UNIVERSITY OF AGDER

Improving on-time delivery at Aker Solutions

A case study of the Spare Parts division

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This master's thesis is carried out as a part of the education at the University of Agder and is therefore approved as a part of this education. However, this does not imply that the University answers for the methods that are used or the conclusions that are drawn.

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Preface

This master thesis is a result of a work done during the 4th semester of the master program industrial economics and technology management, at the University of Agder. The theme of the thesis is a part of the in depth study topic supply chain management. We choose the subject supply chain management as we both find the subject interesting and relevant. Supply chain management involves several areas that are of great importance in today's business environment. It is also a subject that's been widely researched on, but has still a lot of room for improvement. Therefore, we found it suitable to have our master thesis focus on supply chain management and research regarding certain areas within the subject. We choose to write our thesis in collaboration with another business, since we are under the assumption that real life data collected from a case study, helps strengthen the reliability of the thesis. We both wanted to explore the oil industry, thus was Aker Solutions a natural choice. The subject on-time delivery was a result of a presented idea from Aker Solutions and their Spare Parts division.

The thesis is a result of a close collaboration with Aker Solutions' Spare Part division. With this we would like to thank Aker Solution and their Spare Part division for all their benevolence and openness during the whole process. We would like to thank the following participants of the workshop and the interviews: Mette Korsten, Szymon Tyma, Kim Alexander Hansen, Tone-Kristin Svendsen, Jeanette Elise Andersen, Phillip Tryland, Vidar Halvorsen, Isabelle Kreutz and Tor Ragnar Møller Hansen. We would also like to give a special thanks to Kjetil Andersen and Vidar Bjørkmann, which have contributed with fantastic feedback and valuable input through every step of our work. We hope this thesis can be of as much use to you, as you have been to us. Final thanks go to our supervisor Dr. Bjørnar Henriksen, which has given us constructive feedback throughout the process. Henriksen's input has been determining for the thesis and the final result.

Kristiansand 02.06.2014

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Abstract

The purpose of this thesis is to present possible solutions to how Aker Solutions' Spare Parts division can improve their on-time delivery. This thesis is a case study that focuses mainly on the supply chain of the Spare Parts division and not the entire organization. Spare Parts' main task is to provide spare parts to customers. The process of providing the spare parts can involve both internal and external factors. The internal processes include the Procurement division if the items aren't on stock, and warehouse for picking and packing. The external processes include the suppliers that provide Aker Solutions with the products they are selling to their customers. An increasing competition in the oil- and gas industry has led to a stronger focus on achieving a competitive advantage over its competitors. For the Spare Parts division, competitive advantage can be obtained when increasing the on-time delivery and the reliability of the delivery dates given to the customer. Since the effects of having downtime in the drilling activity is much more cost heavy, than paying for an overpriced spare part, a factor such as price is not the most important. The important element is to have the spare parts delivered in a reliable and effective manner. Considering that Aker Solutions' competition also provides most of the same products/services to the same prices, the focus has to be elsewhere than cost when you want to achieve a competitive advantage.

The theory of the thesis focuses on competitive advantage, process improvement- and supplier performance. Insight in a typical process map and how it can be improved has been given, with the use of the tool process mapping. The process map theory has been strengthened with the lean philosophy. The supplier performance theory is mainly based on an article from Tom Davis, a technology manager at Hewlett-Packard. The article describes the uncertainties in a supply chain network. Furthermore, researchers input on how to improve supplier performance, as well as Kraljic´s matrix on how to categorize and work with your suppliers is also described.

Method

The thesis is focused around a case study of Aker Solutions' Spare Parts division, a study that includes both qualitative and quantitative method. To strengthen reliability and validity of the collected data, interviews, a workshop and a survey have been used. Data has been collected from the ERP-system SAP, with the purpose of obtaining insight regarding suppliers, orders and customers.

Results

The results of the thesis involves two areas: supplier performance and process improvement. Supplier performance laid ground for a priority list of the 10 worst suppliers. The list contains comments, suggested focus and action for these 10 suppliers. These results come from an analysis of a specific selection of suppliers in the Spare Parts division that has room for improvement, with regards to raw-data analysis, Kraljic's matrix analysis and survey results.

The approach regarding process improvement led to an improved process map for Spare Parts. The process map was improved through several steps, starting with Spare Parts current process map. The idea was to make the map as accessible as possible, have the map reflect upon the processes as they really are, and to have all involved divisions on the same map. Since the total process of providing customers with spare parts also includes other divisions, it is important to have the map include those processes as well.

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1. Introduction

1.1 Background

The Spare Parts division in Aker Solutions is delivering as the name states, spare parts to their customers. Spare parts that are needed to prevent downtime in drilling activities, as downtime means a great loss of potential income. This means that the price for the services Aker Solutions provide isn't necessarily as important to the customer anymore, since having a non-operative drilling rig is much more cost heavy. The reliability of the services you provide is of much more importance. If you can perform well in this area, the chances are good for obtaining a strong competitive advantage.

1.2 Industrial challenges

The reliability in the services Aker Solutions' Spare Parts division provide has been heavily focused upon, especially in the last couple of years, since Aker Solutions has seen a lot of potential for improving this specific area. The problem lies in the delivery dates given to the customer. It is crucial that these delivery dates is maintained, since they work as an important KPI for evaluating the Spare Parts division.

There are two angles you can look at when striving to obtain more reliable delivery dates: You can analyze the internal process, which includes all the processes linked to getting a demand from a customer to final delivery, and all communication between the parties involved. Another angle is the external angle, mainly focused on the performance and quality of the suppliers. Both of these angles are important and should be included. Spare parts operate with the involvement of both procurement and warehouse, meaning the processes in which these parties are involved should be as informative and effective as possible. Every factor that is of importance to the reliability of the delivery date should be thoroughly investigated. The suppliers that are involved with Spare Parts are also of heavy influence to the delivery dates. When Spare Parts need to buy products from suppliers, the lead-time on the specific product is used when setting the final delivery date. If this lead-time is to differ from what it usually is (normal practice), the product will be late delivered.

1.3 Research questions

Improvement of processes, communication and supplier performance is important key-words for the Spare Parts division. If a good and sufficient strategy for these areas can be obtained, it can be possible to improve the On-Time delivery (OTD) and obtain a greater competitive advantage.

This thesis focuses on the following two research questions:

1. **Can Spare Parts improve their OTD with the external measure supplier performance management?**
2. **Can Spare Parts improve their OTD with the internal measure of process improvement?**

1.4 Purpose of the thesis

With the research questions described, the purpose of this thesis is to develop suggestions for improving OTD in Aker Solutions' Spare Parts division.

1.5 Structure

Chapter 2 - Includes the theoretical framework of the thesis. This framework consists of principles, tools and theory that are important to have an understanding of, when reading and evaluating our research.

Chapter 3 - Gives a presentation of Aker Solution as a case study. Organizational structure, financial situation, vision and values are key elements in this chapter. It also gives a presentation of the Spare Parts division and its challenges.

Chapter 4 - Presents our methodological approach. It explains our use of qualitative and quantitative method, as well as the basis for the interviews and workshop used in the thesis. The chapter also presents a more thorough explanation to our research questions.

Chapter 5 - Includes our results. Information collected from SAP, results gathered from interviews, workshop and survey is presented here.

Chapter 6 - Presents the discussion of the thesis' research questions. This consists of both subjective and objective analyzes of the questions based upon theory and data collection.

Chapter 7 - Gives a conclusion of the thesis. This chapter sums up the discussion and gives a final "answer" to how the presented challenges can be solved.

Chapter 8 - In this chapter final remark, personal experiences and thoughts on areas of future research are presented.

2. Theory

This chapter presents a theoretical framework actively used throughout the thesis. The presented theory is important to have an understanding of when reading and evaluating the thesis. Porters' value chain and his view on competitive advantage are first presented. It is further given an explanation of uncertainties in a supply chain and how it can be managed with the use of supplier performance management. Process improvement with the use of tools like process mapping and value stream mapping is further explained. The lean philosophy, continuous improvement and lean management are included as well.

2.1 Definitions

Often repeated expressions and terminology is explained. The definitions are either taken from theory or from the working language at Aker Solutions.

ERP – Enterprise resource planning, a management system which help companies to upgrade their capability to generate and communicate timely and accurate information (Umble, Haft, & Umble, 2003).

GRPT – Goods Received Processing Time is a time-factor in SAP estimating the time it takes to get the product from a given supplier to Aker Solutions and processed.

KPI – Key performance indicator. Indicators of performance used to evaluate suppliers.

Lead time – The duration from a product has been ordered to the product is ready for shipment.

OC – Order Confirmation, a document from a given supplier to Procurement, confirming a PO.

OTD – On-Time delivery, a measurement in percentage of how many deliveries that arrive on the final destination on time. 1-OTD (inverse) is the measurement of late deliveries.

PO – Purchase Order, a document from the Procurement division to a given supplier, confirming a request for that order.

QT – Quotation, a document from a customer to Spare Parts, confirming a request for order.

SAP – System analysis and program development. SAP is the largest and most used ERP system as of today, with 50% of the marked share (Gargeya & Brady, 2005). SAP was founded in 1972 by 5 individuals and has grown to include over 50 000 employees, 250 000 customers and a revenue of 16.82 billion euro in 2013 (SAP, 2014).

SO – Sales Order, a document from the Spare Parts division to a given customer, confirming that customers order.

"Worst supplier" – The term "worst supplier" is used in this thesis as a factor describing the reliability of delivered goods from a supplier. Factors such as customer service, price, HSE, etc. is not taken in to account when using this term.

2.2 Supply chain management

Cooper, Lambert, and Pagh (1997) argue that supply chain management (SCM) has risen to prominence over the past ten years. Some researchers claim that globalization is a leading factor, because more and more companies have gone global when using suppliers (Mentzer et al., 2001). Furthermore, a large global network of suppliers means a more complex flow of materials through the company, which creates a need for more effective coordination and a closer collaboration with the suppliers. According to Mentzer et al. (2001), delivering a defect free product to the customer fast and cost-effective isn't the competitive advantage it used to be, but now rather a requirement to stay in the market.

A precise definition of the term "*supply chain management*" can be hard to come by, much because of the expression being frequently used on different levels. The term is often used as both an operational term describing material and product flow, but also as a management philosophy. The authors of the article "*Defining supply chain management*" have made a thorough study of SCM, which includes several different approaches to the subject. This ended in the following definition: "*Supply chain management is the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole*" (Mentzer et al., 2001, p.18)

2.2.1 Porters value chain and competitive advantage

"*Competitive Advantage describes the way a firm can choose and implement a generic strategy to achieve and sustain competitive advantage"* (Porter, 1985, p.26). Porter (1985) argues that competitive advantage cannot be obtained by treating a firm as one division, but rather focusing on the many activities a firm performs such as designing, producing, marketing, delivering, and supporting the final product. This is also known as the "*industry structure view*", where over normal returns is a result of a firm´s participation in an industry with a good structural organization (Dyer & Singh, 1998). A second view, which stands in contrast to the "*industry structure view*", is the "*resource-based view*". This view argues that what resources a firm have and how the firm manages those resources reflects the firm´s competitive advantage (Barney, 1991). Porter´s value chain was

first introduced in his book "*Competitive Advantage*", published in 1985. He describes a firm's value chain as a tool to perform a systematic analysis of the activities a firm performs and how the activities interact with one and another. Porter (1985) states that this is necessary to understand how a firm can accomplish competitive advantage. Furthermore Porter states that: ***"****A firm´s value chain and the way it performs individual activities are a reflection of its history, its strategy, its approach to implementing its strategy, and the underlying economics of the activities themselves*" (Porter, 1985, p.36). Meaning even though some of the chains in competitive firms can be similar, the total value chain is for certain to differ. This difference is one of the key sources to competitive advantage, and the explanation to how some firms can gain a bigger advantage than other.

Value is defined as the amount buyers are willing to pay for what a firm provides them (Porter, 1985). If the value a firm commands, exceeds the costs spend on the product it produces, the firm is profitable (Porter & Millar, 1985). To create value for the customers that exceed the amount spended on producing the product is the goal of any strategy (Porter, 1985).

2.2.2 The processes of the value chain

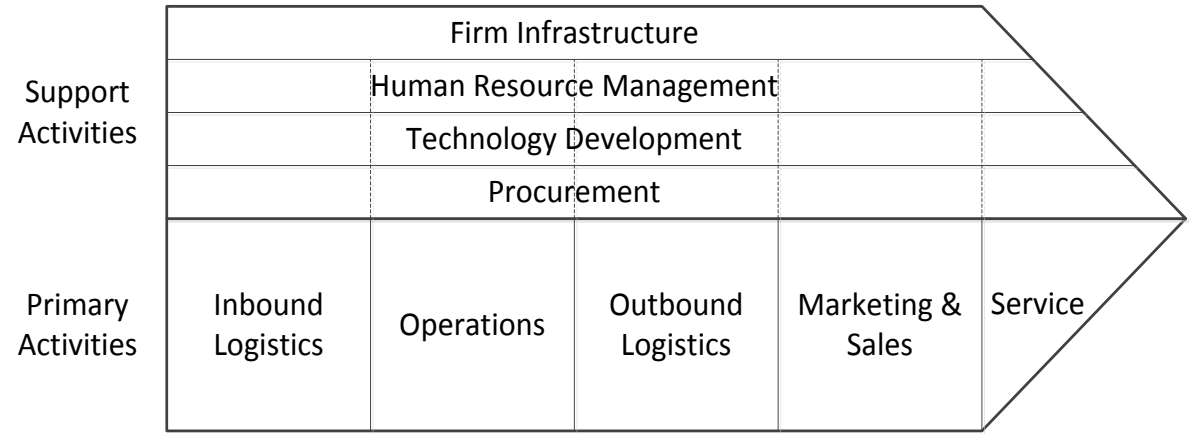

Figure 1: Porter's value chain (Porter, 1985, p.37)

The value chain divides firms' processes into primary processes and support processes. These are all processes a company performs in order to do business. A company must either perform these processes at a lower cost than its competitors or perform them in a way that gives the processes differentiation, which again allows the firm to get a better price for its products (Porter & Millar, 1985). The processes at the bottom of the value chain model (Figure 1) are the processes involved in giving the product added value, while the processes on the top of the value chain is called supporting processes, which provides support to the primary processes. (Porter, 1985).

The primary processes consist of 5 generic categories. These are inbound logistics, operations, outbound logistics, marketing and sales and service (Porter, 1985):

- **Inbound logistics** – Typical processes can be material handling, warehousing, inventory control, vehicle scheduling, and returns to suppliers.
- **Operations** –Typical processes can be machining, packaging, assembly, equipment maintenance, testing, printing, and facility operations.
- **Outbound logistics** – Processes regarding collecting, storing and distributing the products to the customers. Typical processes can be warehousing, material handling, transport, order processing and scheduling.
- **Marketing and Sales** – Typical processes can be advertising, promotion, sales force, channel selection, channel relations and pricing.
- **Service** – Typical processes can be installation, repair and training.

Naturally all the processes involved may not be vital to every industry. Which processes that are vital for competitive advantage differentiates depending on the industry.

The support processes consist of 4 generic categories. These are infrastructure, procurement, human resource management and technology development (Porter, 1985):

- **Infrastructure** – General management, quality management and business management.
- **Procurement** – Includes processes such as purchasing and storing, not the physical handling of the products.
- **Human Resource Management** – Recruiting, hiring, training and developing.
- **Technology Development** – Development of new technology, know-how knowledge and procedures.

2.3 Uncertainties in the supply chain

An article written by Tom Davis, technology manager at Hewlett-Packard (HP), shows the uncertainties in a total supply chain network (Davis, 1993). As shown in Figure 2 there are many uncertainties linked to the total outbound uncertainty from a company to the end customer. This predicament is according to Davis what many businesses fail to see. As a company analyzes its own manufacturing process to best stand up against uncertainties, they ignore all external uncertainties that also affect the total supply chain network. For instance, if a company knows that their operations have a 95% chance of being completed on time, with no errors on machines, manpower, etc. What happens to that percentage if the supplier(s) delivering the necessary materials have an on-time delivery (OTD) of only 70%? The company's actual OTD out to customers would then get greatly reduced (Davis, 1993).

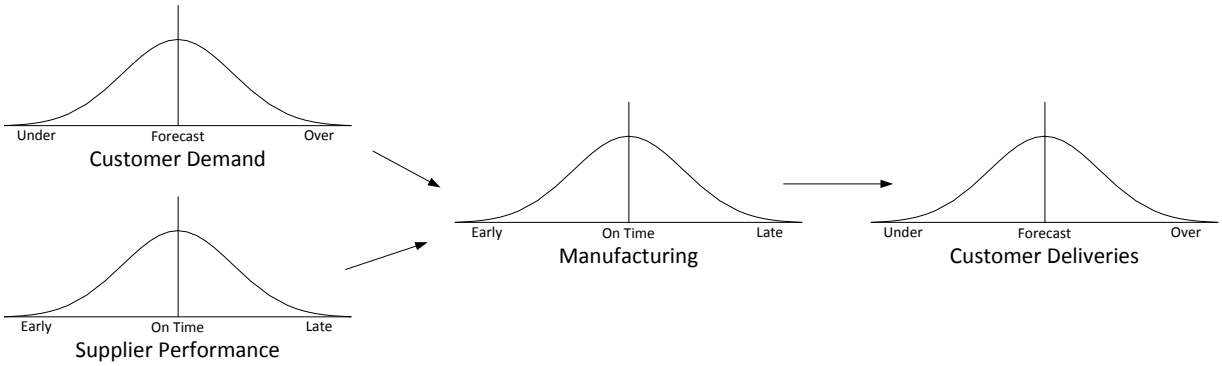

Figure 2: Uncertainties in the supply chain (Davis, 1993)

2.3.1 Customer demand

Customer demand as seen from figure 2, marks a major source of uncertainty according to Davis (1993). Depending on the product a company is selling and the factory's location, customer demand can be very variable. Orders often respond to an up-and-down demand. A stabile flow of materials is very unlikely and therefore most factories keep some stock, filling orders from the inventory as needed. The problem with this uncertainty is that it escalades corresponding to the variables in demand. "*The more variable the orders, the more stock is required to reliably meet customer demand*" (Davis, 1993, p.38).

2.3.2 Supplier performance management

The supplier performance uncertainty is related to variables within the supplier that affects the supply chain (Davis, 1993). A machine break-down, an unreliable material flow-system or a bad sub-supplier to the supplier, are examples of issues that can lead to products being late delivered (Davis, 1993; Gordon, 2008). Looking at the supplier performance is often referred to as supplier performance management (Fawcett, 2007) or business relationship management (Gordon, 2008). According to Gordon (2008) it is important for mangers to evaluate, measure and monitor the supplier performance to reduce risk, cost and to strive for continuous improvement. More and more companies agree that one of the most important tools in managing a supply chain and to achieve competitive advantage is measurement (Beamon, 1999; Fawcett, 2007). According to Fawcett (2007) measurement creates understanding, drives behavior and leads to results. Even so, many companies struggle with understanding what to measure and how to measure it (Fawcett & Swenson, 1998). Albert Einstein once said: "*Not everything that counts can be counted and not everything that can be counted counts*" (Fawcett, 2007, p.408). According to Lambert (2008) most companies use measures that have several problems preventing them to fully utilize their supply chain performance. For instance, they look at measures for the company as a whole, instead of looking at the company as an organ of the supply chain. Beamon (1999) states that a company essentially uses two types of measurement; cost and customer responsiveness. Cost measures can among many factors be related

to operations and inventory cost, while customer responsiveness relates to internal logistics measures like fill rate, lead-time and on-time performance. There is much research on the utilization of measuring cost (Christopher, 1998; Cohen & Lee, 1988; Lambert, 2008; Tzafestas & Kapsiotis, 1994), customer responsiveness (Davis, 1993; Gilmour, 1999; Lee & Billington, 1993) and a combination of both measures (Davis, 1993; Towill, Naim, & Wikner, 1992). Beamon (1999) further states that there is need for better multi-firm measures to effectively measure the supply chain performance. Such measures like information flow and supplier performance have been identifies as appropriate for analysis but have not yet to be used in extensive supply chain modeling research (Beamon, 1999).

2.3.2.1 Kraljic's matrix

A popular and well known supplier performance tool is called the Kraljic's matrix (see figure 3). It is a highly acknowledged and accepted purchasing tool used to map all suppliers in different boxes based on the type of product(s) their supplying the company, and the volume of that product (Gelderman & Van Weele, 2003; Kraljic, 1983). As seen in figure 3 the suppliers get rated by the complexity and the importance (volume) for the company, giving it a (x,y) value and putting it in the leverage, strategic, non-critical or bottleneck box (Kraljic, 1983; Krause, Handfield, & Scannell, 1998). The **non-critical** box refers to low-volume and low-complexity products. These are products easily obtained and have little or no negative consequence on the company if they fail or get delayed. According to Kraljic (1983) purchasing should focus on buying functional, efficient and standardized products. Order volume should be optimized based on inventory management. The **leverage** items are not very complex and vital to the company, but they are of high need in volume. Because of this high volume purchasing has more power and should use this to push prices, look for alternative suppliers and optimize order volume (Kraljic, 1983). **Bottleneck** products are products with a high complexity, meaning they're important to the company and there are few alternatives. Furthermore they're needed in low quantities giving the company less purchasing power. Purchasers should focus on controlling the suppliers and legally insure any volume bought. In addition Kraljic

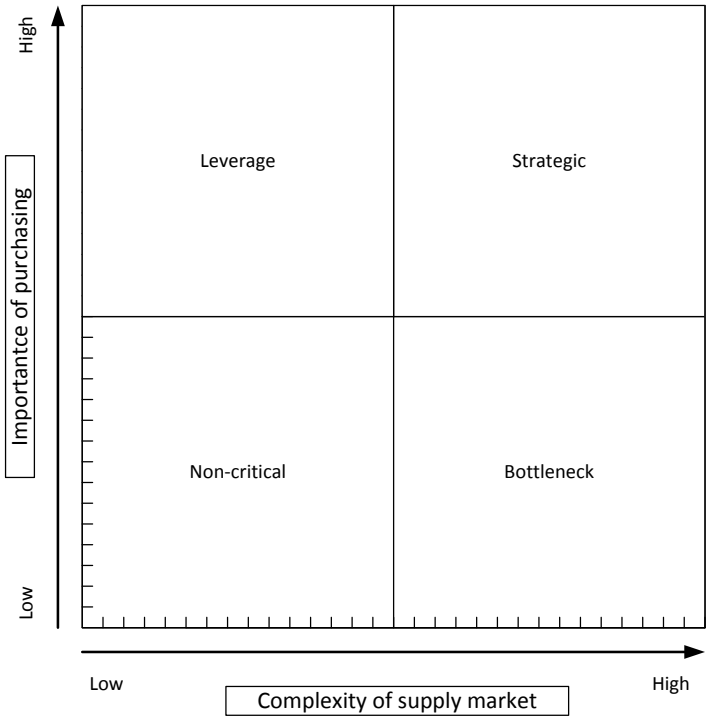

Figure 3: Kraljic's matrix (Gelderman & Van Weele, 2003)

(1983) stress the need for a back-up plan in case anything goes wrong. Since this is a bottleneck product an error could result in a total stop in production. The last box represents the **strategic** products. These are highly complex products needed in large volumes. Purchasing decisions should according to Kraljic (1983) be made on the top level. Accurate demand forecasting and detailed marked research is necessary. There is need for good risk analysis and contingency plans. The company should also consider making the products themselves if possible. A well determined mapping of all suppliers in Kraljic's matrix can give a good foundation for further purchasing strategy and provide the company with the necessary information to further develop their supply chain (Gelderman & Van Weele, 2003; Kraljic, 1983). However, there are several unanswered issues researchers have gathered regarding Kraljic's matrix:

1. Weighting of the supplier in the matrix is the most important factor for success, but at the same time the most difficult thing to do as the method is very subjective (Olsen & Ellram, 1997).

2. The matrix doesn't include strategies for how to handle the different strategies and responses to the suppliers (Kamann, 2000).

3. To move suppliers across boxes in the matrix would prove extremely useful and effective in some cases, but there are no guidelines as how to do this (Cox, 2001).

2.3.3 Manufacturing: Process improvement

Another source of uncertainty is the manufacturing process itself (see figure 2). There are many different problems that can occur in this part of the supply chain. A machine can break down, a product (or a batch) can fail, manpower gets tied up in other projects, etc. According to Davis (1993) an important factor to measure is the process performance. Examples of actions are to shorten the cycle time and to remove bottlenecks. To fully understand and improve this part of the total supply chain, it is important to widen the perspective and look at this process as all internal process linked to the product/material being bought in, to the finished product is delivered to the customer (Anjard, 1996). These processes include everything from creating an order, information flow across internal/external divisions, receiving the order, to the product is picked up by or delivered to the customer. In the two following chapters two tools that can be used in improving processes are presented.

2.3.3.1 Process mapping

Fawcett (2007) states that in if an organization does not design its supply chain, but let it evolve based on processes and choices made independently over the years, you can expect poor coordination, long cycle times, customer service issues, too high inventory and lower than optimal profit. Great supply chains must be designed properly in order to being able to fulfill the needs of customers and stakeholders.

"*Process mapping is to identify, document, analyze and develop an improved process*" (Anjard, 1996, p.1). Process mapping helps us understand the business and improve the performance of your processes (Anjard, 1996). The primary goal behind process mapping is in many ways to make the entire "*business picture*" more visible (Fawcett, 2007). It is a graphic representation of a system, which consists of different tasks that must be performed to produce a desired outcome. Why is it important to focus on the processes? To answer this question it can be natural to first consider what a process is and what it includes. Rummler and Brache (2012) states that the process level is the least understood and managed level of the total enterprise. Anjard (1996) explains a process as a series of activities that transforms input to something of value for a customer (see Porter (1985) definition of value), while Hunt (1996) describes a process as steps designed to produce a product or service. Wig (1996) defines a process as a combination of factors that together produces a certain result. Based on these definitions a conclusion that processes and the management of them are important to gain and maintain competitive advantage, can be drawn.

The result of the process mapping will be an improved process map, which shows the work processes and how the different inputs, outputs and task are linked to one and another (Anjard, 1996). The process map underlines important steps of the total process and highlight what steps are the most fragile to certain changes. Fawcett (2007) states that by creating a high-level process map, we can better understand the interdependencies and flows within the supply chains. Furthermore it is stated that we can look more closely at different processes to explore what opportunities we have on improving or removing the current process. Certain criteria should be fulfilled in order to do a successful process mapping. The team performing the mapping should have a good understanding of the process at hand; they should have a credible relationship to other team members and also to the organization. A certain degree of creativity and energy level is also recommended (Anjard, 1996). A solid definition of the process mapping can be useful. This includes determining the boundaries of the process, and what you want to improve.

How to draw a process map

A flow chart can be used to draw a process map. Some of the purposes of a flow chart are (Wig, 1996):

- To illuminate a process the way it actually is.
- To illuminate the coherence between the different activities in the process.
- To exchange information about the process.
- To develop a joint opinion of the process in a group.
- To identify quality deviation in the process.

The use of a flow chart can help decide the grade of details. It is important to remember to be flexible in the use of techniques. A tip can be to use yellow stickers before drawing the final chart, that way it's easy to make changes while drawing. When drawing the flow chart, there are different symbols representing different actions. The procedure in drawing a flow chart is as follows (Wig, 1996):

1. Agree on the purpose of the chart.
2. If you're dealing with larger and more complex processes, you should make an overview of the main areas of what the chart will involve.
3. Define the outer limits of the processes.
    a. Have a clear start point for the first activity, and place it at the top of the wall.
    b. Mark the end of the process and place it at the bottom of the wall.

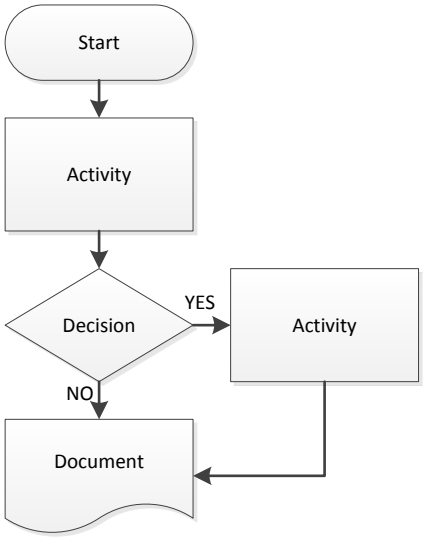

Figure 4: A basic flow chart (Wig, 1996)

4. Describe every step of the process. Start with the first. Always ask yourself what the next step in the process is.
5. Every decision that affects the next step or later activities needs to be marked with a decision symbol (see figure 4). When you're dealing with a point of decision, choose an answer and continue drawing the chart.
6. If a point that is unknown to the people drawing the map, note it down and continue drawing the chart.
7. Repeat step 4, 5 and 6 until you have reached the end of the chart.
8. Go back and construct the other paths of the decision symbols. Describe every extra activity expanding from the decision symbol.

9. Undergo the chart one more time to check if you have included every decision/control activity or special activities that can cause more work in a different process.
10. Discuss how your group will deal with steps you are insecure of.
    a. Make a physical observation of the process if possible.
    b. Discuss the chart with the operators.
11. When the flow chart is correct, analyze it!
    a. What is the flow chart actually saying?
        i. Are some steps unnecessary?
        ii. What input in the process leads to extra activities?

2.3.3.2 Value Stream Mapping

"A value stream is the process flow from the "point of requested need" to "closure of all activity" after the product or service has been provided" (Nash, 2008, p.1). A value stream is different from a standard supply chain or value chain because traditional supply or value chains involves every activity both within company, but also within other companies involved, whereas a value stream only includes the specific activities of specific parts of the company, which adds value to the product/service in question (Hines & Rich, 1997). On the other hand, there seem to be researchers claiming that a value stream includes both the value adding activities as well as the non-value adding activities (Rother & Shook, 2003). "*Value stream mapping*" is a tool that helps you to get an overview of the flow of materials and information in the value stream. The way you perform the mapping is simple, where you follow a product/service from the customer to the supplier while trying to draw a detailed map of every step in the process. Then after mapping the actual situation, you draw a map of how an ideal process should flow (Rother & Shook, 2003). The purpose of "*value stream mapping*" is to learn how to see value and waste, which again leads to making the process as effective and value creating as possible. As a process tool, value stream mapping is a way to "*see*" the process and communication flow within the value stream. Lean thinkers have acknowledged the tool, much because of the way value stream mapping gathers, analyze and present information in a very specific time period (Nash, 2008). *"Value stream mapping has brought us a process mapping technique that enables all stakeholders of an organization to visualize and understand a process. These maps can enable everyone i.e., management, the workforce, suppliers, and customers to see value, to differentiate value from waste, and to create the plan of action for waste elimination"* (Nash, 2008, p.1).

2.4 Lean and lean thinking

"*Lean thinking could be the antidote to economic stagnation*" (James P Womack & Jones, 1996, p.16). Lean and lean production is a value-adding and waste-eliminating philosophy that originates from the Japanese car manufacturer Toyota. It's been getting a lot of attention due to its high focus on adding value to the customer and the process of eliminating 7 different forms of waste (Howell, 1999). The lean philosophy focuses not only on the production processes but on the supply chain as a whole. It also strives for continuous improvement (known as kaizen), so that the implementation of lean thinking becomes more of an endless process than a one-time operation (Standard & Davis, 2000).

2.4.1 History

Japan and Toyota's innovational conceptions which resulted in several successes in the industry and management, has drawn a lot of attention around the world (Eikeland & Borg, 2013; Golhar & Stamm, 1991; Huang, Rees, & Taylor, 1983; Huson & Nanda, 1995; Wig, 1996; James P Womack & Jones, 1996). To understand the philosophy and how it became a reality for Toyota, we must go all the back to the 20th century and to the United States were the great depression scattered the country. Henry Ford was a car manufacturer and CEO of Ford Industries. Ford managed to mass produce identical cars with an extreme efficiency. This was the concept of standardization and mass production (Eikeland & Borg, 2013; Wig, 1996). Since the work demanded such a low level of expertise, it was easily learned and since the country struggled with high unemployment, workforce was easily obtained. Ford could offer them minimal pay. The news of Ford's great success in USA reached all corners of the world and the Japanese decided to travel over to find inspiration they could bring back to Japan and Toyota.

One major problem with Ford's mass production system was that it had a bad quality system. The cars were produced in batches, so if one car had an error the whole batch of cars would have the same error. The solution was installing a crew that fixed newly produced cars (Eikeland & Borg, 2013). This problem and other issues was something Toyota wanted to improve. With Ford's system of production as a foundation they came up with a new concept called the "*Toyota Production System*" (TPS). Standardization and mass production of the same car wasn't good enough anymore, people no longer wanted the same car. Furthermore, when the labor started to balance, workers didn't like to be treated as variable cost no longer. TPS attended these issues by treating workers like resources rather than variable cost and the production changed from mass standardization to mass customization (Eikeland & Borg, 2013). This would soon prove to be a great achievement. In the early 80's a survey covering the quality management of American and Japanese car manufacturers was released. This survey showed that 15 % of American personnel worked on controlling other workers,

as opposed to Japanese personnel who only had 1 % (Wig, 1996). The concept of lean comes years later when the Massachusetts Institute of Technology (MIT) decided to investigate the great success Toyota had achieved, to bring it back to the US. According to Eikeland and Borg (2013) a student looked at the system and said "*this is so lean*", and the concept was born. The investigation of TPS led to a well know book called the "*The machine that changed the world*", describing the case study done by MIT over a 5-year period (James P. Womack, 1990).

2.4.2 Tools and concepts

There are many tools and concepts associated with lean and lean thinking (Eikeland & Borg, 2013; James P. Womack, 1990). It is according to Eikeland and Borg (2013) important to remember that many of the concepts does not originate from Toyota and their production system. Lean is simply a collection of new and old concepts developed and simplified to fit a company's effort to strive towards continuous improvement. Relevant core concepts for this case study are described as follows:

2.4.2.1 Continuous improvement (Kaizen)

Continuous improvement (also known as Kaizen) is a management approach originating from Taichi Ohno and his Toyota Production System (see figure 5). The management philosophy has proven to raise the efficiency of many processes and is closely related to total quality management and just-in-time (JIT) (Zangwill & Kantor, 1998). The word "kaizen" is Japanese and stands for sustainable change (Wig, 1996). Eikeland and Borg (2013) have illustrated Kaizen as an umbrella embracing all other lean concept like JIT, TQM, Six Sigma, etc. Japan and Toyota constantly focuses on small improvements and adjustments, resulting in a major difference in total (Wig, 1996).

2.4.2.2 Deming's circle

"W. Edwards Deming is considered by many to be the founding father of the quality movement" (Beckford, 1998, p.65). Deming is well known for his seminars for Japanese engineers and managers (Moen & Norman, 2006; Wig, 1996). Among his work is the Deming's cycle, an improvement of an already invented concept, which consist of design, production, sales and research. The cycle was later translated to the PDCA cycle, consisting of plan, do, check, action (also referred to as Deming's cycle) (Deming, 2000; Moen & Norman, 2006) (see figure 5). The PDCA cycle is one of the most important tools in quality management and has

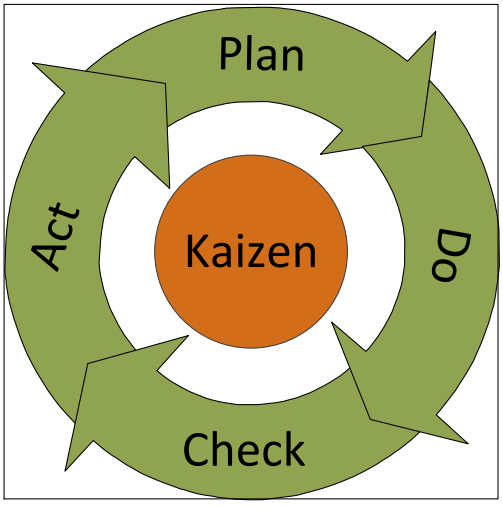

Figure 5: The PDCA cycle (Moen & Norman, 2006)

been extensively used in the development of quality policies (Cheng, 2008; Sokovic, Pavletic, & Pipan, 2010; Wig, 1996). It is a tool to clarify and illuminate the processes from planning, to execution, to control and then standardization. The cycle shows all necessary activities to make an improvement and it shows the entire process from a broad perspective. This illuminates the process of learning (Wig, 1996). It is a clear instruction to the organization that good quality activity is best performed through continuous improvement (Beckford, 1998). Wig (1996) has divided the cycle in sub-segments, giving a more detailed overview of the processes involved (see figure 6: The PDCA cycle – detailed (Wig, 1996)).

1. The first phase is the **planning** phase. This is the place to identify where you are and where you want to go (Eikeland & Borg, 2013; Wig, 1996). To do this there are several tools available. Normally the current situation consists of analyses, benchmarking, delivery performance, etc. The wished situation is relied upon the strategies and goals of the company. Moen and Norman (2006) stress the importance of aiming at improvement in this phase. Deming (2000) states that focus should be on long-term goals and planning. "*Where do we wish to be five years from now?"* (Deming, 2000, p.24). Lastly, it is discussed how the company is supposed to get where they want (Wig, 1996).
2. The next phase is the **do,** or **execute** phase. This phase consists according to Wig (1996) of communication, resource gathering and execution. It is important to communicate with all involved workers and train them so that they're able to perform (Deming, 2000; Wig, 1996). Additionally, there are usually resources needed other than workers (materials, machines, etc.). Finally the plan is executed (Wig, 1996). According to the article by Moen and Norman (2006) this should preferably be carried out on a small scale.
3. The third phase is **control.** This is by Wig (1996) divided into control according to plan and control according to goals. This gives a confirmation on the progress. According to Eikeland and Borg (2013) the company should also analyze the results as regards to the expected result. Did everything happen exactly as expected or did many unforeseen events occur but with the same result? If any results show errors in the process this should get immediate attention, so that further planning can avoid this error (Moen & Norman, 2006).
4. The fourth and final phase of Deming's cycle is the **action** phase. This is phase were you either adopt the change to the company's policy or abandon it, before you run the cycle all over again (Moen & Norman, 2006). Wig (1996) has divided this phase into implementation of corrective measures, summary (learning) and standardization. Corrective measures is done to fix a deviation or to make a process even better. A summary is to reflect over the learning process, what can be used when the process starts over? What cannot be used?

What can be implemented in other processes (Wig, 1996)? A company should also encourage continual learning and advancement (Deming, 2000). The action and changes that improved the result is standardized and built in to the company's policy.

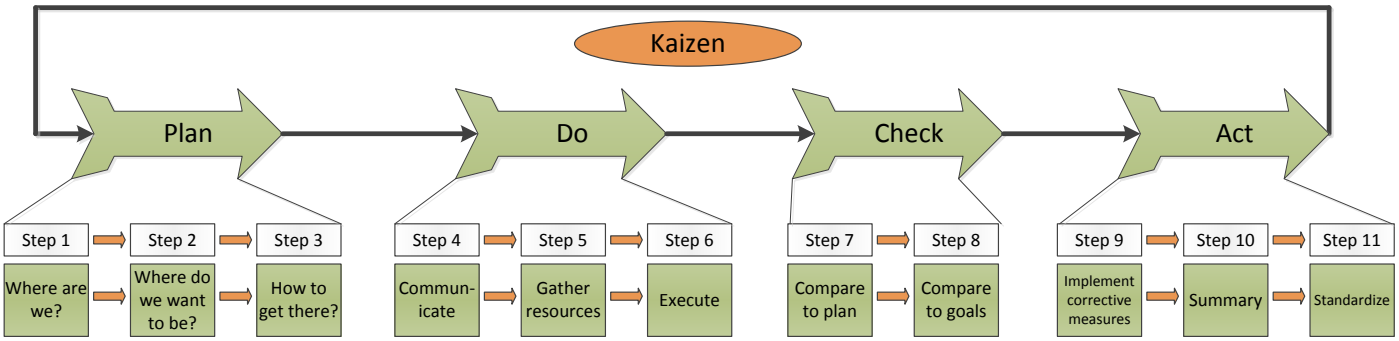

Figure 6: The PDCA cycle – detailed (Wig, 1996)

2.4.2.3 Lean management and worker involvement

"*Lead as you had no authority*" – Fuijo Cho, Toyota

The lean philosophy strives for communication between workers and managers. In the Toyota culture they use the Japanese word "Gemba" which means "in the place of action" (freely translated) (Wig, 1996). This symbolizes that managers needs to spend time where the actual value is created (Eikeland & Borg, 2013). If problem arises or changes need to be made, being at the same level as the shop floor workers to work together can make the difference. "*Hard work and best efforts will not by themselves dig us out of the pit. In fact, it is only by illumination of outside knowledge that we may observe that we are in a pit"* (Deming, 2000, p.23). Managers need to gather information from more than just the top-level.

A very important aspect of the lean philosophy is worker involvement. As Toyota realized back when they were developing TPS from the foundation of mass production, workers are resources, and companies can achieve a great competitive advantage if their able to utilize their human resources (Eikeland & Borg, 2013). The objectives for worker involvement are to recognize, appreciate and to make the job more interesting. In addition it is about maximizing the use of worker knowledge (Treville & Antonakis, 2006). Furthermore Treville and Antonakis (2006) suggest that lean production can have an important effect on workers intrinsic motivation. Intrinsic motivation is motivation dominated by internal forces, the worker value an activity as opposed to doing it because there is some external coercion (Ryan & Deci, 2000). Treville and Antonakis (2006) further suggest that over excessive lean implementation can limit the motivation, and that the results in behavior strongly depend on the lean configuration. This is also supported by Jackson and Martin (1996) who

concluded that good work environment relies on management decisions and the design of lean production. A case study by Gabriel (1997) in which they applied lean management, top-down information flow and frequent meetings involving both managers and workers, resulted in great success. There was a high level of commitment and motivation in the team, and the projects managed to balance quality, performance and value to the customer.

2.4.2.4 Five why's

The 5 why´s is a method presented by Taichi Ohno and the Toyota production system. The idea is to use problem solving to systematically trace every error back to its ultimate cause. You do this by asking "*why*" as you progress through the problem, while devising a fix making sure that the problem will never happen again. When Ohno first presented this idea to the production workers, it was to be expected that the production line would stop all the time. Naturally this was exactly what happened at first, but as the workers gained experience on how to do the tracing and identifying, the errors dropped dramatically. The use of this method also showed its impact on the end of the production line, where the amount of rework needed before shipping fell drastically while the quality of the cars improved (James P. Womack, 1990).

2.5 Summary of theory

The theory described is generally based on the concept of supply chain management and Porter's (1985) value chain on how to achieve competitive advantage. As a supplement to this foundation, Davis' (1993) explanation of the uncertainties in a supply chain network has been described. This will clarify in which area the thesis' research questions will operate. Furthermore, as a theoretical background for analyzing the external uncertainty of supplier performance, the concept of supplier performance management is described. Kraljic's matrix is also explained as a tool for this research question. The theory of process improvement through process mapping and value stream mapping is also describes, as a base for analyzing the uncertainty regarding internal processes. Lastly, the concept of lean and different lean techniques and continuous improvement has been explained, as they are to supplement the results of the thesis' research questions.

3. Aker Solutions as a case study

Aker Solutions is a multi-international company that delivers products, systems and services in the oil and gas industry worldwide. They deliver solutions in almost every aspect/process from searching after oil and gas to the actual making of gasoline or other end products. Aker Solutions' origin can be traced back to 1841, as a small mechanical workshop in Oslo, Norway. Today Aker Solutions employ approximately 26.000 people in about 30 countries (AkerSolutions, 2014a).

3.1 Vision and values

Vision: "*To be the preferred partner for solutions in the oil and gas industry through living our values"* (AkerSolutions, 2014f).

Aker Solutions share a common set of values that strives to guide the company's policies, operations and ultimately the behavior. There are a total of six values and Aker Solutions describes them as follows (AkerSolutions, 2014f):

1. **Customer drive** – Customer trust and customer satisfaction are key elements to Aker Solutions. The only way to achieve this is to have consistent and predictable performance.
2. **HSE mindset** – Aker Solutions take personal responsibility for Health, Safety and Environment. They continuously strive for zero accidents to personnel, material and non-material assets. They have a high focus on employee health and to continuously improve the work environment. They work on using materials and energy efficiently to minimize waste and damage to the environment.
3. **People and teams** – To deliver a strong result are impossible without a highly capable workforce. The company makes every effort to the development of people and teams, to create a sustainable foundation for efficient value creation. All Aker Solutions' major achievements are team efforts.
4. **Open and direct dialogue** – Aker Solutions value early, accurate, honest and reliable communication. They expect the highest standards of ethical behavior and integrity. They encourage people to challenge each other as the best decisions are often taken when different opinions and cultures meet in open and direct dialogue.
5. **Hands-on management** – "*We know our business and get things done" (AkerSolutions, 2014e).* Once a decision is made, Aker Solutions strives to combine all efforts and focuses all energy on execution.
6. **Delivering quality results** – It is important when doing a job, to understand both the risks and opportunities and to know how to manage them. Aker solutions take pride in delivering as promised and continuously strive to beat their goals.

3.2 Key performance indicators

Aker Solutions measure performance, quality and risk on several levels. Figure 7 shows what this includes. Success is measured after the following KPI´s (Kongelf, 2011):

- BA performance
- EBITDA Development
- Negative Cash Positions
- PEM Compilance
- Supply chain/3rd party
- Engineering
- Manufacturing
- Liquidated damages
- Warranty cost
- Availability of service
- Resource base
- Client Relations

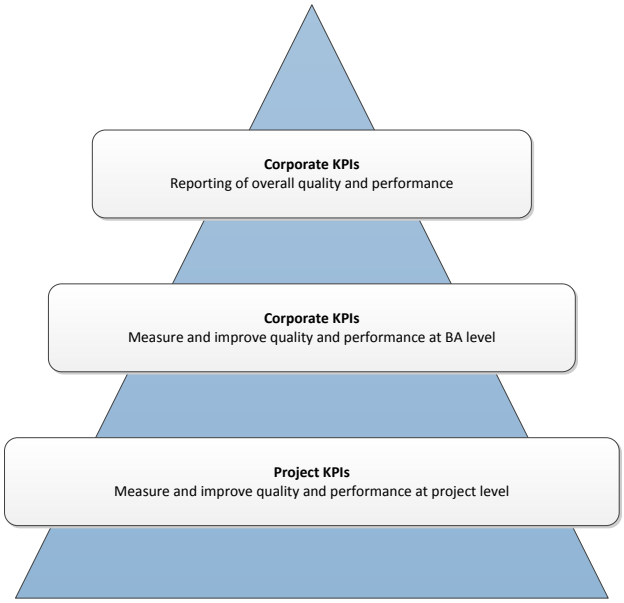

Figure 7: Aker Solutions' view on performance, quality and risk on several levels (Kongelf, 2011)

3.3 Corporate structure

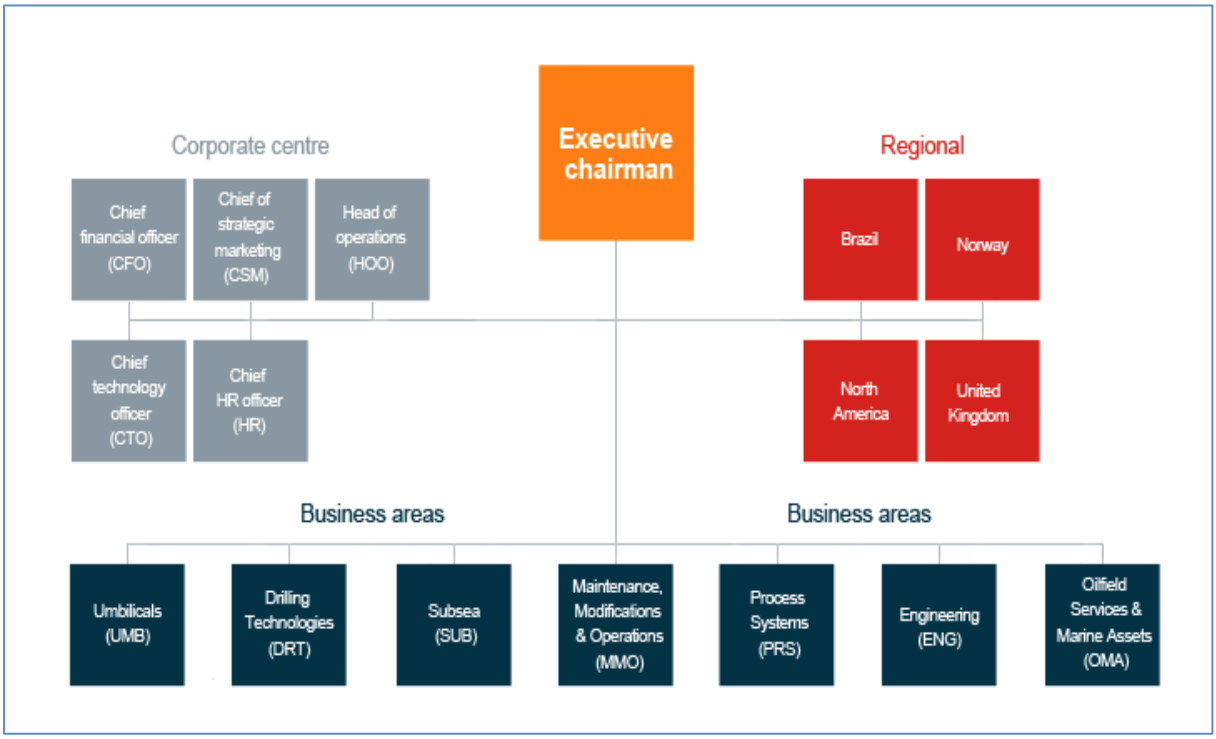

Figure 8: The corporate structure at Aker Solutions (AkerSolutions, 2014b)

Figure 8 (previous page) shows the corporate structure within Aker Solutions as well as the business areas focused upon. The product and services Aker Solutions provide can be divided into 6 different technology segments, respectively (AkerSolutions, 2014g);

- Drilling technologies
- Engineering
- Maintenance, modifications and operations
- Subsea technologies and services
- Subsurface and well services
- Well stream processing

This thesis is written in collaboration with Aker Solutions' Spare Parts division. The Spare Parts division is located under the field Drilling Technologies. Drilling Technologies delivers drilling equipment, systems and lifecycle services for onshore and offshore drilling units. Aker Solutions offers support throughout the entire process of the equipment they provide. In addition, they provide drilling life-cycle services to their customers. Drilling life cycle services includes a 24/7 technical support throughout the entire life cycle to a specific product. This service includes provided spare parts, technical support, overhaul/modifications and professional rig training (AkerSolutions, 2014c).

3.4 Key financial numbers

Some of the key financial numbers is presented in figure 9. As figure 9 shows, the operating revenue has been falling, with its peak in 2008. The income has stabilized in 2012 (PROFF, 2014). Key financial numbers from 2013 and the first quarter of 2014 show that the revenue now is stabilized (AkerSolutions, 2014d).

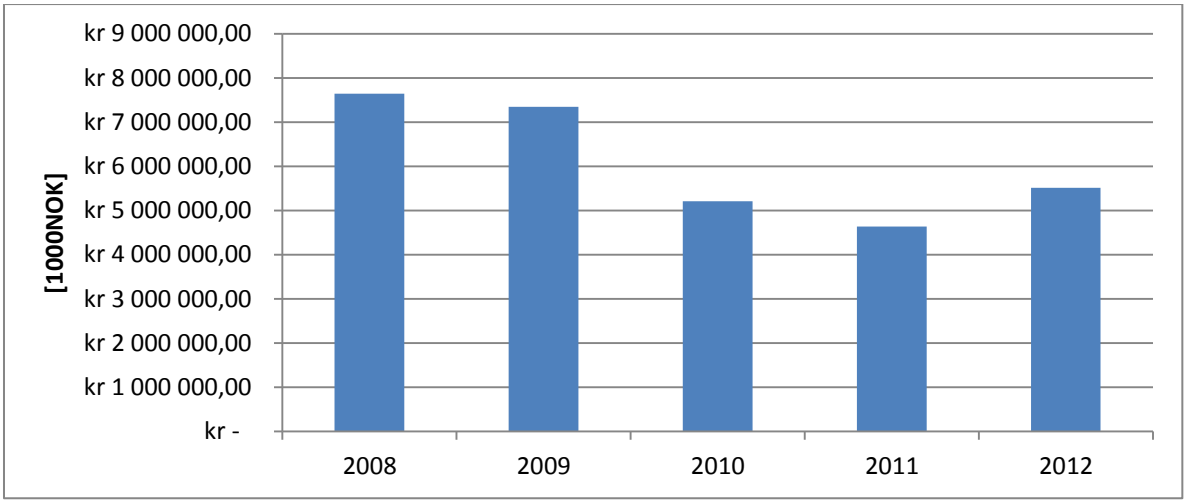

Figure 9: Revenue at Aker Solutions from 2008 to 2012

The total profitability however, has grown steadily from 2008 to 2011, but with a downfall of 2.7% from 2011 to 2012 as shown in figure 10:

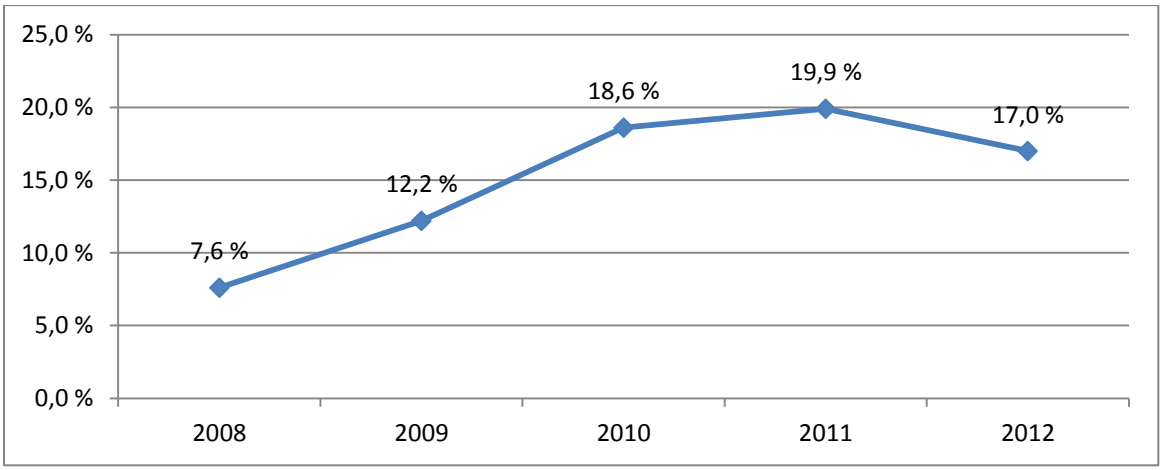

Figure 10: Profitability at Aker Solutions from 2008 to 2012

3.5 Spare parts division and their processes

As previously mentioned, this thesis is focused on one of the drilling lifecycle services Aker Solutions provide, namely the Spare Part division.

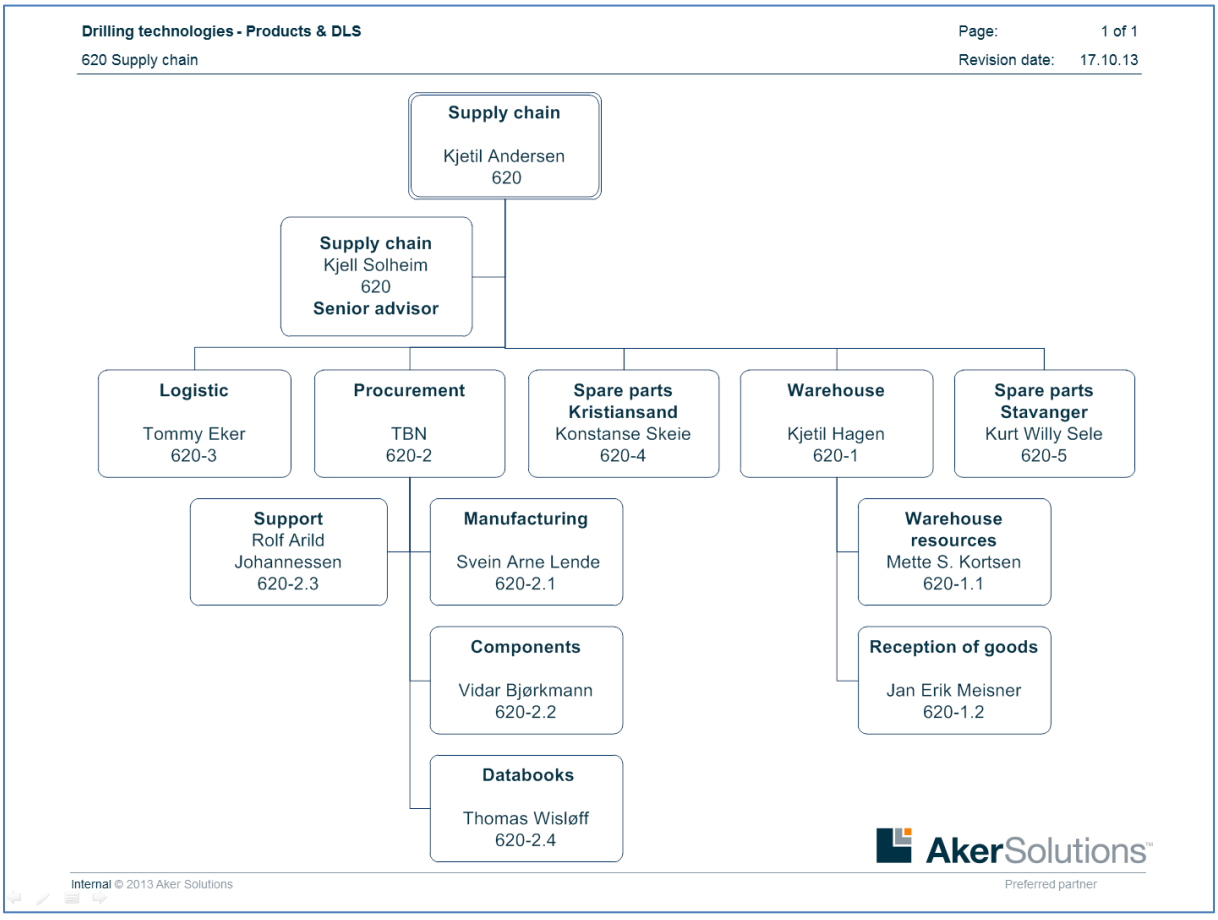

Figure 11: The organizational structure for Aker Solutions – Drilling Technologies

Figure 11 (previous page) shows the organizational structure for Drilling technologies – Products and DLS and where you find Spare Parts Kristiansand in the supply chain. It should be noted that Kjetil Andersen is now the manager of Spare Parts Kristiansand, not the supply chain manager as shown in figure 11.

Spare Parts' function is to provide customers with spare parts for their drilling rigs. The process of establishing a quotation and providing the specific spare parts to the customers can be a complex process, which involves many steps. Figure 12 shows how the process looks like when providing customers with spare parts. As seen from figure 12, this is a process that involves a lot of steps and many different people. Following the process from the start, you receive a customer enquiry containing information of what spare parts the customer needs. The next step is to establish a notification in SAP and evaluate the enquiry. This is to see if the enquiry is a warranty claim or if the spare parts requested is outdated. If it's a warranty claim, the enquiry will be forwarded to a different division. If the spare parts are outdates, an expeditor must work through a process of updating the items. Furthermore, a quotation containing payment and delivery term is established and sent to the customer. The customer can either accept or decline. If the customer accepts the quotation, the accepted quotation gets evaluated and registered as a sales order (SO). If the case is an urgent delivery case or a so called "RED case", the SO is handled by 24/7 support, if not the next step is to check if the items are available on stock. If the items are available, an order confirmation (OC) is sent to the customer. Warehouse then takes over with picking and packing according to the OC and delivers according to the INCOTERMS. If the items are not available on stock (most cases), the case is handed over to procurement. Figure 12 shows the process map as explained.

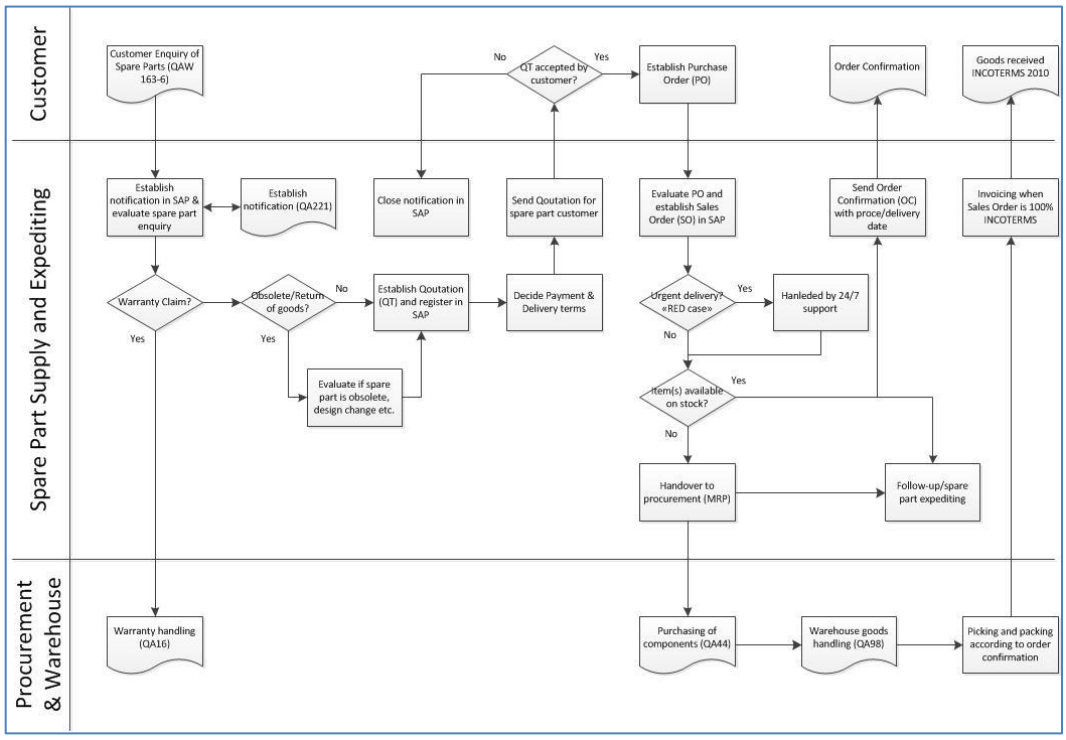

Figure 12: The original process map for Aker Solutions' Spare Parts division

Procurement works through a process of purchasing items from vendors. This process can be challenging regarding the dependency of the different vendors. The purchasing process is a factor that has been challenging for Spare Parts. This is due to the process often being hard to set a specific duration to. When purchasing items, an important element is the vendor lead-time. This is the time expected for the vendor in producing and delivering the product. The problem is that the lead time can vary, meaning the lead time should in some cases be much longer. Another factor in the purchasing process is the actual time needed in working through the entire purchasing process. As per now, Spare Part operates with a time factor of 8 days added to the lead time and goods received processing time (GRPT). The purchasing process is shown in figure 13.

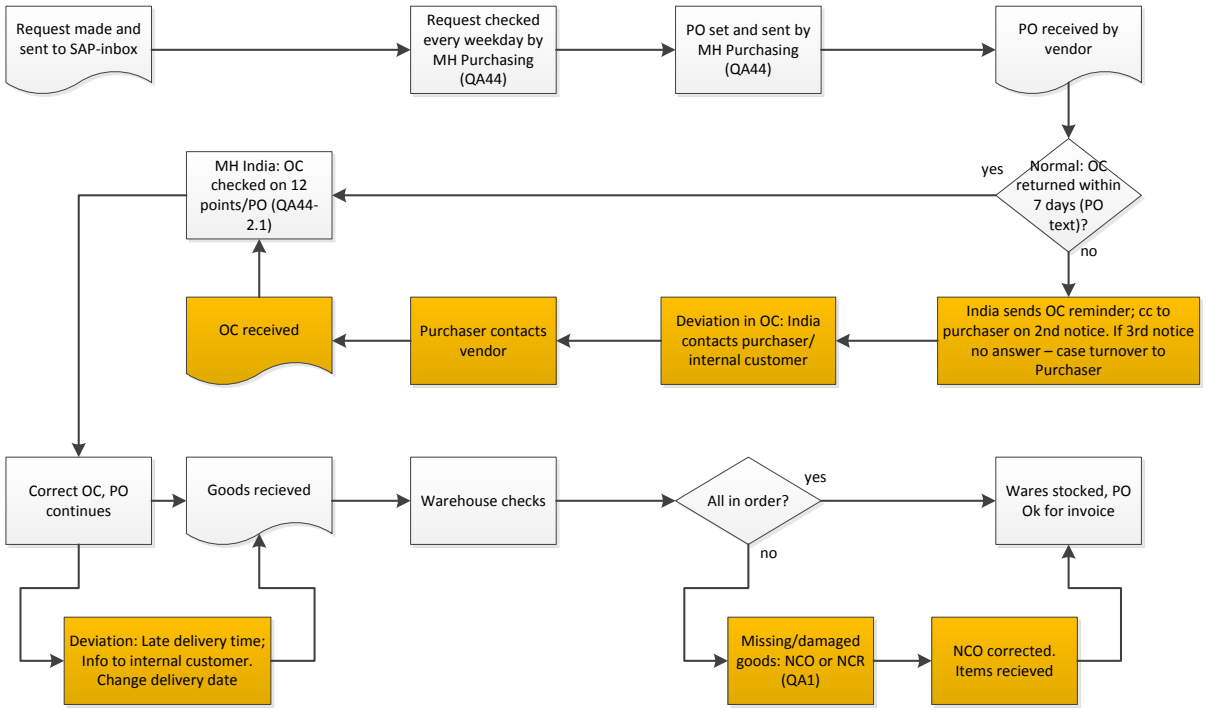

Figure 13: The original process map for Aker Solutions' Procurement division

3.6 Challenges in Spare Parts

An increasing competition in the oil-and gas industry has as earlier stated led to a stronger focus on achieving a competitive advantage. Some of the challenges for the Spare Parts division are in accordance with the spare parts being delivered on time. Spare parts are items that are normally needed to prevent downtime in the drilling activities. Considering downtime in most cases is more cost heavy than the price of the spare parts, a factor such as price isn´t as important as it used to be. What is important is that the spare parts are delivered in a reliable and effective manner. The Spare Parts division has lately had an increasing focus on improving the reliability of the delivery dates given to the customers, in other words improving their OTD. It has become clear to them that they need to increase the OTD in order to stay competitive. After several minor changes and solutions they have managed to improve it from roughly 30-86% in 2 years. However, they believe that there is still room for improvements, but in order to obtain further improvements, a more thorough analyze of the situation has to be done.

4. Method

This chapter contains a theoretical background on the different methods and techniques used for collecting data, followed by a subchapter describing the methods and techniques used in this thesis and an explanation as to why these were chosen. Furthermore, a subchapter focuses in on this thesis' research questions and another subchapter considers the quality criteria's. Until finally, the overall quality, reliability and validity of the thesis is reflected upon.

4.1 Quantitative versus qualitative

A known difference in approaches is the qualitative and the quantitative approach. According to Berg (2004) a social psychologist named James M. Dabbs Jr. tried in 1982 to differentiate between qualitative and quantitative data. The simple result was that quality was essential to the nature of things, while quantity is the amount of something. Furthermore they differentiate in the overall form and focus (Berg, 2004). The qualitative researcher often tends to describe the unfolding of social processes, unlike the quantitative researcher who focuses on the social structure itself (Maanen, 1979). Qualitative research refers to meaning, symbols and definitions. Quantitative research refers to the measures of things (Berg, 2004). In the qualitative approach the use of open-ended questions and emerging approaches is frequent. When researching by a quantitative approach, the questions are closed-ended and the approach itself predetermined (Mertens, 1998). Qualitative research is most appropriate when it exist a problem that needs to be explored. According to Creswell (2012) it should take place in a natural setting. In the specific place the participants experience the problem under investigation. Instead of bringing everyone into a test room they observe them and get close-up information from them, when they're in their own environment. Furthermore, data is collected through looking at documents, observing and interviewing the participants. The use of multiple methods is commonly used in qualitative research. The design is emergent, meaning that planning beforehand is limited. Questions, documents, places, etc. may change during the process (Creswell, 2012).

Several researchers also stress the many advantages by interplaying with qualitative and quantitative methods (mixed methods) for more reliable quality results (Creswell, 2012; Denzin, 2009; Jick, 1979; Linhorst, 2002; Mertens, 1998; Morgan, 1996; Strauss, 1998).

4.1.1 Case study

"*The case study exists to systematize evidence so as to suggest hypotheses for testing and, pending that, to provide a basis of fact and insight for possible application to decision making*" (Schramm, 1971, p.2). The purpose is to map why a given solution was implemented, how it was implemented and what the consequence of this implementation was. Schramm (1971) further stress that this is

why case studies is an effort to decision making and company policy, rather than a tribute to science. Yin (2003) points out that a case study should not be mixed with qualitative research. Case studies can contain both qualitative and quantitative evidence and does not always need to include direct observations (Yin, 2003). A strong benefit with the case study is that one can enter a situation "after the fact" (Schramm, 1971). Therefore all valuable evidence can be counted for. On the other hand, if one enters too late, relevant information/history could be lost. Some of the early problems and errors may have been forgotten. Yin (2003) stresses another disadvantage with the case study as the concern for not being able to scientifically generalize the results from the study. "*How can you generalize from a single case?"* (Yin, 2003, p.10). However, as stated by Strauss (1998) one can still learn from the case. An additional disadvantage with the case study is according to Yin (2003) that they consume too much time and that the results provide too many unreadable documents. But perhaps the greatest weakness is according to Schramm (1971) the enormous responsibility it places on the researcher, rather than on the method itself. As opposed to experiments that offers specificity and support to the researcher, the case study has a much trimmer database of support. According to Yin (2003) there are some situations were a specific strategy has a distinct advantage. For the case study this is when; "*a how or why question is being asked about a contemporary set of events over which the investigator has little or no control*" (Yin, 2003, p.9).

4.1.2 Triangulation

Berg (2004) states that different research methods impose different perspectives on reality. Furthermore, different methods have different line of sight, but towards the same point. Therefore a research study can obtain a more reliable picture of reality, if it uses multiple methods, multiple lines of sight (Berg, 2004; Strauss, 1998; Yin, 2003). The use of multiple lines of sight is often called triangulation. According to Berg (2004) triangulation is commonly used in navigation and military practices. In these cases an object or point is located by using three different points all sighting towards the unidentified object or point. Usually these three lines form a small triangle around the point/object and symbolize the "triangle of error", the real location of the point/object is definitely located within this small triangle. The necessary amount of sights doesn't have to be three, but the more sights the more accurate the results. This view of research is further examined by Norman K. Denzin, a sociology professor at the University of Illinois, USA (Berg, 2004; Denzin, 2009). Denzin (2009) claims that every problem should be examined from as many different methodological perspectives as possible, and introduces the metaphor "line of action". For example a study could combine the use of participant observation, document analysis, interviews and surveys, as different lines of action. Since each of these methods implies a different line of action towards reality, each method will reveal a different aspect of this reality. Furthermore, Denzin (2009) states that since

each researcher uses their own interpretation of their lines of action, the results is expected to be different.

4.1.3 Data collection techniques

Interview

The most important people to interview are the people with most information (Schramm, 1971). The purpose of the interview is to help the researcher gather information (Berg, 2004; Christensen, Nielsen, & Schmidt, 2011). How to prepare and conduct an interview has been widely discussed and a common outline had not yet surfaced (Berg, 2004). The method of approach doesn't necessarily have to be equal for all interviews, Denzin (2009) stress that an interview method can and should be different from others. According to Creswell (2012) the researcher brings certain beliefs and philosophical assumptions to the research whether he/she is aware of it or not. Denzin (2009) further stress that there should be some sort of database containing several common standards to all interviews, allowing each researcher to adapt their own to their case. There are different opinions as to how many participants that is necessary to interview for the results to prove valid, it depends on the study-type and the situation (see Bertaux, 1981; Creswell, 2012; Kuzel, 1992). A common philosophy is "*the more the merrier*".

As stated earlier there are several different approaches as how to conduct an interview. Berg (2004) illustrates the major interviews structures, divided by standardized, semi standardized and unstandardized interviews. The standardized interview may be linked to a survey; there exist a formal structure, no deviation from the questions and no room for the participant to answer openly. The more unstandardized the interview is, the less rules, structure and formality applies. This could prove very helpful in open field research were new problems or issues may occur during the interviewing process. The interviewer then needs to adapt to the situation and create new questions. A typical unstandardized interview is one were the result is answers on questions the researcher didn't have in the first place (Berg, 2004).

Focus group interview

"*Focus groups are a data collection technique that capitalizes on the interaction within a group to elicit rich experiential data*" (Asbury, 1995, p.414). This form of interviewing is designed for small groups were learning is achieved from discussing topics relevant to the group and the researcher (Berg, 2004). The method allows members to express ideas in a spontaneous matter, instead of following a tight structure like a regular interview (Burke & Duthie Jr, 1997). A classic focus group contains a few participants guided by a host/moderator. The moderator then tries to gather information from the group by pressing discussions on relevant important topics (Berg, 2004). If the

topics is complex Krueger (1994) recommend no more than 7 participants. As all methods there are positive and negative consequences. Morgan (1996) stress that since this method requires mutual self-disclosure, there are definitely unacceptable topics among the participants. In addition there is the issue that people affect each other, and in a focus group interview this could for instance lead to one participant controlling the others. Furthermore, Linhorst (2002) stress that the method is both time-consuming and complex. There are often very few questions that can be addressed because of this. Another time-consuming activity is the handling and analyzing of collected data (Linhorst, 2002). There is also the issue regarding the moderator. Studies have shown that the moderator's behavior can greatly affect the participant's discussion in the focus group (Morgan, 1996). Linhorst (2002) argues that the focus group technique has its limitations, but it also has a great potential as an important data collection tool. The technique can easily be used with other qualitative and/or quantitative methods. Additionally a study by Morgan and Krueger (1993) showed that the focus group had a synergistic effect in which they called the "group effect". The focus group technique has also shown other positive side effects, including empowering and educating the participants, as well has having therapeutic effects on them (Linhorst, 2002).

Surveys

Survey as a type of quantitative research is considered to be one of the most important areas of measurement (Trochim, 2006b). There are two main categories to surveys; questionnaire and interview, and under these several subcategories (Trochim, 2006c). As stated earlier quantity is the amount of something and consequently making a quantitative study a measurement of something. A survey is often cost-effective, demand low work effort and gives a high number of responses. On the other hand a survey is not flexible, it's hard to measure the quality of responses and it can't contain open-ended questions (Trochim, 2006a). As clearly stated the interplay between a quantitative and qualitative study is well argued to provide more reliable results. As a clear method for this Morgan (1998) suggest a survey follow-up on a qualitative study, to help evaluate and interpret the results from the qualitative study.

4.2 Focusing in on research questions

4.2.1 Improving OTD with supplier performance management

As an external measure to improve Spare Parts' delivery precision to their customers, supplier performance management is to be tested as an approach. The 10 worst suppliers are to be extracted from the ERP system SAP, based on their OTD and volume. Based on different analyses, interviews and a survey, a priority list of the 10 worst suppliers will be created. The present suppliers are then

suggested placed in the Kraljic (1983) matrix based on their volume and complexity. The different placements in the matrix give the suggested approach for that supplier.

4.2.2 Improving OTD with process improvement

As an internal measure to improve Spare Parts' delivery precision to their customers, improvement of the company's internal process map is to be tested as an approach. Based on the theories of process mapping, the lean concept of value stream mapping and Porter (1985) understanding of how to achieve competitive advantage, a new improved process map of Spare Parts orders is to be created. The quality of this map is further enhanced by conduction a workshop with Spare Parts and Procurement workers as they have great influence on the processes. With the supplement of interviews and a final survey, the overall reliability and quality of the process map is assured.

4.3 Selection of method and techniques

The thesis is due to the Denzin (2009) theory of triangulation and many other researchers view on multiple methodological approaches, based upon both qualitative and quantitative methods. Furthermore, several techniques have been used. Basically this is a case study with workshop, interviews and survey as techniques for gathering information. Furthermore, the study will analyze the results and discuss the issues at hand to be used as a foundation for suggesting improvement measures.

4.3.1 Techniques

Interview – Interviews will be of the unstandardized approach; this makes it easier for both the interviewer and the interviewee as there is no formal structure to follow. The purpose is only to gather as much information as possible. Interviews will be conducted for the Spare Parts, Procurement and warehouse division.

Workshop – The workshop should include workers from both Spare Parts and Procurement, four from each division, making it a total of eight participants. This is one participant more than what's recommended by Krueger (1994) but due to the possibility of cancellations a little slack is included. The warehouse division is not being included in the workshop as they have little or no interaction with Spare Parts.

Survey – The questionnaire is split two-ways and given to the Spare Parts division. The first part of the questionnaire has the purpose to assure the quality of the priority list of the 10 worst suppliers. The survey will let the participants prioritize the 10 worst suppliers as taken from this thesis' results. The second part has the purpose to assure the quality of the new process map for Spare Parts processes. The survey will clarify if the new suggested map corresponds to their processes and if this

should replace the existing map. In addition, participant can leave comments (optional) on either of the survey questions.

4.4 Quality criteria's

The factors that decide the overall quality on this thesis are many. First of all, the workers selected for interviews, workshop and survey must have relevant positions in Aker Solutions. For interviews and workshop it is important that notes are taken, making it possible to log as much as possible. Another important quality criterion is the researchers' ability to apprehend relevant information, comprehend the content and to analyze the results appropriately. Furthermore, it is important for the reliability of the results that as many as possible takes the survey. With both relevance and participation a representative selection is secured.

4.5 Research quality, reliability and validity

This thesis is mainly meant as a guideline and help to the Spare Parts division in Aker Solutions. It is important not to generalize the results as there are many presumptions and other factors scoping this case. However, the results presented in this thesis are of high reliability to the Aker Solutions' Spare Parts division in Kristiansand. This is because every method and technique has been used towards this division. Every interview, workshop and survey has included employees from Spare Parts and other employees linked to Spare Parts. The results should also be applicable towards other Spare Parts divisions at Aker Solutions, or even Spare Parts divisions of other companies within the same field of expertise. But the more away from this thesis' case presumptions, the more the overall quality of the results weakens. Moreover, the validity of the results is strengthened by this thesis' use of triangulation as a methodological approach. The more information that is gathered from different techniques, the more reliable the results will be after an analysis of the combination of information gathered (Denzin, 2009; Yin, 2003).

5. Results

This chapter presents the collected data from SAP, workshop and survey. The findings presented are used as a foundation for further discussion.

5.1 Supplier performance

As a measure to reduce the uncertainty regarding the performance of suppliers, information of the worst suppliers was conducted. The ERP system SAP was according to Procurement manager components, Vidar Bjørkmann only able to provide supplier delivery results for the whole organization. To filter the list as regards to Spare Parts' consumption, it was cross matched with the sales records the last year from Spare Parts. The sales record list contained responsible suppliers for all order-lines sold by Spare Parts. In addition, suppliers with less than 100 PO/year were neglected. The following list was used for further analysis (see Table 1):

No	Supplier name	PO/year	PO Late/year	Days delayed /year
1	Ahlsell Norge AS	167	18	144
2	Aker MH AS	213	47	1253
3	Aker Solutions Hannevika Workshop	481	137	3406
4	Aker Wirth GmbH	2463	682	16392
5	Andersens Mek. Verksted A.S	1304	322	5136
6	ASI Automatikk AS	270	79	872
7	Bartec Technor AS	1406	510	12673
8	Bondura Technology AS	176	11	135
9	Bosch Rexroth A/S	498	167	2286
10	Bosch Rexroth B.V.	119	53	2347
11	Cafrex Sp. z o. o.	151	79	4182
12	Cavotec Micro-control AS	224	65	1210
13	Certex Norge AS	531	246	3526
14	Danfoss Power Solutions AS	638	156	1063
15	GS-Hydro Norge A/S	2765	761	7843
16	Hydac AS	335	58	1229
17	Hydratech Industries AS	1085	361	7030
18	Hydreco Hydraulics Norway AS	410	157	5332
19	Hydroscand AS	252	37	380
20	Hypteck AS	159	34	116
21	J.P.Sauer & Sohn	547	368	5736
22	Kolberg Caspary Lautom AS	667	214	2565
23	Kwintet Norge AS AVD LOCHNER	437	89	826
24	Mits Hydraulikk ANS	121	21	74
25	National Oilwell Varco Norway AS	104	18	462
26	Norgren AS	301	101	2451
27	Onninen AS	1018	321	11635
28	Parker Hannifin A/S	1343	204	2740
29	Pepperl+Fuchs AS	243	50	515
30	PGNIG Technologie Sp. z.o.o	1052	738	34770
31	Phoenix Contact AS	238	20	103
32	Safe Consulting AS	190	49	376
33	Scana Mar-el AS	105	33	839
34	ScanCab A/S	183	80	932
35	Scanco AS	149	7	52
36	Schaeffler Norge A/S	416	65	2069
37	Servi Cylinderservice AS	999	298	5030
38	Servi Hydranor AS	1937	292	5665
39	Siemens AS	544	105	2029
40	Sigurd Seland AS	232	100	1807
41	Skiltspesialisten	223	15	161
42	Step Offshore AS	157	95	2207
43	T.O. Slettebøe as	760	58	506
44	Teamtrade AS	225	54	1168
45	Tormatic A/S	137	27	284
46	Tranberg AS	644	145	1366
47	Trelleborg Industri A/S	124	22	206
48	Wago Norge	433	84	362

Table 1: List of all suppliers linked to Spare Parts in the year 2013

Continuing, three factors were calculated: Average days delayed, OTD and $\frac{PO/year}{OTD^2}$. The list was then sorted by the last mentioned factor (lower score is better). This was done after a dialogoue with Spare Parts manager Kjetil Andersen and Procurement manager components Vidar Bjørkmann, so that both volume and OTD could be weighted. This gave the following result (The full list can be found in appendix E: Frequent Spare Parts suppliers (2013)):

No.	Supplier name	PO/year	PO/year late	Total days delayed	Average days delayed	OTD	PO/year /OTD^2
1	PGNIG Technologie Sp. z.o.o	1052	738	34770	47	30 %	11808
2	J.P.Sauer & Sohn	547	368	5736	16	33 %	5108
3	Aker Wirth GmbH	2463	682	16392	24	72 %	4710
4	Bartec Technor AS	1406	510	12673	25	64 %	3462
5	GS-Hydro Norge A/S	2765	761	7843	10	72 %	5264
6	Hydratech Industries AS	1085	361	7030	19	67 %	2437
7	Onninen AS	1018	321	11635	36	68 %	2172
8	Servi Cylinderservice AS	999	298	5030	17	70 %	2029
9	Andersens Mek. Verksted A.S	1304	322	5136	16	75 %	2299
10	Certex Norge AS	531	246	3526	14	54 %	1843
A	**Total (10 worst suppliers)**	**13170**	**4607**	**109771**			
B	**Total (all suppliers)**	**27176**	**7653**	**163491**			
C	**Percentage (A/B)**	**48,5 %**	**60,2 %**	**67,1 %**			

Table 2: The 10 worst suppliers linked to Spare Parts

Servi Hydranor AS with an OTD of 85 % was originally on the list due to a very high volume. Since an OTD of 85 % is considered to be good or "better than most" according to Spare Parts manager Kjetil Andersen, it was neglected from the list and replaced with Certex Norge AS. As seen from Table 2 the sum of PO/year, PO/year late and total days delayed has been calculated, in addition with the sum of all Spare Parts suppliers, making it possible to find the share of the 10 worst suppliers (see row C in Table 2).

Furthermore the monthly history of on-time and late deliveries from all the Spare Parts suppliers was extracted from SAP (see **Error! Reference source not ound.**). As seen from this list the OTD of the suppliers varies a lot over the year of 2013, from only 57% to 81%. Moreover it is clear that the OTD on average improves during the year.

Month	PO/year	PO/year late	OTD
Jan.13	2795	1207	57 %
Feb.13	3039	1167	62 %
Mar.13	2454	843	66 %
Apr.13	2577	677	74 %
Mai.13	2282	573	75 %
Jun.13	2057	412	80 %
Jul.13	3737	919	75 %
Aug.13	1825	400	78 %
Sep.13	2056	381	81 %
Okt.13	4281	891	79 %
Nov.13	4150	839	80 %
Des.13	1786	333	81 %

Table 3: List of PO's, late PO's and OTD of all Spare Parts suppliers

The next table shows the total delivery history from Spare Parts to their customers, in the period from March 2013 to January 2014, as extracted from the ERP system SAP (see table 4). Table 4 distinguishes between the internal and external performance data and also subgroup all delays in delay specifics.

Delivery history											
Number of line items INTERNAL	**MAR 2013**	**APR 2013**	**MAY 2013**	**JUN 2013**	**JUL 2013**	**AUG 2013**	**SEPT 2013**	**OCT 2013**	**NOV 2013**	**DEC 2013**	**JAN 2014**
No of On Time Deliveries	266	949	1034	841	988	1003	577	922	369	169	346
No of Late Deliveries	261	139	138	380	148	260	98	129	69	57	37
No of Early Deliveries	947	818	820	324	318	394	490	893	479	377	410
Total delivery - total per month	1474	1906	1992	1545	1454	1657	1165	1944	917	603	793
Total delivery - accumulated per month	1474	3380	5372	6917	8371	10028	11193	13137	14054	14657	15450
Total ON TIME - per month	1213	1767	1854	1165	1306	1397	1067	1815	848	546	756
Total ON TIME - Accumulated	1213	2980	4834	5999	7305	8702	9769	11584	12432	12978	13734
Number of line items EXTERNAL	**MAR 2013**	**APR 2013**	**MAY 2013**	**JUN 2013**	**JUL 2013**	**AUG 2013**	**SEPT 2013**	**OCT 2013**	**NOV 2013**	**DEC 2013**	**JAN 2014**
No of On Time Deliveries	343	374	636	491	794	830	501	353	1126	629	1129
No of Late Deliveries	209	357	202	455	372	333	390	395	383	201	289
No of Early Deliveries	618	605	644	561	514	685	660	675	678	570	308
Total delivery - total per month	1170	1336	1482	1507	1680	1848	1551	1423	2187	1400	1726
Total delivery - accumulated per month	1170	2506	3988	5495	7175	9023	10574	11997	14184	15584	17310
Total ON TIME - per month	961	979	1280	1052	1308	1515	1161	1028	1804	1199	1437
Total ON TIME - Accumulated	961	1940	3220	4272	5580	7095	8256	9284	11088	12287	13724
Number of line items Total	**MAR 2013**	**APR 2013**	**MAY 2013**	**JUN 2013**	**JUL 2013**	**AUG 2013**	**SEPT 2013**	**OCT 2013**	**NOV 2013**	**DEC 2013**	**JAN 2014**
No of On Time Deliveries	609	1323	1670	1332	1782	1833	1078	1275	1495	798	1475
No of Late Deliveries	470	496	340	835	520	593	488	524	452	258	326
No of Early Deliveries	1565	1423	1464	885	832	1079	1150	1568	1157	947	718
Total delivery - total per month	2644	3242	3474	3052	3134	3505	2716	3367	3104	2003	2519
Total delivery - accumulated per month	2644	5886	9360	12412	15546	19051	21767	25134	28238	30241	32760
Total ON TIME - per month	2174	2746	3134	2217	2614	2912	2228	2843	2652	1745	2193
Total ON TIME - Accumulated	2174	4920	8054	10271	12885	15797	18025	20868	23520	25265	27458
Delay specifics	**MAR 2013**	**APR 2013**	**MAY 2013**	**JUN 2013**	**JUL 2013**	**AUG 2013**	**SEPT 2013**	**OCT 2013**	**NOV 2013**	**DEC 2013**	**JAN 2014**
1 day delay	82	176	299	187	356	490	171	229	174	0	0
2-5 day delay	105	231	138	112	289	258	226	74	154	0	0
5-10 days delay	43	107	43	150	284	38	121	75	77	0	0
10-30 days delayed	143	138	81	115	291	72	97	213	61	0	0
More than 30 days delayed	86	43	61	22	44	33	114	49	33	0	0

Table 4: The delivery history of Spare Parts from March 2013 to January 2014

5.2 Process improvement

As information gathering tools towards improving the internal processes, interviews of workers in relevant positions, a survey of relevant divisions and a workshop was conducted. The survey results are presented in the next chapter of results, chapter 5.3, while the full interview logs can be found in appendix A-D.

The workshop contained workers from both the Spare Parts and the Procurement division in Aker Solutions. Of the total eight participants invited, seven attended. Following, the findings from the workshop is presented here (full explanation of finding can be found in appendix F):

1. The Spare Parts process of checking a product isn't correctly reflected in the process map.
2. The rule of handling Spare Parts orders instantly was argued to be ineffective and sometimes pushed 1 day to achieve better order volume.
3. Not satisfied with the division in India, resulting with Procurement workers doing their job.
4. Expired product not registered by the supplier gives huge SO delays as it wasn't discovered until after SO date was set.
5. The procurement department had little insight in Spare Parts processes.
6. The problem with suppliers forgetting to inform of out-of-date products happens every day.
7. Misunderstandings as how Spare Pars' safety time and GRPT is calculated.
8. The 8 days safety time is ignored by Procurement, resulting in a correct use of this safety factor.
9. The lead times from suppliers is poorly updated. Lack of communication with suppliers. Suggestion of adding both "normal" and "worst case" lead times from all suppliers.
10. Handling of NCO or NCR can consume a lot of time and result in great delays.

5.3 Survey

The final result presented in this thesis is the survey results. The survey was created to ensure the quality of the results and add more helpful input to the final conclusion of the thesis. The survey was divided in two: The first part was about the supplier performance management, making the participants rate the worst suppliers to find additional information and to compare the results to the thesis. Furthermore, the second part was about the process mapping and value stream mapping theory. The participants were asked how satisfied they were with their current process map, what issues that were pressing and if they were willing to change the map with the one created in this thesis. Since this required that the new process map for Spare Parts was done, they survey was given towards the end of the research period and then integrated into this thesis.

The survey had a total of 3 questions/tasks. The questions/tasks and results from the participants was as follows:

Q1: Supplier performance management. Rate these suppliers from best (score=1) to worst (score=10), based on an overall subjective experience of that supplier. Think OTD, service, HSE, customer drive, etc.

Supplier	Result
PGNIG Technologie Sp. z.o.o	8,4
J.P.Sauer & Sohn	6,8
Aker Wirth GmbH	5,8
Bartec Technor AS	3,6
GS-Hydro Norge A/S	5
Hydratech Industries AS	5,25
Onninen AS	3,75
Servi Cylinderservice AS	4,2
Andersens Mek. Verksted A.S	2,6
Certex Norge AS	4

Table 5: Results from question 1 in survey

Q2 (The improved process map from this thesis is presented): Does this map reflect the actual processes in Spare Parts?

Answer	Result
Yes	40%
To some extent	40%
No	20%

Table 6: Results from question 2 in survey

Q3: Would you want to change your current process map with the new process map introduced in this survey?

Answer	Result
Yes	20%
Maybe/Don't know	60%
No	20%

Table 7: Results from question 3 in survey

6. Discussion

This discussion is divided in three. Chapter 6.1 presents an analysis of the uncertainty in the Aker Solutions supply chain. An overall mapping of these uncertainties and their locations in the supply chain will give foundation for this thesis' research questions. This foundation is based on Davis (1993) theory of supply chain uncertainties and supplemented with raw data from Aker Solutions, to give a thorough understanding of how this model look like at Aker Solutions' Spare Part division.

The next part, chapter 6.2 is focused on the external measure of supplier performance management to improve OTD. Supplier performance data from results is used together with relevant theory to perform different analysis of the worst suppliers. These suppliers are then prioritized and given suggested action-plans.

Chapter 6.3 uses the internal measure of process improvement to improve OTD. This discussion is based on the theory by Porter (1985) on how to achieve an effective value chain, theory on lean thinking with special regards to continuous improvement and the much valued techniques of process mapping and value-stream mapping. A suggested improved process map is given together with an action plan as how to maintain and further improve the process map. In addition a list of other suggested actions is presented.

6.1 The uncertainty model in Aker Solutions

As clearly seen in theory, measurement of the supplier base is complex and difficult. There are many different variables to measure and each variable can provide different conclusions. Even though there has been little research on supplier performance measurement there is a theory of uncertainty, developed by technology manager at Hewlett-Packard (HP) (Davis, 1993). This model of uncertainty states that a company should not just look at the internal variations when looking at the uncertainty in outbound delivery. There is a whole specter of variations that affect this output; the customer can order an unusually large amount of a selected product, the supplier can have a machine malfunction, the company's internal processes can defect somehow. All these issues will in turn affect the uncertainty of final delivery or delivery performance.

If this model of uncertainty is implemented in this case about improving OTD in Aker Solutions Spare Parts, it should be customized as there are relevant differences between this supply chain and the supply chain at HP. First of all, when Davis (1993) talks about manufacturing, he talks about all internal production related processes that varies. This is usually associated with machines breaking down, shop-floor workers being preoccupied elsewhere, etc. The manufacturing process in Spare Parts is quite different. The only production-like processes are related to making smaller changes to the products (painting, mount a module together from parts, etc.) and the process of making the

product ready for shipment. In addition there are many other internal processes related to communication with suppliers and customers, document- and information flow and cooperation between divisions. Therefore a modification is necessary for further analysis (see figure 14.

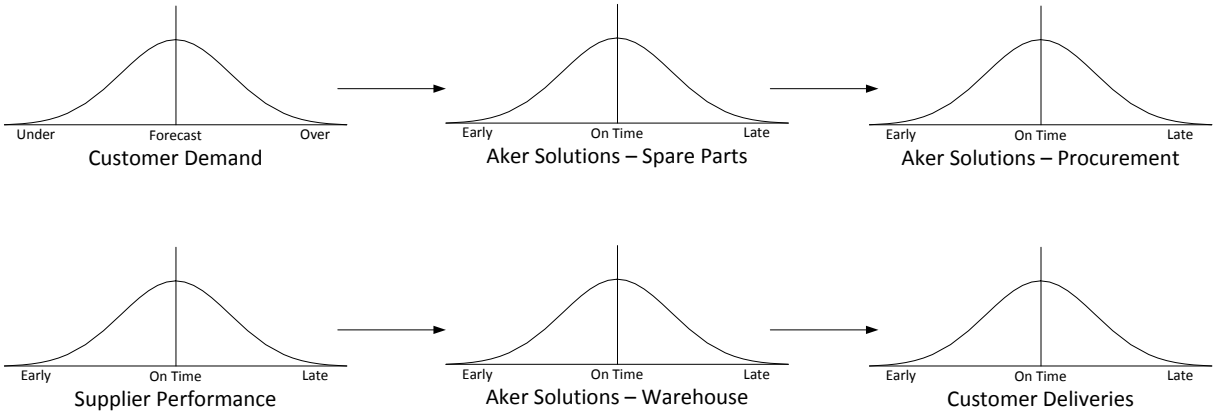

Figure 14: Uncertainties in the Spare Parts supply chain

As shown in figure 14 there are internal processes within Spare Parts, Procurement and warehouse in Aker Solutions. As explained in chapter 3.5, when a customer has a demand (related to a spare part product), the Spare Parts division creates a quotation (QT) and furthermore a SO if the customer accepts. By then the delivery date has been set and Spare Parts continues to communicate with the customer. The order itself gets hand over to Procurement who then orders the required product(s).

With regards to uncertainty there are a few important aspects and factors to remember, especially when looking at Aker Solutions supply chain. Since the delivery date doesn't get set until Spare Parts creates a SO, all uncertainty linked to customer demand and Spare Parts should be neglected. If there is an uncertainty in the customer demand or the Spare Parts division uses unusually long time processing the order, there is no problem but to push the delivery date a little when creating the SO. In other words, this doesn't affect the overall uncertainty of the final delivery (OTD). However, after the SO is set and the case handed over to Procurement, all variations are a factor of uncertainty. When Spare Parts calculates the estimated delivery date in the SO they use a fixed safety factor of 8 workdays. This factor was set by the management of Spare Parts in collaboration with Procurement and warehouse. This factor assumes that it takes 1 day from the case has been handover to Procurement, until they place a Purchase Order (PO) with the relevant supplier(s). After an interview with two purchasers within the Procurement division and the workshop, it was discovered that this was not always the case. Normally it would take 1 day, because the ERP program SAP needed the following night to update and Procurement usually handled all Spare Parts orders as soon as possible. However, in some rare cases this got delayed 1 day because of benefits with higher volume orders. In addition, the safety factor of 8 days also assumes that the supplier uses 1 day to respond

to the PO from Procurement. As clearly shown in the Procurement process chart it could take a lot more time. With the PO sent to the supplier(s) they have 7 days to respond. If they don't respond within 7 days the case gets handover to Aker Solutions' division in India and before they finally get an order confirmation (OC), many more days could have passed. Another pressing issue that adds uncertainty to the supply chain comes when the OC is received from the supplier. The OC contains a delivery date but this date has many times proven to mismatch the estimated delivery dates Spare Parts uses when creating a SO. If this is the case, Aker Solutions has promised a delivery date that can't be maintained, and they can't hold their suppliers responsible since these are only estimated lead times and not guaranteed. To clarify the uncertainty, there are uncertainty linked to a deviation in the estimated lead times from a supplier and the actual lead time. Furthermore, there are uncertainties as regards to deviation in the actual lead time from the supplier and the promised delivery time from the supplier. In this case Aker Solutions can hold the supplier somewhat responsible but it still counts towards the total uncertainty.

When the items finally arrive at Aker Solutions, they get as stated earlier hand over to warehouse. They need some time to process the goods, check for errors and proceed with picking and packing for final delivery. The time it takes to do this varies a lot and the uncertainty linked to this step is therefore of great magnitude. After two interviews with two different workers in the warehouse division it was clear that error was a huge factor to how fast items would pass through their system and out to the customer. The biggest problem was argued to be the NCO/NCR system. NCO = Non Confirmative Observation, NCR = Non Confirmative Report. When an item arrives at Aker Solutions, the warehouse division goes through a checklist (see Figure 12: The original process map for Aker Solutions' Spare Parts division). If there is an error of lesser importance a NCO is created. If there is an error that has a significant consequence to the use of the product, a NCR is created. An NCR is also created if many smaller errors occur multiple times. If a NCO or NCR is created the product(s) is put in quarantine until the problem is fixed. The time a product stays in quarantine has proven to vary a lot and according to a warehouse worker it can differentiate from a couple of hours to several weeks. Sometimes, especially when there is a NCO the warehouse workers can fix the problem themselves; it could be a mismatch in the delivery note but the product is correct, a different package than expected was delivered and it needs to be sorted, etc. An NCR is more severe and is usually dealt with by the Procurement division contacting the supplier. Examples of NCR issues could be delivery of wrong product, damaged product, etc. Another problem causing delays according to a warehouse employee is issues with the ERP system SAP. There are mainly two problems with this system. The first is that SAP only sees the warehouse as one division in one location, which means that there might be some extra work when a product is located in another warehouse. The second problem is

to do with the division system; SAP sometimes has a problem when dealing with products bought in lengths. For instance, if a customer orders two pipes with the lengths 5m and 10m, SAP can mix this up and deliver one pipe of 15m. It can also deliver the correct pipes but retracts 15m of the warehouse.

The final step of uncertainty in the model is the total uncertainty that affects the end customer. This is referred to as OTD. This percentage shows how many order-lines that are delayed. It is important to clarify that a SO can contain several order-lines and an order-line can contain several items of that specific product. As OTD results closest to reality best reflects the situation, numbers from January 2013 to January 2014 have been used. In addition deliveries to internal customers are neglected as they don't reflect the process described in this case. As a result of analyzing the late deliveries from Spare Parts out to external customers, a table of OTD was generated (see figure 15).

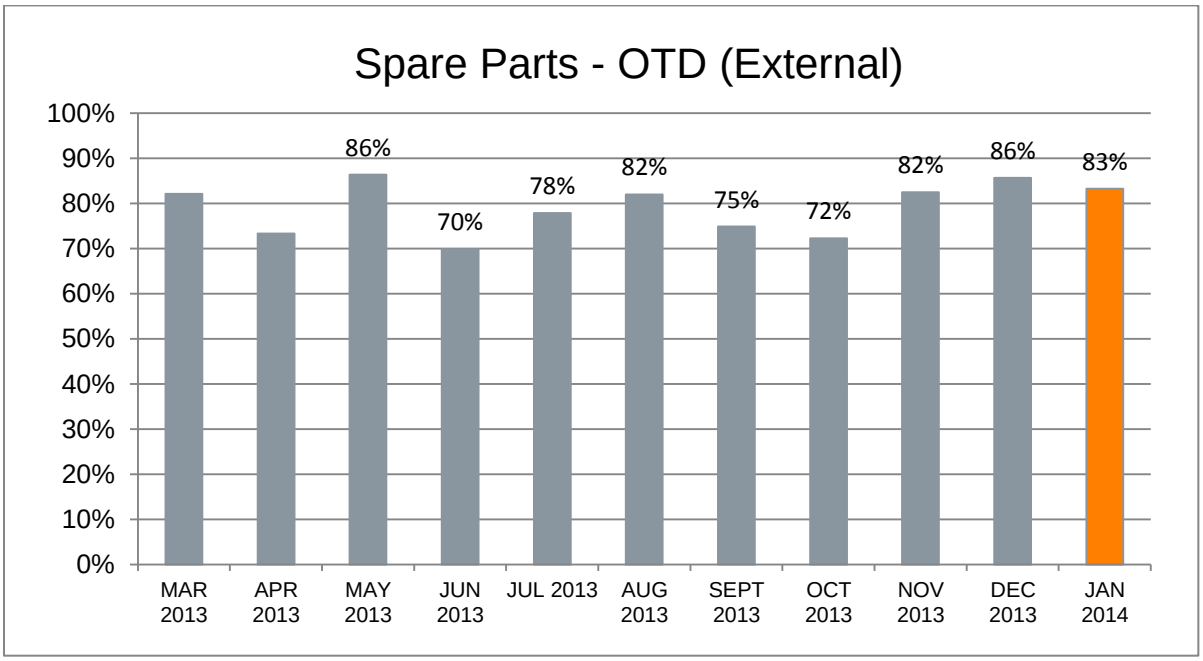

Figure 15: OTD from Spare Parts to customers

As seen in figure 15 the OTD varies from month to month, from 70 % in June 2013 to 86 % in May and December 2013. As of latest (January 2014) the OTD is at 83 %.

After removing all uncertainty up till the process where Spare Parts creates a SO and after estimating the other processes by roughly predicted uncertainty, in addition adding the known total uncertainty (OTD) to the end customer, the final uncertainty model for the whole process would look like the following figure (figure 16, next page):

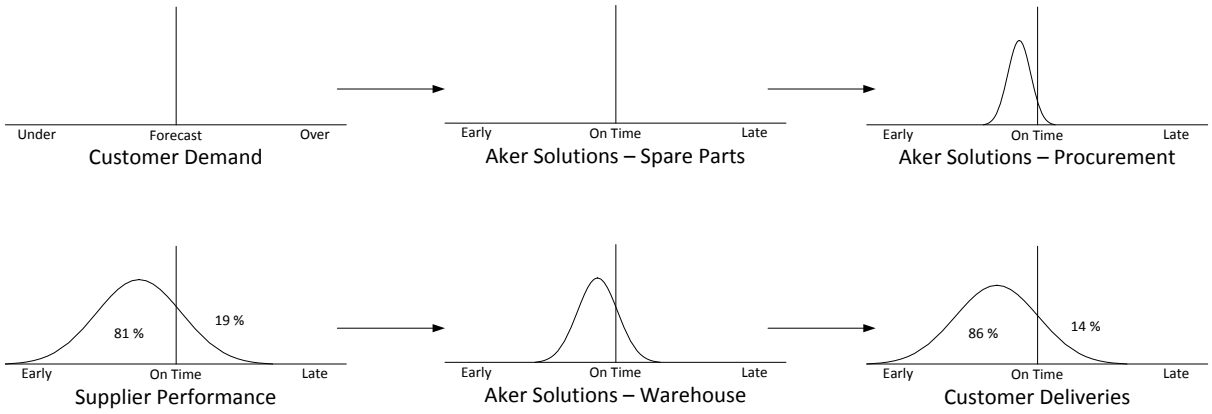

Figure 16: Actual uncertainties in the Spare Parts supply chain (December, 2013)

As clearly shown by figure 16, the majority of uncertainty lies within the supplier performance. Both interviews with workers from the Procurement and Spare Parts divisions, the workshop and dialogue with Spare Parts manager Kjetil Andersen and Procurement Manager for components Vidar Bjørkmann, points towards the supplier performance as the primary source of bad delivery precision. This is also confirmed by the supplier performance results (see Table 2: The 10 worst suppliers linked to Spare Parts in results). As results show the supplier performance is far from the optimal level according to theory. Christopher (1998) suggest a score of 2 (scale 1 to 10) to suppliers with an OTD of 80 %. From Table 1: List of all suppliers linked to Spare Parts in the year 2013, only 18 of total 48 suppliers have an OTD of 80 % or better. This means that 62.5% of the suppliers get the lowest score. This further indicates that the theory on OTD doesn't reflect real practice in this industry. Manager at Spare Parts Kjetil Andersen stated that a supplier with an OTD over 90 % is very hard to come by.

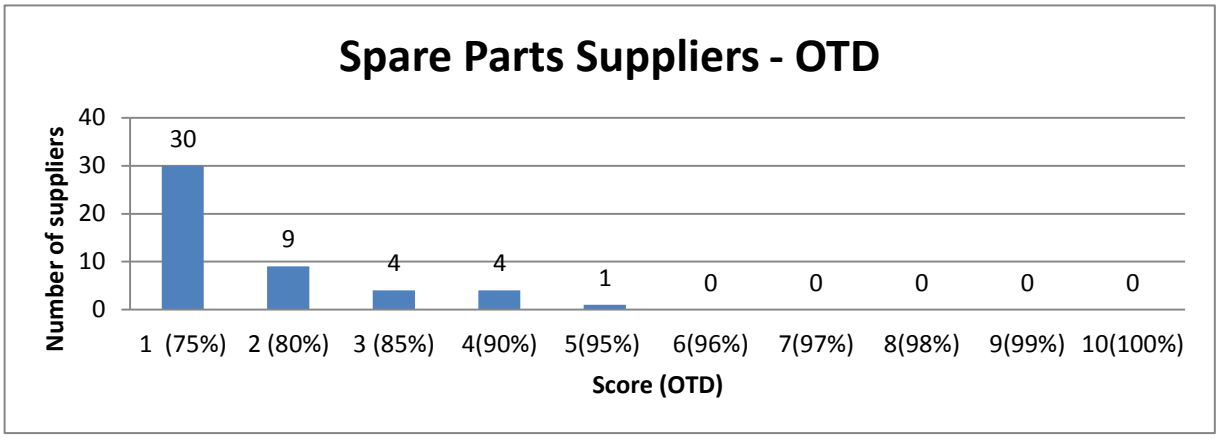

Figure 17: OTD of Spare Parts suppliers (over 100 PO/year) in 2013

To further look at the uncertainty differences within the supply chain it is important to emphasize that the OTD from Aker Solutions out to customers is expected to be higher than the OTD of Aker Solutions' suppliers according to Spare Parts manger Kjetil Andersen. This is because of different measures implemented internally. Firstly, there's the safety factor of 8 days that Spare Part expediters operate with when setting a delivery date to a customer. In addition there's also a safety

factor added by the Procurement division as mentioned earlier (GRPT). These safety factors add some slack to the delivery date, giving Aker Solutions a higher possibility of delivering on time, even if the supplier is late. Furthermore, the uncertainties representing internal processes are smaller but nonetheless just as important. The safety factors that adds a buffer to the delivery date doesn't count for much internal slack. The 8 days safety factor Spare Parts operates with weigh up for SAP handover time and warehouse processing time. These are processes bound to happen no matter the order. Furthermore, the GRPT is merely to count for product transport time. In other words, if something unexpected happens that results in one or more processes being delayed, there is a very low buffer. This can also be linked to an important finding in the workshop. For instance, when Procurement sets a PO they expect 7 days for the supplier to respond, the safety factor works on the presumption that this takes 1 day.

As stated earlier and shown by figure 15 the OTD from Spare Parts to their customers varies from 70% to 86% during the period from March 2013 to January 2014. A more thorough analysis of these numbers has also been retrieved from the SAP system. As Table 4: The delivery history of Spare Parts from March 2013 to January 2014 from results show, SAP is able to divide all late deliveries into groups based on how long they were delayed. It is important to clarify two things: First, these numbers show both internal and external deliveries, as SAP was unable to provide us with more detailed information. Secondly, these numbers are based on order-lines, not SO's. A SO can as earlier mentioned contain several order-lines, making these results more unreliable. Nevertheless, the results can still be used as an indication to the situation and a supplement to the discussion. Using these numbers from a period from March 2013 to November 2013 gives the following figure (figure 18):

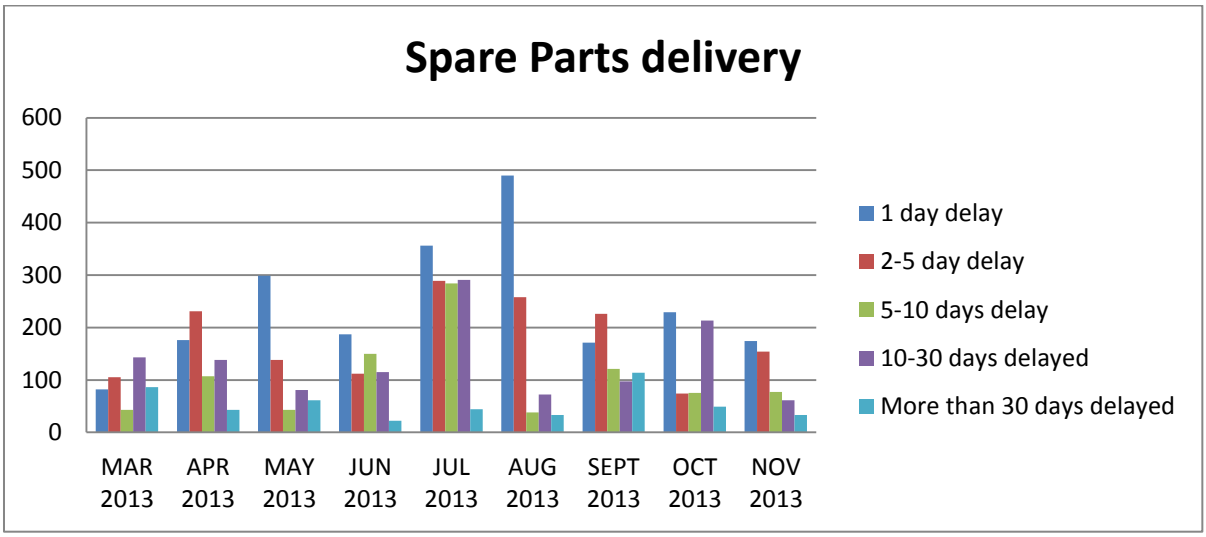

Figure 18: Distribution of late deliveries in Spare Parts (2013)

As clearly seen by figure 18 (previous page) there are a lot of varieties as regards to how many days an order-line has been delayed. It can also be argued if the group of 1 day delayed SO's is the most significant. This group is the largest group in 6 of the total 9 months and second largest in 2 of the remaining months. These results are very interesting and also unexpected. The supplier performance results given in Table 1: List of all suppliers linked to Spare Parts in the year 2013, indicates that the overall delivery from Spare Parts to customers should be several days delayed, not just a couple of days. This suggests that the already implemented safety factors have a positive effect on Spare Parts delivery precision, supporting the claim that Aker Solutions' OTD always is higher than supplier OTD.

As stated by several interviewees it should be easier to work with the delayed orders that are only a few days delayed. Implemented measures should have more effect on these orders and they should also be more reliable as the variation is low. Therefore, a further breakdown of these results is necessary. The following table shows the percentage of delays fewer than 5 days and exactly 1 day, as opposed to all delayed order-lines (figure 19):

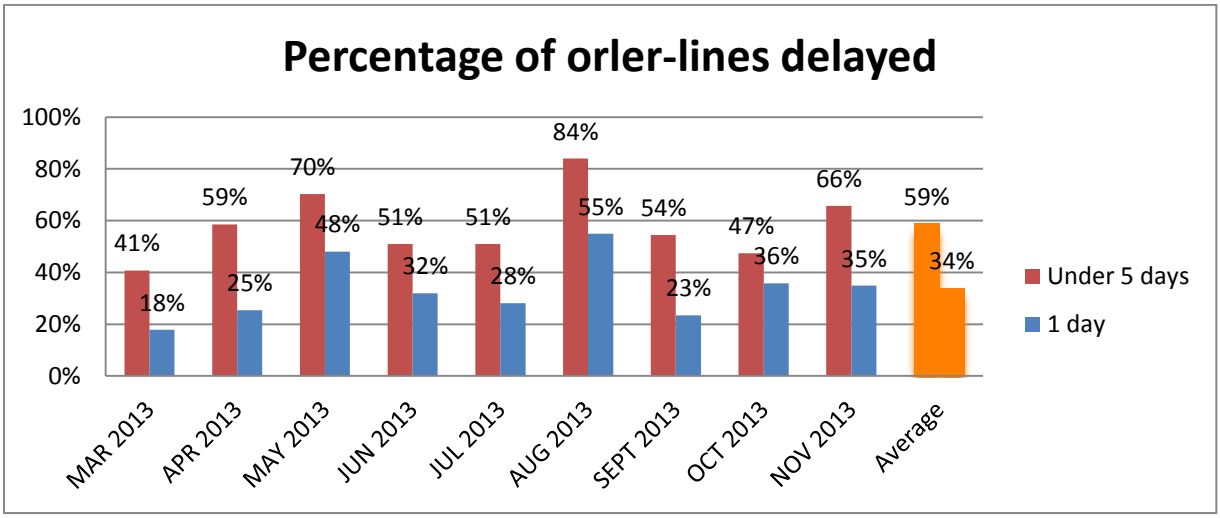

Figure 19: Percentage of order-lines delayed 1 day and <5 days, from Spare Parts to customer

As seen from figure 19 there are great variations, spanning from 41% in March to 84% in August on all order-lines fewer than 5 days delayed, and from 18% to 55% of order-lines only delayed 1 day. A reliable trend line is hard to predict but the calculated average percentage of 59% and 34% gives a good indication. It is clear that order-lines delayed less than 5 days most definitely stands for the majority of all delayed order-lines. Furthermore, these results indicate that if Spare Parts in 2013 had increased their safety factor from 8 to 9 days, roughly 34% of all order-lines delayed that year would have been prevented. Additionally, raising the factor to 10 or 11 days might have prevented roughly 50%.

6.2 Reducing uncertainty with supplier performance management

Since the uncertainty linked to supplier performance is argued to be the most essential for improving the total delivery precision, it is important that Spare Parts work on optimizing their supplier base. However, it is also important to remember that improvements in internal processes probably are easier to implement, because there is much more control of these processes. A supplier can be bad but that doesn't mean that we know why and how to fix, and there is also a chance that some suppliers are too crucial for the company to easily be replaced. However, it is possible to analyze the worst suppliers to suggest how to further proceed with them. A good overview of all suppliers and which ones that cause the most delays/problems, gives a solid foundation for supplier performance management. The following discussion gives foundation for prioritizing the 10 worst suppliers. In addition, suggested further actions are given, much based on Kraljic's matrix.

In figure 20, the 10 worst suppliers are analyzed as opposed to all Spare Parts related suppliers. Figure 20 shows the total volume, the volume of late deliveries and the total days delayed of the 10 worst suppliers as opposed to all suppliers linked to Spare Parts. As seen from figure 20 the worst suppliers' stands for 48.5% of the volume, 60.2% of the volume of delayed PO's and 67.1% of the total number of days delayed. To comparison, the 10 worst suppliers is 20.8% of all suppliers selected for this analysis. It is clear, that even after the filters of ignoring suppliers with less than 100 PO/year and 100 order-lines/year, the Pareto principle still is eligible for this situation. Only 10 selected suppliers (20%) stands for almost 50% of the volume and 60% of all errors. This is a clear indication that continuous focus on improving these suppliers can give a higher OTD and a stronger competitive advantage.

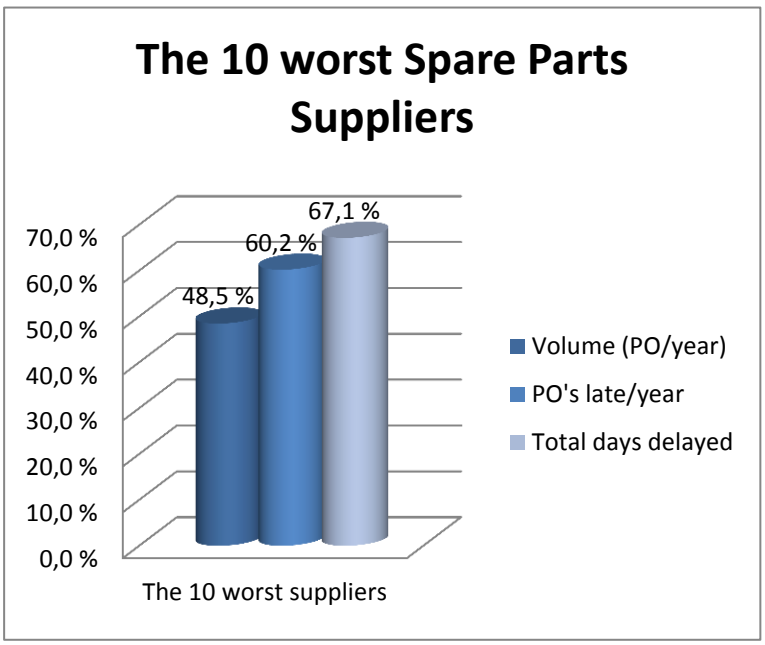

Figure 20: PO's, PO's late and days delayed of the 10 worst Spare Parts suppliers as opposed to all Spare Parts suppliers (over 100 PO/year)

A further breakdown of data is necessary to suggest a priority list for supplier performance improvement. The following discussion is based on the performance data of the 10 worst suppliers, given in results (see table 2: The 10 worst suppliers linked to Spare Parts, in chapter 5.1).

6.2.1 Analysis of OTD

Figure 21 shows the OTD of the 10 worst suppliers linked to Spare Parts.

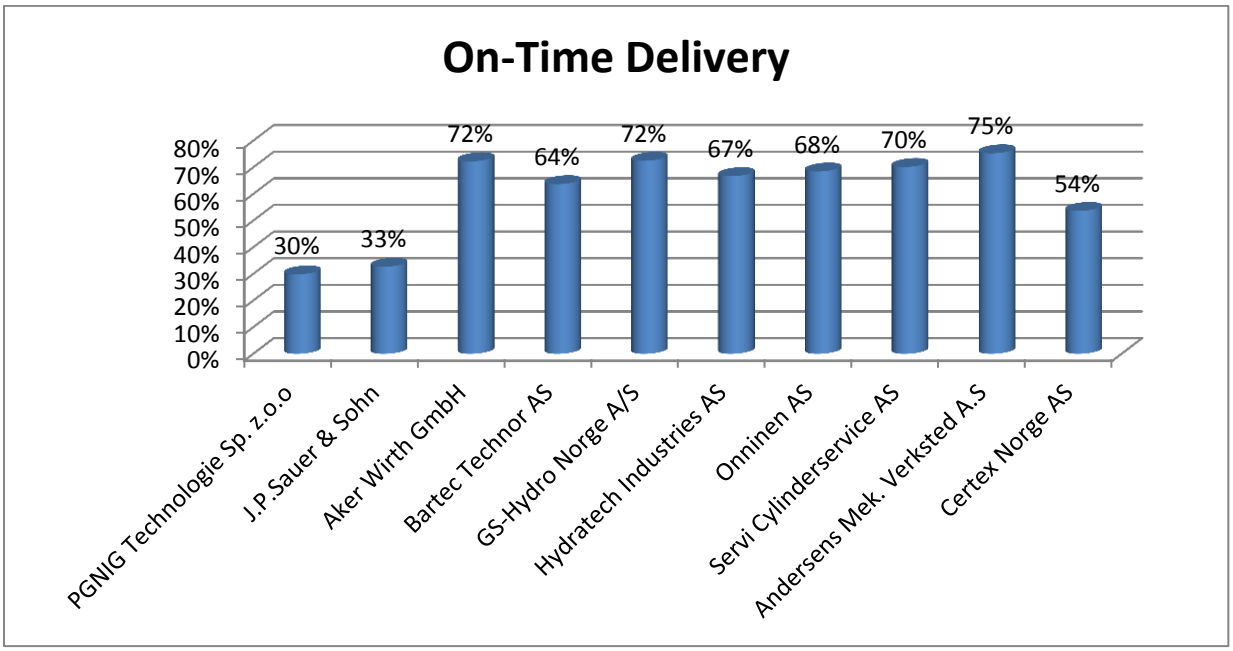

Figure 21: OTD of the 10 worst suppliers linked to Spare Parts

From figure 21 there are especially two suppliers that draw attention; PGNIG Technologie Sp. z.o.o and J.P.Sauer & Sohn with an OTD of 30% and 33%. In addition Certex Norge AS also has a very bad OTD of 54%. A closer look at the volume of these suppliers show that all three suppliers have more than 500 PO/year. The average PO/year of all suppliers linked to Spare Parts after filtering is 566 and the median 318. The difference between average and median suggest that a very few suppliers stands for a much bigger volume than the rest. However, since the three suppliers with worst OTD have a much higher volume than the median of 318, it suggest that these suppliers are in special need of attention.

6.2.2 Analysis of late PO's

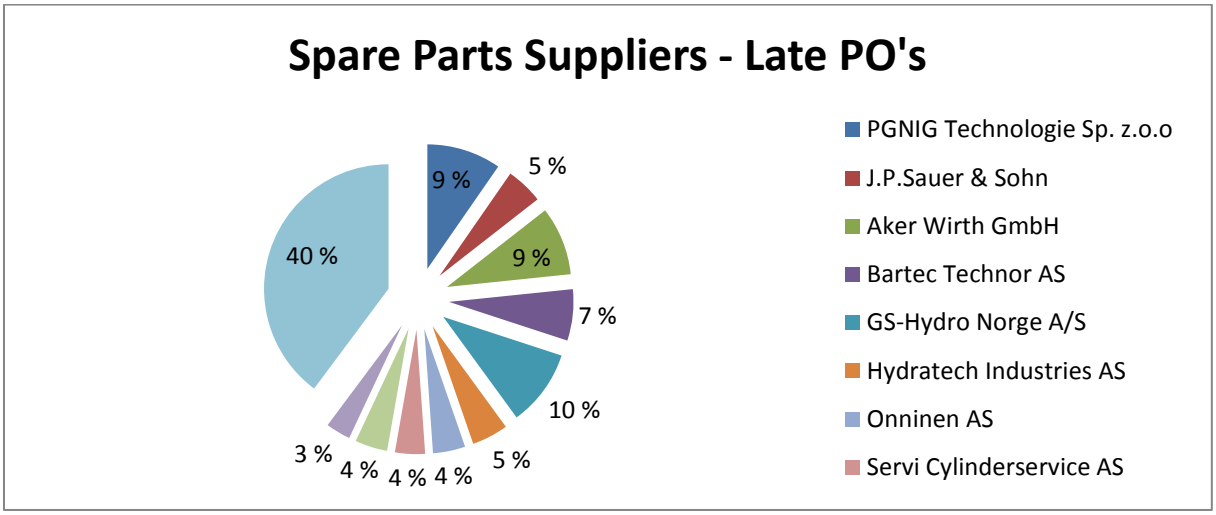

Figure 22: Distribution of the 10 worst Spare Parts suppliers as opposed to late PO's

A further analysis can be done as opposed to number of late deliveries by the suppliers, since OTD only shows the late deliveries as a function of volume. Placing the 10 worst suppliers in a table with regards to the number of late deliveries in 2013 the following figure is produced (figure 23):

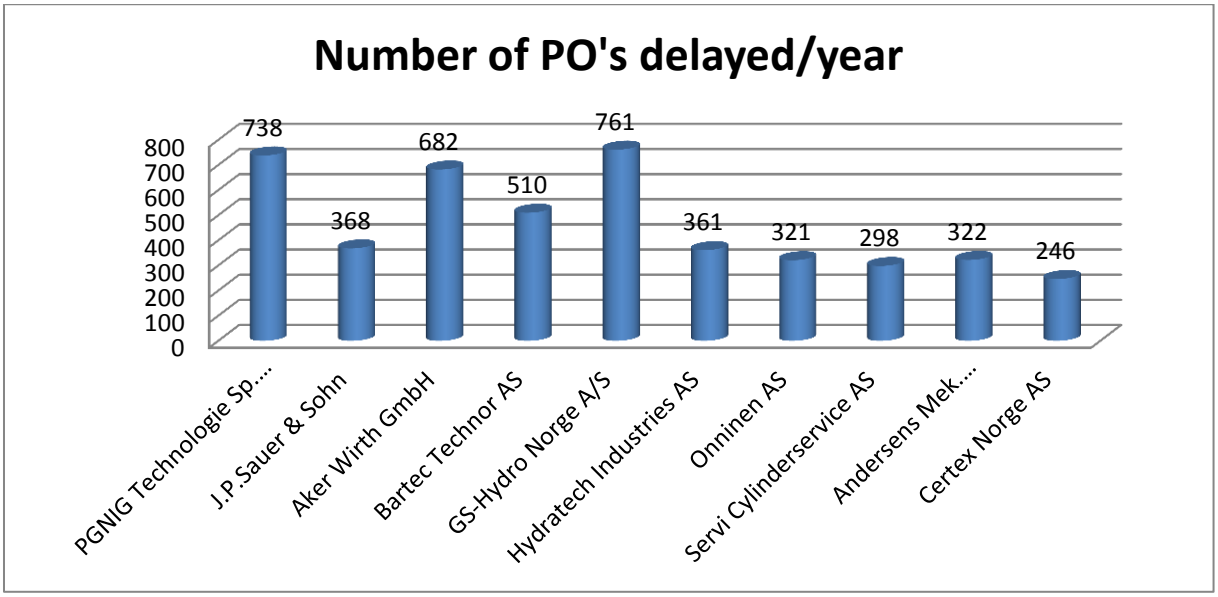

Figure 23: PO's delayed/year of the 10 worst Spare Parts suppliers

As seen from figure 23 PGNIG Technologie Sp. z.o.o, Aker Wirth GmbH and GS-Hydro Norge AS stand out from the rest as regards to most late delivered PO's. Those three suppliers stand for 2181 late PO's, making 47.3% of the 10 worst suppliers and 28.5% of all Spare Parts suppliers, suggesting these suppliers should be prioritized for supplier performance improvement. Bartec Technor AS should also be considered as they have 510 late deliveries, 11.1% of the worst 10.

6.2.3 Analysis of days delayed

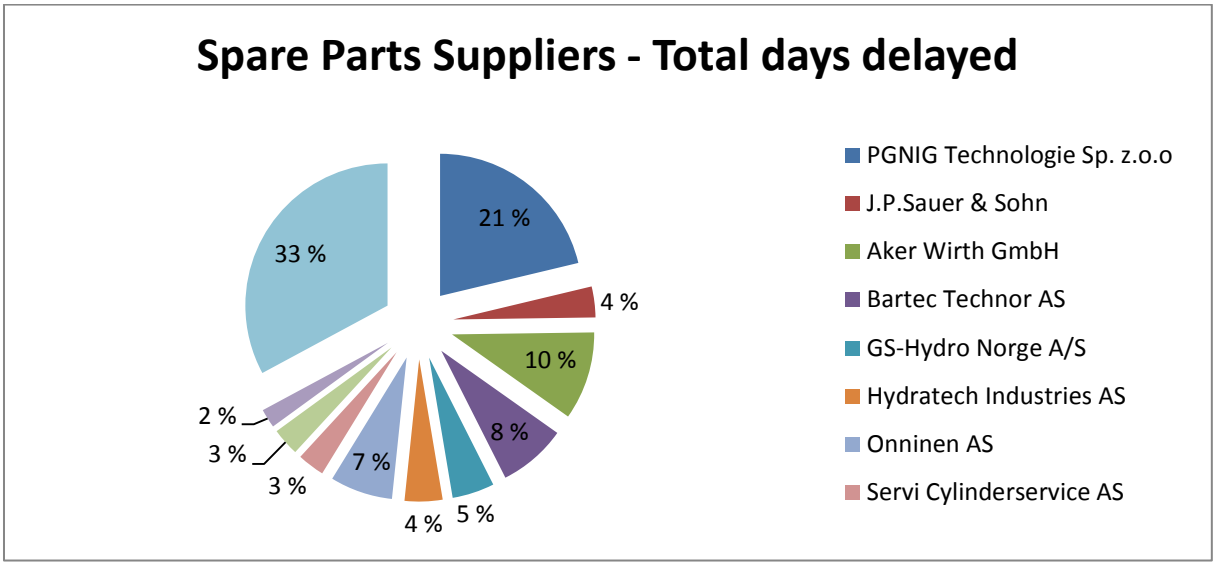

Figure 24: Distribution of the 10 worst Spare Parts suppliers as opposed to total days delayed

Another interesting analysis can be drawn from how many days each PO has been delayed. A problem with this number is that it is calculated with regards to PO, not the delivery package. Let's say Aker Solutions orders in many different products from the same supplier, in other words creating many PO's. The supplier sees this as an opportunity to deliver all PO's with one single package. If the package arrives too late, the number of days delayed will be multiplied by the number of PO's, making the number somewhat unreliable. However, the results can still be used in an analysis to give an indication where the problem is located. If the total number of PO's not on-time from the worst supplier is divided with the total days delayed by that supplier, the following figure is created (figure 25):

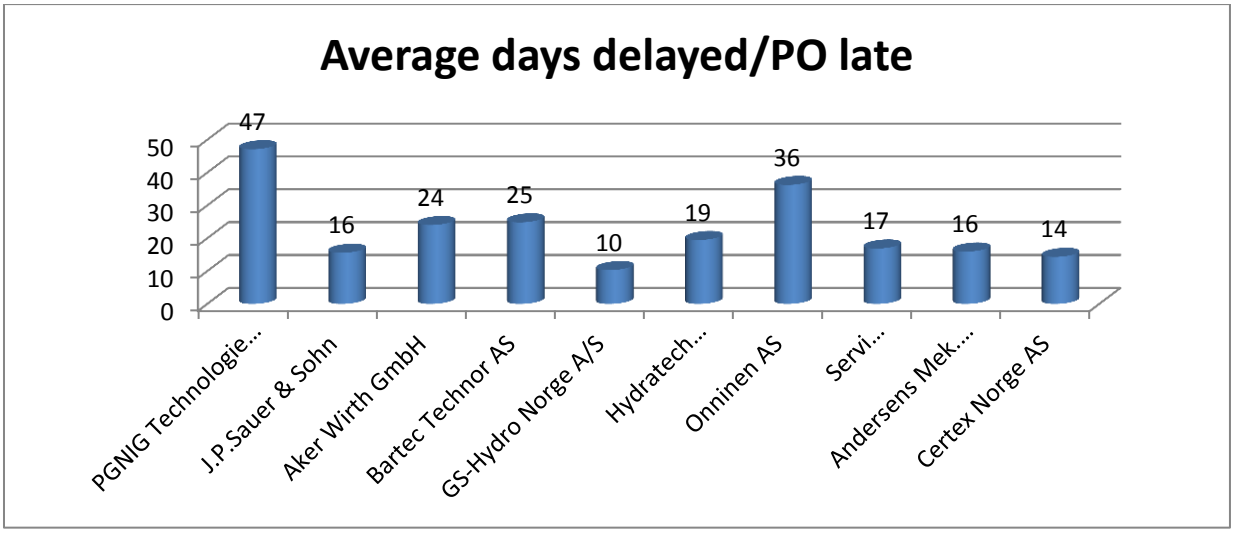

Figure 25: Average days delayed/PO's late of the 10 worst Spare Parts suppliers

Figure 25 shows the average number of days a PO is late of all PO's late delivered. From this it is clear that PGNIG Technologie Sp. z.o.o and Onninen AS has the worst statistics, with an average of 47 days and 36 days delayed. In other words, if one of these suppliers is late with a delivery they will severely delay the SO from Spare Parts to customer. The OTD of PGNIG Technologie Sp. z.o.o and Onninen AS are 33% and 68%, indicating a critical concern as to buying from these suppliers.

6.2.4 Rating the 10 worst suppliers

As these analysis' focuses on different angles and factors towards the suppliers, a comparison between them is necessary to conclude which suppliers are better or worse. The following figure (figure 26) shows this comparison. The figure has summed up the ratings from every analysis (10p=worst, 1p=best), resulting in a score between 3 and 30 points.

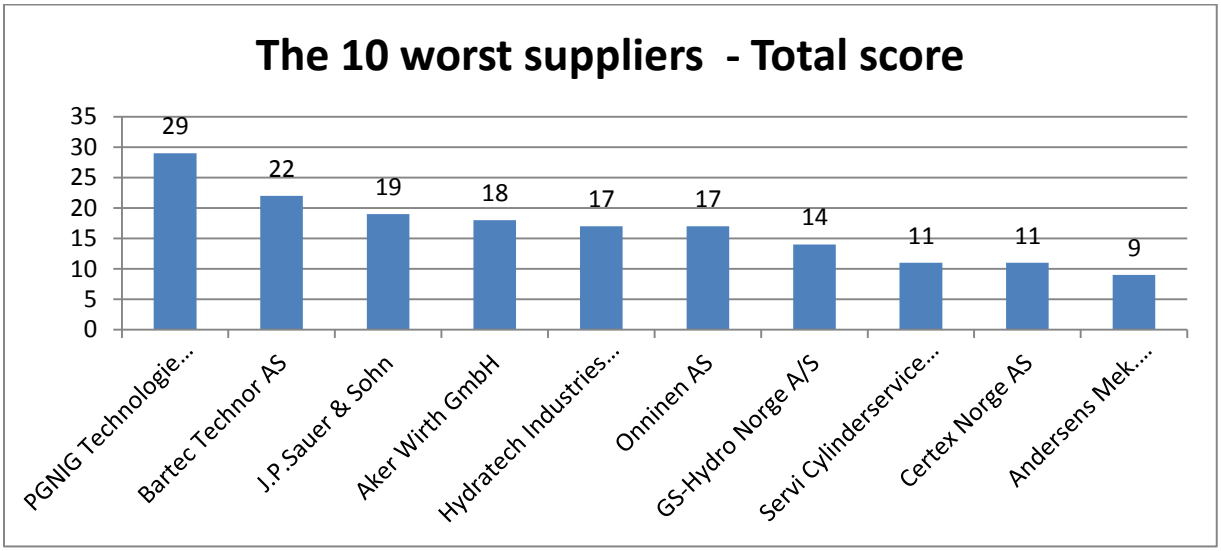

Figure 26: the 10 worst suppliers sorted by comparing all analyzes

As figure 26 show, PGNIG Technologie Sp. z.o.o has 29 points, making it by far the worst supplier. Bartec Technor AS falls on second place (second worst) with 22 points. This supplier has not strung out to be the worst in any analysis but has an overall bad performance. Not far behind follows J.P.Sauer & Sohn, Aker Wirth GmbH, Hydratech Industries AS and Onninen AS. These suppliers have also got an overall bad score and needs to be prioritized for improvement. GS-Hydro Norge AS gets a lot of points much because the enormous volume it stands for, making it hard to not get many late deliveries, even with a high OTD. The OTD of this supplier is among the top of the worst suppliers but it's still way lower than optimal. It is important to weight this supplier's volume when prioritizing. Moving on, the thesis will categorize the suppliers through Kraljic's matrix for a better understanding of which actions to take.

6.2.5 Using Kraljic's matrix

From theory, the Kraljic (1983) matrix has been described as a tool for improving the supply chain. A tool used to categorize all suppliers in a matrix depending on the complexity of the product and the volume needed of the specific product. The suppliers get placed in 1 of 4 boxes in Kraljic's matrix. Furthermore, each box in the matrix provides a specific way of thinking and handling with regards to that supplier. However, using Kraljic's matrix to categorize Spare Parts suppliers was proven to be a tough task. As stated by both Spare Parts manger Kjetil Andersen and Procurement manager components Vidar Bjørkmann, most of the suppliers in Aker Solutions' supplier base stand for the delivery of multiple products. This was implemented as a supply chain improvement measure to shorten the supplier base and lowering cost due to large orders. The result could mean that one supplier supply products from possibly all boxes in Kraljic's matrix. However, the fact that a supplier delivers multiple products only raises the complexity of that supplier, still making it possible to map them in the matrix. A substantial interview with Spare Parts manager Kjetil Andersen gave the following mapping of the 10 worst suppliers (see appendix A for interview log):

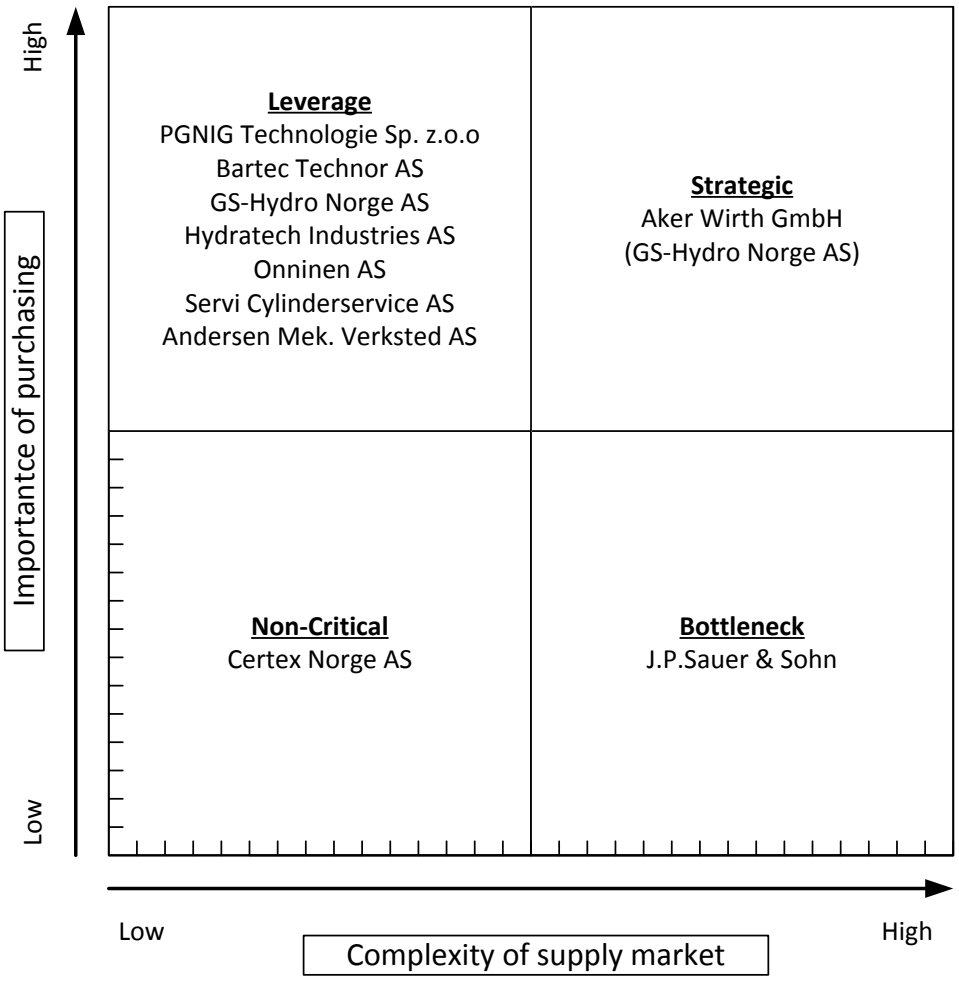

Figure 27: The 10 worst suppliers in Kraljic's matrix

Figure 27 (previous page) shows that most of the suppliers' falls under the "leverage" category. This means that they provide products that are relative low on complexity, but rather high on volume or importance of purchasing (Gelderman & Van Weele, 2003). GS-Hydro Norge AS is in addition to be in the "leverage"-box also marked as a strategic supplier. This is because of the extremely large volume they provide Aker Solutions and the high varieties of products. According to Spare Parts manager Kjetil Andersen, it should be easy to find an alternative supplier who's able to provide many different standardized products, but with GS-Hydro Norge AS the numbers are so high it would become very challenging. Moving on, J.P.Sauer & Sohn is the only bottleneck supplier. The products they deliver are mainly their own design and of high importance to Aker Solutions, making them very complex. Furthermore the volume can also be argued to raise the supplier to strategic. The line between what is seen as high and low is hard to draw and this only strengthens the critic of how subjective the Kraljic's matrix is, as also explained in theory. The same problem goes for Certex Norge AS, which is the only supplier in the non-critical box. Since the volume of these two suppliers is considerably lower than the others, they were chosen as low-volume suppliers.

6.2.6 Survey

As an extra measure to ensure the quality of the priority list of the worst suppliers, a survey was conducted in the Spare Parts and Procurement division of Aker Solutions (see questions and answers in results, table 5, 6 and 7) The participants rated the 10 worst suppliers from best (score=1) to worst (score=10). They were told to base this on an overall subjective experience of the suppliers. This raises the possibility that employees have different opinions and experiences with the suppliers. If then a supplier differentiate a lot from the list conducted in this thesis, this could suggest that this supplier has good customer service, HSE, etc. This is because the thesis has only considered direct performance (OTD and days delayed). The following table shows how the employees rated the worst suppliers (lower is better):

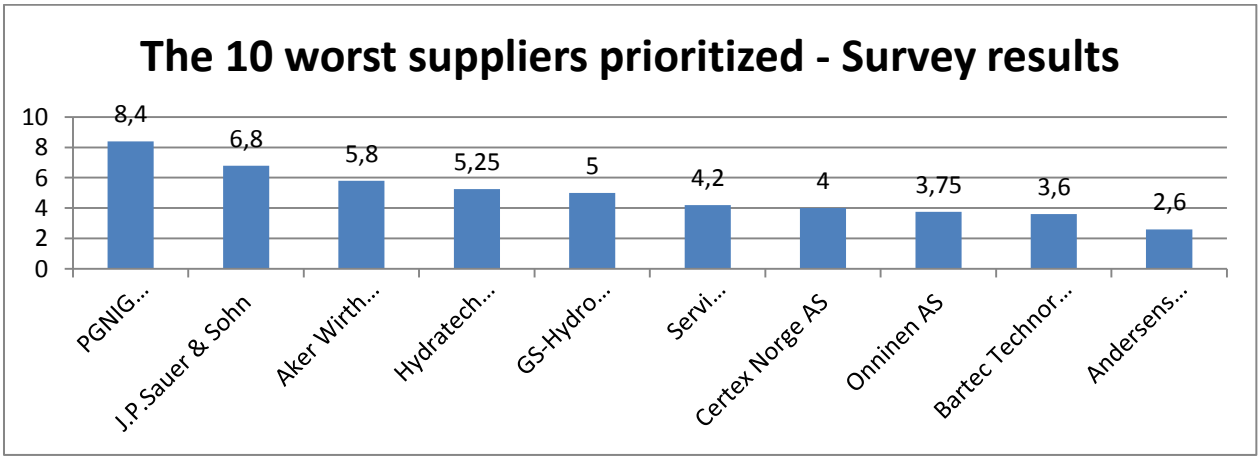

Figure 28: The 10 worst suppliers prioritized, results from survey

As clearly seen in figure 28 (previous page) PGNIG Technologie Sp.Z.o.o is suggested to be the worst supplier. Furthermore J.P.Sauer & Sohn and Aker Wirth GmbH follow straight behind. A clear trend is that the worst suppliers suggested by the thesis coincide with the survey results. Furthermore, a clear deviation is the supplier Bartec Technor AS which in this case is the second best, rather than the second worst from analysis. It is important to point out that this survey must be taken very lightly into consideration, because of two factors. Firstly, only 5 participants from the Spare Parts division answered the survey, making the selection very slim and the results somewhat unreliable. Secondly, the rating is done subjectively, meaning that the factors that weighted their answers could be different from person to person. However, the more or less total agreement as to who's the worst and best supplier is worth mentioning. PGNIG Technologie Sp.z.o.o has proven by far to be the worst supplier from analysis and it would seem that the Spare Parts division agrees.

6.2.7 Summary and suggested actions

If the total score of the suppliers from the raw-data analysis is put in a new table, along with the results from the Kraljic analysis, the final priority of the 10 worst suppliers is given in the following tables (table 8 and table 9). Comments as to what focus to have and which action to proceed with is also given with regards to theory (Gelderman & Van Weele, 2003; Gordon, 2008; Kraljic, 1983). It is thus important to remember that these results are mostly based on raw performance data. This must be taken into reflection when considering alternative suppliers, as there can be other factors (service, HSE, etc.) that balance out the supplier's performance results.

Priority	Supplier	Kraljic	Comment
1	J.P.Sauer & Sohn	Bottleneck	Clearly among the very worst suppliers. A challenging supplier since they deliver their own design. Gets priority 1 because it is a bottleneck supplier. **Focus**: Cost and short term sourcing **Action**: Find alternative supplier if possible. If not, secure volume by increasing safety time on this supplier. Audit the supplier; look for improvements by focusing on their lead-times and their uncertainties.
2	PGNIG Technologie Sp.z.o.o	Leverage	Clearly the worst supplier considering OTD on volume. Without it, 9% of all delayed PO's and 21% of all days delayed could be avoided (ALL Spare Parts suppliers, 2013). **Focus**: Cost/price and material flow. **Action**: Find alternative supplier ASAP.
3	Aker Wirth GmbH	Strategic	Stands for 10% of all days delayed and 9% of all delayed PO's (ALL Spare Parts suppliers, 2013). Gets prioritized because it is a strategic supplier. **Focus**: Long term availability **Action**: Increase communication, obtain a better supply relationship. Make contingency plans.
4	Bartec Technor AS	Leverage	A supplier with overall bad performance. An OTD of 64% being the 3rd biggest Spare Parts supplier. **Focus**: Cost/price and material flow. Auditing **Action**: Because Aker Solutions buys in such large volumes, the power of purchasing is great. Use this to either improve their OTD (audit, make them invest in improvement measures) or look for alternative supplier(s).

Table 8: Priority list of the 10 worst suppliers and suggested action for these suppliers - Part 1

Priority	Supplier	Kraljic	Comment
5	Hydratech Industries AS	Leverage	Delivers standardized products easily obtained elsewhere. Spare Parts uses several suppliers for the same type of products. As a leverage supplier, Aker Solutions has great purchasing power. **Focus**: Cost/price and material flow **Action**: Explore possibility of using Servi Cylinderservice or an alternative supplier for all products. Consider phasing out this supplier.
6	Onninen AS	Leverage	Delivers standardized products, easily found elsewhere. As a leverage supplier, Aker Solutions has great purchasing power. **Focus**: Cost/price and material flow **Action**: use purchasing power to optimize order volume. Scout for alternative supplier.
7	GS-Hydro Norge A/S	Leverage (strategic)	The largest supplier. Delivers a huge variety of products. But also stand for the largest number of late PO's of all Spare Parts suppliers (10%). As a leverage supplier, Aker Solutions has great purchasing power. **Focus**: Cost/price and material flow **Action**: Inventory optimization, audit the supplier.
8	Servi Cylinderservice AS	Leverage	Delivers standardized products, much of the same category as Hydratech Industries. Also with this supplier the purchasing power is great. **Focus**: Cost/price and material flow **Action**: Use this supplier or alternative for products from Hydratech Industries AS as well. Optimize order volume.
9	Andersens Mek. Verksted A.S	Leverage	Delivers after Aker Solutions' design. Stands for a high volume but are still easily replaced. **Focus**: Cost/price and material flow. Supplier relationship **Action**: Consider alternative supplier. If not, increase communication to obtain a better relationship. Consider making it a strategic supplier.
10	Certex Norge AS	Non-critical	Gets lower priority because it is a non-critical supplier. However, future action is required since this supplier is on the verge of becoming a leverage supplier. **Focus**: Functional efficiency **Action**: Better inventory optimization. Consider alternative supplier.

Table 9: Priority list of the 10 worst suppliers and suggested action for these suppliers - Part 2

6.3 Reducing uncertainty with process improvement

The Spare Parts process map was the starting point for how the process was evaluated. The map focused mainly on the Spare Parts processes, naturally, and had little focus on other dependent divisions (Procurement and warehouse). According to the manager of the Spare Parts division, Spare Parts operates with certain safety times when other divisions are included in the process. This means that when Spare Parts is for example in need of providing an item that isn´t on stock, the Procurement division is asked to purchase that specific item. The process of purchasing the item is a step that doesn't include Spare Parts in any way, but still very important. Spare Parts uses as previously mentioned an 8 day calculated safety factor for the duration of this process. Though, as discovered when exploring some of the delayed PO´s in SAP, the actual processing time could in some cases exceed the safety factor or vary a lot. Therefore, it can be adequate in regards to the flow of the process and the communication between the different divisions to have a thorough understanding of each other processes, so that the delivery date given to the customer can be even more reliable. A solid process map can help in achieving better flow in the total process and highlight what steps and activities that need to be redesigned, removed or added. It is further discussed how/if "Process Mapping" can help improve the Spare Part process, the communication between different units and eventually lead up to more reliable delivery dates.

After evaluating the internal process maps for the divisions it was clear that the process maps had room for improvement. Spare Parts own process map was the only map that had similarities to a flow chart, and it could seem like the map was drawn following the standard step by step method as presented in the theory chapter. The original process map is presented in figure 12. Surprisingly, the other process maps were either poorly made or not updated in several years. The process map for procurement was unorganized and it seemed like the different activities were included, with no clear view of how the activities worked together. The symbols and descriptions used in the map were also hard to understand. For warehouse an updated map was non-existent. The focus in the discussion is mainly on the Spare Parts and Procurement division and the communication between them. This is because the Procurement division is more heavily involved with the Spare Parts, and improvements in this area seem more suitable than in the processes where the warehouse division is involved. However, warehouse is still important for the Spare Parts processes and its on-time delivery.

It is important to mention that the presented measures don't involve the creation of a totally new process map. The original map weren't bad, as it had several good and effective aspects to it. What is presented are different measures that can help improve the already existing map, whether this includes changing, removing or adding different steps, processes and descriptions. Since it is the

Spare Parts division our case is based around, it is this division the measures are meant for. However, it is not unlikely that other divisions can find the presented measures useful as well.

6.3.1 How can a successful process mapping of Spare Parts be obtained?

As previously mentioned, Spare Parts and Procurement had flaws in their process maps. While Spare Parts was the only unit who had a map that could have resembles to how a process map should look like, Procurement had a rather poorly made map. In order to gain competitive advantage, the first step should be to focus on improving the process maps with the purpose of improving communication, understanding of each other processes and lean thinking (working together). Supporting a statement retrieved from an interview of a procurement employee, regarding possible solutions; an answer specifically highlighted miscommunication as the biggest issue. An idea is to combine the different processes in one single map, to present the total picture in a more sufficient way. Since the main focus is the Spare Part processes, it can be adequate to obtain a suitable picture of the how the other corresponding processes looks like and how they should interact with the Spare Part processes. A finding from the workshop (see appendix F) showed that both Spare parts and Procurement had limited knowledge of each other processes. The main processes were covered, but details and complicities were unknown. When the goal is to obtain more reliable delivery dates, it is only natural to think that a better knowledge of each other processes is necessary. When using the "flow chart" method as presented in the theory chapter the following combined map of the divisions as shown in figure 28 were drawn.

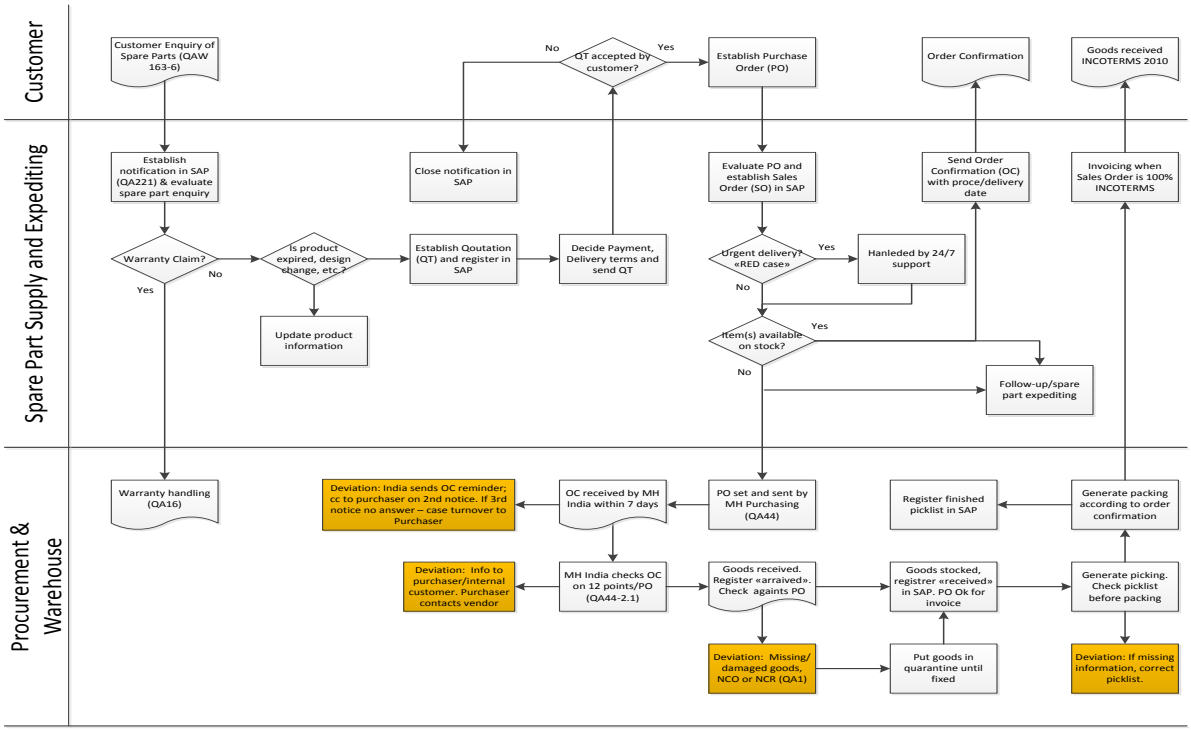

Figure 29: A suggested improved process map of Aker Solutions' Spare Parts division

Additionally, the map has taken elements from the value stream mapping technique. One thing that came to light when viewing the original map for Spare Parts was that the map seemed too complex, and it could seem like that the expeditors handling the different orders didn't follow the entire process described in the map, step by step. This got confirmed in the workshop when the participants were asked to draw the process map based on the process they normally followed. The main steps of the process were covered, but far from everything. When comparing their idea of the process to the actual map, the participants were familiar with almost every step, but didn't feel the need to include some of them in their own idea of the process as the steps were either in most cases nonexistent or they took little to no time to finish.

The original process map is a map that covers every single step of the total process. But this isn't necessarily the ideal process. Based on the value stream mapping technique, the ideal process is free from the unnecessary steps, which is of no value to the service (Hines & Rich, 1997). It's more effective to have a map describing the process the way it is, based on the thoughts of the employees as well as what activities that adds value to the product. In that way the map can be of much more use to the employees instead of having no real function, as the case is now.

Another important element in the combination of the different process maps is communication. Communication is a leading factor in achieving reliable delivery times, something that were enlightened early in the work with the thesis. The workshop showed (see appendix) that the participants didn't feel comfortable explaining each other processes. They all believed their own process were more complex than the other processes, as the workshop revealed when the participants were asked to draw the processes for the other division. Spare Parts is heavily dependent on Procurement when items are not on stock, as well as warehouse for picking and packing of the items. Meaning the processing time for handling orders from Spare Parts is of great importance when giving customers a reliable delivery date.

The effects of having a better organized and adequate process map can be more than just assuring more reliable delivery dates. It can present the process in a way that can better show where you can be more effective, which again leads up to increasing the chance of delivering on time. As Figure 19: Percentage of order-lines delayed 1 day and <5 days, from Spare Parts to customer, shows, as much as 33.9% of every order being delivered too late, were delayed with only 1 day. It is thinkable that some of these late deliveries could have been avoided with a more effective progression. Perhaps a more suitable solution to this problem could be to increase the safety factor with 1 or 2 days, which would have caused these specific orders to be delivered on time. It can be argued however, how suitable this solution is, considering that the orders and delivering times changes a lot. You can risk

adding extra days to orders where it is not necessary, which again can cause the spare parts to be delivered later than possible. In the end, the question is if the customers are willing to accept delivering dates 2 days later than usual, though some improvement of the OTD with a solution like this seems likely. Table 10 presents a better organized (short) presentation of our suggested measures (see figure 29).

Number	Measure
1	Combine the Spare Parts process map and the Procurement process map, possibly also the warehouse division.
2	Remove, add or combine different steps to increase the overall flow and simplicity of the processes.
3	Add 1-2 days on the 8 days safety factor.

Table 10: Suggested internal actions and priorities for the Aker Solutions' Spare Parts division

6.3.2 Continuous improvement

The lean philosophy presents continuous improvement as an important management tool (Zangwill & Kantor, 1998). It is important to remember that the possible solutions presented are based upon the current situation. This means that the improved process map isn't necessarily as useful say 5 years from now. Vendors can change, the organizational structure can change, customers can change etc. Therefore, to make sure a "healthy" process map is maintained, Spare Parts should work continuously with improving their process map and adjust it to possible changes.

Deming's circle can be a viable solution for obtaining continuous improvement. As Wig (1996) claims, the "PDCA" circle is an important tool in quality management. In our case it can help improve the quality of the process map, but also the quality of the process of improving the process map. The PDCA circle should not be used after a noticeable change has occurred, but it should rather be used as a "status report" you perform from time to time. As the planning phase of the circle identifies where you are and where you want to go, this helps you clarify what needs to be done. However, as previously mentioned, Deming (2000) states that the focus of the PDCA circle should be on long term goals, maybe as much as 5 years forward in time. It is clear that the need of updating a process map occurs more frequently than each 5th year, especially in the oil business. But as the nature of the PDCA circle is to secure a continuous improvement, and the process the circle presents isn't limited to only long term changes, the method can be a sufficient tool for obtaining an updated process map and eventually more reliable delivery times.

A possible solution to how the lean philosophy can help maintain continuous improvement is shown in table 11. This should frequently be done in regards to the process map, possibly every year.

Step	Activity	Comment
1	Plan	Gather different key-employees regarding the process and discuss where you are, where you want to be and how you get there. A workshop can be a good tool to use in this situation.
2	Do	Gather the necessary resources for obtaining the planned actions. Explain the planned actions to all the people involved and execute the actions (improve the process map).
3	Check	Do the process map match the planned map? Do the process map reflect your actual real processes? Do the process map reflect your goals? If not, repeat step 1 and 2 again.
4	Act	Implement and standardize the corrective measures.

Table 11: How continuous improvement can be obtained in Aker Solutions' Spare Parts division

6.3.3 Other ways to improve OTD

The workshop is based upon worker involvement as presented in the lean philosophy. Some of the findings from the workshop presented measures that seemed reasonable in addition to the process mapping. As a side note to the discussion regarding process improvement, some of the workshop findings are further discussed.

An important finding from the workshop was the misunderstanding of the safety time (see appendix F). As mentioned earlier the delivery date given to a customer is based upon 3 times; the lead-time from supplier, the goods received processing time (GRPT) and the 8 days safety time. As the lead-time is measured in calendar days, while the GRPT and safety time is measured in working days (meaning they exclude "red" days), confusion can occur as to what the delivery date really includes. The workshop showed that many of the participants were under the assumption that the delivery date was based on calendar dates, resulting in a delivery date some days before the actual planned delivery date. A finding highlighted some misunderstanding regarding the different "time-factors" used when setting delivery dates. A solution suggested by the participants was to convert all factors to calendar days, in that way eliminating any confusion as to what days the delivery date includes. A problem with this solution as mentioned by Kjetil Andersen, can be that due to the complexity of SAP and it is difficult to in make changes affecting the actual layout and presentation of data. However,

this is something that might be an idea to focus on improving in the future. Another solution more easily implemented was to better inform the employees of what the different time factors actually involves. A better understanding of why the different values were set might help in seeing the logic of excluding non-work days when setting a delivery date.

Another suggested measure is regarding wrong lead times given from suppliers. The lead-time isn't updated frequently enough. The idea with the lead times is that they operate as the maximum number of days the supplier needs in delivering the items. A problem occurs when this isn´t always the case. In some cases the lead-time in SAP is several days less then what it actually is. This can result in delivery dates that are bound to fail from the start. A possible solution suggested by one participant was to add two new informational fields in SAP. As of today SAP contains 1 lead time based on the vendors previously lead times and the GRPT. The new fields will contain the "normal case" lead time and the "worst case" lead time. This means that the lead time can now be based upon another factor, increasing the reliability of the delivery date. Another supplier dependent factor will also cause a need for a more frequent communication with the vendors when updating the lead times. Again, as previously mentioned, it is needed to make changes to the structure of SAP when wanting to make changes like this, something that is not easily doable. See Table 12: Other suggested actions and priorities for the Aker Solutions' Spare Parts division.

One problem that also were mentioned was in regards to the checking of the products ordered from customers, to see if the products has expired, if the prices are correct or if the products needs a replacement. The process map didn't reflect the actual time needed for this step, as it could sometimes be very time consuming, and if the order contained an extensive amount of products, it would almost for certain be delayed. Maybe Spare Parts should revise what this step includes and how it is done. A certain process time could be added to this step, depending on the order volume. As problems also were mentioned in regards to vendors not updating their products and causing huge SO delays, considering outdated products weren't discovered until after the SO date was set, one solution that could benefit both problem is a more frequent communication with vendors regarding outdated products.

Another finding showed that the "rule" of always to make the PO the same day when handling handovers from Spare Parts, didn't always get followed. The rule was not completely understood by all, as well as certain disagreements with the rule were expressed considering problems with storage costs and purchasing of smaller volumes. This rule should be thoroughly explained to all parties involved, to keep people from ignoring the rule, no matter the cause.

Number	Division	Measure
1	Spare Parts	Convert Spare Parts safety time to calendar days.
2	Spare Parts Procurement	Give better information about the different time factors.
3	Procurement	New informational “box” in SAP giving information about the “normal case” and “worst case” lead time.
4	Spare Parts	Revise what the process of updating and checking an enquiry includes. Possibly add an extra safety time based on the volume of the order.
5	Procurement	Obtain better communication with suppliers regarding outdated products.
6	Procurement	Thoroughly explanation of the rule and why it can’t be ignored.

Table 12: Other suggested actions and priorities for the Aker Solutions’ Spare Parts division

7. Conclusion

Can Spare Parts improve their OTD with the external measure supplier performance management?
A clear indication that supplier performance management will improve the OTD of the Spare Parts division, have been given by this thesis. Chapter 6.1 clearly shows the supplier performance as the largest are of uncertainty. The OTD of the Spare Parts division to customers is clearly linked to the supplier's OTD, even though there are differences argued to be a result of already implemented measures (safety factors, GRPT). There are strong reasons to believe that supplier performance is strongly correlated with Spare Part performance.

A suggested focus presented in chapter 6.2 is to work on improving the worst suppliers. Different analysis of these suppliers has been given with regards to volume, OTD, days delayed and complexity. These analyses are also supplemented by survey results, although these results are expected to have low reliability. There are definite indications that improvement on the 10 worst suppliers will give immediate positive results on Spare Parts overall performance. See table 8 and table 9 for full priority list with suggested focus and actions.

Can Spare Parts improve their OTD with the internal measure of process improvement?
The discussion gives insight in different measures which can be implemented to improve on-time delivery. The discussion presents process mapping and lean concepts as tools to obtain and maintain process improvement. Communication, flow of information and coordination is important factors when trying to manage and improve processes. Therefore, to answer if internal process improvement can be used to improve their OTD; it seems adequate to focus on what degree process improvement will improve these factors. It is difficult to guarantee if the suggested measures will help improve these factors and the overall OTD, because there is no way to evaluate the measures after they have been implemented. However, the research from this thesis, including workshop, survey and interviews, all indicates that the suggested measures includes most of the factors that has been highlighted as important to improve the OTD. Taken the theory into consideration as well, it only strengthens the reliability of the proposed measures.

On the other hand, it is important to remember that how the measures are implemented and how you work with continuously improving them, is vital in regard to failure or success. Suppliers, employees and organizational structures are certain to change over time, meaning the processes need to be updated. This has been taken into consideration in the thesis, as the PDCA circle can be a good tool for this. If Aker Solutions and their Spare Parts division choose to implement the proposed measures with a focus on continuously improving them, there is reason to believe that the OTD can be improved.

8. Final remarks

8.1 Research assessment

The case study in general is considered to have good quality and should serve as a great help to the Spare Parts division, on their work on improving OTD. The results provided are generally based on information gathered from the different techniques described in chapter 4.3.1 and relevant theory. Still, it is reasonable to assume that the results carry some indications of subjective input. This should be taken into consideration when studying the results.

Interviews – All interviews followed the same procedure as described in chapter 4.3.1. The questions were in most cases open, giving room for the interviewee to come up with own thoughts on the subject. Interviews were successfully conducted from all departments as planned. For the Spare Parts division much information was also gathered by unlogged dialogues with the Spare Parts manager Kjetil Andersen, making the need for other interviews in this division smaller. However, it is expected that a more thorough picture of the interview subjects, could have been extracted if other interviews was conducted. Two interviews of warehouse employees were conducted, due to several unanswered questions gathered from the workshop. This gave us a solid insight in the warehouse processes and their link to Spare Part and Procurement.

Workshop – Almost all (7 of 8) participants invited showed up, making a representative selection from both Procurement and Spare Parts a fact. All participants were very involved during both stages of the workshop, resulting in a lot of gathered information. The case examples given (extracted from real situation) was suitable and highlighted many areas of potential problems. The information given to the participant's beforehand stage 1 should be more explaining. They were only told to draw their process map as they see it, a very open task resulting in different interpretations for the two divisions. The procurement division understood the task as to draw a complete map of every possible process for all possible situations that could occur. Spare Parts on the other hand, felt that a map of the normal situation was the answer to the task. Anyway, since the discussion from both divisions was virtually fully logged, many more outcomes could be used in further analysis.

Survey – The survey was good in its purpose but bad in its implementation. The thought was to let both the Spare Parts and the Procurement division take the survey. The survey never seemed to reach the Procurement division and only reached 5 employees in the Spare Parts division, making the results somewhat unreliable. However, some of the results were very evident on some answers making some of the results useable for analysis. Nevertheless, the low participation on this survey is taken into consideration in both the analysis and conclusion.

8.2 Future research

This thesis has by its investigation explored other areas that need attention to ensure a high performance output from the Spare Parts division in Aker Solutions. Two central findings were explored, both with links to the Procurement division. These findings are expected to have great potential for improvement if analyzed. The first finding is with regards to the NCO/NCR error handling system. The second finding is linked to the India division.

NCO/NCR system

As fist discovered as a finding in the workshop (appendix F), and later elaborated by interviews with warehouse employees (appendix B and C), the difficulties caused by the NCO/NCR system can results in major delays. As explained in chapter 6.1 of the discussion, the problem occurs when a delivery from a supplier has some sort of error, minor or major, and is put into quarantine until fixed. As stated by a warehouse worker the issue is usually only damaging when the delivery problems are small (NCO-issue). This is because a NCR problem is immediately dealt with by the responsible Procurement buyer. A NCO-issue is considered a minor error and therefore not notified to the Procurement division. This is also logical as there are over 2000 NCO each year, making it an impossible follow-up job for Procurement. However, there are many registered NCO's that could much easier be fixed both at the time and for the future if Procurement was involved. At the same time, there are many NCO's that is easily fixed on the spot and therefore making reporting unnecessary. A further analysis of the NCO/NCR system with regards to people involved in solving them, and the need of quarantine on all problems should be conducted. This case would require including both the Procurement and the warehouse division.

The India division

The India division handles as explained in chapter 3.5 the follow-up on suppliers after Procurement sets a PO. A supplier is required to reply with an OC within 7 days, if they're late India handles the notices. Furthermore the India division checks the OC for errors. From the workshop an important finding was issues regarding the India division (see appendix F). There have been situations where the India division has trouble following up the supplier's. There is also mistrust to this department as some Procurement employees check the OC themselves, in addition to letting India do this. There should be a thorough investigation and analysis regards the benefits and miss-benefits to the India division. Furthermore an analysis of the overall necessity of this department. This case would require including both the Procurement and the India division.

8.3 Personal experiences

Having Spare Parts manger Kjetil Andersen and Procurement manager for components Vidar Bjørkmann, available for scoping of thesis and answers to general questions has been a great help. The simplicity of arranging a workshop and interviews has also been of great help to our work, concluding that this kind of a case study generally needs great assistance from management. Furthermore, it has been very informative and educational to experience how Aker Solutions as an organization operates. We also feel that we have established a good foundation and insight into the oil and gas industry.

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Aker Solutions

APPENDIX A: Interview of Spare Parts manager Kjetil Andersen

Time: 06.05.14

Location: Aker Solutions - Korsvik

I. Attendees

Kjetil Andersen	**Fredrik Roalsø**	

II. Rèsumè

The purpose of this interview was to try place the 10 worst suppliers in the Kraljics matrix. By gathering as much information as possible as to what products the different supplier's supplies and as to the complexity of these products, we can suggest a placement in the Kraljic matrix.

The list of the bottom 10 suppliers was extracted from the thesis' results. The following notes and conclusion was taken from the interview:

- **PGNIG Technologie Sp. z.o.o** – This supplier deliver products designed by Aker Solutions. In other words, they are easily switched. At the same time, they supply a very high volume and varieties of products. This could make it complicated to find another supplier. Conclusion: LEVERAGE
- **J.P.Sauer & Sohn** – They supply compressors in which they design themselves. Their design is unique, making them important for Aker Solutions. If a part has a malfunction, only this supplier can supply spare parts. The volume this supplier represent is hard to place, it's significant but not among the top. Conclusion: BOTTLENECK
- **Aker Wirth GmbH** – This is a part of Aker and there is no one else to go to. The design is unique and at the same time very complex. In addition, they represent large volume consumption. Conclusion: STRATEGIC
- **Bartec Technor AS** – They supply standardized products with low complexity. These products can easily be found elsewhere. They supply a whole variety of products, but the troubles of finding another supplier that supply the same should be small. In addition, they represent a large volume. Conclusion: LEVERAGE
- **GS-Hydro Norge AS** – Low complexity, high volume. Many products are standardized and can be found elsewhere (hoses, connectors, etc.). At the same time, they represent an extremely large

volume and variety of products. Conclusion: LEVERAGE (ALMOST STRATEGIC)

- **Hydratech Industries AS** – Deliver hydraulic cylinders that's easily found elsewhere. They represent a large volume. Conclusion: LEVERAGE
- **Onninen AS** – Highly standardized components, easily found elsewhere. Stands for relative large volume consumption. Conclusion: LEVERAGE
- **Servi Cylinderservice AS** – Much alike Hydratech industries AS, they also supply cylinders that can be found elsewhere. They also represent a large volume. Conclusion: LEVERAGE
- **Andersen Mek. Verktsted AS** – Delivers what Aker Solutions designs. They are easily replaced a part from the fact that they stand for a high volume. Conclusion: LEVERAGE
- **Certex Norge AS** – Delivers standardized non-complex products that can be found elsewhere. The volume of this supplier is like J.P.Sauer & Sohn hard to place, but considered to be low. Conclusion: NON-CRITICAL

Aker Solutions

Appendix B: Interview of warehouse employee 1

Time: 19.03.14

Location: Aker Solutions - Korsvik

I. Attendees

Warehouse employee	Fredrik Roalsø	Magnus Jortveit

II. Rèsumè

The purpose of this interview is that we wanted to see how the warehouse process looked like. Since packing and sending (warehouse) is a part of the process in which OTD is measured by, we think it is important for Spare Parts to have a certain understanding of what the processes in warehouse looks like when setting a SO. The interviewee was from the warehouse department (herby referred to as person A). Person A started explaining the process from when an item arrives at the warehouse to when it is registered and placed in the warehouse. Furthermore also explained the process of generating picking and preparing the items for sending.

When an item arrives the warehouse it is checked against a receipt. If package is in order and also fits with the PO (meaning Aker has received what they requested) it is marked OK and registered in SAP. If its not in order, the item(s) can be registered as arrived but not delivered. This is something that happens a lot, even up to many times a day. The procedure then is that the person responsible for the PO (procurement department) is contacted and the item is placed in quarantine (specific area for this) until the problem is solved. It is also possible that the item(s) is returned to the specific vendor if it's an excessive problem.

An example: Say you have placed an order of 50 sets, consisting of 5 parts each. If you then receive the item(s), but not in sets, a NCO (non confirmative) has to be made. The physical condition of the items is ok, but they need to be in sets before they can be placed in the warehouse. In other words, the vendor has delivered the correct item(s), but the packing is wrong. This is something that happens a lot. An error like this is usually dealt with pretty fast, but some NCO´s can take weeks to solve. The purchasers usually dealt with the NCO´s/NCR´s themselves before, but now Aker has established a specific position just for handling NCO´s.

There exist a lot of NCR´s (non confirmative reports) as well. An example of a NCR is when an item(s) is

registered with 1 item on stock. This is an item that is measured in length. When a purchaser orders two of this item, the order is confirmed because the required length is on stock (but only as 1 item). As the needed length is on stock, the order is registered as OK in the system, when its actually only 1 item on stock that can't be split up.

So, if the item(s) is registered as delivered in SAP and registered in to warehouse the item is stored in its specific location. Warehouse generates picking 3 times a day, where certain criteria for the picking list needs to be in order:

- If inland, there is no need for netto weight.
- If the item(s) is controlled by a serial number this has to be marked on the picking list.

The picking list is then sent to packing, where the packing is mainly based on the date of the list. They operate by the FIFO (first in first out) principal here. The warehouse has 24 hours from when the picking is generated to the item(s) has to be packed and ready to sending. The list is registered as completed in SAP, while some papers that's belonging to the shipment is printed out.

Person A also mentioned some troubles with item(s) based on length (meters). Say a customer is ordering a 100-meter long cable in 1 length. In SAP, this cable is registered as on stock, while this isn't necessary the case. The specific cable is often stored at different locations in the warehouse with different lengths. When SAP sees an order of a 100-meter long cable, but you only have 3 cables of 40, 40 and 20 meter, SAP says the item is on stock, when its not. This is a problem that's caused a lot of extra work. Currently there is no solution in SAP on how to change they way the system views item(s) measured in meter. This has made the warehouse department deploy a person to only deal with this kind of problems.

Documentation is another area that can consume some time. If a customer demands documentation and the vendor hasn't given any to Aker or the documentation hasn´t arrived yet, this can cause some waiting.

Another problem person A also mentioned was when the item(s) wasn't physically in its place, when SAP says it should be. This can happen sometimes and may cause some extra work/time.

Aker Solutions

Appendix C: Interview of warehouse employee 2

Time: 25.03.2014

Location: Aker Solutions - Korsvik

I. Attendees

Warehouse employee 2	Fredrik Roalsø	Magnus Jortveit

II. Rèsumè

A warehouse employee (herby referred to as person B) took us through a normal process of how they handled items in the warehouse. At first he showed us the outside of the warehouse where all the items arrived. Person B explained how they check the items based on certain criteria like how the BA-numbers and order-numbers must match. How they must measure and check certain items, and even paint some items if that is needed.

Person B also mentioned another warehouse in Vennesla, which handled bigger modules. Meaning that every big module that arrived in Korsvik, needed to be transported further to Vennesla. SAP also operates with only 1 single warehouse, meaning the warehouse in Vennesla and the one in Korsvik is one single warehouse in the system.

We then went inside the warehouse, where person B did the actual process of handling a smaller item that had arrived to the warehouse. This process included opening the package, checking that the receipt matched what was actually inside, registering the items in SAP, printing out labels which needed to be placed on every single item (in our case this included 20 USB-cables), transporting the items to its destination and placing the items at their place in the warehouse. Now, this was a normal process and a smaller item. It is natural to think that a bigger item would take longer time in handling. Computer components, which are more fragile than other items even had its own locked room in the warehouse.

One of the main problems “name” mentioned was with the NCO/NCR. The items that didn’t match with what Aker had of information about the item. When this was the case, the item went to a so-called quarantine where it could stay for up to 60(!) days. The problem here was the time it took to manage the NCO/NCR. Aker operates with NCO, which means that when an item was wrong, the warehouse needed to send a report to a NCO analyst, which then again looked into the problem and fixed it. But a NCR only occurs when there is 3 or more NCO for one vendor. The NCO is in most cases an easy fix for the

warehouse alone, so person B meant it was unnecessary to send every NCO to the analyst for fixing. According to a report from person B, there was 1121 NCO in 2013 and only 8 NCR. If most of those NCO didn't have to go through a process with the analyst and back, they could save a lot of time. The NCR´s however is good for an analyst to handle, when trying to spot trends.

Another problem that person B mentioned was with loosing work force. Every worker in the warehouse has his/hers tasks. Person B said that you needed at least 6 months-1 year of experience before you could do a good job. Meaning when warehouse lost so much as 3 people due to different circumstances, this made a big impact on the effectiveness of the warehouse, much because those people was hard to replace. This problem didn't occur to the procurement apartment, which only thought of the warehouse as one unit, and was under the assumption that they could operate like normal.

Aker Solutions

Appendix D: Interview of Procurement employees

Time: 03.03.2014

Location: Aker Solutions - Korsvik

I. Attendees

Procurement employee	Procurement employee 2	Fredrik Roalsø

II. Rèsumè

We discussed possible internal problems with resulting consequence of late delivery to end-customers.

Procurement employee 1 and 2 is hereby referred to as person C. One possibility explained by person C is the problem with expired products. If a product has expired the supplier is supposed to notify Aker Solutions and a notification will show up in SAP. When Spare Parts wants to sell this product they will go through their protocol and find that this product has expired. In other words, they cannot sell. The problem occurs when the supplier doesn't notify Aker Solutions. When Spare Parts' checking for availability they think the product is still in production (it might not be in stock) and confirms an order to the customer on a delivery date based on the lead-time of that product + the goods received processing time and a safety factor of 8 days. When the procurement department the next day gets this demand they send a purchase order (PO) to the appropriate supplier who then declines any order saying the product is out of production. The procurement department then have to fix the problem by finding alternative product(s) and do tests (if applicable) to see if that can be used as an alternative. This process of coarse consumes time and may result in a late delivered product from Spare Parts to the end-customer. Another internal problem is hard to directly pinpoint but occurs due to lack of good flow of information between departments. The different departments all have their own way of working, their own process map and protocols. Because of the differences between these operations strategies problems might occur. An example from person C was that the technical department is using FRAMES as an operational program instead of SAP, which is used by procurement. "Flow of information between departments in Aker Solutions is without a doubt a key problem" (Person C).

Other topics of the meeting were also discussed:

The Spare Parts department has implemented a strong risk-reducer. If procurement gets a demand from Spare

Parts they have to order it in at once. Procurement often looks at the demand from different departments together, to find correlations between the products demanded and the suppliers that supply them. If there's a demand from a department to get a specific product in 60 days, but the lead time + safety time on that product is set to 30 days, procurement might want to delay the order to see if other demands occur. That way they save money on delivery costs, delivery costs and warehouse costs. This of course is not applicable with demands from Spare Parts as they are instructed to order in instantly. "When SAP calculates the earliest date a product can be delivered it takes the lead time of the product plus the GRPT and considers the holidays" (Person C).

Appendix E: Frequent Spare Parts suppliers (2013)

No.	Vendor Name	PO/year	PO/year late	Total days delayed	Average days delayed/PO	OTD	PO/year /OTD^2
1	PGNIG Technologie Sp. z.o.o	1052	738	34770	47	30 %	11808
2	GS-Hydro Norge A/S	2765	761	7843	10	72 %	5264
3	J.P.Sauer & Sohn	547	368	5736	16	33 %	5108
4	Aker Wirth GmbH	2463	682	16392	24	72 %	4710
5	Bartec Technor AS	1406	510	12673	25	64 %	3462
6	Hydratech Industries AS	1085	361	7030	19	67 %	2437
7	Andersens Mek. Verksted A.S	1304	322	5136	16	75 %	2299
8	Onninen AS	1018	321	11635	36	68 %	2172
9	Servi Cylinderservice AS	999	298	5030	17	70 %	2029
10	Certex Norge AS	531	246	3526	14	54 %	1843
11	Parker Hannifin A/S	1343	204	2740	13	85 %	1867
12	Servi Hydranor AS	1937	292	5665	19	85 %	2686
13	Kolberg Caspary Lautom AS	667	214	2565	12	68 %	1446
14	Bosch Rexroth A/S	498	167	2286	14	66 %	1127
15	Danfoss Power Solutions AS	638	156	1063	7	76 %	1118
16	Hydreco Hydraulics Norway AS	410	157	5332	34	62 %	1077
17	Tranberg AS	644	145	1366	9	77 %	1073
18	Step Offshore AS	157	95	2207	23	39 %	1007
19	Aker Solutions Hannevika Workshop	481	137	3406	25	72 %	940
20	T.O. Slettebøe as	760	58	506	9	92 %	891
21	Siemens AS	544	105	2029	19	81 %	835
22	Sigurd Seland AS	232	100	1807	18	57 %	717
23	Kwintet Norge AS AVD LOCHNER	437	89	826	9	80 %	689
24	Norgren AS	301	101	2451	24	66 %	682
25	Wago Norge	433	84	362	4	81 %	667
26	Cafrex Sp. z o. o.	151	79	4182	53	48 %	664
27	Schaeffler Norge A/S	416	65	2069	32	84 %	584
28	ScanCab A/S	183	80	932	12	56 %	578
29	ASI Automatikk AS	270	79	872	11	71 %	540
30	Hydac AS	335	58	1229	21	83 %	490
31	Cavotec Micro-control AS	224	65	1210	19	71 %	445
32	Teamtrade AS	225	54	1168	22	76 %	390
33	Bosch Rexroth B.V.	119	53	2347	44	55 %	387
34	Pepperl+Fuchs AS	243	50	515	10	79 %	385
35	Aker MH AS	213	47	1253	27	78 %	351
36	Hydroscand AS	252	37	380	10	85 %	346
37	Safe Consulting AS	190	49	376	8	74 %	345
38	Phoenix Contact AS	238	20	103	5	92 %	284
39	Hypteck AS	159	34	116	3	79 %	257
40	Skiltspesialisten	223	15	161	11	93 %	256
41	Scana Mar-el AS	105	33	839	25	69 %	223
42	Tormatic A/S	137	27	284	11	80 %	213
43	Ahlsell Norge AS	167	18	144	8	89 %	210
44	Bondura Technology AS	176	11	135	12	94 %	200
45	Trelleborg Industri A/S	124	22	206	9	82 %	183
46	Mits Hydraulikk ANS	121	21	74	4	83 %	177
47	Scanco AS	149	7	52	7	95 %	164
48	National Oilwell Varco Norway AS	104	18	462	26	83 %	152

Appendix F: Report of workshop at Aker Solutions

Report – Workshop at Aker Solutions

Improving On-Time Delivery

Date: 12/03/2014
Hosts: Fredrik Roalsø and Magnus Homme Jortveit

Participants - Spare Parts:

Name	Function
Kim Alexander Hansen	Sales Manager
~~Christina Bjerte Hansen~~	~~Sales Manager~~
Tone-Kristin Svendsen	Expediter
Jeanette Elise Andersen	Expediter

Participants – Procurement:

Name	Function
Philip Tryland	Buyer
Vidar Halvorsen	Buyer
Isabelle Kreutz	PO Assistant
Tor Ragnar Møller-Hansen	PO Assistent

Agenda

Goal: The focus and goal of the workshop is split 2-ways. The first goal was to uncover the differences and correlations between the Spare Parts and Procurement department and to what extent the participants knew about it. The other goal was to gather as many ideas and thoughts as possible. There are many different reasons for the problems at hand and if one or more solution is eligible there are many factors to consider.

Round 1

In round 1 the participants were split in two groups, one for the department of Spare Parts and one for Procurement. In their separate groups the participants did to the best of their ability to create the process map of their own department, in addition to the other department. Creating a total process map from an enquiry is made from a customer to the product is actually delivered to the customer. The process maps were created with post-it notes on a poster. An important prerequisite is that the item(s) ordered by the customer is not on stock; therefore it must be bought by the procurement department. The host took notes of the discussion that went on creating the map.

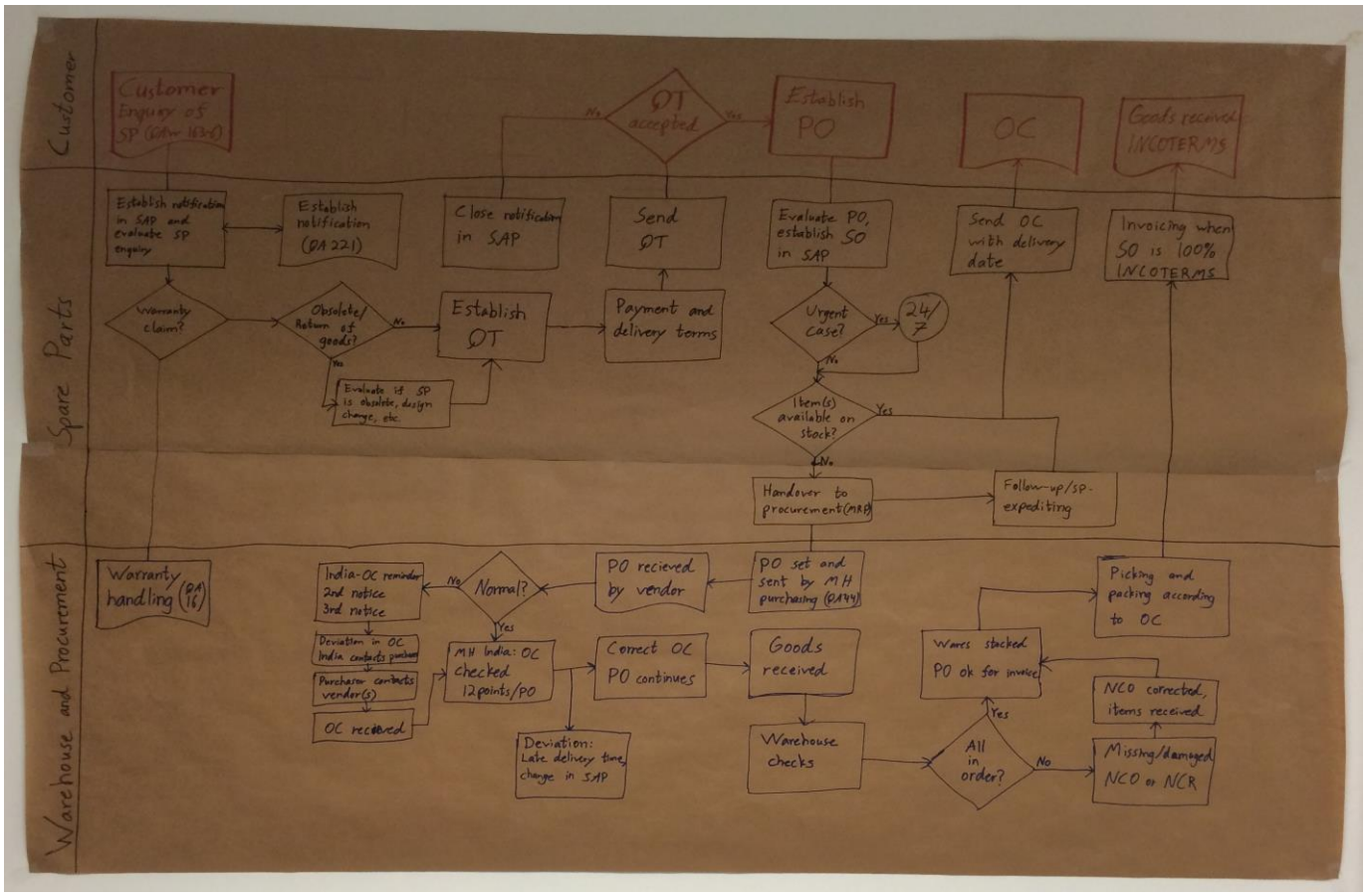
Round 2

In the second round the participants were all gathered together after a short break. The results from the first round were taped to the wall, along with a big poster of the “real” organizational process map from Aker Solutions’ system. The participants along with the hosts could then easily see the differences. A few minutes were then taken to discuss these results and to get a better understanding of them. Any process or part of process that distinguished itself from the “real” process map was discussed. Thereafter the host presented two cases taken from actual orders in Aker Solutions. Both cases addressed different internal and external issues with the total process. The “real” process map was used during this exercise. The focus was to find the bottlenecks, discuss the impact and possible consequences and to brainstorm possible solutions. Thoughts, suggestions and other revelations from the participants got noted.

Tools

A small set of tools were used during the workshop. This was to better visualize the exercises, get a better brainstorming effect ensuring all aspects are addressed, get to the bottom (root) of all presented issues, and to better be able to document the workshop. The tools were as follows:

- **Post-it notes and whiteboard markers** – This was used for the visual effect; using different colors can by example help visualize the difference between a normal scenario and a case scenario. In the case exercise red represented the actual time elapsed and orange the planned time.
- **A big poster of the "real" organizational process map** - This was also to give a visualizing effect. The poster could easily be compared with the results from round 1. In Addition it was used in the case exercises for the same reason.
- **Computers and cameras** – This was used to document as much of the workshop as possible.
- **The 5 why's technique** – This technique from the Lean thinking is simple in its method and gives great results. When an issue is presented, one simply asks "why?" and continues to ask this question until you get to the root of the pressing issue.
- **Involving people** – Another important aspect of Lean thinking is to involve all the workers when addressing issues and brainstorming for solutions. One should look at the employers as resources and used them for what their worth. An important aspect is to also involve workers that are not directly affected by the presented issue or problem. This way you might get new insights to help address the problem(s). In other words, it might be beneficial to try letting the procurement department address the problems in the Spare Parts processes and vice-versa.



Results

The workshop was considered to be a success as many new insights and ideas were gathered. The main results are sorted by round 1 and 2, and the total numbers of findings is 10.

Round 1

Spare Parts: Observations showed that Spare Parts had no problem explaining their own processes, from an enquiry is made by a customer, and to the case were sent over to procurement. It is important to emphasize that this process was a so called "text book process", meaning this was normal process without any obstacles or difficulties. Even though they had no problem explaining their processes in general there were some aspect of the "real" map that was left out. But as the "real" map for Spare Parts is highly detailed this was to be expected. The next step was to draw the map for the procurement department. They didn't feel as comfortable doing this task and that might have reflected the result as it got quite simplified.

Finding 1 – When a customer wants to buy a product, Spare Parts must check the product before proceeding with a quotation. This check is to see if the price is right, if the product has expired or for some reason needs a replacement. The participants from Spare Parts expressed some frustration when discussing this part of their process. They felt this step in their process map and in their work description didn't reflect the time needed for this step to be completed. They feel they don't have the capacity to run this check on every order, especially if an order contains several products. A participant even stated that if the order has over a 100 different products it would almost certain be delayed.

Procurement: Observations showed that they had generally good control over their own processes. There were a lot of similarities between the "real" organizational map and the map they made with post-it notes. When it comes to determine the Spare Parts processes there was a few left-outs, but the main processes were taken in to account. The participants stated that it was much more difficult to work on the process map for Spare Parts, and that they felt they have little knowledge of it. It should also be said that the time spent on the map of Spare Parts was much more limited.

Finding 2 – When the host addressed that they should focus on orders coming from Spare Parts, it didn't take long before the exceptional rule regarding Spare Parts orders came up: Make Purchase Order (PO) the same day when buying for Spare Parts. Even so, it was clear that this rule was not completely understood by all. There were also some complaints about this rule, regarding the problems with storage costs and not being able to purchase with large volumes from suppliers. A participant even stated that the 1 day rule could be pushed an extra day if there was a lot of money to be saved.

Finding 3 – There was mixed opinions as to how good the group in India was operating on handling errors and reporting. The consequence of this is that some employers in the procurement department requests a copy of the Order Confirmation (OC) that is supposed to be sent solely to the department in India. This way they can control the OC themselves and report if anything is out of the ordinary.

Finding 4 – There is a great problem when it comes to dealing with expired products. When a Spare Parts operator sells a product to a customer he/she checks the product beforehand. This is to uncover if the price is right, if it's still on the market, etc. If the Spare Parts operator then sees that

the product is expired there will be no issue because the product hasn't been sold yet. However, if the supplier forgets to inform about the expired product(s) the problem won't be discovered until someone from Procurement tries to order it in. From this point on there's increasing delays trying to find replacements and testing them. On example that was brought up was a chip that had expired and the replacement process took almost 1 month. On the other side a participant stated that this was very variable and if the case is vital, they can devote more resources to finding a replacement.

Finding 5 – It got uncovered that the knowledge of Spare Parts processes is somewhat limited. The main processes were taken in to account, but a lot of details and complicities around the processes didn't show. There was one exception of this and that is the process of checking the item(s) and reporting to Procurement if anything is wrong. It should also be stated that even though they managed the general process map of Spare Parts, this was more or less done by a single participant.

Round 2

This part of the workshop was as stated earlier to discuss the process maps made in the first round, and to brainstorm a few cases. The participants looked very motivated during this exercise and supplied the meeting with a lot of thoughts, ideas and until now unknown issues. Especially the cases proved to be a successful exercise.

Finding 6 – While discussing the problems with expired products were the supplier forgets to inform Aker Solutions, it seem to be clear that this is worse problem than expected/assumed. The procurement department informed that this problem occurs almost every day, and it's especially bad the last quarter of the year as a lot of products gets modified/changed then. An example of this issue was brought up regarding the supplier Siemens. They sometimes changed their product(s) from shelf items to spare parts and the consequence for this is a massive increase in price and lead time. It was suggested that a better communication with the supplier(s) might help solve the problem. It should also be mentioned that informing Aker Solutions of changes in products is legally binding. However, the participants had little clue as how to punish the supplier and if there even was procedures for this.

Finding 7 – There was a lot of misunderstanding regarding the different "time-factors" used on every item. There are 3 times; the lead time from the supplier, the goods received processing time (GRPT) and the 8 days safety time (ST) Spare Parts adds to their orders when giving a delivery date to their customer. The lead time is measured in calendar days, but the two other time-factors is measured in work-days, meaning they exclude "red" days (holidays, etc.) and weekends. Many participants had the assumption they all were measured in calendar days, resulting setting the delivery date many days earlier than planned. A solution suggested by the participants was to convert all factors to calendar days. Another solution might be to better inform the workers of what the different time-factors actually mean. If they understand why the different values were set the also might see the logic excluding non-work days when setting an order.

Finding 8 – It was feared from beforehand that the orders set by Spare Parts, included the ST when Procurement looked at the date the item(s) needed to be on stock. This could result in "giving" the ST to the supplier instead of using it as a buffer. While addressing this possible issue it was clearly stated and tested that this wasn't an issue. The 8 days ST were ignored when Procurement bought inn items.

Finding 9 – While discussing the issues with wrong lead times from suppliers many problems was addressed. It was stated by many participants that the lead times is not updated enough, the lead times is supposed to be “worst case” scenarios but that isn’t always the case, in addition the problems with changes in products would also often inflict the lead times. The lack of communication with suppliers was mentioned again. It was also suggested that a new informational field should be added in the ERP system SAP. As of today it contains the lead time from supplier and the GRPT. The suggestion was to add a box containing the “normal” lead time. This way, the systems hold the “normal” scenario and the “worst case” scenario.

Finding 10 – While discussing a case were an order got delayed much because of the handling time in warehouse, an interesting explanation came up. If an order from a supplier has any errors (NCO or NCR) this has to be fixed in order to proceed with delivery, and this can sometimes consume a lot of time. This can most often be blamed on the supplier but not always. An example brought up was a case the supplier chose to let their supplier deliver directly to Aker Solutions. Since they used different numbers for both material and product order the items had to be checked by inventory as they didn’t know where these products originated.