TAMPERE UNIVERSITY OF TECHNOLOGY

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IMPROVING LOGISTICS PROCESSES IN A GLOBAL SPARES SUPPLY ORGANIZATION

Master of Science Thesis

Professor Miia Martinsuo and Assistant Professor Ilkka Kouri have been appointed as the examiners at the Council Meeting of the Faculty of Business and Technology Management on 7. December, 2011.

ABSTRACT

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This thesis studies logistics processes related to balancing of the inventories between supply channels. Balancing operations are based on lateral transshipments, which are a recent field of studies and have been on the focus of the optimization studies during the past few years. The findings of the study model current processes and material flows, reveals issues related to processes, studies cost figures and provides alternative solutions for improvement. The main objective of the study is to provide a construction that makes it possible to improve decision-making related to inventory balancing between the distribution centers of the organization. This study answers three main questions: How does the existing inventory network look like? What kind of issues and development areas are there? How is it possible to improve current inventory pooling operations?

This study is a single case study carried out in a global spares supply organization willing to improve their logistics processes. To achieve the objects of the study, several methods were needed: literature survey on logistics models, sourcing methods and logistics cost models, qualitative information through interviews in the case company, study of the existing process descriptions and contract terms in addition to several quantitative analyses on the performance of the operations. Due to multiple methods, reliability and validity is increased as is the extent of the study.

Findings of this study demonstrate that the expansion of the company on Asian markets is in its infancy and that the processes lack standardization and appropriate tools. Asian Distribution Center is highly dependent on European suppliers. Despite the strategic aspect of Asian supplier markets, supplier base does not yet provide a comprehensive alternative for balancing transshipments from Europe. This underlines the importance of processes on inventory balancing as they provide significant cost reductions against local sourcing in Asia at the moment. It is recommended to continue balancing using European supply chains, but to set up ocean deliveries for major flows and to focus sourcing efforts on establishing local suppliers for materials that have the highest importance by their total value. Future studies should provide more detailed information on quality and sourcing related costs to improve cost analysis and comparisons in addition to benchmarking values and ratios.

TIIVISTELMÄ

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Tämä diplomityö käsittelee logistisia prosesseja, jotka liittyvät samalla organisaatiotasolla olevien varastojen tasapainotukseen. Tasapainotus perustuu lateraalikuljetuksiin, jotka ovat olleet viime vuosina optimointimallien keskiössä. Diplomityön löydökset mallintavat yrityksen prosesseja ja materiaalivirtoja, nostavat esiin niiden ongelmakohtia, tutkivat kustannuksia ja tarjoavat vaihtoehtoisia ratkaisuja prosessien parantamiseksi. Päätavoitteena on luoda konstruktio, jonka avulla parantaa päätöksentekoa koskien jakelukeskusten varastojen tasapainotusta. Diplomityö vastaa kolmeen päätutkimuskysymykseen: Millainen on nykyinen varastojen verkosto? Millaisia ongelmia ja kehitysalueita siinä on? Miten toimintamallia voidaan kehittää?

Tämä diplomityö on yksittäiseen tapaukseen perustuva tilattu tutkimus. Tutkimuksen tavoitteiden saavuttamiseksi on käytetty eri metodeita: kirjallisuusselvitystä koskien logistisia verkostoja ja kustannusmalleja sekä hankintatoimen metodeita, kvalitatiivista informaatiota yrityksessä toteutetuista haastatteluista, nykyisten prosessien kuvausten tulkintaa, yhteistyöyritysten välisiä sopimuksia sekä lukuisia raportteja yrityksen operatiivisesta toiminnasta. Eri metodien myötä tutkimuksen reliabiliteettia ja validiteettia on parannettu sekä laajuutta kasvatettu.

Tulokset osoittavat, että yrityksen laajentuminen Aasian markkinoille on vielä alkutekijöissään; prosessit vakioimatta ja työkalut puutteelliset. Aasian toimituskeskus on yhä hyvin riippuvainen eurooppalaisista toimittajista. Strategisesta painopisteestä huolimatta yrityksen aasialaiset toimittajat eivät vielä kykene kilpailuun. Siten varastojen tasapainotuksella on suuri merkitys kannattavuuden parantamisessa. Tutkimus suosittaa eurooppalaisten toimittajien käyttöä varastojen tasapainotuksessa keskittymällä luomaan säännöt halvempien merikuljetusten käytölle ja kehittämään Aasialaisia toimittajia arvoltaan merkittävimpien materiaalien osalta. Jatkotutkimuksissa tulisi tarjota tarkempaa tietoa laatu- ja hankintakustannuksista, jotta kustannusvertailuja voidaan parantaa ja vertailu lukujen perusteella helpottuu.

PREFACE

I’m finishing the writings of this study in a furious winter storm and looking back on the sunny days of June when I had a chance to choose the topic of my thesis from multiple areas of industrial engineering. The reason I ended up with inventory management was to challenge myself by facing unfamiliar and complex issues – and that’s exactly what I got. Dozens of millions of data cells, unwritten routines and hundreds of journals on unfamiliar topics, let alone information caps and security issues. But in the end, it was worth it.

An infinite number of people have contributed to the completion of this thesis. First, I would like to thank you, Miia and Ilkka, for your time and guidance on this subject. Thank you Hannu, for providing this opportunity, mentoring and all the upcoming tasks! There are plenty of people in our unit who would deserve to be mentioned, but especially I want to thank you Hilkka and Krisztina, for your time and encouragement on my career. Thank you Kimmo and Tuomas, for your help on getting the data I needed.

I want to thank all the members of my family. My parents have always underlined the importance of education and guided me on my way to university. Thank you Toni for proofreading, and I wish I may provide my assistance on your thesis in a couple of years! And finally, I want to thank you Jasmiina, for caring and reminding me of what really is important in life.

Tampere, 22.12.2011

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ABBREVIATIONS AND NOTATION

WACC	Weighted Average Cost of Capital
DC	Distribution Center, an outsourced unit responsible for logistical operations.
EDMS	Engineering Data Management System, system that is used in the company to manage product data.
EOQ	Economic Order Quantity, the level of inventory that minimizes the total inventory holding and ordering cost
ERP	Enterprise Resource Planning, a system that integrates all data and processes in a company into a unified system.
FL	Front Line, autonomous business unit that is responsible for sales and services.
GSS	Global Spares Supply, centralized spares supply organization that serves internal autonomous and external local units.
KPI	Key Performance Indicator, a measure of performance used to evaluate success of an organization or part of it
PLC	Product Life Cycle, the life of a product consists of phases which affect the management of the product
ROP	Re-Order Point, the level of inventory when an order should be made to bring the inventory up by the economic order quantity
SAP	Systems Applications and Products in Data Processing, Enterprise Resource Planning software.
SCM	Supply Chain Management, a set of approaches to improve efficiency of the flow from manufacturers to the final customer
SKU	Stock Keeping Unit, unique identifier for a product that can be purchased and that is held in inventory

1. INTRODUCTION

1.1. Towards optimal spares supply chain management

Technical systems consist of parts, which have the nature to sooner or later elapse and expire causing the system to lose effectiveness or stop working. The main purpose of the after sales services is to prevent harmful downtimes by maintaining the sold products and their level of efficiency. Spare parts are needed to replace the parts that are malfunctioned to restore the performance of the product or the system. As long as there is no spare part to replace the broken part, the product or system will not work properly and in most occasions it leads to financial losses and the customer satisfaction to crash down. To avoid these unwanted situations companies have the possibility to reserve spare parts in inventories. On the other hand, large inventories tie up capital and are hardly ever on the level of total coverage of the materials. In global companies there are several layers of inventories around the world to make it sure there's no need to start designing manufacturing molds when an uncommon part breaks down. Air transfers ensure that almost any part can be sent to another continent within hours and small van stocks make it sure that bolts and nuts are not needed to be treated the same way. Most likely materials are not manufactured by the company, but bought from an external supplier who buys materials from another supplier. These buyer-seller relationships combined then form supply chains. When it comes to modern supply chain management of spare parts, there can be found numerous attributes that affect the decision-making.

Generally thought, inventory optimization is a confrontation of service performance and capital commitment. Basically it is as mentioned before, but by examining the subject further it can be seen that it is possible to dramatically drop down the inventory levels without losing the customer satisfaction. In fact, each member of the supply chain benefits from the correctly set inventory metrics that make it possible to reduce the value of the inventories. This can be done by knowing the demand, lead times and costs accurately. Lead times and the costs are relatively simple to determine. Knowing the demand is though, in most occasions impossible, but examining and understanding the basics of the demand, then putting it into a mathematical form is only complex. However, when the complexity is combined with millions of transactions, there is a lot of space for small and unprofitable operations, that all summed together form significant amounts of wasted resources and opportunities.

Operational environment of a global corporation is in a continuous change and rapid responses are needed, but they must be done while everlastingly improving the cost-effectiveness. To achieve this, inventory planning must be done throughout the supply chain on each level of the corporation. Mikosh et al. (2005) divide the inventory planning on three levels; strategic, tactical and real-time. This thesis is about tactical and real-time inventory planning in a centralized global spares supply organization. Newly created distribution center network of the case company, consisting of three inventories is a response to the growing interest on both the supplier and customer market in Asia. Transshipments between the distribution centers on the same level of the supply channel are called lateral transshipments. These material and information flows are on the scope of this study. In other words, this study is about improving inventory management regarded to lateral transshipments in a case company.

1.2. Research problem, objectives and limitations

This thesis studies the problem of achieving the targeted level of service performance with the lowest possible costs in inventory management. This problem is studied through three main questions. How does the existing inventory network look like? What kind of issues and development areas are there? How is it possible to improve current inventory pooling operations? Structures and processes are studied to understand the system and drivers of operations. Next, current issues, time consuming tasks and development possibilities are examined. A specific issue is then chosen to be further analyzed and possible solutions are described and evaluated. These main topics build the basic structure of the study and they are studied in more detail on each section.

The objective of the study is to study current processes and material flows so that it is possible to improve decision-making related to inventory balancing between the distribution centers of the organization. In other words, this study focuses on balancing operations and material flows on the same level of supply channels. This study is done from the point of view of a single centralized global spares supply unit within the limits of its authority in the corporation.

1.3. Research methodology

This thesis is a case study which aims at combining scientific literature and empirical findings to improve the cost-effectiveness and service performance of inventory pooling operations in a specific case company. Being a case study which aims at improving decision-making of the case company, the approach of the study is inductive, empirical and normative. A mix of qualitative and quantitative methods was chosen to analyze the cross-sectional state of the company and some longitudinal data about the key figures. There are three major steps in this study

1) System and process analysis

2) Analysis of a specific issue

3) Recommended actions/action plans are provided based on the data & literature

First, distribution network, lateral transshipments and potential improvements will be examined to obtain better understanding of the system and the most important targets of development. This is done using semi-structured interviews and by studying process descriptions. Interviews will be performed in two rounds; on the first round general questions are asked from a member of each team, mostly team leaders involved and they are asked to name persons that have the best experience of the specific areas of the study, and on the second step interviews with these recommended persons will focus on more specific questions. A quantitative study will be done performing data extractions from the Enterprise Resource Planning system, studying process descriptions and Key Performance Indicators reports. This includes inventory levels, lateral transshipment sales orders and other data. The most important KPIs are collected and examined. These results will then indicate the exact target of the following studies.

Based on the studies, a specific issue that has the largest impact on the performance of the field of the studies is then chosen. Analyses in more detail are performed to achieve a deeper understanding of the relationships between the actual operations and the business drivers. This includes studies of costs and effects on service performance. Different options are considered based on possibilities of the current operational environment. These options and their impacts on business are evaluated so that it is possible to compare them in terms of costs and effects on service performance. As the last step of the studies, recommended actions are given based on the analyses.

1.4. Structure of the study

The structure of this study consists of introduction, literature, methodology, findings and conclusion. Introduction provides the general overview of the study with the descriptions of the topic and methodology in brief. Literature section examines the scientific bibliography of the topic from general logistics literature to the most recent journals of the inventory pooling operations and lateral transshipments. Method and material describes the scientific philosophy and approach of the study, study techniques, data collection and analysis of the trustworthiness of the study.

Findings consist of the qualitative and quantitative methods combined and examination of the findings. A specific area is then chosen and further studied. At the end of the findings section, discussion of the findings is done, in which the findings of the whole study are analyzed. Last section of the study is the conclusions, where theoretical and managerial contributions are presented. Assessment of the study and limitations are concluded after the given contributions. Finally, at the end of the conclusions section, recommendations for future studies are proposed.

2. LITERATURE REVIEW

2.1. Spare parts management

Physical technical constructions require maintenance to run effectively. These constructions typically consist of several products or components that elapse and expire at different times, i.e. have asynchronous life cycles. As these parts of the construction are at the end of their life cycle or have already malfunctioned maintenance operations are needed to ensure that the construction is able to maintain the level of performance that is required. These parts are known as service parts or in more common, spare parts. Modern maintenance operations typically involve spare parts management that aims at providing the needed spare parts at the right time with the chosen service level with the lowest possible costs. Spare parts are a part of industrial services and can be divided into two classes: services that support the product and services that support the customer operations. (Mathieu 2001)

Spare parts management differs substantially from the other materials. Spare parts typically possess many distinctive characters which impact the way they need to be treated. Spare part consumption is not known beforehand, the scope of the materials is wide, consumption per item low, and the price is generally high. Due to the distinct nature, Huiskonen (2001) states that standard industrial methods can not be applied to manage spare parts and customized management policies are required. In literature, spare parts are typically classified and managed based on their criticality.

2.1.1. Spare part classification methods

The very basic categorization of a spare part is whether it is repairable or not (Fortuin & Martin 1999). Those spare parts that are not repaired are typically known as consumables. Fortuin & Martin (1999) divide repairable spare parts into incompatible, single-type and recyclable parts, which define whether there can be found an identical part for the replacement or not. Repairable spare parts are common e.g. in aviation industry and military organizations as the parts are expensive or there are limitations on the availability of the materials. However in this case, only consumable spare parts are considered.

Williams (1984) classified the spare parts based on the variation of the demand. Eaves & Kingsman (2004) extend this by proportioning the number of the supplies to the lead time, and the size of the orders to the lead time. They further identify five classes by the demand: smooth, irregular, slow-moving, slightly irregular and highly irregular. Gajpal et al. (1994) seek wider perspective by evaluating the criticality of the parts. They included consequences of a stock-out, standardization type of the part and lead time. Other ways of classifying are characteristics of the supply chain, problems in warehousing and utilization of the parts. In most methods the classification of the spare parts is based on the criticality and type of demand. (Persson & Saccani 2007) There is also growing interest on applying the life cycle of the products into the classification.

One of the most important classification methods in spare part management is the ABC method. The method relies on the fact that a small number of products form the largest portion of the turnover. The ABC method, which stems from the Pareto analysis, divides products into A, B and C class. Class A consists of 5 to 20% of the stocked items which form 60 to 80% of the total value of the inventory. Class B consists of 10 to 30% of items that account for 15 to 30% of the total value. Class C represents the lowest-value items that are about 50 to 85% of the item count and only a fraction of the total value. (Schönsleben 2000) Sometimes these classes are extended with class D that represents items that have not had any annual movements.

As the parts have been classified, the management methods and rules for the items are different for each class. Class A items are managed so that the value of the stock is reduced and the processes and monitoring is improved. This involves smaller batches more frequently and more evaluations in terms of sourcing. Class C items should be made always available. As the inventory value is lower, stocking of the items ensures the deliveries on time without tying up capital. Purchasing of the items is considered as transactions with no real efforts by the sourcing activities. Management methods on class B items are a mixture of classes A and C. (Schönsleben 2000) Sometimes the ABC method is expanded by adding XYZ to the categorization so that each item has a class of A, B or C in addition to a criticality class X, Y or Z. Criticality can be evaluated as the supplier risk or lead time of the part. (Paakki et al. 2011)

2.1.2. Stocking of spare parts

In modern global competition, customer satisfaction has become one of the most crucial elements. In addition, high customer satisfaction is a major factor in profitable service business. Operational interruptions require rapid responses, which underlines the role of spare part management. Availability of the needed spare parts is ensured by either stocking the materials on regional depots or by arranging high-performance supply chains. The most critical parts are typically expensive and their demand is stochastic which makes stocking non-favorable. In common, Botter & Fortuin (2000) suggest three basic questions as the basis for inventory control situations

- Which ones to stock?
- Where should they be stocked?
- How many units should be kept in stock?

Spare parts management is about answering these three basic questions in an efficient and feasible way (Botter & Fortuin 2000). Even though there are differences between the industry sectors, spare parts are an integral part of companies' offering. What is common to most of them is the possibility of providing added value by the means of logistics. It is obvious that service management of high quality produces added value to the initial product improving the image of the company and hence also the profitability.

One of the most challenging issues in spare part management is the stochastic demand. Success in spare parts logistics affects both the reputation of the company and the financial performance. Focusing the efforts on the most critical items and control the others by some simple rules is the basic idea behind the models. Syntetos et al. (2008) have examined inventory management using case studies. They made three major observations concerning the performance of spare parts inventory management systems. According to their studies, inventory planning needs to be carefully linked to the information systems of the company. Exceptionally important is to enforce the compatibility of the ERP and planning systems.

Syntetos et al. (2008) also observed that the varying demand mechanisms behind the spare parts differ greatly from the typical fast-moving items and thus require significant amount of expertise. This is why typical sales agencies in Europe that were examined failed in managing spare part inventories. Despite the fact that most of the inventories were run by third parties, they lacked of the required know-how on regional level. Finally, frequencies of the demands were also seen intermittent. Combination of non-predictable and fragmented demands of expensive, operationally critical items significantly argues on behalf of the importance of spare parts management.

2.1.3. Spare parts in logistics systems

As presented, the role of logistics in spare parts management is emphasized. Pfohl & Ester (1999) divide spare part logistics into two: customer-driven processes and support processes. Customer-driven processes are the ones that have direct connection with the customer's order fulfillment. Support processes cover all the other processes that are not directly connected to the customer but support the customer-driven processes. However, there are numerous links to other processes that should be taken into account. Such processes may include e.g. other processes of the company or the other parties of the supply chain. Huiskonen (2001) suggests a general approach that consists of four elements. The model is shown in Figure 1.

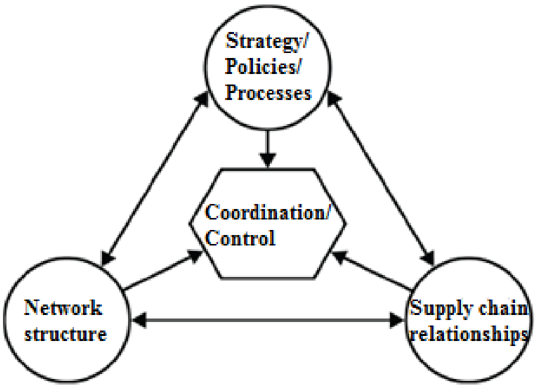

Figure 1 The logistics system design process (Huiskonen 2001)

During the analysis and decision-making, four elements are needed to be considered. This updates the traditional view as several, most likely differing interests are being regarded. The element of strategy, policies and processes defines e.g. if the customers are segmented and what levels of services is provided for each customer. It determines the role of logistics system in supporting the chosen strategy. Customers' interests are realized in availability and price of the parts. The network structure element defines the complexity of the system. If the locations are owned by the supplier, the element only considers it, but as the ownership or controlling is established any other way, more parties are involved. The element of management of relationships has increased its significance during the last years. It includes aspects such as level of co-operation, responsibilities in controlling, sharing the risks etc. All the three elements deal with the issue of what types coordination and control mechanisms best support the ultimate objectives of the system. Coordination and control element consists of decisions about inventory control policies, performance evaluation, incentives and information systems. (Huiskonen 2001)

2.2. Logistics and distribution

Logistics were first considered centuries ago in military terminology describing the transportation of goods and equipment. Since then, the word "logistics" has spread to cover all the operations needed to move things between different locations. What isn't widely known, is the fact that some of the most advanced logistic systems are still developed by the research centers of globally operating militaries, especially when it comes to spare parts. Also, it is typical to associate logistics to warehouses and transport. In loose terms that is correct, but according to Christopher (1998), logistics is nowadays more and more about satisfying the needs of the customer. It is needed to understand the idea of a supply chain, a web of autonomous enterprises collectively responsible for satisfying the customer by conducting all phases of design, procurement, manufacturing and distribution of products (Whitman et al. 1999). Christopher (1986) says it is essential to manage all the interrelated activities in moving materials and information from their sources to users. Christopher (1998) states that time has become a critical subject in management and customers expect their products delivered within narrow timeframes. In addition to time, the role of services has become indispensable part of the offering. Stock & Lambert (2001) present logistics as a functional silo within the companies, which deals with the management of both material and information flows through the supply chain.

2.2.1. Concept of supply chain management

Supply chain management (SCM) is a combination of approaches to improve the long-term performance of both the company and whole supply chain involving suppliers, manufacturers, logistics and customers (Chopra & Meindl 2001). It includes the link between upstream (such as manufacturing) and downstream (such as distribution) value chain entities. In supply chain management, integration of these value chain entities is required to create cooperative environment that facilitate information exchanges, materials and cash flows (Kukalis 1989). Several authors define SCM as the flow from suppliers to the final customer (Chibba 2007), but the fundamental basis for supply chain management is the management of relationships to increase the cost-effective outcome of each of the actors in the chain (Christopher 2005). According to Chibba (2007), the concept of SCM consists of three elements: physical material flow, information flow and financial flow. Further, supply chains can be seen as dynamic flows, in which companies form strategies to manage these flows accordingly (Chibba 2007) and SCM as a network, where suppliers interact on the same premises (Christopher 2005). In general, SCM is about overlooking achievements of a single firm to the supply chain ability to satisfy the customer needs cost-effectively. Figure 2 presents a supply network.

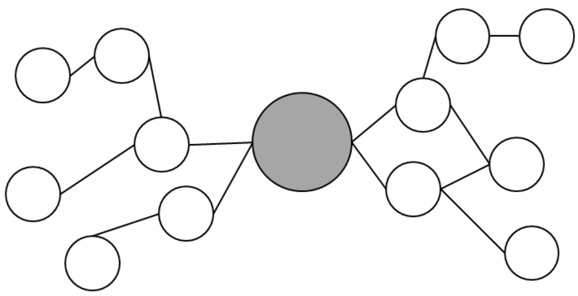

Figure 2 Supply chain network (Christopher 2005)

A supply chain network may consistof different types of channel relationships. A direct supply chain may involve only three interacting parts: supplier, manufacturer and customer. However, it is typical that the supply chain embraces both the suppliers' suppliers and customers' customers. As the companies evolve and start acting more globally, also the complexity of the supply chain network will increase. (Mentzer et al. 2001)

According to Christopher (2005), SCM can provide a set of ways to increase efficiency and productivity in addition to reduced costs which will contribute to decreased unit costs enhancing the customer value and satisfaction. Nonetheless, Stank et al. (2005) remind about the fact that the benefits of the SCM will not come without sacrifices. Implementing SCM philosophy will not be done easily (Stank et al. 2001) and it is needed to include all the typical business functions to meet the full potential of SCM (Mentzer et al. 2001). It has been argued that SCM creates sub-optimization if each member of the supply chain tries to maximize its own interest. A fundamental part of the SCM concept is information sharing throughout the supply chain but the fear of information being revealed to the competitors is a common barrier for openness. Handfield & Nichols (2002) state that the greatest challenge of SCM is the building of trust between the parties of the supply chain.

2.2.2. Supply chain strategies

There are several strategies to consider when it comes to supply chains. Chibba (2007) narrows these into four major strategies. Strategies are narrowed based on the fact that different supply chains have similar characteristics of one another. Strategies differ e.g. in terms of time spans they focus on and the type of demand. These four supply chains strategies are

1) Agile supply chain
2) Lean supply chain
3) Efficient supply chain
4) Hybrid supply chain

Agile supply chains are built to be able to rapidly react on changes in the environment. The dynamics of the relationship and structure, event-driven and event-based management and high visibility of information across the supply chain are the sources of success in agile supply chains (Baramichai et al. 2007). Li et al. (2008) have studied agility and flexibility in supply chains and describe agility as an ability to cope with a shift in demand. In general, agile supply chains are able to adapt to changes in operating environment. In contrast, Lean supply chains overlook short term goals and focus on long-term goals and focus on the entire process instead of single processes (Chibba 2007). Lean is a production philosophy developed by Toyota and, even though it was developed to improve the performance of the automotive industry, it has now spread to all the other industries too. The main focus in Lean is on reducing waste, and waste can be found in all of the processes within a supply chain. In general, the main sources of waste are unused creativity of the employees in a supply chain, high levels of inventories, defects and overproduction (Liker 2004). Liker (2004) says that the main focus of lean supply chains has changed over the years. The relationships with the suppliers are seen more long-lasting and the traditional cost cutting is avoided. Womack (1990) points out the fact that several actors cannot have sufficient understanding of the processes to reduce waste which argues on behalf of decreased number of the actors involved.

Efficient supply chains typically deal with more functional products, e.g. groceries. They are usually sold in large volumes and their demand is relatively easy to evaluate. It is characteristic for the products that they remain the same and the role of innovation is considered scarce. (Chibba 2007) This is the reason why efficient supply chains focus on improving their operations. Hybrid supply chains target on the benefits of both Agile and Lean philosophies by optimizing the combination of costs and service level to obtain a high degree of customer satisfaction (Mason-Jones et al. 2000). Companies with hybrid supply chains often tend to have decoupling points which mark the transition from a strategy to another (Krishnamurthy & Yauch 2007). The products with characteristics of stabile demand and low variation are supplied applying the principles of Lean and the products with more fluctuating demand are supplied using Agile systems (Mason-Jones 2000).

To determine which strategy to use Christopher (1998) underlines the importance of time in modern management disciplines. One way to manage time related issues in SCM is to apply product life cycles (PLC) in managerial decisions (Chibba 2007), which is also recommended by Christopher (1998). The life cycle of a product typically consists of phases which are the same for most of the products. There are four typical phases distinguished in product life cycles: introduction, growth, maturity and decline (Chibba 2007). Each phase is characterized by needs that require different managerial approaches. In SCM, changing sales volume and product characteristics require different supply chain strategies. This is presented in Figure 3.

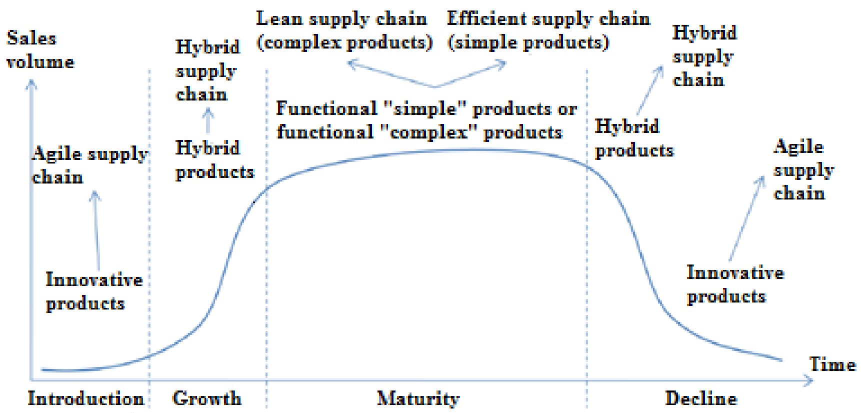

Figure 3 Supply chain strategies on product life cycle (Chibba 2007)

PLC is a natural part of logistics and SCM as it’s a natural part of all actions related to products, such as marketing which is also highly related to distribution. Nonetheless, Grantham (1997) states that there are some limitations in the model. It is needed to be aware of the facts that products are mortal and may get an abrupt end. Moreover, with the right strategies it is possible to generate growth after the maturity which is not present on the model. Despite the criticism, the idea of identifying the different needs of the products and customers is universally considered to be of great worth.

2.2.3. Supply chain evaluation

Traditional performance metrics such as ROI or stock turnover do not capture the wide concept of supply chain performance and it has been needed to develop more specific measures of supply chain performance (Chibba 2007). According to Holmberg (2002), there exists a need to measure the performance of a single performance metric over the whole supply chain. Many attempts to establish such a performance tool have been seen but the most widely spread model is Supply Chain Operations Reference, SCOR (Jian et al. 2009). Other suggested methods in literature are e.g. Balanced Scorecard, Activity Based Costing and Chan & Qi’s (2003) model. SCOR was introduced by the Supply Chain Council and it’s a framework for evaluating and comparing supply chain activities and their performance. It provides standardized definitions for processes, their elements and metrics, and it enables managers to benchmark the performance of the supply chain so that it is possible to find the areas to improve (Huan et al. 2004). Geary & Zonnenberg (2004) studied companies that had used SCOR-model and found out that they achieved remarkable economical and operational advantages. SCOR-model has begun an industrial standard for the companies who seek for advantages through supply chain management (Huan et al. 2004).

There are four distinct processes in SCOR-model: plan, source, make and deliver. Each of them is considered to be level 1 process and they define the scope and content of the supply chain. The plan process is involved through the whole supply chain in terms of supply chain planning, sourcing, manufacturing and delivering. All the processes are in a relation and dependent of each others. This is presented on Figure 4.

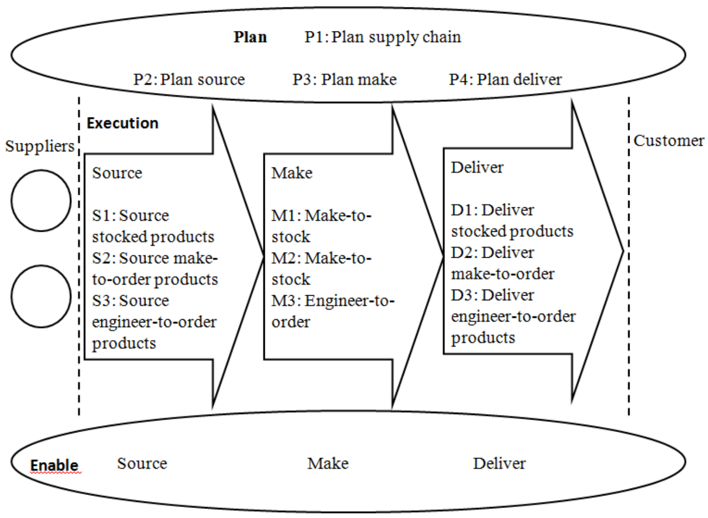

Figure 4 SCOR-model categories (SCS 2008)

The source process purchases materials and services to meet the planned or actual demand. The make process refines the materials to finished goods to meet planned or actual demand. The delivery process supplies the finished goods and services to meet planned or actual demand. These top level processes are then divided into two levels with increasing details. The middle level is a configuration level that is about process categories and where processes are configured with operations strategies. These categories are divided into three: plan, execution and enable. Processes adjusting the resources to meet the forecasts are included in the plan-group, core processes transferring the planned demand into action included in the execution-group, and the ones controlling the flow of information are included in the enable group. The lowest level on the scope of the SCOR model defines a process flow diagram with elements for each process enabling the company to adjust the chosen operations strategy. (SCS 2008)

Chan & Qi (2003) propose a model that takes into account single activities of the supply chain, prioritizes them and converts them into one index of the supply chain performance. It includes a conceptual performance model, performance measurement and aggregation method and is based on mathematical framework that avoids the problems of imprecise human judgments. It is built on key- and sub-processes that form a hierarchy of a supply chain model and which are measured. Based on these values and their relative importance and relative weight, the performance grade of the supply chain can be aggregated.

Chan & Qi's (2003) model is typically recommended by academics in contrast to SCOR model, which is in favor of the practitioners. It is also said that both models are too complex for managers to be applied as there are too many local measures included. To overcome these issues, Theerunaphattana & Tang (2007) recommend managers to combine both models and remain on the highest level of measures instead of monitoring the operations in very detail. Hierarchy of supply chain model by Theerunaphattana & Tang (2007) is presented on Figure 5.

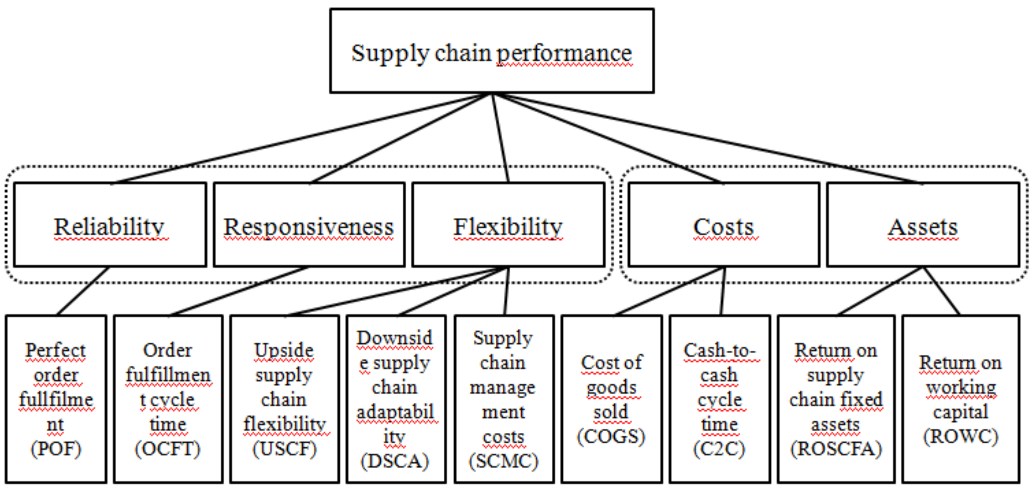

Figure 5 Hierarchy of supply chain model (Theerunaphattana & Tang 2007)

It is recommended to remain on SCOR model level 1 metrics. This is because level 1 metrics are smaller numbers of more relevant, integrated, balanced and strategic measures of performance. Implementing of the model begins by adapting a clearly defined supply chain strategy as it affects the relative importance of performance and attributes. It simply proceeds from SCOR level 1 measures to calculating the relative weights of the strategies and metrics to convert the performance data into a single index of overall supply chain performance. (Theerunaphattana & Tang 2007)

2.2.4. The role of distribution centers in different supply chain strategies

It is universally accepted that the level of inventories should be minimized. Even though there is not much literature about distribution centers in supply chains, the concept of distribution centers is well established and different roles of distribution centers in different supply chain strategies are identified. Baker (2004) considers different distribution center strategies in two supply chain concepts. The role of the distribution centers are viewed in agile and lean supply chains. In agile supply chain there are only few inventories and levels of inventories are kept down. Inventories are seen as the last option to balance supplies to the market demand. Lean supply chains consider prolonged lead times, excess resources and high levels of inventory as waste. As Toyota puts its efforts on the flow, inventories of end products are still regarded to be necessary.

According to Baker (2004), inventories are needed in modern supply chains. Even though low levels of inventory are considered as a key element in eliminating waste and reducing costs, he recognizes three typical reasons of holding inventories in modern supply chains

- Strategic inventories
- Volatile markets
- Global sourcing

Strategic inventories may be held because of several reasons, but they are typically related to reasons that overrun the terms of minimum costs. They are typically used to prevent risks in availability or price fluctuations. On volatile markets, high levels of availability provide competitive advantage. Global sourcing has led to uncertainty and increased lead times which tend to enforce holding of inventories. Regardless of whether inventories are held or not, short lead times from the receipt of order to actual delivery are expected, especially in agile supply chains. Cutting down the lead times is however considered as reducing waste consequently denoting the importance of short lead times also in lean supply chains. (Baker 2004) In other words, reducing lead times is directly related to cost reduction which is one of the typical targets of re-engineering in any business.

Baker (2004) identifies four different types of distribution centers with different advantages and that are compatible with different supply chain conditions. Nonetheless, Baker (2004) reminds that using a single type for all the operations may not be recommendable which is confirmed by Harrison & Van Hoek (2008), who advice to adjust strategies to the market and the actors on the market. Suggested four strategies are known as

- Service level segmentation
- Postponement
- Cross docking
- Third party logistics provider

Adapting the operations to the different needs of the customers and, in wider concept, customer segments, is called service level segmentation. It is about identifying the customer values and setting up the appropriate strategy for each customer segment. It is typical to design different supply chains for each market sector. (Baker 2004) This could be done e.g. using vendor managed inventories which are controlled by a supplier at the customer (Cetinkaya & Lee 2000). Postponement strategy is about postponing product differentiation so that the final customization of a product is done as late as possible. When inventories are held within agile systems, inventory may be held as work-in-progress so that it is possible to customize the end-products as the orders and specifications from the customers are received. This strategy enables supply chains to respond to exact market demand without overproducing specific items if the demand is not met. It is possible to postpone on different levels or units in the supply chain but distribution centers are seen as a key option at the tail end of the chain. (Baker 2004)

When inbound material is unloaded and directly or with extremely short storage time loaded upon outbound transportation supply chain is known as agile supply chain. In agile supply chains distribution is frequently done directly to end customers or via cross docking and in transit merges. Cross docking may be used when supplying from upper level inventories or from the same level, i.e. in virtual pooling. It is also possible to combine postponement and cross docking so that value added services are performed continuously as the products flow through a warehouse. To create a fluid flow of materials, it is usually needed to redesign the plants to have adjacent facilities for inbound and outbound operations with sorting abilities. Third party logistics provider strategy is about using external actors who operate throughout the supply chain and are regarded to be in a good position coordinate and integrate capabilities to support a dynamic and flexible supply chain network. Management expertise, assets, staff and information systems can be easily used to complete particular operations and they can be used more flexibly than in an individual company. (Baker 2004)

2.3. Sourcing in supply chain management

Average manufacturing company disposes about 50% of its income on materials, supplies and services that are required to process the goods. For a long time purchasing function has been considered as an operational function with no strategic importance. (Baily et al. 2005) Nowadays, because of the globalization, companies tend to outsource many activities that have earlier been their own operations which has significantly increased the weight of the purchasing activities (Van Weele 2005). Due to this, companies have set up their operative purchasing activities under purchasing units, short and medium term activities under procurement units and long-term proactive management activities under sourcing units. Monczka et al. (2005) define global sourcing as a centralized procurement strategy for a multinational company in which a central buying organization seeks economies of scale through corporate-wide standardization and benchmarking. Further, the close relationship of sourcing and supply chain management is a result of growing emphasis concerning the importance of suppliers. Relationships to suppliers are shifting from adversial approach to a more cooperative approach with selected suppliers.

2.3.1. Role of sourcing activities

The main role of purchasing is to provide the materials and services that are needed in the processes of the company. According to Van Weele (2005), sourcing contributes the competitive position of the company by

- Reducing quality costs
- Standardizing products
- Consulting product design and innovation
- Reducing stock
- Increasing flexibility in supply chain
- Fostering purchasing synergy

Chen et al. (2004) state that strategic purchasing is a vital link between the partners in a supply chain. Through strategic purchasing, it is possible to obtain competitive advantage by closer tying up with the selected suppliers, promoting communication between the partners in the supply chain and by developing long-term strategic relationship orientation. Chen et al. (2004) highlight the impact of higher customer responsiveness on mutual gains and higher financial performance. This is presented on Figure 6.

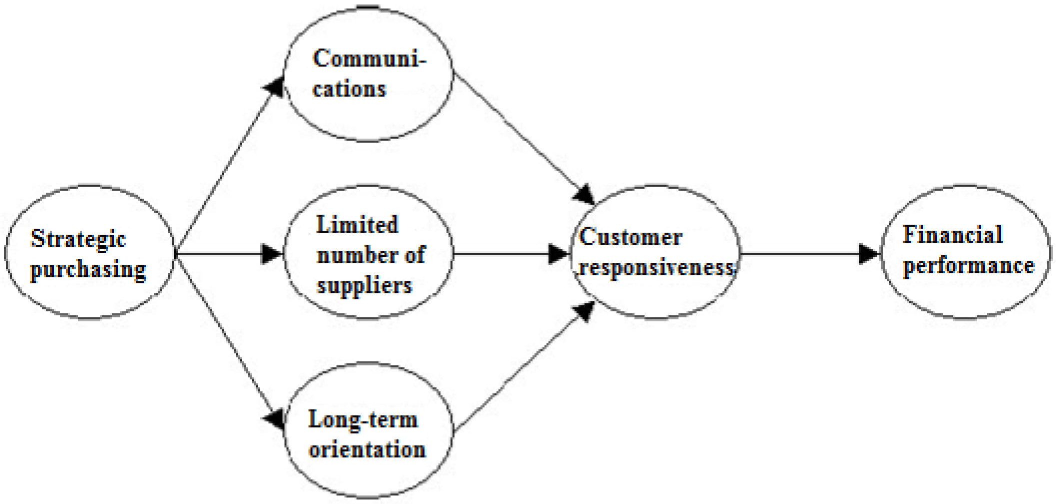

Figure 6 The contribution of strategic purchasing to the companies' financial performance (Chen et al. 2004)

According to Chen et al. (2004) there are strong relations in the connections to customer responsiveness except for the long-term orientation which has a relation, but it is not considered as significant. They emphasize the importance and omnipotent weight of reducing suppliers which is not as emphatically considered by all the scholars. Cox (1996) discusses a problem of conceptualization and theory building in the developing discipline of purchasing and supply chain management. Cox approaches the question through proactive procurement management and notifies the importance of understanding the value chain and the position of the company on it. Sourcing activities should then follow the guidelines that best fit the strategic goals of the company. Despite the slight difference in the contributions, it is obvious that strategic sourcing has a crucial role in financial performance. As Dimitri et al. (2006) state, it affects short-term performance in supply chain inputs and long-term performance by determining the incentives of R&D.

2.3.2. Global sourcing and low-cost countries

A sourcing strategy with intention of taking advantage from global efficiencies in the purchasing is known as global sourcing (O'Connell 1999). It is also defined as a defensive tactic toward lower prices of foreign products (Cavinato & Kauffman 1999). If a company investigates for feasible places to find resources that support competitive advantages of production it is in fact adopting a global sourcing strategy. In addition to sourcing for supply and price differences in diverse resources, companies may be forced to source globally because of the inappropriate state of the local supplying environment. (O'Connell 1999) It involves specific benefits which may go beyond the initial lower costs such as learning the possible ways of doing business in the market, acquiring of skills related to international activities or accessing resources that are not available locally, stimulating competition through developing alternate supplier sources and capacity of the total supply. (Tsay & Pullman 2008) Cavinato & Kauffman (1999) see five key drivers shaping the global purchasing industry:

1) Politics
2) Infrastructure
3) Currency
4) Climate
5) Culture

Corresponding disadvantages are country specific and unique. Major drawbacks in global sourcing may include increased transportation costs, increased possibilities of supplies interruption by e.g. natural disasters or political changes, longer lead-times or delays, dependency on foreign sources. (O'Connell 1999) There are also possible hidden costs connected with cultural differences and time zones, financial and political risks, risks with intellectual property losses and increased monitoring costs compared to domestic supply (Tsay & Pullman 2008).

Low-cost country sourcing is a series of procurement activities in which the company locates materials in countries with lower production and labor costs which cut down operational expenses. It is typically considered as a part of global sourcing strategy. The main principle in low-cost country sourcing is to achieve sourcing efficiencies through identification and utilization of the cost arbitrage in different geographical areas. (Rae 2005) It is common that globally sourced products or services are labor-intensive manufactured products manufactured from China or English speaking call centers or programmers from India (Li & Zhang 2008). Even though global sourcing and especially low-cost country sourcing are often combined with the lowest possible cost, there can be seen a shift toward knowledge and design sourcing from another countries globally, including high-tech countries in Europe (Tarek & McCaffer 2002).

2.3.3. Sourcing cost models

A commonly used term in cost modeling is the total cost of ownership, TCO. To exactly determine the value of the TCO, deeper cost analysis such as activity based costing, ABC, are required. However, there are limitations, such as insufficient visibility into processes or preliminary phase of the supplier identification that make it impossible to generate exact cost data. In such occasions, landed cost is considered (Hollmann 2006). Landed cost provides a good first pass at cost modeling. Typically landed cost consists of purchase price, customs costs and shipping costs. Young et al. (2009) has introduced a landed cost of six cost elements

- Purchase price

- Transportation
- Custom & import
- Inventory
- Overhead and administration
- Risks and compliance

Purchase price is the price that is paid to the supplier over time. Transportation costs include all the costs related to transportation, insurance on it and packaging. Customs and import costs consist of tariff rates, breakdowns, drawbacks and fees related to terminals. Inventory costs are the costs of the cycle stock, safety stock and in-transit stocks. Overhead and administration costs include sourcing staff, relationship collaboration and costs related to learning curve. Risks and compliance costs include potential risk of supply disruption and cost of potential risk of damage to reputation, health, safety and environment. (Young et al. 2009)

In contrast to the model proposed by Young et al. (2009), Robinson (2006) has used landed costs to compare manufacturing locations. Only four cost elements were involved: labor, logistics, and inventory and tax costs. Even though Robinson (2006) emphasizes the use of detailed cost information, he suggests focusing on the main cost elements to meet the business needs as it will most likely assure the overall costs. Morita (2007) focuses his landed cost studies on comparing local supplier with Chinese supplier. He divides the costs into material, transportation, inventory and labor costs. He suggests adding risk factors into the model and underlines the effects of changing volumes and currency rates. Feller (2008) has developed a total landed cost model for an engineering instrument manufacturing company. The model consists of three cost elements

- Material
- Transportation
- Inventory

Feller (2008) has included all the other categories into the greater elements. In addition to the classification of the elements, he also suggests including risk analysis into the studies. Risks are identified into five areas: purchasing, inventory, finance, logistics and suppliers. Total landed costs are calculated first without risks and the costs of the risks are then added based on statistics. Feller (2008) underlines understanding of both the costs and the risks of each supplier. However, data about the risk costs and the actual allocation still remains difficult.

2.4. Inventory structures and transshipments

The importance of controlling material flows through the entire supply chain from the suppliers to the manufacturers, distribution centers, retailers and to the customers is nowadays fully recognized by top management of the organizations (Axsäter 2006). Because of the high investments in raw materials, work-in-progress and finished goods there can be seen significant potential for improvements that not only free up capital, but also increase the efficiency and even service level of the supply chain. In addition, stocks are often used to balance conflicting goals between different functions in the organization, e.g. marketing & production. As Axsäter (2006) states, uncertainties and economies of scale are the main reasons for holding inventories. Uncertainty is usually caused by the changes and fluctuation of demand, variations in lead-times, costs and other parameters. Economies of scale are achieved through savings in transaction and acquisition costs due to the larger order quantities.

Nonetheless, numerous reasons why not to hold large inventories do exist. Olsson (2007) highlights four major costs of high inventories: inventory risk cost, storage space cost, inventory service cost and investment costs. As Bloomberg et al. (2002) state, firms must produce and store additional stock to meet the changes in demand and if they were able to forecast the demand accurately, several logistic activities would lose their necessity or at least lose cost impacts dramatically. The challenge is to examine and find the optimum inventory levels and practices to balance the benefits and costs of holding inventories (Olsson 2007). This discussion is usually grouped under the concept of inventory management (Bloomberg et al. 2002).

2.4.1. Inventories in distribution systems

In inventory systems, each inventory lies between two activities or processes, which can be seen as supply and demand processes. Production, transportation and other activities are included into the supply process and activities that use and subtract material from the inventory are included into the demand process. (Zipkin 2000) This is presented in Figure 7.

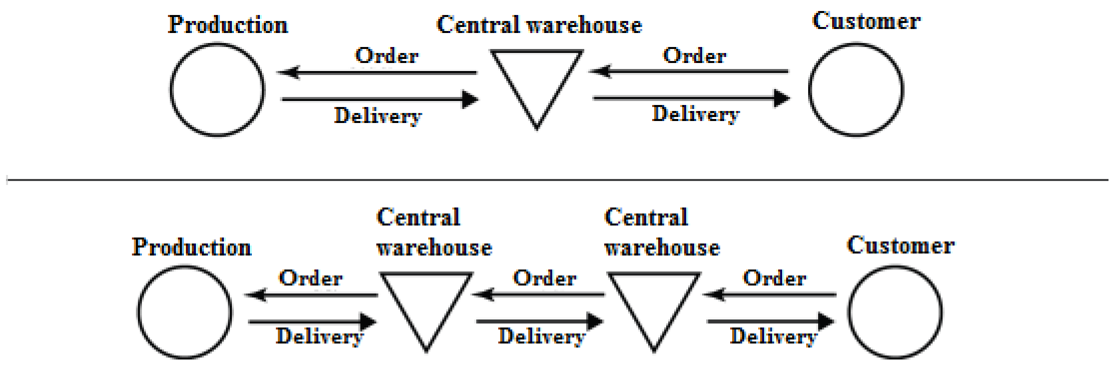

Figure 7 Inventory system (Aronsson et al. 2006)

In an inventory system, the structure of the system is one of the most important aspects (Olsson 2007). Figure 7 presents on a general level both the position of a single inventory and the positions of two different-level inventories. In literature (e.g. Axsäter 2006), inventory systems are typically introduced based on these levels, echelons. Straightforward, the most simple inventory system is a single-item, single-echelon inventory system. As demonstrated in Figure 8, a very basic single-echelon inventory consists of an inventory and only downstream material flows.

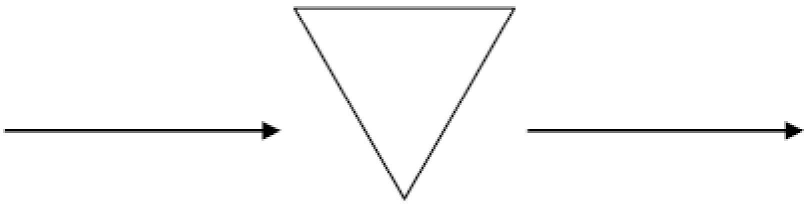

Figure 8 A single-echelon inventory system (Olsson 2007)

A serial system is provided, when two single-echelon systems are coupled. Then, each installation has at most one immediate successor. This two-echelon inventory system is presented in Figure 9. At installation 1, customer demand occurs, and it is replenished from installation two, which replenishes using external suppliers (Axsäter 2006). Multi-echelon inventory systems are typically used to provide support over widely spread service base network. These systems usually consist of a higher level echelon serving the lower level echelons to support in replenishments. (Lee 1987) Even though the system in Figure 9 seems unsophisticated, calculations to optimize the operative actions become substantially challenging when compared to single-echelon systems.

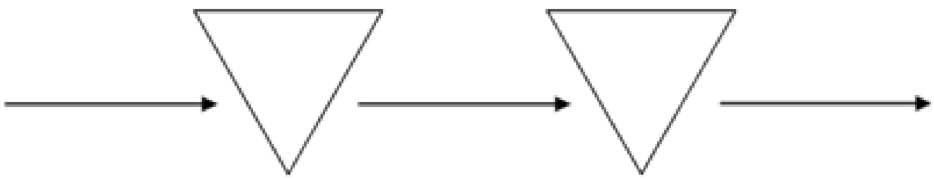

Figure 9 A two-echelon inventory system (Axsäter, 2006)

It seems self-evident, that most two-echelon inventory systems consist of more than one lower-level inventory. This is called divergent inventory system (Olsson 2007), which is shown later in Figure 10. In a divergent two-echelon inventory system each installation has at most a single immediate predecessor. According to Olsson (2010), demand uncertainty in such systems can lead to very high inventory investments. The structure of the system, the demand variations, the transportation times and the unit costs are the factors that determine the best distribution of the total system stock (Axsäter 2006). Sometimes it is more beneficial to keep large stock at the central warehouse, but according to Axsäter (2006), in most occasions the optimal solution is achieved when having a very low level of stocks at the central warehouse.

2.4.2. Lateral transshipments

A commonly used strategy to add flexibility to possibly high stock rate divergent inventory systems is to establish transshipments between locations at the same echelon (Olsson 2010). These arrangements are known as lateral transshipments. They can be used either to take place at predetermined times before all demand is realized or on the other hand at any time to respond to stock-outs or potential stock-outs (Paterson et al, 2011). Paterson et al. (2011) refer to these two types as

- Proactive transshipments – lateral transshipments are planned beforehand and they are used to redistribute stock amongst all stocking points in an echelon at predetermined moments in time so that it is possible to cut down the handling costs

- Reactive transshipments – lateral transshipments to respond to situations in which a stocking point faces a stock out and another has sufficient stock available

Paterson et al. (2011) also note that proactive, also known as preventive lateral transshipments are most useful in retail sector. Reactive transshipments are feasible when transshipments costs are relatively low compared to the costs of holding large amounts of stock and high downtime costs. Furthermore, this is typical in situations in which the demand is stochastic, e.g. in spare parts business. Kranenburg (2006) has studied the use of lateral transshipments and shows that it is possible to gain savings in inventory related costs of up to 50%. Dada (1992) shows that backorder reductions of 30-50% are not uncommon when using lateral transshipments. According to Lee (1987), reactive lateral transshipments reduce the level and cost of backorders. However, additional transshipment costs and order process costs will incur. Figure 10 demonstrates lateral transshipments.

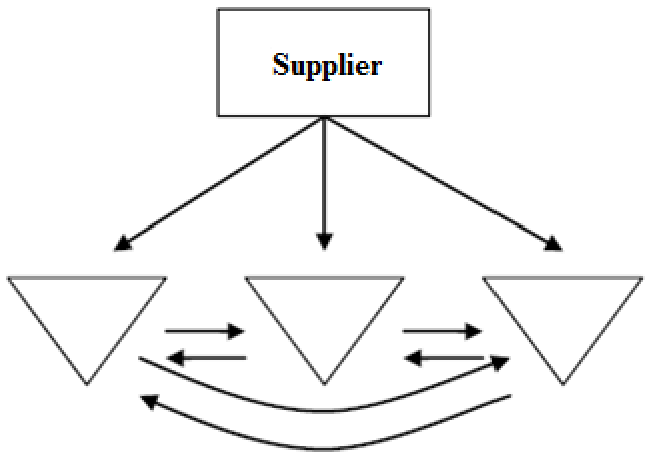

Figure 10 Lateral transshipments (Olsson, 2007)

Axsäter (2003) states that there is a certain decision rule for lateral transshipments; a demand that cannot be supplied from a stock on hand should be always supplied using lateral transshipments from other warehouses having the needed stock. In literature (e.g. Lee 1987), these cases are also known as emergency lateral transshipments. Otherwise, emergency transshipments occur from the upper level to the lower, i.e. from central to local warehouse (Dada 1992). This name describes the nature of the transshipments and underlines the need to rapidly fulfill the demand to prevent high downtime costs.

2.4.3. Unidirectional lateral transshipments

Establishing bidirectional transshipment links in an inventory system is not always feasible or cost efficient. Also, the complexity of the inventory model is reduced when the most insignificant, unnecessary transshipment links are not established. Difficulties in establishing contracts between locations regarding the design of the transshipment policy added to the effort and cost of implementing information systems are some of the reasons for not to allow transshipments among all locations in the system. The models of the system become more complex to formulate and also more complex to analyze when bidirectional transshipments are allowed. To minimize the complexity, Olsson (2009) has further developed Axsäter's (2003) model called unidirectional lateral transshipments and it is presented in Figure 11.

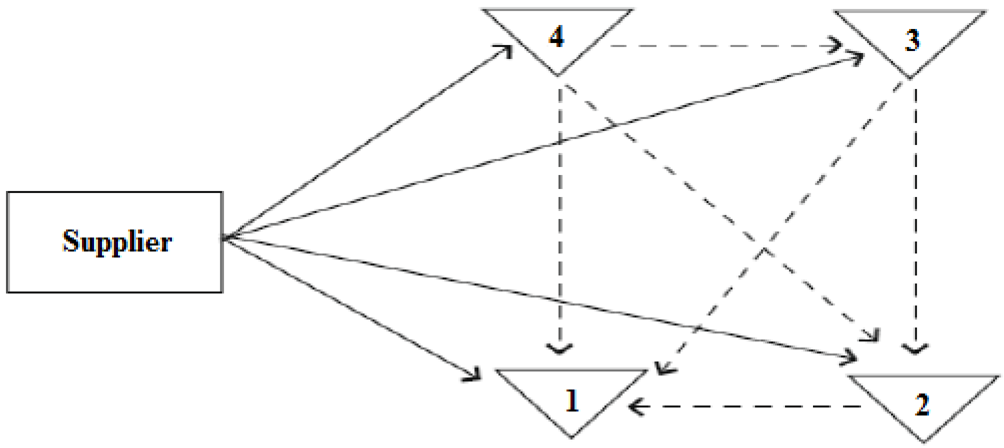

Figure 11 Unidirectional lateral transshipments (Olsson, 2009)

In Figure 11, filled arrows represent regular replenishments while dashed arrows represent lateral transshipments. Within an echelon, locations are often non-identical and can have very different backorder or lost sales cost. It is more reasonable to allow transshipments from a location with a low backorder or lost sales cost to the location having higher cost. (Olsson 2009) According to Axsäter (2003), unidirectional transshipments are preferable in situations where backorder costs differ significantly between locations and can relate to product substitutions.

2.4.4. Partial pooling and unidirectional lateral transshipments

Kranenburg & van Houtum (2009) introduce a model in which local warehouses are further divided into main and local warehouses. Customers are supplied from the local warehouses, but in a case of a stock-out, replenishment location is evaluated based on the downtime costs. Normal replenishments are done from central warehouse, but when downtime costs are considered to be high, an emergency shipment is sent from another local warehouse. Using the nearest local warehouse it is possible to drastically reduce the downtime that in the case of critical spare parts cuts down the costs dramatically. Based on taxonomy of main and regular local warehouses, supplies are sent from the nearest local warehouse, which is considered as main local warehouse. This is presented in Figure 12.

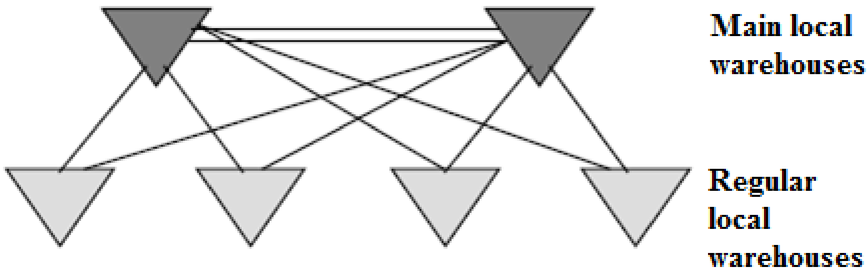

Figure 12 Pooling structure with main and regular local warehouse (Kranenburg & van Houtum, 2009)

Both main and regular warehouses can receive lateral transshipments, but only main warehouses are allowed to send replenishments. This type of network provides different kinds of pooling strategies; complete pooling, partial pooling and no pooling. The model of Kranenburg & van Houtum (2009) relies strongly on the fact that there are differences between local warehouses in terms of size, working hours and logistical environment. Warehouses with the described characteristics are the most suitable candidates to act as main local warehouses. According to Kranenburg & van Houtum (2009) with this kind of partial pooling it is possible to obtain the major part of the full pooling benefits, e.g. cost savings.

2.5. Ordering policies in inventory pooling

According to Ling et al. (2005), literature on inventory pooling can be divided into three categories: component commonality, inventory transshipments in supply chains and inventory pooling in multi-echelon supply chains. End products that use same common components open up the possibility to reduce safety stocks and maintain the service level by pooling the same inventory of the common components. In addition to product and distribution structures, ordering policies affect inventory pooling operations. These policies are a sum of the limits of the operational environment and business guidelines.

2.5.1. Partial and complete pooling

Sherbrooke (1968) introduced the METRIC model in which individual locations are supplied by with repaired items from a central warehouse. Baker et al. (1986) study a two-product system with component commonality and found out that total safety stock dropped down after pooling and while total stock of specialized parts increased. Sherbrooke (1968) designed the model lying on two echelons, as the others considered it using virtual pooling. Transshipments within an echelon create a virtual centralization of the inventory and utilize the benefits of inventory pooling of the type. According to Paterson et al. (2009) two different policies in pooling are

- Partial pooling – part of the stock of the installation is held for future demand
- Complete pooling - installation shares all of its stock

Partial pooling systems reserve items for future needs so that transshipments to satisfy all the demand are not automatically sent. Having this possibility of reserved items, the system then has additional decisions needed to make which makes it more complicated to control and optimize. Complete pooling is applicable in environments where holding costs and backordering costs are relatively high compared to transshipment costs, such as spare parts distribution systems. (Paterson et al. 2009) In literature, also term “no pooling” is used to describe the situation in which all the installations are replenishing directly from external suppliers without a shared inventory.

2.5.2. Order timing and policies

Regular orders can be timed either on continuous review or periodically. Continuous review refers to an inventory concept in which the inventory position is monitored continuously. It is based on re-order points (ROP) that are the stock levels that having fallen below will launch a batch quantity, targeting at an economic order quantity (EOQ) that is the cost formula minimizing order quantity, to be ordered. Periodic review refers to certain given points when inventory position is monitored. The need for stock replenishments is evaluated at these given points. Both concepts include a trigger for cases in which inventory position drops below a specific amount of stock. Periodic review is typically considered for items with low demand, while continuous review is used for items with high demand. According to Paterson et al. (2009), these two concepts are the most typical timing methods related to ordering. Further, policies in literature include (R, Q), (s, S) and (S-1, S). Also general types and other policies are examined.

(R, Q) and (s, S) are the most common policies in inventory control. R is an integer and stands for ROP, Q is an integer for batch quantity. In (R, Q) policy a batch quantity of Q is ordered as the inventory position drops to, or below, the re-order point R. In continuous review replenishments are ordered exactly when the inventory position meets R or if the triggering order directly drops the inventory position below R. On periodic point of view, the inventory position may drop below R before the inspection is done at the end of the period. Because lead time, the time used from a purchase to actual delivery, (L) is not zero in practice and the inventory position will be below R as the Q is received, with continuous demand the inventory position is rarely R+Q. (Axsäter 2006) (R, Q) policy with periodic review, with period T, and continuous demand is presented on Figure 13.

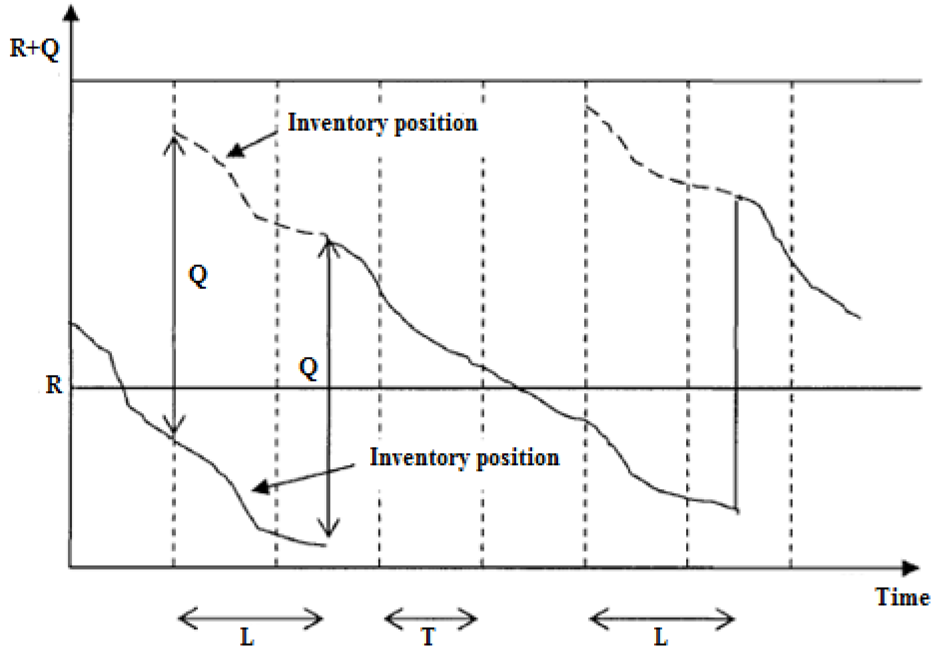

Figure 13 (R, Q) policy with periodic review and continuous demand (Axsäter 2006)

(R, Q) policy is similar to KANBAN policy which is used in lean supply chains. In KANBAN there are containers with a card on their bottom and as the items in a container are used the card, which is a KANBAN, is used and a quantity of items in a container are ordered. There are always a specific amount of containers available to meet the demand. The difference between (R, Q) and KANBAN is the fact that if there are more outstanding orders than KANBANs, no more orders can be triggered, i.e. backorders are not subtracted from the inventory position. (Axsäter 2006) If this is not taken into account, on the ordering point of view they are similar even though they may differ in actual operations.

(s, S) order policy is similar to (R, Q) and if re-order point is always hit, s=R and S=R+Q. s is an integer for ROP, S is an integer for the maximum level of inventory position. In (s, S) policy meeting the re-order point will always trigger an order that at the specific moment would meet the maximum level of inventory. Multiples of a given batch size are no more ordered as the order quantity may vary. However, in (R, Q) and (s, S) if items are not consumed to a quantity below ROP, no order is triggered for that period. Because of this, some variations will always order to keep the certain inventory position unless the consumption is zero. (Axsäter 2006) (s, S) ordering policy with periodic review and continuous demand is presented on Figure 14.

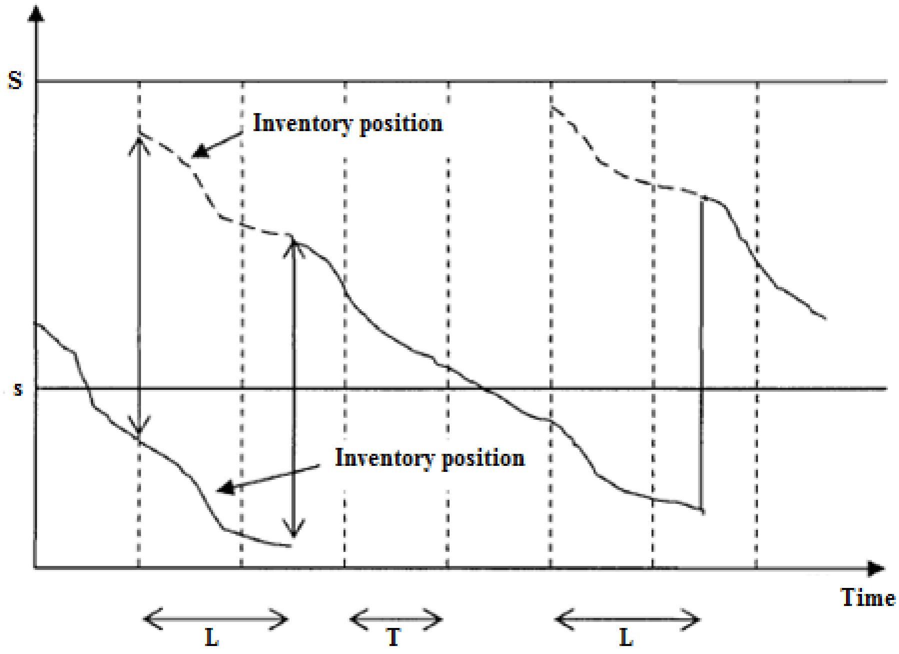

Figure 14 (s, S) policy with periodic review and continuous demand

When inspection will always trigger orders unless the consumption is zero, it is typically an (S-1, S) policy. (S-1, S) policy is equivalent to an (s, S) policy with s=S-1 and to an (R, Q) policy with R=S-1 and Q=1. With expensive and slow-moving items, low ordering costs compared to holding and backordering or lost sales costs, such as in spare parts environments, the (S-1, S) policy is very appropriate. (Olsson 2007) For single echelon systems it has been proved that the (s, S) policy is the most optimal. However, no major cost differences exist between the policies which makes (R, Q) policy popular due to its practicality and easiness of use. (Axsäter 2006)

2.6. Inventory costs

Having stock is expensive. It is estimated that total inventory costs form from 14% to more than 50% of the total value of the product annually (Bloomberg et al. 2002). Inventory costs are typically considered as a sum of different cost categories. Axsäter (2006) considers four different categories of inventory related costs: holding costs, ordering or setup costs, shortage costs or service constraints and other costs. However, even though most of the scholars consider same types of costs, there are differences in the means of categorization (e.g. Waters 2003). Classifications are needed to understand cost structures of inventories and to allocate different costs to be able to model and optimize inventory systems. Axsäter (2006) points out four different classes of inventory costs: inventory carrying costs (holding costs), ordering or setup costs, shortage or service constraints and other costs. These groups are all variable costs and the classification is done based on the guiding parameter they vary with.

2.6.1. Inventory carrying costs

Bloomberg et al. (2002) discuss inventory related costs dividing them into ordering costs and inventory carrying costs. Inventory carrying costs which, according to Axsäter (2006) are also known as inventory holding costs, are variable with the inventory level. In literature, e.g. Goldsby & Martichenko (2005) and Lambert et al. (1998), inventory carrying costs are categorized as capital costs, inventory service costs, inventory risk costs and storage space costs. These categories then are further divided into subcategories which are shown in Figure 15.

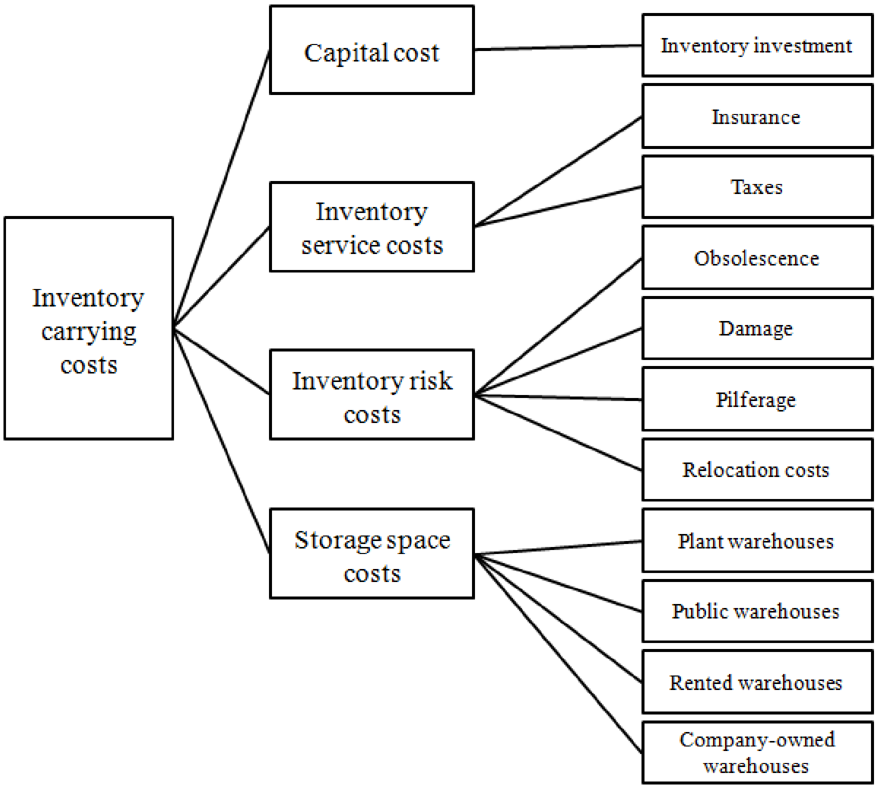

***Figure 15 Inventory carrying costs** (Goldsby & Martichenko 2005)*

Categorization presented in Figure 15 exposes the varying sources behind the term inventory carrying costs. One of the interesting features of this classification method is the way to combine both accounting costs and economic costs (Goldsby & Martichenko 2005). Accounting costs are explicit and they call for a cash payment in contrast to economic costs that are implicit and not necessarily involving an outlay but rather an opportunity cost. Inventory carrying costs and subclasses are all incremental and vary with the quantity of the inventory (Lambert et al. 1998).

When materials are held in stock, capital is tied up into inventories. All the capital tied up in these inventories should be considered using opportunity cost thinking, which in terms of inventories is usually known as capital costs. Capital cost is the biggest factor in inventory costs (Goldsby & Martichenko 2005) and this explains the high enthusiasm for getting rid of all the inventories that are not necessarily needed to ensure the customer satisfaction. In general, inventories should be viewed as investments and companies need to review whether it is more beneficial to hold certain amount of inventories or to focus the money somewhere else to achieve higher economical profits. According to Berling (2005), there are two things that are needed to be evaluated to determine the cost of the capital: the value of the products stored and the expected return on the invested capital.

There are several ways to calculate the value of the products stored. Typical approaches to evaluate the value are to use purchase or selling price, or to mathematically evaluate a value between these, e.g. calculating averages. Berling (2005) points out two ways of determining the return expected; using the opportunity cost of the company or calculating the weighted average cost of capital, WACC. Opportunity cost is the return of an alternative investment having the same degree of risk and which is lost when the company undertakes an investment in substitution of another. WACC is the sum of the costs of the sources multiplied by its share of the total funds. According to Gaither and Fraser (1984), it is more common to simply use the cost of loaned capital. In turn, Axsäter (2006, p. 44) clearly states that "In general, the percentage should be considerably higher than the interest rate charged by the bank." After all, investments in inventories are often financed by debt (Berling 2005), which favors the costs of the loaned capital as it is usually also the easiest way.

Lambert et al. (1998) allocate insurance and tax costs to the class of service costs. Berling (2005) applies taxes as a percentage of the inventory value and insurance costs as a percentage of the average storage value. Inventory risk costs are divided into obsolescence, damage, pilferage and relocation costs. All of these increase with the size of inventory. Obsolescence costs are costs of holding large inventories so that the products somehow outmode so that it becomes impossible to sell them with their original price. (Goldsby & Martichenko 2005) Damage costs are caused by unsuccessful handling in storages so that the products cannot be sold with their planned price. Pilferage costs are substantial and caused by thefts from storages. Relocation costs are caused by transfers between inventories to avoid obsolescence and shortages or by incorrectly delivered goods and lack of delivery of shipments to customers. (Lambert et al. 1998)

2.6.2. Ordering costs

On a general level, inventory costs consist of two types of costs: carrying costs and ordering costs. Ordering costs are the costs related to the ordering process, i.e. process costs of ordering, not the actual price of the product. Bloomberg et al. (2002) describe the relationship between carrying costs and ordering costs inverse in terms of increasing quantity and value of the inventory. This relationship is presented in Figure 16. Increased quantity leads to cut down of the ordering costs, but is not achieved for free. Inventory carrying costs are seen to increase in somewhat fixed proportion to the size of the inventory. It is obvious, that companies are willing to optimize this formula.

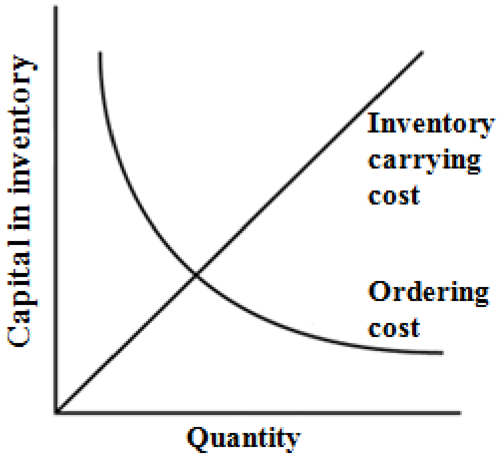

Figure 16 Inventory cost figures (Bloomberg et al., 2002)

Axsäter (2006) lists fixed costs related to ordering or setup that are not related to the batch size: setup and learning costs, administrative costs and costs related to transportation and material handling, costs of order forms, authorization, receiving, inspection and handling of invoices from the supplier. In general, ordering costs are usually divided into administrative, material handling and transportation costs. Due to their nature, they can be cut down by increasing the quantities. Inventory carrying costs and ordering costs are summed and the cost minimum of the total is typically on the intersection point of the two curves.

2.6.3. Shortage costs or service constraints

The cost model in Figure 16 has limited possibilities to be used. If a customer needs something that is not in stock, various costs can occur. The costs associated with inability to satisfy customer demand are known as shortage costs. Typically there are two options that the customer may take; wait until his order is backlogged or to choose another supplier. If the customer chooses to wait, there are extra costs for administration, price discounts, material handling and transportation. In other hand, if the customer chooses to buy from another supplier, costs of lost sales occur. It usually denotes that the contribution of the sale is also lost in addition to the lost of good will, which leads to loss of potential future revenues. (Axsäter 2006) Hence, two types of shortage costs are noted

- Backorder costs – extra costs of backlogging
- Costs of lost sales – lost contribution of an order and future sales

Shortage costs a usually very difficult to estimate. When customer demand occurs and stocks are empty, the customer normally becomes unhappy. The cost of the customer disappointment is extremely difficult evaluate and it’s agreed among the scholars that this cost is not considered insignificant. (Mercado 2008) However, some simple situations exist; if it is possible to e.g. buy a component from a shop next door at a higher price, it is quite simple to determine the cost. Because of the nature of the shortage costs, it is common to replace those using so called service constraints that simply determine e.g. the average waiting time. In many situations it is simpler to determine an adequate service level than to determine adequate shortage costs. It is typical that the real motivation of a service constraint is an underlying shortage cost. (Axsäter 2006)

2.6.4. Other costs

Inventory carrying costs, ordering costs and shortage costs are typical in inventory models. It is obvious, that also other costs exist. Axsäter (2006) lists the costs of operating the inventory control system as an example of costs that are not included into the presented classes. Further, there are also some assumptions that do not work in all situations. It goes without saying that assuming the costs the same and not depending on the lot sizes is insufficient. It is typical that discounts and savings in higher lot sizes are achieved.

In addition to the costs already mentioned, Kilpi et al. (2008) have studied interface costs. They have examined the possibilities to reduce costs of expensive spare parts by establishing cooperation between different actors of the business. Interface costs consist of annual fixed costs of maintaining relationships between the parties of the cooperating network, e.g. in a de-centralized system. The interface costs are considered to be proportional to the complexity between the parties of the cooperating network.

2.7. Overview of the theoretical framework

Supply chain management is one of the most important sources of competitive advantage. This advantage is obtained by targeting shared goals that best serve the final customer. Increased number of the parties involved increases the complexity of the chain which is likely to decrease efficiency, i.e. increase waste. Resources are wasted on unnecessary operations, transshipments, oversized and over leveled inventories. On the other hand, lost sales and backorders become extremely expensive for the company. Inventory management focuses on designing the strategic, tactical and operational level structures and operations to best match the unique requirements of each case. Supply chains are usually seen as downstream value chains but when it comes to inventories, also horizontal actions and backward logistics are required. This field of inventory management has been on the scope of the academics recently.

2.7.1. Key terminology

This study is limited on inventory balancing improvements. To understand the field of the study it is needed to consider the terminology in more detail. The need for inventory balancing stems from inventory pooling. It has been proved that inventory pooling may provide remarkable cost reductions, e.g. Kranenburg (2006) has shown cost reductions of up to 50% in semiconductor spare parts logistics. Inventory pooling is based on lateral transshipments. Relations and dependencies of the key terms used in this study are shown on Figure 17.

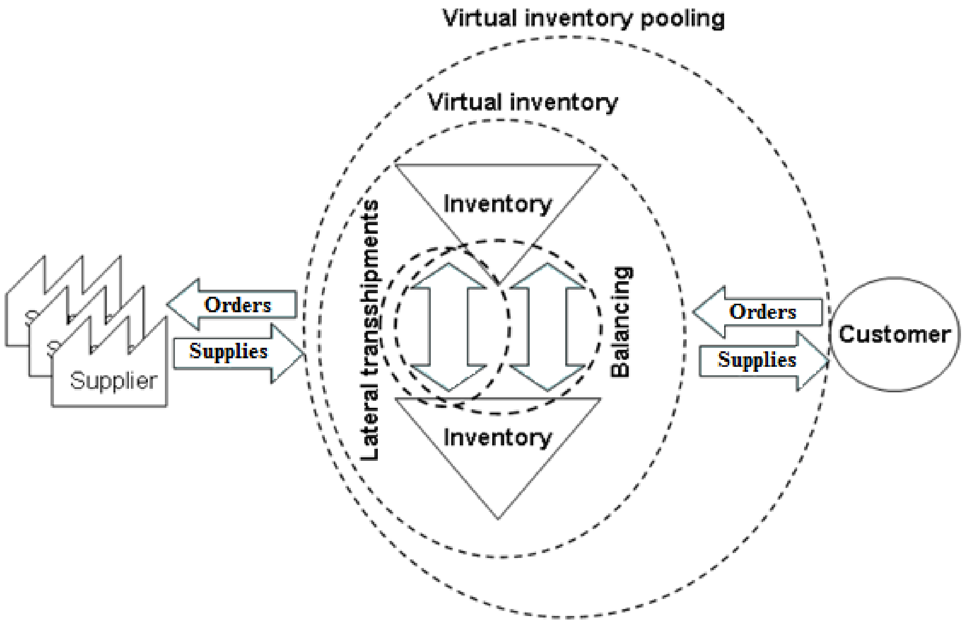

Figure 17 Key terminology

Ling et al. (2005) find three categories of inventory pooling in literature. The one used in this study is about inventory transshipment in supply chain which "creates a virtual centralization of the inventory by utilizing the benefit of inventory pooling within the same inventory echelon". Virtuality is in other words obtained through pooling the supply chain inventories on horizontal level. Virtual inventories balance their stock levels by arranging lateral transshipments. Balancing is in other words the target that is carried out performing lateral transshipments. According to Paterson et al. (2009), "modern flexible systems allow lateral transshipments within an echelon" so that "members of the same echelon pool their inventories". In this study, transshipments that are performed within an echelon are considered as lateral transshipments.

In basic inventory management literature (e.g. Axsäter 2006), these terms have already become standardized. However, some academics have later expanded the definition of the terms they have been studying. Kranenburg (2006) defines partial pooling as inventory structure, even though it has been widely used to describe a pooling policy that reserves a part of the inventory denying the pooling of total inventory levels. In addition to this, pooling has been widely used as a synonym for virtual pooling and balancing. The most relevant terminology in this study is used as stated on Figure 17. Other terms are used as described on the presented literature.

2.7.2. Framework of the study

This study considers typical issues related to supply chain management and inventory control. These are considered on basic supply chain literature, such as Christopher (2005), and basic inventory control literature, such as Axsäter (2006). However, the basic SCM models assume the chain being vertical, which is questioned on the study. Efficiency of the supply chain is obtained through arranging horizontal or lateral transshipments. Paterson et al. (2011) have examined the field of lateral transshipments and classified the models and characteristics of the recent studies. This study relies on the same classification to model the structures of the case company. One of the most important single studies on lateral transshipments is Kranenburg & van Houtum's (2009) study of partial pooling and unidirectional lateral transshipments. The idea of arranging regular single direction transshipments is then examined in the case company.

As the lateral transshipments have not been considered on detailed level, more specific studies are performed. Material classifications presented on literature are applied in the case company on managerial decisions. This classification is used to examine the current material flows. Because of the early state of the lateral transshipment policies, more detailed classifications, such as Paakki et al. (2011), are not used in the study.

Inventory carrying costs are considered based on the basic literature. The basic idea, such as stated by Axsäter (2006), is to divide the costs into subgroups and it is widely accepted method to be used in the models. However, to completely evaluate the costs of the different solutions it is needed to expand the cost analysis to cover all the actions from sourcing into actual transportations and all the administrative costs (e.g. Young et al. 2009). Comparing the solutions is possible also using models that are not as complicated. Feller (2008) proposes a method that consists of sourcing, inventory and transportation costs. These cost groups consist of the related costs so that all the relevant costs are taken into consideration.

As a result, the structure and the characteristics of the inventory system are examined with the framework proposed by Paterson et al. (2011). The material flows are examined applying the classification methods used in the case company. Cost analyses are performed by applying the principles of inventory carrying costs suggested by Axsäter (2006), total landed costs suggested by Young et al. (2009) and especially the cost groups proposed by Feller (2008).

3. RESEARCH METHOD AND MATERIAL

3.1. Single-case design

This chapter explains the methodology behind the study. To examine the subject a case study approach was conducted. Case study is an empirical study, which according to Yin (2009) "investigates a contemporary phenomenon in depth and within its real-life context". It gives answers on "how" and "why" questions which help to explain experiments or phenomena (Perry 1998; Yin 2009). Its function is to correct old theories and to deduce hypotheses, which can be later examined in more detail (Malhotra & Birks, 2006). To date, case studies have become popular and relevant research strategies (Eisenhardt 1989). Case studies belong to the most significant research methodologies in the management field (Gibbert & Ruigrok 2010).

A three-step single-case study was chosen to clarify the structures of the current system, scan the known issues and evaluate the possibilities to develop inventory pooling operations. Due to the nature of the issue, it is necessary to study a company that has spread its actions wide enough to provide the amount and complexity of the sales order data needed to reveal the issues. With dozens of sales branches, three distribution centers, thousands of suppliers and a centralized management body, KONE GSS can be seen as an exquisite case company. Having started in 2006, the organization studied is rather young and case studies are proved to be especially valuable in the preliminary stages of an investigation (Eisenhardt 1989; Flyvbjerg 2004). As an inductive approach, case study generates new theories without the need of earlier empirical evidence or literature (Eisenhardt & Graebner 2007; Perry 1998), but on the other hand are entailed one of the weakest study methods when it comes to the quality of the research design (Yin 2009).

Perry (1998) suggests that both induction and deduction approaches should be included to diminish the weaknesses of the case study. Perry points out that the analysis of the earlier theory increase the value of the new theory and it can be used to triangulate further evidence and quality to the results. To suppress the views that regard case studies subjective and liable and to enforce the legitimacy of the research method, Eisenhardt & Graebner (2007) highlight the need to carefully justify the theory building, deliberate sampling and interviews, extensive presentation of evidence and prominent theoretical arguments. Disciplined fulfillment of the highlighted points will establish the present study (Gibbert et al. 2008).

A case study can be qualitative, quantitative or a combination of both of them (Yin 2009). Quantitative research methods focus on the collection and analysis of data, and qualitative research methods in other hand see the result as the theory (Cooper & Schindler 2008). Typical qualitative case study data sources are verbal reports, personal interviews, observations and written reports (Ghauri 2004). Quantitative methods are deductive, which aim at testing the theory on the basis of the data collected in the study. Qualitative methods emphasize the inductive approach (Cooper & Schindler 2008). The combination of the quantitative and qualitative research methods is on most occasions considered to add the quality and the value of the research. The kind of approach is called triangulation, which aims at observing the issue from two or more different angles. Triangulation includes the gathering of the data using multiple data collection methods. (Eisenhardt 1989; Flick 2004) Qualitative and quantitative research methods can succeed one another or they can be used simultaneously to compensate the weaknesses of each other (Cooper & Schindler 2008). This provides more solid validation of new theories and makes it possible to expand the field of the study.

This study consists of three major steps. First, there were qualitative interviews with KONE employees and studying of the process documents to understand the current inventory pooling environment of the company, to identify issues related to everyday operations and to evaluate the possibilities of improvement. In the second step, quantitative studies were performed as data gatherings from the ERP system, from the document systems and reporting systems to examine the structures and processes. In the third step a specific area was chosen and further examined. Recommended actions were considered on the basis of the observations. In particular, KONE GSS is especially attractive target of the study because

1) The company is acting globally and is within the largest elevator & escalator manufacturers

2) The offering of the company consists of about 100 000 coded material items

3) Spare parts supply chain consists of multiple levels of actors, which are not only making vertical transactions but also horizontal moves

4) GSS is a rather young organization and highly interested in supply chain excellence

The quantitative and qualitative research methods target on answering the research questions and obtaining the research objective. Research questions and objectives presented above are summarized in more detail in the following sections.

3.2. Data collection and analysis

This section outlines the steps of preparing and performing the data collection approaches. The methodologies of the qualitative interviews and the quantitative inventory survey are described in chronological order to clarify and alleviate the understanding of the empirical process.

3.2.1. Interviews

In total nine interviews were performed in GSS Hyvinkää office 17.6.2011-4.7.2011. In addition to this, interview questions were emailed to China for one interviewee. All the interviewees were employees of KONE GSS and their work was highly related to inventory pooling operations. Half of the interviewees were men and half of them were women. Three of the interviewees were team leaders in logistics, inventory planning and customer service. One of the interviewees was a process owner and the rest were senior-level employees on each team of the unit, expect for the technical service team. Interviewees represent all the teams within the organization, except technical customer services team. Typical work titles were “team leader”, “senior” and “specialist”.

Interviews lasted from 25 minutes to 1 hour 15 minutes. The average length was 40 minutes. All the nine interviews were in Finnish and the questions sent via email were in English. In each interview there were two interviewers so that the other one interviewed and the other one took up notes. This involved the author of this thesis and another thesis worker working with his own thesis regarding logistics. All the interviews were recorded and documented. Interviewees were interested in the study and were extremely willing to take part. Interviews were semi-structured so that the main areas of interest and the questions were determined beforehand. However, interviews were designed so that there was some space for the interviewees to approach the question from their point of view taking into account their area of specialization. Inventory system can be viewed from different viewpoints, e.g. physical or system point of view, and these may differ depending on the operation system, interviewees were also asked to draw a picture of the inventory system as they see it.

Interviews targeted on clarifying the existing inventory pooling environment and finding out potential improvement areas or problems. Questions were determined so that certain main areas of interest would be answered. Interviews were performed in two rounds; first round interviewees were chosen by their working title and they were asked to name persons with knowledge they thought would best match the questions. These persons named by the previous round were then interviewed on the second round. On the first round the main areas of interest consisted of

1) The structure and hierarchies of the inventory system

2) Transshipments between distribution centers and their significance

3) Main issues regarding to lateral transshipments

4) The most important areas of development in inventory pooling

In addition to general questions, each interviewee had two or three more questions concerning their own specific experience. These were typically simple questions to briefly describe something, e.g. what ERP systems are used. Interviews were split so that the interviewees answered specific questions related to their tasks before questions about the issues on their side. This was done to make them answer more on their specific viewpoint. The second round consisted of the same general questions as the first round and more specific general questions about the current inventory structure and processes. The main areas of interest on the second round were

5) The costs of backorders and lost sales

6) Types of lateral transshipments and routines within different levels of the system

7) Policies of current lateral transshipments

8) Costs considered and reported

The base for the questions was a list of information needs that were possible to examine using qualitative approach. This list was then further divided into general and more specific areas of interest. General information, such as improvement ideas were assigned on the first round and more specific needs were assigned for specific person or on the second round. These information needs were then formed into main questions and more focusing questions. First interview was used to test the questions with team leader of the inventory support team. Questions were then evaluated and some improvements were done to make the questions easier to understand and to ensure that interviewee will provide descriptive answers. Question lists are provided in Appendices 4 and 5.

Data was analyzed through iterative process. Notes were taken during the interview and they were completed by listening to the recordings afterwards. All the answers were combined together with their source so that it was possible to recognize later who had given each answer. Then, similarities were searched and answers were categorized into larger entities. Some comments that best described the findings or revealed something special were then chosen as direct citations.

3.2.2. Quantitative data gathering

Quantitative data was gathered from several sources. The most important source was the ERP system SAP R/3 which is the basis for all operational processes. Multiple data queries were performed to analyze operational actions, which were then combined. This included combinations of sales orders, customer, and material and delivery information.

Internal system logics, e.g. in data tables required special knowledge of the specific data structures. Due to the nature of a special case needs, the author was not able to do the data extractions alone. Most of the extractions were done with the help of senior employees of each team.

Most of the gatherings were based on ERP reports. Time scale was chosen to be the first five months of 2011 as there had been great growth especially in CDC because of the start-up of the operations. All the transshipment operations of GSS were included into the analyses. Also, all the material groups and materials were included. Due to this, reports reflect actual everyday operations of the case organization.

To complete the analysis, also historical data was needed. Historical data is not at the moment stored e.g. into a business intelligence warehouse which would make it easy to explore, so it was needed to collect and combine data from operational reports. This included KPI reports, production meeting minutes and controlling reports. In practice, all of the data had been taken out from the SAP in the past. Due to the fact that transportation and warehouses have been outsourced and run in a separate ERP system within a different company, it was needed to request data outside the company. Panopa and DHL were however able and willing to offer the information needed. Also contracts between KONE and third party providers were examined to evaluate the costs of logistics.

Processes were studied through official process descriptions and work instructions. KONE has strict policies and instructions for process descriptions which made it possible to browse, compare and combine them. However, the subject of the thesis made it more complicated as inventory pooling operations are not described and modeled in the extent that would have been needed. Because of this, it was needed to examine and complement the processes with other sources, such as the interviews. Process descriptions were then shown to the personnel working with the related tasks whether they were correct.

3.3. Validity and reliability of the study

Validity and reliability of the study is discussed in this section by evaluating the research methods used. To ensure the rigor of a case study, the most influential model is so-called natural science model, which includes reliability and validity (Gibbert & Ruigrok, 2010). If the same or another researcher would repeat the research, the reliability could be seen high if the results would stay the same. Validity indicates if the findings are credible and if they can be transferred into larger content. (Miles & Huberman, 1994)

- Reliability refers to the accuracy with which a measurement can be repeated, leading to the same result (Yin, 2009)

- Validity describes whether "you are observing, identifying or measuring what you say you are" (Mason, 1996)

Division into two parts is done to evaluate the trustworthiness of the study. Evaluating of the quality of the research is done using Yin's (2009) four step model. The model includes: reliability, construct validity, internal validity and external validity. Reliability is further divided into internal and external reliability. These steps are described and performed in the following two subsections.

3.3.1. Reliability

Yin (2009) suggests documenting all procedures and measures taken in form of a case study protocol, consisting of the description of the case study questions, procedures of the data collection, outline of the case study report, questions of the case study and evaluation of the study or a case study database, containing the responses of the survey and a survey report. In this study, both measurements are applied. This study is a report of the research describing the content and processes of the data collection and analysis, also providing the interview and ERP survey frameworks. Data from the ERP is the official operational documentary and it is assumed to be correct. However, other sources were used to review the reliability of the ERP reports and all the results were reviewed by a senior employee.

Internal reliability describes measurements consistency within itself, while external reliability refers to the possibility to replicate the study (Bryman & Bell, 2003). It is possible to measure internal reliability using test-retest-measures, e.g. split-halves test. Interview results repeated similar issues which highlights internal reliability of the study. Findings of the interviews were used in this study only as indicative guides. They were used to reveal issues and development areas on processes which were then further evaluated using more reliable sources. Even though some of the interview findings may be only subjective or pure personal opinions, they would not decrease the reliability of this study. The triangular methodology and mutually supportive qualitative and quantitative results enforce internal reliability.

3.3.2. Validity

Validity is a prerequisite for the reliability. Without a truthful validity, the study is not measuring what the researcher wants even if it's reliable. In literature (e.g. Cooper & Schindler 2008; Yin 2009), various types of validity can be found. The most common ones in case studies are construct validity, internal validity and external validity. Construct validity is, on most occasions, the first step to cover where data collection methods ought to be justified (Yin 2009). Cooper & Schindler (2008) explain that it answers the question of "what accounts for the variance in the measure?" Construct validity is in major role in the phase of data collection (Gibbert & Ruigrok 2010). Yin (2009) sees construct validity being the phase on which investigators typically fail. He provides three measures to ensure construct validity: use of multiple sources (triangulation), establish chain of evidence and have the key informants review the study.

Internal validity is the causality between the variables and is the base for strong arguments in conclusions (Yin 2009). It examines whether the research method examines what is proposed (Cooper & Schindler 2008). Yin (2009) suggests different methods to obtain internal validity: pattern matching, building explanation, pointing out rival explanations and using of logic models. In this study, hypotheses were not given by the author but hypotheses were proposed by the personnel of the case company which were then examined using quantitative studies. Explanation building was done comparing the results to the existing literature. These two methods were applied on this study. Internal validity has a significant role in this study as there were interviews through most of the functions in the organization and it was possible to ensure a high level of correspondence between the observations and the concepts.

External validity is about the ability of the data to be generalized (Cooper & Schindler 2008). However, case studies have been argued not to provide the possibility of generalizing the findings. This risk has been seen very high in single case studies as the possibility of subjectivity is increased. (Yin 2009) It is important to understand the difference between analytical generalization and statistical generalization. Analytical generalization designates generalization from empirical observations to population, leaving the statistical generalization which is generalization from observation to population. As a result of this, it is possible to formulate general theories even using a single case study. (Gibbert & Ruigrok 2010) Reasons for choosing the case company have been described. However, the scope of the study is limited, and the findings cannot be generalized. Actually, only construct validity is important to the study.

As stated, in this study the highest efforts are focused on construct validity. Multiple sources are used but they remain in only one case company. Triangulation is used by combining interviews, ERP system reports, contracts with involved parties and process descriptions. This study is also built so that the chain of evidence is revealed to make it possible to follow the process. All the data is also archived with exact time frames. In addition, key informants were asked to review each finding to eliminate possible sources of uncertainty.

4. FINDINGS OF THE STUDY

4.1. Company overview

KONE is a global supplier of elevator, escalator and automatic door solutions. Having net sales of 4 987 M€ and operating income of 700 M€ in 2010 (KONE Corp 2011a) it is regarded as one of the largest elevator and escalator companies in the world. It was founded in 1910 and since then it has been continuously growing and expanding its operations over all continents. (KONE Corp 2009) KONE employs approximately 33 800 employees and is presented in around 50 countries worldwide (KONE Corp 2011a). When comparing annual statements 2006 and 2011, it can be seen that the company has continued its growth with sales increase by 40% and improved its operating income from 10% to 14%. On the first quarter of 2011, both the net sales and the operating income kept growing (KONE Corp 2011b).

The company states that it has been committed to understand the needs of its customers serving them with industry-leading applications and innovative solutions for maintenance and modernization. It targets to offer the best People Flow experience through developing and delivering solutions that make it possible for people to move smoothly, safely, comfortably without need to wait in buildings. (KONE Corp 2009) KONE has divided its business lines into new equipment business and maintenance and modernization business. New equipment business accounts for 46%, maintenance 37% and modernization 17% of total sales. (KONE Corp 2011a) Shares are presented in Figure 18 from which it can be seen that the service equipment business consisting of maintenance and modernization forms bigger share than the new equipment business.

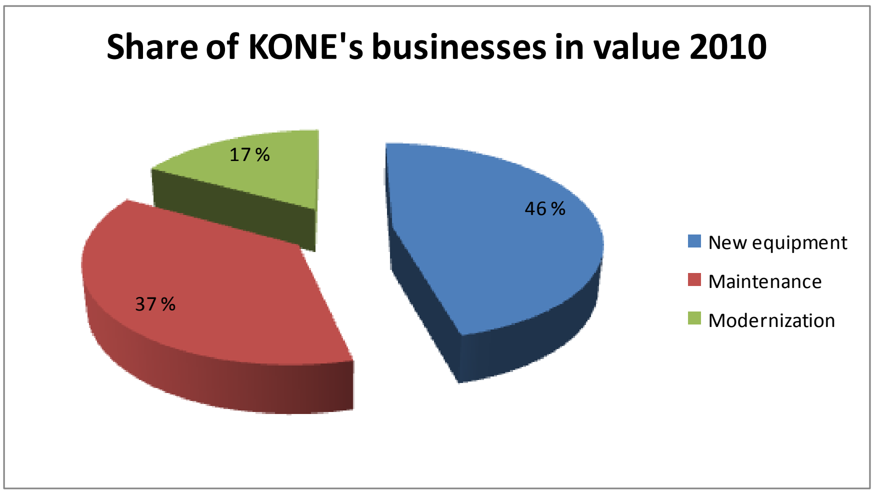

***Figure 18 Share of KONE's businesses in value in 2010 (*KONE Corp 2011a)**

KONE has approximately 34 000 employees, more than half of them located in Europe, Middle-East and Africa, one third in Asia and Pacific area and about 15% in America. Geographical market shares in these locations were 58%, 21% and 21% accordingly. The importance of business in Asia has been increasing and it is continued by solid growth in China and Southeast Asia. KONE has about 250 000 customers worldwide most of them being maintenance customers. (KONE Corp 2011a) KONE's key customers are builders, building owners, facility managers and developers. Market segmentation is done based on the purpose of the building; residential, office, hotel, retail, infrastructure, medical and special buildings. (KONE Corp, 2009)

The biggest players on the elevator and escalator market are Otis, Schindler, ThyssenKrupp and KONE. There is no official or certain information of the market shares, but Koncept Analytics (2010) have evaluated the market shares through available data, e.g. financial statements and the results are presented in Figure 19. Given figures are global and there are significant differences in market shares between market regions. Others consist of globally smaller companies including e.g. Fujitec, Hitachi, Mitsubishi and Toshiba, which forms a strategic alliance with KONE. New elevator manufacturers in Asia are increasing their sales rapidly (Koncept Analytics 2010).

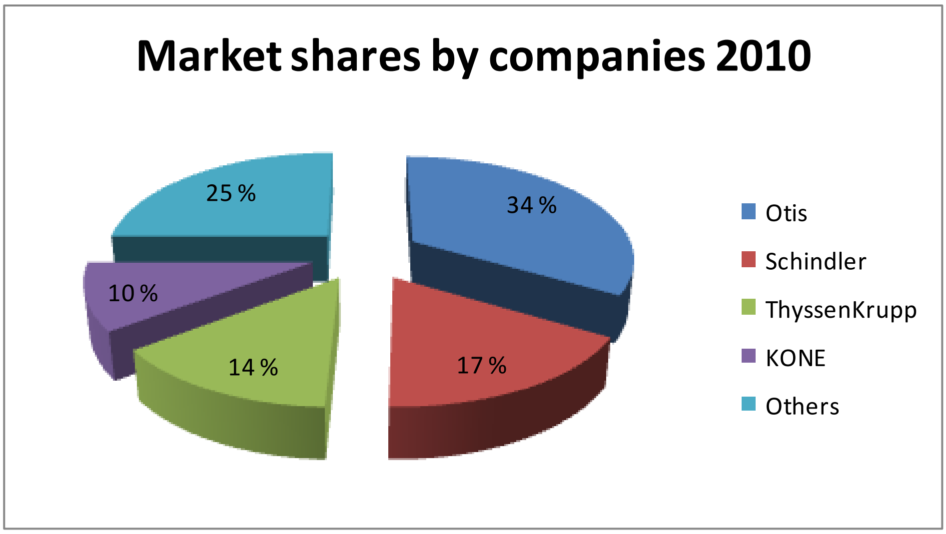

Figure 19 Market shares by companies in 2010 **(KONE 2010)**

KONE has development programs that are given in periods of three years and they are defined to continuously improve competitiveness and to enable profitable growth to meet the long-term financial targets. New and ongoing development programs are customer experience, employee engagement, innovative solutions for people flow, service leadership and delivery chain excellence. The key drivers for the technical solutions are improved energy-efficiency, superior ride comfort and appealing visual design. In total, research & development expenses represent 1.4% of KONE's net sales.

4.1.1. Front lines

KONE has organized its spares supply operations using local autonomous sales branches called Front lines (FL) and a centralized service provider organization called Global Spares Supply (GSS). Front Lines are responsible for customer sales and services typically for the country they are located in. There are about 50 FLs and they have major differences in their size and level of development. In principle, they are autonomous, but there have been great efforts to encourage them to closer collaboration with GSS. Overlapping, expensive and outdated processes are being replaced by the global practices.

Because of their autonomous status, FLs have the possibility to purchase their materials using any sales channel they want to. When it comes to corporate management, this involves several impracticalities and waste of resources. From the corporate point of view, FLs should focus all their purchases through GSS to enable all the advantages of global centralized material management and purchases. Furthermore, centralized material management thinking will need to be expanded to also cover FL proximity stocks including service vans.

4.1.2. Global spares supply

In terms of management, GSS is a centralized management body (Kauremaa 2011), it was established in 2006 in a reorganization of the Service Business Unit (SEB) and it is responsible for supplying spare parts for KONE, inherited brand and competitor elevators, escalators and automatic doors all around the world except most of the areas of the Americas. Furthermore, GSS has expanded its offering into work clothes, tools, chemicals and commercial spare parts. Its main offices are located in Finland and China, in addition to three delivery centers in Germany, China and Singapore.

GSS offering consists of over 100 000 coded material items. Main customers are KONE’s regional business units Front Lines, which represent over 90% of the sales. The mission of GSS is to deliver the right spare part with minimal possible costs at the right time to the right place. The vision is to minimize equipment downtime and to prevent interruptions to business with the support of sourcing, purchasing and stocking the relevant parts and by the support to FLs to assure logistics excellence. GSS aims at becoming a full service provider not just providing spare parts but everything that is needed to perform maintenance operations.

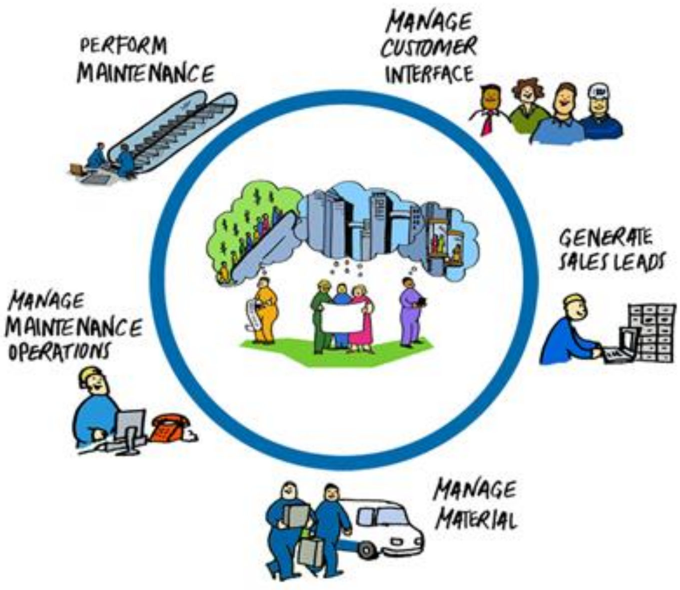

Figure 20 Maintenance process (KONE 2010)

KONE has defined five core processes: customer, solution creation, maintenance, delivery and management & support. GSS is part of the maintenance process (Figure 20) and focuses on material management. "Manage material" process is presented in Appendix 1. It describes the process from using tools to material identification proceeding to material ordering procedures and finally delivering the items. Simultaneously there are running processes to manage both GSS and FL inventories, offering and price lists and master data maintenance routines. Each process involves a team e.g. inventory planning and pricing teams and there are about 100 employees working in GSS.

There are several advantages that GSS is offering to FLs. The most important is the savings in process costs as the spare parts supply become more and more automatic. Kauremaa (2011) has studied the advantages of the organization type by interviewing FL supervisors. Supervisors pointed out that the support given by GSS benefited them in terms of resource efficiency, increased service level, delivery performance, supply chain management capabilities and some local benefits.

4.1.3. Distribution centers

GSS has three Distribution Centers (DCs), which are located in Germany (EDC), Singapore (ADC) and China (CDC). Distribution centers are responsible for the logistics between the suppliers and customers of GSS. Each of the three DCs are operated through third parties, but all the information flow, material management, purchasing, inventory balancing and customer services are done by the GSS. DCs deliver supplies to internal customers (FLs), external customers (retailers and competitors), but also make stock transfers between DCs. Supply chain network is shown on Figure 21. More detailed material flow diagram is presented in Appendix 2.

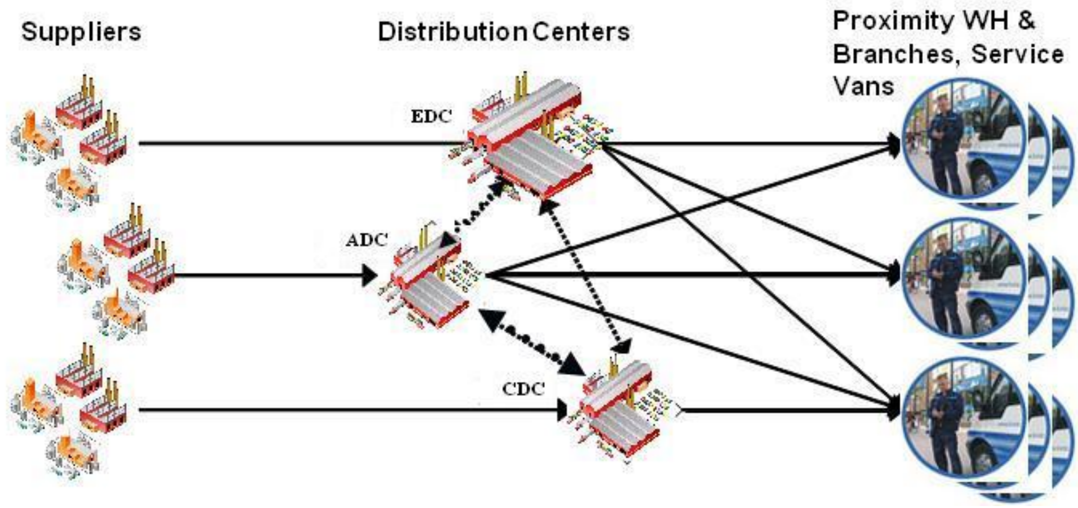

Figure 21 Supply chain network (KONE 2010)

European Distribution Center, EDC, is the largest and the most developed DC. It is located in Herten, Germany and it is run by Panopa Logistik. Since 2006, it has doubled its yearly outbound lines to over 660 000 in 2010. Asian operations are managed through Asian Distribution Center, ADC, which is located in Singapore and run by DHL. However, yearly outbound lines of ADC are less than 10% of the lines in EDC. An exception to Asian operations area is China, which is operated through China Distribution Center, CDC. CDC is located in Songjiang, China and it is run by DHL. CDC is the youngest DC and it is placed in China in response to China's intense national regulation. It is growing rapidly, but high rate of manual operations is limiting the growth and development. At the moment, twice as many outbound lines as in ADC are being supplied.

4.2. Initial structures and processes

GSS is responsible for supplying spare parts for all KONE elevators, escalators and automatic doors, as well as commercial replacement parts and components of other manufacturers. This involves both internal and external customers. A global network of suppliers, distribution centers and distributors are needed in addition to an extensive administration organization. The spectrum of services includes service parts supply chain strategy and design, warehouse and operations management, inventory management, transportation management and reverse logistics. To improve the performance of the inventory management, the structure and processes of the inventory operations are examined in the following.

4.2.1. Spare parts management

There are over 112 000 coded material items in GSS offering. This includes elevator, escalator and automatic door spare parts, tools, personal protection equipment, chemicals and many other products related to maintenance. These items differ significantly by their characteristics which greatly affect the way they should be managed. The basic breakdown of the products is whether it is held in stock, resulting in two main categories: stock and non-stock materials. At the moment, there are about 48 000 stock items and about 68 000 coded non-stock items on the GSS offering. Whether the product is stocked or not depends on the number of orders in a year. For normal items, required order rate is at least six orders a year. For certain products, there’s some flexibility; products that are being forced to the markets, only three orders a year are required. These include e.g. automatic door and escalator spare parts. Evaluation is done on monthly basis. 51 000 items have a list price, rest of prices for non-stock items are determined based on the price from the supplier at the moment of a purchase. According to the listing of active items on price list, most of the products are still related to elevators. Shares of spare parts between product groups are presented on Figure 22 which is based on the price list of the unit in June 2011.

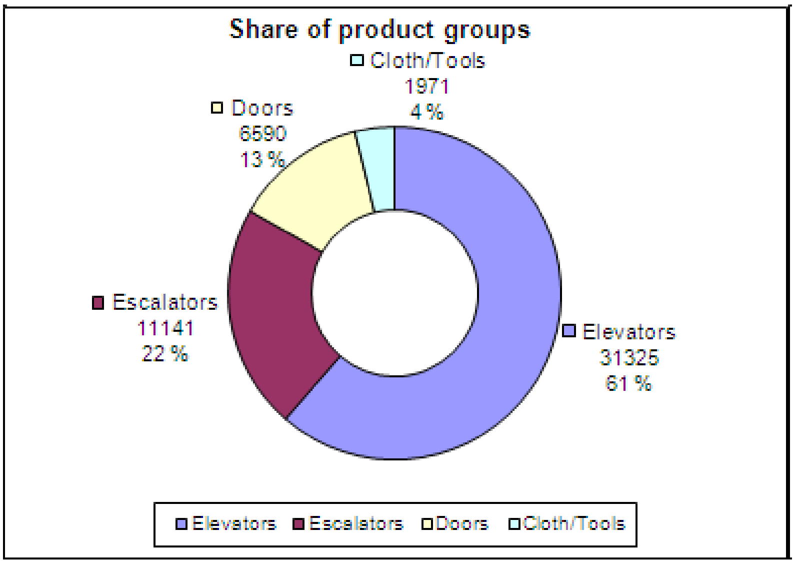

Figure 22 Share of spare part product groups (Based on price list of the unit in June 2011)

More specific classification is based on the availability of the materials on the markets. This classification is used to evaluate the value of the products and the consequences of a stock out. This then further affects the supply chain of the products. In total, there are four different item categories

1) Key parts

2) General parts

3) Standard parts

4) Commercial parts

Key parts are specific KONE design, such as PC boards. There are typically one or two approved suppliers on the market. As the stock-out costs will most likely exceed the inventory costs, higher inventory levels are applied to secure sufficient service performance level. Agility in supply chain is preferred to improve responsiveness. Products with similar qualities but that are relatively easy to backward engineer or to copy and for this reason cannot be considered key parts, are identified as general parts. These include e.g. door panels and there are more possible suppliers available than for the key parts. In general, what incorporates key parts and general parts is the fact that the available supplier base is limited and it is needed to ensure that service performance is not harmed by stock-outs.

Standard parts are industry specific spare parts but they still have comprehensive range of suppliers to choose from. As a globally acting company, KONE has good purchasing power and leverages against vendors operating on niche markets. Standard parts consist of e.g. door rollers and ropes. Commercial parts are common throughout all common industries and thus have multiple suppliers. These include items such as relays, lamps, bolts and nuts. Because front lines can source these also locally, availability risk is minimal also in occasions in which GSS has supply problems.

Products are further divided into product and component families. However, this is related more to technical management and does not directly affect inventory management the way as e.g. item category does. Total amount of product characteristics consist of about 70 attributes in addition to technical documents. Based on these characteristics several classifications can be done within the limits of inputted data of the materials. From the inventory point of view, most important single technical characteristics of a material are length and weight. They affect e.g. transport type and possibilities to store up them.

4.2.2. Supply chain

GSS is a global supply chain coordinator and it has personnel in Finland, France, China, Singapore and India. In addition to this, front lines, autonomous business units, operate all around the world. Material flows are coordinated from the local suppliers to the distribution centers and to the customers, who maintain the maintenance base and make the actual repairs and replacements of the spare parts. Material flow is coordinated from the spare parts suppliers to distribution centers and to the address chosen by the customer. GSS is not actively managing the entire supply chain from the very beginning, neither at the end of the supply chain. This is because KONE has divided its spare parts supply chain into two lines

1) Supply line

2) Front line

GSS is responsible for the supply line, and the autonomous business units for front lines, as their names are. In this supply chain, about six steps or levels can be seen, two supply line and from two to four front line levels. The current supply chain of KONE spare parts is presented in Figure 23 which illustrates responsibilities and actors on the delivery chain.

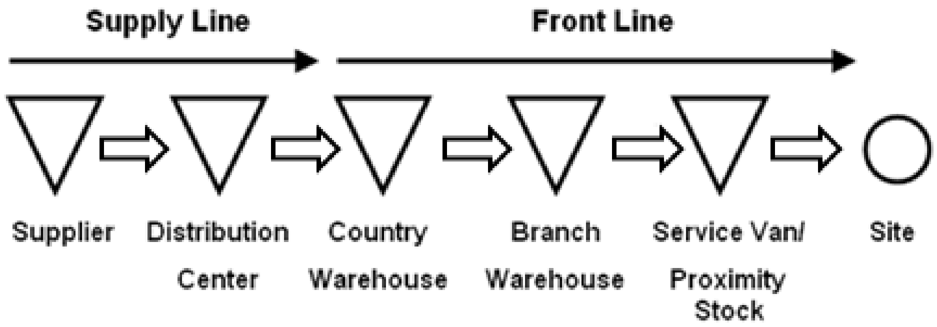

Figure 23 Spare parts supply chain (KONE 2010)

The supply chain presented in Figure 23 only describes the responsibilities of the organizations. Depending on the urgency of the supplies and the structure of the front line, supplies can be sent to different levels of the supply chain. Supply line is highly automated and standardized but great differences exist between the front lines. The most developed and largest front lines, such as Great Britain, have advanced logistics system with different level inventories and optimized proximity stocks. E.g. in rapidly growing Asian market, front lines are far behind in automation and education. It is obvious, that some differences in practices exist.

In addition to material flows, GSS manages the information flow of the supply chain. In fact, the main focus of the organization is to manage the information flow as warehousing and transportations have been outsourced to third parties. More than 50% of the information flow of the deliveries is fully automated and about 40% requires some administration, e.g. purchase order confirmations. In Figure 24 both material and information flows in the supply chain are presented on a general level as viewed by GSS in daily operations. Even though some of the suppliers are supposed to hold inventories for GSS, almost all the deliveries of stocked materials are sent from the suppliers to a distribution center for further processing.

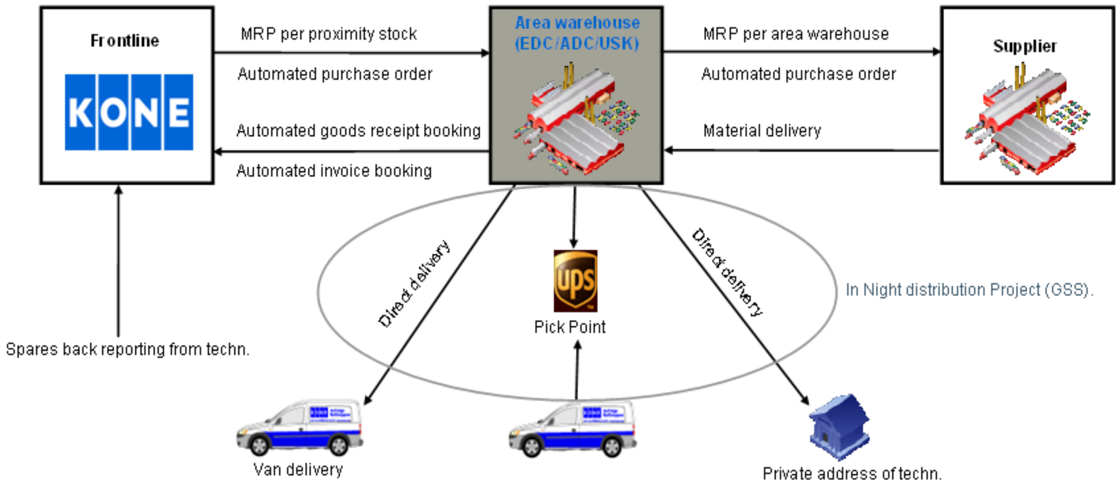

Figure 24 Supply line (KONE 2010)

Appendix 3 describes the information flow in more detail. MRP information is gathered from either front line order amounts and material consumption based on back reported spares consumption by the technicians on sites. However, some interviewees revealed that in practical terms, material consumption is not back reported on a level that would allow the organization to manage the supplies to the end of the supply chain. As a result of this, MRP data is actually flowing from the suppliers to the distribution center and to the suppliers.

4.2.3. Order fulfillment process

On overall level, there are two kinds of orders from the front lines: stock replenishments and material requisitions. In addition, there are larger, individual orders which are related to e.g. campaigns. Stock replenishments are planned, material requisitions are unplanned. Stock replenishments are based on daily MRP runs by each storage location and they are consolidated in a weekly basis. Another trigger for a purchase order is the actual need for a replacing spare part on the field. Order process with these two options is presented in Figure 25 which is combined from the official process descriptions in KONE intranet.

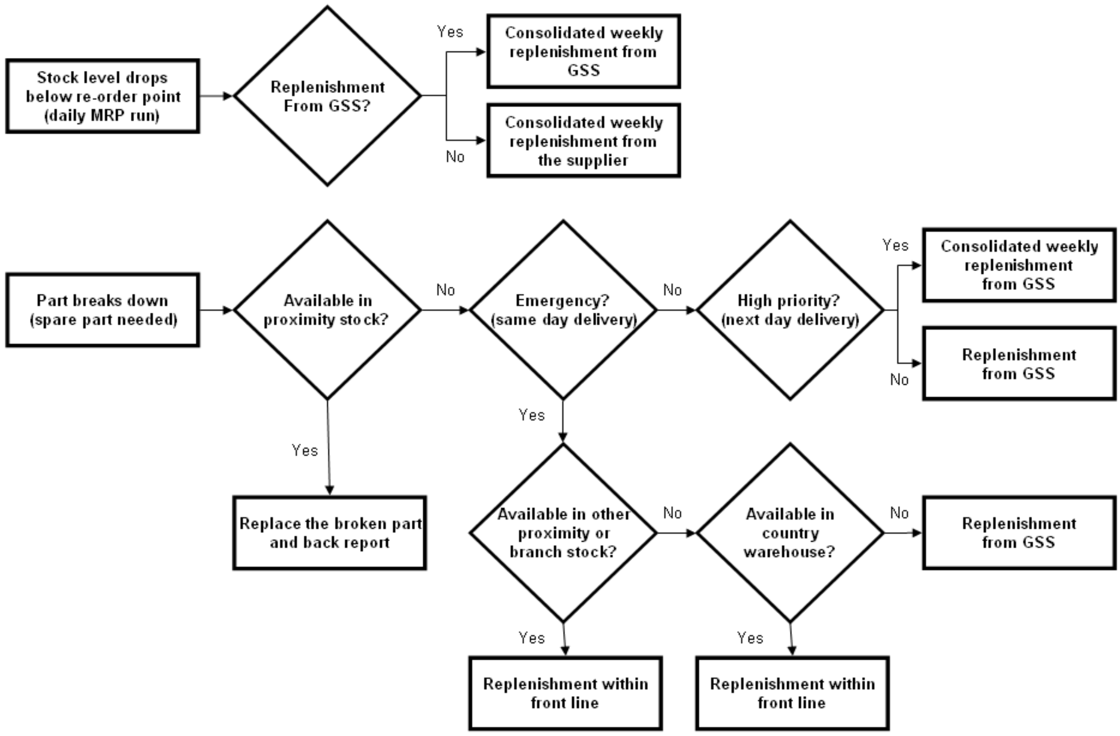

Figure 25 Order type decision process (combined from the official process descriptions)

Front line field technicians have proximity stocks e.g. in their service vans which consist of the most common spares needed in their maintenance area. If the needed spare part is not included in their own inventory, they consider the urgency of the need for the spare part. There are three types of urgencies which affect the way they the order is fulfilled. Urgencies are divided into emergency, which should be delivered during the same day, high priority, which should be delivered the next day and normal priority, which is delivered on a chosen day. These are presented in Table 1.

Table 1 Order fulfillment types by urgency

Urgency	Order type	Inventory	Delivery time
Emergency	Requisition	Nearest possible	Same day
High priority	Requisition	DC	Next day
Normal priority	Requisition	DC	Chosen day
	Replenishment	DC	Chosen day

Depending on the urgency, they either request it within their own front line or from GSS. GSS delivers it either in a consolidated delivery or in an individual delivery. It is delivered from the nearest DC. It should be noticed that some reactive transshipments are supplied the same way as proactive transshipments if spares are not needed to be installed immediately. In some cases even the DC may not have the item on stock. Then it is needed to send the part from another DC or if it’s not available in any DC, order is sent to a supplier. This is the sequence for order fulfillment and it’s presented on Figure 26.

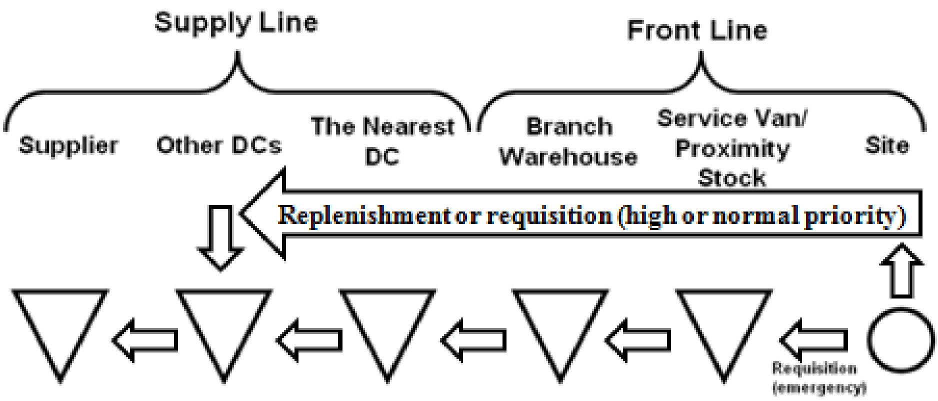

Figure 26 Order fulfillment process

Presented order fulfillment process is for stock items. Non-stock items are either directly sent from a supplier or in some cases consolidated in a distribution center and then sent to the front line. Non-stock items may have a delivery time of weeks or months and the order process is typically more manual because technical services are needed.

4.2.4. Inventory structure

There are three distribution centers in GSS which serve regional business units with branch and proximity stocks. EDC is responsible for Europe, Middle-East & Africa, CDC is responsible for East-Asia & Pacific and CDC is responsible for supplying in China. In addition, there is a fourth distribution center in USA, but it's organized under separate spare parts organization and these two organizations are acting autonomously. Distribution centers under GSS are run by third party companies; Panopa in EDC in Germany and DHL in ADC in Singapore and CDC in China. Panopa is responsible for 3-5 different companies' inventories in EDC, DHL is responsible for about 15-20 in ADC and CDC. Inventories are however managed and owned by GSS. This is shown in Figure 27.

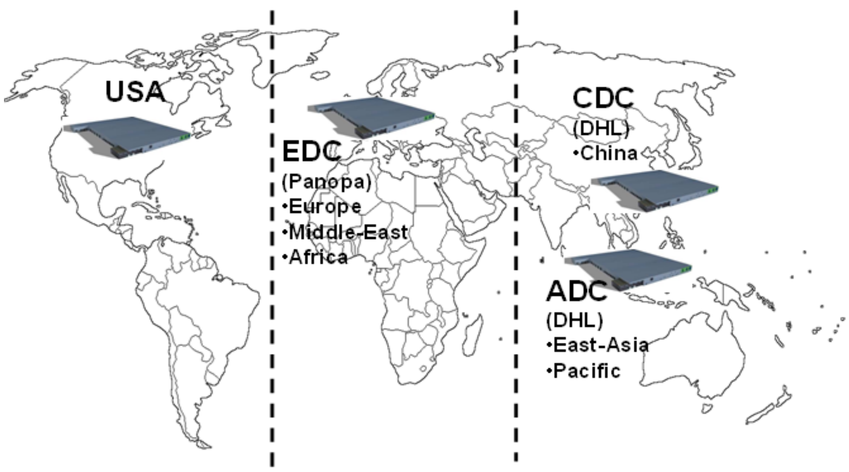

Figure 27 Distribution centers

At the beginning of the interviews, interviewees were asked to draw a picture of the GSS inventory structure and describe it. In practical terms, each of the answers represents a three DC network. Some interviewees added an option for a new DC and some added suppliers and front lines. What was more interesting was the way they described the relationships between the distribution centers. According to the organization policy, each of the DC's is on the same level of hierarchy. However, 7 interviewees said that EDC is considered as the main DC in practice. They explained that this is because of the substantially better abilities to process and supply compared to ADC and CDC. According to the team leader of logistics, invoicing and quality, "EDC is the place of development which sets the standards for the other distribution centers". Process development specialist summed the system "In principle, distribution centers are equal, but in practice EDC is considered to be the main DC".

Interviewees called inventory system as a "triangle" and in the drawings EDC is drawn on the top. All the distribution centers were described independent, though process development specialist revealed that ADC relied heavily on EDC in supplying. Further study proved that there are great differences in terms of inventory levels, value and number of operations between the distribution centers. However, each DC is supplying its local customers and has local suppliers. Distribution centers, their relations and general information about them are presented on Figure 28.

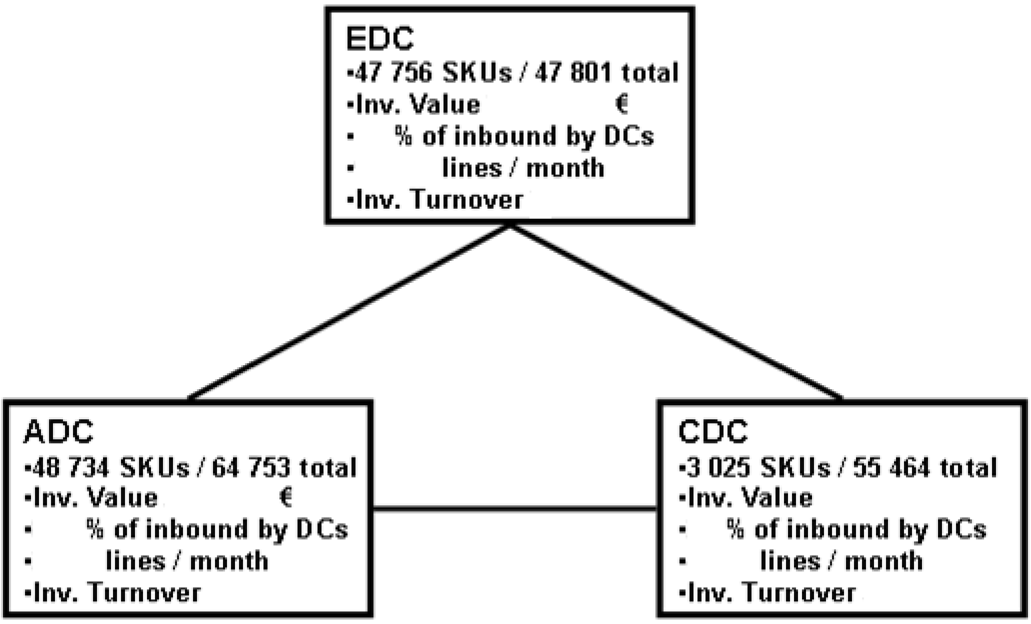

Figure 28 Distribution centers with details

Figures represent the number of stock-keeping units, the total number of all materials, the average inventory value in first five months of 2011, share of inventory balancing movements of total purchases, average number of outbound lines and inventory turnover calculated for a year on the same time period. EDC is clearly the largest DC.

What is interesting is the fact that CDC has superior inventory turnover. According to the interviews, this is due to the fact that inventory levels are kept low and stock transfers often require ordering from the suppliers. It is needed to examine service performance levels to understand possible negative effects of reaching such high turnovers. ADC has the lowest inventory turnover which most likely is related to the lower level of operations performed. Even though ADC has been running its operations for a couple of years longer than CDC it has not been able to build up the needed supplier base on its region.

Front line inventories are managed by the front lines. GSS is providing material master data services to the front lines but does not have possibilities to manage inventory levels. However, tools have been developed to analyze the consumption of the materials to optimize the so called proximity stocks. In future, as new tools are introduced also FL inventory levels are better controlled by GSS but, after all, front lines are responsible for their business and have the last word when it comes to their inventory systems. At the moment, GSS recognizes three echelons in the inventory system. It is possible to divide the system even further, but because of the divergent systems of the front lines, share in three levels is the most definite and universal model. In addition, the more echelons there exist, the more complicated the modeling becomes. Inventory structure is presented on Figure 29.

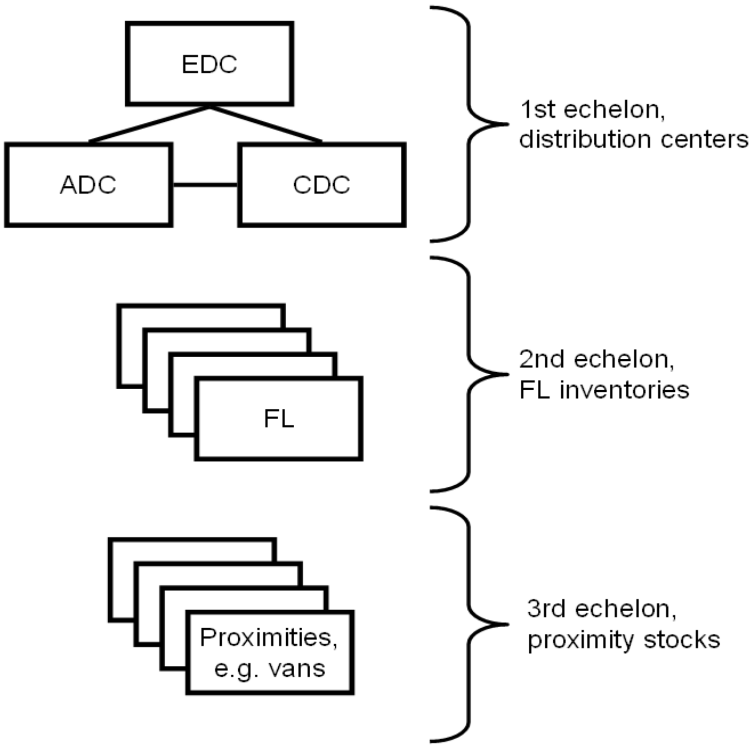

Figure 29 Inventory structure seen by GSS

Inventory structure on Figure 29 is a simple description of the system but reveals the most important steps of the supply chain within KONE. The same kind of structure is shown e.g. on structure model shown on Appendix 2. Because of the divergent natures of the echelons, in terms of inventory management, they are optimized separately. Highest volumes are on the 1st echelon and inventories on it are completely owned by the GSS. Also, ADC and CDC are new, rapidly growing inventories on a market area which is seen as the most promising growth are at the moment. This is the reason why the main interest of GSS is set on the first level of the described inventory system.

4.2.5. Key performance indicators

Since 2006, GSS has grown at fast pace. Sales of 44 M€ have doubled and year 2011 will run very close to 100 M€. In a centralized global spares supply unit profit is not the case as the sales focus on internal customers and the advantage is pursued through centralized processes and purchases. GSS is mainly pursuing growing sales to increase its bargaining power and to lower costs of each transaction. Sales from the three latest years are shown on Figure 30.

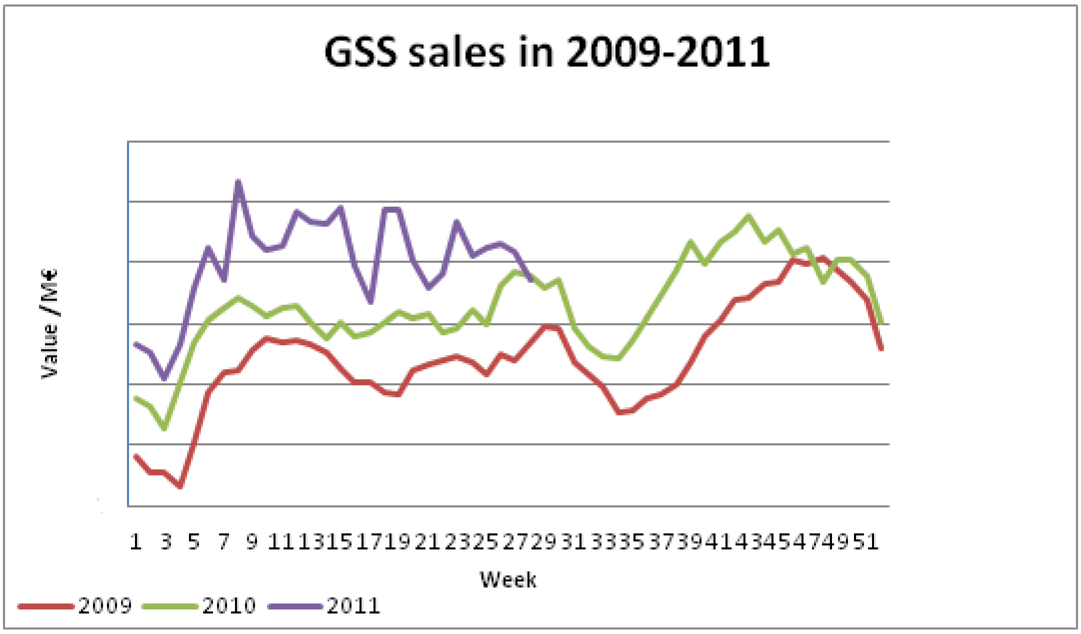

Figure 30 GSS sales 2009-2011

In GSS, each of the eleven teams has its own key performance indicators. KPIs are monitored on weekly basis and used to determine employee bonuses. All the KPIs and target values are presented on Appendix 6. All the meters are given target, exceed and minimum values. There are very general meters that by themselves reflect the performance of the organization but also very specific meters that are roots for the main KPIs. In a relation to inventory pooling improvements, the most important KPIs are those defined as general KPIs and service performance measures of customer service team. General GSS KPIs are

- Net stock rotation

- GSS market share
- Coded material usage

Net stock rotation is the total rotation of the three distribution centers. Market share is the share of total front line purchases. Coded material usage is the share of coded material items per all items being supplied. High stock rotation is related to cost-effectiveness but by lowering the stock levels negligently service performance will suffer which will decrease the market share. Using coded materials decreases process costs and lead time but some customers may prefer or be forced by some reasons to buy with material descriptions and would not buy if it was not possible. Market share is a sum of several factors but it is obvious that all of the three are tied up to each others and strict actions on one KPI may have a negative impact on another. Instead, improvement is done on more specific areas which all summed up improve the performance of the whole organization. In a case of inventory pooling, market share and profitability are best served when the balance between lowest costs and targeted service level are achieved.

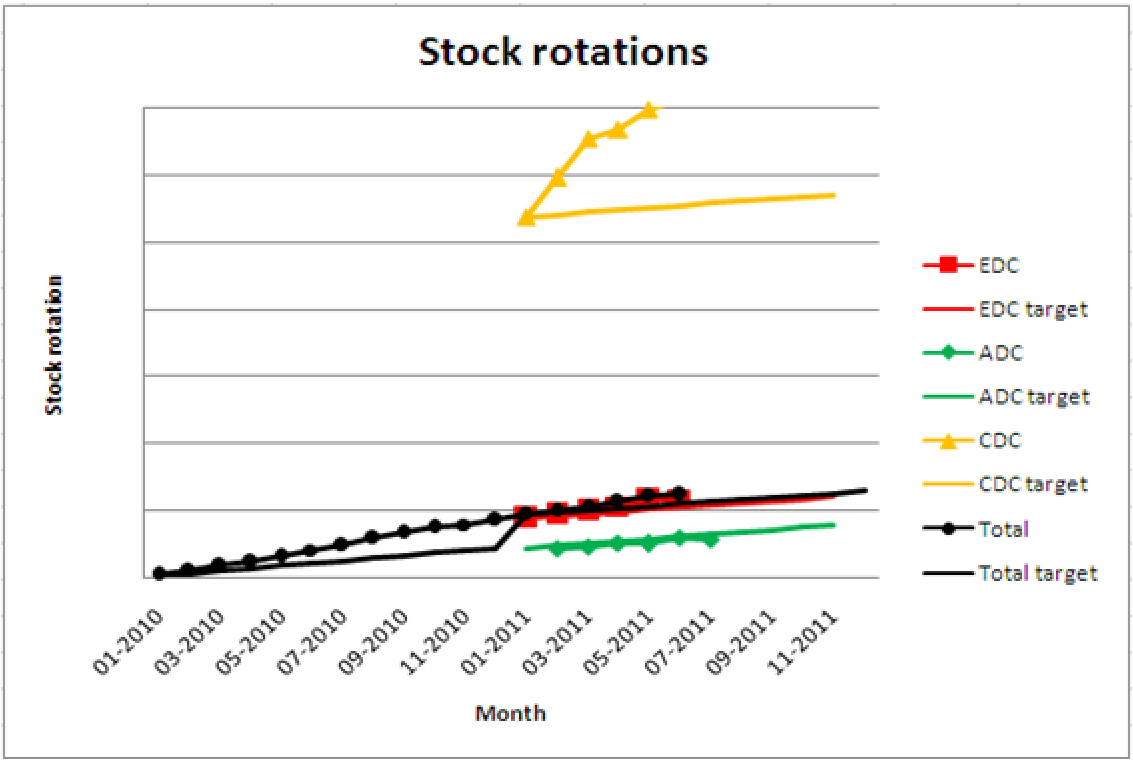

Figure 31 Stock rotation

On Figure 31 stock rotations are presented. Until 2011, stock rotations were monitored only as the total sum of the inventories but now it is being monitored by each DC. Also the target rotations are given for each DC separately. EDC is operating at quite typical cycles and it has been developing firmly. Stock rotation at ADC is not on an adequate level but this is a result of its differing supplier base. What is remarkable, is CDC, which acts at retailer-level rotations. This is due to the nature of being more of a consolidation center than a real buffering inventory. In the interviews it was said that quite often there is no inventory and when large transfers to other DCs are ordered, it purchases from the local suppliers because no sufficient inventories are kept. In total, GSS stock rotations seem to be on a reasonable level, but there are major differences between the DCs which occur due to their diverse roles.

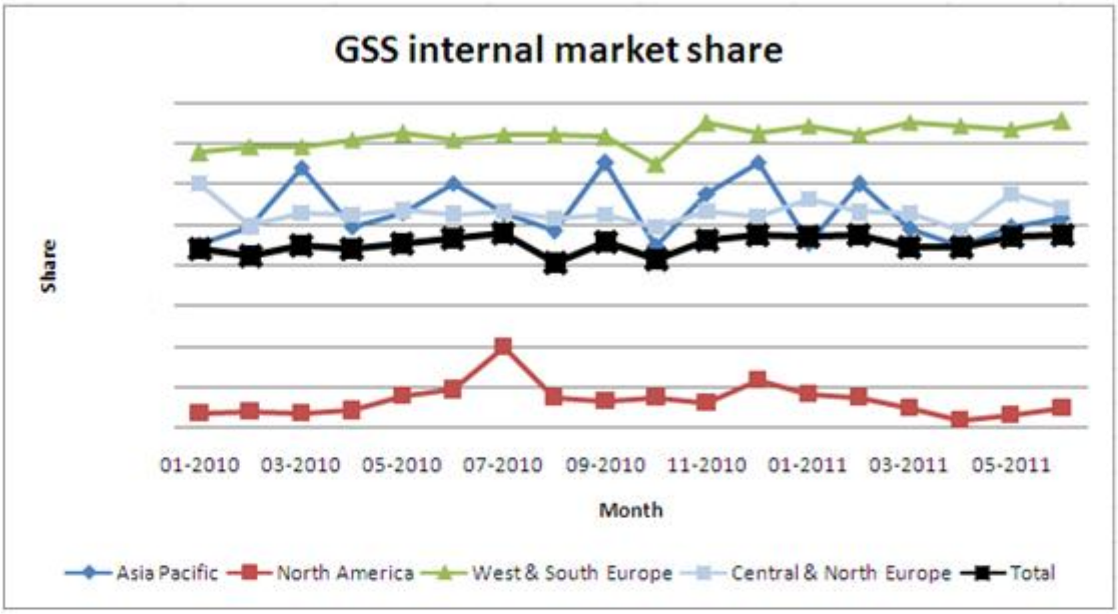

Figure 32 GSS internal market share

Because there are major regional differences between front line maturities, it is needed to examine GSS market share by geographic regions. GSS share of the total front line purchases is presented on Figure 32. Even though the organization is centralized, business units are allowed to buy from the local markets. It can be seen that the share is slightly growing, but the new front lines push the share down. In Europe, the share is high, but in North America, the share is extremely low. However on the focus areas, GSS market share is on reasonable level and growing as the front lines are developing their systems to integrate material codes and master data to be able to take advantage of the centralized supply organization. Coded material usage is presented on Figure 33.

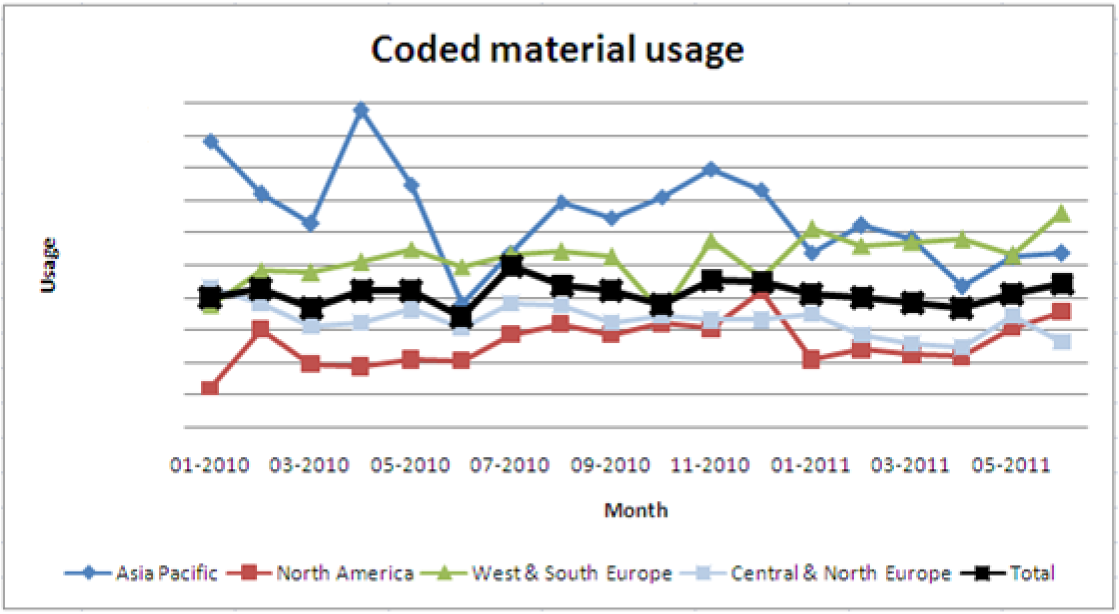

Figure 33 Coded material usage

There is a link between material code usage and GSS market share. The strongest sales area, West & South Europe is the area where material codes are used the most. It can also be seen that as the new front lines especially in Asia start up their operations, GSS figures in Asia drop down. All in all, coded material usage is growing steadily which enables still only decreasing process and material costs as the full advantage of centralized system is taken.

Service performance is measured as the share of deliveries delivered on the calculated date. It includes both the process within GSS and third parties such as logistics. In general, it is the rate on which supply line was able to deliver in time. Service performance of each DC is monitored both in total and separately. Also the target values are set separately. For ADC, the values are the highest, for CDC they are the lowest. High variance in performance is seen also on the target-setting; exceed and minimum values are set to 87,3% and 86,5%. For ADC and CDC this difference is 10%. However, this does not describe the actual state as considerable variance in EDC service performance still exists. Service performance of each DC from the first half of 2011 is presented on Figure 34.

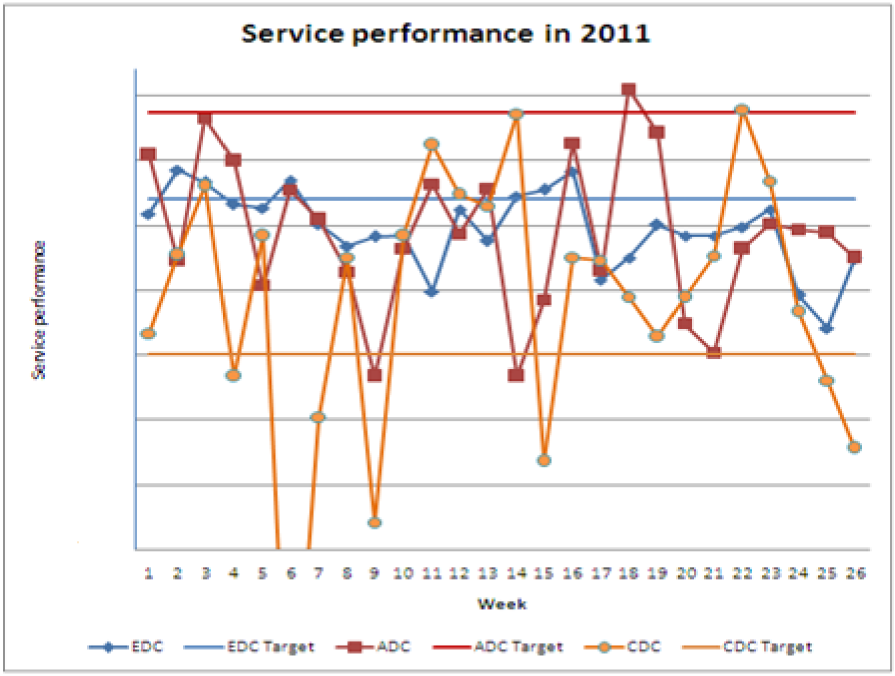

Figure 34 Service performance in 2011

It can be seen that very high variance exists in service performance in Asia. This leads into situations in which it is impossible to promise just-in-time deliveries for the customers and they need to either order in advance or to order from retailers or competitors. EDC is already operating on an adequate level but especially deliveries from CDC do not establish operational or inventory planning. It is obvious that GSS market share suffers. However, both ADC and CDC have been improving their performance continuously during the time they have been operating.

4.3. Inventory balancing analysis

An increasing trend is to make inventory transshipments within an echelon. This is a consequence of seeing all the inventories within an echelon as a single virtual inventory. One of the most important reasons of virtual inventory pooling is the supplier base. Inventory systems are typically considered in echelons. If another inventory is supplying an inventory they are modeled on different echelons. At the moment, inventory balancing in GSS is about the movements between the distribution centers. In general, these processes have not been developed as the focus of the spare parts organization has been on starting the operations in Asia. This can be seen in everyday processes as no standardized instructions or models are being used and employees spend their time on resolving the issues of non-standardized operations. Despite the fact that inventory support and planning processes are highly standardized, inventory balancing is only based on routines. Major improvements could be done just through modeling and standardizing of the processes.

4.3.1. Issues and improvement ideas emerged in the interviews

Interviews were used to look deeper into the matter, to discover issues related to everyday processes and to scan possibilities of improvement. Questions asked on the first round focused on GSS inventory structure, issues in lateral transshipments, products causing issues and improvement ideas. Questions about GSS inventory structure and improvement ideas were exactly the same on the second round so they are combined and presented on the same figures. Identical themes were repeated but varying tasks of the interviewees can clearly be seen on the richness of the given answers.

General issues in lateral transshipments focused mainly on the issues of China. China's customs were seen as a real challenge as it typically takes about one week in the customs if everything is on correct form. Any scarcity, e.g. in documents, will result in additional delays. This was highly underlined by all the interviewees. There are also major issues when it comes to quality. Both the products and the packages are not on the required level, according to the person responsible for logistics. This has lead to use of air transports as emergency transshipments are needed. Both CDC and ADC are still based on very manual processes and lateral transshipments require lots of manual work e.g. in consolidation. On the system side, the difference of production systems also consumes resources as EDC and ADC are in different system in SAP than CDC, which was mentioned by the interviewees attending process and system development.

More task specific issues are mostly results of problems in Asia. Almost half of the interviewees mentioned that some specific items supplied from China or Asia altogether cause remarkable challenges on service performance. Inventory pooling is seen difficult by the inventory planners as information about availability from the suppliers is not on adequate level to support inventory planning.

Lacks of information extend to somewhat all the areas of stock levels, lead times and availability. This has then resulted in a stack of issues that concern all the functions of the organization. Purchaser responsible for the consolidations highlights the problems of the insufficient information. Some mention forecasting methods which do not cover e.g. customer sales campaigns and make consumption analysis impossible added to physical limitations of some items that need to be transported by sea for three months even though they are considered as emergency transshipments. Team leader logistics, invoicing and quality even says that "At the moment, no systematic stock transfers are done". Products causing the problems are well known; escalator spare parts, especially tall profiles. Other products that cause problems in all of the distribution centers are electronics, such as circuit boards that are classified as key parts. In short, according to the interviewees the most important issues related to stock transfers at the moment are:

- Long and varying lead times from China and Asia

- Quality issues of products and their packages
- Insufficient information in terms of inventory pooling
- Lack of coordination

These issues were mentioned almost in all of the interviews and also verified in further analyses. Development ideas concentrate particularly on stock transfers. Team leader inventory support and planning sees that to become more cost effective it is needed to standardize the actions with given models and calculations for appropriate cycles of replenishments and to improve visibility between the inventories. Most of the answers focus on these same ideas and provide ideas where to find cost savings. ADC is named to waste resources on air transports and it is said that it is needed to get rid of emergency transshipments between proactive replenishments. What connects the answers is the need to find standardized ways of working and principles whether a product should be supplied from Europe, China or both. Team leader customer service requests for “Responsible persons for periodic tasks”.

When the interviewees were asked to name changes that will, or should be performed, a wide range of answers were given. Some of the answers stated that all the inventories need to be included into the same planning system and checkups will need to be automatic. It was also said that stock transfers should be added in a reasonable pace. Tools to evaluate variations in demand caused by seasonal factors or campaigns were requested and possibilities to evaluate consumption through their life cycle. Physical characteristics were also requested to make it possible to plan transshipments. In general, interviewees saw improvement possibilities in

- Inventories under one planning system
- Automatic stock transfer process
- Planning tools to extend forecast from statistical information to signals from the field and product life-cycles
- Physical characteristics from EDMS to SAP
- Introducing total cost models

At the end of the interview, interviewees were asked if there was anything else they wanted to add. One very important question emerged twice; if a supplier is decided to be moved to other continent, is it really known what are the actual consequences and costs? There are issues in processes, quality, availability and extremely long lead times with reduced agility but their costs are not known. What was surprising was the fact that customers, whose default distribution center has faced a stock-out, are not able to check if there was stock left on another DC. The only way to do this is to ask from GSS customer service officer who has limited access to stock levels in CDC and most of the front line personnel do not even consider this possibility.

In total, issues related to stock transfers can be said to result from the difficulties of the set up of the new distribution centers in Asia. Operations have faced several unexpected difficulties because of a strategic movement implemented with a high pace. As a result of this, all the interviewees are aware of the issues in transshipments and have faced issues related to lateral transshipments in their work tasks. Lateral transshipments have become more and more important and it seems that tools and methods have not yet been developed to serve fluent and effective processes.

4.3.2. Current lateral transshipment flows

According to GSS policies, all the distribution centers are regarded to be on the same level, but as it can be seen, most of the inbound of ADC is formed by the EDC and on the other hand, CDC is supplying EDC. In such cases, another echelon should be considered. Another way of viewing the system is to set up hierarchies within an echelon. If no suppliers within the range of wanted costs or quality are available at the region, lateral transshipments are needed. In GSS, there are lateral transshipments between all distribution centers but the most important material flows can be easily separated so that the number of remarkable one-direction connections is limited to two. Figure 35 presents the lateral transshipments between the three distribution centers.

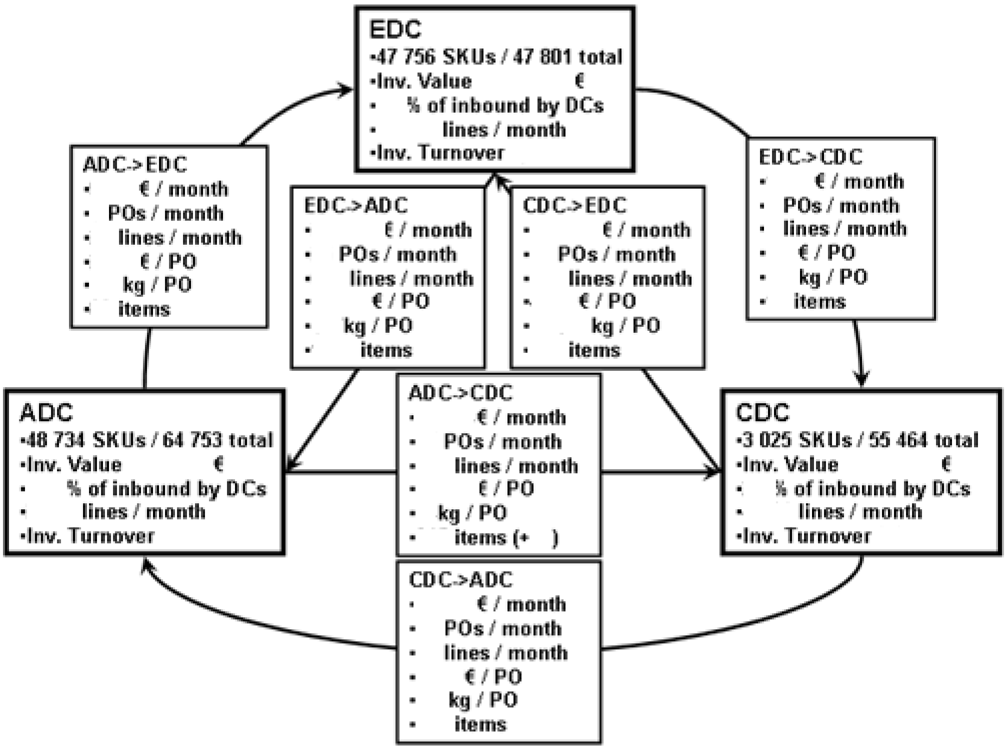

Figure 35 Lateral transshipments between DCs

Information was gathered from the SAP from the beginning of the year 2011 to the end of May which should ignore startup activities in CDC and be long enough to reveal normal operations and material flows. First, the average value of the transshipments in a month and the number of purchase orders is presented. Then, the average value and weight are calculated. Lastly, there is the number of the different materials that have been sent. Weight of an average PO is calculated for determining the possibilities for transshipments, whether it is possible to use air, rail, road or water transshipments. The roles of the distribution centers in relation to each other and the role of consolidations can easily be seen. The most important findings of the information presented on Figure 35 are

1) CDC is acting as a supplier for the others
2) EDC is greatly supplying ADC
3) Only purchases from EDC to ADC seem to be highly consolidated
4) Only purchases from EDC to CDC seem occasional
5) There is a possibility for crossing material flows

Stock transfers are consolidated by a single purchaser in China. All the movements are consolidated, except for the transfers from EDC to CDC and ADC to CDC which are seen by the purchaser as normal shipments. At the moment, transfer frequencies are not based on mathematical models or any other calculations, but are they simply sent as a consolidated transshipment every week. Neither is the transportation type based on any model or other mathematical methods. Periodic routines of the purchaser responsible for consolidations are presented on Table 2.

Table 2 Lateral transshipment consolidation

Direction	Delivery sent	Transportation	POs created	Delivery requested	Other
EDC-->CDC	Doesn't belong to stock transfer, it is a normal shipment				
EDC-->ADC	Every Monday	air	Every Monday	Next Monday	Line value > 40 EUR
CDC-->EDC	Every Tuesday	air or sea	Every Friday	Next Month	
CDC-->ADC	Every Tuesday	air or sea	Every Friday	Next Month	
ADC-->EDC	Every Friday	air	Every Friday	Next Friday	Line value > 20 EUR
ADC-->CDC	Doesn't belong to stock transfer, it is a normal shipment				

Differences between the directions in value and size make it obvious that same basis for each of the directions is not reasonable. Also, transshipments from ADC to CDC are not part of the stock transfer processes even though they are almost double the size of the transshipments from ADC to EDC. Because the supplier base of ADC is extremely narrow and EDC is acting as the major supplier, in addition to CDC, it seems pointless that such a lot of purchases are still being transshipped from ADC to EDC. Also the transportation types, whether to use air or sea transports, seems unreasonable as all the transports between EDC and ADC are done using air transports.

Lead times were also analyzed. Lead time is the time from request confirmation to actual delivery and it consists of lengths of different phases. These include consolidation time, operations in the inventory, customs in the sending country, delivery, customs in the receiving country and delivery to the receiver. As there are known to exist variations in some of the phases, deliveries were tracked. Tracking of the orders required special requisitions but at least two cases were used to evaluate each transshipment type on each direction. At the moment, there are two possibilities of transshipping the goods, either by an airplane or a ship. Both types were tracked and analyzed. Lead times are presented on Table 3.

Table 3 Lead times for typical lateral transshipments

		Lead time	
		Air	Ocean
Direction	EDC-ADC	10	30
	CDC-EDC	10	40
	ADC-CDC	10	20

Presented lead times are for normal transshipments and are based on tracking three shipments. In case of real emergencies it is possible to cut down the lead time by a couple of days. Process time and customs stretch air delivery lead times even though the actual delivery is about 2-3 days. When it comes to ocean deliveries, the effect of this issue is not relatively that important. There are some materials that, however, will need to be delivered only using either air or ocean transport. This is related to the concern of material characteristics in ERP system. At the moment, the ERP system used does not directly enable viewing of the characteristics that affect logistics such as weight or length.

4.3.3. Classification of the current inventory pooling system

Paterson et al. (2009) divide existing models of lateral transshipments by their ordering and inventory system related characteristics. These characteristics are categorized into three groups: system, ordering and transshipment related characteristics. System related characteristics include the number of items being planned, echelons and locations in the inventory system, whether they are considered identical in terms of operating and costs and how the unsatisfied demand is considered. Ordering related characteristics include timing of regular orders, whether the orders are reviewed periodically or continuously, and the order policy. Based on the classification, characteristics of the current ordering system are presented on Table 4.

Table 4 Classification of the current inventory pooling system in inventory balancing

	Characteristics	
System	No. Items	Multi
	No. Echelons	1
	No. Locations	3
	Identical depots?	Yes (not in costs)
	Unsatisfied demand	Backorder
Ordering	Timing	Contin. (per. cons.)
	Order policy	(R, Q)
Transshipments	Transshipment type	Pro- & reactive
	Pooling	Partial
	Decision-making	Centralized
	Transshipment costs	Per transshipment

In the case organization, each item is being planned individually in terms of inventory position. In the case company, there are several echelons possible to consider, but inside GSS there is only one level and three locations. These three locations are similar in principle, but in practice, there are differences in their roles, and their costs need to be reviewed separately. Unsatisfied demand is considered as backorder. Lost sales are understood but not considered essential and they are found too difficult to evaluate. Each item has a re-order point and re-orders quantity, i.e. order policy is (R, Q).

Both proactive and reactive lateral transshipments are possible. Proactive transshipments are always sent on weekly basis but reactive transshipments can be delivered immediately. Partial pooling is applied as it is not possible to order inventories to zero, as only half of the existing inventory levels are provided for lateral transshipments. Decision-making is centralized but as the inventories of the front lines are not managed by the case organization, on the wider extent decision-making may be seen decentralized. Transshipment costs are allocated per transshipments as major differences in terms of item and order characteristics exist that make it difficult to evaluate the cost of the individual orders and items.

4.3.4. Items being balanced

To understand what items are being balanced between the inventories, KONE item group classification is used. In interviews there were mentions that the products being supplied may not completely be considered and some balancing operations may lead into situations in which balanced items are later sent back to the supplying inventory. ADC was mentioned to possibly have this kind of issues. On the other hand, some categories may not be reasonable to send to another continent if it is possible to source them locally. On Table 5, all the transfers during 1.1.-31.5.2011 have been analyzed and item category shares by total items are then calculated.

Table 5 Material groups being stock transferred

	Group shares in value						Scope & scale	
Direction	KP	GP	SP	CP	No Cat.	No code	Items	€ / month
EDC->ADC	43,83 %	17,00 %	5,38 %	27,73 %	0,10 %	0,00 %		€
EDC->CDC	35,77 %	3,13 %	0,00 %	39,48 %	21,62 %	0,00 %		€
CDC->EDC	33,85 %	14,30 %	38,12 %	6,87 %	6,86 %	0,00 %		€
CDC->ADC	23,36 %	11,13 %	41,89 %	17,46 %	6,16 %	0,00 %		€
ADC->EDC	85,68 %	2,09 %	2,95 %	6,21 %	3,07 %	0,00 %		€
ADC->CDC	48,86 %	27,56 %	8,57 %	12,65 %	1,21 %	1,16 %		€

Materials are being classified into groups by their uniqueness. Only KP or GP parts are the kind that may not be able to be supplied regionally. Transfers to other continents are expensive, generate risks and possess several issues. In addition, because of extremely long lead times, other groups should be sent only in reasonable cases. It can be seen that majority of the transshipments consist of key parts but also standard and commercial parts are being sent to a significant extent. There are obviously item flows that could be rationalized but the most important flow in value, from EDC to ADC, seems deliberate. CDC seems to be supplying standard parts which can be justified because of the purchase price cost reductions. However, as pointed out in the interviews, total costs should be considered, as quality issues are known to cause both increase of the costs and to reduce service performance. Items with no code only have negligible significance.

Table 6 Count and value of items moving to both directions

		To		
		ADC	EDC	CDC
From	ADC	X	10 items 2 262€ / month	1 item 10 781€ / month
	EDC	10 items 5 179€ / month	X	0 items 0€ / month
	CDC	1 item 381 € / month	0 items 0€ / month	X

To examine whether there were items being transferred back to the supplying DC, shipped items to a direction were compared to the opposite direction shipments. First five months of year 2011 were examined and some suspected cases were found. Intersecting transshipments are presented on Table 6. Stock transfers to intersecting directions are emergency transshipments that result from inappropriate inventory planning. Transshipments between ADC and EDC occur in volumes that are formed by more than just single cases. This study does not reveal if these shipments include occasions in which the individual items that were sent to another DC are being sent back, but as that arose in the discussions and some items are clearly been sent to both directions, it seems likely to happen. Anyhow, frequent intersecting stock transfers are a waste of resources.

4.3.5. Considered costs

In the case company, supply chain costs are not considered on detailed transshipment level. It is done only on material item and order line level by dividing the total costs by the number of items or order lines. However, it is needed to separate purchasing costs, inventory carrying costs and delivery costs. Delivery costs are relatively easy to evaluate as they consist of freight, tariff and tax costs. Cost of backorders or lost sales should also be included. Freight costs are reported only on average level, not separating different transportation methods. This is partially due to the fact that freight fees are negotiated on corporation level with the third party providers such as Schenker, CEMA, DHL and UPS. Tariffs and taxes are normally monitored precisely. Some actions are ongoing at the moment to cut these costs down, e.g. by electronic customs and certified suppliers. To find out the exact values for the transshipments it is needed to compare route specific contracts and track individual transshipments. Inbound and outbound costs are also easy to evaluate by each distribution center.

Determining the exact inventory carrying cost with exact class separation as presented in the literature is difficult. Capital costs are given in corporate budget instruction and for the year 2011 the capital cost is 5%. Inventory service costs are monitored separately on each distribution center. As third parties are responsible for the operations without owning or managing the inventories, the cost they invoice from the case company does not include all the inventory carrying costs. However, on the scope of the studies it is not needed to take into account all the possible costs such as obsolescence because of the nature of the materials being transshipped. According to KONE policies, a material is considered to have obsolescence costs if it is being kept in stock for more than two years. The cost analyses should provide information needed to compare different options related to lateral transshipments which at the current state of the case company do not yet require exact values as its more about comparing different methods or practices instead of inventory position values. Inventory carrying cost can be determined using capital costs, inbound, storage and outbound costs.

Purchasing costs in lateral transshipments are not significant as they only require 2-3 hours a week which makes these costs relatively low. Consolidation work by the responsible purchaser is the only varying cost as purchases will need to be done in any option, and they will demand weekly consideration in any case. In case of transshipments from EDC to ADC some urgent deliveries will be sent anyway. Because of this, purchase costs are not considered in the following analyses.

If the demand is not met, costs will occur. This was one of the topics in the interviews. According to the business controller of the organization, these costs are not monitored or any other way evaluated. Interviewees considered these costs as backorder costs as it is the most important materials cannot be ordered from any other retailer. According to the process owner, a process cost of at least 100€ will occur if a front line will need to purchase the material by itself. The backorder cost in the case company is about the cost of 3-4 working hours added to the increased freight costs. On some occasions a penalty fee may occur which makes the cost extremely high. In such occasions, it is reasoned to arrange the delivery at any costs.

Table 7 Considered costs related to lateral transshipments

Costs	
Inventory carrying costs	Capital cost
	Inbound
	Storage
	Outbound
Delivery costs	Capital cost
	Freight
	Tariff & tax
Backorder cost	Process cost
	Freight
	Penalty fee

Considered costs are presented on Table 7. Inventory carrying costs can be determined by using the costs invoiced by third party actors in addition to capital costs. Delivery costs include freight, tariffs and taxes. Capital cost should also be considered because of the long lead times. Backorder costs of the process, added freight costs and possible penalties are reviewed to provide better understanding of the cost of not meeting the demand.

4.4. Evaluation of the issues

In the interviews, several issues emerged. Most of them were related to inconveniences in Asian distribution centers. This seems to be a result for the fast pace strategic shift which has not yet been followed by appropriate development in processes. For the case company, it has been more important to set up the operations following the geographical shift in demand and supply markets. Because of this, lead times have stretched, quality issues increased and incompatibilities in information systems appeared. This has decreased the customer satisfaction and increased unexpected costs. Even though it has been possible to cut down the purchasing prices, it is not known what the impacts on total costs are.

Continuous proactive intercontinental lateral transshipments should only be considered for materials that are of high value and cannot be sourced locally. In other words, these flows should consist of key and general parts. In some occasions it may be profitable to transship standard parts laterally but in such occasions total costs should be considered to take into account e.g. the consequences of probable increases in quality issues. It is obvious that transshipping commercial parts from Europe to Asia using air transports is a waste of resources. And the case organization has not been able to reach its strategic targets of expanding its supplier markets in Asia. According to Asian operations manager, the current situation is a result of applying single sourcing strategy that focuses sourcing to large suppliers in Europe.

At the moment, negative effects are only considered as wasted resources on transportation logistics and loss of customer satisfaction. More accurate analysis do not exist, however – as noticed in the literature – there are several fields that are affected by unplanned inventory management. Take for example the inventory turnover in CDC, which at a quick look is exemplary, but is in fact only a consolidation center because of tense Chinese foreign trade policies. Inventory turnover of 9 is a result of warehousing items for 5 weeks which is extremely satisfying when compared to EDC where items are warehoused for about 15 weeks. After some analysis, these figures no more look the same. In fact, lead time of eight weeks results on at least doubling the warehousing time which splits the inventory turnover into half. Costs of lost sales are not considered by any indicators. As long lead times will most likely also decrease the service performance, the benefits of lateral transshipments are likely to lose some of their significance.

Situation in transshipments from EDC to ADC is interesting. ADC has inventory turnover of only about three even though EDC is supplying it with air deliveries. If these transshipments are done using ocean deliveries, inventory turnover will drop even lower. In such occasions, sophisticated planning tools need to be considered to ensure sufficient service performance. It is obvious that standard and commercial parts can be sourced locally and it may even cut down the lead times of certain common parts. Driver that is even more important in this case is the long-term strategic goal of moving suppliers to Asia which is promoted if the organization applies local sourcing in Asia. There are also global actors that have regional branches with local production which makes it possible to focus sourcing without the need for long-lasting expensive transshipments.

This study is limited to inventory management regarded to lateral transshipments. At the moment, the most significant issues related to lateral transshipments are those related to transshipments from EDC to ADC. Due to the high volumes, low performance indicator rates and strategic targets, this direction is chosen for further studies. Possibilities of rearranging the transshipment methods and local sourcing are evaluated in terms of impacts on costs and service performance.

4.5. Establishing transshipments between European and Asian distribution centers

To take advantage of the lateral transshipments it is needed to understand the material flow and its requirements for the processes. Classification of the items based on the uniqueness and availability is extremely suitable for the analysis needed. Cost information about the transshipment types, process costs, inventory holding costs and local purchase prices is needed in addition to lead times and possible other consequences to compare the possible options. This requires combining data from ERP system, third party logistics providers and strategic sourcing. Because of the required manual work by the parties and lack of existing data, some analyses are done only for some representative materials.

4.5.1. Current material flow

In logistics there are several factors that affect the transportation type. In this study, these factors are limited to availability of suppliers, value and weight. At the moment, transshipments are performed on weekly basis and using air transportations. However, some ocean transshipments have already been sent in testing purposes. Weekly average values of the transshipments in 1.1.2011-31.5.2011 are presented on Table 8. Average weight and value are calculated per order line. Total weight and value are calculated as total weekly averages, i.e. how much is sent at the moment.

Table 8 Weekly transshipments from EDC to ADC in 2011

	Weekly values			
Group	Order lines	Tot. weight/kg	Tot. value/€	Value/weight
KP				35
GP				48
SP				29
CP				20
No Cat.				39
Total				30

It can be seen that KP and GP groups form about 61% of the value delivered with about 48% of the total weight. In weight, CP group is the largest. When air transportation is used, pricing is based on weight which favors the lightest and most expensive groups. By dividing the value of the material group by its weight it can be seen that general parts are the most valuable ones and commercial parts the least expensive. This fact favors ocean transportation with commercial parts. However, no extreme differences exist between the item category groups. When reviewing the material flow in weekly totals, the weight and the value of the materials are significant and it seems possible to even consider complete containers on weekly or every second week basis. Even though the analysis does not reveal any other physical characteristics it is known that some longer materials are being delivered from Europe to Singapore. This is one fact added to the others that favors the use of ocean transportation.

However, the classification method does have some exceptions. Even though it is impossible to find exact numbers of exceptions in each category, it is possible to evaluate the remarkable amount of e.g. commercial parts that cannot be sourced locally.

These exceptions arise from the reason that they have been further processed or modified, contract with the supplier prevents any other sourcing, or they are components used in competitor equipment. Because of this, it cannot be assumed that all the CPs, let alone SPs, could be sourced locally as there are hundreds of different materials being balanced. Though, sourcing category manager of spare parts disclosed that it is possible to source some KP or GP group parts from Asia. He also underlined that according to their analyses, sourcing savings in Asia are only obtained in China. As a result of this, supplier base is built to China, supplies supplied locally to CDC and transshipped laterally to other distribution centers.

4.5.2. Sourcing possibilities in Asia

In contrary to lateral transshipments, a possibility of sourcing of some materials in Asia was also studied. Materials that were being transshipped from EDC to ADC were sorted by their value by each category. Ten most valuable transshipments were given for the strategic sourcing team to be analyzed, whether they could be sourced in Asia and for what cost. Identification was based on the identification number used in the company, free text descriptions and supplier information. In this analysis, only existing suppliers were used as there is great uncertainty on standardization state of the parts and quality which make it extremely difficult to compare the total cost of the parts. Given prices are based on current contracts.

Table 9 Key part sourcing availability and price comparison in Europe and Asia

Key parts	Supplier in Asia	Total value	Price in Asia
Material KP1	Yes	€	+83,21 %
Material KP2	Yes	€	+84,15 %
Material KP3	Yes	€	+70,77 %
Material KP4	No	€	-
Material KP5	Yes	€	+129,99 %
Material KP6	Yes	€	-
Material KP7	Yes	€	+71,96 %
Material KP8	No	€	-
Material KP9	No	€	-
Material KP10	Yes	€	+92,12 %

On Table 9 there are price comparisons for key parts. Total value stands for the average monthly value that is being delivered from EDC to ADC at the moment. As assumed earlier, availability is low and because of being provided by third party providers, prices are extremely high. For the chosen 10 most important materials by total value, no straight contracts with manufacturers occur at the moment in Asia. It seems rational to remain sourcing these materials from Europe. There were only three materials in top 30 materials by value which had a straight contract with a manufacturer in China. This underlines the fact that the case company has its roots on Europe and the most important parts are still being developed and produced with trusted manufacturers.

Table 10 General part sourcing availability and price comparison in Europe and Asia

General parts	Supplier in Asia	Total value	Price in Asia
Material GP1	Yes	€	+66,42 %
Material GP2	Yes	€	+3,12 %
Material GP3	No	€	-
Material GP4	No	€	-
Material GP5	Yes	€	+90,27 %
Material GP6	Yes	€	+94,70 %
Material GP7	Yes	€	+81,21 %
Material GP8	Yes	€	+89,14 %
Material GP9	Yes	€	+227,01 %
Material GP10	Yes	€	+84,45 %

General parts are categorized closely to key parts. Table 10 presents general part availability and price comparisons between Europe and Asia. As for the key parts, no straight contracts with manufacturers exist at the moment. Availability is better, but only one material seems reasonable to be sourced from the local provider. There is not a single Asian supplier for the top 30 materials at the moment. On top 50, there are seven materials that have direct contract with Chinese manufacturer, but these materials represent only a minor part of the total value and it is likely that sourcing costs for such items become relatively high.

Standard parts differ from the previous categories. Materials categorized as standard parts, such as batteries, motor units, connectors and capacitors, are being manufactured in Asia. Prices are significantly lower for most of the materials compared to those of key or general parts. However, the company could use even more Asian manufacturers – e.g. the most valuable material in total is a simple battery, but there is only an expensive third party provider for it at the moment. Sourcing availability and price comparison for standard parts is presented on Table 11. Prices are marked with "+" if they are higher in Asia and "-" if lower.

Table 11 Standard part sourcing availability and price comparison in Europe and Asia

Standard parts	Supplier in Asia	Total value	Price in Asia
Material SP1	Yes	€	+71,22 %
Material SP2	Yes	€	+24,71 %
Material SP3	Yes	€	+35,46 %
Material SP4	Yes	€	+36,27 %
Material SP5	No	€	-
Material SP6	No	€	-
Material SP7	Yes	€	+126,14 %
Material SP8	Yes	€	-50,81 %
Material SP9	Yes	€	+188,15 %
Material SP10	Yes	€	+5,00 %

Because of their classification criteria, commercial parts should provide substantial savings when comparing sourcing prices between Europe and Asia. Table 12 presents sourcing availability and price comparison for standard parts. Surprisingly, also the commercial parts seem expensive by their sourcing prices in Asia. On top 30 materials there are only seven direct contracts with Chinese manufacturers. It is obvious that having a Chinese manufacturer does not provide any savings in sourcing prices with the current suppliers.

Table 12 Commercial part sourcing availability and price comparison in Europe and Asia

Commercial parts	Supplier in Asia	Total value	Price in Asia
Material SP1	Yes	€	+33,27 %
Material SP2	Yes	€	+33,13 %
Material SP3	Yes	€	-9,07 %
Material SP4	Yes	€	+33,02 %
Material SP5	Yes	€	+92,26 %
Material SP6	Yes	€	+37,62 %
Material SP7	Yes	€	+14,08 %
Material SP8	Yes	€	+26,64 %
Material SP9	Yes	€	+30,89 %
Material SP10	Yes	€	+67,89 %

On total, current supplier network in Asia is extremely narrow and the company is not able to benefit from the local manufacturers' lower price level. Even though the company has set its strategic goals on shifting its supplier base to Asia, a lot has to be done before there is an independent supplier network in Asia even in parts that are considered as standard or commercial parts. However, even though the sourcing prices are high, the total costs that cover the whole process from the supplier to the customer to compare the two possibilities needs to be considered.

4.5.3. Transshipment cost analysis

To make it possible to compare different options, it is needed to analyze the costs of the transshipments. Transshipment costs consist of inventory carrying costs, delivery costs and process costs. As there are little to no differences in process costs between the options, it is not considered in this analysis. In addition to transshipment costs, the backorder cost is also considered to evaluate the costs of low service performance. Inventory carrying cost is based on actual invoices by the third parties in 2011. The given inventory cost consists of all but capital and obsolescence cost. For the capital cost the official WACC of the company is used with the actual inventory values and turnovers. Obsolescence cost is ignored as all the items that are being transshipped are actively moving materials. Inventory carrying costs by each DC are presented on Table 13.

Table 13 Inventory carrying costs

DC	Invoiced inv. costs	WACC	Inv. carr. cost / line
ADC	€	€	€
CDC	€	€	€
EDC	€	€	€

Inventory carrying costs in ADC are substantially higher than the costs in the other DCs. In addition to the high invoiced inventory costs, the low inventory turnover is seen in the capital costs. Because of the low level of inventories and low level of labor costs, CDC has the lowest inventory carrying costs. Despite the high level of automation, EDC is visibly more expensive than CDC in terms of the inventory carrying costs.

Delivery costs consist of freight and tariff costs. Taxes are typically paid for both the transshipment value and freight costs but in case of Singapore, taxes are not needed to be considered because of the MES status. Tariffs are managed by third party logistics partner CEVA. Ocean delivery is performed using full 20 feet container which is not priced by weight but is just a fixed container cost. It is possible to reserve only a part of the container which lowers the costs but may have some operational disadvantages. Air transfer costs are invoiced based on the weight of the freight. Air transfer has a minimum cost limit which makes single line deliveries expensive. Delivery costs determined in contracts with the third party logistics providers from EDC to ADC and from CDC to ADC are presented on Table 14.

Table 14 Delivery costs

	EDC->ADC		CDC->ADC	
	Air	Ocean	Air	Ocean
Capital cost	5 %	5 %	5 %	5 %
Freight	15€+1,55€*KG	961,49 €	22,89€+1,67€*KG	620,14 €
Tariff	5,74€+0,11€*KG	238,73 €	5,74€+0,11€*KG	238,73 €

Delivery costs from CDC to ADC are studied to make it possible to compare locally sourced materials from China. It is obvious that high volumes are needed to make it possible to make ocean transfers cost effective. To further evaluate the costs, it is needed to use two varying cost factors: the net value and weight of the materials. To do this, average weight and average value are used. This determines the delivery method that is recommended for the given volume. On Figure 37 there are presented weekly air and ocean delivery cost figures from EDC to ADC.

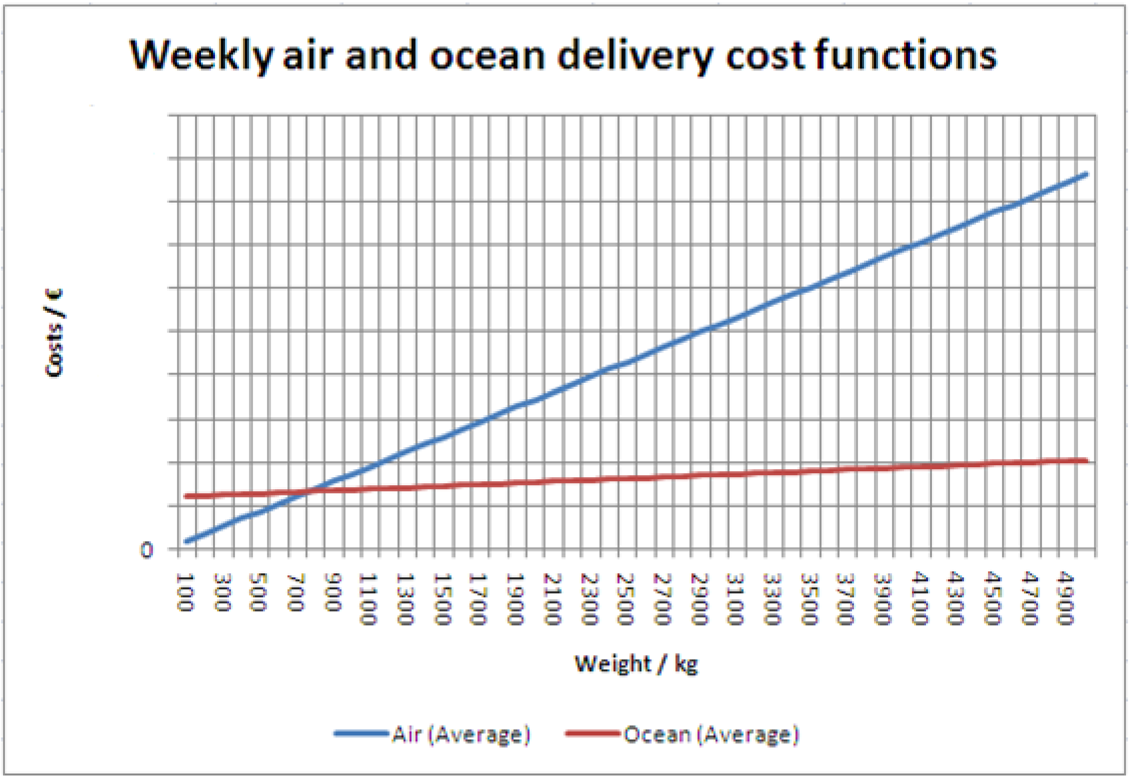

Figure 36 Weekly air and ocean delivery cost functions

When reviewing delivery costs, intersection point of the curves settles on an average weight of 700kg. Savings increase linearly as the net weight increases. It seems likely that even with very low volume, regular ocean deliveries provide substantial savings in transshipment costs. However, there is a big difference in lead times between air and ocean deliveries.

4.5.4. Costs of backorders

Backorders include working efforts by several teams. In addition to normally processed orders, backorders require increased controlling. The most critical, such as contracts with penalty fees of about 10 000€, involve an expeditor to control the process. There are on-going backorders every day and critical orders are estimated to require about 4,5 working hours each. This evaluation was based on calculations with the customer service team leader and expeditor. If the order is on an extremely critical location, such as an airport, the time will ever increase.

To calculate the backorder costs it is needed to know the total process costs of the organization. Process costs include e.g. management costs as managers are typically involved in problematic cases and all the IT systems that are the base of the daily processes. The average monthly process cost in the case company during 1-6/2011 was 1 905 274€. Average monthly manpower during the same period was 15 568 hours. By dividing the process costs by manpower, hourly process cost is 122€. An average backorder then generates a cost of 550€ added to increased freight costs.

4.6. Alternative solutions

It is obvious that the current processes do not either produce the best results or implement the strategic goals. There are two ways to develop the existing system without changing the structures: to establish ocean transshipments with the existing material flows from EDC or to source from the Asian suppliers. These two possibilities are further compared in the following sections.

4.6.1. Regular ocean transshipments with current material flows

Current material flows from EDC provide sufficient volumes for regular ocean deliveries. To study the costs of the different delivery options by weight and value current material flow was used. All the costs are based on contracts with the third parties. Following figures are calculated by assuming that all the materials are delivered using the same method. The results are presented on Table 15.

Table 15 Transfer costs from EDC to ADC using the current material flows

	Capital cost	Freight	Tariff	Total
Air weekly	161 €	4 381 €	239 €	**4 781 €**
Ocean weekly	482 €	961 €	239 €	**1 683 €**
Ocean bi-weekly	482 €	481 €	119 €	**1 083 €**

Air deliveries form 27,9 % of the costs of purchase price and delivery cost summed together when using consolidated weekly deliveries. Ocean deliveries cut this cost down into 9,8 %. It can be seen from Table 15 that ocean deliveries are obviously more cost effective even when using the whole container for fewer volumes. It is also possible to reserve only e.g. half of the container which will reduce the costs by about 30%. Deliveries bi-weekly will cut down the costs even more. However, the limit weight of a 20-feet container is 21 000kg and limit capacity 26 cubic meters. With the current or forecasted following material flows, these containers provide sufficient transportation capacity.

There are significant differences in transshipping costs between the material groups. It is needed to evaluate the cost function of each material group individually. Average value of given weight unit is calculated and used to evaluate the average costs of the group. This is done only for the ocean deliveries as the differences between the groups on air deliveries are minimal due to the short delivery time.

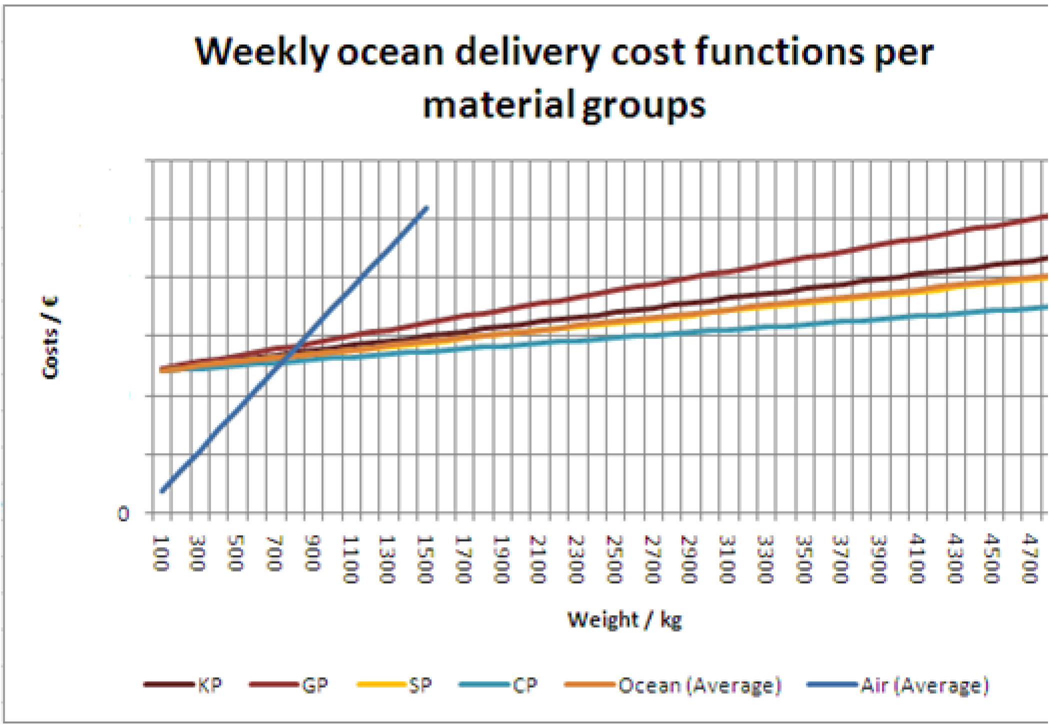

Figure 37 Weekly ocean delivery cost functions per material groups

Weekly ocean delivery costs are presented on Figure 38. This analysis shows the impact of the capital costs as the value of the materials increase. GP and SP groups do not have significant differences. However, there is a remarkable difference between key parts and commercial parts. Differences between material groups when using air deliveries are minimal. Figure 38 provides the information needed to calculate and compare different delivering possibilities.

Despite the fact that arranging regular ocean deliveries instead of air transportations, it does not support those strategic goals set by the top management. Enforcing the supplier base in Asia, and especially in China, is something that should be done even if some additional costs would occur. Arranging delivery types or schedules will not support these strategic goals. In addition to these, stretches in delivery times will most likely affect negatively the service performance. Because of this, it may be reasonable to consider delivering the most critical materials using air transportation and all the others using ocean deliveries.

4.6.2. Local sourcing

Most of the materials delivered from ADC are sourced from Europe. Arising supplier markets provide competitive advantage in sourcing especially on standard and commercial materials. Most critical materials require knowledge that may not be available or even transferable to Asia for lower manufacturing costs. This was seen on sourcing availability analysis, which revealed that especially KP and GP group parts were extremely expensive to be sourced from a local provider. It became obvious that the case company is just beginning its sourcing activities in Asia.

Alternative sourcing possibilities were evaluated and compared by calculating the total landed costs. Landed costs involved purchasing prices, inventory carrying costs and delivering costs. Calculating principles are presented on previous sections at a more detailed level. They include all the direct costs related to transshipment except for those of sourcing activities and possible differences in quality related costs. However, the given values provide comprehensive background for comparisons. Detailed cost analyses by the ten most valuable materials of each material group are presented on Appendix 7.

Table 16 Relational total landed cost difference between Asian and European sourcing alternatives

	Average total cost difference	
Group	Air delivery	Ocean delivery
KP	+79,61 %	+86,13 %
GP	+87,38 %	+89,15 %
SP	+41,00 %	+51,39 %
CP	+29,02 %	+34,04 %

Table 16 presents average relational differences between materials being sourced and delivered from Europe and China to Singaporean ADC. Given figures clearly show that with current suppliers, delivering the materials from Europe is financially profitable as Asian deliveries are remarkably more expensive (marked with "+"). Out of 40 materials, less than five seem financially reasonable to be sourced from China.

When expanding the analysis on other aspects, European suppliers provide better service performance, such as given SP KPI, and better overall quality. Lead time on air deliveries is exactly the same due to Chinese and on ocean deliveries it is 20 days instead of 30. Shorter lead time on Chinese ocean deliveries improves flexibility, but still does not fit on urgent cases. Sourcing unit needs to put on major efforts on Asian suppliers before local supplier base provides comprehensive alternative for the European one. After all, it may still be reasonable to pay higher prices for the chosen suppliers to develop and enforce sourcing activities in Asia because of the corporate strategic aspect.

4.7. Discussion

The findings of the interviews revealed both typical issues presented in literature, such as O'Connell (1999) about sourcing from the low cost-countries or Huiskonen (2001) about the nature of spare parts management, in addition to more specific issues related to the company and its operating systems. Most of the general issues related to inventory balancing were consequences of rapid transition into emerging markets. Supplier uncertainties, insufficient integration of operating systems and non-sophisticated controlling processes were seen as the most important issues. All of these were also discovered by examining KPIs and current processes. On the basis of these issues, interviewees found several improvement possibilities in the current system. In general, these considered

- Inventories under one planning system
- Automatic stock transfer process
- Planning tools to extend forecast from statistical information to signals from the field and product life-cycles
- Physical characteristics from EDMS to SAP
- Introducing total cost models

It is obvious that these issues represent typical areas of development on inventory management and that the global inventory management processes are on a basic level of development. As cost information and planning and controlling tools do not provide sufficient basis for standardized routines, it is necessary to build up a model or a construction of the current system. This study aims at studying the logistics processes of the case company and providing a construction that makes it possible to improve decision-making. It is limited to processes of lateral transshipments as they become more and more important because of the strategic interests on emerging markets. Analysis of the processes revealed that there are inadequate coordination and planning in processes and that the strategic shift of sourcing into Asia is on a very basic level.

Axsäter's (2006) writings on inventory management form the basis for understanding and modeling of the systems and Paterson et al. (2011) further determine the characteristics of lateral networks. The best-fitting model for the system was introduced by Kranenburg & van Houtum (2009). It is known as unidirectional lateral transshipments with partial pooling. At the moment, all distribution centers are considered to be equal to each other. However, quantitative analyses unambiguously argue that there are more complex relations between the centers. The most important single finding was the fact that ADC relied its sourcing totally on the other DCs. Due to this, the company is not able to gain the advantage of the cost arbitrage that Rae (2005) sees as the main principle in expanding to Asian markets.

Kranenburg & van Houtum (2009) find several advantages in establishing hierarchical relations. It is obvious that ADC is being supplied by the others and is then considered as regular local warehouse. EDC and CDC are sourcing locally supplying the others globally. Even though ADC in Singapore has excellent logistic connections, the other aspects force it to be considered to be on a lower echelon. What Kranenburg & van Houtum (2009) suggest in practice is to set up a system which enforces unidirectional lateral transshipments from the units with higher capabilities and wider inventories on the same echelon. It is required to plan and schedule the transshipments sent from the other distribution centers, especially from EDC, to improve the low level of performance and high costs in ADC.

In the case company there was no exact cost data available. The only cost monitored on item level was purchase price. Because of it, it was needed to apply a basic cost model. Robinson (2006), Morita (2007) and Feller (2008) have applied simple total landed cost methods which provide sufficient cost information for comparisons. To evaluate the monetary value of risks, or to expand the analysis on extent such as suggested by Young et al. (2009), much more sophisticated data is needed. Due to very diverse characteristics of the materials, it would become extremely complex to evaluate inventory carrying costs. Using third party logistics it has become a lot easier to calculate delivering costs as all the costs related to delivery, including customs and tariffs are carried by the logistics partner.

At the moment, there are no evaluations on the costs of quality issues or increased risks on service performance. Another issue is that the costs of backorders are not being monitored. Evaluating shortage costs is usually difficult and as Mercado (2008) states, these costs seem not to be insignificant. On this study an average value based on time consumed is given. However, despite major efforts on clarifying penalty fees, no figures were given and it was needed to remain on harsh level. To apply sophisticated mathematical models such as the one suggested by Kranenburg & van Houtum (2009), it is needed to have developed cost information systems. In the case company, available information does not enable such models at the moment. However, a lot of attention is paid on the system and logistics excellence is defined as a key field of development.

Analyses on material flows discovered that even though the company is acting globally, it heavily relies on European supplier base. Managers were not aware of the issue even though there were some speculations by senior employees. It was also common opinion that it is needed to expand on emerging markets, but all the parties of the organization agreed that no sufficient cost information is available. Even though this information was highly appreciated, no efforts had been put on it. In fact, KPIs of the company did not include any service performance-related cost parameters.

This study reveals the fact that lower costs in Asia are not a foregone conclusion. Great efforts on sourcing and collaboration are needed. This does not only concern unique or high technological level materials, but also cross industrial commercial materials. Developed supply networks in Europe provide comprehensive alternative for Chinese suppliers even when reviewing lead times as Chinese customs have proved to be time-consuming and uncertain. Based on the findings of the study, regular consolidated transshipments from Europe best serve Asian deliveries.

5. CONCLUSIONS

5.1. Research summary

The overall purpose of this study was to provide a construction that makes it possible to improve decision-making related to inventory balancing of distribution centers of the organization. Inventory balancing is executed by lateral transshipments that are defined as transshipments on the same hierarchical level of the inventories (Axsäter 2006). The conceptual model of the study was highly labeled by the framework suggested by Paterson et al. (2011). This thesis was carried out in a company that wanted to study its lateral transshipments and to discover alternative solutions in supplying the main distribution centers. Three main questions guided the structure of the study

- How does the existing inventory network look like?
- What kind of issues and development areas there are?
- How is it possible to improve current inventory pooling operations?

A lot has been written about supply chains and inventories. Lee (1987) and later Axsäter (2006) have written about multiple echelons and modeling of the inventory structures. On the basis of these studies added with more sophisticated classifications suggested by Paterson et al. (2011) current inventory network was seen to involve three echelons. By the limitation of the study, efforts were concentrated on the top level which consisted of three distribution centers. There are remarkable material flows between the DCs but these transshipments have not been planned or studied by the management. The increasing significance of the flows has generated a growing interest on developing the processes.

This study involved both qualitative and quantitative analysis. Current processes, issues and development needs were studied using interviews with senior employees of each involved team of the organization. Interviews revealed that there are shortcomings in planning, arrangements and information systems related to inventory balancing. Arranging of the transshipments is now performed by a Chinese purchaser with insufficient instructions and tools. Another highlighted area was the extremely low level of cost information. At the moment of the interviews, there was no information on costs or actual lead times, total value of material flows or the difference of total costs when sourcing from alternative sources.

Issues emerged on interviews were then studied on quantitative analyses using data from the ERP system, contract terms and single invoices. These findings are in line with the interviews and emphasize efforts on developing the balancing system. Quantitative findings underline the importance of inventory balancing between European and Asian Distribution Centers. In addition, the performance figures of ADC were seen not to be on satisfactory level. Inventory balancing operations of ADC were then chosen to be studied further.

At the moment of the studies, inventory balancing operations were arranged on weekly basis and mostly sent using air deliveries. Cost information was gathered using contract terms and invoices to evaluate different alternatives. Weekly or bi-weekly ocean deliveries, air deliveries and sourcing from China were compared to each others in terms of costs and assumed risks. When the study was carried out, almost all the materials were sent using air deliveries even though there were no urgent customer demands on causing the need. There were also extremely high differences in sourcing costs between China and Europe in addition to evaluated risks. Findings of the study recommend remaining sourcing from European suppliers. In addition, there seem to be some potential for cost reductions in better planning of the deliveries. Detailed cost figures were also given on Appendix 7 for the most important materials of each material group. Given results provide tools for managerial decisions on improved inventory balancing processes.

5.2. Recommended actions and action plan

At the moment, it is recommended to arrange weekly ocean deliveries from EDC to ADC for orders which are based on upcoming demand. Most of the orders can then be delivered on these regular transshipments which should be regarded in the setting of the inventory positions such as ROPs. In addition to urgent cases, also those orders with actual customer need should also be considered to be delivered using air deliveries. This is because of the significant costs of not meeting the demand. Better understanding and estimates of the customer need will cut down the need for expensive air deliveries in less valuable materials.

Major efforts are needed to reinforce the supplier base in Asia. It can be seen that third party suppliers do not provide the pursued advantage and that there is a lot of potential in local manufacturers. With the given information, strategic sourcing may prioritize the materials and start negotiating contracts for the most important materials. For example, there are two extremely valuable materials by purchase price and logistics costs which should be rapidly negotiated to be sourced from Asia. On total, recommended short-term actions involve

- Setting up a reporting and monitoring system of material flows of the balancing operations

- Evaluating new suppliers for the most important materials by value
- Establishing weekly ocean deliveries between EDC and ADC

Regular reporting and monitoring of the material flows should be set up. This study revealed the fact that very little was known on material flows, their value and the costs from alternative sources. It is recommended to monitor the flows of balancing operations at monthly basis to make it possible to focus the efforts on most valuable and critical materials. This is already being planned and will take place on the beginning of 2012.

Weekly ocean deliveries from EDC to ADC should be established during the first half of 2012. At the beginning, deliveries should consist of relatively heavy standard and commercial parts with stabile demand. As the deliveries and their effect on inventory ratios are known, also other materials with low value per weight ratio and stabile demand should be included. Materials with high value and stochastic demand should be sent using air deliveries. It is shown that it is possible to save up to 18,1 % in total landed costs when using ocean deliveries if no backorders occur. However, there are still some items, such as circuit boards, that should be sent using air deliveries because of their criticality or low weight. Backorder cost of 550€, possible extra delivery costs, possible contract penalties and losses in reputation should always be considered when choosing an option with longer lead time.

Strategic sourcing should focus its efforts on the most important items by their value which can be seen from Appendix 7. Efforts should be focused on the most valuable materials on the list, such as the most valuable material on key, general and commercial part categories which are all reliably heavy materials. This should be prioritized to be done on the first quarter of 2012. Given list of most important materials should be evaluated to be sourced from Asia during year 2012. On a longer scope, strategic choice of shifting the focus of supplier base on emerging markets should be emphasized by developing chosen suppliers.

5.3. Contribution to theory

Companies are expanding their operations to cover global activities. This is a result of both targeting on the growing sales of emerging markets but also pursuing the arbitrages of the lower costs. Global operations require global inventories, which complicates the supply chain. Company and industry specific materials may not be available on all the continents and it is both time and money consuming task to build up such sourcing networks. Availability is perhaps the most typical reason for inventory balancing processes. However, inventory balancing activities may also provide significant cost reductions on logistics processes what is also seen on this study.

As the findings of the study reveal, local sourcing does not automatically provide lower costs even when talking about areas that are typically considered as low cost-countries. This is most likely a result of highly developed manufacturing capabilities, collaboration and centralized high volumes in Europe against early stage relations with low volumes on less developed manufacturers in China. Especially on such occasions, lateral transshipments from Europe provide overwhelming advantages against sourcing from China. In addition to cost advantages, standard lead times, lower risk levels and evaluated lower level of quality issues emphasize inventory balancing activities.

Several articles provide evidence on the savings of balancing processes. However, most of them only consider mathematical methods with only some materials. It is needed to combine information from forecasting tools, ERP and PDM systems what makes the process a lot more complex. What is shown on this study is the fact that even though companies have logistical capabilities of arranging balancing operations, integration of information systems limits the possibilities of inventory pooling activities.

5.4. Assessment of the study and limitations

This study is a single case study based on systematic problem-solving. Due to this, both theoretical and practical implications are limited. Also, the structure of the network is not very common by its nature and the industry has some restrictions because of the security issues in people transportation. However, the findings of the study seem to be in line with the literature and both the qualitative and quantitative analyses supported each others.

In addition to the nature of a single case method, there are some limitations in the models that have been used. Most of them are related to the information used on the basis of total landed cost analysis. Limitations arise from the lacks of information in sourcing and quality costs. The matrix organization of the company complicates cost allocations especially in sourcing. Also the quality costs were limited outside the scope of the study because of challenges in allocating the costs on specific materials and their suppliers. Because of these limitations, only a very simple method suggested by Feller (2008) was applied. On overall level, sophisticated inventory optimization models were only presented and not applied as implementing of them will require a lot of development in the information systems to provide the data needed.

In sourcing analysis, only existing purchase prices were used. This was chosen to make the prices comparable as there would not be any additional costs and the materials in existing contracts are exactly the same. However, this may have excluded potential suppliers with lower costs from the analysis. To better understand the possibilities of sourcing savings in Asia, further studies are needed.

In the beginning of the study, study questions and targets were set. Each of the three questions has been answered on this study. This study also provides a construction that enables improving the logistics processes so that the set level of service performance is achieved with lower costs. Theoretically, this study only applies existing models in analyzing the processes of the company. All in all, given contributions have been noticed by the management and actions are taken on both arranging of the regular ocean deliveries and evaluating the possibilities of sourcing the materials in Asia.

5.5. Recommendations for further studies

This study continued the series of publications emphasizing the need for inventory balancing. Studying the field of inventory management and balancing continuously reveals possibilities for improving the processes. The field of lateral transshipments has been on the focus of the logistics researchers during the past few years and several models have been introduced. Based on the findings of this study, the most important issues in inventory balancing may still rely on more simple level. Another major issue seems to be the integration of different ERP- and BI-systems. Sharing of information, such as costs, demand and forecasts, is commonly known issue in supply chain management.

Detailed analyses on quality and sourcing costs should be performed in the case company. Better understanding of the costs would provide more precise figures on alternative options in every field of logistics management. Also, more studies on case companies would provide benchmarking values. At the moment, especially spare parts lack of such data. Lateral transshipments are a recently found area of logistics research and require more applied research.

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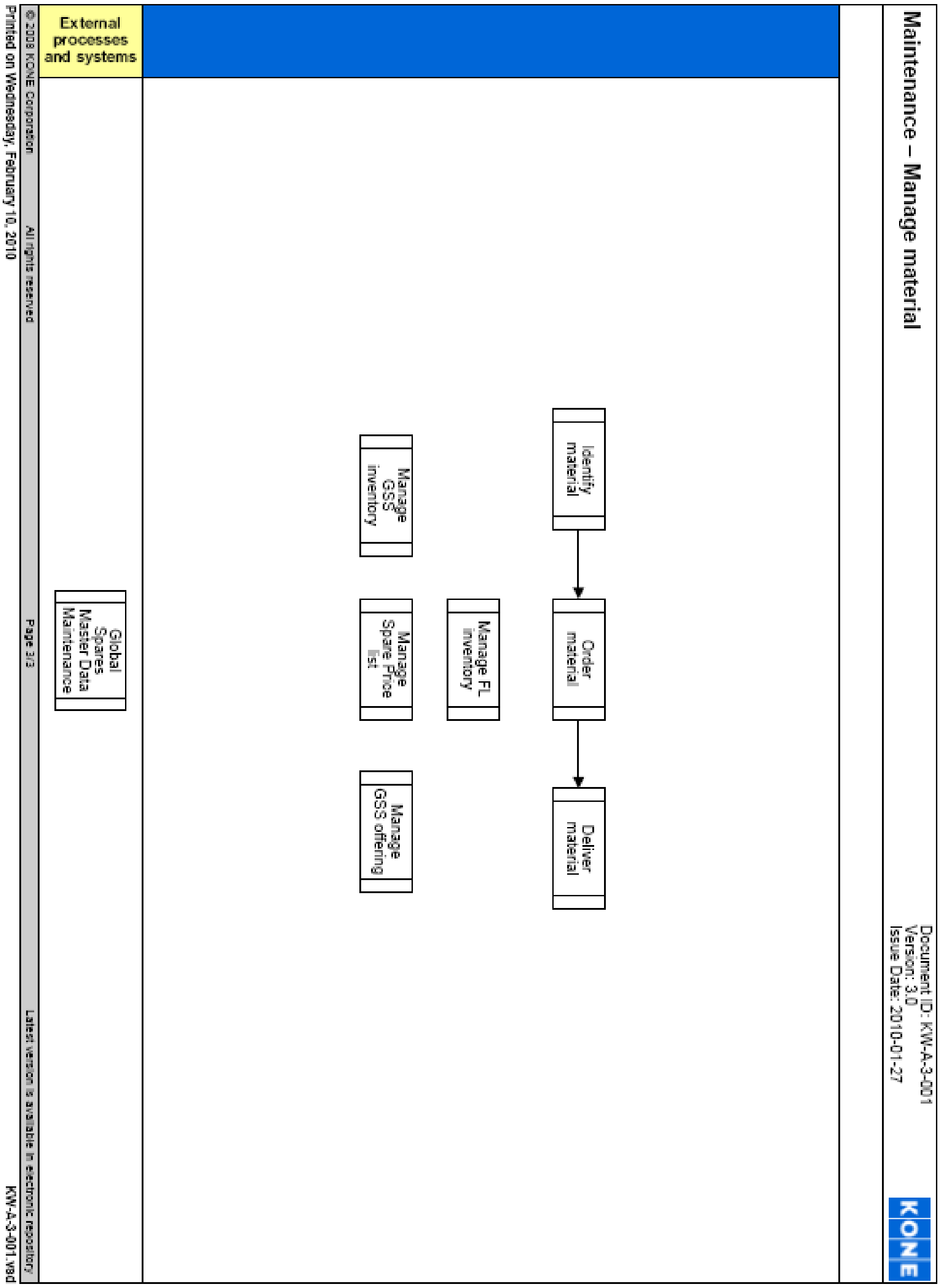
LIST OF INTERVIEWS

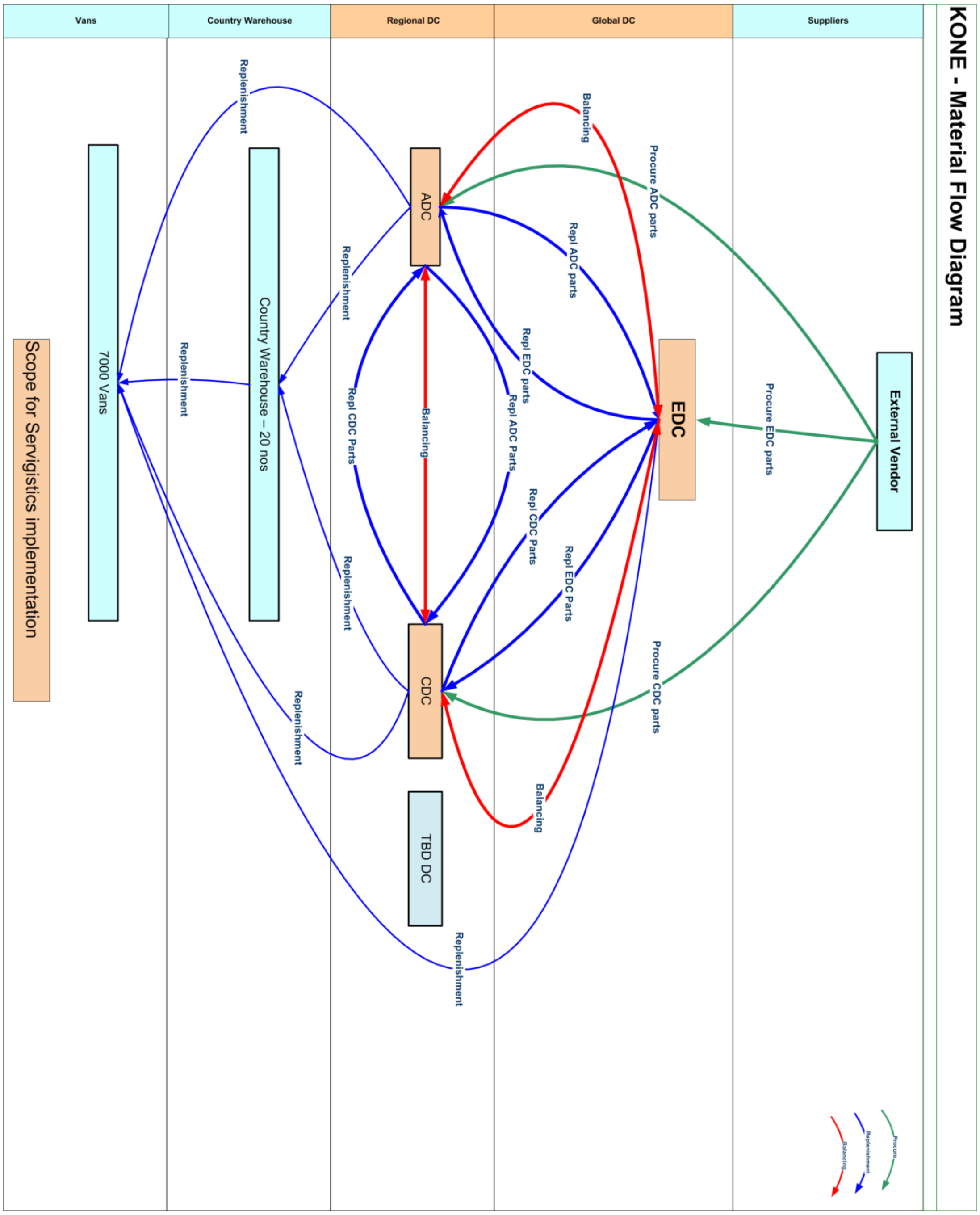
Date	**Title, department, location of the interview**
17.6.2011	Team leader inventory support & projects, GSS. Hyvinkää office.
17.6.2011	Application & project specialist, GSS. Hyvinkää office.
17.6.2011	Customer service teal leader, GSS. Hyvinkää office.
20.6.2011	Process development specialist, GSS. Hyvinkää office.
28.6.2011	Team leader logistics, invoicing & quality, GSS. Hyvinkää office.
28.6.2011	Senior inventory planner, GSS. Hyvinkää office.
30.6.2011	Process owner & change team manager, GSS. Hyvinkää office.
1.7.2011	Senior customer service officer, GSS. Hyvinkää office.
4.7.2011	Expeditor, GSS. Hyvinkää office.
7.7.2011	Purchaser, GSS Asia. Email interview.

APPENDICES

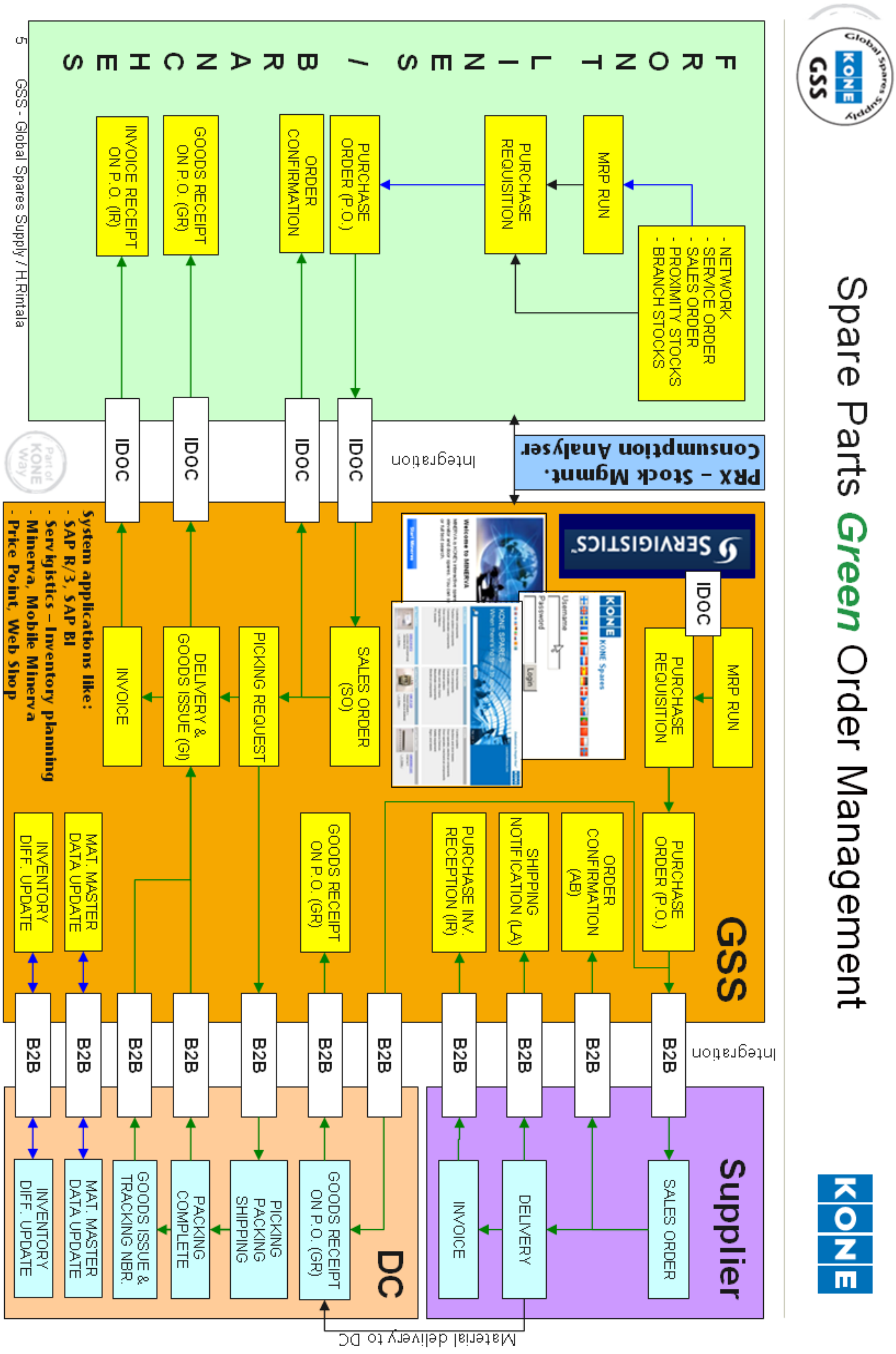
Appendix 1. Material management process



Appendix 2. Material flow in Servigistics planning tool



Appendix 3. GSS order management process



Appendix 4. Interview questions on round 1, version 2

Job title:
Sex:
Interview language:
Date:

How long have you been working for KONE and what are your main tasks ?

1. Describe briefly, how does the inventory system of the company look like?

-> What kind of actors and hierarchy levels there exist?

2. How would you describe each distribution center and their transshipments?

-> Describe their characteristics related to each others?

-> What kind of transshipments there are?

3. What kind of special actions or processes are needed to take when acting with them ?

-> Does some distribution center need specific procedures?

The following ones are specified to the specific field of the interviewee and interviewees are asked to name specialists that are able to answers the specific questions.

Sourcing:

Describe the process of inventory pooling between distribution centers?

When do we use lateral transshipments instead of local suppliers?

Inventory:

How high inventory levels do we have in relation to the inventories of front lines?

Describe the lateral transshipment between each distribution center?

ERP:

How are inventory pooling operations handled in ERP system?

What ERP systems are used and how are they jointed to each others?

Customer service:

What is the role of lead time according to level of service performance of different types of products and product families?

How is it possible to affect service performance in terms of inventory pooling?

Logistics:

What kind of transport methods are used between different distribution centers?

What kind of transport methods are used with different orders and products?

4. What kind of problems there are, related to your job?

-> Which of them causes the most additional work?

5. What products, product families or orders are behind these issues?

6. According to inventory pooling, where lies the most potential to improve?

-> How is it possible to affect the service performance using inventory pooling?

-> What are the ways to decrease costs?

7. What are the upcoming improvements or what should be done to improve according to inventory pooling?

8. Is there something you'd like to add related to inventory pooling?

Appendix 5. Interview questions on round 1

Inventory balancing interview – Round 2, Version 1 *Page 1/2*

Title:
Sex:
Language of the interview:
Date:

How long have you been working for KONE and what are your main tasks ?

1. Describe briefly, how does the inventory system of the company look like?

-> What kind of actors and hierarchy levels there exist?

9. Are there any differences between DCs or do we consider them as identical in terms of lateral transshipments?

-> Are there any special occasions or processes in which this occurs?

10. How do we approximate the costs of not meeting the demand?

-> Do we have any figures or models to count them?

-> In your opinion, what should be considered when calculating them?

11. What triggers our lateral transshipments and upon what basis?

-> How it is done today and how in future?

12. What kind of periodic transshipments do we have?

-> What is sent as emergency transshipments?

-> What kind of problems do you see related to proactive stock balancing?

13. Do we reserve stock or is it possible to order all the stock using lateral transshipments?

-> Are there any items with different approaches?

14. What kind of transshipment costs are taken into account and how are they calculated?

-> What kind of transportation cost differences there are between items and orders?

-> On what basis they are allocated? (order line, weight, purchase order…)

7. What are the upcoming improvements or what should be done to improve according to inventory pooling?

8. Is there something you'd like to add related to inventory pooling?

Appendix 6. GSS KPIs by teams

ADC Team	Exceed	Target	Minimum
ADC total service performance	%	%	%
EXW COT (combined stock&non-stock)	%	%	%
CDC team	**Exceed**	**Target**	**Minimum**
CDC total service performance	%	%	%
EXW COT (combined stock&non-stock)	%	%	%
GSS General	**Exceed**	**Target**	**Minimum**
Net stock rotation		3,7	
KPI D07 (GSS market share)	%	%	%
Coded Material Usage	%	%	%
Customer service team	**Exceed**	**Target**	**Minimum**
GSS total service performance	%	%	%
DDU COT (combined stock&non-stock)	%	%	%
Direct sales team	**Exceed**	**Target**	**Minimum**
Revenue			
Account Receivables			
Service Performance	%	%	%
Global technical services	**Exceed**	**Target**	**Minimum**
Backlog	0		
Solving time			
Tender's solving time			
Project service performance	%	%	%
Data backlog	0		
Data solving time			
Inventory support & projects	**Exceed**	**Target**	**Minimum**
ADC-Stock balance difference	%	%	%
CDC-Stock balance difference	%	%	%
EDC-Stock balance difference	%	%	%
Logistics, invoicing & quality team	**Exceed**	**Target**	**Minimum**
EDC COT inbound	%	%	%
EDC COT outbound	%	%	%
FB- claim ration (Monthly)	%	%	%
Feedback material request in process			
Invoice COT	%	%	%
Pricing team	**Exceed**	**Target**	**Minimum**
Credit note	0		
Purchasing team	**Exceed**	**Target**	**Minimum**
Decrease no. of missing AB´s / no. of missing AB	%	%	%
Zero Stock materials (with open sales)	%	%	%
PO automatisation level	%	%	%
No vendor materials	%	%	%
Reduce & improve NCF process			
Change team	**Exceed**	**Target**	**Minimum**
Outstanding work orders	Not determined		

Appendix 7. Total landed cost analysis for each material group