with the customer to find out which spare parts are needed for the service. That requires understanding from both technicians and the customer of how pre-planning works. The biggest challenge is to get dealers to adapt to a different way of ordering parts and with that the customers to change their spare part demand patterns.

When it comes to the distribution structure the locations of the LDC have to be connected and close to the contracted transport providers hubs. The location of warehouses is crucial as the transport lead time between the LDC and dealers needs to be within a time limit that allows for pre-planning orders three hours in advance. In some cases this is not possible and some dealers can only receive rush orders once per day due to transport limitations but these dealers still have to pre-plan with the time limit set. Transportation problems are the biggest challenge aiming towards the dealers, as there is often a need to transport very large amounts of parts to certain dealers while other have smaller amount of orders that need to be transported. To name an example there are dealers that need two deliveries every night to provide all the parts that are needed. It creates a lot of waste to deliver parts at night time.

Standardization of work procedures can also be challenging as every actor needs to participate and have a common standard to work. As cars tend to be quite customized there is not always possible to know exactly what parts are required in a service. Even if the technicians have a thorough dialog with the customer it is not always known which exact parts are in that car, which makes it difficult to pre-plan and there is a risk of the wrong part being ordered or if it is not ordered that it is not available on stock, either at the dealer or in the LDC.

Future development

The next thing is to build the transportation plans into the system, cut off time in the system and let the system decide upon which type of order is needed. Pre-planned orders that receive a problem to deliver on time are managed by VCS but rush order that cannot be delivered are the responsibility of the dealer to follow up on.

ICT will have an impact on how the end-customer orders services as it will be possible to get more accurate what needs to be repaired or serviced and it will also give the customer more power to order specific services on their own. The option of having a more similar distribution structure in the supply chain with Volvo GTO that would require a longer lead time for pre-planning has not been looked at. Pre-planning is currently used in Sweden, 100% in England and in major city areas around Europe. Implementation on a global level is currently being done and will be the concept used for delivering VCS parts.

5 Analysis and Discussion: Part I

This chapter analyses and discussed the empirical findings and theoretical framework, and answers research questions 1 and 2. This chapter gives an evaluation of the current state at Volvo GTO and which parameters affect the current spare part control. The impact pre-planning will have on the parameters is then identified and evaluated.

5.1 Current State at Volvo GTO

Aftermarket service is the most profitable source of an organization (Wagner and Lindemann, 2008) and a major driver for these benefits is customer loyalty (Bundschuh and Dezvane, 2003). The aftermarket business at Volvo Group is highly important for the whole organization as it aims to contribute to continuous relationship to their customers by providing them service over the product life-cycle. Supply chains for the final vehicle and spare parts differ as the ASC are more complex and requires responses to unpredictable customer demands (Cohen et al., 2006, Jouni et al., 2011). The competition in the automotive aftermarket industry is very high and there is a need for a high response to customer demand in order to gain customer loyalty. The main characteristics of ASCs concerns high numbers of parts in inventory, high variety of parts (Cohen et al., 2006, Jouni et al., 2011), different price levels of parts, and the need of highly responsive customer service (Huiskonen, 2001). The main goal of ASCs is to fulfil customer demands in a profitable way. This is in line with the vision of Volvo GTO and the four main goals.

5.1.1 Volvo Group Aftermarket Goals

Volvo has set goals for the MM department to improve uptime of the vehicles while reducing logistics cost, inventory cost, and lead time (Volvo Group, 2015d). They want to provide the customer high uptime in a cost efficient way. It is a challenging task to provide an efficient aftermarket service in the automotive industry (Cohen et al., 2006) and it is important to apply their goals to the ASC (Wagner and Lindemann, 2008) and find a balance between high uptime of the vehicle and cost factors.

High uptime is one of the key drivers for a customer satisfaction and is thus a crucial factor for the overall success of the company (Cohen et al., 2000). High uptime of vehicles requires high availability at dealers in order to get the vehicle repaired at the right time and in the right way at the first time. There are many processes within Volvo that support higher uptime as most of them seek to provide high availability at dealers. The inventory management aims at keeping the right parts in right amount in every DC, including the dealer stocks, by using stock holding policies that provides higher availability of fast moving parts at dealers. Deliveries from CDCs supports high availability with stock orders and other DCs are located near the dealers to gain higher responses to day orders that are more time sensitive. Backorder recovery has a great influence on the uptime as it provides parts that are unavailable as fast as possible (Cohen et al., 2006).

Transportation cost accounts for the majority of the variable logistics cost and by reducing the total logistics cost it requires efficient transportation. Transportation cost is mainly driven by frequency and efficiency of the transport. The flow of material is optimized in order to provide cost efficient transportation but still respond to customers demand with responsive deliveries. Reliable and responsive transportation is essential to increase customer satisfaction (Chae, 2009), as it secures high availability of parts and high uptime of the vehicle. However, if high flexibility of transport is needed to respond to unpredictable customer demand, there is often a need for less cost efficient transportation.

Inventory cost comes in line with the amount of parts that are kept in stock (Cardamone, 1996). Volvo GTO controls the inventory at DCs with segmentation of parts and stock holding policies. In that way they are able to determine which parts should be kept centralized and which should be kept in other DCs or at dealers stocks. As the parts differ in price and frequency, inventory levels can be controlled so that slow moving expensive parts will only be kept in CDCs but not in high amount in other inventories as they would most likely become obsolete, result in higher inventory cost and tied-up capital. Reduction of inventory cost requires efficient inventory management as every single part cannot be kept at all location in the supply chain.

Lead time is defined as the time between when an order is received and until the part has been delivered. Lead time can physically be reduced by increasing numbers of DCs that are located near the dealers or by delivering parts in a less time consuming transport mode (Abrahamsson, 1993). Volvo GTO aims to reduce the lead time and currently there are both SDCs located near the dealers to serve them with low lead time and also flexibility in transportation where parts can be delivered with less time consuming transport modes.

5.1.2 Balancing the Goals

Improving the availability of parts at dealers increases the uptime of the vehicle. When parts are not available at dealers' stocks, the whole ASC needs to react to the situation and make sure that the parts are delivered to dealers in time. Parts are often ordered as day orders and that means that there is a need for fast responsive transport. The transport between DCs and dealers is then not performed in the most efficient way, but with focus on the time between order and delivery. Deliveries that are time sensitives are often transported with air instead of road transport which is comparable much more expensive.

Inventory levels both at DCs and at dealers stock are optimized according to historical sales data and stocking policies. Inventory level at dealers is crucial as it is the inventory next to the customer and thus the availability is important with regards to high uptime. The majority of parts that are kept in dealers' inventory have high demand frequency and preferably lower price. However, when securing high availability at dealers less frequent and costly parts are needed at the stock. Keeping every single part available at inventories results in high tied-up capital (Cavalieri et al., 2008) and increases the risk of obsolescence parts. Because of high variety of spare parts, inventory management is important to secure that right amount and variance of parts are kept at stock to respond to customer demand, as high variety of parts increases inventory-cost, warehousing, and stock-out cost (Jouni et al., 2011).

The lead time from DCs differ between dealers because of the size and location, it also depends on if the parts are available at SDCs or needed from CDCs. Longer lead time means that it takes longer time to deliver the part to a dealer than to one that has a short lead time. Decreasing lead time can be done by decreasing the distance between Dcs and dealers, or by transporting parts more frequent or with less time consuming transportation mode. By having more decentralized distribution setup, the average lead time will decrease as the DCs will be located near the dealers. However, with higher amount of DCs the inventory level will increase and there is a need for higher amount of warehouses, higher inventory cost, and higher amount of operators (Abrahamsson, 1993). By choosing faster transportation modes it often results in higher transportation cost, such as changing from a road transport to air transport.

5.2 Spare Part Control

The spare part control at Volvo GTO is divided into processes that as a whole aim to create parts availability at dealers to fulfil customers demand. The processes within the ASC play a key role to link every practice and increase the overall performance. These processes have common goals, to keep high availability of spare parts at dealers in order to gain high customer satisfaction with increased uptime of the trucks, as well as reducing inventory levels, logistics cost, and lead times. The main processes within the distribution network are;

- *Dealer Inventory Management* secures availability at dealers which results in customer satisfaction and high uptime of the trucks.
- *Backorder Recovery* is a process that reacts to backorders in as efficient and shortest time as possible.
- *Demand Planning and Life Cycle Management* uses historical sales data to forecast in long-term what is needed from the suppliers. The purpose is to make a plan for material flow from CDC to dealer in order to achieve customer satisfaction with right inventory level and cost.
- *Refill Management* secures availability at SDCs and RDCs. Material is sent within the network in order to reduce transportation cost and shorten the lead-time to customer.

5.2.1 Spare part control at dealers

Dealers are located next to the customer in the ASC and therefore it is one of their main responsibilities to serve the customer in an efficient way. The main connection between the dealers and DCs can be seen in Figure 10. Dealers keep stock that is optimized by Volvo GTO based on historical sales data from each individual dealer.

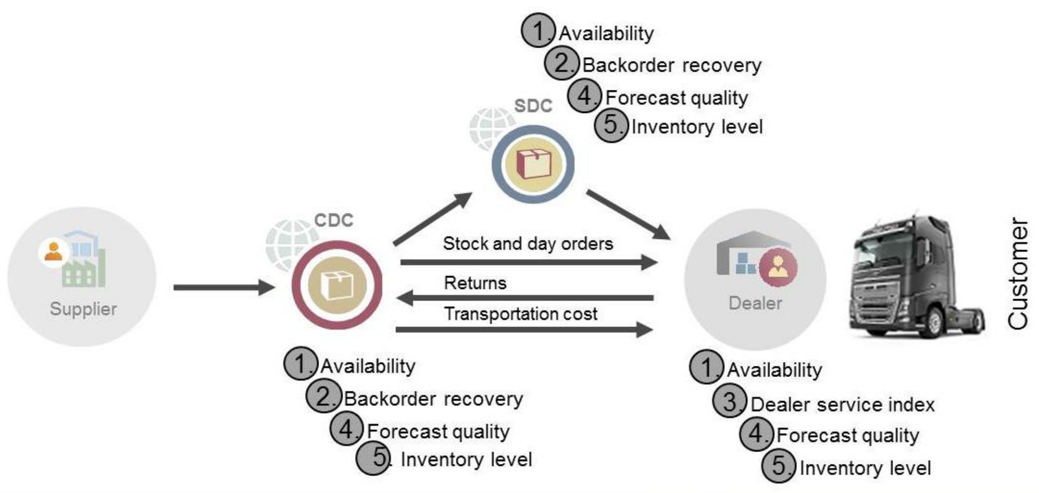

Figure 10: Distribution setup including performance indicators.

At the dealers the parts that are kept on inventory are high moving parts that have high service levels. The price of the part is not taken that much in consideration as the high frequent parts have a really high chance of being sold but preferably parts with high prices are kept centrally. Orders from dealers can be both *stock orders* and *day orders*. Stock orders are to provide the spare parts to the dealer according to safety stock levels and reorder points. Day orders are made for spare parts that need to be quickly delivered to the dealer and are made for parts that are not available in the dealer stock when the spare part availability is checked.

Stock orders: Stock orders are done automatically by DIM according to an agreement with the dealers. Ordering spare parts and delivering them with stock orders requires efficient responses as the goal of stock orders is to deliver the parts in the most efficient way where lead time is longer, and transport is done in an cost efficient way (Fisher, 1997). The lead time from a CDC to a dealer is dependent on the location and frequency of deliveries to the dealer. Stock orders are focusing on having as low transportation cost and efficient transport as possible. The reason for having parts ordered by stock orders is to have the fastest moving spare parts needed available at the dealer to ensure that the customer gets higher uptime. This affects then the stock level at the dealer as the parts are to be kept upstream in the ASC (at dealers) creating high tied-up capital upstream. The impact stock orders have on the CDC is that the parts have to be available in CDC when the delivery comes to fulfil it, as the CDC is responsible for the majority of parts being at the dealer when needed. There is no need for other DCs when ordering stock orders, as it is a centralized delivery process when ordering stock orders, from CDC to dealer. Higher amount of stock orders means that higher amount of parts will be sent from CDCs and there is less need for a high tied-up capital at SDs. However, the inventory level will be high on a central level, in CDCs, as parts need to be available for stock order services. Stock orders require thus higher tied-up capital downstream the ASC and longer lead time to dealers, but they result in cost efficient transport as orders and parts can be consolidated. Stock orders are affected by the behaviour; the higher the forecast accuracy the more correct the parts ordered from the CDC. Low forecast accuracy results in uncertain demand for the whole chain, wrong amount of ordered parts, increasing risk of obsolescence parts and returns, and poor availability.

Day orders: Dealers place day orders when the parts that they need are not available in the dealer stock when the customer requires it. This is the main principle, but dealers place day orders both when they get services that require parts not available, often with a short time of notice (customer wants service tomorrow e.g.), or when manually following up on spare parts needed for services that are not available at the dealers stock. Day orders are considered to be an excellent way of receiving parts as the dealer doesn't need to think about the parts need long in advance or keep it (get it delivered) long time in advance. For the downstream supply chain this means a different thing. Managing the day orders requires responsive actions as the lead time from when the part is ordered is relatively short, by current definitions it is one day after the order. Parts that are placed with day orders are parts that for some reason are not at the dealer stock, the assumption can be made that day orders are placed for parts that do not have high frequent orders (placing them at medium movers) or are not available due to other unconventional reasons (backorders e.g.). Day orders are primarily supported by SDCs. In the Nordic market the day orders supported by SDC are sent by truck or air (depending on the location) and have the possibility to be consolidated with stock orders coming from CDC to the dealers if there is a transport to the dealer that day, but it is delivered solo if there is not a stock order refill on the way to the dealer. Orders that are placed in the end of the work day are delivered before 8 am with to the dealers. So the shipments are either consolidated with planned deliveries or additional deliveries are made resulting in either way higher transportation cost. The second way to receive parts ordered by day orders is from CDC, these part are then slow moving or medium moving and expensive parts that are not often used at the dealers but have to be available for the dealers when the customer wants it. Delivering parts from the CDC anywhere in the Nordic market requires it to be delivered by air. All deliveries are flown to a central location and then to the final destination or by truck if it is near. This transport accounts for half of the transportations cost in the chain, but the number of parts that are delivered is only a minor part of the total spare part need. It can be determined that day orders have very high transportation cost, require a short lead time, it doesn't require tied-up capital upstream in the chain but the inventory level downstream needs to be high. Day orders are time sensitive and need to be shipped to the dealers with emergency transport. These transports are often shipped by air when the lead time is too long for a road transport, and that usually results in very high transportation cost. Day orders also require high availability at the distribution centres, and responsive actions from Volvo GTO.

The *information flow* from dealers is both automatic and manual. Dealers get automatic refill on stock based on forecast but they can also order manually. Real sales data is used from dealers to forecast customer demand.

Returns are performed when parts are sent from dealers downstream to CDCs, that can occur because of obsolete parts or if parts are not needed at the dealer's' stock. Returns of part affect the spare part control since there is a need for a transport from the dealer to the DCs, also the part will increase the inventory level at that specific DC. When parts are returned from the dealer as it has not been used it requires transport both to and then later from the dealer. As stated before there are two ways of getting the parts to the dealer and if that part is not used it can be sent back to CDCs where Volvo GTO takes the charge and refunds the parts according to their policies. Having to deliver parts to the dealer to later return them as they have not been used is a cost that could be avoided if the right parts at the right times is at the dealer. Unused spare parts thus require higher transportation cost. It also creates higher inventory level upstream in the supply chain.

5.2.2 Spare part control at Volvo

Inventory Control: In CDCs and some RDCs (with purpose to expand to other warehouses) parts are classified in order to better manage the extremely high number of SKUs and reduce tied-up capital in the DCs. Classifying the part numbers of spare parts into relevant categories makes the control more efficient as it makes it possible to manage them on a segment level instead of each single part number (Jouni et al., 2011). The SKU´s in the distribution centres do not all follow the same demand patterns and require different levels of safety stocks. Classifying the spare parts reduces the high stock and safety stock levels as the demand for each segment are optimized instead treating all the parts the same. Furthermore, using more criteria for classifying the spare parts will make the control more relevant but if too many criteria are used the amount of categories becomes too large to manage (Huiskonen, 2001).

Martin et al. (2010) explains that it compensates the variations in demand and risk of unavailability with high stock levels and high reordering points and quantities. SKU's do not all have the same demand so categorization of the different spare parts and is necessary to optimize the balance between availability and cost in the ASC.

With segmentation it is possible to optimize which parts should be kept in which inventory and in what amount. Inventories at dealers should include critical and fast moving parts as they are most important and most used for services. Having a part available at dealers inventory is crucial when responding to unpredictable customer demand and will thus impact the lead time of the parts as there is not a need for a delivery of the part if the part is already available at dealers' stock. This reflects on the other warehouses in the ASC as when there is a need for a backorder it is important to have a part available at SD in order to have lower lead time. Tied-up capital is directly related to inventory control as there is a need for a great inventory management when optimizing inventories within the ASC. Inventory levels are controlled based on parts' segmentation that concerns the frequency, price, and life cycle of the parts in CDCs and some RDCs. When basing the demand forecasts on historical sales with the criteria of frequency of orders and price it is necessary to keep in mind the life cycle phase of the part as with the longer time of the existence of the spare part the lower the service level should be as the part soon faces obsolescence.

Transport Control: Transport control plays a key role in the distribution of spare parts as it connects actors together and secures reliable deliveries for the parts (Anand and Grover, 2015). Dealers behaviour impact the transportation as there is a need for a different transport control when stock, day ordering or returns occur. Stock orders are delivered in a cost efficient way where parts can be consolidated and send with a full truck load to dealers. Day orders are time sensitive and thus they are often sent with air transport when the lead time is too long for a road transport. The main differences in the transportation lies thus in direct and indirect distribution. As some of the parts are only kept centralized the transport can be provided direct to the customer in cost efficient way, but in some cases the parts require short lead time and deliveries are needed to be transported from SDCs or RDCs. Table 3 summarizes how the spare part control practices affects goals.

Table 3: Impact from spare part control, findings from research question 1.

	Uptime	Lead time	Transportation cost	Inventory cost
Spare part control at dealers				
Stock-orders	Secures availability at dealers	Long lead time	Low due to efficient transportation	High tied-up capital at CDC and dealers
Day-orders	Secures availability at dealers	Short lead time	High due to Emergency transport	High tied-up capital at CDC, SDC Low tied-up capital at dealers
Returns			Extra transport from dealer to distribution centre	Increases at Volvo Decreases at dealers
Spare part control at Volvo				
Inventory control	Secures right parts and right amount of parts at right inventories	Right parts kept at right inventories based on stockholding policy	Can be optimized by using a total cost optimization approach	Inventory level is controlled based on parts' segmentation
Transport control	Emergency transport		Optimization of transport in a cost efficient way	

5.3 Factors Influencing Performance and Selection of Parameters

In order to reach goals within the ASC, Volvo has identified several Key Performance Indicators (KPIs). Figure 10 shows where the KPIs are located in the distribution setup. Each KPI plays important role for the performance and has a great impact on the ASC.

Aftermarket parts availability

Availability of parts is the most important KPI in ASCs in the automotive industry (Cohen et al., 2006, de Leeuw and Beekman, 2008). In the ASC this KPI is measured at DCs. The KPI is supported by many PIs and other parameters but it also has a great effect on the upstream ASC. If the availability at warehouses is low it will affect the dealer availability (Cohen et al., 2006). The severity of the effects can differ but often it results in customers' dissatisfaction and lower uptime of the vehicles. In the aftermarket industry, the spare part control needs to be responsive and able to react to unpredictable customer demand (Fisher, 1997). Customers want the parts to be available when they come for a maintenance service at dealers, and if the parts are not available the customer might go to another dealer to get the service. The availability is essential for a competence and customer satisfaction. The effect of availability of parts is direct related to the uptime of the vehicle. If the part is not available at dealers' stock the right service cannot be provided in the right way at right time. Availability of parts in the DCs also reflects on the uptime as it supports the availability downstream the ASC and might thus result in wrong amount of parts on orders from dealers. In line with low availability the transportation cost will also increase. If a part is not available when it is needed it is often sent with rush transport. Since the lead time of parts delivered by trucks can be counted in days there might be a need for air transport which is much more costly than a road transport. Inventory management is essential for availability of parts, both at dealers and at DCs. If wrong parts or wrong amount of parts are kept at inventories it can result in low availability, but also by ensuring high availability the inventory level will increase and the inventory cost increase in line with that.

Aftermarket parts backorder recovery

If a spare part is not available at dealers' stock, there is a need for a backorder-system. The dealer seeks after the part downstream the ASC in order to get the part as soon as possible. The backorder recovery indicator measures the capacity of the inter logistics services to fill dealer backorder. Backorder recovery has downstream effects on the ASC as the dealers expect to get the unavailable part as soon as possible. The performance of backorder recovery at Volvo affects the dealer satisfaction, customer satisfaction and the vehicle uptime. It also affects the transportation cost as it might be a need for emergency transport, if the lead time is too long for a regular transport. Backorder recovery requires high availability at DCs which is supported by inventory level and does therefore affect the inventory cost.

Dealer service index

Inventory levels at dealers are forecasted and the dealer service index (DSI) is used as an indicator to measure the capacity of the stock and how it reacts to the forecast of demand. Dealers are the actors that are located next to the customer in the ASC at Volvo and their performance will thus affect end-customer satisfaction and product uptime. DSI directly affects the availability of parts as it measures the forecasted demand that should support high availability, thus if the DSI is low it will result in low availability and low uptime of the vehicle. Low DSI will in the same way as availability result in higher transportation cost and can affect the inventory cost.

Other performance factors

Not only KPIs are essential to support the performance of the ASC at Volvo, there are also other performance indicators that are important.

Forecasting quality

Forecasting quality is a huge driver for a good performance within the ASC at Volvo. As Christou (2012) points out, it is a difficult task to make a relevant and accurate demand forecast, but the closer the forecast is to real demand, the better can the SC perform. Both the inventories at distribution centres within Volvo as well as dealers' stocks are forecasted based on historical sales data. However, customers can show up for a service at dealers in unpredictable times and thus it can be hard for the supply chain to react to that. Forecasting quality has a great effect on the uptime as poor forecasting quality results in low availability. In the same way as low availability of parts it will affect the transportation cost.

Transportation

Transportation is not considered as a KPI. It is still a very important parameter when it comes to overall performance of the ASC. It supports many indicators within the flow and affects their performance. Reliable transportation is crucial when it comes to lead time and other time related parameters (Chae, 2009). The transport between distribution centres and dealers can vary both with regards to distance, frequency, time, and capacity. Efficient transportation requires effective planning factors that optimize the best route for the distribution setup. Transportation cost has a great influence on the total cost of Volvos' ASC. One reason for that is because of emergency transport that is required by the dealers. Uptime of vehicles are affected by transportation reliability both with regards to refill (inbound transport) and when reacting to stock- and day orders. If parts are not delivered at the right time it will not be available for service at the right time and the uptime of vehicles decreases. Transportation has also major impact on the lead time as the lead time differs between transport modes. With faster transport the lead time decreases and vice versa. Transportation cost is directly affected from the transport mode as they differ in both cost and time. Furthermore, with optimized transportation parts can be delivered in efficient way with high capacity. Stock orders that are transported to dealers can be consolidated on the way to gain full truck load, but with emergency truck transport is not performed in as efficient way.

Inventory level at DCs and at dealers

Inventory level is not measured as a KPI at Volvo but it is an important parameter that has huge influence on many performance indicators. Inventory levels at distribution centres are a big part of the total cost of the organization. It is challenging to find the optimal inventory level, especially within a supply chain that needs to react to unpredictable customer demand. Forecasting quality is important support factor for the inventory level which also affects availability of parts. Though availability is crucial for Volvo, inventory cost is also an important factor. Too high inventory level results in high inventory cost and increases the risk of obsolete parts. Inventory level also affects the lead time as if a part is not available and the safety stock cannot react to customer demand, the lead time will increase. Table 4 summarizes the effect the performance of the spare part control has on the four goals.

Table 4: Impact from spare part control performance, findings for research question 2.

	Uptime	**Lead Time**	**Transportation cost**	**Inventory cost**
Availability of Parts at CDC, SDC, and RDC	Downstream availability	Downstream availability	Emergency transport	Depending on inventory management
Availability of Parts at dealers	Right the first time	Reduces waiting time for parts	Emergency transport	Depending on inventory management
Backorder Recovery	Availability in a time sensitive way	Reduces waiting parts for parts	Emergency transport	Depending on inventory management
Dealer Service Index	Availability of parts at dealers		Emergency transport	Depending on inventory management
Forecast quality	Availability of parts in the ASC	High forecast accuracy increases availability	Emergency transport	Depending on inventory management
Transportation	Emergency transport	Differ between transport modes	Depending on efficiency of transport	
Inventory Level at DCs	Supports downstream availability	Depending on Safety Stock		Depending on inventory management
Inventory Level at Dealers Stock	Supports availability at dealers	Depending on Safety Stock		Depending on inventory management

5.4 Pre-Planned Service Activities

To the authors knowledge pre-planned service activities have not been discussed within literature to a large extent but as stated in section 1.1, according to Oxford Dictionaries online to pre-plan is defined to plan in advance. As it has been defined by Volvo GTO it means that spare parts are only ordered by dealers according to real customer demand. Pre-planning is not common nowadays when controlling spare parts in the automotive industry, but according to the benchmark study, section 4.5, VCS has had a great experience from pre-planning. With pre-planned service activities and implementation on their LDC concept, VCS has overcome many of these challenges.

Effective pre-planned service activities means that only parts that are needed are ordered for a specific service, meaning that the demand of spare part is known in advance. When demand is known the supply chain can reduce waste and obsolescence parts, and decrease inventory levels, (Christopher and Ryals, 2014). This is in line with VCS experience of pre-planning as they were able to decrease the total tied-up capital within the supply chain, where the majority of the inventory reduction was at dealers. Furthermore, the numbers of obsolescence parts decreased and the turnover rate at dealers got higher, thus inventory at dealers became healthier. This is also supported by Fisher (1997) who argues that when demand is known the whole supply chain can change from responsive to efficient distribution (Fisher, 1997). Christopher and Ryals (2014) state that with known demand parts can be pulled according to customer demand through the ASC instead of being pushed according to a forecast. With pre-planning it is possible to have customer focused supply chain while decreasing cost and increase customer satisfaction as the part will be available when a service is performed. VCS has increased their customer satisfaction with pre-planned service activities as the waiting time for a service is minimized and the vehicle can be repaired the right way at the first time.

As confirmed by VCS pre-planning increases the availability of spare parts and pre-planning in practice supports efficient inventory management since only parts that are needed for a service are reserved, and dealers need to have a service booked to be able to reserve a part. VCS keeps high availability with efficient pre-planning, low inventory levels, short lead time and frequent transportation. Returns from dealers back to VCS are mainly related to rush orders and are not to pre-planned orders. Although VCS dealers can order any part they want, they know that if they have to return parts it will affect the total cost of the ASC.

Dealers need to be well informed in order for pre-planning to be performed in an efficient way to gain the advantages, such as lower inventories. Furthermore, it also decreases handling cost and returned parts in the whole supply chain affecting the total logistics cost in a positive way. Dealers can have their part available when the service is performed and logistics cost can be reduced at the same time. Not only does the overall cost reduction of the supply chain affect the price of the part for dealers, but dealers can also structure their services in a more efficient way and increase the number of services per day as they receive responsive and reliable parts availability to provide their customers.

Though pre-planning brings many advantages to the ASC, it also requires balance between cost and service. VCS manages to keep acceptable end-customer satisfaction with high availability of the spare parts. The distribution setup at VCS requires short lead times and high amount of transportation between their LDCs and dealers. For pre-planning to work effectively in other settings, companies need to consider their main goals and find a balance between them with regards to their distribution setup.

5.4.1 Pre-planning at Volvo GTO

Pre-planned service activities at Volvo GTO occur when dealers reserve parts that are needed for a service when the service is booked, two weeks in advance. This means that when a customer comes in for a service, Volvo GTO has had two weeks to distribute the parts to the dealers. Pre-planned service activities have an impact upstream the ASC. When dealers pre-plan their service activities they know when the customer comes for a service and what parts are needed for the service. This information need to flow from the dealers and to Volvo GTO. There is not a need for a different information system to handle this information as the information system between Volvo GTO and the dealers has been taken into consideration when designing the pre-planning process at Volvo GTO. Pre-planned service activities will have great impact on both spare part control and performance indicators within the ASC, Figure 11. Using diagnostics to identify what services a truck needs will push it further towards preventing instead of curing which is in line of what Lawrenson (1986) recommends with maintenance services.

Spare part control at dealers

Dealers play a key role when it comes to pre-planned service activities as it all starts at their side of the ASC. When they receive an order for a customer service it is their responsibilities to order spare parts needed for that service.

Ordering spare parts two weeks in advance increases the availability of parts as the lead time from CDC to dealers is shorter than two weeks, and if the part is not available at CDC the spare parts have a greater opportunity to react before the customer requires the spare parts. High availability at the dealers' stocks has a great impact on both spare part control and performance of the ASC. When the parts are available for a customer service at the right time, dealers can perform the service in the right way at the right time. This results in high uptime of the vehicle as the vehicle does not have to be kept at dealers workshops when waiting for parts to arrive. High availability also results in efficient ordering control. As day-orders are used as rush orders when parts are not available, high availability will reduce day orders and therefore the amount of rush transport. This will also impact the inventory level at SDCs as there is not a need for as high inventory level of parts that are kept in stock to serve day-orders. Inventory level at dealers can be reduced as the availability of parts will be gained from pre-planned orders but not with the amount of inventory kept on stock. This does not only affect the inventory level but also the returns from dealers to Volvo GTO. Since only parts that are needed for a service will be ordered, there is a less risk of high amount of obsolete parts or parts that are not needed in the nearest future. As the availability of parts are directly related to back-orders, with higher degree of availability the back-orders will be reduced.

Spare part control at Volvo GTO

When Volvo GTO receives an order from their dealers they have two weeks to deliver it to dealers. Thus the ASC can respond in more efficient way to the customer demand.

Availability of parts at CDC will increase since it will be available in the time it is needed. Though the availability of part is not at CDC when the order is received, the lead time is long enough to get the part from suppliers in time. Furthermore, as the part will be available at CDC and can be delivered to the dealers in right time, the inventory level at other DCs can be reduced. As the spare part control can rely in a higher extent on CDCs to serve the parts, the other DCs can reduce the amount of inventory with the amount of pre-planned orders that will be served from CDCs. Transportation will also be affected by higher availability as the transport can be optimized for longer timeframe and there will not be a need to provide emergency deliveries.

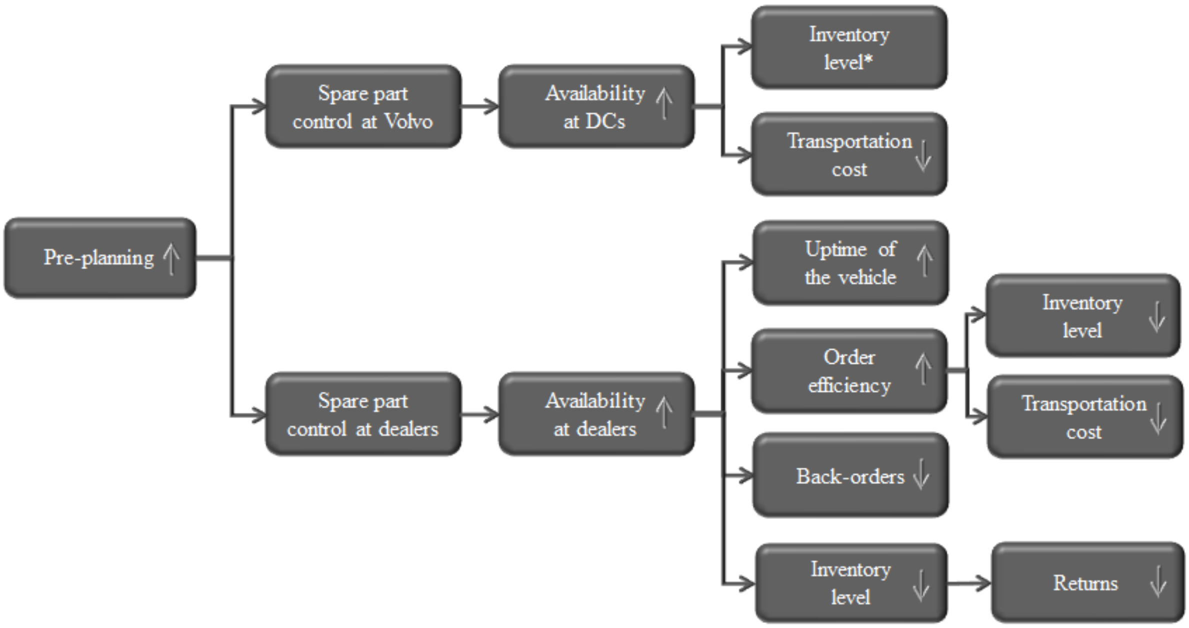

Figure 11: The impact from pre-planning on the aftermarket supply chain, findings from research question 2.

* Inventory level from the link of Volvo is affected with higher availability at each DC. The inventory level at CDCs will be steady, whereas inventory levels at SDCs and RDCs can decrease as the inventory will be kept centralized.

6 Analysis and Discussion: Part II

This section presents the case study of the two chosen dealers. In order to see the possibilities that pre-planning provides on the spare part control, historical sales data from two dealers is analysed. The investigation of the dealers' behaviour and practices provides the quantitative evidence to support research question three; what are the opportunities for the spare part control for different planning scenarios.

Two dealers in the Nordic market were chosen to investigate; due to maturity of the market in the area, their location, their connection to Volvo GTO, and their current estimated pre-planning activities. The dealers are dependent Truck Service Centres meaning that they are owned by the Volvo Group. The dealers receive stock and day orders from the CDC in the area and day orders are supported by a SDC. In this area it is quite common to receive parts from other Truck Service Centres when parts are required within a short time frame. This is done for the parts that are needed sooner than the lead time from either the CDC or SDC can respond to and is done for spare parts that are not available on stock at the dealers. Depending on the location and proximity of other Truck Service Centres these inter-branch sales and receives of spare parts is used. If the part needed is not available at other branches they are delivered by normal means from DCs. Inter-branch deliveries are treated as a normal sales or buys, hence not organized by the Volvo Group. In this area milk rounds between Truck Service Centres are scheduled daily for inter-branch exchange and often this is the chosen method before ordering day orders from the DCs as the spare parts can be delivered with the shortest possible lead time with this method. The lead time from the SDC to the dealers is less than one day and the lead time from the CDC are 10-14 days for stock orders and one day for day orders, based on the frequency of deliveries to the dealers. Table 5 presents the main characteristics of the two dealers.

Table 5: Characteristics of the studied dealers.

	Dealer 1	**Dealer 2**
Dealership	Large Truck Service Centre	Small Truck Service Centre
Average Service Index	Above target	On target
Stock order deliveries	4-5 times per week	2 times per week
Day order deliveries	Every day; cut off time 8pm, delivered before 6 am	Every day; cut off time 8pm, delivered before 6 am
Lead time from CDC	10 days	13 days
Share of day orders	On target	Above target
Inventory control performance	Above average	Above average

When a service is booked the dealers check both the time available in the workshop and the availability of spare parts; the dealers have the possibility to see if the parts are available in their own inventory, at the CDC, SDC and other Truck Service Centres. All spare parts that are used in the workshop have a work order assigned to it; no material is used if there is not an existing work order requiring for that specific part. This requires the technicians to know what spare parts are needed for the service when the work order is made so that the spare parts are available at the dealer when the actual service takes place. As Romeijnders et al. (2012) point out when spare parts are missing for planned services there are consequences as would be for unplanned services and knowing what spare parts will be used can limit the consequences. Not all services at the dealers are planned; preventive maintenance as defined by various authors (Lawrenson, 1986, Kennedy et al., 2002, Romeijnders et al., 2012) is more often planned as repairing or replacing parts that are not broken can be planned whereas corrective or breakdown maintenance cannot be known before hand and therefore not planned in advance.

Spare parts are all treated the same at dealers, independent on their segmentation. The only concern of the dealers is that the parts should be available when they require them to be used for their services and let Volvo GTO manage the effectiveness of the distribution chain. For the dealers to have their parts at the actual time for a scheduled service, they manually check for the spare parts availability in the work orders three days before. If the parts are not available, they need to be manually ordered by the dealer, which is normally automatically done for other orders that extend the three day limit. Sales over the counter are a difficult to plan beforehand as it depends on the customer informing in advance what spare parts they require, which is a behaviour change that dealers cannot control. This is confirmed with the performance at VCS where sales over the counter are not pre-planned to the same extent as workshop service orders.

The turnover rate for spare parts indicates how much is sold per annual usage of spare parts. Cohen et al. (2000) state that in the automotive aftermarket, a turnover rate of 7 is normal and according to the VCS representative, a turnover rate of 8-10 has been the norm in the automotive industry for the last 15 years. The turnover for the both dealers are lower than stated by Cohen (2000), where manually orders have significantly higher value than automatically orders. Manually ordered spare parts are most often day orders that have a work order assigned to them knowing what spare parts will be used in the order whereas automatically ordered spare parts are delivered to the dealers based on forecasted demand. Dealer 2 has a much lower turnover rate than dealer 1, which implies that the spare parts that are on stock are not sold as frequently as for dealer 1. At VCS the turnover rate is around 30, but when excluding pre-planned spare parts the turnover rate is 8-10. This is due to the amount of spare parts having assigned accurate work orders that are delivered at the right time in the right amount. In line with the higher turnover rate at VCS, tied-up capital is reduced at the dealers as the majority of spare parts arrive at the dealers only to be sold within a few hours not having any stops at the inventory. Pre-planning spare parts has proven to have positive results on the tied-up capital and turnover rate.

To keep the end-customer satisfaction at an acceptable level there needs to be high availability of the spare parts, and therefore pre-planning cannot be done for all requested spare parts. The pre-planning concept is known by the dealers but the noticeable benefits of planning services two weeks in advance and reserving spare parts at the same time is not clear enough. This is due to the dealers having the option to have all spare parts delivered the next day if not available on stock without any extra cost, which gives an acceptable customer satisfaction for the end-customer. Although the pre-planning process with regards to customer service is actively used by the dealers it does not affect their current ordering behaviour as the spare parts are not necessarily reserved when the work order is made disabling the supply chain to react in a cost efficient way to deliver the parts on the right time. The current order behaviour of dealers requires high tied-up capital in their stock as instant availability is necessary to support spare part requirements where it is not reserved at the same time as a work order is created. Not reserving the parts when the service is scheduled requires a lot of day orders to supply the spare parts which could be possible to avoid and instead send the parts in a cost efficient way from DCs to dealers. Furthermore, inter-branch deliveries affect the accuracy of what parts are needed on stock and what is delivered to the dealers when they do not actually need the parts affecting the automatic refill.

6.1 Analysis of Current Planning Scenarios

The historical sales data was used to analyse distinguishing behaviour at the dealers in order to identify potential pre-planning scenarios. There are several factors that influence the pre-planning potential, which will be analysed and discussed in this segment.

6.1.1 Segmentation of Spare Parts

The segmentation of spare parts based on demand, price and life cycle phase is a step towards a more efficient inventory management. The highest amounts of spare parts that are sold are categorized as faster moving parts in the segment EA-EE and EF-EJ. Fast moving parts that are in the prime phase are the most sold ones and the faster moving the higher amount is sold. Other parts in the prime phase that are less sold are categorized as medium; EK-EO and slower moving parts; EP-ET, and EU-EZ and are also located in the prime phase but with lower service level and required inventory level than the faster moving parts. For other segments later in the life cycle the service level decreases and so does the automatic refill and inventory level at dealers. Segmentation of parts decreases the risk of obsolescence parts at dealers stocks as they do not hold high stock levels of parts that are in the slower moving categories. There are different consequences when different categories of spare parts are held in the wrong amount at dealer's stock. Too high amount of fast moving is easier to correct as the parts are easily sold, but it is more complex to handle large amount of slower moving parts as they are not sold as frequently and can get obsolete at the dealers' stocks. Critical parts are in a class of its own as they do not follow the same method when categorized in segments. Critical spare parts are often kept in a high amount at the dealers stocks as they are required to be instantly available. The pattern of spare parts sold from the segment perspective is the same for both dealers.

6.1.2 Order Type to DCs

As defined in section 4.2.2 there are two types of orders from the dealers to the DCs; stock orders and day orders. Stock orders are orders that replenish the stock at dealer warehouses according to re-order points and safety stock levels in a cost efficient way. Day orders are orders made for parts that are not available at the dealer stock when the end-customer requires them with responsive and high transportation cost. The majority of orders and parts are delivered with stock orders, Figure 12.

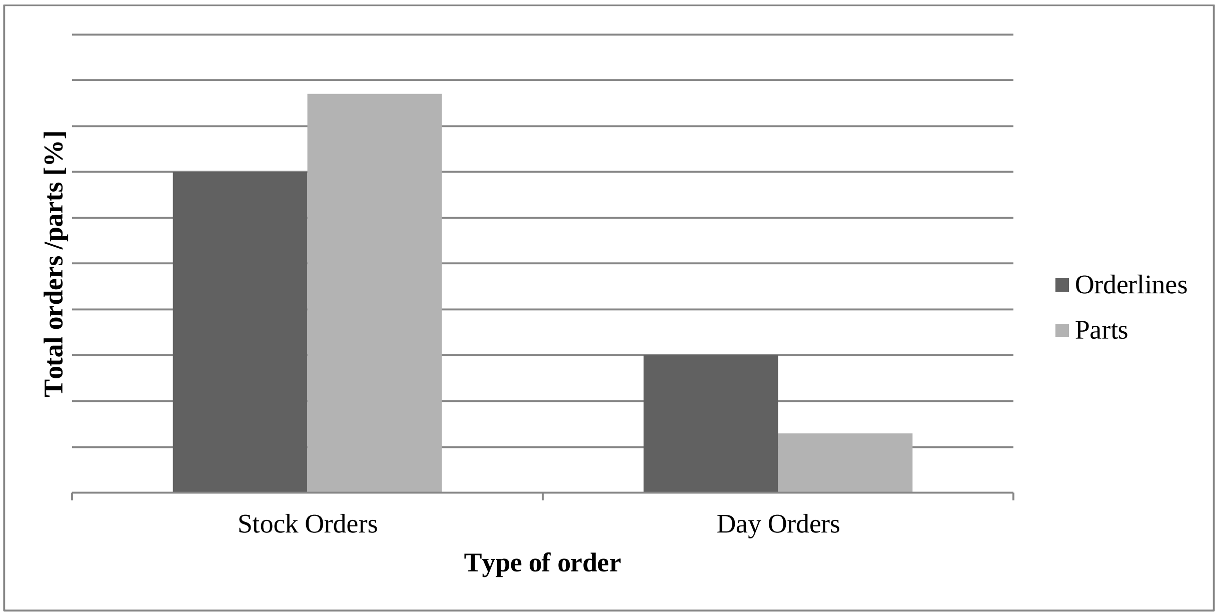

Figure 12: Amount of orders and spare parts with regards to type of order.

The stock orders shipped from the CDC account for the majority of the part numbers ordered. The amount of day orders are less than the stock orders but stand for significantly lower amount of part numbers. That means that each stock order includes much higher amount of parts than each day order. The lead time from the CDC to the dealers is too long to use road transport for day order deliveries; therefore air freight is used except for spare parts that are over the weight limit for air transport. Therefore day orders are much more expensive and shipped in less efficient way than stock orders. There is a difference in the segments of spare parts when it comes to type of order, Figure 13.

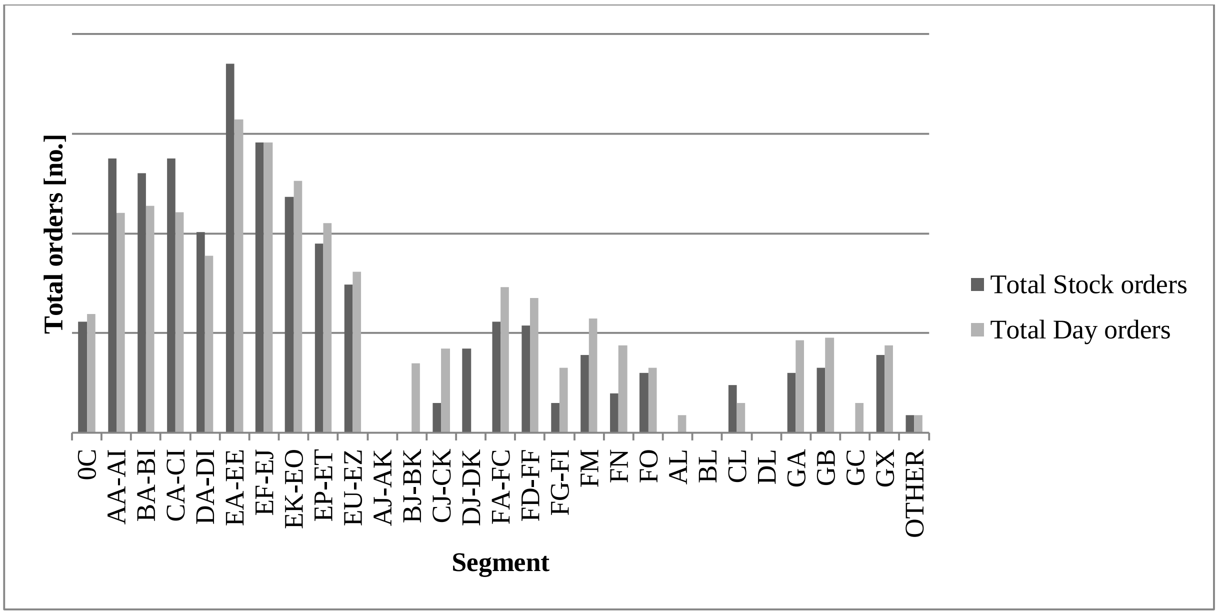

Figure 13: Division of day orders by segment.

The majority of all orders whether it being a stock or a day order, are made from the faster moving segments in the prime phase. The fast moving segments, EA-EE, stand for the majority of both stock orders as well as day orders. The medium fast moving segments, EF-

EJ, represent the second higher amount of day orders where but lower amount for the total stock orders. These two segments have the largest influence on the total amount of orders.

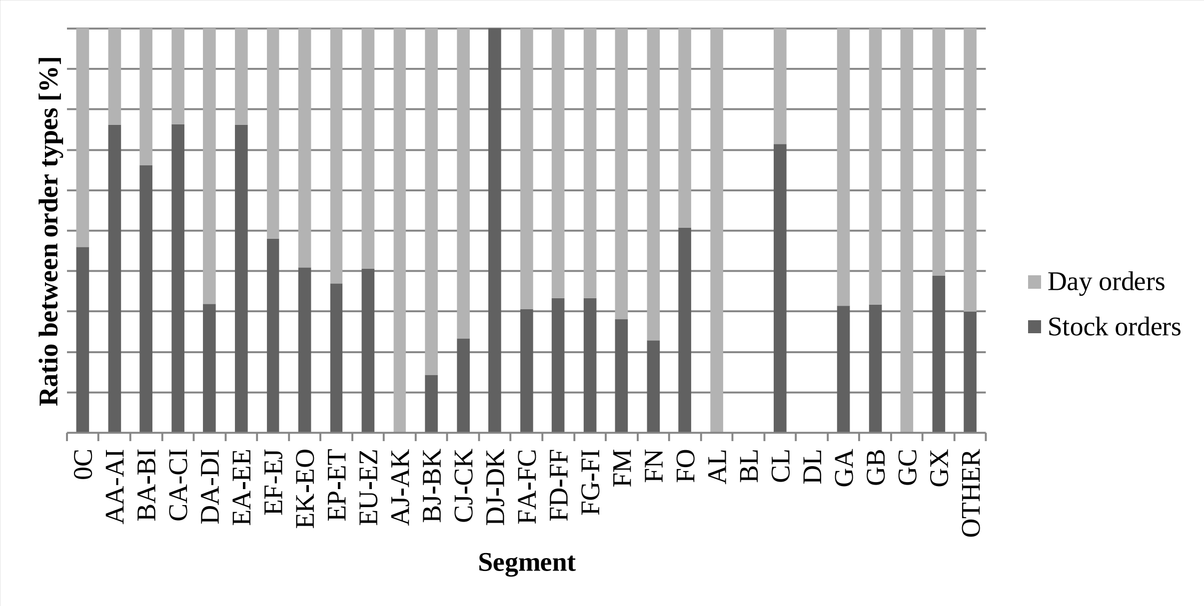

Figure 14: Type of orders for each segment of parts.

Looking further in detail at the segments and type of orders, Figure 14, segments EA-EE are often ordered by stock orders which means that a low amount of their parts ordered by day orders counts for the majority of total day orders. Parts in segments EF-EJ are ordered with a high amount of day orders which accounts for high amount of the total day orders. For the slower moving segments or segments in the later life-cycle phases day orders are more common, the majority of the segments have more spare parts ordered by day orders than stock orders. It is therefore clear that different segments of parts have different impact on orders to the DCs.

6.1.3 Time between Reservation and Sales of Spare Parts

Comparing the two dealers and the timeframe of the current spare part orders it is evident that the majority of spare parts are reserved in the system the same day as they are sold, Figure 15.

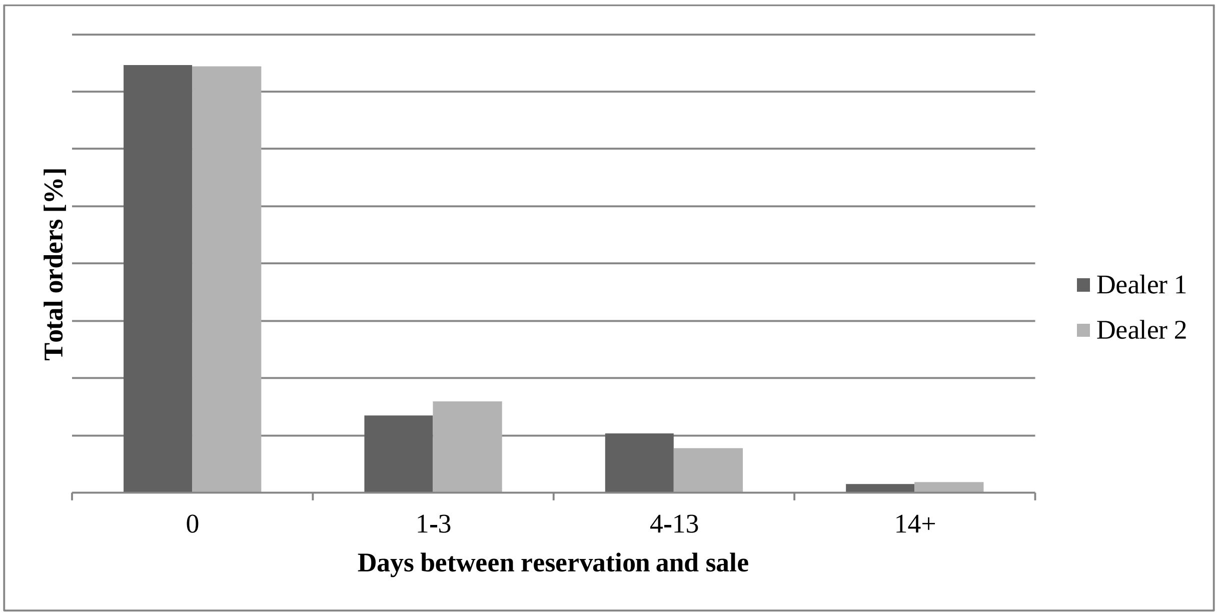

Figure 15: Time between reservation and sales for both dealers.

There are four categories defined with regards to the reservation and sale of spare parts at the dealers. The first category where spare parts are reserved on the same day as they are sold contains most of the orders. The spare parts in the first category are either available at the dealers' stocks or the parts have been received with inter-branch deliveries. The second category contains spare parts orders that are sold within three days after the reservation of the spare parts, therefore spare parts that are delivered from DCs as day orders that have one day lead time to dealers. The third category defines spare part orders that are sold up to 13 days after the spare parts are reserved in the system either as they are not delivered at the right time within the three days of ordering or the customer does not require them until later. The last category, which contains the least amount of orders, is for spare parts that are sold after 14 days and therefore fall under the pre-planning concept. Pre-planned orders the potential to reduce the inventory level and increase the turnover rate at the dealer. Spare parts that are pre-planned do not have to be kept in stock and could be scheduled to be delivered in a cost efficient way at the right time, or when they are to be sold. The potential of cost reduction lies therefore in moving the amount of orders to the right side of the graph.

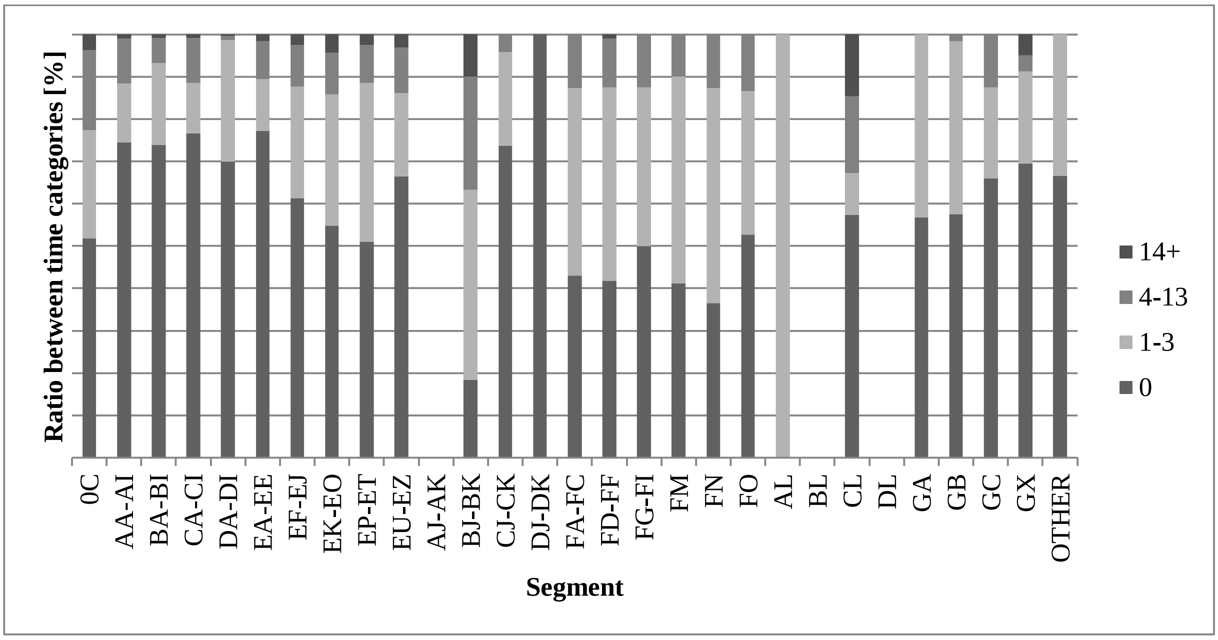

Figure 16: Time between reservation and sales by segments.

Figure 16 shows how much time is between reservation and sale for each segment. It's evident that the majority of every segment has no days in between reservation and sale which represents the dealers' main behaviour. Pre-planning orders are not common for any of the segments but the highest numbers of orders in category four is for segments 0C, EK-EO and some critical spare parts segments. Spare parts in the initial spare part segment, 0C are new on the market and have the most variance in days between reservation and sale. When looking at the service level in the CDC (Appendix IV) it can be seen that parts in segment 0C have very low instant service level compared to the target service level. The variance in days between reserved and sold part can be caused of this low service level at the CDC as they might not be available when reserved, but it could also be caused of low forecasting quality as the parts are new on the market and thus the historical sales data is not available. Pre-planning could have great impact on spare part segments with low service levels as the time between reservation and sale for the parts will be higher. It is argued that fast moving segments should have higher availability at dealers than slow moving and especially parts that are in the phase out phase. Not only fast movers have the majority of their parts reserved the same day as they are sold, but it is evident that also some slower moving parts, such as segment GA, has their majority of their parts reserved and sold the same day. That is often because they are available at dealers' stocks when needed for a sale. Pre-planning would have impact on the stock at dealers as parts could be kept more centralized, this would be especially beneficial for the parts that are in the later life cycle phases in order to keep healthy stock. There is also a need for a reduction of the parts that have 1-3 days in between reservation and sale since they are mostly received by day orders. As has been stated, day orders result in higher transportation cost and with higher degree of pre-planning these categories can be reduced.

6.1.4 Work Order Type at the Dealer

There are two types of work orders at the dealers; orders that are sold over the counter (following the *customer initiated parts request* process), and workshop orders where the parts are used for maintenance and repairs of the trucks (either following the *workshop initiated* *maintenance offer* or *customer initiated maintenance/repair* process depending on who initiates the service). There are significant differences when it comes to the two types of orders with regards to the end-customer order behaviour, the timeframe available to source the parts and the amount of spare parts in each order. For over the counter sales spare parts are sold when the customers are at the Truck Service Centres where the vehicle doesn't have to be stationary whereas for workshop orders the vehicle has to be in the dealers' workshops reducing the uptime of the vehicle. Looking at the differences in spare parts segments there are the same patterns for over the counter sales as for workshop orders where the majority of all parts are sold from the fast moving segment in the prime phase. The majority of orders are for spare parts required for workshop orders, Figure 17.

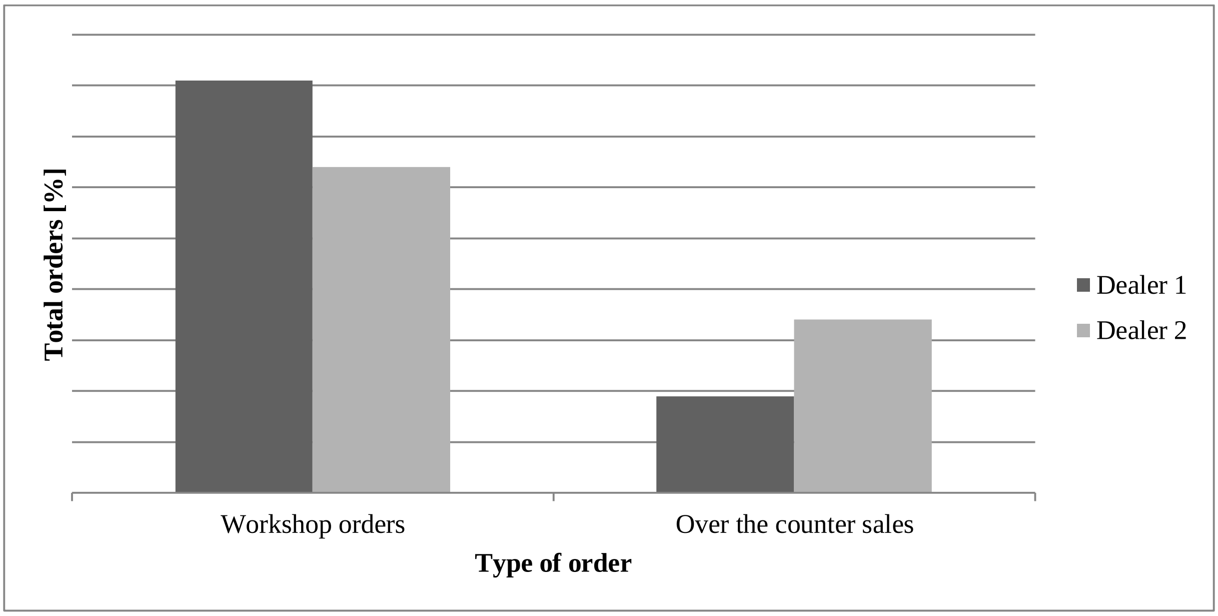

Figure 17: Type of work orders at the dealers.

Over the counter orders

Spare part orders for over the counter sales are mainly required straight away as the end-customer requires the parts within a short time frame whereas workshop orders are for spare parts that have the purpose of being used at the dealership by the technicians.

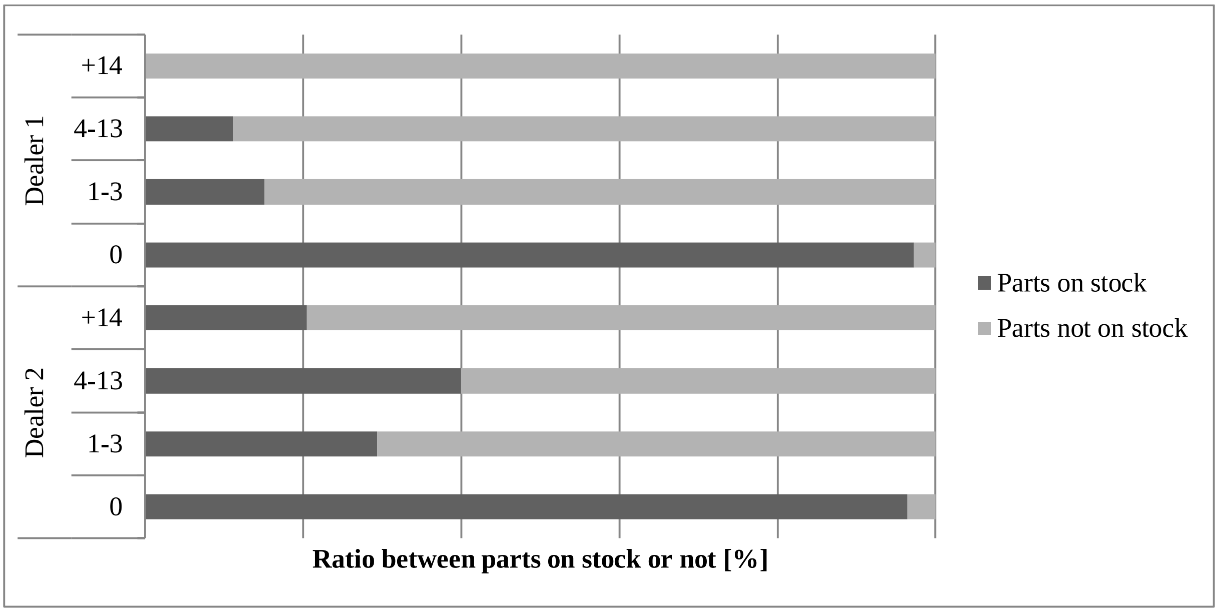

Figure 18: Instant availability of spare parts for over the counter sales.

The dealers sell the majority of the parts the same day as the order comes into the dealership. Of all over the counter orders the dealers sell the majority of the parts the same day. Almost all spare parts are available on stock when they are requested or ordered via inter-branch, Figure 18. Having this high amount of parts available requires high levels of inventory at the dealer to support the instant availability of the parts. When the parts are not sold the same day it is mainly due it not being available and that it needs to be day ordered from DCs.

When spare parts are not sold on the same day they are reserved it is either due to them not being available on stock or the customer order the part from the dealer some days in advance. Almost all orders that are sold within three days are due to the ordered spare parts not being available on stock. This also applies for the orders that are sold in the next time category; 4-13 days. For orders that have two weeks between the reservation and sale there are differences between the two dealers what the reasons are. For dealer 1, spare parts are only sold after 14 days for over the counter sales due to the parts being delivered late from the CDC. For dealer 2 there are much more orders that have 14 or more days in between the reservation and sale than for dealer 1 and the most common reason is that the reservation is made long before the sale where the parts are available shortly after the reservation. So the assumption can be made that the customer is aware of the lead times for parts when they are not available and orders for spare parts are made before the customer needs them. Those parts are mainly ordered as day orders from the CDC.

Workshop orders

Spare parts used for workshop orders are the majority of the orders and spare part use. Different from over the counter sales the majority of parts are available on stock for all time periods, Figure 19.

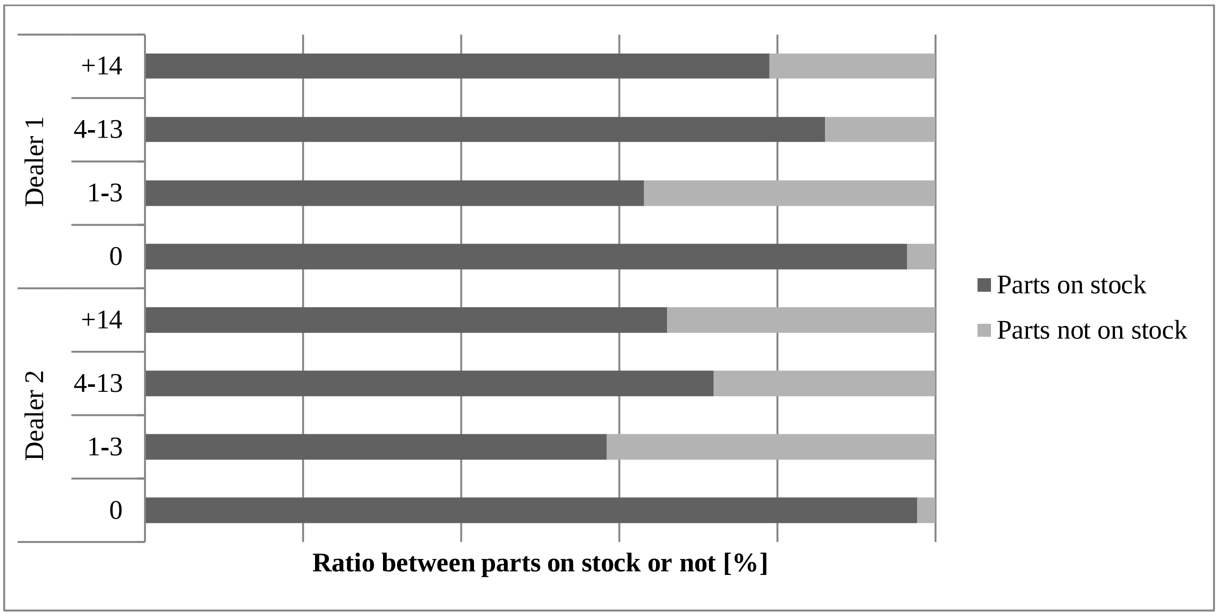

Figure 19: Instant availability for workshop ordered spare parts.

Majority of the spare parts are sold are in the first time category, the same day as they are reserved for workshop orders, where most of the parts are available on stock. As for the over the counter sales it is important to be able to serve the spare parts when they are requested but the spare parts that are used for maintenance and repair services both availability of the i) spare parts and ii) technicians is the deciding factor for when a service can take place. Therefore there are differences in the amount of orders with a longer time between reservation and sale of the part that are available on stock. Either all spare parts needed for the service are not available or the reservation of spare parts is done for a service that will take place later in time. For the parts that are not available on stock but still sold the day that they are reserved use inter-branch deliveries to get the part as soon as possible to keep the uptime of the vehicles as high as possible.

The spare parts that are used for workshop orders are mostly reserved and sold on the same day where the majority of the parts are available at stock. For sales that occur within three days of reservation of the spare parts it due to no parts being on stock or a part of a work order not being on stock at the time of reservation. When a spare part is reserved when a work order is made the part can be on stock and the service takes place after the reservation is made. One influencing factor is that three days before a service the availability of the spare parts are manually checked in the system and then ordered to be delivered from a DC before the day of the service. As it takes one day to receive a spare part when it is ordered as a day order both spare parts that are ordered after a check-up of availability and spare parts that are needed for services as soon as possible.

Spare parts for workshop orders that have more than three days between the reservation and sale account for small amount of the total sales for the dealers. One significant difference between over the counter sales and workshop sales is that when there is a longer than three days between reservations and sales there are much more parts on stock when the reservation is made for workshop orders than when the parts are sold over the counter. For dealer 1 there are more parts on stock for the reservations made for sales after four days, dealer 2 has to rely on more deliveries at the right time to support services that are scheduled later in time, applies both for the third and fourth time categories. Most orders have all or a part of the spare parts on stock when the reservation is made. The spare parts that are not available on stock are most often ordered manually with a short delivery lead time or delivered as an inter-branch order. This means that the spare parts often arrive at the dealer stock long before they are meant to be used for the scheduled service.

At both dealers some orders have an assigned maintenance service to it, meaning that the service is scheduled according to a maintenance contract. This does not necessary mean that the spare parts are ordered in advance providing opportunities to transport parts in a cost efficient way while securing the availability to the end-customer as often the parts are reserved the same day or a few days before the scheduled maintenance service. In some cases the parts are reserved in advance providing opportunities to send the parts from the CDC in time but day orders are the most common for the parts that are not on stock.

6.1.5 Type of Service

Services at the dealers can be divided into preventive maintenance services that can be planned in advance and reactive breakdown services that offer less potential to be planned in advance. At the dealers their services and spare part need is characterised by the nature of the service. As planned maintenance services need to be scheduled in advance at the dealers the spare part requested have the possibility to be reserved at the same time. As breakdown services often do not give notice ahead both the technicians providing the service and the spare parts requested the supply chain has little or no time to respond in a cost efficient way.

6.1.6 Factors that Impact the Pre-Planning Potential

There are a few factors that have impact on the pre-planning potential. Five factors; segmentation of spare parts, the type of orders from the dealers, the work order type at the dealers, the timeframe from reservation to sale of the spare part, and the type of service were identified. The findings are summarized in Table 7 and the possible impact presented with regards the possible cost reduction or avoidance and high uptime of the vehicle.

Table 6: Summary of influencing factors from current planning scenarios.

Factors influencing pre-planning scenarios	Possible impact	Less possible impact
Spare part segments	Prime phase: • Fast moving parts • Medium-Fast moving parts Decline and phase out phase	Initial phase Critical parts Prime phase: • Slower moving parts
Order type to DCs	Day orders: • Large part of total orders Differ between segment	Stock orders: Cost efficient
Timeframe	Spare parts sold the same day as reserved	
Work order type	Workshop orders	Over the counter sales Unplanned services
Type of service	Maintenance services Planned services	Breakdown services Unplanned services

6.2 Identified Pre-Planning Potential

The scenarios chosen to be presented in this section reflect the dealers' behaviour and the orders made. As some scenarios of spare part requirements have more potential to be beneficial by pre-planning the spare parts requirements different scenarios have to be identified based on the dealer behaviour and characteristics.

Spare parts required for planned services

Planned services as defined in section 3.2 are preventive and corrective maintenance. They are not as time sensitive with regards to retrieve the spare parts as for unplanned repairs where there is an immediate loss of uptime. Services that can be planned for the customer before arriving can also give the opportunity to plan the spare parts required for the service with the lead time required, in a cost efficient way. Repair and breakdown services are mostly unplanned services which cannot be pre-planned. Considering diagnostics to increase preventive maintenance will decrease the amount of unplanned services of this type as ICT makes it possible to use more preventive measures than reactive measures. As the lead time required for pre-planning is 14 days unplanned services will not benefit to any extent as the uptime will suffer if spare parts cannot be delivered within a day or two.

Spare parts required for workshop orders

Workshop orders are made for the maintenance and repair services that take place in the workshop by the technicians. This type of services require both the technician and the spare parts being available at the right time in order to minimize the time needed for the service and maximizing the uptime of the vehicle. Workshop services account for most of the spare parts ordered and used by the dealers, where most spare parts for services take place on the same day as they are reserved. This requires high amount of inventory at the dealers and fast responses and transport to deliver the spare parts that are not available. Inter-branch deliveries are common to keep up with the lead time as there might take too long time to get the parts from SDCs or CDCs. One reason for the large amount of services where spare parts have no time between the reservation and sale can be due to the fact that the spare parts are not reserved when the work order is created.

Pre-planning spare parts to a high degree requires the end-customer to be willing to schedule their spare part requirements 14 days in advance and for the technician to reserve the spare parts in the system at the same time. Connecting this to workshop order requires the technicians to know what spare parts will be used for the service that is scheduled. It requires a dialog with the customer when the initial contact is made so it is plausible to schedule and reserve the spare parts required. For sales over the counter it is possible to pre-plan the spare parts requested by the end-customer but due to the custom of having the most common spare parts instantly available it is proven to be difficult to reach the same degree of pre-planning as for spare parts used in workshop services.

Spare parts required on the same day as they will be sold.

When spare parts are sold the same day as they have been reserved in the system the spare parts were required to be available on stock or to be delivered from a Truck Service Centre or a DC on the same day. Spare parts that are kept on stock at the dealers are categorized as fast moving spare parts, or the spare parts that are used for the most common services, and critical parts that are required to be on stock as they are categorized to be more critical than other segments. As identified in Figure 18, this behaviour is the most common one for dealers and from the data analysed three scenarios have been identified representing control of spare parts.

- *All spare parts in the order on stock;* the parts are reserved in the system and as the parts are available on stock they are sold shortly after.
- *No spare parts in the order on stock;* the spare parts are reserved in the system, retrieved from another Truck Service Centre and sold later the same day.
- *A part of the spare parts in the order not on stock;* when a part of the spare parts required are not on stock there are two different approaches used; either the missing spare parts are delivered from a Truck Service Centre and the complete order is sold on the same day or the spare parts that are on stock are sold the same day and the rest when the spare parts ordered from a DC arrive at the dealer stock, this is further explain in the following scenario.

The majority of all spare parts sold at the dealers fall into the first time frame, where the EA-EE segments or fast moving spare parts in the prime phase which also accounts for most of the spare parts at dealers' stocks. As the majority of spare parts sold at the dealers comes from this segment, the high tied-up capital in inventory is necessary to secure high instant availability and as the demand for those spare parts comes on the same day as they need to be sold. The characteristics of this segment supports the assumption that the spare parts in the segment are used for very common services, such as preventive maintenance services that in theory should not be difficult to plan two weeks in advance. Surely not all spare parts in this segment are used for maintenance but a significant part of them are giving this segment high probability of gaining advantages if the spare parts required are pre-planned. Spare parts required for over the counter sales and for reactive maintenance do not have the same opportunities for pre-planning as their use is more often unplanned than planned. For reactive services it is important to have instant availability of the spare parts to ensure high uptime of the vehicle. Therefore it can be concluded that spare parts for planned proactive services will have the highest possibility of pre-planning.

Spare parts required are sold one or more days after reservation depending on the availability of the dealer stock.

In this scenario fall all orders where the spare parts are sold at least a day after they are reserved in the system within at least 14 days, or in the second and third time category, section 6.1.3. When spare parts are sold after the day they were reserved either the customer or service requires parts later or the spare parts are not available on stock then they are requested. Spare parts that are on stock are sold when needed but when not on stock they have to be delivered from the DCs. There are two possible scenarios;

- *All the spare parts are sold on the same day;* the spare parts that are available on the dealer stock are sold when the remaining spare parts arrive at the dealers from the DCs.

- *The spare parts are sold when available at the dealer;* the spare parts that are available on stock are sold immediately when the customer requires the parts and the remaining parts are sold when the they arrive at the dealers from the DCs.

The most common scenario is when the spare parts are reserved on the same day as they are required and the remaining spare parts are ordered as a day order and delivered within three days of the reservation in the system. When spare parts are ordered as day orders it takes one working day to deliver the spare parts to the dealers. If it takes longer time to deliver the parts they are sold when they arrive at the dealers. For preventive maintenance services the spare parts have to be at the dealers when the service is scheduled where the uptime of the vehicle is only affected when the vehicle is in the workshop. Therefore it is important to have the spare parts available when the service is scheduled to take place whereas for spare parts used for reactive breakdown services the uptime of the vehicle is down for a longer time if the spare parts are not available. Spare parts that are not available on stock have to be sent with day orders when not pre-planned so increasing the degree of pre-planning for spare parts that are not normally kept instantly available at the dealers´ stocks would give the opportunity to reduce day orders.

There are also opportunities to decrease the tied-up inventory at the dealers for not so common spare parts, both for slower moving spare parts and for spare parts that are in the decline or phase out phase. As this type of parts are not used in so many services the dealers do not necessarily have to keep them in stock; some spare parts are kept on stock and have a higher risk of obsolescence than parts with a higher service level or the spare parts have to be sent to the dealer with a short lead time. If pre-planning the spare parts is used it is possible to centralize the stock of these spare parts, decreasing the tied-up capital and increasing the turnover rate at the dealer.

Spare parts required are reserved in the system more than 13 days before they are sold.
The last time category, 14+ days, presents the spare parts that are sold with more than 13 days from their reservation. When the spare parts are reserved in the system 14 days in advance of them being sold they fall under the pre-planning concept. Most work orders that have more than 13 days between the reservation and sale of the spare parts receive the spare parts shortly after being reserved, so that the method of delivering the spare parts are the same as for day orders. This means that the spare parts with more transportation cost than necessary and are kept on stock at the dealers generating more tied-up capital and slower turnover rates. For this scenario it becomes evident that in order to reduce inventory levels and avoid high transportation cost it is not only the dealers that have the responsibility to reserve the parts when the service is scheduled, the supply chain has to make sure that the parts are delivered in a cost efficient time when they are needed.

6.2.1 Potential pre-planning scenarios

Five scenarios are identified based on the different factors and the pre-planning potential, Table 8. The scenarios are discussed in terms of; ease of implementing the pre-planning concept with regards to the characteristics of the spare parts and the nature of demand, and the potential impact pre-planning will have on the tied-up capital at the dealer level and transportation cost to the dealers. The potential impact on dealers' inventory levels was evaluated by taking in consideration the impact the chosen scenario can have on the total amount of inventory. The potential impact on transport was evaluated both in terms of the amount of day orders within the chosen scenario and the impact the scenario can have on the total amount of transport. The uptime of the vehicle depends on the spare parts being available at the dealers when at the right time and with a higher degree of pre-planning in the ASC it is possible to have the right spare parts at the right time with a balance between inventory and cost levels.

Table 7: Potential pre-planning scenarios and future performance potential.

Scenarios	Ease of implementing	Potential impact: Inventory at dealers	Potential impact: Transport
Pre-planning fast moving spare parts for preventive maintenance (S1)	High; parts can be planned	High; parts are kept in high amount at inventory	High; parts are sent with high amount of day-orders
Pre-planning slower moving spare parts for preventive maintenance (S2)	High; parts can be planned	Low; parts are kept in low amount of inventory	Low; parts are sent with low amount of day-orders
Pre-planning critical spare part segments (S3)	Medium; depends on service type	Low; have different stocking policies	Low; parts are sent with low amount of day-orders
Pre-planning spare parts for breakdown services (S4)	Low; services and parts are unpredictable	Medium; if parts are kept at dealers Low; if parts are delivered from Volvo	High; if parts are sent with day-orders
Pre-planning spare parts sold over the counter (S5)	Low; depends on customer request	High; parts are kept in high amount of inventory	High; parts are sent with high amount of day-orders

Scenarios that will have the highest potential to improve the spare part control practices are those who both show high potential impact and a higher ease of implementation. The scenarios are presented in Figure 20, where three scenarios show possibilities to be implemented.

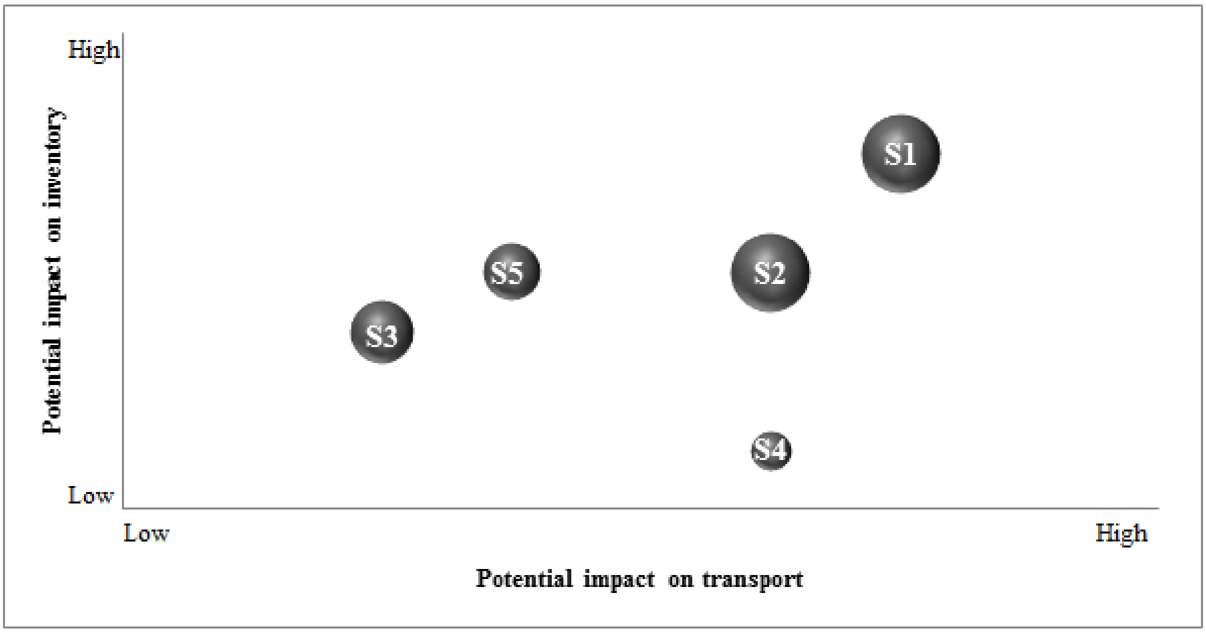

Figure 20: Pre-planning scenarios with high potential of improved performance.

The three scenarios are; pre-planning fast moving spare parts for preventive maintenance (S1), pre-planning slower moving spare parts for preventive maintenance (S2), and pre-planning critical spare part segments (S3). As these scenarios have high potential impact and are relatively easy to implement they have the potential to show the greatest effect on the ASC.

6.3 Effect from Pre-Planning Scenarios

The three chosen scenarios shows that with a higher degree of pre-planned service activities there will be a different level of impact based on the factors identified in section 6.1.

6.3.1 Different Effect from Segments of Spare Parts

The segments of spare parts that will gain the most benefits from pre-planning are the most common ones used; both fast moving and medium moving segments in the prime phase. The possibilities to have an accurate forecast are high securing availability at the CDC and opportunities to support the demand at the dealers in an accurate way. Slow moving spare parts with low service level could also benefit from pre-planning as the parts would not have to be stocked at many locations in the supply chain especially expensive spare parts that create high amount of tied-up capital. Excluded are spare parts that are commonly used for breakdown services as the lead time required would not provide the desired uptime of the vehicle as well as efficient logistics cost if not kept on stock close to the dealers. Scenarios 1 - 3 found identified in section 6.2 were analysed with regards to effects on transport cost where the focus was on reduction of day orders, and inventory level at dealers.

6.3.2 Reduction of Day Orders

Reduction of day orders will have greatest benefits regarding the cost perspective. Day orders require more frequent transport than stock orders and therefore there is a potential to improve the cost efficiency by reducing day order shipments. Not only is there a low amount of parts per shipments, but they are often much more expensive than shipments for stock orders. Air transport is approximately six times more expensive than truck transport as the parts cannot be consolidated on their way and the price for air transport is also much higher than for truck transport for the distance from Gent to the two dealers. Day orders therefore stand for high transport cost compared to stock orders, which is in line with the current situation in the aftermarket supply chain as the highest transport cost is caused by day orders from Gent. With a reduction of day orders, the spare parts supported by the SDCs could be decreased largely as they are mostly used to serve day orders. As pre-planned orders are shipped in a cost efficient way like stock orders they will only be delivered from CDCs and the need of other DCs will decrease.

6.3.3 Reduction of Inventory Levels

The majority of spare parts kept in inventory are faster moving spare parts in the prime phase, segments EA – EJ, as they are most frequently requested by the customer. Critical spare parts that are required to be instantly available at dealers also account for a significant part of the dealers' stocks. The correctness of the inventory is fairly accurate as accurately forecasting the demand for faster moving spare parts with predictable demand is easier than for spare parts that have sporadic demand. Furthermore, there is a need for a great control of the part flow in order to decrease the risk of high amount of slower moving parts in inventory when they transform into the phase out. Later in the life cycle of the spare parts the service level is reduced as the primary product is no longer demanding the spare parts in the same amount as before. It is therefore important to decrease large inventories of these spare parts and to only order the spare parts when the demand is known. Reduction of tied-up capital is one of the focus areas where pre-planning will have an impact without negatively affecting the uptime of the vehicles. Pre-planning the spare parts gives the supply chain the opportunity to deliver parts to the dealers at the right time; just before the service takes place, in a cost efficient way. Not all types of services or segments will have the same opportunities for inventory reduction, but with a higher degree of pre-planning there will be a noticeable amount of spare parts that can be stocked centrally instead of at the dealer level.

6.3.4 Reduction of Returns

Spare parts that will not be used by the dealer can be returned to the CDC. Increasing the amount of spare parts that are pre-planned, where their demand is therefore known, will reduce the number of obsolete parts and returns as more parts are assigned to a specific order. Described at VCS the majority of spare parts that are returned come from spare parts ordered by day orders and where pre-planning should reduce day orders it will also have an impact on returns. Later in the life-cycle it becomes more important to manage spare parts that risk becoming obsolete and have to be returned or scrapped.

6.3.5 Analysis of the Scenarios

Different pre-planning scenarios for different segments were analysed in order to estimate the possible reduction of day-orders and inventory levels at dealers. Three scenarios; S1, S2, and S3, were calculated for three different amount of pre-planning, Appendix V. The degrees of pre-planned services activities calculated were 10%, 30%, and 70%. This amount of pre-planning is established with regards to minimum amount to see effects from the scenario; 10%, the amount that is considered the maximum amount before changes of distribution setup is needed; 30% and the third scenario in order to see the results where pre-planning is the main method used to plan spare part requirements; 70%. The data analysed was the average data from both dealers.

S1:Pre-planning fast moving spare parts for preventive maintenance

Figure 21 shows how different degrees of pre-planning of faster moving parts, segments EA-EJ, affects the reduction of total amount of day orders and the total cost reduction of orders.

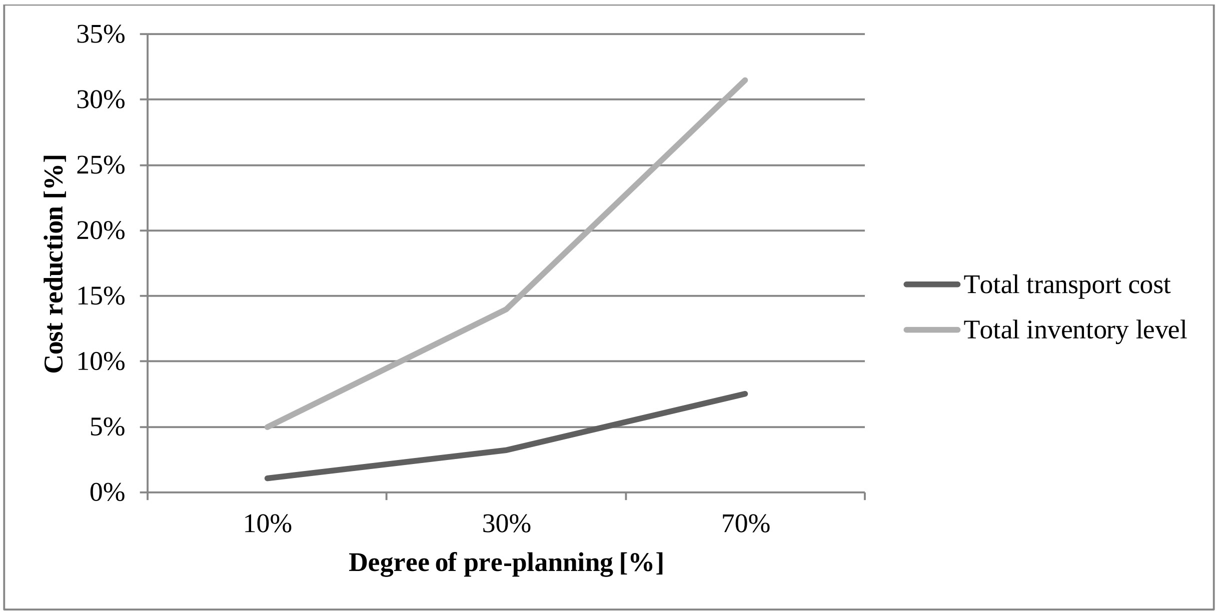

Figure 21: Reduction of total inventory levels and transport cost with different degree of pre-planning, scenario 1

Day orders from faster moving spare part segments represent the majority of total day orders, but within the segments there is a fair balance between stock and day orders. Note that there are different ration between day and stock orders for the fast moving and the medium fast moving spare part segments. The degree of pre-planning has different effect on both the reduction of day orders and transportation cost reduction. Pre-planning spare parts in this segment will provide cost reductions in transportation cost as the total impact on transportation cost is very high whereas the difference within the segment will not provide a high degree of cost reduction due to the current way of ordering. As the majority of amount of spare parts sold comes from these segments the impact from scenario on the total cost will be significant.

Faster moving spare parts segments represent the majority of the total inventory level at dealers. As these segments have a great effect on the total inventory level the potential by reducing the spare parts on stock is high. To further elaborate on the inventory level reduction, the average inventory level was also used to calculate the turnover rate at dealers for the three scenarios and therefore higher degree of pre-planning will also affect the turnover rate. The most significant increase in turnover rate was in within scenario 1 where 10% of pre-planning increases the turnover rate with 6%, 30% of pre-planning increases the rate with 22% and with 70% the turnover rate can be increased with 52%.

S2: Pre-planning slower moving spare parts for preventive maintenance

Slower moving spare part segments, EK-EZ, has less effect on the total day order and total cost reduction, Figure 25. Still there are potential for reduction of transportation cost as the within these segments the majority of orders is day orders whereas the possible cost reduction on inventory levels will not be as large.

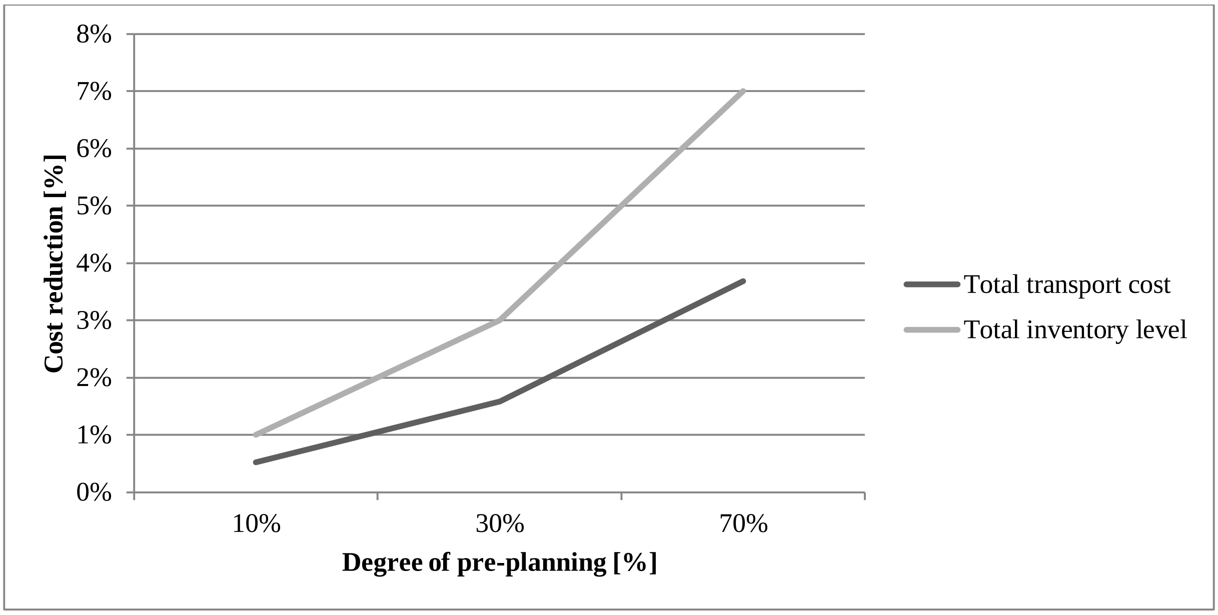

Figure 22: Reduction of total inventory levels and transport cost with different degree of pre-planning, scenario 2

The impact on the total amount of day orders and inventory level is not as high as for scenario 1 as the parts in scenario 2 only represent a small amount of the total spare parts at the dealers. With a higher degree of pre-planned spare parts in this scenario the possible cost reduction of in transportation mainly lays within the opportunity to decrease the amount of day orders in the segments, increasing the amount of spare parts delivered in a cost efficient way.

Slower moving segments represent only a minor part of the total inventory level at dealers as they are mainly kept downstream in the supply chain. The spare parts that are available on stock from these segments have a higher risk of obsolescence that faster moving spare part segments and therefore one important aspect of inventory reduction of spare parts in the slower moving segments is to reduce the risk of the spare parts becoming obsolete as it can be difficult to return the parts on stock before the time limit.

S3: Pre-planning critical spare part segments

Critical part segments do not have high effects on total day orders or the total transportation cost reduction. As critical spare parts are often kept at the dealers' stocks they have a greater impact on the total inventory reduction, Figure 26.

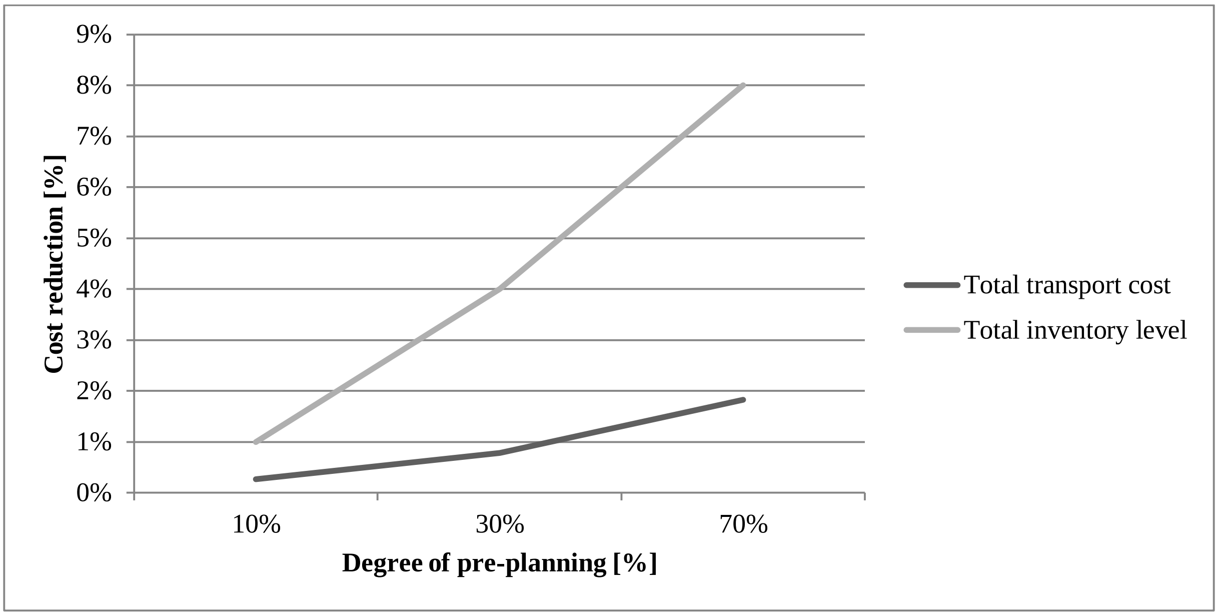

Figure 23: Reduction of total inventory levels and transport cost with different degree of pre-planning, scenario 3

Critical spare parts often have the requirement to have high instant availability and are kept at dealers´ stocks and are mainly delivered by stock orders in a cost efficient way. Therefore the potential cost reduction in transportation for this scenario is not very high. The opportunities for cost reduction are instead on the spare parts that are kept on stock. Critical parts do not follow the same stocking policy as the other movers and certain amount of these parts need to be kept at dealer's stock. These segments only represent a minor of the total inventory level but there are opportunities within this segment of being reduced at dealers' stocks by being pre-planned.

There is a great potential when pre-planning the spare parts used and the impact for the identified scenarios differs with regards to transportation cost and inventory levels. As the scenarios identified are all independent there are possibilities to combine a different degree of pre-planning for the different scenarios for a larger potential in cost savings.

7 Results

This chapter summarizes the main findings of the analysis. It identifies focus areas were Volvo GTO can benefit from pre-planned service activities, obstacles to overcome, and what needs to be improved before higher degree of pre-planning can be implemented.

In order to provide customers with great services in a cost efficient way, a different planning environment of the spare parts is needed. As stated in section 1.2, the purpose of the thesis is to investigate the impact on the aftermarket supply chain at Volvo GTO with higher degree of pre-planned service activities at dealers. There are opportunities within the spare part control with regards to pre-planning where it can have beneficial impact both on higher uptime of vehicles as well as a cost reduction. There needs to be focus on areas that will have beneficial impact on the ASC with regards to balance between reduction of lead time and reduction of cost. Also there is a need to overcome prerequisites for higher degree of pre-planning.

7.1 Focus Areas

Volvo has four goals; to improve uptime of the vehicles, reduce logistics cost, tied-up capital and lead time, and there needs to be a balance between these areas for a higher degree of effective pre-planned service activities Pre-planned service activities have different impact on different parameters within the ASC and Volvo GTO needs to focus on where they can benefit the most on a higher level.

Distribution Setup

The distribution setup at Volvo GTO is designed in a way that it is possible to provide pre-planned orders with two weeks lead time from the CDC. Two weeks of lead time is the time that is needed for the supply chain to respond to customer demand and at the same time providing cost efficient transport and inventory handling. Additionally, if pre-planned parts are only delivered from CDC the amount of parts from SDC can be reduced as well as the inventory level at dealers. The current distribution setup contributes to reducing transportation cost and inventory levels upstream the ASC. Another aspect is the reduction of information lead time as pre-planning provides quicker information lead time giving the supply chain more time to respond to customer demand.

If the focus is on reducing lead time, the uptime of vehicles can be even higher as there will not be as long time for delivery if emergency maintenance services arise. Having shorter lead times for pre-planned orders requires shorter distance to the dealers and these orders have to be delivered from DCs other than CDCs. It also requires higher amount of transportation where parts are not consolidated from CDCs, or increasing numbers of DCs that would be located near the dealers. Therefore, if the focus is on reducing lead time, the other goals; lower transportation and inventory cost cannot be fulfilled.

Inventory control

Segmentation of spare parts is crucial for companies that have high amount of part numbers, such as keeping slow movers at CDCs and faster moving parts at SDCs and dealers stock. Figures show that there is a lack of focus on the parts that are representing the highest amount of cost. This cost is mainly related to transportation cost, as day orders from the DCs to dealers include few numbers of parts but represent very high amount of shipments. In addition, these shipments are often more costly than for other orders as often these parts are delivered with air transport. The main reason for day orders are because of low availability at dealers, where the right amount of parts and the right parts are not kept at stock, and dealers are ordering parts with a short time in advance. Pre-planning will have the impact on the inventory control that parts can be kept in a centralized inventory setup as parts will be delivered on time to dealers before a service occur, and therefore the inventory at dealers can be reduced by the parts that are only kept on stock in order to be available for possible upcoming service.

Transportation

With higher degree of pre-planning the parts can be delivered in the same way as stock orders are delivered today, in a cost efficient way from CDCs. Parts can be consolidated on their way to dealers and the transportation is optimized with a longer time frame. Nowadays parts are often sent with rush transport that represents the majority of the total transportation cost from CDCs. It is important to find a balance between transportation and lead time as shorter lead time requires faster and/or more frequent transportation, which results in higher transportation cost. More efficient transportation can be provided in the ASC by increasing the amount of pre-planning, but the two following statements need to be considered:

- Day orders: It is important to consider the cost of shipment per part. Figures indicate that low amount of parts are shipped with comparable high amount of time sensitive shipments which results in high transportation cost. Therefore a balance of transportation cost and the cost of target availability need to be found.
- There needs to be found a balance between transportation and lead time, as there is not possible to reduce lead time at the same time as reducing transportation time. Pre-planning requires orders in two weeks in advance where the transportation cost can be reduced if the lead time will not be shorter than two weeks for pre-planned orders.

7.2 Effect from Pre-Planning Scenarios

Five pre-planning scenarios were analysed where the focus was put on the three scenarios with the highest potential for implementation and calculations in order to see direct effect on inventory level at dealers and cost reduction of transportation cost with regards to decreased amount of day orders.

S1: Pre-planning fast moving spare parts for preventive maintenance

This scenario has high effect both with regards to total inventory levels and transportation cost as the spare parts in the scenario represent the majority of all spare parts sold at the dealers. The impact on inventory levels at dealers is high as well the transportation cost reduction due to the amount of spare parts in the scenario. This scenario should not be complex to implement as preventive services can be planned and they are not time sensitive.

S2: Pre-planning slower moving spare parts for preventive maintenance

This scenario has comparable low effect on the total inventory level at dealers and transportation cost as the spare parts in the scenario do not account for a large amount of the total spare parts but the potential to reduce cost for the segments presented in the scenario is feasible. For same reason as S1 this scenario is not complex to implement.

S3: Pre-planning critical spare part segments
Certain amounts of critical parts need to be kept on stock at dealers as they do not follow the same stocking policies as other parts. There is a potential to reduce the inventory level but as they are mainly delivered with stock orders they do not have high effect on the transportation cost. Implementation of this planning scenario is considered medium complex as it depends if it is for a maintenance service, which can be easily implemented, or for breakdown services, which are complex to implement.

7.3 Prerequisites for Pre-Planning

Prerequisites for pre-planning need to be overcome before it can be implemented in a higher degree. Following prerequisites were stated:

Collaboration between Volvo GTO and dealers
There is a need for a holistic understanding of the impact from higher degree of pre-planning and both actors need to have same vision of how it can be performed and why it is important for the whole ASC.

Set lead time: As pre-planning requires two weeks in lead time to be managed in a cost efficient way, it is important that both actors are aware of the required time. Dealers need to make the customers aware of the benefits, such as higher availability, and provide an understanding of that pre-planning service visits two weeks in advance is crucial for them to be able to manage the service in efficient way. Volvo GTO has to collaborate with the dealers and secure that with two weeks of lead time the spare parts can be delivered in time before the service at dealers occur.

Changing dealer's behaviour: Dealers are not pre-planning their service activities today mainly because of old habit. They appreciate the current ordering system and are not aware of how higher degree of pre-planning will affect their performance in positive way. Increased diagnostics has an effect on the dealers' behaviour as it is possible to identify when customers need a service and what need to be repaired in that service. It is though also important to involve dealers at an early stage and Volvo GTO needs to inform dealers about the impact from higher degree of pre-planning and train them how to do it in efficient way.

Lack of incentives is one of the reasons why dealers are not pre-planning today. They have access to manual orders that are frequently used. The logistics cost for these orders is higher for Volvo GTO but it does not directly affect the dealers. Informing the dealers about impact from higher degree of pre-planning and how the potential cost reductions will affect them as well as other actors in the ASC will increase the possibility of making the willing to change their ordering behaviour.

Measure current situation to identify areas for improvements
Volvo measures many performance indicators but today there is a lack of measurements that concern pre-planning. It is essential to measure how much is pre-planned today in order to identify improvement areas. Therefore, Volvo GTO needs to measure how much each dealer is pre-planning their services today in order to identify potential pre-planned parts orders. As there are many dealers that only pre-plan their services there are great potentials for them to plan their parts at the same time.

Pre-planned service activities from dealers needs also to be measured as it will highlight which dealers are pre-planning and which are not. This should be done in order to set goals for amount of pre-planned service activities. Goals related to amount of pre-planned service activities are important and they should be in line with the size of dealers.

ICT

A key enabler for improving higher uptime of the vehicle in a cost efficient way by improving pre-planned service activities is IT and 'connected vehicles'. ICT provides direct monitoring of the vehicle with regards to condition and usage. More accurate data on parts needed for a service can be gathered from ICT and is a key step when improving the degree of pre-planned service activities. As ICT can monitor the condition and usage of vehicles, unplanned services can be reduced in line with increased preventive maintenance services.

7.4 Summary of Findings

It has been concluded that higher degree of pre-planned service activities have a beneficial impact on the ASC at Volvo GTO where high uptime of the vehicles can be provided in a cost efficient way. Figure 24 illustrates the opportunities and potential benefits from higher degree of pre-planning, as well as obstacles that need to be overcome.

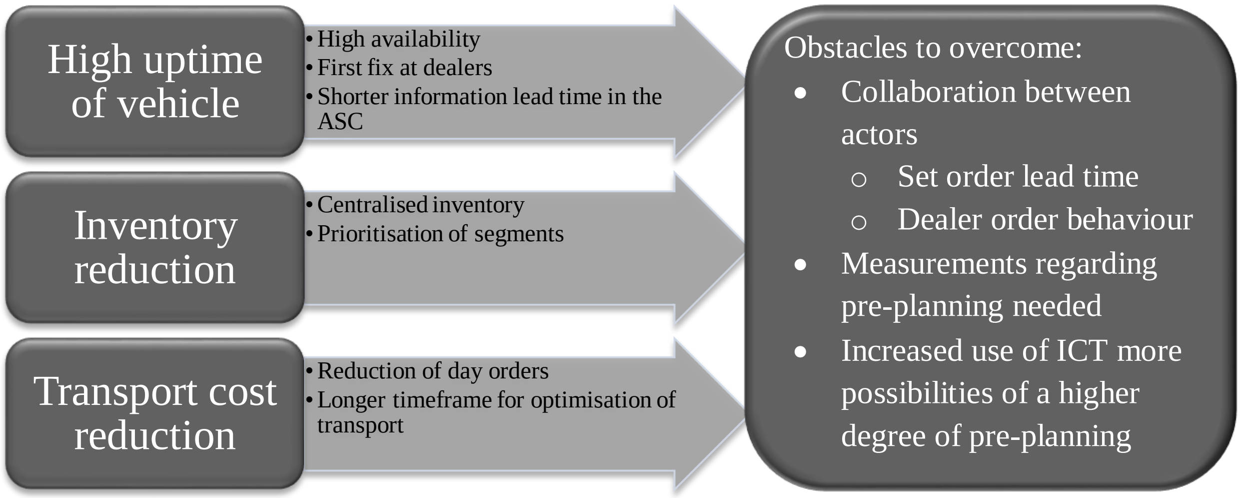

Figure 24: Summary of findings.

7.4.1 Opportunities and Potential Benefits from a Higher Degree of Pre-Planning

- High uptime of the vehicle can be provided to the customers as the availability of spare parts needed for a service will be high. Furthermore, dealers can perform services in effective way as the vehicles can be fixed in the right way at first time. This is further supported by reduction of shorter information lead time between the actors in the ASC as Volvo GTO will be informed two weeks in advance which spare parts are needed for a service.
- Inventory reduction both at dealers' stocks and at SDCs can be decreased. Spare parts can be kept more centralized in the ASC as the parts will be available at dealers in time before services occur and there will be a less need for parts to be sent with day orders from SDCs. As different segments of parts have different impact both on

inventory level and transportation cost, the segments need to be prioritized in which inventory they need to be kept and with which amount.

- Transportation cost can be reduced in line with decreased amount of day orders. Also the time frame for optimization of transport will be longer, or two weeks, Volvo GTO can provide deliveries to dealers in more efficient way.

7.4.2 Obstacles for a Higher Degree of Pre-Planning

- There is a need for a collaboration between Volvo GTO and the dealers as both actors need to understand the importance of two weeks lead time in order to provide services in a cost efficient way.
- Dealers need to be informed on what impact higher degree of pre-planning will have on the total cost reduction in the ASC in order to be willing to change their ordering behaviour.
- Measurements that concerns pre-planning need to be implemented to identify improvement areas and the possibilities of higher degree of pre-planning.
- Increased use of ICT will support higher degree of pre-planned service activities as diagnostics are available to transform emergency services into preventive maintenance services that are easier to pre-plan.

8 Conclusion

This chapter represents the conclusion on the results of the thesis, theoretical and managerial implications, and proposes fields of further studies.

Pre-planning has been defined as planning in advance. For the ASC at Volvo GTO it applies for dealers planning services and reserving the spare parts required two weeks in advance. Pre-planning spare parts in advance brings advantages to the ASC in the form of cost reductions and high uptime of the vehicles. Pre-planned service activities are currently not performed up to a high degree in the ASC at Volvo GTO. This concept has been developed within the automotive industry where it has resulted in a beneficial impact on spare part control.

The results from this thesis is the impact pre-planning has on the ASC and identifications of planning scenarios where pre-planning affects the ASC at Volvo GTO. It is concluded from the analysis that pre-planning can have great positive impact on the current spare part control with regards to practice and performance. The identified impact is related to the cost, cash, and service balance where the main focus is on higher uptime, and reduction of transportation cost, inventory cost, and lead time. Pre-planned service activities provide high availability at CDCs and at dealers' stocks with a determined lead time of two weeks. It has effect on dealers' behaviour as the need for day orders can be reduced in line with higher amount of availability of parts. Transportation can be optimized for longer time scope where the focus on time sensitive deliveries can be reduced. Inventories in the ASC can be centralized with reduction of inventory levels at SDCs and dealers, that both results in less inventory cost and returns of spare parts, and higher amount of turnover rate.

Pre-planned service activities will have different effect from different segments of spare parts and different amount of pre-planning. The major potential benefits are within segments of faster moving parts in the prime phase as if they are pre-planned they can have great impact on reduction of total inventory levels at dealers, and total amount and total cost of day orders.

The theoretical contribution is related to the focus of the thesis on aftermarket services in automotive industries where characteristics of spare part control in ASCs were investigated. It was verified how important aftermarket services are in the automotive industries and which challenges companies need to overcome in order to keep long-term customer loyalty and perform in a cost efficient way.

The limitations of this thesis are related to the type of methods focusing on the impact from a higher degree of pre-planned service activities and not including detailed investigation on prerequisites for this concept to work. As the concept pre-planning has different meanings within different industries and has not been introduced to a large extent in theory, the definition of pre-planned service activities was decided in collaboration with Volvo GTO. As empirical data from Volvo GTO was used to analyse current spare part control at the company, the detailed results can not directly be reflected on other industries. However, the concept pre-planning was investigated and analysed in more general terms and therefore the benefits and obstacles of higher degree of pre-planning can be matched with industries/companies with same characteristics as Volvo GTO. Industries that use spare parts for planned services can benefit from the concept pre-planning as these services can be pre-planned in an easy way. Where the demand for spare parts are more unpredictable it is more complex to implement pre-planning as it has been shown that emergency services for a product are important for customers to be provided as soon as possible often on the cost of efficiency.

This thesis may contribute to future work at Volvo GTO and identify areas that need further research. The results provide Volvo GTO identifications on which areas should be focused on when improving practices and performance of the spare part control with regards to pre-planned service activities. The effect from areas where pre-planning can be increased are stated according to analysis from two studied dealers. Also it identifies prerequisites for pre-planned service activities to work in higher degree. As in the current distribution setup the lead time cannot be decreased while reducing the cost influencing factors. Therefore future research should including more detailed calculations on the balance between reduction of lead time, transportation cost and inventory cost while improving availability in order to estimate how the optimal pre-planning process can contribute to its identified benefits. Prerequisites for pre-planning need to be overcome as change of part ordering behaviour has a great influence on lack of pre-planning. Higher degree of pre-planning is complex to estimate on data that does not include the current amount of pre-planning, and therefore is a need for start measuring performance indicators that are related to this concept.

9 References

ABRAHAMSSON, M. 1993. Time-Based Distribution. *The International Journal of Logistics Management,* 4**,** 75-84.

ALEXANDER, W. L., DAYAL, S., DEMPSEY, J. J. & VANDER ARK, J. D. 2002. The secret life of factory service centers. *The McKinsey Quarterly,* 7**,** 106-115.

ANAND, N. & GROVER, N. 2015. Measuring retail supply chain performance: Theoretical model using key performance indicators (KPIs). *Benchmarking: An International Journal,* 22**,** 135-166.

BACCHETTI, A. & SACCANI, N. 2012. Spare parts classification and demand forecasting for stock control: investigating the gap between research and practice. *Omega,* 40**,** 772-737.

BAXTER, P. & JACK, S. 2008. Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. *The Qualitative Report,* 13**,** 544-559.

BHAGWAT, R. & SHARMA, M. K. 2007. Performance measurement of supply chain management: A balance scorecard approach. *Computers & Industrial Engineering,* 53**,** 43-62.

BOYLAN, J. E. & SYNTETOS, A. A. 2008. Forecasting for Inventory Management of Service Parts. *Complex System Maintenance Handbook.* London: Springer London.

BRAX, S. A. & JONSSON, K. 2009. Developing integrated solution offerings for remote diagnostics. *International Journal of Operations & Production Management,* 29**,** 539-560.

BRYMAN, A. 2006. Integrating quantitative and qualitative research: how is it done? *Qualitative Research,* 6**,** 97-113.

BRYMAN, A. & BELL, E. 2011. *Business research methods,* Oxford, Oxford University Press.

BUNDSCHUH, R. G. & DEZVANE, T. M. 2003. How to make after services pay off. *The McKinsey Quarterly***,** 116-127.

CARDAMONE, P. J. 1996. Critical spares inventory management. *Transactions of AACE International,* MAT21-MAT24.

CAVALIERI, S., GAIARDELLI, P. & IERACE, S. 2007. Aligning stratigic profiles with operational metrics in after-sales service. *International Journal of Productivity and Performance Managment,* 56**,** 436-455.

CAVALIERI, S., GARETTI, M., PINTO, R. & MACCHI, M. 2008. A decision-making framework for managing maintenance spare parts. *Production Planning & Control,* 19**,** 379-396.

CHAE, B. K. 2009. Developing key performance indicators for supply chain: an industry perspective. *Supply Chain Management: An International Journal,* 14**,** 442-428.

CHAN, F. T. S. 2003. Performance Measurement in a Supply Chain. *International Journal of Advanced Manufacturing Technology,* 21**,** 534-548.

CHOPRA, S. & MEINDL, P. 2013. *Supply chain management: strategy, planning, and operation,* London, Pearson, Boston, [Mass.].

CHRISTOPHER, M. & RYALS, L. J. 2014. The Supply Chain becomes the Demand Chain. *Journal of Business Logistics,* 35**,** 29-35.

CHRISTOU, I. T. 2012. Forecasting. *Quantiative Methods in Supply Chain Management: Models and Algorithms.* London: Springer London.

COHEN, M. A., AGRAWAL, N. & AGRAWAL, V. 2006. Winning in the Aftermarket. *Harvard Business Review.* Boston: Harvard Business School Press.

COHEN, M. A., CULL, C., LEE, H. L. & WILLEN, D. 2000. Saturn´s Supply-Chain Innovation: High Value in After-Sales Service. *Sloan Management Review,* 41**,** 93-101.

COHEN, M. A. & LEE, H. L. 1990. Out of touch with customer needs? Spare parts and after sales services. *Sloan Management Review,* 31**,** 55-66.

CORSTEN, D. & GRUEN, T. 2003. Desperately seeking shelf availability: an examination of the extent, causes, and the efforts to address retail out-of-stocks. *International Journal of Retail & Distribution Management,* 31**,** 605-617.

DE LEEUW, S. & BEEKMAN, L. 2008. Supply chain-oriented performance measurement for automotive spare parts. *International Journal of Automotive Technology and Management,* 8**,** 56-70.

FISHER, M. L. 1997. What is the right supply chain for your product? *Harvard Business Review.* Boston: Harvard Business School Press.

FORTUIN, L. & MARTIN, H. 1999. Control of Service Parts. *International Journal of Operations & Production Management,* 19**,** 950-971.

FROWEIN, B., LANG, N., SCHMIEG, F. & STICHER, G. 2014. *Returning to Growth: A Look at the European Automotive Aftermarket* [Online]. www.bcgperspectives.com: BCG: The Boston Consulting Group. Available: https://www.bcgperspectives.com/content/articles/automotive_service_operations_returning_growth_look_european_automotive_aftermarket/ [Accessed 8. June 2015].

GAIARDELLI, P., SACCANI, N. & SONGINI, L. 2006. Performance measurement system in after-sales service: an integrated framework. *International Journal of Business Performance Management,* 9**,** 145-171.

GIANNOCCARO, I. & PONTRANDOLFO, P. 2002. Inventory management in supply chains: a reinforcement learning approach. *International Journal of Production Economics,* 78**,** 153-161.

GOFFIN, K. 1999. Customer support: A cross-industry study of distribution channels and strategies. *International Journal of Physical Distribution & Logistics Management,* 29**,** 374-398.

GOFFIN, K. & NEW, C. 2001. Customer support and new product development. *International Journal of Operations & Production Management,* 21**,** 275-301.

HILLETOFTH, P. 2011. Demand-supply chain management: Industrial survival recipe for new decade. *Industrial Management & Data Systems,* 111**,** 187-211.

HILMOLA, O. & LORENTZ, H. 2011. Warehousing in Northern Europe: longitudinal survey findings. *Industrial Management & Data Systems,* 111**,** 320-340.

HUISKONEN, J. 2001. Maintenance spare parts logistics: Special characteristics and strategic choices. *International Journal of Production Economics,* 71**,** 125-133.

JONES, K. 2001. Planning for aftermarket supply chain. *MSI,* 19**,** 32-34.

JOUNI, P., HUISKONEN, J. & PIRTTILÄ, T. 2011. Improving global spare parts distribution chain performance through part categorization: A case study. *International Journal of Production Economics,* 133**,** 164-171.

KENNEDY, W. J., WAYNE PATTERSON, J. & FREDENDALL, L. D. 2002. An overview of recent literature on spare parts inventories. *International Journal of Production Economics,* 76**,** 201-215.

LAMBERT, D. M. & COOPER, M. C. 2000. Issues in Supply Chain Managemetn. *International Journal of Operations & Production Management,* 29**,** 65-83.

LAWRENSON, J. 1986. Effective Spares Management. *International Journal of Physical Distribution & Materials Management,* 16**,** 3-111.

MARTIN, H., SYNTETOS, A. A., PARODI, A., POLYCHRONAKIS, Y. E. & PINTELON, L. 2010. Integrating the spare parts supply chain: an inter-disciplinary account. *Journal of Manufacturing Technology Management,* 21**,** 236-245.

ROBINSON, A. 2014. *3 Automotive Aftermarket Trends Driving Changes & Best Practices in the Supply Chain* [Online]. Available: http://cerasis.com/2014/10/20/automotive-aftermarket-trends/ [Accessed 8. June 2015].

ROMEIJNDERS, W., TEUNTER, T. & JAARSVELD, W. 2012. A two-step method for forecasting spare parts demand using information on component repairs. *European Journal of Operational Research,* 220**,** 386-393.

SACCANI, N., JOHANSSON, P. & PERONA, M. 2007. Configuring the after-sales service supply chain: A multiple case study. *International Journal of Production Economics,* 110**,** 52-69.

TSANG, A. H. C. 2002. Strategic dimensions of maintenance management. *Journal of Quality in Maintenance Engineering,* 8**,** 1.

WAGNER, S. M. & LINDEMANN, E. 2008. A case study-based analysis of spare parts management in the engineering industry. *Production Planning & Control,* 19**,** 397-407.

WAHBA, E. M., GALAL, N. M. & EL-KILANY, K. S. Framework for Spare Inventory Management. 2012 Çanakkale. World Academy of Science, Engineering and Technology (WASET), 1849.

WANG, W. & SYNTETOS, A. A. 2011. Spare parts demand: linking forecasting to equipment maintenance. *Transportation research,* 47**,** 1194-1209.

WISE, R. & BAUMGARTNER, P. 1999. Go downstream: The new profit imperative in manufacturing. *Harvard Business Review.* Boston: Harvard Business School Press.

VOLVO GROUP. 2015a. *About us - About us : Volvo Group Global* [Online]. Available: http://www.volvogroup.com/group/global/en-gb/volvo%20group/Pages/aboutus.aspx [Accessed 8. June 2015].

VOLVO GROUP. 2015b. *Annual Report 2014 - Trucks* [Online]. Available: www3.volvo.com/investors/finrep/ar14/eng/trucks/introduction.html [Accessed 8. June 2015].

VOLVO GROUP. 2015c. *Our vision - Our vision : Volvo Group Global.* [Online]. Available: http://www.volvogroup.com/group/global/en-gb/volvo%20group/visionmission/Pages/vision.aspx [Accessed 8. June 2015].

VOLVO GROUP. 2015d. *Parts Distribution - Parts Distribution : Volvo Group Global* [Online]. Available: http://www.volvogroup.com/group/global/en-gb/productsandservices/logisticssolutions/partsdistribution/Pages/default.aspx [Accessed 8. June 2015].

VOLVO GROUP. 2015e. *Volvo Group presentation 2015* [Online]. Available: http://www.volvogroup.com/SiteCollectionDocuments/VGHQ/Volvo%20Group/Volvo%20Group/Presentations/Volvo%20Group%20presentation%202015%20English.pdf [Accessed 8. June 2015].

Appendix I

Table 8: List of interviews.

Date	Organization/Department	Position	Topic
Processes			
2015/01/21	Volvo GTO Material Management	Manager	DIM process development
2015/01/21	Volvo GTO Logistics Development	Process Manager	Transport Material process
2015/01/22	Volvo GTO Logistics Development	Director	Logistics development organization
2015/01/22	Volvo GTO Logistics Development	Process Manager	Manage Packaging Material Process
2015/01/22	Volvo GTO Logistics Development	Process Owner	Transport Product process
2015/01/22	Volvo GTO Material Management	Process Manager	Plan Material Parts Process
2015/01/23	Volvo GTO Logistics Services	Vice President OD/VPS & Quality	Logistics Services organization
2015/01/23	Volvo GTO Logistics Development	Process Manager	Handle order parts process
2015/01/23	Volvo GTO Logistics Development	Process Manager	Transport parts process
2015/01/27	Volvo GTO Material Management	Director	MM development Process
2015/02/05	Volvo GTO Logistics Development	Process Manager	Warehouse Process
Dealer perspective			
2015/02/18	Volvo GTS Process & Solution Management DCL	Workshop Process Manager	WPP processes at dealers
2015/02/17 2015/03/19	Volvo GTS Business Systems	Business System Specialist	GDS - Preplanning in theory at dealers
2015/04/13	Volvo Truck Service Centre	Employees in Spare Parts	Observation on dealer behaviour and practices
2015/04/23	Volvo GTS	Purchaser	Case study dealers behaviour and practices
Supply chain perspective			
2015/02/16	Volvo GTO MM Theoretical Optimization	Theoretical Optimization Specialist	Optimize Service and Inventory parameters
2015/02/12	Volvo GTO DIM Process Development	Business Process Manager	DIM processes, concept and benefits
2015/02/19	Volvo GTO MM Process Development	Process Manager	Backorder Recovery Process
2015/03/16	VCS Sverige AB	Project Manager	Pre-Planning at VCS

2015/04/27	Volvo GTO MM Process Development	Project Manager	Transportation in the aftermarket SC
2015/04/08	Volvo GTO Logistics Service Planning	Planning and Strategic Performance Manager	KPIs and PIs in the aftermarket SC
Pre-planning			
2015/04/23	Volvo GTO Logistics Development	Concept Development Manager	Open discussion regarding pre-planning potential
2015/04/27	Volvo GTO Material Management & Development	Manager Logistics Development	Open discussion regarding pre-planning potential

Appendix II

Interviews regarding process descriptions

Introduction

- Description of the thesis topic and its purpose.
- Purpose of the interview.
- Brief description of the interviewee; their position with the company and role within the specific cooperation.

Interview guideline questions

- Please describe your process:
    - What is the process description?
    - What is the purpose of the process?
    - How the process is connected to the level 0 process of Volvo Group?
    - How does the process contribute to the plan material parts (aftermarket supply chain) process?
- Please describe the practice of the process:
    - What are the main practices that are performed in the process?
    - How is the practice measured within the process?
    - What are the main challenges within the process?
- Process performance
    - What performance measurements are responsibilities of the process?
    - What KPI´s are influenced by the process?
- Will a higher degree of pre-planning affect the process?
    - How will a higher degree of pre-planned service activities influence the process?
    - How will a higher degree of pre-planned service activities influence practices within the process?
    - Can you see any challenges with a higher degree of pre-planned service activities?
    - Can you see any benefits from a higher degree of pre-planned service activities?

Further questions

- Is there anything else you would like to add that has not been discussed?
- May you be contacted again if additional information will be needed?

Interviews regarding practice/performance and benchmarking study

Introduction

- Description of the thesis topic and its purpose.
- Purpose of the interview.
- Brief description of the interviewee; their position with the department/company and role within the specific cooperation.

General information regarding pre-planning activities

- Could you describe the spare part control practices for the department/company?
- How does the department/company define pre-planning?
    - When did the department/company begin to pre-plan service activities?
    - Why did the department/company start pre-planning?
    - How has the supply chain changed/adopted with increased pre-planning?
    - How much is pre-planned vs. not pre-planned?
    - How is the distribution structure linked to the control practices?
    - What type of actors participates in pre-planning processes?
- Could you describe the spare part control performance at the department/company?
    - What are the performance measurements (KPI´s)?
        - Why these chosen measurements (KPI´s)?
    - What parameters are affected by pre-planning?
        - How is the impact directly linked to pre-planning?
        - How are they affected?
    - Have you improved any processes/parameters by pre-planning? (if you have not been doing this from the start)

Impact from pre-planning

- How does pre-planning influence the identified actors?
    - Do they get incentives by pre-planning?
    - Have they always been willing to pre-plan their service activities?
- Does pre-planning work the same for all spare parts?
    - Do you segment the parts?
        - If yes then how?
    - Are all parts equally important when it comes to stocking?
        - How do you differentiate?
        - How does differentiation affect parameters?
- What are the main challenges and obstacles for pre-planning that the department/company has experience?
- What are the main benefits from pre-planning that the department/company has experienced?
- What is your opinion on the department/company impact from pre-planning and the effect it has had on the current supply chain structure?

Further questions

- Is there anything else you would like to add that has not been discussed?
- May you be contacted again if additional information will be needed?

Appendix III

Table 9: List of domain, key words and articles for literature study.

Domain	Subject	Articles
Supply Chain Management	Forecast	Hilletofth (2011)
		Jones (2001)
	Responsive	Fisher (1997)
		Christopher and Ryals (2014)
		Abrahamsson (1993)
	Inventory Control	Giannoccaro and Pontrandolfo (2002)
	Challenges	Lambert and Cooper (2000)
Aftermarket services	Aftermarket supply chain	Goffin and New (2001)
		Goffin (1999)
		Cohen et al (2006)
		Cohen et al (2000)
		Lawrenson (1986)
		Lindemann (2008)
		Saccani et al (2007)
		Cavalieri et al (2007)
		Chopra and Meindl (2013)
		Wise and Baumgartner (1999)
		Bundschuc and Dezvane (2003)
	Automotive industry	Robinson (2014)
	Preventive services	Brax and Jonsson (2009)
Inventory Management	Spare part control	Cardamone (1996)
		Fortuin and Martin (1999)
		Kennedy et al (2002)
		Romeijnders et al (2012)
		Wagner and Lindemann (2008)
		Wahba et al (2012)
		Cavalieri et al (2008)
Performance Measurements	Performance Indicators	Anand and Govern (2015)
		Bhagwat and Sharma (2007)
		Chan (2003)
	Aftermarket supply chain	Chae (2009)
		Leeuw and Beekman (2008)
		Corsten and Gruen (2003)
		Jouni et al (2011)
Spare Part Management	Classification	Bacchetti and Saccani (2012)
		Huiskonen (2001)

	Demand characteristics	Wang and Syntetos (2011)
		Martin et al (2010)
	Automotive industry	Boylan and Syntetos (2008)
Distribution set up	Aftermarket supply chain	Goffin (1999)
		Goffin and New (2001)
		Johansson et al (2007)

Appendix IV

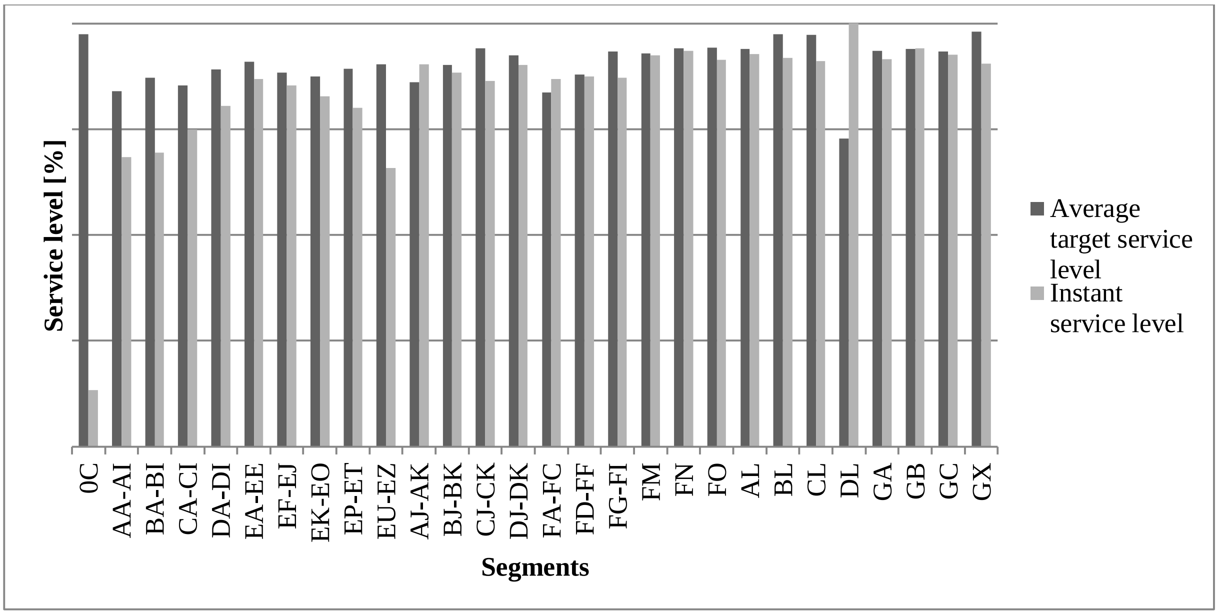

Figure 25: Service level at CDC.

Appendix V

Reduction of inventory cost:

Reduction of average inventory at two dealers was calculated on a part segment level. The percentage of how much each segment group of parts are hold on inventory compared to the total inventory was calculated to see the impact on the total inventory cost reduction. Also the instant availability was used in order to calculate possible inventory level reduction. It was assumed that the average cost for each spare part segment was the same when calculating the total cost reduction.

Reduction of day orders:

Reduction of average numbers of day orders at two dealers was calculated on a part segment level. The percentage for each segment group of how much each segment group of parts are sent with day orders compared to the total amount of day orders was calculated both to see the impact on the total inventory cost reduction and also when calculating the reduction of day orders for each segment.

Reduction of transportation cost

It was assumed that the transportation cost for day orders are 6 times more expensive than for stock orders, and that the transportation cost for pre-planned orders are the same as for stock orders, when calculating the reduction of transportation cost.