Logistics and Transport Management

Master Thesis No. 2004:11

Storage Layout at Kalmar Industries in Lidhult

-Improved usage of the outdoor storage area, thereby a more efficient material flow

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Abstract

The main purpose of this study is to examine the possibilities of improving the layout of the outdoor storage of Kalmar Industries in Lidhult. It will be explored whether or not it is possible to relocate articles based upon certain principles, in order to decrease internal transportation with a view to achieving achieve a more efficient and functioning material flow. The thesis also contains discussions concerning various problems that a possible change of a storage layout might lead to.

Outside located storage areas is a topic within the field of logistics that has not been investigated and analysed in detail. Most of the studies carried out that are in line with this topic are based on indoor storage and other types of warehouse functions. Therefore, we found it interesting to examine this challenging and complex topic.

The study is mainly focused on the articles that are stored outside. These are large articles that cannot be stored inside due to size or weight. The investigation looked at the articles from when the supplier enters the main entrance until the final products leave the area and pass the gate on the way to the customer.

Acknowledgement

Working with our graduate thesis has been a very interesting experience. Today, the subject area for our research is of great interest, which is reflected in the great enthusiasm from our respondents in our empirical studies.

We would like to express our gratitude to a number of people who have contributed to this thesis.

Firstly, we would like to thank all the respondents. Their cooperation and interest in helping us investigate Kalmar Industries in Lidhult.

Secondly, we would especially like to thank Anders Svensson at Kalmar Industries for giving us the opportunity to do this investigation and supplying us with the needed information.

Finally, we would like to thank Leif Enarsson, our tutor at Gothenburg School of Economics and Commercial Law, for his great guidance and support during the process of developing this thesis.

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List of Abbreviations

This list covers solely the abbreviations used in this thesis. All abbreviations are arranged in alphabetical order.

DRP	Distribution Requirement Planning
ECR	Efficient Customer Response
EFTA	European Free Trade Association
ERP	Enterprise Resource Planning
EU	European Union
FIFO	First In First Out
FTL	Full Truckload
IS	Information System
JIT	Just- In –Time
KCH	Kalmar Container Handling
KRTC	Kalmar Rough Terrain Centre
LIFO	Last-In-First-Out
LTL	Less than Truckload
MRP	Material Requirement Planning
MERCOSUR	El Mercado Común de Sur
NAFTA	North American Free Trade Agreement
PDCA	Plan, Do, Check, Act
QR	Quick Response
RORO	Roll On Roll Off
RTG	Rubber Tyred Gantry
SKU	Stock Keeping Unit
VMI	Vendor Managed Inventory
WIP	Work In Process

Executive Summary

Kalmar Industries is a market leader in the field of container handling equipment. Every forth container that is handled in ports around the world is lifted or transported by a Kalmar machine. The business environment that Kalmar Industries operates in is becoming fiercer and fiercer, and in order for Kalmar Industries to stay competitive in this challenging and tough environment, it is essential that there is a clear focus on customer satisfaction. To satisfy customers, Kalmar Industries must have a well-functioning materials flow. Not only from the suppliers to Kalmar Industries, and from Kalmar Industries to the customers but also within the company. The internal customer is just as important as the external customer.

The main purpose of the thesis was to investigate the possibilities to improve the layout of the outside storage area leading to more efficient materials flow. It was explored whether or not it was possible by relocating articles based on certain principles to decrease the internal transportation distance and achieve a more functioning materials flow. Further, the study looked at how Kalmar Industries can give the storage area clearer markings and signs, and thereby make it easier to find the correct articles. The thesis also contains discussions around various problems that we came across during the course of the study.

Various theories have been outlined and discussed in order to undertake this study in a satisfactory manner. Theories such as layout and design principles and materials management, among many others, are discussed. Different types of processes including effective-, flexible processes and identifying processes, are also discussed.

From the methodology chapter we learned that this study is mainly a descriptive and an exploratory research with both quantitative and qualitative data. Primary data such as visual observation and personal interviews have been used as well as secondary data such as the theories mentioned earlier.

The results from the research in this study show that there can be savings made by changing the storage layout, relocating the articles and improving the information flow.

Our first alternative was to leave the articles on their present location, i.e. status quo, but with improved markings and signs on the area. This alternative would make it easier to find the articles and it would lead to improved safety. Improved safety in terms of zebra crossings on the ground where pedestrians normally walk. As the articles are then easier to find, the internal transportation can be decreased due to less driving to the wrong location.

Relocating the articles based on their frequency led to a decrease of the internal transportation distance of 1 558 762 meters per year. This decrease should give Kalmar Industries savings of up to 62 350 SEK per year. This is a reduction of the total internal transportation by 23%. This alternative however, can make the storage area more unstructured leading to difficulties in finding the correct articles. The reason is that the articles are no longer located according to what product group they belong to.

The third alternative in this study was relocating the articles based on product groups. This would make the storage area more structured and the articles would be easier to find. This alternative would also lead to a decrease in internal transportation. By relocating the articles based on product group we have been able to decrease the internal transportation by 1 463 644 meters. This is a decrease of 22%. Further savings when choosing this alternative could be achieved due to it being easier to find the articles thus saving even more time and money.

1 Introduction

In this first chapter, an overview of the thesis is provided, in order for the reader to become acquainted with the subject. The thesis' background and a short discussion around the problem will be followed by a presentation of the thesis' purpose and outline. The strategic importance of the project will also be discussed as well as the purpose of the study.

1.1 Background of Thesis

The world economy is, and has been for some time, in a radical shift. We are moving away from a world where national economies are isolated from each other by barriers that hinder cross-border trading and investments; by distance, time zones, and language; and by national differences in government regulation, culture, and business systems. The globalisation of markets is merging national markets into one huge global marketplace, where companies have great opportunities to earn money. However, the emergence of globalisation has made the business world tougher. Competition between companies is fiercer than ever and staying profitable is not as obvious as in earlier days. The main drivers of globalisation are the changes in customer preferences, technological improvements and the decline in barriers to the free flow of goods, services and capital[1].

1.1.1 Drivers of Globalisation

Customer preferences have changed in many ways. Customers nowadays expect goods to be available at all times, in the right quality and to the right price. Furthermore, technology is continuously improving. It is particularly the dramatic developments in recent years in communication, information processing and transportation technologies that have pushed the world towards globalisation. One of the most notable trends in the global economy in recent years has been the movement towards regional economic integration. Free trade zones, such as EU, EFTA, NAFTA and MERCOSUR have decreased the number of trade barriers between nations, which has further strengthened globalisation[2].

[1] Hill, 2000, p. 5-7
[2] Hill, 2000, p. 232

Production has also become global. Firms source goods and services from locations anywhere around the world in order to take advantage of national differences in the cost and quality of factors of production (labour, energy, land and capital). The aim of this is to lower the overall cost structure allowing the firms to compete more effectively. In order for firms to become more efficient the concept of Supply Chain Management has developed.

Supply Chain Management consists, according to Bowersox, et al., of firms collaborating to leverage strategic positioning and to improve operating efficiency. As late as the early 1990's the average time that a company needed to process and deliver goods to a customer from warehouse inventory ranged from 15 to 30 days. Today, however, as customers are more demanding, firms must be able to manufacture to exact specifications and rapidly deliver to customers anywhere around the globe. Customer order and delivery of goods can be made in hours. Service failures that often occurred in the past are no longer acceptable. Instead, perfect orders i.e. delivering the correct assortment and quantity of products to the right location on time, damage free with correct invoice is what customers expect.[3]

1.1.2 Cope with the Challenges

In order to cope with these challenges in the new business environment it is essential that companies have, among many other things, a well-functioning material management, i.e., an efficient physical supply of materials throughout the supply chain. An efficient materials flow is crucial in order for firms to meet customer expectations and thereby deliver the products at the right time, in the right quality and quantity, at the right price and at the right place.

To achieve a well functioning materials flow companies must put much emphasis on the different warehouse operations and inventory management, including the stratification of articles, product flow patterns and the layout of the storage. Today control and communication in materials flow demands computerised systems. Information systems refer not only to computerised solutions but also to all communication and data processing connected to the materials flow. Thereby, the overall control of the entire materials flow can be

[3] Bowersox, et al., 2002, p. 3

viewed as one process, in order to see how the different parts are integrated and influence each other.

Logistics and Supply Chain Management have during the last centuries grown in popularity because of the firms' needs to become more customer- oriented and cost effective. Much research has been done in these areas and they will most certainly continue to be investigated in the future. Outside storage and its layout, however, are areas within logistics that have not been studied in-depth and there is a clear need for further research. This is the reason why this study will be conducted.

1.2 Strategic Importance of the Project

There are many reasons for holding inventory such as balancing supply and demand, and achieving economies of scale. By holding inventory, cost reductions in other business areas can be made. For example, in purchasing where ordering large quantities will lead to lower per unit price but also increased inventory. This is a very delicate balance that companies must consider, as holding inventory is very expensive.

As globalisation of markets and of production is constantly growing, more and more goods will be traded across the world, thus more goods need to be stored. This fact further strengthens the importance of conducting studies in the areas of outside located warehouse layout design and materials management.

1.3 Problem Discussion

The group of Kalmar Industries is divided into several subsidiaries where some are located in Ljungby, and some in Lidhult. In this study, the assigner is Kalmar Industries in Lidhult, and principally the company Kalmar Container Handling (KCH), which is referred to throughout this thesis, when mentioning Kalmar Industries in Lidhult. This company has grown rapidly in recent years, mostly as a result of mergers and acquisitions, and has become market leader within product areas such as reach stackers, terminal tractors and straddle carriers. The company now sells and delivers products all over the world. The production has increased and as a result, the production and storing areas have grown significantly. The expansion has led to the fact that many logistical activities have been overlooked, including where the articles should be located in order to have an efficient materials flow. Overlooking logistical activities is a common thing in many organisations under rapid growth. The result of this development for Kalmar Industries is that many of the articles are not placed at an optimal location in the outside storage area, leading to unnecessary internal transportations. The internal transportations need to be more efficient in order to cope with the workload and further growth.

The main problem, within this study, is that Kalmar Industries in Lidhult does not use its outside storing area in the most beneficial way. By not using the outside storage area in a favourable way, further growth will be problematic. If this problem is not looked into, it can lead to increased costs in terms of production stops, decreased service levels, and thereby lowered customer satisfaction. Another problem to consider is that the existing storing area today is divided between two different subsidiaries within the group of Kalmar Industries, the Kalmar Container Handling (KCH) and the Kalmar Rough Terrain Centre unit (KRTC). However, focus will be put upon the company KCH.

In order to carry out this study in a satisfactory manner, thus finding answers to the problems and give recommendations on how to improve, much information is needed. Firstly, the authors have to broaden their knowledge in this subject through, literature, articles and informational sites. Secondly, both the outside located storage area and the material flow have to be mapped in order to find the exact location of the articles. Thirdly, the opinions of the employees and the people in charge of the storage activities have to be taken into consideration. This is done through interviewing the people concerned. The next step is to look at improvements and thereafter give recommendations on how to make changes in order to optimise the storage layout.

1.4 Research Questions and Information Need

In this section, the research questions will be outlined. These are the main problem and three sub-problems. Together with each question the information need will be presented.

1.4.1 Main Problem

- ***What are the possibilities to improve the layout of existing outside located storing areas, thus improving the material flow and the handling of incoming and outgoing goods?***

This is the overall question on how to improve not only the location of the articles but also the layout of the outside storage and thereby achieve a more efficient materials flow. To answer the main question research has to be conducted on how the storage area looks today and where the articles are located. Further information will be needed in areas such as the time and distance it takes the trucks to move to reach the articles in different locations. It will also be looked into whether there are any alternative ways of storing some of the articles according to which product family they belong to or how often they are used.

1.4.2 Sub Problems

- ***In what ways is it possible to change the storage layout?***

The first sub problem deals with the layout of the outside storage area and includes issues such as the possibility to change the transportation roads within the area in order to improve the use of the trucks, and improve the markings and signs at the area. Further, the study will look at how it is possible to categorise the products according to their value, similarity, frequency, size or weight.

Additionally, is it possible to improve the internal transportation by clearer markings and signs? How should the markings look like and which articles should be concerned? Can different areas be marked with different colours depending on what articles are stored there?

- ***How is it possible to make the internal transportation more efficient?***

With the second sub problem, the aim is to find out how the internal transportations and materials flow can be improved. By relocate the articles, according to certain factors such as volume or size, the material flows can be improved. This will also give indication as to which articles should be emphasised. Also looked into will be if the truck routes can be changed so that the driving distance can be shortened. Furthermore, the importance of information and communication will also be highlighted in order to improve the planning of the internal transportation.

- ***How is it possible to make loading and unloading more efficient?***

This question deals with the areas where the articles arrive at and where the loaded trucks leave. Here one must have information about frequency and size of the deliveries as well as knowledge of what type of articles, and when they are to be delivered. This is a matter of how reliable and precise the deliveries are, i.e. the delivery safety.

1.5 Purpose

The purpose of this investigation is to change the "storage layout" for Kalmar Industries in Lidhult, KCH, which aims to change the outdoor located storage area, the logistics flow of materials and loading- and unloading locations under certain prerequisites. The "layout" will be used as a basis for decision-making of a reconstruction project in the year 2004. Thereby this study can be seen as a pre-study for further studies within this area.

1.6 Problem Delimitations

To optimise the storage layout and to increase the efficiency of the materials flow and the internal transportation goes much hand-in-hand, i.e., they are connected to each other. You cannot look at one of these in isolation and still come up with a satisfactory improvement. Therefore, to be able to undertake a study in this complex field of logistics it is important to limit the scope of the study. In a study like this, there are many parameters to take into considerations, such as a vast number of articles with different size, value, volume, weight as well as a large storing area where large changes are possible. If these parameters are not limited, it will be too complex and probably impossible to conduct a study of this nature. Therefore, the scope of this study will be limited as follows.

The study will mainly focus on the articles that are stored outside, and on some articles stored inside two tents within this area. These mainly large articles cannot be stored inside due to size or weight. The investigation will look at the articles from when the supplier enters the main entrance until the final products leave the area and pass the gate on the way to the customer. It will be "a gate-to-gate investigation" where we exclude the inside storage and the materials flow inside the assembly plant and focus on the middle section of the supply chain, that is the work in process part in figure 1-1 below. However, Kalmar Industries does not store raw materials but instead semi-manufactured article storage.

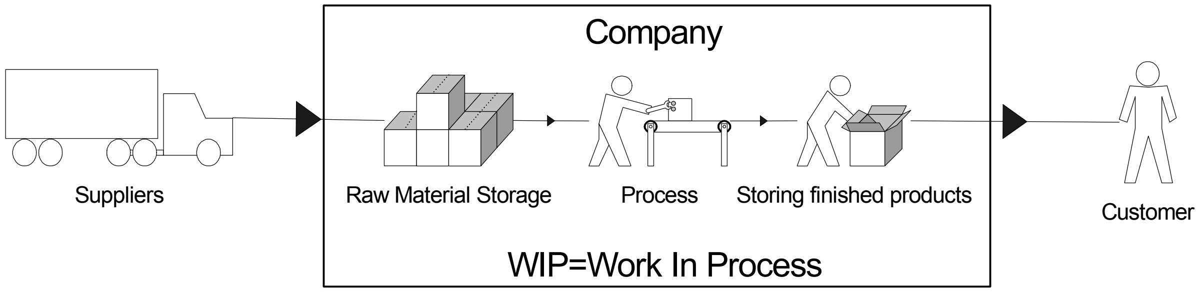


Figure 1-1: Supply Chain

Source: Lumsden, 2002, p 144

The study will focus on the layout of the storage area together with the location of the articles. However, there will also be discussions around other issues that are related to the main topics such as information to truck drivers working on the storage area and order quantity.

Although the purchasing and production have great impact and importance on how the storage will function, these parts will not be in focus within this study's limits.

Apart from the by us decided delimitations, there are a number of factors that will further limit the scope of the study. Kalmar Industries has a storage area that can be expanded but, naturally, only to a certain extent. Furthermore, there are a number of buildings on the area that cannot be moved from their present location. The production-assembly plant, office building and paint-shop are examples of these buildings.

The knowledge we have of the different articles is solely based upon the data gathered at the company and the observations made. It might therefore be difficult to decide a correct placement since we do not have enough product knowledge.

1.7 Definitions

In this section, essential expressions and words that are often used in the thesis will be defined. These words can have different understanding depending in what way you are using it.

In the study, efficient material flow means steady, constant and well-functioning flow of materials. Constant flow is a description of flows that are kept at a certain level and that are not fluctuating over time.

Another word that might be confusing for the reader is "truck" because this is used both for the description of vehicles that enters the area with incoming goods, and for forklift trucks handling the internal materials flow. Consequently, both a driver of a trailer truck and a forklift truck can be mentioned as a truck driver. A route truck is also mentioned in the text and this is a truck that drives a special route where it collects products from approximately thirty suppliers.

Another concept that is often used through the thesis is change of the storage layout. When using this concept both changes of the storage design, i.e. roads, ground, area sizes, and changes of location of articles is included.

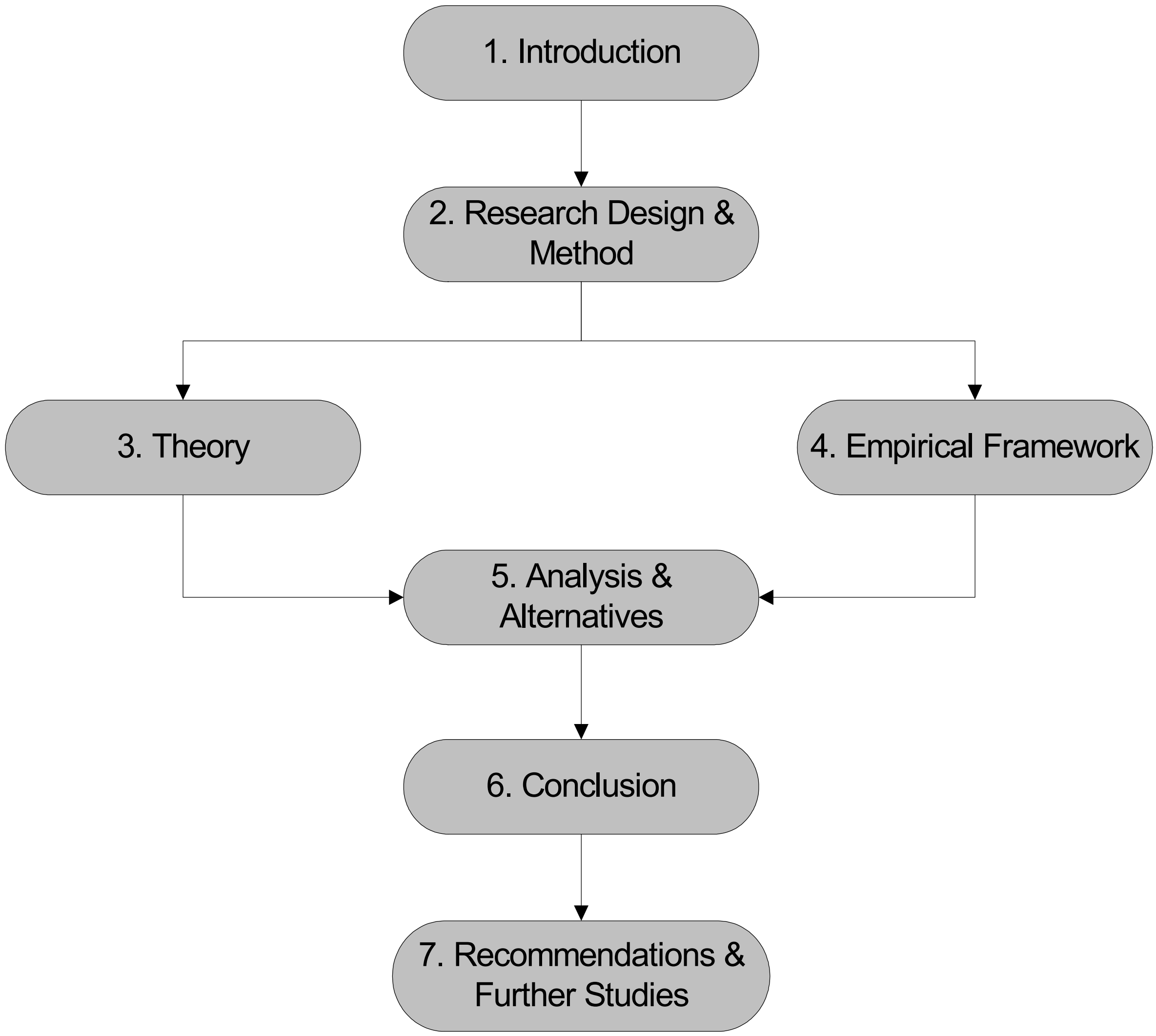
Internal transportation is a concept that is given a lot of focus in this study. By internal transportation all transportation of goods and articles are included. All inbound movements as well as trucks coming with incoming goods. However, in the calculations made in the analysis internal transportation is only referred to the flows between the articles' location and the assembly plant. What can be mentioned in the line of the same topic is that all routes in the area that aredriven by the forklifts, asphalted or not asphalted are classified as roads.

1.8 Disposition

A time plan was made at the beginning of this work in order to dispose the time given for making this thesis in the best way. However, firstly, a disposition model, shown below, is made in order to illustrate the contents of this thesis which prepares the reader for the contents of the study and which has made it easier to plan the total thesis work.

A timetable was made in the beginning of this study and illustrates the weekly plan of how the total thesis work has been conducted. This is shown in Appendix 1.

Figure 1-2: Disposition Model



Introduction

2 Research Design and Methodology

In order to carry out a study, an optimal research method has to be decided upon. The choice of method is dependent on the purpose of the study, the problem definition, and the frame of reference and time constraints. It is therefore not what is theoretically interesting, but what is possible within the limitations of a given method that will determine the outcome of the research. By describing the theory of methodology used, we wish to clarify how the research problems and the information needs have been approached.

2.1 Introduction

This chapter deals with the planned research design and data collection methods used. The methodology approach and the analysis approach will be presented, followed by a discussion concerning both secondary and primary data collection. Finally, we will discuss the thesis' method problems and errors.

2.2 Research Design

Research design or methodology refers to the procedural framework within which the research is conducted. It describes an approach to a problem that can be put into practice in a research program or process, which could be formally defined as an operational framework within which the facts are placed, so that their meaning may be seen more clearly.

Firstly, the research design is a plan and structure for selecting the sources and types of information used to answer the research questions. Secondly, it is a framework for specifying the relationships among the research's variables. Thirdly, the research design guides the data collection and the analysis phases of the research work.[4] In other words, the method is a tool used to retrieve new knowledge.

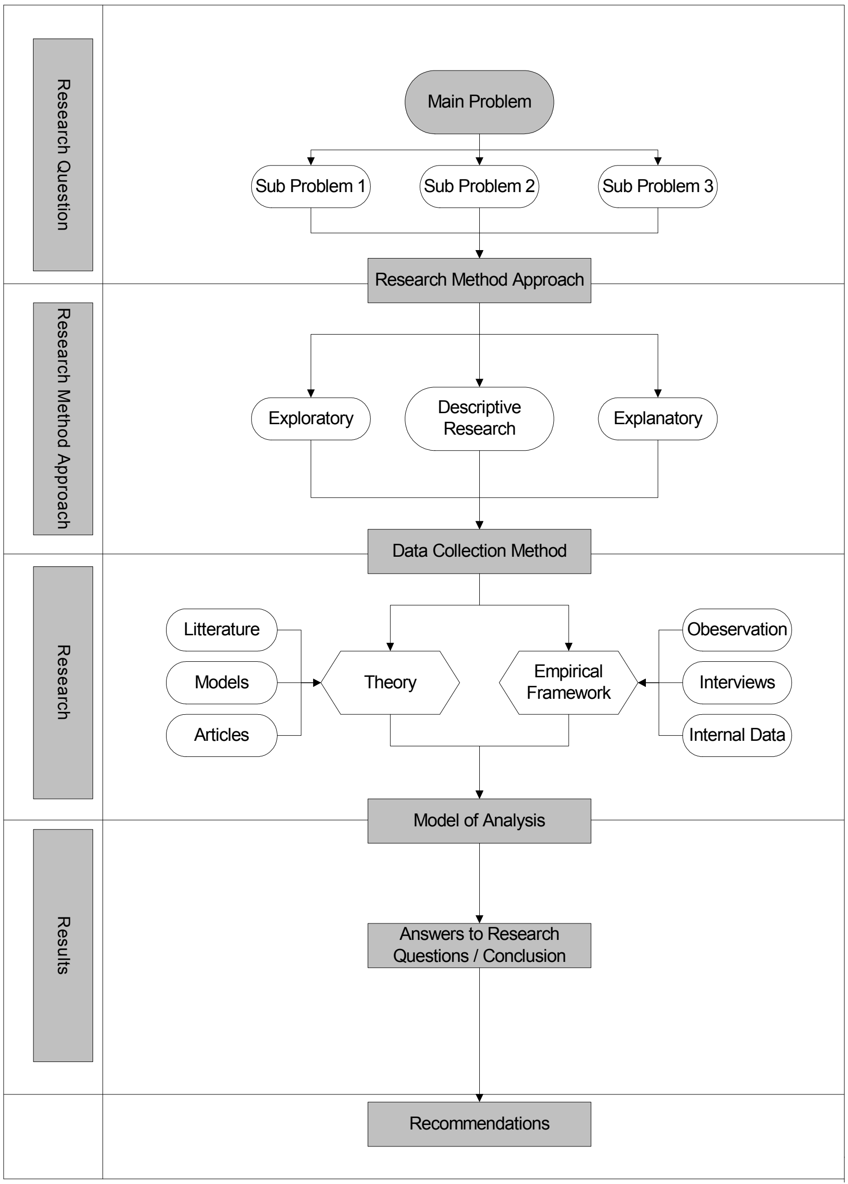
A good design will make sure that the information gathered is consistent with the study objectives, and that the data are collected by accurate and economical procedures. Research objectives are dependent upon the stages of the decision-making process which information is needed. There are different types of

[4] Cooper & Schindler, 1998, p. 130

research methodologies, e.g. exploratory, explanatory, conclusive and performance-monitoring research.[5]

Every empirical research has an implicit, if not explicit, research design. In most elementary sense, the design is the logical sequence that connects the empirical data to a study's initial research questions and, ultimately, to its conclusions. The research process model in figure 2-1 gives the reader an overview of how the thesis is conducted and how the different parts of it are linked together.

Figure 2-1: Research Process Model



[5] Kinnear & Taylor, 1991, p. 135

2.3 Methodology Approach

As stated above[6], a research can be divided into different types of research designs: exploratory, explanatory, conclusive; which can be both descriptive or causal, and a performance monitoring research. However, in this thesis mainly the descriptive, explanatory and exploratory research will be used and explained since the others are not applicable on this research. Another method to categorise different types of research is to identify the project as a quantitative or qualitative study, which will be mentioned in later section of this chapter.

This kind of study can also be explained by the induction and deduction process where induction occurs when fact is observed, and to draw conclusions from them and make hypothesis. Deduction is the process where the hypothesis is tested if it can explain the fact or not. However, these two concepts will not be mentioned in this thesis since the method approaches and data collection methods are instead explained by the above-mentioned approaches, i.e. explorative, descriptive, and explanatory research approaches[7].

2.3.1 The Value of Information

The value of information for a company might be measured in the time required to make a decision or in increased profits to the company. Before selecting a research approach, it is necessary to estimate the value of information, i.e. the value of obtaining answers to the research questions. This estimation will help determine how much time should be spent on the research. The value of the research information may also be judged in terms of "the difference between the result of decisions made with the information and the result that would be made without it".[8]

[6] Kinnear & Taylor, 1991, p. 135
[7] Ibid
[8] Aaker & Day, 1986, p. 33

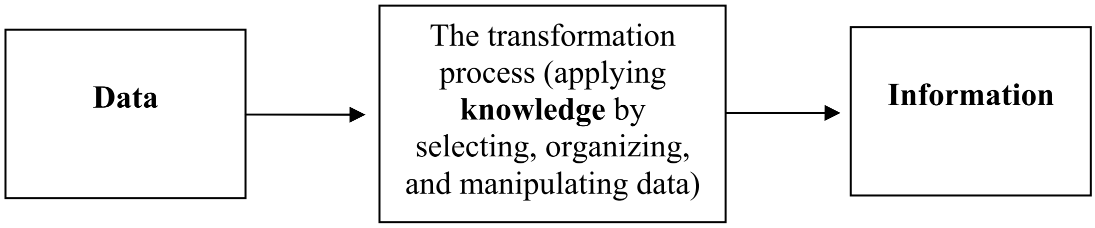


Figure 2-2: The Process of Transforming Data into Information.

Source: Stair & Reynolds, 2001, p. 7

Therefore, when the first valuation of the present information is done a decision of which research approach to select is made. The thesis's assigner, Kalmar Industries, had found that the value of the existing information within the scope of this thesis was low, i.e. there were no existing layout of the present outdoor located storage area and its materials flow. Consequently, the decision of further investigation was made. When the valuation is done some method questions have to be asked. How can the information be found and gathered? How should the mapping procedure be done in order to describe the present situation,? Which employees should be contacted for further information and how many? Should this be done through quantitative research, such as questionnaires or through qualitative ones by carrying out interviews?

2.3.2 The Explorative Research Approach

The explorative research method is the most appropriate when knowledge of the subject is relatively small. This is a form of pre-examination where necessary knowledge is acquired in order to precise the task and the problem definition, and to enter more deeply into the subject. This research design is characterised by flexibility in order to be sensitive to the unexpected and to discover insights not previously recognised. When using an explorative design the objective of the research is to broaden the field of alternatives identified with the hope of including the "best" alternative, in the set of alternatives to be evaluated. Useful techniques are observations; direct and indirect, case studies, studies of secondary data and interviews with experts on the subject.[9]

In this thesis, an explorative research has been used in the form of examining at an early stage, what areas and factors have to be included in the research. This was done in cooperation with the tutor at the company. The whole thesis can

[9] Kinnear & Taylor, 1991, p. 133

also be seen as an exploratory study in the way that it is a pre-study and base for further studies within this field of research. Because there is a great need of input and information of how to change and improve the existing storage area of Kalmar Industries in Lidhult. This study also includes different alternatives of how to change the storage layout, which are evaluated to come up with the best alternative change.

2.3.3 The Descriptive Research Approach

When it is desirable to provide information for the evaluation of alternative research approaches, the descriptive research approach within the conclusive research is often used. The descriptive research method requires more basic knowledge of the subject than the explorative one. A descriptive study is characterised by a clearly defined problem to be explored, specified objects of exploration, a detailed need of information and a detailed and well-structured research design. Facts and state of things are surveyed and the properties of a number of objectives are described. The aim of a descriptive research is to describe how things are, for example, by mapping or observations without explaining why and that must not only be viewed as a fact gathering expedition. It covers an array of research interests and requires skilful planning if they are to be used effectively in decision-making. Data collection methods are surveys, studies of primary and secondary data and simulations.[10]

The descriptive method is highly suitable for the empirical study in this research since the main research question is to find the best way of using the outdoor located storage area. To be able to choose the "best", optimal storage layout plan, based on given conditions, there must exist some parameters that have influence on the storage layout and change it in different ways. The study is descriptive in the way that the storage area is observed and all the articles stored outside are mapped, listed and then sorted in different ways. The problem studied is clearly defined and the facts on the subject have been surveyed, such as studies of both primary and secondary data. The theoretical platform provides a descriptive background and the sources of data in this type of research include interviews and secondary data.

[10] Kinnear & Taylor, 1991, p. 137

2.3.4 Explanatory Research Approach

In an explanatory research method, the aim is to search further for connections between cause and effect. An explanatory study can be done with different focus as the following:" in-depth" by focusing on specific research unities, "in breadth" by focusing on different connections or "over time" by focusing on the development and changes over time. The difference between descriptive and explanatory is quite small. Almost all descriptive research contain explanatory parts as well. The main difference between the two is that an explanatory research usually is concentrated on relatively few variables while the descriptive research covers a broader perspective.[11]

In this study, the explanatory research approach will partly be used in order to find the cause of shortage of storage space and see the connection between the different departments of the company and their functions. Therefore, the explanatory research design aims to explain these connections and how different factors are connected to each other and what impacts they have on each other. In order to get an understanding interviews have been made, both structured and unstructured ones to get a deeper understanding for the cause and problem of the symptom. The symptom in this case is the unorganised storage area and the shortage of storage space.

2.4 Data and Information Collection

The human perception and mind are all but objective and each individual can see things from a certain perspective. In fact, the interpretation is inseparable from subjective perceptions. Therefore, it is important to systematically reflect the nature of the problem from different perspectives. By doing so, the interpretation can reach a higher level of quality, which will give the empirical study a higher value.[12] Therefore, the situation has been viewed from many different perspectives, by using different data collection methods, to be able to interpret the empirical situation in the best possible way.

There are several methods to use in a data and information collection process. The first grouping of this thesis is whether secondary or primary sources of data are used. Secondary data for this thesis is for example studies made by

[11] Lekvall & Whalbin, 1987, p.129
[12] Alvesson & Sköldberg, 1994, p. 77

others for their own purposes. The authors of the thesis, especially to answer the research questions of this study, collect primary data. Primary and secondary have both strengths and weaknesses but normally complement each other in a good way[13].

2.4.1 Secondary Data Collection

Secondary data can be divided into two categories: internal and external data. Internal secondary data is available within the company studied, e.g. annual reports. External secondary data is provided by sources outside the organisation, such as reports and books. However, internal data should always be valued above external data. The advantages of secondary data are that they save cost and time. Secondary data can also serve as comparative data which primary data can be evaluated and interpreted against. Two major disadvantages of secondary data exist is that this data may not fit the project since it was not acquired for this purpose and the accuracy may not be as good as that of primary data.[14]

2.4.1.1 Internal Data

Internal secondary data originates within the organisation studied and is a part of the normal operations, such as sales and cost data, research and development, etc. However, many organisations do not collect and maintain sales and cost data in sufficient detail to be used for many research projects. Additionally, internal data can be proprietary and not accessible to all. The advantages of internal secondary data are their low cost and availability.[15] In this thesis information such as annual reports, documented article information, storage area map have been obtained from the company.

2.4.1.2 External Data

External secondary data is obtained from two main sources: syndicated sources and library sources. Syndicated sources are services that collect standardised data to serve the needs of an array of clients but are fortunately often expensive and sometimes not available for the public. Library sources are e.g. government documents, periodicals, books, and research reports.[16]

[13] Aaker & Day, 1986, p. 54
[14] Kinnear & Taylor, 1991, p. 180 ff.
[15] Ibid, p. 151
[16] Ibid, p. 182

The library is a rich storage base for secondary data but nowadays-computerised databases make literature search much faster and easier to use. Although, a lot of information about storage and warehouses was found it was more difficult to find specific information about outdoor located storages and how to handle the materials flow within the storage area. The theory that was found was not entirely applicable on this thesis' problem area, and can therefore just be used as help in the analysis work. Other external data sources that have been used are conversations with experts in the field of outdoor located storage areas and materials flow, and articles on the subject.

2.4.2 Primary Data Collection

Data collected by those conducting a study for a predetermined purpose is primary data. It is advantageous due to its high degree of reliability and control over errors[17]. Primary data can be collected in a number of different ways, for example through interviews, observations and case studies.

Another way to label a research project is to identify it as quantitative or qualitative. Depending on which one of the two methods that is used different types of primary data is obtained. The qualitative type of investigation proceeds from the researcher's subjective perspective and the quantitative approach proceed from the researcher's ideas about which categories and dimensions should be in focus.[18]

In a quantitative research, the collected data is coded in order to be analysed quantitatively. This type of research is designed to explain what is happening and the frequency of occurrence and includes large-scale surveys, experiments and time-series analysis. Quantitative methods are more formal and structured but it does not mean that this approach is objective since the numbers and techniques used are not always interpreted at the optimal level of objectivity. Instead, objectivity can be subordinated predetermined perceptions of the researcher.[19]

[17] Patel & Davidson, 1991, p. 56-59
[18] Ibid
[19] Ibid

In those studies where data cannot be analysed efficiently in a quantitative way, qualitative research is appropriate. The analysis and interpretation of the data is more subjective in a qualitative research.[20] The qualitative approach allows a wide range of interpretations and perceptions of what seems to be more or less characteristic in the research, since the method is based on more of an understanding of the situation. The important thing is to increase the understanding of the research problem and be able to describe the whole in which this problem exists.[21]

In this investigation, both qualitative and quantitative data have been used. These techniques were used in order to receive as much useful information as possible. The strong sides of each approach are used to complement each other. By using both a quantitative and a qualitative research approach, a more accurate shape of the whole picture illustrating the nature and complexity of storage layout and materials flow of a company will be obtained. In this thesis, both quantitative as well as qualitative research is essential in order to get correct information, since the employees who are managing, the flow of the material is an important information source. Quantitative researches as numeric data in form of information about different article numbers will be handled. Qualitative researches will be made through interviews and meetings with different knowledgeable employees within the logistical area of the organisation.

2.4.2.1 Direct observation- Quantitative research

Observational methods allow the recording of behaviour when it occurs, thus eliminating those errors associated with the recall of behaviour. It is often less costly and more accurate than asking the respondent to recall the same behaviour at another point of time. By making a visit to the research "site", there is an opportunity for direct observation. The observation can be either formal or informal with data collection activities. Formal ones can involve observations of meetings, sidewalk activities, storage or factory work, photographing, etc. Less formally, direct observations might be made throughout a field visit, including short interviews at the same time.

[20] Lekvall & Whalbin, 1993, p. 141
[21] Holme & Solvang, 1997, p. 87 ff.

Observational evidence is often useful in providing additional information about the topic being studied.[22]

Advantages with direct observation:[23]

- Reality, covers events in real time
- Contextual- covers context of event
- Less costly

Disadvantages with direct observation: [24]

- Time- consuming
- Selectivity- unless broad coverage
- Reflexivity- event may proceed differently because it is being observed.
- Cost- hours needed by human observers.

The direct observation included in this thesis was made during the procedure of mapping where a walking-through method was used at first. In the first part of the research, the authors were walking through the area mapping by hand in writing the location and the exact article number of the products. This was a time consuming procedure but gave the most accurate result. The second part of the research consisted of an observation and mapping of the materials flow. However, it was a rather difficult task to find a method of measuring where the main material flows were and the time and distance the internal transport was using. When it comes to find the different flows of material at the storage area, we were in contact with one of the truck drivers, working at the storage area who told us where the main traffic flow within the storage area. Thereafter, manual hand timing was made on these distances and distance measurement in metres was taken on the same routes.

2.4.2.2 Interviews- Qualitative Research

The whole point of doing qualitative interviews is to raise the value of the information and to create a foundation for deeper and more extensive knowledge about the subject studied. While an observation can accurately record what people do and how it is done, it cannot be used to determine the motivations, attitudes, and knowledge that underlie the behaviour. Therefore, it

[22] Yin, 1994, p. 86
[23] Ibid
[24] Ibid

is good to have interviews as a complement.[25] There are two types of face-to-face interviews: unstructured and structured interviews.[26]

In an unstructured interview, the interviewer does not enter the interview setting with a planned sequence of questions that will be asked of the respondent. The objective with this kind of interview is to cause some preliminary issues to surface so that the researcher can decide which variables need further in- depth investigation.

When it comes to structured interviews, it is known at the outset what information is needed. The interviewer often has predetermined questions to ask the respondent either personally or through telephone or mail. In this interview, focus can be put on those subjects discussed during the unstructured interviews.

The advantages of interviews are that[27]:

- the interviewer can ask attendant questions depending on the answers received.
- the interviewer can clarify the questions, clear doubts and add new questions.
- the situation can make the respondent more comfortable, leading to more honest answers.
- the interviewer can use visual aid to clarify points.
- they are targeted and focused on the topic of the study.
- this method makes it easier for the interviewer to build a relationship when body language can be interpreted[28].
- the interviewer can perceive what has not been said[29].
- the respondent and give more in depth answers[30].

[25] Kinnear & Taylor, 1991, p. 147
[26] Sekaran, 2000, p. 222 ff.
[27] Ibid, p. 250
[28] Eriksson & Wiedersheim-Paul, 1991, p. 86
[29] Yin, 1994, p. 80
[30] Holme & Solvang, 1991, p. 110

The disadvantages of interviews are that:

- the interviewer, so called interviewer bias due to poorly asked questions, can affect answers.[31]
- The respondent may be concerned about confidentiality of information given. Therefore, sensitive questions may be difficult to ask due to the non-anonymity of the respondent.[32]
- accessibility may be limited[33].
- inaccuracies due to poor recall may occur[34].
- there are few adequately qualified interviewers and those that are qualified are highly paid[35].
- this method is relatively expensive and time consuming[36].
- The respondents can terminate the interview at any time[37].

In this research, both structured and unstructured interviews were made. The booked interviews were structured in the sense that we had specific questions as guidelines, which were followed, but they were also unstructured in the sense that these questions were not handed out to the respondents in advanced. They had instead only been informed of the subject of the interview. Thereby, the interviews were open and welcomed for open qualitative questions and not too locked up and controlled.

Unstructured interviews in the form of spontaneous face-to-face conversations with people working as truck drivers at Kalmar Industries in Lidhult, and with the tutor Anders Svensson at Kalmar Industries, have also been used.

2.5 Research Evaluation and Errors

When conducting a study, the researcher must be critical since there are many pitfalls that might decrease the credibility of the research. Errors can result in serious misinformation being communicated to managers. However, to be aware of these weaknesses and to consider them when drawing conclusions

[31] Yin, 1994, p. 80
[32] Sekaran, 2000, p. 250
[33] Eriksson & Wiedersheim-Paul, 1991, p. 86
[34] Yin, 1994, p. 80
[35] Kinnear & Taylor, 1991, p. 316
[36] Holme & Solvang, 1991, p. 110
[37] Sekaran, 2000, p. 250

from the findings may counterbalance them to some extent. We will therefore conclude this chapter with an evaluation of this thesis' research.

2.5.1 Evaluation

A critical awareness of different types of research errors and that they may be evident is important from the beginning of the research process. It is as important to choose the direction and approach, as it is to evaluate the validity and the reliability of the study. A research design is supposed to represent a logical set of statements and one can judge the quality of any given design, according to certain logical tests. However, this part of the thesis will focus on the credibility of the study and define whether it can be trusted to give an objective picture through pointing out the validity and reliability of the study.[38]

2.5.1.1 Validity

According to Kinnear and Taylor, the validity of a measure refers to the extent to which the measurement process is free from both systematic and random error. Systematic error refers to an error that causes a constant bias in the measurements, while random error involves influences that bias measurements but are not systematic.[39] According to Lekvall and Wahlbin, validity is defined as the research method's ability to measure what it is intended to measure. Therefore, the main question that validity deals with is: Are we measuring what we think we are measuring? [40]

Validity can be divided into three parts; construct validity, and internal and external validity. To meet the test of construct validity, the investigator should be sure of first selecting the right specific types of changes that are to be studied, and second to demonstrate that the selected measures of these changes do indeed reflect the specific types of change that have been selected. Internal validity deals with the study itself and the direct connection between the theoretical framework and the empirical. External validity concerns the study with all its contents in a broader perspective, which implies if it is possible to generalise from the study, or not. When the study does not have internal validity, the external validity can be excluded as well.[41]

[38] Yin, 1994, p. 34 ff.
[39] Kinnear & Taylor, 1991, p. 231
[40] Lekvall & Whalbin, 1993, p. 211 ff.
[41] Yin, 1994, p. 34 ff.

This study includes both internal and external validity. The validation process in this thesis consists mainly of the opinions expressed by the tutor at the University of Gothenburg, and partly of the opinions expressed by the tutor of Kalmar Industries and comparisons with other similar research projects. Our validation process has also mainly been focused on the external validity since this research not only fills an essential value but will also be read by others. Furthermore, the validity in this research has been established by clearly defining the subject with the aim of ascertaining that no irrelevant questions have been asked. Multiple sources of information have been used; several people within the company as well as experts on the subject have been interviewed in order to gain a deeper understanding of the subject. Other sources of information are homepages, annual reports, literature and articles.

2.5.1.2 Reliability

According to Lekvall and Wahlbin, an interview that is based on a qualitative approach involves an inherent factor of uncertainty concerning reliability of data collected. Reliability concerns whether things are measured in a proper way, without random errors.[42] The reliability is concerned with consistency, accuracy, and predictability of the research findings. The more clearly a problem analysis is formulated, the smaller is the risk of random errors and greater the probability of a high reliability. This means that the measurement must be performed several times in the same way without very different results in order for the reliability to be high.[43] Reliability is a necessary but not sufficient condition for validity.

In order to increase the reliability of this study, only well-known researchers, authors and institutions has been used in the construction of the theoretical framework. The reliability of the primary data, e.g., the interviews is difficult to measure. It is heavily dependent on the credibility of the person interviewed, position, expertise, situation, expectation and own perception on the subject. Therefore, the interviews are conducted in a non-leading manner by designed questions, with the aim to keep the interviews as open as possible. To increase the reliability of this study further the respondents interviewed have been given the information regarding the subject of the study before the interview to give

[42] Lekvall & Whalbin, 1993, p. 213
[43] Eriksson & Wiedersheim-Paul, 1991, p. 27

them possibility to prepare themselves. The questions in the interview guides were used as guidelines, which made it possible for the respondents to discuss other relevant issues. The fact that the interviews were recorded also improves reliability since it reduces interpretation errors. As many persons as possible, relevant for this research, have been interviewed.

The empirical framework has also been sent to the respondents in order to give them possibility to correct mistakes and explain things that they thought to be unclear. We were both well read on the company and the theoretical background when conducting the interviews, which further increased the reliability. Something that may affect the nuance is the fact that the interviews were conducted in Swedish, and then translated into English in this thesis paper.

2.5.2 Research Errors

According to Patel and Davidson, there are three criteria for reliability that are important: respondent errors, measurement errors and interviewer effect.[44]

2.5.2.1 Respondent Errors

Respondent errors arise when the research is erroneous because the respondent cannot or will not give correct answers. As the topics discussed are relatively complex, it demands good knowledge from the respondents. It may therefore be hard for us to see what is correct or faulty but we have done our best in order to be objective and read the answers in the right way.

In this research, some essential errors have arisen during the research. One of the respondents was not aware of the fact that the interviewers had signed a secrecy contract since the respondent asked about it at the end of the interview. This was also shown during the interview because of the fact that no clear and detailed answers were given. Another fact to consider is that the respondents from the company had different positions in the organisation, which might have affected the answers received since they look at the problem from different angles. Therefore, it is important to try to turn this fact into something positive and therefore plan how to handle the persons interviewed during the interviews.

[44] Patel & Davidson, 1991, p. 86-87

2.5.2.2 Interviewer Effect

Interviewer effect arises when the interviewer in some way affects the respondents' answers. This risk is of course larger as the authors of the thesis are unaccustomed to interview situations. In evaluating the quality of the data identified, the researcher must be sensitive to the origin of the data and the research design.

It is hard to avoid not controlling an interview. The answers you aregoing to get all depend on how you as an interviewer asks the questions. When using open questions a more relaxed conversation form is hold and the respondent is able to talk freely without thinking too deeply on possible consequences. By doing this, the interviewer can act more as a support. In this study, we as interviewers tried to act more as a support in order to get as freely answered questions as possible.

2.5.2.3 Measurement Errors

Measurement errors arise when the tools of measurement are wrong, for example poorly formulated questions. As we have made sure that, an objective party read the interview guides before the interviews took place we feel that these errors have been minimised.

Since the article data has been gathered through visual observations there, might be the case of missing articles when doing the observation and can therefore not be taken into account. Since the matching with the company's computer system and the articles found on the storage area was made after three days some articles might have left the area during that time. Therefore, the balance of articles given in the company data might not agree with the data gathered during the observation.

Furthermore, when matching the gathered article data with the data provided from the computer system at Kalmar Industries in Lidhult it was found that a lot of information was missing of some articles. Fortunately, these articles could not be included in the research. The human interference in gathering data and calculations of it could also lead to some measurement errors.

During the twenty weeks long research work, some changes in the storage area has been made. Therefore, the storage layout and its functions have not looked the same during the period. The storage area map has changed slightly during the research and thereby some suggestions made in this study may already have been implemented.

2.6 Summary of Methodology Chapter

In this chapter, we have described what the methodology literature says about different methods to use when writing a research. Some problems that might appear during a thesis study are also mentioned and what research errors that must be taken under consideration. This thesis is mainly a descriptive and partly an exploratory and explanatory research with both quantitative and qualitative data. Primary data such as visual observation and personal interviews have been used as well as secondary data such as theory, which is gathered in the next chapter, articles and internal information gained from the company.

In the empirical part, Chapter 4 that follows the theoretical chapter, data obtained in the research is both presented in text, figures and diagrams in order to clarify the meaning and understanding of the results.

3 Theoretical Framework

This chapter consists of description of the theories that are most vital for understanding the thesis' subject. First, a broader view of process thinking and logistical goals will be given and then be followed by theories more focused on inventory principles, and material handling and management.

3.1 Introduction

Logistics mainly deals with the materials flow and the activities and systems connected to it. In order to deliver the products when they are needed and at a low cost, it is required that the flow of materials is controlled efficiently. The opinion on logistics has gradually turned from only being an instrument for cost reduction to also include the issue of tied up capital and income related issues such as delivery service.[45]

Another important issue to consider is that the material flow cannot be viewed isolated from the information flow. Today, control and communication in materials flow demands computerised information systems. Information systems refer not only to computerised solutions but also to all communication and data processing connected to the material flow. Thereby, the overall control of the entire materials flow can be viewed as a process in order to see how the different parts within it are integrated and have influence on each other.[46]

Holding inventory is a major use of capital and it is therefore of major importance to focus on inventory management. The objectives of inventory management are to increase corporate profitability, to predict the impact of corporate policies on inventory levels, and to minimize the total cost of logistics activities. The amount of products in stock is dependent on how much has been ordered. Therefore, the order quantity has to be optimised, which can be done by the economic order quantity model, i.e. the Wilson equation. However, this thesis will mainly focus upon the structural function of the inventory, the material flow and how the two can be optimised in an efficient

[45] Lumsden, 2002, p.143
[46] Ljungberg & Larsson, 2001, p. 180

manner. One thing goes hand-in-hand with the other but major focus will be put on the latter.[47]

3.2 A Process Oriented Approach

It takes a lot of effort and hard work to change a traditional function oriented organisation into a process oriented. According to the author Anders Ljungberg, the function oriented organisation has over the years given both the employees and the leaders stability in terms of clear functions. However, this feeling of security and traditional thinking might lead to sub-optimisation, internal hierarchic disputes, lack of customer focus, bureaucracy, slow decision-making, and difficulties to adapt the organisation to external changes. By describing the organisation in terms of processes, it will facilitate the understanding of how different parts of the organisation are integrated and cooperate in order to create value to the customers, external or internal. Changes and developments into a process-oriented organisation must be carefully planned. However, several components of a function-oriented organisation are similar or even identical to those in a process-oriented organisation. Therefore, the well- functioning parts of the old organisation must be taken care of instead of just being rejected and replaced. One of the most difficult issues within the development process is the changing of attitudes of the employees and not only the changes of the organisation.[48]

3.2.1 Effective Processes

First, when the process is identified, it is possible to start to make it more efficient and to improve it. In order to know if the process is effective, and if all activities add value to the product or the customer, it is necessary to know the use of resources, such as economical costs, time, personnel, and system resources. The development work of improving processes is similar to the one of improving the quality, follows the five steps below, and is further illustrated in figure 3-1 below.[49]

- **Plan:** Identification and mapping (Determine the processes and illustrate them.)

[47] Stock & Lambert, 2001, p. 226
[48] Ljungberg & Larsson, 2001, p. 180
[49] Ibid, p. 137 ff.

Analysis and reconstruction (How well does the process work? Can they be improved?)

- **Do:** Implementation of new or changed processes (How to make the new processes work in practice?)
- **Check:** Measurement of the processes (Were the processes improved? What will be the next step?
- **Act:** Continuous improvements of the processes (What can be even more improved? Do the processes need to be adjusted to new expectations and conditions?)

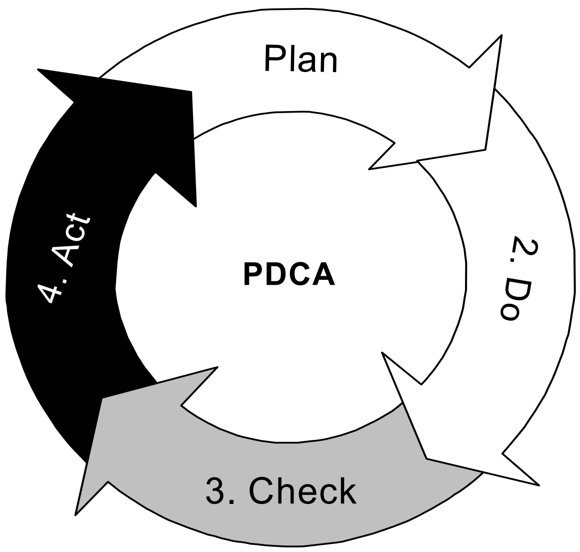


Figure 3-1: PDCA-Cycle Model

Source: Ljungberg & Larsson, 2001

The last step in the development work is one of the most important since there are always things to improve within an organisation. Therefore, the employees themselves, i.e. the process owners, should accomplish the continuous improvement work.[50]

3.2.2 Flexible Processes

A flexible process can be described as a type of process that easily can be adjusted to changes in external and internal condition, i.e. that the process can adjust rapidly without high additional costs or resources.[51]

[50] Ljungberg & Larsson, 2001, p. 142
[51] Ibid, p. 180

3.2.3 Identification of Processes

In order to identify and map a process one must know what a process is. One basic definition of a process is *"a sequence of events or changes"*. The purpose of the process itself is to satisfy an internal and external customer need. The identification of the need will activate a number of activities that will cooperate in order to satisfy the need, e.g. an ordered product to a delivered one and a satisfied customer.[52]

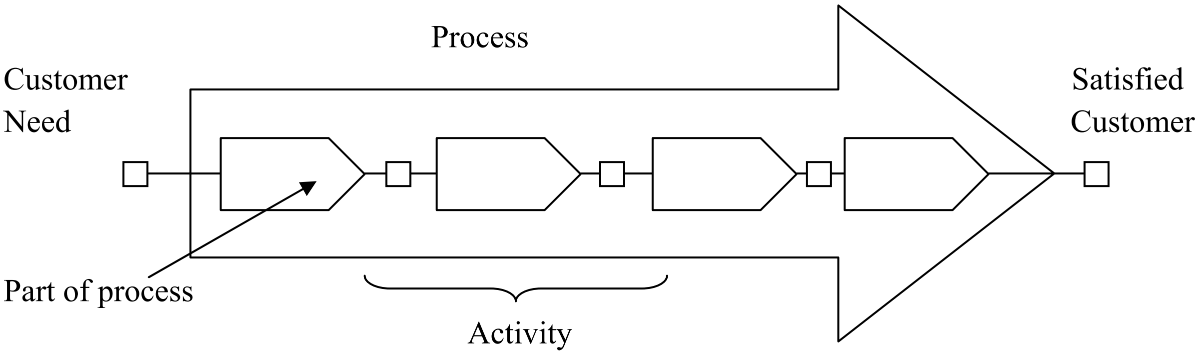


Figure 3-2: Process and Part of Processes

Source: Ljungberg & Larsson, 2001, p. 193

When processes are mapped and visible as in figure 3-2, shown above it is easier for each employee to see where their own work fits into the whole organisation, and thereby gives them a fully understanding of how the processes within the company look like. However, it is important to understand that process mapping does not signify improvements of the processes since the mapping is only one-step in the development of the organisation's processes.[53]

3.2.4 The Components of the Process

The process can be illustrated as figure 3-3 below and include five key words: *object in/ input, activity, resources, information, and object out/ output*. The input is what starts a process, such as an order, i.e. customer need. An *activity* is what adds value to the *object in* or the input, such as planning of production and production of the products. *Resources* are needed in order to complete the activity, such as human resources, material handling equipment, storage area, etc. *Information* supports and controls the process. The *object out* is the result

[52] Ljungberg & Larsson, 2001, p. 194
[53] Ibid, p. 188

of the transformation, for example a finished product, and can sometimes activate the next object in.[54]

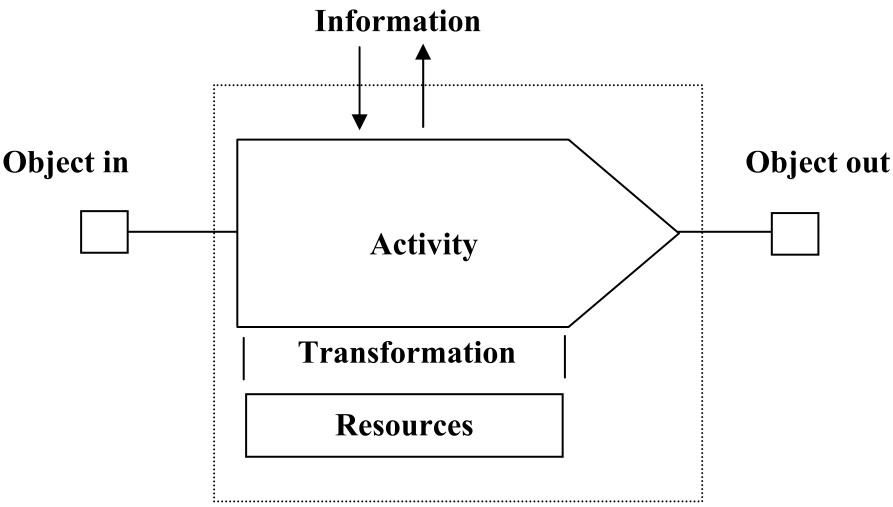


Figure 3-3: The Components of the Process,

Source: Ljungberg & Larsson, 2001, p. 194

3.3 Logistical Goal

The logistical goal mix is the fundamental balance between service, costs and tied-up capital, which all affect profitability. Although all firms try to reach high profitability the problem, or dilemma, is that if a firm improve one part of the business it will have negative effects for other parts. An example can be to reduce transport costs by decreasing the number of shipments. The firm gets lower transportations costs but at the same time increased tied-up capital as a result of larger volumes in stock. Furthermore, the service to customers is lowered due to the decrease in number of shipments. Important here is to look at the entire picture and try to arrange these three components in order to optimise the total result.[55]

To be able to reach the best possible solution to this dilemma firms must often come up with new and intellectual ideas. This is of great importance when it comes to lowering the tied-up capital in order to decrease costs is the efficiency

[54] Ljungberg & Larsson, 2001, p. 194
[55] Lumsden, 2002, p.146-147

of the materials flow, and the layout of the storage. Large savings can be made in this area.[56]

3.3.1 Logistical Profitability

There are mainly three ways of increasing profitability. This can be done partly through cost reduction, partly through increasing the incomes and partly through reducing the amount of capital tied up in stock, an increase of the rate of capital turnover. The best way to improve profitability is to use all three methods simultaneously and materials management is a cost effective combination of the three methods.[57]

3.3.2 Logistical Efficiency

The logistical efficiency can be described in terms of service, costs and tied up capital. However, the problem is that a measure taken to improve one part of the business might lead to negative effects for other parts. For example, a measure used to reduce the costs might at the same time have bad effects on the service level, and thereby the revenue in the long run.[58]

3.3.3 Delivery Service

To obtain a good delivery service, low costs for logistics, low amount of capital tied up and a high quality is demanding. As shown in the figure 3-4 below delivery service is the part of logistics that generates revenue, at least in a longer perspective. A good delivery service can be everything from being a fast deliverer and always keeping its promises, to having such a reliable distribution that the goods are never damaged during transport. There is also an important interrelationship between marketing and logistics primarily when discussing service. However, the delivery service only refers to the parts in customer service that deals with the physical flow. Delivery service is a comprehensive concept that can be broken down into different parts, such as lead-time, delivery reliability, delivery security, degree of service, flexibility, and information.[59]

[56] Lumsden, 2002, p.146-147
[57] Ibid, p. 145
[58] Lumsden, 2002, p. 147
[59] Ibid

This dilemma and cost trade-off between delivery service, tied up capital and logistical cost is, according to Professor Kenth Lumsden, called the "logistical mix of goals". In figure 3-4, the concept of the fundamental balance and the logistical mix of goals, which is based on models made by Lumsden is illustrated.[60]

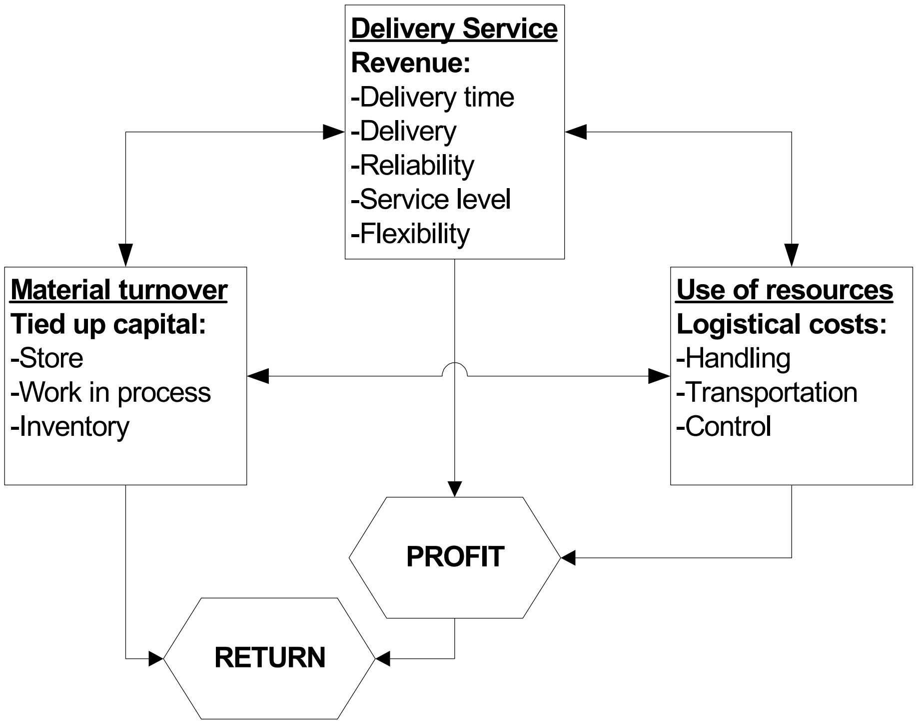


Figure 3-4: "The Fundamental Balance- The Logistical Mix of Goals"

3.4 Why Hold Inventory

Holding inventory is very costly for most firms and inventory often represents the single largest investment. As a result of globalisation companies are trying to satisfy the needs of diverse market segments. This together with the fact that customers have become more used to a high level of product availability has resulted in high inventory levels. Apart from this there are, according to Stock and Lambert, five further reasons for holding inventory. These are:[61]

1. It enables the firms to achieve economies of scale.
2. It balances supply and demand.
3. It enables specialisation in manufacturing.
4. It provides protection from uncertainties in demand and order cycle.

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60 Lumsden, 2002, p. 146

61 Stock & Lambert, 2001, p. 228

5. It acts as a buffer between critical interfaces within the supply chain.

All of these reasons for holding inventory should be weighted against the costs associated with holding inventory. Costs, such as capital costs, inventory costs, inventory service costs, storage space costs, and inventory risk costs.

3.4.1 Economies of Scale

For a firm to achieve economies of scale in purchasing, transportation and manufacturing, holding inventory is crucial. Per unit price reductions is possible if the articles are purchased in large volumes. The same goes for transportation. The more a firm transports at once the lower the price per unit for the transportation will be. This is due to lower transportation rates per unit for full truckloads (FTL) than for less than truckload (LTL). It is the same reasoning whether it comes to raw material or final products. For final products, it is also possible to achieve manufacturing economies. The reason is that plant capacity is greater and per-unit manufacturing costs are lower if a firm schedules long production runs with few line changes.[62]

3.4.2 Balancing Supply and Demand

Another reason for holding inventory is that most firms have demand and supply that will fluctuate over time, so-called seasonal supply and demand. An example of this can be a manufacturer of ice cream. During summer, the demand is much higher than for the rest of the year. It would be very costly to have manufacturing capacity to handle the high volumes during the peak summer-months. Instead, the ice-cream manufacturer produces at a somewhat constant level with a stable workforce, during the entire year and thereby uses the inventory to handle the peak demand. This would result in inventory built-up at various times but at a lower total cost. The same goes when there is a stable demand but the supply of raw material change, for different reasons, during the year.[63]

3.4.3 Specialisation

By holding inventory, each of a manufacturer's plants will be able to specialise the manufacturing of products. The final products are shipped to large warehouses from where the products are transported to the customer. By doing

[62] Stock & Lambert, 2001, p. 228-229
[63] Ibid, p. 229

this the manufacturer can keep longer production runs and decrease the cost of transportation.

3.4.4 Protection from Uncertainties

Protection from uncertainties is another reason why firms hold inventory. Excess of raw materials can be the result of speculative purchases, where the purchaser believes in a future price increase of, or for example a strike. Seasonal availability of raw materials, as mentioned earlier, is a further reason for holding inventory in order to protect from uncertainties. Some raw materials, such as fruit, cannot be purchased the whole year, thus the built-up of inventory.[64]

Work-in-process inventory is held because the manufacturer wants to avoid work stoppage or breakdown of machinery. As stated by Stock and Lambert, "the stockpiling of work-in-process within the manufacturing complex permits maximum economies of production without work stoppage".[65]

Finished goods inventory is held to improve customer service levels. By holding finished goods, inventory firms can avoid or reduce the likelihood of stock-out as a result of unanticipated demand.

3.4.5 A Buffer throughout the Supply Chain

There are several critical interfaces in the supply chain where inventory can act as a buffer. These interfaces are:

- Supplier-procurement.
- Procurement-production.
- Production-marketing.
- Marketing-distribution.
- Distribution-intermediary.
- Intermediary-consumer.

In today's global business environment, most members of a supply chain are geographically diverse. It is therefore necessary for these members to hold inventory in order to achieve time and place utility.

[64] Stock & Lambert, 2001, p. 230
[65] Ibid, p. 230

3.5 Inventory Types

Inventories can be categorised into six different types, signifying the reasons for which they are accumulated. In the following section, these different types will be further presented in order to give further understanding of the subject. The inventory types are cycle stock, in-transit stock, safety or buffer stock, speculative stock, seasonal stock, and dead stock.[66]

Cycle stock is inventory that results form the replenishment process and is required in order to meet demand under conditions of certainty, i.e. when the firm can predict demand and lead times perfectly. Consequently, if demand and lead- time are constant only cycle stock is necessary.

In-transit inventories are items that are in route from one location to another. They may be considered part of cycle stock even though they are not available for sale or shipment until after they arrive at the destination.

Safety or buffer stock is held in excess of cycle stock because of uncertainty in demand or lead-time. A portion of average inventory should be devoted to cover short- range variations in demand and lead-time. Thereby, variability in demand and lead-time increases safety stock.

Speculative stock is inventory held for reasons other than satisfying current demand. Materials may be purchased in volumes larger than necessary in order to receive quantity discounts, due to forecasted price increase or materials shortage, or to protect the company against the possibility of production interruptions.

Seasonal stock is a type of speculative stock that involves the accumulation of inventory before a season begins in order to maintain a stable labour force and stable production runs.

Dead stock is the set of items for which no demand has been registered for some specific period.

[66] Stock & Lambert, 2001, p. 432

3.5.1 Inventory Carrying Cost

Inventory carrying costs should include only those costs that vary with the quantity of inventory and that can be categorised into the following groups: capital costs, inventory costs, inventory service costs, storage space costs, and inventory risk costs. Inventory carrying cost is the cost associated with the quantity of inventory stored. The majority of these costs and the fact that inventory levels are influenced by the configuration of the logistics system show the need for an accurate assessment of inventory carrying costs. Each company should determine its own logistics costs and strive to minimize the total of these costs but at the same time follow its customer service goals.[67]

3.6 Layout and Design Principles

The optimal warehouse layout and design for an organisation will vary by the type of products being stored, availability of financial resources, level and type of competition, and customer needs. Where should things be located in the organisation's logistics system? More specifically, where should products be located within the warehouse? According to Bowersox, et al., the layout and the material handling system are integral and the layout or storage plan of a warehouse should be planned to facilitate product flow.[68]

Before deciding the layout and design there are also various cost trade-offs between labour, equipment, space, and information to take under consideration. The main goal with a good warehouse layout is that it can increase output, improve product flow, reduce costs, improve service to customer, and provide better working conditions.

However, according to David E. Mulcahy, warehouse layout philosophies are based on eighteen different factors with different conditions. These factors are type of stock keeping unit (SKU) handled, SKU popularity or Pareto's law that is further mentioned in part 3.7.1, i.e. travel distance for the transportation vehicle, family grouping, SKU rotation, rack row and aisle direction, aisle length, building height, storage vehicle, order-pick method, internal transportation method, sorting method, handling of returns and out-of-season

[67] Stock & Lambert, 2001, p. 193-196
[68] Bowersox, et al., 2002, p. 400

product transfers, receiving and shipping dock design, facility construction, building size and shape, and SKU flow pattern.[69]

3.6.1 Goals with Layout Design

The ideal warehouse design is a one-floor building that eliminates the need to move products vertically. The use of vertical handling devices, such as elevators and conveyors, to move products between the floors requires time, energy, and typically creates handling bottlenecks. Therefore, where it is possible warehouses should be designed as one-floor operations to facilitate materials handling. The goal with warehouse design should be to maximize the cubic utilization and to facilitate continuous straight product flows through the building.[70]

Furthermore, there are three areas within these goals mentioned above that especially are desirable to cover when designing storages. These are reaching as high filling rate as possible, reduce transportation work, and to facilitate the finding and access of the products. They connect easily to the order of work.

3.6.1.1 High Filling Rate

Maximum use of the storage area gives a low accessibility of the goods. However, a 100% filling rate will give enormous problem with accessing the goods and it will decrease the flexibility. The storage with high filling rate will now have the lowest possible capital cost with respect to equipment and facilities but very high operating costs.[71]

By instead using maximum handling efficiency the access to every article would be immediate, and they would be easy to localize, which will enable fast picking. This system would have low operating costs but unreasonably high capital costs, since the capacity use of the building and equipment would be low.[72]

[69] Mulcahy, 1994, p. 3.13
[70] Bowersox, et al., 2002, p. 398
[71] Lumsden, 2002, p. 216
[72] Ibid

3.6.1.2 Reduced Transportation Work

Moreover, high frequency goods should be placed where the transportation distance reaches a minimum, while low frequency products can be located farther away. By doing this transportation work will be reduced, which will be further discussed in part 3.12. This will both save time and money.

3.6.1.3 Storage- and Handling Efficiency

The design of the storage has a major impact on handling and storage of articles, since a material handling system is the basic driver of a warehouse design. Regarding the condition of easy found and accessible goods, this means that it is easy to reach the item or pallet without moving other items or pallets that are in the way. If the products are hard to find and the handling takes too long, the costs will also be higher.[73]

Efficient handling is often in conflict with storage of articles. Since efficient handling assumes that articles are easy to reach while efficient storing assumes a high degree of use of the storage. Due to this conflict, the warehouse often is a compromise between maximum store efficiency and maximum handling efficiency.[74] This is a trade-off in similarity to what Hassan states that an incorrect estimated storage need could lead to crowded conditions on the one hand or wasted space on the other hand[75].

Storage costs decrease with increased turnover rate and more efficient storing methods, while handling costs increase. Therefore, an optimisation of the total efficiency must be done with respect to both storing and handling at the same time. Thereby, cost efficiency requires balance between storing and handling.[76]

3.7 Stratification of Articles

When it comes to the storage of articles, it is important to understand that different articles should be treated in different ways depending on their characteristics. It is therefore beneficial to differentiate articles after, for example, volume, and weight or volume value. The most interested method for

[73] Lumsden, 2002, p. 215
[74] Ibid, p. 215
[75] Hassan, 2002, p. 436
[76] Lumsden, 2002, p. 215

the majority of firms is the volume value. This method can be seen used in the so-called ABC Analysis.

3.7.1 ABC Analysis

Most firms have a vast assortment of products and articles that need to be stored. It is therefore natural to ask the question which parts of the assortment, i.e. which articles, are in need of special attention. The reason for this is that it is not beneficial to closely examine and give equal attention to all articles. Normally, it is not possible time wise treating all articles equally. It is more useful to look at, for example, articles with high volume and gives these special attentions in term of storage routines, control and trying to decrease order costs.[77]

It was in the 18th century that Villefredo Pareto found, when he was studying the distribution of wealth in Milan, that 20 percent of the people controlled 80 percent of the wealth (the Pareto Principle). What Pareto found out that long ago has shown to fit into many situations such as determining the most valuable articles or customers.[78]

The logic behind the ABC analysis is the Pareto Principle, more commonly known as the 80/20 rule. This rule shows that in many cases 20 percent of most firms' articles generate 80 percent of the volume value (Vv).

Vv = n * p
n = the number of a certain article number during a specific time period
p = the article's value

The ABC analysis is conducted so that the articles are differentiated according to their importance. The articles with the highest volume value are the most important and therefore called A-products. These products should be given special attention like reducing lead-times, reducing uncertainties, reducing order costs, and increase frequencies. The less important articles in category B and especially in category C (B-products and C-products) do not have to have as sophisticated order principles and control techniques as the A products.

[77] Nordén, 1986, p. 65
[78] Stock & Lambert, 2001, p. 256

Simpler order principles and control techniques is sufficient to ensure acceptable delivery service to minimal costs.[79]

There are clear advantages of using the ABC analysis when deciding issues such as where the articles should be placed in the warehouse, how frequent they should be ordered or how large the quantities should be. However, there are also disadvantages. The ABC analysis, i.e. controlling the storage only from the classification of volume value, does not consider profitability. Articles with high profitability can end up as C-products and thereby be given low priority. Further, an article with low price and high consumption may be put into the same category as an article with high price and low consumption. This could result in that the products are treated in the same way when they in fact should be treated differently and different control principles and tools should be used. Another negative aspect is that products that complement each other are being separated as a result of the ABC classification.[80]

3.7.2 Fixed or Floating Placement

There are two types of placement principles that can be used when storing articles: fixed or floating placement. Fixed placement means, as the name suggests, that each of the articles has a fixed or given location in the storage. The size of the storage is therefore equal to the sum of the safety stock of all articles plus the order quantity[81]. This type of placement requires larger space than with floating placement. However, the advantage is that it is easier for whoever is handling the articles to find them.

When using floating placement a package can be given any location in the storage, i.e. as soon as a location is free, another package can be put in that space. When using this type of placement the total number of package locations needed is reduced as a result of better usage of the package locations[82]. The drawback of this principle is that it can be difficult to find the articles if the storage is large, and if there are many people handling the articles. Difficulty in

[79] Lumsden, 2002, p. 217
[80] Ibid
[81] Ibid, p. 223
[82] Ibid.

finding the articles quickly leads to increased handling-time and reduced efficiency.[83]

3.7.3 Time for Access

The location of articles in storage directly affects the time for access. Time for access can be reduced by placing the articles depending on their frequency. Articles with high frequency should be placed so that they are easy to access, which would lead to shorter distance to drive. This means, that the capacity of the storage increases, i.e. larger volumes can be handled with the same use of space[84].

As already mentioned, the utilisation of the storage is another crucial factor that influences the time for access. The location and storing become more difficult if the utilisation is too high. This means that it takes a longer time to find the correct products, which in turn increases the time of access.[85]

3.7.4 Placement Principles

It is very difficult to find an optimal solution to where all the articles should be placed in storage. This is due to the complexity of storing a large amount of articles. Another reason is the fact that the circumstances of storing change on a regular basis, e.g. new products with different weight, volume, size and frequency are to be stored. Further, as stated by Lumsden, there is no general method of determining the most beneficial location for an article. [86] However, there are a number of principles that can be used so that the placement of articles can be improved in order to increase the efficiency of the materials flow. These principles are listed below.

3.7.4.1 Principle of Product Rotation

The warehouse layout is often based on the required SKU rotation. There are two of these SKU rotation methods, such as first in first out (FIFO) and last in first out (LIFO) rotation.[87]

[83] Lumsden, 2002, p. 223
[84] Gunasekaran, et al., 1999, p 328
[85] Lumsden, 2002, p. 225
[86] Ibid, p. 226
[87] Mulcahy, 1994, p. 3.20

First In First Out, or FIFO, is used if a product has to be consumed within a specific period. FIFO means that the article that arrived first is also the one that is picked first. FIFO requires that the storage have a layout, which enables the oldest article to be picked first. In the case of FIFO, storage methods such as depth storage and free stacking are to be avoided, as these would lead to extra work. This storage method utilizes a large square foot area.

LIFO is another method belonging to the Principle of Product Rotation and means that the article that arrived last is to be picked first. When using LIFO it is often possible to use the available space in a better way. This type of product does not have fixed lifetime. This feature allows the warehouse layout to use dense storage concepts that reduce the building square foot area.

3.7.4.2 Principle of Popularity

The principle of popularity states that the articles should be grouped together according to their frequency. In this case, it means that the articles with the highest frequency or volume should be placed near the shipping department, or near to where they should be used, in order to reduce transport work and save time. The principle of popularity is based on the ABC analysis, and it is not unusual that 80 percent of the volume come from 20 percent of the articles, so-called A-products. Just as with the ABC analysis, the principle of popularity is based on the assumption that there is a steady consumption. Under ideal conditions, an article remains in the same group all the time. However, this is often not true in the real world where frequency of the articles changes continuously.[88]

3.7.4.3 Principle of Similarity

Articles that are to be shipped together should also be stored together. This is the essence of the principle of similarity. By storing these articles close or next to each other will reduce the driving distance and the time it takes to collect them.

3.7.4.4 Principle of Size

According to the principle of size, the articles that are large, heavy or difficult to handle should be stored close to where they will be used or close to the

[88] Lumsden, 2002, p. 227

shipping area. The reason for this is that it is much more costly to handle such articles and therefore the transportation distance should be minimised.

3.7.4.5 Principle of Aisle Length

Picking and storing efficiency is much influenced by the length of the aisles. You can increase storing efficiency by using long aisles but at the cost of the picking efficiency. With long aisles, as just stated, the storing efficiency increases but whoever is collecting the articles must drive a greater distance in order to reach another aisle. Short aisles, on the other hand, decreases storing efficiency since cross-aisles need space but this gives easy access to other aisles (increased picking efficiency).[89]

3.8 How to Increase the Storage Space

According to David Mulcahy, there are different ways of how to increase the storage space. When it is necessary to increase the storage utilisation in the design of a new facility or in a reconstruction of an existing facility, there are several options to consider as solutions to the project. Four different options of reconstruction will be discussed in the following section: more efficient use of airspace, the usage of narrow-aisle or very-narrow-aisle vehicles, the usage of dense storage concepts, and storage expansion.[90]

3.8.1 More Efficient Use of Airspace

The first option is to use the airspace more efficiently by using freestanding or equipment supported mezzanines, taller racks, or different types of stacking frames. Each of these storage equipment alternatives increases the number of unit loads, cartons, or single items that are vertically stacked per square foot of floor space. However, these solutions require a lift truck to reach the new elevated stacking position.

3.8.2 Use Narrow Aisle or very Narrow aisle Vehicles

The second solution is to use narrow-aisle or very-narrow-aisle material handling vehicles with tall racks. This solution is best applicable to an indoor storage area. In a building, these material handling vehicles and racks increase the number of rack rows for unit-load storage within the building structure.

[89] Lumsden, 2002, p. 229
[90] Mulcahy, 1994, p. 3.33

3.8.3 Use Dense Storage Concepts

The third possibility is to use dense storage material handling rack storage equipment. This method is especially good for a building that uses floor stack, flow racks, and drive-in or drive-through racks. These storage systems require fewer aisles than standard racks do.

3.8.4 Expansion of Storage Area

The final solution to increase the storage capacity is to expand the existing building or storage space with the same or new material handling equipment. The expansion can be either above or below ground.

3.8.5 Delimitations and Demands when changing the Storage

The demands are derived from different functions in the company, such as the type of goods, flow, transportation routes, layout design, the environment, working environment, future perspective, flexibility and the employees. Delimitations that must be taken into consideration and which are set by the employees are knowledge, habits and education. Other delimitations are technical, economical, time restraints, marketing, and juridical. *Technical* delimitations are for example production restrictions, transport systems, existing equipment and buildings. *Economical* delimitations such as investments frames and return on investments demands. Delimitations due to *time restrictions* are project deadlines, delivery time and dead lines. Delimitations caused by the *market* are the demand and supply interference. *Juridical* restrictions that must be taken under consideration are laws, working environment restrictions and cooperative decisions.[91]

3.8.6 Future Expansion

Due to the fact that warehouses are increasingly important in contemporary logistical networks, the future expansion should be considered during the initial planning phase. Normally organisations establish 5 to 10 year expansions plans. Thereby the inventory layout can be designed and flexible for future changes and expansions.

[91] Larsson, Evert, "Metodik och transportanalys", Lecture material, p. 2.14

3.9 Managing Materials Flow

It was at the beginning of the 1980's when more and more firms started to understand the importance of customer service that the concept of materials management developed. As economies moved from being product-driven to market-driven firms realised that in order to meet customers' requirements and stay competitive an efficient physical supply of materials was crucial in an organisation.

3.9.1 Definition of Materials Management

Efficient materials flow is very important in order for firms to deliver their products at the right time, in the right quality and quantity, at the right price and at the right place i.e. the essence of the concept of logistics. The definition of efficient material flow is given in part 1.7. Logistics is defined as "that part of the supply chain that plans, implements, and controls the efficient flow and storage of goods, services and related information from point-of-origin to point-of-consumption in order to meet customers' requirements"[92]. *Materials management* is a subset of logistics and deals with that flow which includes the administration of raw materials, subassemblies, manufactured parts, packing materials, and in-process inventory[93].

The main objective of materials management is "to solve problems from a total company viewpoint by coordinating performance of the various materials functions, providing a communication network, and controlling materials flow".[94] This objective goes very much hand-in-hand with the overall objective of most firms, which is to stay competitive, increase profitability and increase return on investments.

[92] Stock & Lambert, 2001, p. 3
[93] Ibid, p. 274
[94] Stock & Lambert, 2001, p. 275

3.9.2 Scope of Materials Management

Even if materials management does not directly interact with the final customers, it determines the availability of the products to the customer and thereby the delivery reliability, delivery security, i.e. the delivery service. If a company, through sound materials management, has an efficient flow of raw materials, components parts and subassemblies it will have, together with other factors, e.g. frequent transportation, a positive affect on the availability of products to the customer. As stated by Stock & Lambert, "the internal customer is just as important as the final customer"[95].

Most firms strive to be as profitable as possible. According to Lumsden, there are three ways to improve the profitability: through cost reduction, through increasing the income and through reducing the amount of capital tied up in stock. Lumsden further states that the best way to improve the profitability is to use all three methods simultaneously. Materials management is a cost effective combination of the three methods and thereby an effective tool for increased profitability.[96]

Increased profitability goes hand-in-hand with the major objectives of materials management. A shown in figure 3-5 below, the objectives are to lower costs, increase level of service, lower level of tied-up capital, and support other functions within organisations[97]. To be able to reach these objectives it is extremely important to have a good and well-functioning information flow. The flow of materials is very much connected with the flow of information that flows back and forth along the physical flow. Information is the centre of any logistical system, where the speed and quality of the information flow has direct impact on the cost and efficiency of the entire flow. According to Stock and Lambert, "slow, erratic communication can lead to not only lost customers but also excessive transportation, inventory, and warehousing costs, as well as possible production inefficiencies".[98] Information and its importance will be further discussed in part 3.13. Stock and Lambert further state that as competition is getting fiercer and fiercer organisations are increasingly using

[95] Stock & Lambert, 2001, p. 274
[96] Lumsden, 2002, p. 145
[97] Stock & Lambert, 2001, p. 275
[98] Ibid, p. 146

information technologies as a source of competitive advantage. Examples can be systems such as quick response (QR), just-in-time (JIT), and efficient consumer response (ECR) that in the end reduce order cycle time and lower inventory.[99]

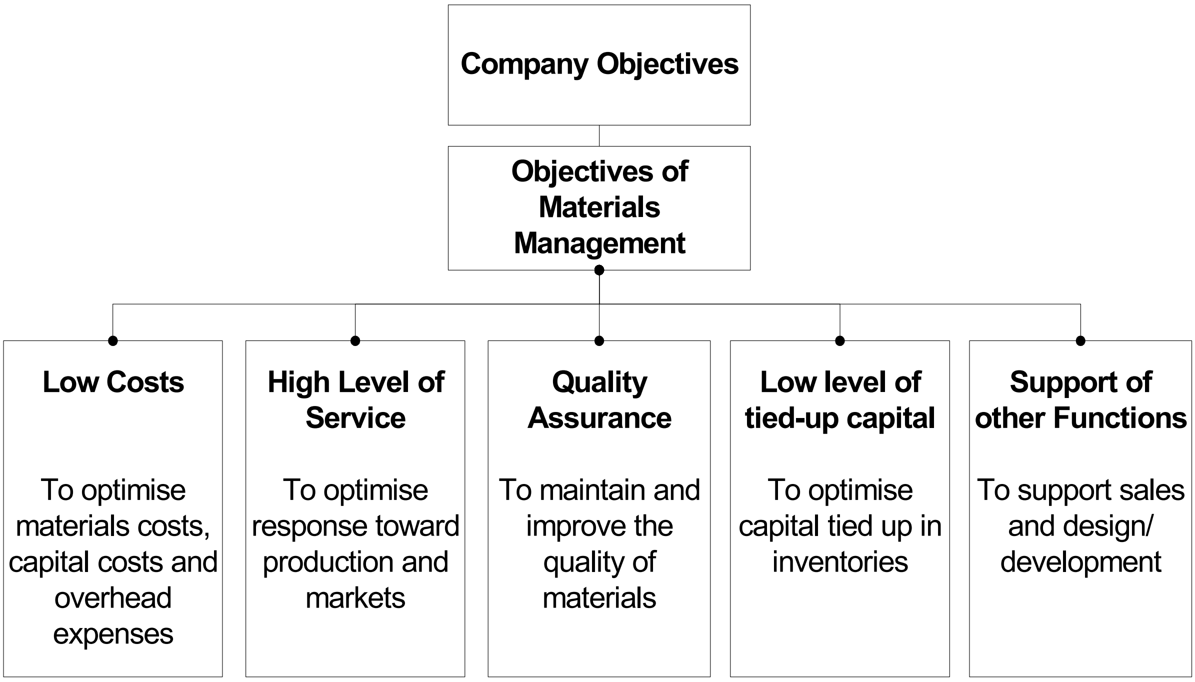


Figure 3-5: The Objective of Integrated Materials Management"

Source: Stock & Lambert, 2001, p. 276

3.9.2.1 Vendor Managed Inventory

There are different actions to take if a company wants to focus on its core business and outsource those functions that can be taken care of by other parties, e.g. the suppliers. Managed inventory is a set of business practices and related technologies that place the responsibility of managing the customer's inventory levels on the vendor, which allows[100]:

- shorter lead-times.
- improved delivery performance.
- decreased stock-outs.
- higher service levels.
- a closer vendor/ customer relationship.
- increased information transparency.

[99] Stock & Lambert, 2001, p. 46
[100] www.bluehabanero.com/intelliops_1.htm, 2003-11-21

- dramatically decreased inventory carrying costs for the customer.

As shown in figure 3-6 below, this relationship can involve three different parties, i.e. the vendor, the customer and the third party[101]:

The vendors (vendor-managed inventory): the vendor or distributor receives electronic data about the customer's sales and stock levels, the vendor is responsible for creating and maintaining the inventory plan or the vendor generates the replenishment order, not the customer.

Consignment: The vendor or distributor places inventory at a customer's location and retains ownership of the inventory. Payment is not made until the item is actually sold or consumed.

Third party: Similar to VMI, except that a third-party company (usually a logistics provider) takes responsibility over maintaining stock levels and the inventory plan.

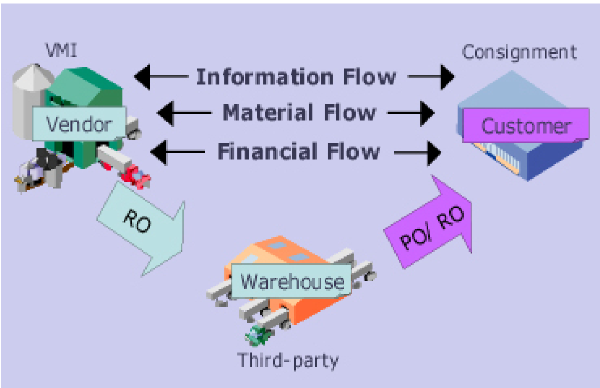


Figure 3-6: Vendor Managed Inventory

Source: www.bluehabanero.com/intelliops_1.htm, 2003-11-21

3.9.3 Administration and Control of Materials Flow

As with many other functions within a firm materials management needs to be well-controlled and administrated. Firms therefore need to identify their level of performance. The level of performance can be measured in many different ways. However, when it comes to measuring materials management firms

[101] www.bluehabanero.com/intelliops_1.htm, 2003-11-21

should observe aspect such as supplier service levels, inventory, price paid for materials, quality levels and operating costs.[102]

Service levels can be measured using methods such as:

- Order Cycle time for each supplier.
- Variability in order cycle time for each supplier.
- Order fill rate for each supplier.
- Percentage of orders from each supplier that is overdue.
- Percentage of production orders not filled on time.
- Number of stock-outs resulting from late deliveries from supplies.
- Number of production delays caused by materials being out of stock.

By using these methods for measuring, firms will be able to get a picture of how well their suppliers are keeping deliveries. Suppliers that are not performing well can be removed and the total service level can be increased.

Inventory should be measured and controlled closely because not only does it directly affects the level of performance but also effects the firm's cost structure. Holding inventory is expensive but in many cases a must. Choosing to minimize or to not hold inventory at all can, as mentioned in Part 3.4 Why Hold Inventory, increase purchasing price of materials, increase transportation costs and can lead to work-stoppage. Below follows measures on how to control inventory[103]. Through:

- amount of dead stock.
- comparison of actual inventory levels with targeted levels.
- comparison of inventory turnover rates with data from previous time periods.
- percentage of stock-outs caused by improper purchasing decisions.
- number of production delays caused by improper purchasing decisions.

Materials *price level* measures, according to Stock and Lambert, include gains and losses resulting from forward buying, a comparison of prices paid for

[102] Stock & Lambert, 2001, p. 287
[103] Ibid

major items over several time periods, and a comparison of actual prices paid for materials with targeted prices[104].

Quality control is another important issue in the area of materials management. When measuring quality control firms can, for example look at the number of product failures caused by materials defects, and the percentage of materials rejected from each suppliers' shipments.

When these, or at least some of these, materials management measures have been established the result should be reported to the management in order for them to evaluate and take proper actions. The actions should be taken so that the main objective of the materials management can be arrived at. Namely, "to solve problems from a total company viewpoint by coordinating performance of the various materials functions, providing a communication network, and controlling materials flow".

The reports that are the basis for the management's decisions should include market and economic conditions and price performance, inventory investment changes, purchasing operations and effectiveness, and operations affecting administration and financial activities.

There are further options for companies to improve materials management performance. Examples can be computerised systems such as MRP, ERP and DRP. However, these are out of the boundaries of this study.

3.10 Product Flow Pattern Philosophy

Handling the incoming traffic in an efficient way can be very hard to master. There are several different descriptions of how to handle this. According to Mulcahy, several different alternatives have to be considered when developing this flow.[105]

3.10.1 One-Way (Straight) Flow Pattern

The one-way flow is a flow where the goods arrive from one side and leave on the opposite side. The pattern is symbolised by the goods need to travel the

[104] Stock & Lambert, 2001, p. 287
[105] Mulcahy, 1994, p. 4.14

entire distance from the receiving to the shipping areas. The model has a disadvantage in the sense that the cost related to the internal transportation will increase due to the operators' inability to perform dual-cycle storage transactions, i.e. a two-way flow pattern. The model is best suited for companies that use a cross docking flow.[106]

In a one-way pattern flow, the road should be at least 4 metres wide where it should be enough room for a 24 m vehicle to manoeuvre. The advantages in using a one-way flow is, better vehicle flow as well as improved yard safety.[107]

3.10.2 Two-Way Flow Pattern

The two-way flow pattern means that the goods are both received and delivered at the same side of the warehouse. This model improves the internal transportation productivity since employees can make dual-cycle trips from the shipping, receiving areas and to the storages. Compared to the one-way flow this model do not require as large truck-yards and roads. This means that the two-way flow model is cheaper from an investment point of view.[108]

The two-way flow pattern allows the arriving truck to travel in both directions between the area gates and the truck dock. The road should be no less than 8 metres wide and be able to manoeuvre a 24-metre long vehicle. For safety reasons there should also be a pathway for employees beside the road. A great advantage of this model is that the docking time will decrease but a disadvantage is that the safety and the control will decrease.[109]

3.10.3 U-Flow Pattern

The U flow pattern is a type of a two-way flow. A U-flow pattern is used when the goods are received at the gate then transported to the left hand side of the warehouse. The finished goods are later sent out from the right side of the warehouse through the same gate as it arrived.[110]

[106] Mulcahy, 1994, p, 3.31
[107] Ibid, p. 4.14
[108] Ibid, p. 3.31
[109] Ibid, p. 4.14
[110] Ibid, p. 3.31

3.10.4 W Flow Pattern

The W-flow pattern reminds of the U-flow pattern. The goods arrive on one side of the building and are then processed or stored in the building. When the goods are transported from the building, the outflow takes place on the left and the right side. You could also draw a parallel of this flow as a double U.[111]

3.11 Internal Traffic system

The construction of traffic system in an inbound industrial area is crucial in case of new construction or reconstruction due to:[112]

- The traffic system constitutes one of the most vital communications links between the people working in the system and the different working stations.
- The traffic system is one of the largest risk factors in an industry due to large percentage of the total injuries in an industry.

The goal of a traffic system is partly to achieve largest possible traffic safety. The traffic system should also be easy to manage in order to avoid complexity. The system should be constructed in a way that the large traffic flows do not need to cross other large flows. Furthermore, the large flows should be split into smaller networks to avoid congestion. Therefore, the large flows that pass between the production sites will be given a high priority and the smaller network will be protected from the transit flows.[113]

3.11.1 Freight Traffic

New docking and handling systems puts pressure on the areas where the goods should be unloaded. The goal is to do the unloading process as fast as possible in order to keep a steady truck flow and avoid congestion. When handling large quantities of goods, it might be necessary to have different areas for the incoming and the outgoing goods in order to avoid congestion. An important issue to have in mind is that the construction of the system must be adaptable for future changers and alternative solutions.[114]

[111] Mulcahy, 1994, p. 3.32
[112] Bergenståhl & Perborg, 1997, p. 115
[113] Ibid
[114] Ibid, p. 117

3.11.2 Loading and Unloading Zones

When creating areas for handling of goods it is important to consider the following issues:

- Well adapted and easy to overview
- Easy to use and organise
- Flexible
- Offer a safe handling from a labour point of view

In order to separate the driving area from the storage area and achieve a smooth flow it is usual to paint a line. By doing this it is possible to summarise the needs of areas by form a rectangular area where storing, unloading and loading are combined. Furthermore, the area should be easy to expand in case of future needs.[115] Further, it is also important to have several locations where goods can be unloaded in order to accommodate various transportation modes, reduce delays and avoid congestion.[116]

3.12 Material Handling Equipment

Materials handling equipment and systems often require major capital investments for an organisation. Like other decisions related to the number, size, and location of warehouses, materials handling decisions can affect many aspects of logistics operations. Both manual and non-automated materials handling equipment will continue to be important although the trend is aiming toward automated warehouses. Materials handling equipment can be categorised according to the functions they perform, such as storage and order picking, transportation and sorting, and shipping.[117]

The goods are often heavy and can therefore not be moved by the work force. Since companies often handle a large variety of products, different kind of equipment is needed. The materials handling equipment can be sorted in seven different categories:[118]

- Manually or partially manually operated equipment
- Forklift trucks
- Tractors and trailers

[115] Bergenståhl & Perborg, 1997, p. 118
[116] Hassan, 2002, p. 437
[117] Stock & Lambert, 2001, p. 442
[118] Burton, 1989, p. 103

- Conveyors and lifts
- Cranes, travelling cranes and gantries
- Vacuum and pressure systems
- Lorry equipment.

The equipment has different fields of application. Therefore, it is important carefully to consider the kind of service the equipment is supposed to serve before acquisition of the equipment.

3.12.1 Forklifts

Forklifts are common handling equipment and are used in nearly all warehouses and production sites. There are several different kinds of forklifts that all are built for different purposes. Some models are used for high stacking and are capable of lifting goods vertically more then 12 meters, primary used in high storing warehouses for order picking. Pallet-less side clamp versions are used for handling of bulky products without pallets. A forklift that has become more and more used during recent years is the narrow-aisle lift truck, this is because companies seeks to increase rack density in their storing areas. The forklift is not economical for long horizontal movements, this is because it is labour intensive. In figure 3-7 below, a typical model of a forklift can be seen.[119]

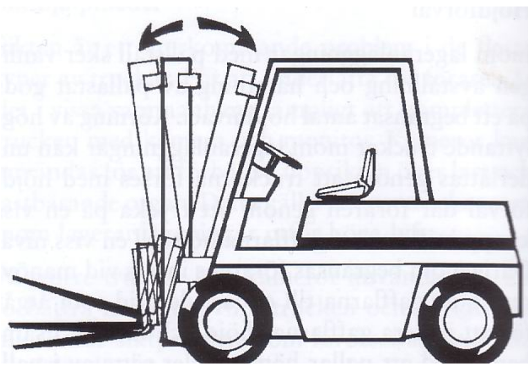


Figure 3-7: Forklift

Source: TFK Institutet för transportforskning och Industrilitteratur AB, 2002, p. 108

3.12.2 Walk-riders Pallet Trucks

A walk-rider, as the one in figure 3-8 below, is a low cost alternative that is widely used in warehouses. The trucks are very useful for loading and

[119] Bowersox, et al., 2002, p. 421

unloading smaller goods in the range of 1300- to 4500 kg that are to be transported longer distances in a warehouse. These models are mostly used for indoor activities and are not suitable for outdoor activities.[120]

Figure 3-8: Walk-rider

Source: TFK Institutet för transportforskning och Industrilitteratur AB, 2002, p. 162

3.12.3 Cranes, Overhead Cranes

An overhead crane, figure 3-9 below, consists of girders in the roof, with a horizontal moveable lifting device. The type of crane is suitable for handling of heavy and bulky goods as well as semi finished and final products. Another advantage that the crane brings is that the floors are free since the crane is mounted in the ceiling. Disadvantages that come with the use of a crane is that a construction like this requires a strong holding frame and the use of cranes might cause congestion and waiting time, depending on that it is than a regular truck.[121]

Figure 3-9: Overhead Crane

[120] Bowersox, et al., 2002, p. 421
[121] TFK Institutet för transportforskning och Industrilitteratur AB, 2002, p. 177

Source: TFK Institutet för transportforskning och Industrilitteratur AB, 2002, p. 182

3.12.4 Gantry Cranes

The gantry crane shown in figure 3-10 is very similar to the overhead crane in its technical data. The crane is constructed like a bridge that can be moved backward or forward on a rail-track in order to cover a larger area. The crane also has a similar horizontal moveable lifting device as the overhead crane. The advantages of a gantry crane are that it can cover a large span and handle very heavy load. The crane is also cheaper to run than an overhead crane for outdoor usage. Disadvantages with an overhead crane are that the gantry crane is slower and the visibility from the manoeuvre room is to the advantage of the overhead crane.[122]

Figure 3-10: Gantry Crane

Source: TFK Institutet för transportforskning och Industrilitteratur AB, 2002, p. 183

3.13 Information

Information and communication are two widely discussed words that lately have gained more focus then ever. Information is often mistakenly translated with data, which is somewhat incorrect. Information could be described as a collection of facts organized in such a way that they add value beyond the value of the facts themselves. Data is more a collection of raw facts about e.g. inventory, part numbers etc.[123]

The most important issues in order for information to be useful are that it should be accurate, complete, reliable and timely. Information transfer can be

[122] TFK Institutet för transportforskning och Industrilitteratur AB, 2002, p. 183
[123] Stair, et al., 2001, p. 4

limited by the speed of paper, faxes etc. Nowadays this problem could be easily solved by the use of electronic tools. There are four reasons why accurate information has become more critical for logistical systems. The *first* is that customers perceive information as an element of customer service. *Second*, right information can help a company-reducing inventory and human resource requirements. Information is also a way to increase the flexibility in a company, to know where to focus money and energy, this *third* is a strategic advantage. As a fourth point, enhanced information transfer and exchange capability of information might bring buyer and sellers closer to a channel relationship.[124]

3.13.1 Information Systems and its Components

The world is overflowing with different kinds of information systems that can be found in all kinds of organisations and everywhere e.g. barcode scanners automatic telling machines etc. All information systems have one common goal and that is to improve the productivity of its purpose.[125]

"An information system (IS) is a set of interrelated components that collect, manipulate, and disseminate data and information and provide a feedback mechanism to meet an objective"[126].

Figure 3-11 is a simple model describing how different components in an information system works.

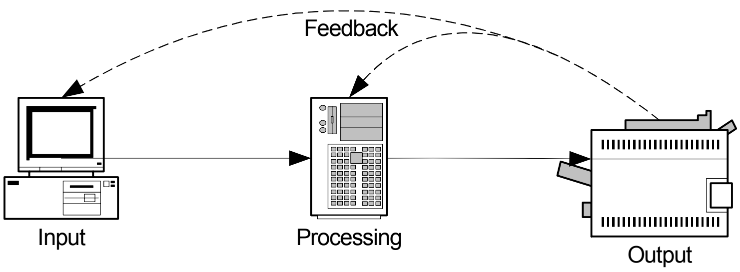


Figure 3-11: Components of an Information System

Source: Stair, et al, 2001, p. 13

[124] Bowersox, et al., " 2002, p. 193
[125] Ibid
[126] Stair, et al., 2001, p. 4

3.13.1.1 Input

The input in an information system is the activity of gathering raw data. Everything that is put into as system is called input and could therefore be everything from work-hours to phone calls. The important thing is that the type of input is determined by the desired output.[127]

3.13.1.2 Processing

The processing part involves the activities of converting the input data into useful information for the output. These activities could be done either manually or preferably automatically depending on what system is used.[128]

3.13.1.3 Output

The output is the production of valuable information. This information is then often used as input in other systems in a company. Output can be produced in various ways depending on its purpose e.g. trough a printer or just handwritten reports.[129]

3.13.1.4 Feedback

Feedback is output that is used for changes of the new input in the system. The feedback could for example show that something in the input data is very wrong and therefore have to be changed. Feedback is very important in management decision-making since this gives managers a hint of what is right or wrong in e.g. the present production.[130]

3.13.2 Information Systems in a Company

The purpose for a company of having an information system is to be able to control various activities inside and outside the company more efficiently. Early information systems were mainly focusing on the financial activities e.g. accounting and to be an instrument for controlling the company's economy. During the 90's, a new system was developed that supported other parts of the organization e.g. material flow as well as logistical activities.[131]

[127] Stair, et al., 2001, p. 13
[128] Ibid
[129] Ibid
[130] Ibid
[131] Lumsden, et al., 2003, p. 1

The new type of information system is called Enterprise Resource Planning (ERP) systems and supports the whole company, nearly all inbound as well as outbound activities. Examples of activities that can be handled with a system like this are accounting support, purchase of material, delivery of products and production activities.[132]

There are many types of ERP systems that are focusing on different branches e.g. some systems are directed towards wholesaling companies, others to purchase and vendor management companies, etc. Large systems like SAP can cover nearly all types of activities in a company but even these systems have their problems, this being that it often takes a very long time to have them implemented i.e. 3-5 years.[133]

3.13.3 Barcodes

Bar coding is a technology for keeping track of goods in different flows. The bar coding technique is a simple technique since it only contains spaces and bars that form an arranged pattern. A special scanner that creates light waves reads the code. The information is then translated into a frequency of zero and one, the binary system.[134]

There are three different variations of encode-data into bar coding. The most commonly used bar code today is called Code 39. The name is given due to the codes pattern where three of nine are wide elements. Another common format is the Code 128. A third coding model is the 2-D that can be seen in various models and is one of the latest matrix barcode that has been developed. The matrix barcode can contain a lot more information than the other barcode models.[135]

A new technology that has been developed by Texas Instrument is called "tag-it". This technology is built upon a system that instead of using scanners uses radio frequency. The system has a great advantage to regular bar codes since it can be updated along the way in the supply chain.[136]

[132] Lumsden, et al., 2003, p. 1
[133] Ibid
[134] Coyle, et al., 2000, p. 408
[135] Ibid, p. 409
[136] Coyle, et al., 2000, p. 411

3.14 Summary of the Theoretical Framework

In this chapter, various theories have been outlined and explained in order to familiarise the reader with the relevant topics. Both theories with a direct connection to the research topics together with those having an indirect connection to the research topics have also been dealt with.

As the purpose of the study is to find out what possibilities there are to improve the layout of existing outside located storing areas, it is crucial that theories relating to warehouse design and inventory are discussed. Therefore, layout and design principles and different inventory types have been looked into in the theoretical chapter. Closely related to the research questions are also the parts on stratification of articles, placement principles and materials management. As these parts are the basis of the thesis they are also studied in depth in the empirical framework, the following chapter under description of storage area, mapping of articles and mapping of materials flow.

To get an overall view and overall thinking of the thesis, and to avoid sub-optimisation theories relating to different types of processes including effective, flexible processes and identifying processes were discussed. Further, logistical goal e.g. logistical profitability and logistical efficiency were discussed in order to understand some of the pitfalls within logistics. These theories go hand-in-hand with the research questions because there are so many factors that influence how the storage areas can be changed to improve materials flows. Changing or improving one part of the business might have negative effects for other parts, and the total cost will increase.

Thereafter, the reasons why firms hold inventory are discussed. This theory was of interest as Kalmar Industries is more or less forced to hold inventory for various reasons that will be further investigated in the empirical chapter. In this chapter, it was explained that holding inventory is not always negative but that it can conversely lead to large savings.

The theoretical chapter also gives some general knowledge relating to information and communication as this crucial in all functioning organisations. Without a well-functioning information flow, the production at Kalmar Industries will suffer leading to decreased customer satisfaction due to late or wrong orders. Furthermore, changing the storage layout will not lead to improving the materials flow if the information flow is not taken into consideration. The information flow at Kalmar Industries will be discussed in the following chapter the empirical framework.

4 Empirical Framework

In this chapter, a short description of the company Kalmar Industries will be given followed by a map of the storage area, articles and the material flow. Furthermore, through this chapter the main questions will be used as a basis for describing the information provided from primary sources.

4.1 Introduction

In this chapter, all gathered information from interviews and observations has been put together. The interview answers will not be specified per each interview but will be grouped all together and divided into different topics. However, the interview questions will be found in Appendix 2-3. Firstly, an overview of the company will be given

4.2 Company Background

Kalmar Industries was until the end of 2002 a subsidiary to the Finnish-based industrial engineering company Partek. In the year 2002, the Finnish company Kone bought up the Partek Corporation. After the Partek Corporation had been acquired, the Kone Board decided to group the corporation in two divisions e.g. Kone Elevators & Escalators and Kone Materials Handling. The Kone Group is the largest engineering company in the Nordics with 23 000 employees and a 5.5 billion EUR in turnover.[137] The Kalmar Group is a part of the Kone Material segment among other companies in this division.[138]

4.2.1 The Kalmar Group and its Mission

The Kalmar Group is one of the world leaders in straddle carriers, terminal tractors and reach stackers.[139] Every forth container that is handled in ports around the world is lifted or transported by a Kalmar machine.[140] This is quite a lot because there are more than 70 million containers circulating in the world, and the expected sum is in a ten year period expected to rise to 140 million. These in turn, indicates that there will most likely be an increased demand for container handling equipment. As we state this facts Kalmar Industries has over

[137] Telephone interview with Jan Goodwin Human Resource Manager, 2003-11-04
[138] Kone- Annual Report, 2002, p. 2
[139] Kalmar Company overview-"The Kalmar Difference", 2002, p. 7
[140] Ibid, p. 10

70 000 machines active around the world[141]. Kalmar Industries has in total 3232 employees[142] and below in figure 4-1 the different market segments are shown. It clearly shows that the European/Middle East/ African sector is the largest with 59% of the sales.

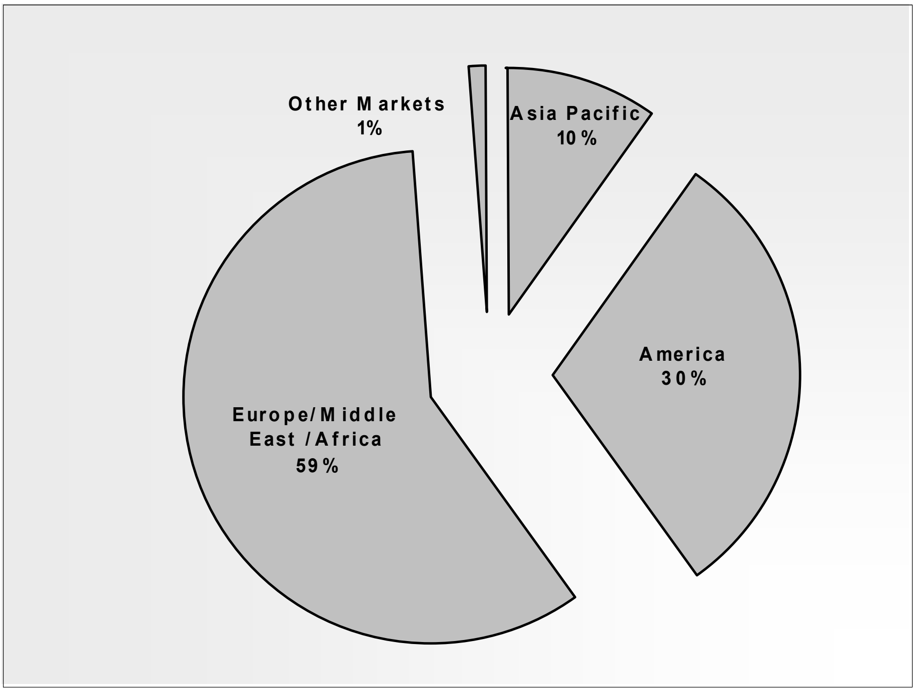


Figure 4-1: Market Segments

Source: Kalmar Company Overview, 2002, p. 7

The Kalmar mission can be symbolized in the words "make things easy". With these three words, the company want to express their excellence and experience in building machines for heavy lifting and moving of heavy loads. Another dimension in the words is that Kalmar promises their customers to make things easy in the way that they can support the customers by offering everything from driver assistance to contract maintenance and fleet management.[143]

4.2.2 Brief Development history

The following part describes in brief, the most important events in the history of Kalmar Industries. Kalmar Industries has had a continuously development

[141] Kalmar Company Overview "The Kalmar Difference", 2002, p. 10
[142] Telephone interview with Jan Goodwin Human Resource Manager, 2003-11-04
[143] Kalmar Company overview-"The Kalmar Difference", 2002, p. 3

since the founding of the company. The facts below are stated in order to give the reader an overview of how the company have developed.144

- 1946 First industrial straddle carrier
- 1946 First lift truck built
- 1953 First mobile gantry crane
- 1958 First terminal tractor
- 1970 First RORO (roll on roll off) truck
- 1971 First truck for handling timber
- 1975 First container straddle carrier
- 1975 First diesel-electric straddle carrier
- 1976 First container ship-to-shore crane
- 1985 First reach stacker- contchamp
- 1986 First diesel electric mobile gantry crane
- 1989 First fully automatic container stacking crane
- 1991 First automated industrial straddle crane
- 1998 New generation standard high speed diesel-electric straddle carrier
- 1999 First automated Rubber Tyred Gantry (RTG) steering and container position verification product- smart trail
- 2002 First fully automated straddle carrier terminal

4.2.3 Business Segments

The Kalmar Group consists of five different business segments as can be seen in figure 4-2 below. However, focus will be put upon the segment of Container Handling since that is the core operation of our assigner KCH. The other four business segments Industrial Segments, Trailer Logistics, Kalmar Solutions, and Dedicated Business that Kalmar Industries are only mentioned briefly in this study.[145]

[144] Kalmar Company overview-"The Kalmar Difference", 2002, p. 10
[145] www.kalmarind.com, 2003-10-10

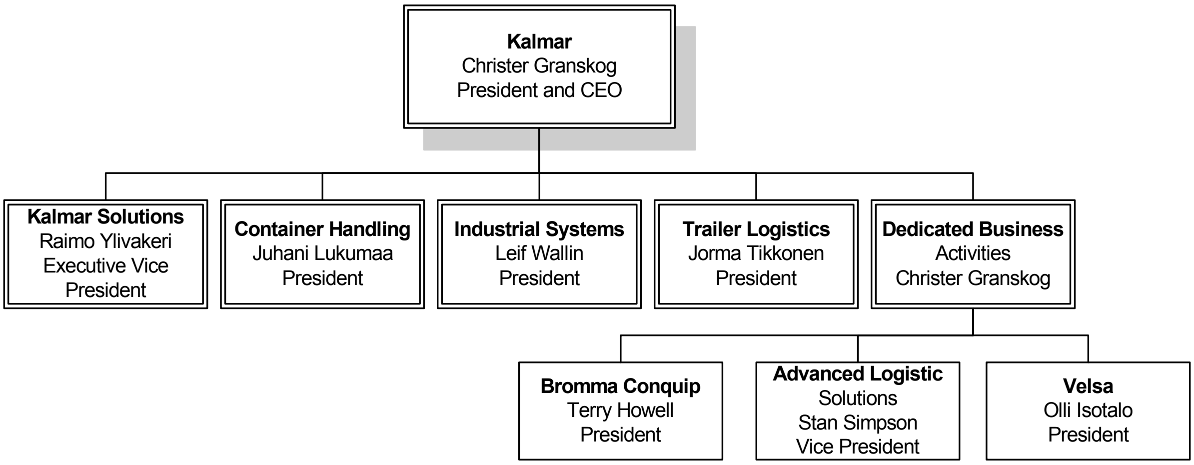


Figure 4-2: Kalmar Business Segments

Source: Magnus Berg, Purchasing Manager, Kalmar Spare parts in Ljungby, 2003-10-28

4.2.3.1 Container Handling

The business segment container handling which is the segment that focus will be put upon in this study supplies ports and terminals around the globe with different systems for container handling, and three different systems for container handling are offered. One of the systems provides the use of straddle-carriers for transportation and stacking. The second system offers the customers a combination of terminal tractor for transport the containers and a Rubber Tyred Gantry cranes (RTG) for stacking, called RTG system. The third system is based on reach-stackers either independently or in combination with terminal tractors. The capacities of the machines are in the range of 20-90 ton lifting capacity.

The *Industrial Systems* sector focuses on heavy industrial branches, primarily within the timber/pulp/paper industries and also in other heavy engineering industries e.g. steel, concrete. This sector is similar to the container sector and, is one of the most important sectors in the company.

The *Trailer Logistics* sector works in the development of terminal tractors. The products are mainly produced for short container and trailer movements in ports, terminals, long-distance truck centres and in the industries. According to Kalmar Industries, the largest potential for this sector is to be found among industrial customers.

Kalmar Solutions is a business segment that offer value added activities as a complement to the other business segments. Traditional customer support is a major activity in this sector. This includes spare parts and service as well as maintenance and repair of machines.

The segment of *Dedicated Business* consists of groups in the company that handle specialised activities, dedicated to special purposes or tailor-made products. One of these groups is the Kalmar Rough Terrain Centre unit (KRTC), which was founded in the 1998. The group construct container handlers that are supposed to work in rough terrain. The one and only customer for this product is the US-army, which need machines that can stand on uneven and rough terrain, see figure 4-4 in part 4.2.4.

There are a few strong companies competing on gaining market shares in this heavy industrial branch. Since Kalmar Industries in Lidhult only manufactures container handlers, the competition excludes several manufactures of smaller trucks. The major competitors in the container-handling branch are listed below, domestic and foreign separated.

4.2.3.2 Swedish competitors

SMV Lifttrucks AB was founded in 1952 and is located in Markaryd (south part of Sweden). The company produces reach stackers in the same range as Kalmar Industries in Lidhult, as well as being located in the same region in Sweden, and can therefore be seen as a close competitor.[146]

Svetruck was founded in 1977, and its main facilities are situated in Ljungby, Sweden. The company produces lift trucks and container handlers in the range of 8-50 ton. Since the founding of the company, 4 000 machines have been produced. Dealers in 50 different countries represent the company. Svetruck's main markets are container ports, rail terminals, steelworks, sawmills, paper- and pulp factories.[147]

BT Industries AB is a company located in Mjölby. The company mainly produces small lift trucks for indoor and outdoor usage but can be classified as

[146] www.smvlifttruck.se, 2003-11-14
147 www.svetruck.se/, 2003-11-14

a competitor in the since that they have a contract with SMV[148], to sell their products. The company is a subsidiary to Toyoda International Sweden AB.[149]

4.2.3.3 Foreign competitors

Fantuzzi is an Italy based container handling company employing 220 workers. The Fantuzzi Group consists of seven different companies that are involved in different branches. The company's main facility is located in the north of Italy and manufactures about 500 units per year. Their reach stackers are in the range of 10 – 70 ton.[150]

Linde Group is a German based engineering company that was founded in 1879. The company produces everything from small lift trucks to reach stackers. The company is divided in three different branches, gas, engineering and material handling. The material handling division consists of three different brands, Linde, Still and OM Pimespo.[151]

4.2.4 Product Description

Kalmar Industries in Lidhult (KCH) produces five different models of container and intermodal handlers i.e. Full Container Handlers, RORO (roll on roll off) models, Forklifters, Reach Stackers and Empty Container Handlers. Their newest product is the Reach stackers ContChamp DRD450, figure 4-3 and is available in different combinations depending on the demand from the customers. ContChamp is an eight-meter vehicle that can carry very heavy load, up to 45 ton. The machine has the possibility of lifting containers on the second row of a rail track, and on the third container row. The service weight of the machine is in the range of 102- 106 ton, depending on configuration and model. The chassis is built of fully welded steal, which gives a rigid construction, and the boom is telescopic in order to lift containers further and higher, up to 5 containers height. This can be seen in figure 4-3 below.[152]

[148] Svensson, Jörgen, Technical Support, SMV Lifttrucks, 2003-11-07
[149] Ekonomisk Litteratur, Sveriges största företag, 2003-36, 2003
[150] www.fantuzzi.com, 2003-11-14
[151] www.linde.com/en/p0031/p0033/p0033.jsp, 2003-11-14
[152] Kalmar Industries Sverige, Technical information container & intermodal handler, p. 1

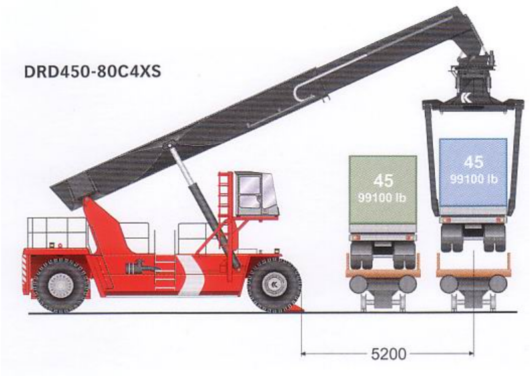


Figure 4-3: Newest model, the ContChamp DRD450

Source: Kalmar Industries Sverige. Technical information container & intermodal handler, p.4

The right picture in figure 4-4 below shows the rough terrain container handler that is produced by KRTC. This machine has, as shown in the picture, a higher capability of transporting containers in rough terrain than the Reach Stacker produced by KCH, left picture in figure 4-4. The full container handler's main purpose is as its name recalls, to handle fully loaded containers, left picture in figure 4-5. The empty container handler, right picture in figure 4-5 is a machine that can lift and stack empty containers at a height of six containers has a lifting capacity of 7-9 tonnes. The other two models of container handlers, figure 4-6 that Kalmar produces are a regular Forklifter and a RORO model. The forklift can be custom built up to 90 tonnes. The RORO is used when loading RORO ships, and is dependent on its being purpose built very small so that it can manage to drive inside a ship.[153]

Figure 4-4: Reach Stackers and Rough Terrain Container Handler

Source: Kone Corporation, 2003-11-18

[153] Kalmar Industries Sverige, Technical information container & intermodal handler, p. 1

Figure 4-5: Full Container Lift Truck and Empty Container Handler

Source: Kone Corporation, 2003-11-18

Figure 4-6: Forklift and RORO

Source: Kone Corporation, 2003-11-18

4.2.5 The Suppliers of KCH and KRTC

The information about the suppliers of KCH and KRTC in this part of the study is gathered from the interviews made with employees at Kalmar Industries in Lidhult at both KCH and KRTC but mainly at KCH[154].

Today only a handful of Kalmar Industries suppliers represents approximately 90 % of the purchasing volume. As many other companies Kalmar Industries struggles for decreasing the amount of suppliers. In the end Kalmar Industries aims to decrease the suppliers with over 30%, and to focus on the larger suppliers. At present they have almost reached the goal.

[154] Appendix 2-3

In order to improve the delivery performance Kalmar Industries use a route truck that drives to about 30 suppliers to pick up their goods. However, if the goods are not prepared at the right time and day the supplier has to carry the cost and arrange transportation for it. When the suppliers miss the route truck, they have the responsibility for delivering the goods within one week. This is the case for those suppliers not connected to the route truck. In case of pre-delivered goods, the goods can be sent back to the suppliers due to lack of storage space. The suppliers are then forced to take it back.

Moreover, late deliveries can lead to stop in production. The goods can also be delayed because of external factors or circumstances that even the supplier cannot prevent.[155] Now the suppliers of Kalmar Industries have a delivery performance of about 80 %[156]. However, this will probably change in the near future when Kalmar Industries implement a time window of one-day delivery instead of one week. One of the purchasers interviewed believes that it is important to retain a good personal contact with the supplier in order to improve the delivery performance.

The company KRTC has decreased their number of suppliers by 30 during the last half-year. The two companies, KCH and KRTC, have many suppliers in common. The two companies also share the route truck, which visit 30 suppliers.

The company KRTC has a fixed delivery plan within its contract, which consists of producing a certain number of trucks to the American army. This makes it easier for KRTC than for KCH to plan the orders. KRTC receives fixed delivery plans from its customer, the American Army, every three month. Thus, the production volume can only be changed every four month.

4.2.6 Orders

All information below is gathered from the interviews made with the employees at Kalmar Industries and the interview questions are shown in Appendix 2-3.

[155] Appendix 2-3
[156] Ljungström, Martin, Consultant, Arrigo Consultance AB, 2003-11-05 at 13.30

At KCH the chief of purchasing, Carina Lööf is responsible of 30 employees, who work with purchasing, quality and inventory. The responsibility of the purchasers is divided for both articles and suppliers, and consists of different teams in the different article categories such as hydraulic, economy, order placement, and quality. Four of the purchasers have an economical responsibility, another four handle and control, while three purchasers have the responsibility for the quality and performance of the suppliers.

KCH is using a special-made computer system called Cics. The order system that is in use today is called Supply Master and shows a more precise delivery time, improved quality and improved delivery service than the old system, according to the chief of purchasing at KCH, Carina Lööf. They use the method make-to-order and therefore, the orders are mainly demand controlled. Once a truck is ordered, the purchasing department gets the order. When they get the order depends on how long the lead-time is for producing a truck, i.e. order time plus production time. Normally, the articles need to be in storage one week before production. The batch size ordered at a time depends on the price of each specific article, the yearly demand and the amount demanded on that specific order.

According to one of the purchasers interviewed at KCH, there are three different ways of ordering articles. The articles with a low value that are frequently used are ordered by the assemblers and are called C-articles. However, B-articles, which are the products with higher value and used quite frequently, are controlled and ordered according to the inventory net through a graphical order system. This computer program bases its prognoses on historical data. Orders of B-articles are often made larger than the prognosis shows in order to keep flexibility in case of larger orders than planned. Moreover, A-articles, which have the highest value and are used most frequently are often customised for one special customer and therefore specially ordered for each truck.

When it comes to the order system, the interviewed purchasers state that there is a lot of double work right now. There should be one common system that can handle everything instead of using two systems at the same time as at present where the data has to be added. They should also exclude the telephone fax that is used when sending orders. It is not trustworthy and only adds many problems.

4.2.6.1 Inventory Control

According to one of the operative purchaser, it is important to have strict control of the inventory and he believes that the recently implemented closed inventory is a good solution in order to improve the control. Thus, production workers and other staff cannot enter the inventory themselves and pick articles. Through this system, the right amount of articles will be shown in the system, the correct information that is needed when placing orders will be found. The employees at the assembly plant need to improve their planning and not ask for an article when it in fact is too late. Reports of defected products are also an important fact in order to achieve improved control of the inventory in the future.

According to the chief of purchase at KCH, Carina Lööf, there are today some suppliers that replenish their articles by themselves, a so called Vendor Managed Inventory (VMI). A better order system is also needed in the future to be able to precede the deliveries more accurate and thereby improve quality and delivery service.

4.3 Description of Storage Area Map

In this part of the empirical chapter, the storage area map will be described in detail referring to its different types of areas such as product areas, loading and unloading zones, test tracks, roads, etc. The information in part 4.3 is gathered from the interviews made with employees at Kalmar Industries.

4.3.1 Storing area

Figure 4-7 below shows the total area for Kalmar industries in Lidhult. The area is 22 hectares and is surrounded by a fence, which secures the company's interests. As can be seen in the figure, most of the area is divided in segments that have been given a name in form of one letter or two. A single letter represents an inside storage within a building or a tent, and a combination of two letters represents an outside storage. The segments are also divided into different colours, this in order to show who has the primary responsibility for each area. The persons responsible for these different areas are listed to the left in Appendix 5. Being responsible for an area means that this person not only is responsible for the activities, the responsible person should also look after the area and keep it clean and structured[157]. In figure 4-7 below, the storage area map of Kalmar Industries is shown. For a larger and clearer vision, see Appendix 6.

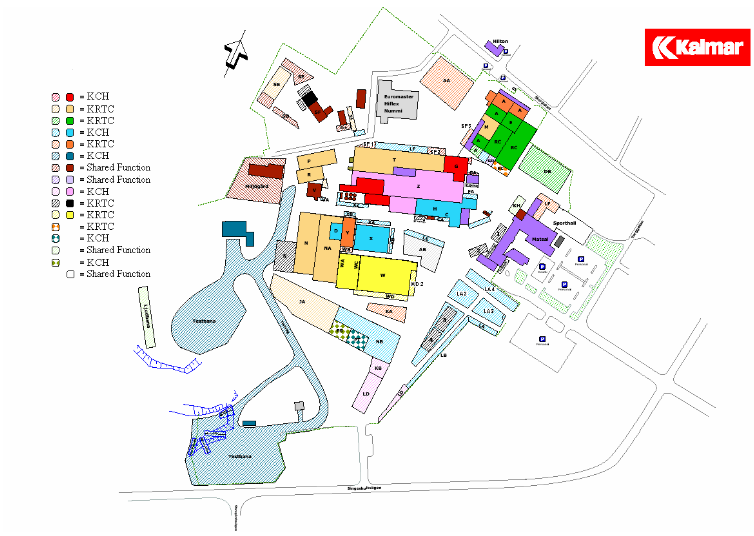


Figure 4-7: Kalmar Industries in Lidhult

Source: Storage Area Map, Kalmar Industries Lidhult

The present situation of the storing area is that there are no clear stated positions for the articles, but most of the goods are grouped together with similar articles. In some sections there are mixed articles, which could be considered as floating storage.

All the truck drivers have worked at Kalmar Industries in Lidhult for several years, and thereby they have good knowledge about the locations of the articles in the storage area. One of the truck drivers believes that it is because of the "old" knowledge that the picking process of goods from the storage area works well without signs telling where the goods should be placed. This type of unclear system could cause problems if, for example, permanent staff would be absent a longer period due to on leave or sickness. However, it is difficult for newly hired personnel to find the right articles before they have learned the system. Another factor in this system is, according to Anders Svensson, that the truck drivers sometimes put articles in a spot where there is free space and this might lead to problems finding the goods.

[157] Anders Svensson, Logistics Coordinator, Tutor at Kalmar Industries

The truck drivers believe that it probably would be more suitable to have fixed position for all articles than the present system, but this in turn would only be possible if the storage places for respective article would be larger. If there was not be enough space for the articles fixed position incoming articles would have to be placed in another slot, and then the system would fail. Nevertheless, large enough spaces for the articles together with better labelling would be appreciated among the employees.

During the interviews, the truck drivers mentioned that there is a bottleneck in the assembly plant at the moment, due to the fact that there is only one entrance to the production hall this affects the inflow of articles. The entrance of the production plant is on the right hand side of the Z building in figure 4-7 above.

4.3.2 Loading & Unloading Zones

There are five different zones where incoming goods can be unloaded, this is in order to control the materials flow in a better way than if they just would have one zone for the purpose. The loading and unloading zones are shown in figure 4-8 below and for a larger picture see Appendix 7. By using different zones to unload the incoming goods, less handling of the goods is needed and the internal transportation of the goods is reduced. The idea behind the different zones is that incoming goods should be unloaded close to its storage place and that several trucks should be allowed to unload at the same time. However, there are some difficulties with guiding the incoming trucks to the right loading zone since the trucks cannot at the moment specify what type of articles they are delivering. They only have a list of all the article numbers and have therefore difficulties with specifying all goods. The zones are not like regular docks used in an indoor warehouse where the goods are unloaded from the backdoor. These goods are often too heavy and bulky and are therefore easier to unload from the long side of the incoming trailer. Therefore, the zones only consist of a flat and clear surface where the lift trucks can unload the material. When loading the final products for deliveries to its customers, the machines are driven from the flat ground by its own power onboard the trailers.

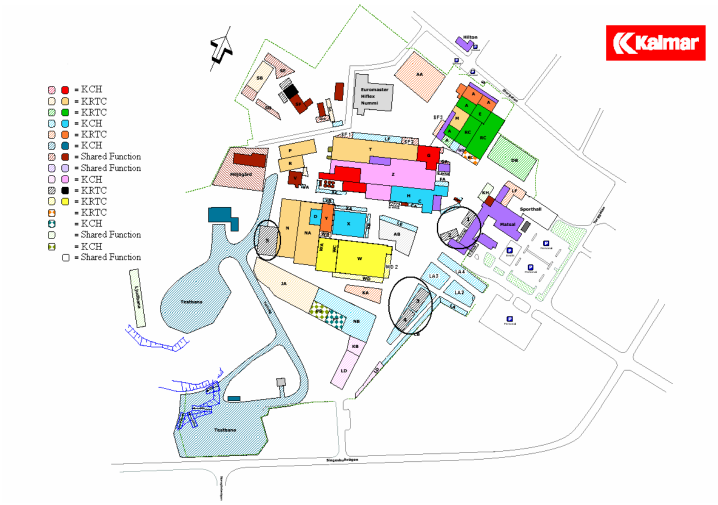


Figure 4-8: Loading and Unloading Zones

Source: Area map, Kalmar Industries Lidhult

4.3.3 Test track

A large part of the total storage area is a test track for finished and semi-finished machines, the grey area on the left side of the map in figure 4-8 above. There are several different test devises in order to test the machines e.g. an artificial hill that is used for testing the tilting ability of the machines and a devise for testing high lift with empty container handlers. Besides the mentioned devices, there is a large area for testing the speed of the machines and other abilities. This last mentioned area is necessary in order for the machine to reach its top speed.

4.3.4 Roads

Most of the roads on the area are asphalted but there are still roads that are not. This might lead to a less safe movement of the goods than if all roads would have been paved. Due to a bumpy ride, the goods could jump off the forks of the truck.

There are no strictly decided routes for the truck drivers to follow. When they get their driving tasks on the truck computer, they always choose the closest way for the collection. It would be too hard to arrange specific routes, according to the respondents. One negative thing with the existing roads is that it is often not possible to pick up goods from both sides. It would be smoother if the driver of the truck could pick goods from both sides of the storage place because they often need an article that is not on the pick side, which causes extra work.

4.3.5 Ground Quality

The ground of the storing area is characterised as fairly instable and soft due to close to wetland. This is negative from a reconstruction point of view since it would cost a lot of money and effort to stabilise the ground and loosen the topsoil. This is also one of the reasons not to asphalt the whole area, as the area is large, according to Anders Svensson. He claims that the area would be better to store articles on if it had been paved. In some sections of the storing area, trails with steel plates on the ground have been placed in order to make the ground more stable and even. The truck drivers also prefer asphalted roads in front of gravelled roads since some goods have been damaged because of the rough surface. The handling of the goods would be even better if the articles were placed with space between them.

4.3.6 Sharing of Storage Area between KCH and KRTC

As mentioned before Kalmar Industries in Lidhult is divided into two different companies i.e. KCH (Kalmar Container Handling) and KRTC (Kalmar Rough Terrain Centre). Therefore, the total storage area has to be shared between these two companies. KCH manufactures civil container handlers, reach-stackers while KRTC manufactures vehicles for rough terrain only for the US-army.

This division between the companies might cause disputes about which areas, in a production point of view, are to belong to each company. The areas that belong to each company are shown in figure 4-7 in part 4.3.1 above.

However, respondents from each company agree that not all functions in the storage have to be separated. It is unnecessary to have totally separated functions if it could be solved better with cooperation, as the shared function of today, i.e. the truck drivers and the recycling area.

4.3.7 Ideas of Improvements of the Storage Area

When the respondents were asked if they could think of any improvements that they thought were necessary at the storage area some things were mentioned. According to information gathered from the interviews, standardised truck routes would improve the flow. Special places for the pedestrians to cross the roads are also a requirement. Thereby, the truck drivers do not have to pay as much attention to the pedestrians as present. Improved marking within the area with signs of the different company areas as well as signs of the different product's placement is also wished for among the employees. Thereby, the articles get their own specific space.

In order to change the inventory some factors have to be taken into consideration. One of these is that it might be useful to place asphalt on the ground where the truck drivers are driving since the bad surface of the ground sometimes has caused destroyed goods.

According to Hans-Åke Bengtsson, the company KRTC has more difficulties reducing their inventory than KCH since they have agreed to hold a certain level of inventory and at the moment have a fixed order level. However, he believes that it would be necessary in the future to look at the possibilities to store the amount of each article that is needed to construct one truck on one pallet. This will facilitate the work for the truck drivers and minimise empty routes. He also believes that fixed inventory locations are better than flexible ones.

The respondents also consider that they would manage an expansion of the business with only the nine truck drivers of today. Since two trucks are not in use during the noon and afternoon these could be further used.

4.4 Mapping of Articles

In this section of the thesis, the placement of articles within Kalmar Industries in Lidhult will be mapped and discussed. When observing the articles' placement on the storage area there was a clear stratification on the different storage areas but also grouped in different product families. Additionally, the frequencies of the articles are also important to include. Therefore, we have chosen to present the article data into three different groups in order to figure out what type of product placement Kalmar Industries is using today. Firstly, the articles' present placement is first described and then they are sorted by the storage area at which they are located. Secondly, the articles are sorted depending on how frequent they are used. Thirdly, the articles are described and grouped in their product families.

The truck drivers use the storage map of the area, which is shown above in figure 4-7 in section 4.3.1. However, the map does only show which areas that belong to KCH and which belong to KRTC. Therefore, each truck driver has to learn and memorize by experience where each article is placed or should be placed.

The articles that are represented in the outdoor warehouse are mostly bulky and heavy e.g. counterweights, stands, cabs and wheels. These articles are mainly classified as A- and B-articles due to their purchase price and their frequent use. In order to map the articles at the outdoor located storage area at Kalmar Industries a visual observation was made and all article numbers within the area were documented. Thereafter, the article numbers found were matched with the article information obtained from the company, which is shown in Appendix 8.

4.4.1 Storage Areas

Since the complete storage area is divided between the two companies KCH and KRTC, as mentioned above, except for the shared functions at the storage area, the focus was put on the areas of KCH. In this part, the articles of the different storage areas that the total area is divided in will be described.

According to one of the truck drivers interviewed, all articles have fixed locations that are decided among the workers. However, there is seldom enough space for all articles in their fixed positions and they are therefore placed elsewhere on a free storage slot. Consequently, it would be appreciated among the respondents to have specific locations with signs for each product family. However, it would be difficult to arrange fixed locations for all articles since some days more articles of one type arrive than on other days. Therefore, the locations must be big enough.

However, the present placement of articles does not seem to be fixed and organised since some articles is placed in different places. From the beginning there might have been a strict thought of locating the articles after the type and family it belongs to, since a vague pattern of placement can be traced. Therefore, the data of articles found on the outside storage area will first be described from the existing storage areas and then described from the different product families.

By looking at Appendix 9 where the articles are divided on the different storage areas one can see that some areas only carry one type of product as in area JA, where different types of girders are placed. However, in some areas different types of articles are mixed and not structured as in area CA. However, there are some exceptions as the two tents on the areas X, D and Y. Inside these tents there are several article groups since all these articles need to be stored inside due to their sensitiveness of the weather. At some storage areas of KRTC, there was a lot of storage space left as at the area JA.

4.4.2 Frequently Used Articles

According to the article data obtained shown in Appendix 10, where the article data has been sorted after their yearly consumption, the articles that are consumed the most is an ordinary clamp and a clamp double. These two articles are both stored inside the X tent, which is situated quite near the assembly plant. These two articles together with a battery seems to be the articles that are used several times on each truck since the consumption of these articles are more than the amount of trucks produced per year, which is 350- 400. However, it does not seem that the company has tried to locate the articles after their frequencies since the fifth and sixth most frequent used articles, the cylinders and the counterbalances, are not located close to the assembly plant.

Those articles found in the area with the consumption of zero during a 12-months period might be the case of old articles or just missing in stock. However, those articles situated in the storage area of KRTC, such as Y and K are also zero, since the consumption information of these articles is not documented in the computer system of KCH.

4.4.3 Product Families

As mentioned above, we can trace that the truck drivers have tried to store the different articles in product families and in specific places. However, this has not succeeded since the articles that belong to the same product family are stored at different storage areas, which is shown in Appendix 11. Yet, to some extent, some of the articles are grouped. When observing the gathered information in Appendix 11, one can guess that the reason for finding articles in many different places can depend on the fact that there was no storage space left at the original area, or that the truck driver could not find the original spot.

4.4.3.1 Final Products

While observing the storage area final products were found in several places, which appeared quite disorganised. Some were placed beside the main entrance gate to the storage area, some were standing beside the loading zone 5, see Appendix 7, and some were standing outside the so called church located in the red building in front of area XA, which is the entrance for final trucks to the assembly plant.

4.5 Mapping of the Material Flow

In this section of the thesis, the flow of materials within Kalmar Industries in Lidhult will be discussed. In this study, the flow of materials is based on where the articles are stored and the volume of the articles. The reason for this is that it is almost impossible, without high-technology equipment, to get an exact mapping of how the articles are transported on the large premises. However, before discussing the materials flow some general information about the trucks (forklifts) and the personnel in use will be provided. This information is all collected from the interviews.

4.5.1 Trucks and Personnel in use

Kalmar Industries in Lidhult at the moment produces, as was explained in the product description five different truck types. In order to keep up with the production, nine truck drivers are employed using six different trucks (forklifts). The forklifts are in the range between 4.5 and 13.6 tons, where there is one 4.5 tons, two that are 5.5 tons, one 8 tons, one 12 tons and one 13.6 tons. However, when there is material that is too large for these trucks the drivers borrow a larger one from the testing department. These trucks can manage to load and unload large articles. All trucks and truck drivers belong to the Shared Functions (SF), a department that perform work for both KRTC and KCH.

The truck drivers under the shared functions at the company work in three shifts. Two truck drivers work from 5 a.m. to 1 p.m. Between 7 a.m. and 4 p.m., which are peak hours, two additional truck drivers are working, and finally between 1 p.m. and 9 p.m. yet anither two truck drivers are working. This means that between 7 a.m. and 4 p.m. when there is more work in terms of loading and unloading, four truck drives are engaged. Most of the deliveries arrive normally around noon. This is the time of the day when it often gets very busy for the truck drivers. Mondays, Wednesdays and Thursdays are especially busy as much deliveries arrive on those days. In the future, the delivery days will be more controlled since there will be specific days to deliver on instead of, as it is today, when the supplier has an entire week in which to deliver.

If a truck driver, for any reason, cannot come to work the rest of the drivers, try to manage the day anyway. If there are problems in handling the workload, Kalmar Industries hires someone from an employment agency to drive the truck. If one of the ordinary truck drivers is away for a long time, Kalmar Industries trains a new employee. This is however, not a good solution, as today as a newcomer it is impossible to know where all the articles are located. The reason for this is that there are no clear markings or signs in the outside storage where the articles are be located. This, according to one of the truck drivers, is a topic that should be look into and improved.

As mentioned before, the truck drivers use the same map as can be seen in figure 4-7 in section 4.3.1. This however, is not commonplace as the drivers know where the articles are located and thereby do not need the map. The location of the articles is to a large extent fixed (fixed placement system) and decided by the truck drivers together with someone from the logistics department. If there is not enough space to put the articles on their normal locations there is some flexibility in terms of placing the articles where there is space, i.e. a floating placement system. This is a system that works fine but as mentioned earlier clearer markings and signs would be beneficial. Furthermore, the respondents believe that it would not be possible to expand any more without hiring more drivers. As there is a new 13.6 tons truck on its way, there will be sufficient trucks to handle an expansion.

4.5.2 Information Flow

According to one of the truck drivers at Kalmar Industries, the information given from the production plant could be delivered in a more efficient way than it is to day. Each truck has a computer inside that informs the driver exactly what article to pick up and deliver to the assembly plant. The information that reaches the computers is good but at the same time, there is a lot of information that either comes directly from the production workers orally or through telephone calls. One of the respondent means that it would be more efficient, if all information came through the truck computers so that all truck drivers receive the same information. Thereby, the truck driver who is closest to the requested articles can pick them up and the internal transport distances will decrease. The truck drivers want to see as much use of these computers as possible.

The interviewed chief of purchasing at KRTC, Hans-Åke Bengtsson suggested that a sort of prioritising of the orders from the production must be done. If the production workers plan their daily work better, the truck drivers can do it as well and thereby the internal transport can be decreased and no empty trucks will return. After the 14th of January, it will be easier to plan the handling of incoming goods since the supplier has to deliver the goods during one day instead of one week in the future. However, the respondent thought that this would not facilitate the work since the truck drivers could not pick more articles than there is space for in the assembly plants. At the moment it is too crowded.

4.5.2.1 Improved Control of incoming Goods

The respondents believe that there is a bad information flow between the department of transport, the truck drivers and the purchaser. When the delivery trucks enter the incoming goods gate, those responsible at the transport department should insert all information about the goods in the truck computers, in order to facilitate the work of the truck drivers. However, this is not always done correctly and fast enough. The truck drivers need this information in order to use the right truck to be able to handle the goods.

Since the truck drivers do not know when during the week the deliveries will arrive and therefore it is hard to plan for the handling of incoming goods. Most of the deliveries arrive at noon or around twelve and during Mondays, Wednesdays and Thursdays.

When it comes to the information flow between the transport administrators and the purchaser, there is a gap. According to the purchasers, the goods arrived must be checked more in detail and always have the right documents since the company cannot accept incorrect articles. One of the respondents thinks that it would also be better if the purchaser could see in the system directly when the goods have entered the gate. He suggested that it could be even better if the company could be connected online through GPS or something similar in order to follow the goods and thereby be able to plan better.

The chief of purchasers at KRTC also agree that it would be preferable to receive the information about incoming goods directly when it enters the company gate or even better, when the supplier has sent the articles and planned arrival.

Another issue to discuss is the fact that today Kalmar Industries only has one delivery address. Therefore, the cost of handling all goods is taken care of by KCH, since the truck drivers and the trucks are employed by KCH. In there exists no internal factorising when it comes to the cost of handling incoming goods.

4.5.3 The Flow of Articles

There are no predicated routes for the truck drivers to follow and the simple rule for the truck drivers to follow is to drive the shortest way possible. As it is not possible to standardise what ways the trucks should take it is very important that the articles are placed at the best possible location.

The placement of the articles has to be based upon many different factors such as size, volume and product rotation. If the articles were placed in a well-organized manner this would directly lead to a more efficient materials flow.

The articles that this study is focusing on are located outside, which means that these articles cannot be stored for a long time. The reason for this is that the tough Nordic climate has a great impact on the condition of the articles. The first in first out (FIFO) principle is therefore necessary for this type of storage. This means that as many articles as possible should be located so that it is possible to reach them from more than one direction. If this is managed, the time to pick the articles would decrease and the flow would become more efficient.

In order to find out if the articles are placed in the best way calculations of the distances, in both meters and time, between the articles' locations and the production plant will be given in the following section.

4.5.4 Internal Transport Distance and Time

As can be seen on the map in figure 4-9, for a greater vision in Appendix 12, the distance in meters and time has been recorded from the assembly building to five different locations (A-1, A-2, A-3, A- 4, A-5, A-6, A-7 & A-8). In order to see the economical effect in terms of reduced internal transport when moving the articles the distances are calculated both in meters and in time. The calculations for the internal transportation are conducted in meters as this gives the most accurate result. The reason for using time is solely to obtain the average speed for the trucks.

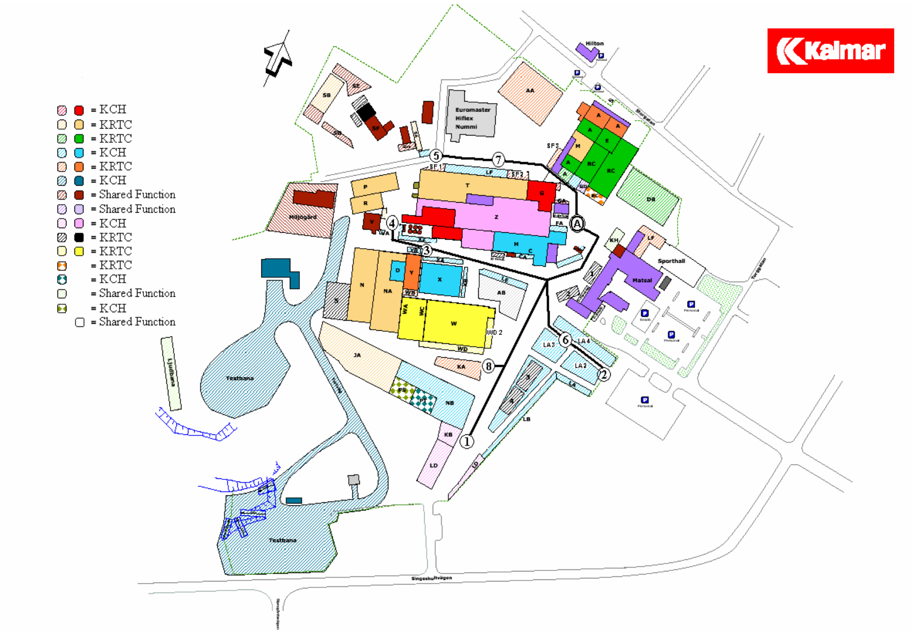


Figure 4-9: The Main Materials Flows.

To get the total savings we have calculated the average speed, which is 10 Km/h. This average speed of the trucks has been calculated based on measuring distances in meters from the assembly to five points on the storage area and how long time it takes to drive these distances in seconds, see figure 4-10 below. Distance A1 for example is 294 meters and took 62 seconds to drive. This means a speed of 17, 07 Km/h. From five of these observations and calculations the average speed of 15, 84 Km/h was obtained. This speed however is the result of driving the trucks without any articles loaded on the truck. It was therefore decided in consultation with Anders Svensson that a likely average speed would be 10 Km/h.

Calculation of average speed for Trucks

Distance	Distance (m)	Time (sec)	Km/h
A1	294	62	17,07
A2	239	54	15,93
A3	228	55	14,92
A4	262	65	14,51
A5	228	49	16,75
A6	160	-	**-**
A7	167	-	**-**
A8	215	-	**-**
			15,84

Figure 4-10: Route Length of Truck Movements

Further, this average speed is calculated without taken the actual loading and unloading of the articles into consideration. The calculations are conducted in this manner because it takes approximately the same time to load and unload all articles.

By knowing where the articles are located and the volume used per year one can calculate how much, in meters, each article is driven to the assembly building over a time-period. These calculations are conducted in each of the tables in Appendix 9-11 and further explained in the following part.

4.5.4.1 Summary of Calculations

As can be seen from the calculations in appendix 10 there are about 60 articles that are used more than 50 times over the last 12 months.

Among the top five used articles, there are three, which are stored in an inside storage in area X, which is a tent belonging to KCH and are, situated about 230 meters from the assembly plant.

Among the articles that are being used and thereby transported, one often can find articles located at LF2. It is almost 228 meters from the assembly plant to this location. This means that every time this article is to be used in the assembly, it needs to be transported 450 meters.

From the calculations, showing the frequencies in descending order we can see many examples of articles that were used a lot during the last 12 months but are located a long way from the assembly plant. The analysis was conducted based on these calculations.

4.6 Summary of the Empirical Framework

This chapter has given the reader an insight in the Kalmar organisation and Kalmar Industries in Lidhult. The history of the company has been presented as well as the different markets and the Kalmar Business Segments. The chapter is mainly based upon information collected from the interviews with the employees.

The chapter starts by describing Kalmar Industries as a subsidiary in the Kone Corporation followed by a more detailed description of Kalmar Industries in Lidhult. Thereafter, the products manufactured and the company production site are discussed and explained.

After the company description, there will also be a description of the storage area, the mapping of articles on the outdoor warehouse and the mapping of flows. In the part where the storage area is described important factors such as roads, ground quality, etc. are mentioned. Thereby, follows the mapping of articles that we have chosen to sort in three different groups, on the different storage areas, on how frequent the articles are used, and their product families. The last section of the empirical framework, where the mapping of flows is done, the internal transportation between different storage locations and the assembly plant is calculated in meters and in time.

Empirical Framework

5 Analysis & Alternative Changes

In this chapter, the empirical material will be analysed, based upon the theoretical discussion, in order to fill the purpose of the thesis and answer the research questions. The analysis model below shows the layout of the analysis chapter.

5.1 Introduction

In this chapter the analysis model, shown below in figure 5-1 gives guidelines of how the analysis work has proceeded.

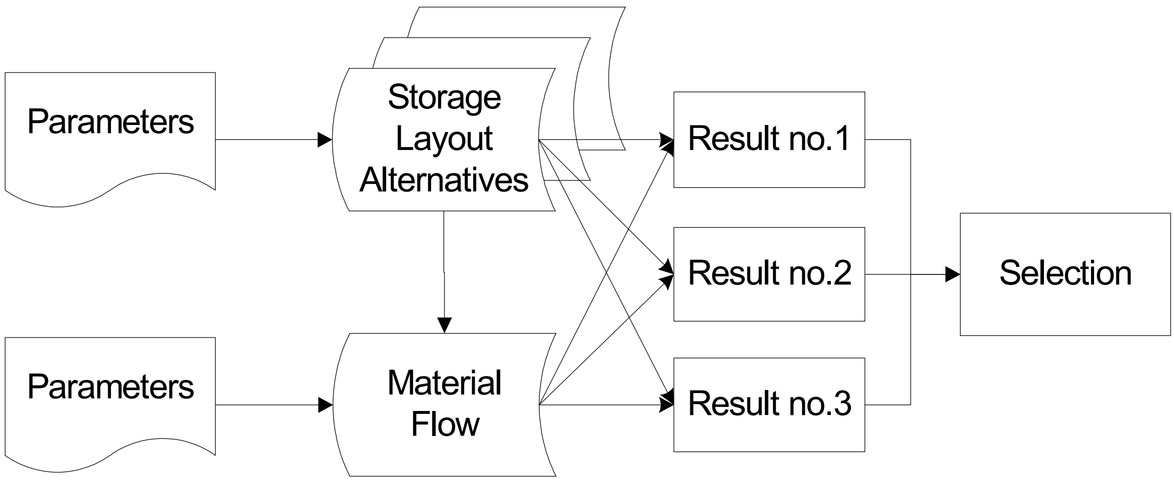


Figure 5-1: Model of Analysis Disposition

Firstly, three main changes of the storage layout will be made. The parameters that we believe change the storage layout the most will be emphasised. By looking at these parameters three possible changes of how to change the storage layout has been derived. These storage layout changes are improved markings and signs at the storage area, group the articles in product families and locate them in fixed places, and locate the articles with high frequency close to the assembly plant. These changes can also be seen as different alternatives of how to improve the storage layout.

Secondly, results of these changes and the impacts these have on the materials flow and the internal transportation will be shown. Additionally, there are other parameters, which will be mentioned such as information and changed picking procedures since these have an impact on the materials flow.

Finally, the result of these changes of material flow together with the result of the changed storage layout will be given in terms of changes in internal transportation and what worth these changes have to Kalmar Industries. Calculations of the reduced internal transportation in terms of time and money saved will be given. Advantages and disadvantages of the different alternative changes of the storage layout will be highlighted and end up with a selection of the best alternative, in our point of view, of how to improve the storage layout.

5.2 Storage Layout Changes

To be able to make changes in the storage layout several parameters must be considered before completing the changes. However, we have decided to focus on those parameters that have come up during the study.

5.2.1 Parameters

These parameters are, among others, restrictions of the storage area, ground quality, road limitations within the area and their safety, inventory control and reconstructions.

5.2.1.1 Restrictions

One of the parameters that have an impact on the storage layout is the actual size of the storage area owned by Kalmar Industries. As described in the theory in part 3.8 there are several ways to increase the storage space, which is one of several purposes of this study. In order to do this the company has to consider several restrictions within its total storage area. Kalmar Industries in Lidhult has an area of 22 hectares. However, this area is divided between the two companies KCH and KRTC. This limits the area that can be used since this division is fixed today. Thereby the storage area cannot be expanded and consequently the present storage must instead be more efficiently disposed and organised.

It has come up during the interviews with the truck drivers that there exists a bottleneck in the production plant. One suggestion can be to construct a new entrance to the assembly plant in order to avoid these bottlenecks and interruptions in production. This bottleneck can also be seen as a restriction since the construction of new buildings is outside the scope of this study.

5.2.1.2 Ground Quality

Additionally, as mentioned in the empirical chapter the present ground quality is not in a satisfying condition since the ground in some places is not asphalted. This is due to the difficulties of doing so with this type of ground, which is placed above a wetland area. However, in this study construction of new roads on the storage area has been avoided since it is a costly procedure due to the type of ground, which thereby limits the possibilities to change the layout. According to the truck drivers interviewed, although asphalted roads would be preferable they believe that a new construction of roads would be unnecessary. However, we believe that there are some areas that are not used in the best way, referring to one area situated between the two office buildings. We believe that there is an unnecessary amount of road space, which could be used better. This is further mentioned in part 5.2.4.2 and illustrated in figure 5-2.

5.2.1.3 Safety

Another important parameter to have in mind is the safety on the storage area. As stated in part 3.11 in the theoretical framework the traffic system is one of the largest risk factors in an industry due to large percentage of the total injuries in an industry. Consequently, the truck drivers think that safety in this area has to be improved. Since one of the office buildings is located in the middle of the storage area, many employees are crossing the area each day. Together with all visitors, walking around in the area this might interfere with safety. The truck drivers stated that they often have to slow down and drive carefully in some areas in order to look out for pedestrians. Therefore, the entire storage area needs to be better marked, displayed and the crosswalks need to be marked. One solution to improve safety even more can be that all visitors have to wear yellow vests in order to be more exposed to the truck drivers.

5.2.1.4 Inventory Control

It is important to be aware that in order to control the inventory, the company must control the purchasing and the deliveries. Now Kalmar Industries in Lidhult has a delivery performance of only 80%. Compared to old figures this percentage has risen during the last two months. If there is once again a decrease in delivery performance then it will be hard for the purchasers to plan and even harder for the production workers since they cannot be sure of having the articles delivered in time. As discussed in part 3.5 of the theoretical framework companies can have different types of inventories, e.g. cycle stock, seasonal stock, safety stock.

Although Kalmar Industries does not want to have a safety stock, they are forced to have one in case of late deliveries. As also stated in the theory, part 3.4 there are different reasons for holding inventory. One of these is to protect from uncertainties, which we think is the case for Kalmar Industries since they cannot trust their suppliers' delivery performance at the moment. Therefore, the company needs to demand more from their suppliers if they want to improve the inventory management. As mentioned in the empirical chapter Kalmar Industries is using the Vendor Managed Inventory (VMI) principles for some of their C-products. However, we believe that Kalmar Industries could use VMI to a larger extent than they are today in order to manage the materials flow better.

5.2.1.5 Reconstruction

Another thing to have in mind is that there are possibilities of reconstruction projects on the area. According to the theory, part 3.8, there are several ways of how a company can increase its storage space, e.g. through more efficient use of air space or ground space, or expansion of the storage area. Therefore, we want to purpose to Kalmar Industries that they do some reconstruction on the storage area. We have decided that the area AB should be used for storing articles instead of having the almost finished trucks that are waiting for final adjustment stored there. This area, as previously mentioned, is very attractive from a storing point of view as it is close to the assembly plant and close to unloading zone 2 and 3. This area was also recently asphalted which makes it easier when picking up the articles. There is also, in comparison to many other locations on the area, asphalt all the way from the location to the assembly plant.

By studying the area at Kalmar Industries, we found that the area close to LE and AB could be expanded, and thereby store more articles in this attractive location, shown in figure 5-2 below. There is no clear reason why the road is so wide at that point. Even if the storing area is made larger it will not be any problems for the trucks (lorries) coming with goods to pass this point. This location is close to the assembly plant it would be very beneficial to use for articles or product groups with high frequency. This would lead to decreased internal transportation and the possibility to have a more constant flow into the assembly plant.

When it comes to the theory principles of product rotation Kalmar Industries in Lidhult is using FIFO. The main reason for this is that the Nordic climate has a great impact on the condition of the articles, since the articles are stored outside. The first in first out (FIFO) principle is therefore necessary for this type of storage. The FIFO principle should be applied to this area and the articles stored here. As they are today when the articles are located close to the fence which makes it very difficult and time consuming to pick-up articles here. The reason is that the truck drivers cannot reach the articles from more than one side meaning that the articles many times a week have to be rearranged so that the oldest can be picked first.

Therefore, we have decided to undertake layout changes at location LA. By moving the road on area LA from its current position towards the fence and store the articles in the middle, as described and shown in figure 5-2 below, and for a larger vision in Appendix 13, it will facilitate access from two sides. The time to access the articles is important as well as the simplicity of picking them from their locations. However, on the one hand a maximum use of the storage area gives a low accessibility to the goods, while on the other hand a 100% filling rate will cause an enormous problem when accessing the goods, according to the theory in part 3.7.3.

As this area is relatively large, we believe that it is possible to change this area, relocate the articles and thereby get a better functioning FIFO system, which will reduce picking time and decrease internal transportation. When making changes in the storage layout it is important to take under consideration how these changes will influence the materials flow, i.e. the truck movement, and if the changes are applicable at all.

Figure 5-2: Changed LA-area.

With the above mentioned parameters in mind three alternative changes of the layout will be explained in the following part. These alternative changes of the storage layout are markings and signs, relocation of articles based on their frequency, and relocation of articles based on their product families.

5.2.2 Alternative 1: Markings & Signs

One alternative change of the storage layout can be to keep the present article location but improve the markings of the storage area since at present there is a lack of markings and informative signs. The existing storage map, which is shown in the empirical part 4.3.1, does not at the moment have any marking of where the articles could be found.

Although the truck drivers know by heart where all articles are stored, the information must be improved in different areas. Especially, when it comes to marking of the different storage areas, and the articles that are placed in each location. We believe that it would be preferable to clearly define each storage area with paint on the ground and to put up signs with information of the articles, name and number, which is specific for each area. Instead of identifying the different storage areas with letters, we believe that numbering the areas would be preferable or just use single letters in alphabetical order. As stated in the theory, information flow and material flow go hand-in-hand and therefore information is essential in order to get a well functioning and efficient materials flow.

Today, the loading and unloading zones are marked with numbers, figure 4-6 in part 4.3.2, but it would be even clearer if all the articles that should be delivered to each loading zone were written on a sign.

As discussed in part 3.13.3 in the theoretical framework, another way to increase the inventory control further would be if Kalmar Industries in Lidhult started to use barcodes. If all articles had barcodes, it could be registered in the information system by scanning the articles every time they leave or arrive to the storage. At the moment there is a delay from when the goods arrive to when they are scanned into the information system. In addition, the barcode system can be implemented, and then the truck drivers working on the storage area would be able scan the incoming goods immediately.

5.2.3 Alternative 2: Articles Frequently Used

When considering how to store the articles in an alternative way than at present, it would also be of interest to look at the frequency of the articles. By frequency, we mean how many of each article that is used in production, i.e. how many times the articles are moved between their location and the assembly plant. This is of interest given that internal transportation in the storage area, and movements to and from the production site could be reduced due to better planning of the storage area. We have chosen to base this alternative upon the principle of popularity, which is previously mentioned in the theoretical framework, would be suitable for Kalmar Industries in Lidhult. In line with this, internal transport distances could be reduced if high frequently used articles are moved closer to the assembly plant, which will be further discussed in part 5.3 below.

Kalmar Industries has already made an ABC analysis of their articles. However, this analysis is based on both frequency and value of the articles. Therefore, this classification should only be used by the purchasing department and not for the outside storage area. In addition, the ABC analysis for the storage should be based solely upon the frequency of the articles instead of using the volume-value. Consequently, we have chosen to use the principle of popularity that gives more control of the articles with a high frequency. All articles with low frequency would in this case have to be moved to the outskirts of the storing area in order to bring space to articles with a high frequency. This

is suitable according to the Pareto principle, 20 % of the articles stands for 80% of the frequency, mentioned in the theory.
For example, as stated in the empirical chapter, final products are to a high degree placed at the storage area AB, which is a highly attractive spot from a storing point of view, close to the production area. Considering this, it would be better if this area was used for articles with high frequency and move the final products closer to the area gate.

5.2.4 Alternative 3: Product Families

A third alternative change of the storage layout is to group the articles in product families and move the entire product family to a suitable location. When deciding which location each product group should obtain we have looked at many different aspects. One important aspect, even in this alternative, is the frequency of the entire product group, i.e. the principle of popularity, which was discussed in the theoretical chapter 3.7.4.2. This means that the product families with high frequency have been given a more favourable location for example closer to the assembly plant. Furthermore, when implementing this alternative we strongly believe that it should be done in combination with the improved markings and signs, which has been explained in alternative one.

According to the theory, there are different ways of grouping the articles. As seen in the empirical chapter the articles at the storage area of Kalmar Industries in Lidhult is not sufficient organised although the basic idea of placement seem to have been to group them according to similarity. However, these areas have not been adjusted enough to the amount of articles ordered since there has not been enough space for all articles and thereby created the unstructured storage area which exists at the moment.

As shown in the empirical chapter, Kalmar Industries in Lidhult today has both a fixed and a floating product placement since the storage areas for the different articles have not been large enough. As mentioned also in the empirical framework, the truck drivers believe that it probably would be more suitable to have a fixed position for all articles than the present system. However, this in turn would only be possible if the storage places for respective article would be larger. If you combine this with grouping the articles in product families there would not be enough space right now on the articles' fixed positions. However, when implementing a storage area based on a fixed space for each product family it is important that each group have an area that is large enough as mentioned in part 3.7.2 in the theoretical framework. Therefore, the third alternative change of the storage layout will be to group the articles in their different product families, and to free larger slots for each product family.

When developing this change both the principle of similarity and principle of size and aisle length will be applied. The last principle mentioned is important to include jointly with the first one since several articles are clumsy and difficult to place in some locations.

When it comes to the final products, they must be located in another place since they are located in different places at the moment. This depends on if they are ready to be shipped away, waiting for test or waiting for entering the assembly plant for final adjustment. A mentioned earlier, the spot directly outside the assembly plant, marked as AB on the storage map in Appendix 5, is a popular spot and should therefore not be used for final products, which take up lot of space. We would instead like to suggest placing the final products on the areas PS, PT and some on JA, which are areas situated close to the loading zone 5 where all final products are shipped away.

5.2.5 Results of Layout Changes

In this part of the analysis, the result of the three above layout changes made will be shown. The advantages and the disadvantages of each alternative will be outlined in order to state the differences of the alternatives. Information about where exactly the articles will be placed after the layout changes will not be explained in detail. For further information about the new articles' locations after relocation of articles most frequently used, alternative two, see Appendix 14. For new information after relocation of article based on their product family, alternative three, see Appendix 15.

5.2.5.1 Result 1: Markings and Signs

An advantage that might arise by improving the information with markings and signs is that it will be easier to keep the storage areas fixed and structured. Thus, it will also be easier to find the articles for people who are new to the area. Clearer markings and signs would facilitate both for the forwarders delivering the goods as well as for the truck drivers collecting them.

By using bar coding the purchasers could see exactly how many articles that are physically in store at the present time, and not only how many that should exist according to their programs. By this system, all departments will be able to reach the same information and the communication between them will improve.

To mark the different storage areas with numbers or with only single letters instead of two letters would improve the understanding and visibility as well as give a logical structure to the area. This change is also beneficial for future software implementations since numbers are easier to handle than letters.

Negative consequences that might come in the line of this change would be that the employees would have to learn the new structure of the storage area, and change some of their work procedures. This adjustment to the new layout and the use of markings and signs will cost time as well money. However, we believe that the cost will be marginal in comparison to the benefits that these markings and signs will contribute with to the storage area.

Advantages
• Fixed & structured storage area. • Forwarders and Truck Drivers will have easier to find the loading zones. • The layout will be more structured and clear if numbers or single letters were used. • Barcodes will enhance higher control. • Barcodes will make it easier to share information.

Disadvantages
• Complications for the workers in the short term with new working procedures. • To develop markings and signs will take time and cost money.

5.2.5.2 Result 2: Frequently used articles

This alternative gives the company improved control of the articles that are most frequently used. The benefits are increased control, more constant flow of important articles, reduced internal transportation, less focus on the not so important articles and a more user-friendly environment. However, there are some disadvantages with this alternative since it might cause an disorganised and unstructured storage environment when the articles will share storage areas.

Moreover, by placing high frequency goods where the transportation distances reach a minimum, and locating low frequency products farther away, the internal transportation will also be reduced.

The wheels with the driveshafts that are located at the LA area will stay at the same place in the future.

This alternative would be even better in combination with the use of better markings and help for visual tracking of the material as mentioned above, including signs area maps etc. This is the case depending on the fact that it might be more difficult to find the articles since similar goods are not sorted in the same sections. For further information about where the articles that are used most frequently are located at the moment, see appendix 14.

Advantages
• Increased control over the most frequently used articles. • Constant flow. • Easier to pick articles. • Reduced internal transportation. • Reduce order picking time.

Disadvantages
• Unstructured storage environment. • All articles will be spread out. • Hard to learn each articles' location. • It costs money and time to rearrange the storage. • Possible resistance for changes from the employees.

5.2.5.3 Result 3: Product Families

As mentioned earlier, the reason for relocating the articles based on what product or family group they belong to is that it is possible to achieve a relatively structured storage area. By structured we mean a storage area where the articles are easy to find and easy to access. The accessibility is of course a very important aspect when deciding where the articles should be located. As the articles stored at Kalmar Industries should be treated according to the FIFO principle it is crucial that the articles are accessible from more than one point.

The LA area is changed in such a way that it will be possible to reach the articles from several points.

We have decided to move all counterweights to area LA. The reason for this is that this is a product group that is used very frequently, over 1200 times, and should therefore be located at a location close to the assembly plant. By changing the layout of the LA area, as shown above, it will be possible to access the articles from at least two ways. This will lead to higher accessibility, which will decrease the time it takes to pick the articles from its location.

The aggregates will also be moved to this location from location LF2. The aggregates are large and more complicated than many other articles to transport. As location LA is close to the assembly plant, we found it suitable for the aggregates to be located here.

The grinders have been moved from various locations to location LD. This is a location quite close to the area gate and far away from the assembly plant. The grinders belong to a product group that is not used that often. This is the reason why they recieved this location.

The driveshafts have been moved to location LF2. LF2 is a location where many different types of products were stored earlier. Articles such as cylinders, counterweights and shields were stored at location LF2.

In turn, the cylinders have been moved to location AB. Prior at location AB Kalmar Industries stored the almost finished products that were waiting for adjustments. From AB to the assembly it is only 152 meters, which makes this location good for storing product groups with high frequency.

At location XZ2, there were steps located prior to the changes. These steps were used almost 1000 times during the last 12 months. Therefore, we decided to move this product group to where the cabins were located earlier. This location, LE is as can be seen from the area map, about 120 meters from the assembly plant. The cabins should be moved from location LE to location KB that is rather far away from the assembly plant. The reason is that one cabin is used for one truck meaning that they only have a frequency of about 390 a year.

Various holds have been moved from the two tents to location XZ2 where the steps were located prior to the changes.

The covers that have been used only 150 times during the last 12 months have been moved to location KB. At location KB, which is rather close to the area gate just some spread articles were located there earlier.

We have decided to move the handles to location NB. This product group was earlier situated at various locations such as XB and CA.

The rails have been relocated to XZ. The reason for this is that the articles are used frequently and should therefore be located close to the assembly plant. The route between XZ and the assembly plant is asphalted which consequently gives a faster a safer movement of the goods. The rails are at present located at several different locations.

Mudguards are not used as frequently as many other product groups, and have therefore been moved to a location further away from the assembly plant.

The result from these changes would be that most of the area would have to be reorganised and goods of the same kind will be located in different sections in the storage area. Even if this were a large-scale change, the result would be a storage area with higher security, improved control and increased amount of free space, which is a more efficient use of the storage area. Appendix 15 gives more detailed information in terms of where the articles that should be grouped in product families are located today.

Advantages
• A structured storage area. • Easy to find and access the articles. • Decreased picking time of the articles. • Higher security. • Improved control. • Increased amount of free space. • Less driving in the area.

Disadvantages
• Costs money and time to rearrange the storage. • Possible resistance for changes from the employees.

5.3 Materials Flow Changes

The changes mentioned above will also have impact on the materials flow. It will be easier for the managers as well as the staff to manoeuvre and control the material flow, because the area will be more structured due to all changes. The internal transportation is probably one of the parts that will draw the largest benefit from these changes since shorter lead-times will come as a reflection of these changes. The changes of the material flow will be further discussed in the following section.

As is shown in the disposition model of the analysis, the mentioned above changes made in the layout of the storage will have a great effects on the materials flow and thereby the material management. Therefore, these impacts will be emphasized in this part while also other parameters, such as information and changed picking procedures, which can have influence on the materials flow, are discussed.

5.3.1 Material management

It was explained in the theoretical chapter that the main objective of materials management is to solve problems from a total company viewpoint by coordinating performance of the various materials functions, providing a communication network, and controlling materials flow. To have an overall view of the problem and to look at the total picture is crucial when it comes to improving the materials flow. Many parameters need to be taken into consideration. However, in this study, the main parameters that will change the materials flow are how the internal transportation is functioning, how information is displayed and how the articles are picked

As mentioned earlier, materials management is a subset of logistics and deals with the flow of raw materials, subassemblies, manufactured parts, packing materials, and in-process inventory. Efficient materials flow is very important in order for firms to deliver their products at the right time, in the right quality and quantity, and at the right price. This is certainly the case for Kalmar Industries as a producing company. If the flow of goods within the company is not functioning well it will be very difficult to satisfy the demanding customers' needs. According to the theory about layout design and goals in part 3.6.1, the goal with warehouse design should be to maximize the cubic utilization and to facilitate continuous straight product flows through the building. Therefore, Kalmar Industries must make sure that there is a constant and continues flow of materials going into the assembly plant. The materials must be delivered to the assembly at the right time, the right quantity and in the right quality to avoid bottlenecks.

5.3.2 Internal Transportation

The first parameter that the company has to consider the internal transportation. Kalmar Industries in Lidhult is not using any particular product flow pattern, which is mentioned in the theoretical part 3.10, since this would be almost impossible due to the large area and many storing locations. Instead, the truck drivers try to go the shortest possible way to pick up the goods. The drivers also try to minimise the empty transportations to and from the assembly plant.

According to the theory, the internal transportation system should be constructed in a way that the large traffic flows do not need to cross other large flows. Furthermore, the large flows should be split into smaller networks to avoid congestion. Therefore, the large flows that pass the production sites will be given a high priority and the smaller network will be protected from the transit flows. This is very important to have in mind, especially when relocating articles with high frequency since the flow will change as well.

Since the trucks and the truck drivers belong to a shared function between the two companies KCH and KRTC it is sometimes difficult to divide the cost between them. As stated in the empirical chapter the costs for the truck drivers are now handled by KCH. There are, however, some problems at the loading zones since both goods to KCH and KRTC are delivered to the same loading zone, and then delivered to each company. We believe that also the cost of handling the goods should be divided between the companies.

Relocating the articles in the storage area will have a great impact on the materials flow. If an articles with high frequency is moved to a location closer to the assembly plant this will affect the flow significantly. The truck drivers will take different routes when picking the relocated article leading to changes in the flow of materials. What these changes in the materials flow look like will be presented and explained in part 5.3.5 where the results of the changes are given.

5.3.3 Information

Another important parameter to have in mind is information flow. As can be seen in the theoretical chapter, information can, if used correctly, have great impact on an organisation including the flow of materials. Information to and from the purchasers at Kalmar Industries will determine when the goods will arrive, and at what quantities the goods will arrive in. As is the case with Kalmar Industries, there are certain days during the week when much of the deliveries arrive. Today, the suppliers have a time window of one week when delivering to Kalmar Industries in Lidhult. This makes it very difficult to control the flow of materials and plan the production. In the near future, however, Kalmar Industries will change to one-day time window for deliveries, which will lead to a more constant flow of incoming goods. This will in turn make it easier to plan the production, thereby also plan and control the internal transportation better.

Another issue relating to information is how the information is displayed in the trucks. By having a more constant flow of materials it will be possible to know further in advance, which articles are to be used in production. This means that the truck drivers can receive information earlier on what articles should be transported to the production. The truck drivers will thereby be able to plan their work better which also will improve the flow of materials.

According to the fact obtained from the interviews, there is a lack of information and cooperation between some departments, mainly between the truck drivers and the production. By looking at the organisational structure of Kalmar Industries in Lidhult, it is a traditional function oriented organisation. However, according to part 3.2 in the theoretical chapter a company should look at its organisation in process thinking manner in order to get an overall view. By implementing this kind of process thinking the employees will get a greater understanding for the importance of each part of the organisation, the importance of having an overall view, cooperate and support each other. However, as explained in the theoretical chapter it can be very hard to implement this in an old traditional function oriented organisation. Therefore, a suggestion can be to implement the possibility of job rotation where the workers have to change department for one day to learn how it works in different departments. This will give the employees greater understanding for different parts of the organisation. When implementing a process thinking into an organisation it is easier to trace and control the processes more easy and thereby do continuous improvements, which is important in this kind of organisation.

Since Kalmar Industries today has different information systems in different parts of the organisation it might cause problems in communication and sub optimisation instead of cooperation and competitive advantages.

5.3.4 Changed Picking procedures

A third parameter to take into consideration is changed picking procedures. Regarding the material handling equipment, it has clearly shown in the empirical chapter that most of the handling in the outdoor storage area is done with the help of trucks (forklifts). It was also mentioned that some of the heavy and bulky products needed the largest forklift (the ones that Kalmar Industries produces) in order to move the goods.

At present, there is only one heavy forklift truck in the area and this is sometimes occupied with other duties. This might lead to delayed unloading of incoming goods or picking of heavy articles. Another weakness is that using the FIFO rule demands that goods first arrived to the storage are used first, which bring a problem for the truck driver when goods are stacked in a row along for example a fence. A way to solve this, according to one of the truck drivers, is by using a Gantry crane. As can be seen in the theoretical chapter, 3.12.4, there are several advantages of using a gantry crane. An advantage is that it can cover a large span and handle very heavy load. The gantry crane, in the case of Kalmar Industries, could then be placed so that the crane, which would ease the burden on the trucks (forklifts), does the unloading of heavy goods. Furthermore, the heavy articles will become even more difficult to handle during the winter, as the grounds get icy and slippery. A gantry crane could facilitate the truck drivers' work during this period because the crane will not be affected by ice and snow as it moves on a rail-track. Another reason for acquiring a gantry crane is that the crane can reach heavy articles that have been place in the middle of an area surrounded by other articles. The trucks in this case would have to move certain articles to be able to reach the article in question. The gantry crane could also be used when loading the finished trucks onto a trailer for he transportation toward Gothenburg. However, a smaller type of gantry crane is to prefer since it otherwise can be hard to manoeuvre.

5.3.5 Results of Layout and Materials Flow Changes

Mapping exactly how the materials flow on the storage area look like was impossible for several reasons. The calculations on the savings made below are therefore conducted based on the internal transportation from the assembly plant to where the article is located and back to the assembly plant. This means that the calculations are not made of the exact meters of the internal transportation. Furthermore, the results in this part are connected to the results and outcome of the three different alternatives discussed in 5.2.5.

5.3.5.1 Result 1: Markings and Signs

In this part, we will show the effects of keeping the current location of the articles and only change the storage layout by improving various aspects such as markings and signs, and the information to the truck drivers and changed picking procedures.

By adding markings and signs, the information flow will be improved. Through adding these signs and markings, the visitors can easily get an overview of the professional structured and nice appearance of the storage area of Kalmar Industries. In addition, the employees will get a greater understanding for this part of the organisation when they see the markings and signs while passing the storage area. Thereby, they hopefully become more respectful to the work of the truck drivers at the storage area, e.g. not to stand in the way for truck drivers.

These markings and signs will also facilitate the work for the truck drivers since they now will find the articles much easier. Thereby, the internal transportation will also improve since it will take less time to find the articles.

However, the disadvantages of implementing markings and signs are that there might be lack of flexibility due to these fixed marked storage areas. These markings and signs will also cause higher costs if the articles must be relocated.

Advantages:
• Easier to find the articles. • Deliveries to right location. • Easier to pick the articles. • More structured internal transportation. • The storage area will get a nicer appearance and look professional to the visitors. • All employees will get a greater understanding for how the storage area is arranged and the importance of functional storage.

Disadvantages:
• Lack of flexibility. • Costly to relocate articles or change layout due to fixed marked areas and signs.

The calculations below show the total distance in meters that the truck drivers have to drive each year. The total meter, 6 743 644 meter is based upon how frequent the articles are used per year, and consequently how many times they have to be driven to the assembly plant. In order to get the cost of driving this distance we have based the cost calculations on the cost of having one truck driver, which are 400 SEK/ hour. To be able to calculate the total cost we have used the average speed of 10 km/h, which we multiply with the amount of meters moved of each article. Thereafter, we divide it with the cost per hour and thereby obtain the total cost of 269 746 SEK.

Results of the Internal Transportation Calculations Current Situation	
Total meter	6 743 644
Cost in SEK	269 746

Figure 5-3: Results of the Internal Trp. Calculations- Current Situation

5.3.5.2 Result 2: Frequently used articles

By changing where the articles are located, as described in part 5.2.2, based on their frequency will lead to changes in the storage layout but also changes in the truck movements, which in turn leads to decreased internal transportation work. This will decrease the costs associated with the truck movements, e.g.

fuel, and work hours. However, by relocating the articles based only on frequency will make it more difficult to find the articles, as some of the articles will be separated from their product group. If this alternative should work, it is very important that there are clear and specific markings on the area as emphasized in part 5.2.1.

The main advantage for the materials flow when relocating the articles based on their frequency is that the internal transportation will be decreased, which is further shown by results of calculations in figure 5-4. The internal transportation will decrease because of the fact that the most frequent articles will now be placed near the production.

It will also be easier to find the articles' locations since the most frequent used now will be situated close to the assembly plant. The company will also be able to control the inventory better since the most frequent used articles represent the main flow of articles.

Negative effects that these storage layout changes can have on the material flow are that it can be harder for the truck drivers to find the articles since they will be spread out over the area. Thereby, the truck drivers might be forced to drive a longer distance than thought.

A disadvantage is that the main internal transportation and the main material flow will be concentrated on the area surrounding the assembly plant. This can cause traffic jams since there also exist two loading zones in the same area.

It can also be hard to learn the new route that the truck drivers have to take in order to find the articles. In order to see the new location of the articles after the relocation see further results in Appendix 14.

Advantages:	Disadvantages:
• Decreased internal transportation. • Easier to find the articles' location since they are situated close to the production plant. • Increased control of those articles that represent the main flow.	• Increased int. transportation due to difficulties to find the articles. • The flow of transport will be concentrated on the area outside the assembly plant- might cause traffic jams. • The material flow will change and the truck drivers have to learn new routes.

The calculation results shown below in figure 5-4 give the total meter in internal transportation that is needed when all articles are relocated based on their frequency. The cost of internal transportation after this relocation based on the frequency was calculated in the same way as explained in part 5.3.5.1 above. However, since we want to find the difference in the cost of internal transportation between the original storage layout, and this changed alternative, we have made a comparison between the costs. By changing the relocation of the articles based on their frequency, we obtained a saving of 23 %.

Results of the Internal Transportation Calculations Changes based on Frequency	
Total meter	5 184 882
Meter reduction	1 558 762
Cost in SEK	207 395
Saving in SEK	62 350
% Saving	23 %

Figure 5-4: Results of the Internal Trp. Calculations-Frequency.

5.3.5.3 Result 3: Product Families

Relocating the articles based on product families will be advantageous in several meanings. The internal transportation will as said in part 5.2.3 decrease. This is due to that product families with high frequency will be moved to locations closer to the assembly plant. Since the storage area will be more organised the truck drivers will find it easier to find the articles, and this will affect the internal transportation. The internal transportation will decrease because the time to find the right article will be lowered.

The alternative of moving the articles based upon their product family will have a great effect on the appearance of the warehouse. Representatives from other companies and organisations visiting Kalmar Industries will be met by a storage that is professionally organised and structured around its materials flow.

Other effects that will come from these changes are that the material management will improve, mentioned in part 5.3.1. The assembly plant will have their required articles on time because of that the driving and picking for that truck drivers will go faster than earlier. The internal materials flow will also be more structured since the positions of the articles will be fixed. Specific routes will automatically be created since most of the driving will be to the product families that have the highest frequency. By creating the new layout of the LA area, shown in Appendix 13, the truck drivers will have easier to manage the FIFO system idea because they will be able to access the articles from different angles.

By reducing the movement of materials and by having high frequent product families located close to the assembly plant the truck drivers can work more efficient. This will in turn lead to that Kalmar Industries in Lidhult will manage a future expansion better due to both the fact that the material handling becomes more professional and that the truck drivers working performances will make it unnecessary to employ new drivers.

Together with the use of new techniques and better utilization of the truck computers, i.e. improved information flow, the material flow will improve. In combination with fixed timeslots for the incoming deliveries, the materials flow could be improved even further. The result of this is that the drivers could plan their entire day and the production department will have their requested products on time.

To see further how the articles have been relocated based on this alternative see the results in Appendix 15.

Advantages:	Disadvantages:
• Decreased internal transportation due to easier access and easier to find articles. • Constant material flow will be created. • The assembly plant will have requested articles on time. • Truck drivers will have easier to schedule their working day.	• Static placement of the articles might lead to long internal transportations in the future. • Future rearrangement of articles might lead to longer internal transportation.

The calculation of the total meter in internal transportation which is needed when adapting the product family alternative (see figure 5-5) is performed in the same manner as the previous calculation for today's internal transportation given in part 5.3.5.1. The cost saving is based upon a comparison between alternative one, markings and signs in part 5.3.5.1 and this alternative. We found out that by implementing alternative three the internal transportation cost could be reduced by 22 %.

Results of the Internal Transportation Calculations Changes based on Product Groups	
Total meter	5 280 000
Meter reduction	1 463 644
Cost in SEK	211 200
Saving in SEK	58 546
% Saving	22 %

Figure 5-5: Results of the Internal Trp. Calculations- Product Families

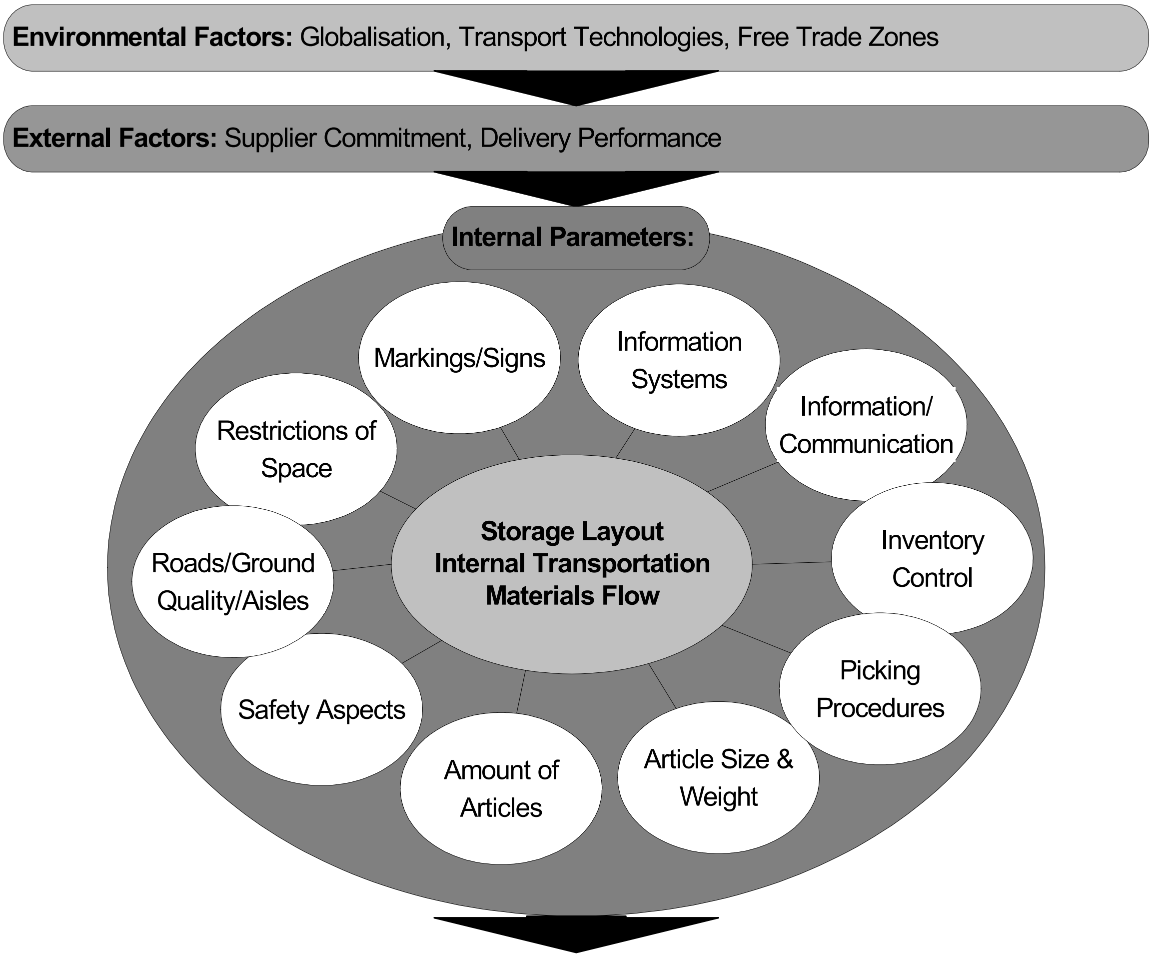
5.4 Selection of Changed Storage Layout

As shown in the model of analysis in figure 5-6 below, this analysis will now end up in a recommendation of which alternative we believe is the best when improving the storage layout and the materials flow. This recommendation is based on the stated advantages and disadvantages for each alternative that have been evaluated in section 5.2.4 and 5.3.4. Furthermore, a comparison between the cost savings of the different alternatives has been made. The results of the cost savings in SEK in internal transportation is concluded in Appendix 16.

We believe that the third alternative when grouping the articles in product families is the best alternative, since this alternative has the most advantages. This alternative, discussed in 5.2.3, means that we group the articles based on product families and move the entire product family to a suitable location.

When deciding which location each product group should obtain we have looked at many different aspects. One important aspect even in this alternative is the frequency of the entire product group, i.e. the principle of popularity, which was discussed in the theoretical chapter 3.7.4.2. This means that the product groups with high frequency have been given a more favourable location, for example closer to the assembly plant. The product families with low frequency have been given lower priority and been moved to the outskirts of the area. However, many other aspects have been taken into consideration such as ground quality, restrictions of the area's size and the principle of size and aisle length. In addition, the important aspect of the area's appearance has been considered. This means that articles that do not look good, e.g. not painted, have been moved so that visitors or customers coming to the area should only see the nicer articles.

Furthermore, when implementing this alternative we strongly believe that it should be done in combination with the improved markings and signs, which has been explained in alternative one. We believe that to be able to make the most out our chosen alternative it is extremely important to improve the communication and information displayed in terms of improved markings and signs. It could therefore be said that alternative three, which we have chosen, is a combination of the three alternatives.



1. Markings & Signs		**2. Articles Frequently Used**		**3. Product Families**	
Advantages	Disadvantages	Advantages	Disadvantages	Advantages	Disadvantages
-Easier to find articles -Deliveries to right location	-Lack of Flexibility -Costly to Relocate Articles	-Decreased Internal trp. -Increased Control	-Might Cause Traffic Jams -Truck drivers have to relearn the Area	-Decreased Internal trp. -Constant Material Pattern	-Static Placement might lead to longer trp. In the future

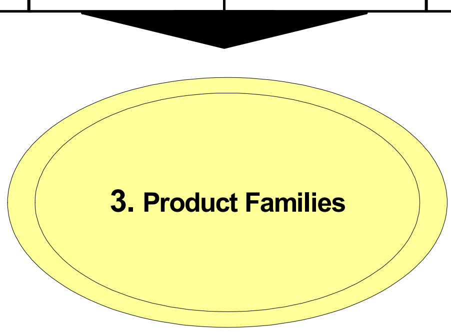


Figure 5-6: Model of Analysis

It is also very important to emphasise that this chosen alternative should be implemented in conjunction with the other recommendations that we give in the last chapter. Without conducting these recommendations or at least looking over the problems that we have come across there will be low impact when implementing the third alternative. One example of this is that it is not worth the burden of relocating articles and changing the layout of the storage area thus improving the materials flow and decrease internal transportation without fixing the bottleneck in the assembly plant. This bottleneck has arisen from the shortage of space in the assembly plant.

The decision to choose alternative three is based on the known circumstances, external factors and internal parameters regarding Kalmar Industries and its storage area, which is discussed throughout the empirical chapter, and on the evaluations that have been made in part 5.2.4.1 to part 5.2.4.3. From the results and the evaluations, we can see that it is possible to make even larger savings and to lower the internal transportation even more when choosing alternative two, which is based solely on the articles' frequency. However, we have concluded that there are more advantages when choosing alternative three and we believe that these counterweights the slightly less savings made in this alternative.

One of the largest advantages of choosing alternative three, in our opinion, is that the area will become much more structured when implementing the third alternative. By achieving a more structured storage area together with improved markings and signs it will become easier for the truck drivers to find the correct articles. This will lead to time savings and a further reduction of internal transportation because of decreased picking time.

In addition, it will be easier for the managers as well as the staff to manoeuvre and control the materials flow, because the area will be more structured. It was discussed in the theoretical chapter 3.9.3 that materials management needs to be well controlled and administrated. When it comes to measuring materials, management Kalmar Industries should observe aspects such as supplier service levels, inventory, and price paid for materials, quality levels and operating costs. This is only possible if the area and the materials flow are well-structured and controlled. Measuring materials management is important because it gives an indication whether or not the company is on the right track.

Another important reason why this alternative is preferred is that it will lead to decreased internal transportation by as much as 1 463 644 meter or a 22 % saving in comparison of the current situation.

5.5 Summary of Analysis

In this analysis chapter, the goal is to come up with a good solution of how to change the storage layout and the material flow to the better. We start by looking at surrounding internal parameters that affect the storage layout and then focus upon three main alternative changes of how to change the storage layout. After having discussed the three different alternatives from the viewpoint of the theoretical and empirical framework, we end the first part of the analysis by analysing the alternatives. This part is called the results of the layout changes since we are highlighting the advantages and the disadvantages of the different alternatives.

In the second part of the analysis, we are looking at what impact the three alternative changes of the storage layout have on the materials flow. However, also other internal parameters are affecting the outcome of the materials flow. These are the truck movement, information and changed picking procedures. Furthermore, we analyse the three alternatives and their effect on the material flow by pointing out the advantages and the disadvantages of the changes. To be able to compare the three different alternatives in terms of cost savings we have made calculations of the cost of internal transportation of the different alternatives.

When comparing the advantages and disadvantages of the different alternatives, and the obtained cost savings we found that the best alternative to implement is the third. The third alternative is to relocate the articles based on their product group but we also believe that this alternative would need to have some influence of the two other alternatives. The reason for this is that in order to succeed with this change of storage layout the markings and signs must be improved as well. We have also found that the best placement of the different product families is to locate them after their frequency. Therefore, alternative three has some influence from alternative two as well.

In the next chapter, the conclusions of the analysis are presented and summed up in an explanatory framework of what external factors and internal parameters that needs to be taken into consideration when implementing our chosen alternative.

6 Conclusions

This chapter serves a presentation of the conclusions. Firstly, we will give a brief discussion about the content of the thesis and end up with our results, which figure 6-1 mainly is focused on. The framework of our analysis, which is shown in figure 6-1, is given in order to facilitate for the reader and easier understand how all parts are linked together and what the company need to have in mind when implementing our suggestion.

6.1 Conclusion

The thesis starts with explaining that the world economy is, and has been for some time, in a radical shift and that we are moving away from a world where national economies are isolated from each other. The globalisation of markets is merging national markets into one huge global marketplace, where companies have large opportunities to earn money. However, the emergence of globalisation has made the business world tougher. Competition between companies is fiercer than ever and there is great pressure from various stakeholders to be as profitable as possible.

In order to cope with the challenges in the new business environment it is essential that companies have, among many other things, a well functioning material management, i.e. an efficient physical supply of materials throughout the supply chain. An efficient materials flow is crucial in order for firms to achieve high customer service levels and meet customer expectations thus deliver the products at the right time, in the right quality and quantity, at the right price and at the right place. Improving the storage layout and the information flow at Kalmar Industries is a step in the direction towards higher customer service level.

The purpose of this thesis was to examine the possibilities to change the storage layout at Kalmar Industries in Lidhult. The study investigated whether or not it was possible to improve the layout of existing outside located storing areas, thus improving the materials flow and the handling of incoming and outgoing goods. Furthermore, it is questioned if the internal transportation could be reduced because of changes in the storage layout.

Conclusions

The study mainly focused on the articles that are stored outside. These, mainly large articles, cannot be stored inside due to size or weight. The investigation looked at the articles from when the supplier enters the main entrance until the final products leave the area and pass the gate on the way to the customer. It was "a gate to gate investigation" where we excluded the inside storage and the materials flow inside the assembly plant and focused on the middle section of the supply chain.

To undertake this study in a satisfactory manner various theories have been outlined and discussed. Theories such as layout and design principles and materials management, among many others, have been discussed. Different types of processes including effective, flexible processes and identifying processes have also been discussed.

From the methodology chapter we learned that this study was mainly a descriptive and an exploratory research with both quantitative and qualitative data. Primary data such as visual observation and personal interviews have been used as well as secondary data such as the theories mentioned earlier.

The empirical chapter gave the reader an insight in Kalmar Industries organisation and Kalmar Industries in Lidhult. The history of the company was presented as well as the different markets and Business Segments. This chapter also gave a description of articles placement in the outdoor warehouse, the trucks used for material handling, the staff's tasks and the storing areas.

The results from the research, as can be seen in the analytical chapter, show that there can be savings made by changing the storage layout, relocating the articles and improving the information flow. We have mainly looked at three possible alternatives for changing the storage layout based on status quo in terms of not relocating articles but with improved markings and signs, based on frequency of the articles, and based on the product families of the articles. These alternatives were chosen based on the known circumstances at Kalmar Industries and the parameters that influence the research questions.

The first of our alternative was to leave the articles on their present location, i.e. status quo, but with improved markings and signs on the area. This alternative would make it easier to find the articles and it would lead to improved safety. Improved safety in terms of zebra crossings on the ground where pedestrians normally walk. As the articles are easier to find the internal transportation can be decreased because less driving to the wrong location. In addition, the storage area will get a nicer appearance and look professional, above all to the visitors. There are however also drawbacks with this alternative. An example can be that it could be costly to relocate articles or change layout because of the fixed marked areas and signs.

Relocating the articles based on their frequency led to a decrease of the internal transportation distance of 1 558 762 meters per year. This decrease should give Kalmar Industries savings up to 62 350 SEK per year. This is a reduction of the total internal transportation by 23 %. Further, this alternative resulted in more emphasis being put on the more important articles. Thereby, only the important articles are being closely controlled and monitored. However, if choosing alternative two the storage area will become more unstructured leading to difficulties in finding the correct articles. The reason is that the articles are no longer located according to what product group they belong to.

The third alternative in this study was relocating the articles based on product groups as well as the frequency within the different product groups. This would make the storage area more structured and the articles would be easier to find. This alternative would also lead to a decrease of the internal transportation. By relocating the articles based on product group we have been able to decrease the internal transportation by 1 463 644 meters. This is a decrease of 22 %. Further savings when choosing this alternative could be achieved due to that it is easier to find the articles thus saving even more time and money.

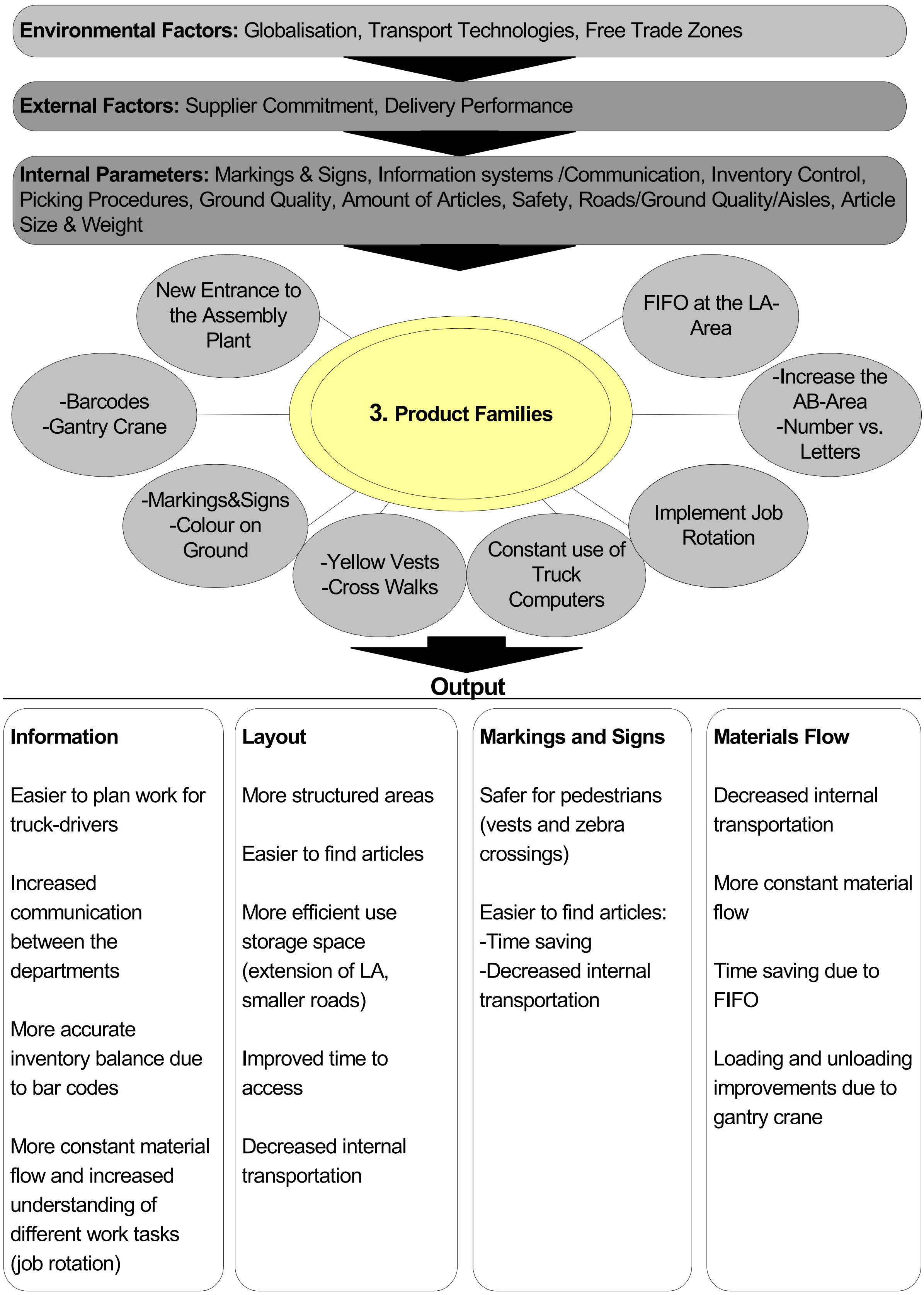


Figure 6-1: Framework of our Conclusions

As shown in the framework of our conclusions in figure 6-1 above, various parameters has influenced our decision on which of the alternatives we believe is the most advantageous. Firstly, we have considered environmental factors such as globalisation and decreased trade barriers as parameters that have influenced our decision. We believe that these external factors indicate an increased trade, which will lead to increased sales for Kalmar Industries. Secondly, there are external factors that Kalmar Industries cannot influence or at least has more difficulty influencing e.g. supplier commitment and suppler delivery performance. Finally, we have considered the internal parameters. These have been most important both when choosing the three alternatives and when deciding which one is the most beneficial. The internal parameters that we have taken into consideration are restriction of space, ground quality, inventory control, picking procedure, safety aspects, roads, information/communication, and information. All of these parameters have been discussed and taken into consideration.

From the results, we can see that from an internal transportation perspective the best alternative would be number two as this lowers the internal transportation the most. However, based on the parameters and the advantages and disadvantages analysed in section 5.3.5 we concluded that alternative three was probably the best one to choose since its advantages counterweight the slightly less savings in internal transportation. One of the largest advantages of choosing alternative three, to our opinion, is that the area will become much more structured when implementing this alternative.

As mentioned in 5.4, when implementing alternative three we believe that it should be done in combination with the actions, which are surrounding the third alternative in figure 6-1 above, such as improved markings and signs, which has been explained in alternative one. It could therefore be said that alternative three, which we have chosen is a combination of the three alternatives.

Further, it is very important to emphasise that the chosen alternative should be implemented in combination with the other recommendations that we give in the recommendation chapter. Without conducting these recommendations or at least looking over the problems, we have come across the impact when implementing the third alternative will not be as beneficial.

6.2 Answer to the research questions.

The research questions have already been answered throughout the thesis especially in the analysis and the conclusion chapter. However, the following is to clarify and summaries the findings, which relates to the research questions.

Sub Problem 1: *In what ways is it possible to change the storage layout?*

There are, of course, several possible ways to change the storage layout at Kalmar Industries in Lidhult. We decided mainly to look at three possible changes or alternatives in which the storage layout would be altered and improved. We analysed the three possible alternatives and concluded that the best alternative would be the one where the articles are relocated based on product families. This alternative would indicate large changes to the storage layout in terms of new placement for many articles. This alternative would lead to a more structured storage layout where good order is possible and thereby improvement in the time to access among many other improvements. Further, we decided to make the area AB larger than it is today. This is because area AB is probably the most attractive in terms of placement of articles. Another change to the storage area is the one conducted at area LA where the area has been redesigned to make the FIFO system possible.

When implementing alternative three it should be done in combination with improved markings and signs. Improved markings and signs would also lead to a positive modification of the storage layout.

Sub Problem 2: *How is it possible to make the internal transportation more efficient?*

By conducting the changes in the layout based on alternative three the internal transportation will automatically be affected because of the relocation of articles. The decision to recommend alternative three was also based, on what would happen to the internal transportation and the materials flow. By relocating the articles based on product families, we saw an immediate decrease of the internal transportation. This change would also, as a result of a more structured area, lead to a more constant flow of materials going into the production.

Sub Problem 3: *How is it possible to make loading and unloading more efficient?*

Once again, because of a more structured area the loading and unloading could become more efficient. The improved markings and signs would also affect the efficiency of loading and unloading as this gives clearer directions for both the forklift truck drivers at Kalmar Industries and the truck drivers arriving with incoming goods.

The gantry crane is a further step towards easier loading and unloading. A gantry crane would facilitate not only when it comes to loading and unloading of really heavy and large articles but also in the picking process.

The discussion around the sub problems leads us to the main problem:

Main problem: *What are the possibilities to improve the layout of existing outside located storing areas, thus improving the materials flow and the handling of incoming and outgoing goods?*

By changing the storage layout in the way proposed, and by conducting some of the recommendations that we give in the final chapter there will be, in our opinion, possibilities to improve both the materials flow and the internal transportation. The loading and unloading process could also be improved as a result of the changes made. For any of the changes and recommendations to be beneficial we must emphasis the need for better, clearer information and communication between various parts in the organisation.

Conclusions

7 Recommendations & Further Studies

This chapter serves a presentation of recommendations to Kalmar Industries and different concepts for further studies. Thereafter, some areas that are of interest for further studies are mentioned. We believe that these further studies can be of interest to pursue, not only from an academic approach but also for the interest of Kalmar Industries.

7.1 Recommendations

Based on the results that we have obtained from observations and the calculations we have concluded that the third alternative, where the articles are grouped in product families, would be the most beneficial for Kalmar Industries in Lidhult. However, we would at the same time underline that it is crucial to have other factors in mind before an implementation is possible. The reason for this is that there are several internal as well as external factors indirect influencing the behaviour of the company.

During the time this thesis was conducted, we came across many different issues and problems that indirect or direct affect the storage layout, stratification of articles and the materials flow. There has not been any research carried out on these issues and problems. However, as they affect this study it is very important that they were highlighted.

The recommendations in this part are briefly presented due to the extensive information on the topics given previously in chapter six the conclusion chapter.

The recommendations given below are displayed in alphabetical order and with no grading.

AB-Area

The AB-Area should be increased in order to handle more articles. This area is very attractive from a storing point of view and the roads in the area are, in our beliefs, unnecessarily large and limits the utilisation. Appendix 13 gives an overview of how we believe what a possible recreation of the area could look like.

Barcodes

Barcodes attached to all the articles on the outdoor storage would facilitate increased control over the articles in stock.

Bottlenecks

At present, there is a bottleneck by the entrance of the production plant building. This problem could be overcome if another entrance/exit gate is created. It takes too long for a truck to enter and exit the building.

Clear Stated Goals

Clear stated goals for the organisation, e.g. delivery service.

Education of the Employees

All members in the organisation should participate in a simplified course in Logistics.

Guidelines

Guidelines of how to work at the storage area are essential to have, and it needs to be improved. These guidelines should include which articles and which production that have the highest priority. Specified tasks for all employees, who has the main responsibility for the respective tasks. Action plans for different situations and emergencies.

Gantry Crane

A purchasing of a gantry crane for usage at the storage area. This would facilitate the loading and unloading process as well as simplify for the truck drivers to keep up the FIFO system.

Information screen

Another suggestion is to have a big digital screen, which gives all information about which goods that have been confirmed at the company, or not. This screen could also be connected to the information system of the company so that all involved could receive the same information.

Implement Time window for Suppliers

In order to control the incoming materials flow to a higher extent than today the suppliers should be given a time window, for when they are supposed to deliver the goods. The time window should be as short as possible, e.g. half a working day.

Implement VMI

Another suggestion for Kalmar would be to implement VMI. Thus, the suppliers would have to have the responsibility for the replenishment of the storage.

LA-Area

The LA-Area should be rearranged according to our suggestions, as shown in Appendix 13. By doing this it will become easier to sustain the FIFO system, since it will be easier for the truck-drivers to pick the articles if the articles are arranged in this pattern.

Markings & Signs

Signs telling where the articles should be placed, and what different areas should be used for would make it easier for all parties working on the storage area. Markings on the ground would make it easy to get the area structured and organised, and will keep it clean from be used to something else.

Name the areas by numbers

When it comes to the area description as a whole, we think that it would be easier if numbers instead of letters mark the different areas. Another suggestion is that single letters could be used instead of a combination of two letters. The present area codes are not that suitable since no clear pattern could be traced.

One Aligned Information System

Implement the same information system in all departments. This would reduce errors and simplify the everyday tasks.

Process thinking

Implement a process thinking, a process oriented organisation. Look it as a holistic view. A good complement to this would be to start with job rotation in order for the employees to explore the essence of other departments work, and get an insight of how other departments function.

Safety

The outdoor storage lacks street lights and pavements which make the areas unsafe. One simple way to avoid accidents could be that all pedestrians wore yellow vests. Another simple action is to paint zebra cross walks on the ground. This would, except from the safety point of view also make it easier for truck drivers, since they now can see the more exposed visitors.

Truck Computers

A constant usage of truck-computers would make it easier for the truck drivers, as well as improve the efficiency and decrease the errors. The present inefficient usage of the computers in combination with phone calls and orally requests could result in personal mistakes that could be avoided if all information to the truck drivers came from the computers. Another aspect of this is that the truck drivers would be able to plan their tasks better if constant interruptions from other department are avoided.

7.2 Further Studies

The result of our thesis is not to be seen as a complete guide for how Kalmar Industries should improve and change its storage layout. Instead, we have made suggestions of how a possible change can be done and additionally highlighted some major issues that we think are important for Kalmar Industries in Lidhult to focus on when carrying out these improvements. We believe that Kalmar Industries has a strong position on the market but they could become even more successful if they start to be more cost effective than they are today. A lot of capital is tied up in storage and therefore processes needs to be improved in order to decrease unnecessary costs.

As mentioned in the problem delimitations of this thesis some areas are not discussed. However, during our study we have found certain areas that could be of interest for further research. Since there are several reasons for the shortage of storage area today, we would suggest that the company takes action before it can improve the use of the storage area. One of these areas is the information and communication part. It would be of interest to look deeper into the present use of information systems. One single aligned system would seem to be more efficient than to use three different systems that the purchases are using today. Another issue that comes hand in hand with this is the possibility to use barcodes or information tags in order to control the articles on the outdoor storage better.

During the work of this thesis, we have noticed that it is hard to predict everything in detail by using theories. Another problem is to find suitable theories, which we consider has been the case in this thesis. In fact, theories on outside-located storage were nearly impossible to find, and therefore we have applied theories on inside located storage on our research. We hope that this study will work as a cornerstone for future studies within this area, and that the study has triggered new topics that would have to be investigated further for Kalmar Industries in Lidhult.

To work with the thesis has been very interesting and educative. During our research, we have only experienced positive response from the employees at Kalmar Industries and all respondents in our empirical research. The availability and possibility for guidance from our supervisor has been very good. It has generated in an efficient work procedure. However, a thesis can always be improved if more time is available, which corresponds with this thesis as well.

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Appendices

Appendix 1: Time Table

Weeks	34- Aug.	35	36- Sept.	37	38	39	40- Oct.
Monday	Planning & making a time table.	Theory	Theory	Method & Theory	Method	Method	Method
Tuesday	Problem-formulation	--“--	Tutor Meeting at 11.00.	--“--	--“--	Info. Meeting about printing thesis at 13.00.	Preparation for Interviews
Wednesday	Introduction Chapter	--“--	Theory	--“--	--“--	Method	Tutor Meeting at 10.00.
Thursday	Problem Questions --“--	--“--	--“--	Visit Kalmar Industries in Lidhult.	--“--	--“--	Visit at Kalmar Industries in Lidhult.
Friday	--“--	--“--	--“--	Method & Theory	--“--	--“--	Empiri.

Weeks	41	42	43	44	45-Nov.	46	47
Monday	Preparation for Interviews	Empiri.	Empir i	Empir i	Tutor Meeting at 10.00.	Analysi s	Analysis
Tuesday	--“--	Interview with Eva Johansson at Chalmers.	--“--	--“--	Empiri. & Analysis	--“--	Visit at Kalmar Industries
Wednesday	--“--	Empiri.	--“--	--“--	Tutor Meeting at 14.00.	Tutor Meeting at 14.00.	Analysis
Thursday	Interviews at Kalmar Industries in Lidhult.	Tutor Meeting at 13.00. + Interview at Kalmar Industries.	--“--	--“--	Empiri. & Analysis	Analysi s	--“--
Friday	Empiri.	Empiri.	--“--	--“--	--“--	--“--	--“--

Appendices

Week:	48	49- Dec.	50	51	2	3
Monday	Preliminary manuscript of thesis before 12.00.	Improve the thesis	Improve the thesis	Thesis Format Workshop in D44 at 8.00-12.00.	Thesis back from English department.	Presentation in Master Class and Opposition.
Tuesday	Make a Presentation.	--"--	--"--		Correct the English.	Presentation in Master Class and Opposition
Wednesday	Make the opposition.	--"--	Final Manuscript of thesis.		--"--	
Thursday	Support Seminars and opposition, 13.00-18.00.	--"--			--"--	
Friday	Support Seminars and opposition, 8.30-18.00.	--"--			--"--	Diploma Day

Appendix 2: Interview Questions to the Purchasing Managers Carina Lööf and Hans-Åke Bengtsson, 2003-10-09

- What kind of tasks do you have as purchasing manager? Are they only strategic i.e. responsible over contracts and agreement or also an operative responsibility.

- How many products/articles do you have the responsibility over? Or are you responsible for a certain number of suppliers?

- How many purchasers are there at the department?

- How are the responsibility divided between the purchasers?

- How many suppliers do you have?

- Do you have any plans to decrease the number of suppliers?

- Which ordering system do you use?

- Do you co-operate with KRTC when it comes to purchasing materials?
  - Which articles?
  - Does the co-operation work?
  - How does the division of costs work?
  - Which company has the main responsibility?

- For how long are the articles stored?
  - How long before production do the articles have to be in storage?
  - How long is the total planning time for ordering articles?
  - How many articles are ordered at the time? Is this decided by the Wilson formula?
  - Do you have a safety stock?

- How is the supplier's delivery security?
  - Safety Stock vs. late production.

  - How often is the production delayed as a result of late deliveries or shortage of articles in store?

- Do you prioritise some of the articles and control them more i.e. ABC analysis?

- Average cost for the outside storage? Maximum and minimum stock?
  - How often is inventory of the warehouse made?
  - Do the purchasers do the inventorying?

- Deliveries
  - How large is the time window for the suppliers to deliver? Within a week or a day?
  - Have you planned shorter time window for the future?
  - How well do the suppliers manage? How many of the suppliers use Kalmar's route truck?

- Does the cooperation between you and the production work well?
  - Do you always get informed when an additional article is taken due to another defect one?
  - What are the plans for future products? Something we need to take into consideration when estimating needed size of storage
  - What do you consider can be improved in the area of purchasing?
  - Can we use your name in the thesis?

Appendix 3: Interview Questions to employees at Kalmar Industries, 2003-10-09

- How many forklifts/trucks are in use per day?

- How many are full time permanent workers?

- Average age? How long have the drivers been employed?

- Which type of trucks is used? Fuel and consumption? How large are they?

- How do the drivers find the products?
    - Do you have any maps to follow?
    - Do you have any routes that should be followed?
    - Could it be possible to standardise the routes? Implement markings on how the drivers should drive?
    - Are the newly delivered articles always placed on the same location?
    - How does it work when a truck driver is not able to come to work?

- How well does it work to have the truck driver under shared function?

- How is the work planned?
    - Do you get information in the morning of which deliveries are arriving during the day and which articles that are going to the assembly?
    - Would it be an advantage to have more detailed info relating to this in order to planner you day better?
    - Would it be easier to have barcodes that identified which articles are stored where and that shows how many are in stock?
    - How do you share the work between the drivers?
    - Do all the trucks get the same information to their computers?
    - Do the drivers get up to date information on a continual basis during the day?

  - Would I simplify to get more information at the time from the assembly?
  - How long before they (assembly workers) need an article do they know about it?
  - Would the planning process be easier if you knew before which deliveries would arrive that day?
  - How often does production stop as a result of shortage of articles?
  - When during the day do the most deliveries arrive?
  - What time of the day and which day of the week is peak for the truck drivers?
  - Have you divided the different work areas among the drivers?
  - Does one driver have responsibility over the incoming goods?

- Do you consider that there is a need to have a larger safety stock of certain articles?
  - Which in that case?
  - Are there any articles that should not be moved from the current position? Why?
  - Which factor is the most important when deciding where the articles should be placed? E.g. size, weight or volume etc.
  - Are there today any articles that you prioritise and therefore should be placed on a specific location based on an ABC analysis?
  - How often is an inventory of the warehouse made?

- Are there any special factors that should be taken into consideration when deciding where the articles should be placed and how the layout should look like?
  - Are there any restrictions when changing the area?
  - There is an idea box. Do you use this?
  - Do you feel that you have the possibility to influence the organisation in any way? Do you get response when you come up with new ideas?
  - Is it possible to give proper marking to each article that is to be stored outside?
  - Fixed or floating placement? Or combined?

- Do you think that the trucks and drivers are used optimal today? Do you think you will manage an expansion?

- How do future expansion plans look like?

- What way do you think is the best for mapping the materials flow on the outside area?
    - Measure the distance between different points?

- Can we use you name in the thesis?

Appendix 4: Interview with Martin Ljungström, Arrigo Consultants, 2003-11-05 at 13.30

Arrigo Consultants have conducted research at Kalmar Industries in Lidhult.

- What have you at Arrigo looked at?

There are three main areas that we (Arrigo Consultants) have looked at and these are:

- Lead-times
- Capital Tied-up
- Delivery security, from order to delivery. Both deliveries from suppliers and deliveries of finished trucks from Lidhult to customers.

The main problem lies within the area of delivery security, which is only 68%. This slows down production and gives problems to the purchasers.

In order to have sufficient work the people in the assembly start building trucks that is not in line as a result of not having the articles for the correct truck. The work ratio is very low. Much of the time workers do nothing due to lack of materials.

There is a bottleneck also inside the assembly building and at the loading dock to the inside warehouse. The overcome the bottleneck in the assembly, Arrigo suggested that some of the articles should be pre-assembled where the painting takes place today.

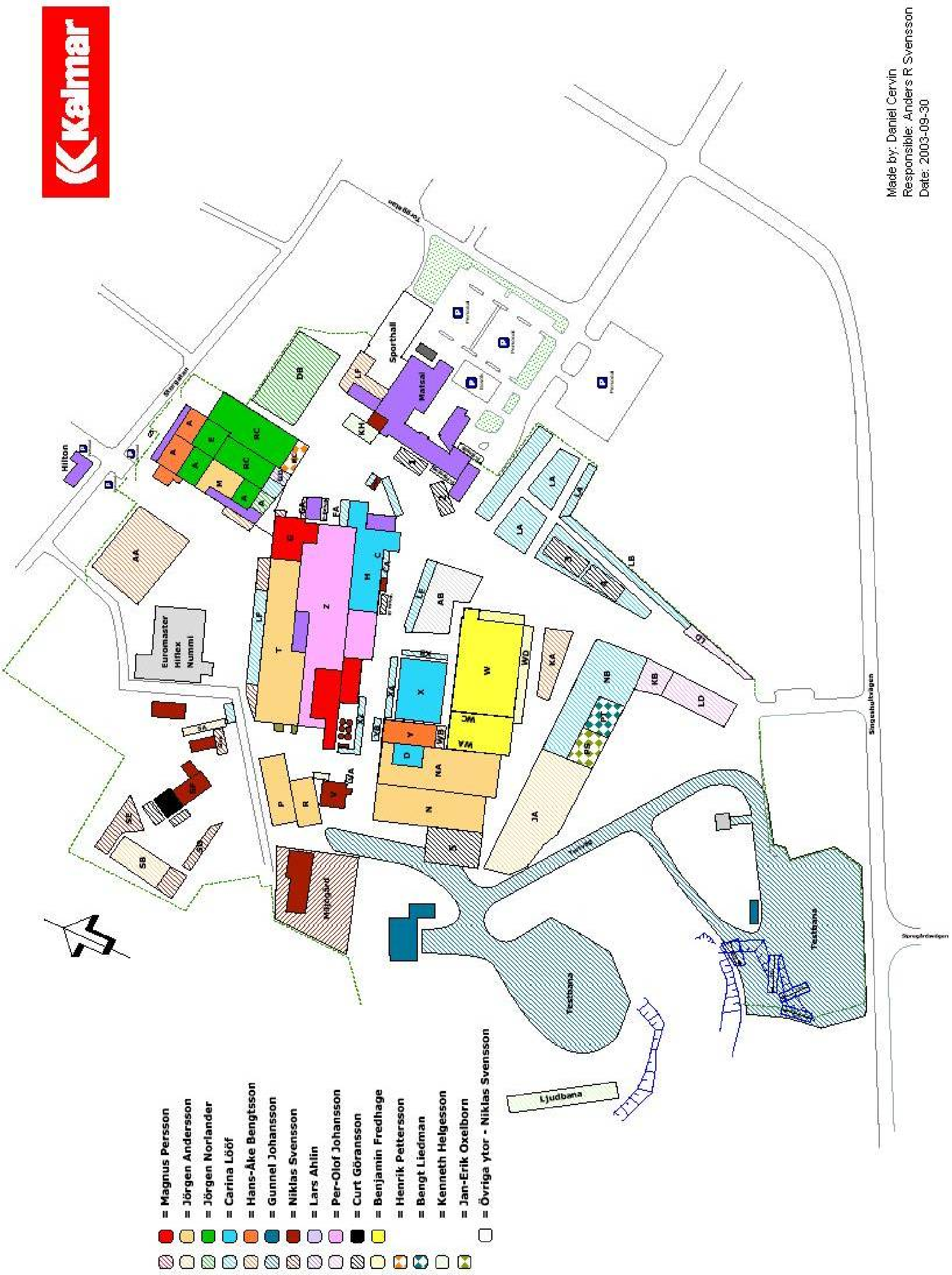
Arrigo has not looked specifically at the outside storage area. Only when it comes to capital tied up with of course is related to the article stored outside as these are often large and expensive.

Arrigo tried to make a flowchart at Kalmar Industries. After realising that it was just a big mess they decided that it was impossible.

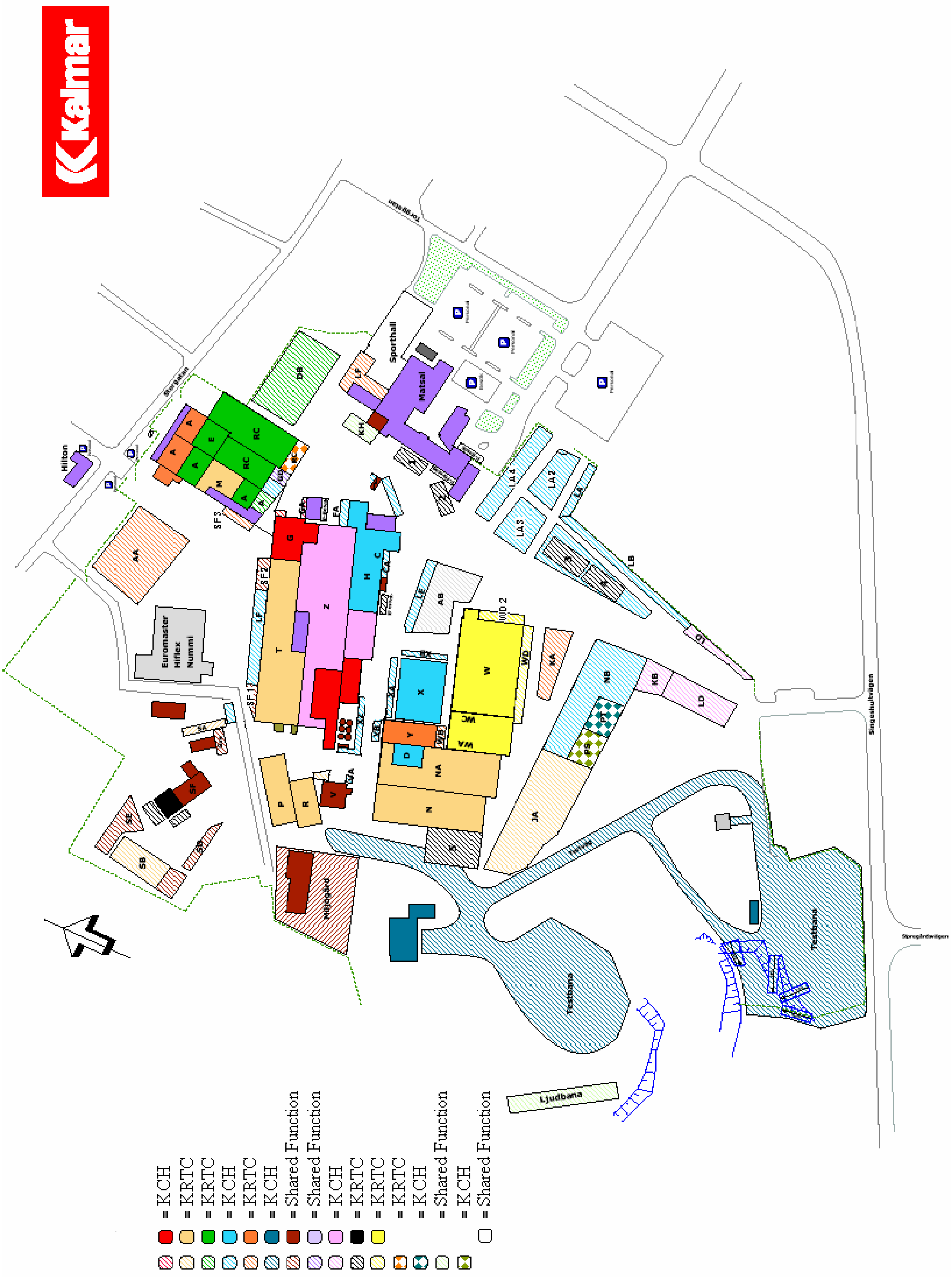
There is a clear need for closer relationship with the largest suppliers. This way it is possible to put more pressure on them delivering on time.

Bad delivery security also gives problem to the truck drivers as many of the deliveries can show up at the same time, leading to that the truck drivers do not have time getting articles to the assembly building.

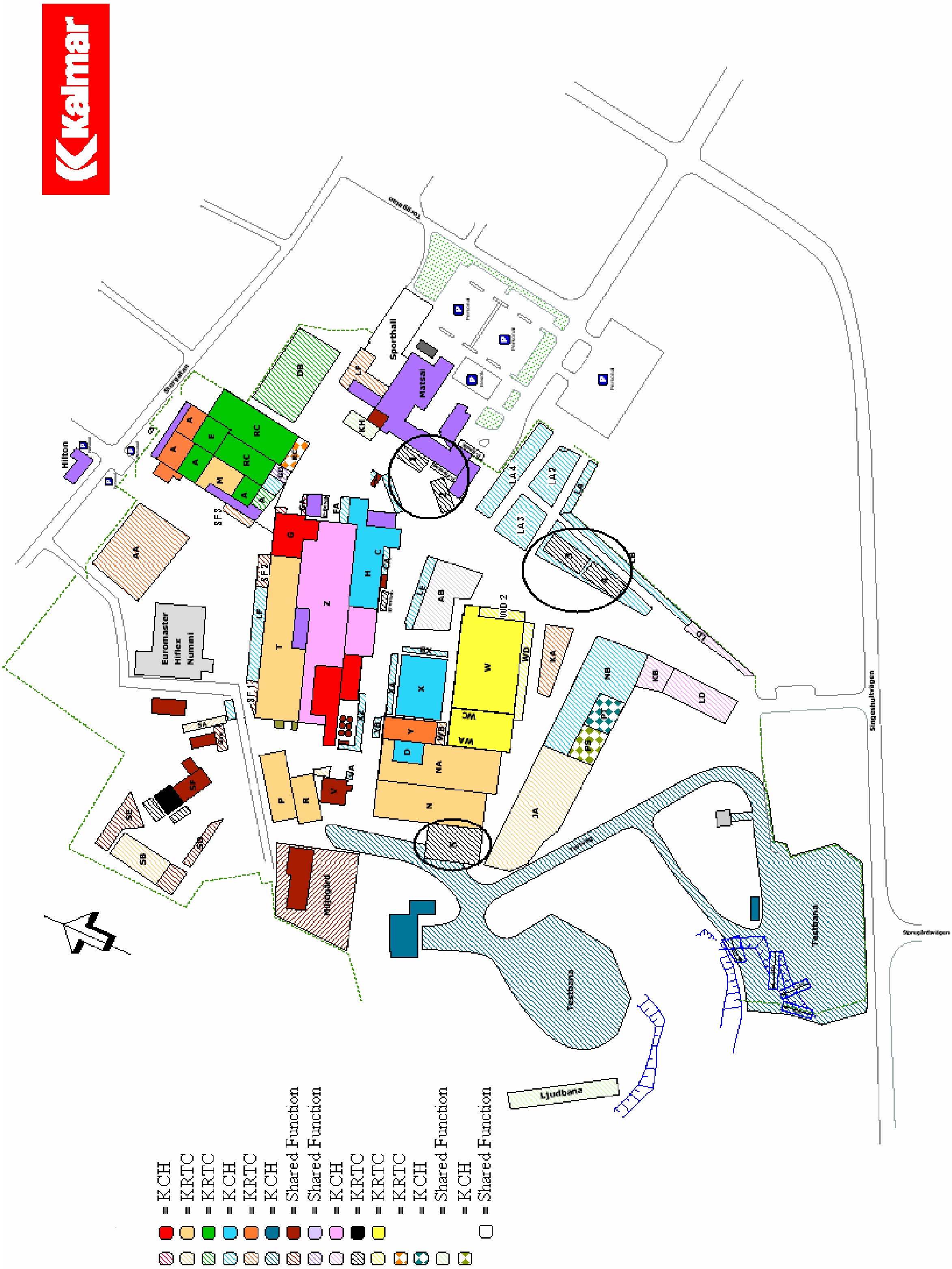
Appendix 5: The Original Version of the storage Area Map at Kalmar Industries.



Appendix 6: Storage Area Map



Appendix 7: Loading and Unloading Zones



Appendix 8: Article Data

Location	Art Nr	Benämning	Ip	IP-namn	Lev Nr	ABC	OQ
LD1							
LB1	A41321.0100	INNERVAGN	0	BLN			0
LB1	Z77122	TRUCK DCD420-12CSG	58	BLN		E	0
LB1	A41320.0100	LYFTVAGN SF	51	NSS	32	A	8
LB1	Z77152	GAFFELTRUCK DCD320-12	58	BLN		E	0
LA1	A40364.0100	MOTVIKT BAK	52	NSS	8489	B	5
LA1	A43102.0200	MOTVIKT	74	HPN	8489	B	6
LA2	923853.0030	AGGREGAT SID 20-40	58	BLN	4495	A	7
LA2	923853.0041	AGGREGAT SID 20-40	58	BLN	4495	A	0
LA2	923853.0024	AGGREGAT TOPP 20-40	58	BLN	4495	A	0
LA3	A40363.0200	MOTVIKT BALJA	54	NSS	8489	B	5
LA3	A40363.0100	MOTVIKT BALJA	52	NSS	8489	B	5
LA3	923562.0045	DRIVAXEL KESS 30.19 B3094	9	AMG	35	A	8
LA4	A02718.0100	MOTVIKT	54	NSS	505	B	8
LA4	A39581.0100	MOTVIKT,ÖVRE	54	NSS	505	B	8
LA4	A02305.0100	MOTVIKT DC 38000-45000	54	NSS	505	A	8
LA4	A12874.0100	MOTVIKT DC2 ÖVRE	54	NSS	505	B	8
LA4	238545.0100	MOTVIKT BAKRE DC 28-42	54	NSS	505	A	8
LA4	A02719.0100	MOTVIKT BAKRE	54	NSS	505	B	8
LA4	A10094.0100	MOTVIKT	52	NSS	8489	B	5
LA4	A41551.0100	RAM DCE 70/90-45E	22	CSN	8259	A	6
LA4	A12874.0100	MOTVIKT DC2 ÖVRE	54	NSS	505	B	8
KA	A33852.0100	SKYLT,TYP AGGREGAT AL	54	NSS	3752	C	0
KA	A39819.010G						
KA	K56918.21X	LYFTBOM KOMPLETT	87	LJA	9167	A	6
KA	A35467.010G				0000037,00		
KA	A36424.010G				0000037,00		
JA	138634.0200	GAFFEL DC RULLE 28-32	52	NSS	350	A	6
JA	A39601.0100	RAMBALK HÖ	20	CSN	5599	B	8
JA	A39601.0200	RAMBALK VÄ	20	CSN	5599	B	8
JA	A10913.0300	RAMBALK DC2 LB HÖ	20	CSN	788	B	8
JA	A10913.0400	RAMBALK DC2 LB VÄ	20	CSN	788	B	8
JA	A39730.0500	RAMBALK VÄ	20	CSN	5599	A	4
JA	A39730.0600	RAMBALK HÖ	20	CSN	5599	A	4
JA	A19012.1300				0000000,00		
JA	A19012.1400				0000000,00		
JA	A39730.0100	RAMBALK VÄ	20	CSN	5599	A	6
JA	A39730.0200	RAMBALK HÖ	20	CSN	5599	A	6
JA	A36470.0100	BALK	80	LJA	7115	B	3
JA	A36516.0100	BALK	80	LJA	7115	B	3
JA	A10912.0700	RAMBALK DC2 HB HÖ	20	CSN	788	A	8
JA	A10912.0800	RAMBALK DC2 HB VÄ	20	CSN	788	A	8
JA	A27344.0334				0000000,00		
JA	A27344.0335				0000000,00		
JA	A15252.0100	RAMBALK HÖ	20	CSN	5599	B	4
JA	A15252.0200	RAMBALK VÄ	20	CSN	5599	B	3

JA	A15252.0300	RAMBALK HÖ	20	CSN	5599	B	3
JA	A15252.0400	RAMBALK VÄ	20	CSN	5599	B	3
JA	A28394.0500	RAMBALK VÄ	20	CSN	5599	B	4
JA	A28394.0600	RAMBALK HÖ	20	CSN	5599	B	2
WD	A35449.0100	CYLINDER 160/125 SL 4750	9	AMG	35	A	6
LF2	A44538.0100	SKÄRM FRAM VÄ	33	AMJ	7554	B	4
LF2	A41191.0100	YTTERSKÄRM VÄ	33	AMJ	7714	B	4
LF2	A41191.0200	YTTERSKÄRM HÖ	33	AMJ	7714	B	4
LF2	A41553.0300	SKÄRMBREDDARE HÖGER	32	AMJ	1285	B	4
LF2	A41553.0400	SKÄRMBREDDARE VÄNSTER	32	AMJ	1285	B	4
LF2	A44504.0100	SKÄRM, FRAM HÖ	34	AMJ	1248	B	4
LF2	A39266.0100	LOCK	80	LJA	8643	B	4
LF2	A44528.0100	SKÄRM, BAK HÖ	34	AMJ	1248	B	4
XB	A43230.0100	RÄCKE FRONT 1300	33	AMJ	1248	B	4
XB	A43230.0300	RÄCKE SIDA L=1200	33	AMJ	1248	B	4
XB	A43230.0200	RÄCKE, SIDA 1600	33	AMJ	1248	B	4
XB	A41700.0100	RÄCKE INSTEG VÄ	33	AMJ	1248	B	4
XB	A09219.0100	RÄCKE BAK	34	AMJ	1248	B	4
X	A02104.0200	CLAMP DUBBEL	63	MSO	6765	B	6
X	921797.0005	BATTERI 140AH 12V	64	MSO	2701	A	10
X	920871.0077	MOTOR,DIESEL TAD 720 VE	34	AMJ	2890	A	5
X	922784.0016	MOTOR,DIESEL CUM. QSM11	34	AMJ	6747	A	8
X	922297.0119	VÄXELLÅDA 15.7TE32418-??	33	AMJ	512	A	8
X	456163.0200	CYLINDER 160/ 80 SL 1275	86	LJA	9639	B	5
X	922297.0119	VÄXELLÅDA 15.7TE32418-??	33	AMJ	512	A	8
X	K56985.80				0000007,00		
X	920871.0078	MOTOR,DIESEL TWD 731 VE	34	AMJ	2890	A	5
X	456103.0100				0000077,00		
X	920871.0079	MOTOR,DIESEL TWD1031 VE	34	AMJ	2890	A	5
X	923581.0034	KYLARE,VÄTSKA VATTEN/OLJA	33	AMJ	8568	B	8
X	922297.0111	VÄXELLÅDA EL.VÄXLING	32	AMJ	512	A	8
X	A24588.0200	PLÅT	36	AMJ	9094	B	4
X	A24588.0300	PLÅT	36	AMJ	9094	B	4
X	A11828.0400	KÅPA MOTVIKT	32	AMJ	7196	B	4
X	A24588.0100	PLÅT	36	AMJ	9094	B	4
X	922297.0094	VÄXELLÅDA EL.VXL.FÖRB.AUT	34	AMJ	512	A	6
X	A39308.0100	FÖRSTÄRKNINGSBALK	32	AMJ	1285	B	4
X	A42366.0500	KÅPA,LJUDISOLERING	34	AMJ	7196	B	4
X	A42366.0600	KÅPA,LJUDISOLERING	33	AMJ	7714	B	4
X	A27829.0100	FÄSTE,VIKTINDIKATOR	80	LJA	2012	B	4
X	920871.0078	MOTOR,DIESEL TWD 731 VE	34	AMJ	2890	A	5
X	920871.0079	MOTOR,DIESEL TWD1031 VE	34	AMJ	2890	A	5

X	A42731.0100	LJUDDÄMPNINGSPLÅT FRONT	32	AMJ	1248	B	4
X	A42366.0200	KÅPA,LJUDISOLERING	37	AMJ	7196	B	4
X	A42546.0100	ISOLPLÅT FRONT UNDRE	37	AMJ	7196	B	4
X	A17451.0400	FÖRVARINGSLÅDA	32	AMJ	7714	B	0 4
X	T55198.10	KYLARE RSD 2T5519810B SJT	35	AMJ	8568	B	10
X	920871.0077	MOTOR,DIESEL TAD 720 VE	34	AMJ	2890	A	5
X	920871.0073	MOTOR,DIESEL TWD1240 VE	34	AMJ	2890	A	5
X	922784.0008	MOTOR,DIESEL CUMMINS	34	AMJ	6747	A	8
X	922297.0115	VÄXELLÅDA EL.VXL.FÖRB.AUT	32	AMJ	512	A	6
X	A11660.0100	0000017,00					
X	A41617.0100	BRÄNSLETANK	33	AMJ	6660	B	4
X	A41640.0100	0000111,00					
X	A36942.0600	BRÄNSLETANK	32	AMJ	6660	B	4
X	A36919.0100	BRÄNSLETANK	36	AMJ	6660	A	4
X	923581.0003	KYLARE,VÄTSKA VATTEN/OLJA	34	AMJ	8568	B	8
X	923581.0025	KYLARE,VÄTSKA VATTEN/OLJA	33	AMJ	8568	B	4
X	923581.0034	KYLARE,VÄTSKA VATTEN/OLJA	33	AMJ	8568	B	8
X	A02104.0100	CLAMP	65	MSO	6765	B	6
X	922784.0016	MOTOR,DIESEL CUM. QSM11	34	AMJ	6747	A	8
y	923828.0713	0000004,00					
y	921079.0030	LJUDDÄMPARE ANSL.115/110	39	AMJ	35	B	6
y							
y	923110.0589	SÄKERHETSFILTER	83	LJA	97	B	2
y	921702.0015	SPEGEL,BACK UTV.	54	NSS	584	A	4
y							
y	A34474.0300	MOTOR OCH VÄXELLÅDSF. H.	10	JAA		B	4
y	A34474.0400	MOTOR OCH VÄXELLÅDSF. V	10	JAA		B	4
y	923581.0018	KYLARE,VATTEN/LUFT/OLJ A	9	AMG	35	A	12
y	922159.0001	FÄSTE,SPEGEL	76	HPN	584	B	4
y	923141.0043	PUMP,2 VÖ 60/VÖ 60	86	LJA	35	B	8
y							
y							
y	923126.0007	KABEL RKKB 2X1,5 SVART	60	MSO	5524	B	0
y	923881.0027	NIPPEL,HYDR.00 04-08	89	LJA	450	B	4
y	A35213.0100	MOTORFÄSTE, FRAM	10	JAA		B	4
y	920969.0014	HUV LUFTFILTER D=179,5	86	LJA	5888	B	10
y	923887.0100	0000181,00					
y	923141.0043	PUMP,2 VÖ 60/VÖ 60	86	LJA	35	B	8
y	A36007.0100	LUCKA BAKRE KPL.	32	AMJ	9094	B	4
y	A41594.0200	KÅPA	33	AMJ	7714	B	4

y	A37213.010G				0000026,00		
y	A36579.0100	INSUGNINGSRÖR	32	AMJ	35	B	4
y	A35995.010G				0000000,00		
y	A36673.010G				0000000,00		
y	A36514.0100	AXEL	80	LJA	4351	B	4
y	929391.0013				0000000,00		
y	923141.0043	PUMP,2 VÖ 60/VÖ 60	86	LJA	35	B	8
y	A36288.0100	HJUL GAFFEL	10	JAA		B	2
y	923828.0713				0000000,00		
y	922772.0032	SLÄPKEDJA RK=200 36L	70	HPN	6079	B	4
y	923110.0588	FILTERINSATS	83	LJA	97	B	2
y	923581.0010	KYLARE,VÄTSKA VATTEN	36	AMJ	8568	B	10
y	A34474.0300	MOTOR OCH VÄXELLÅDSF. H.	10	JAA		B	4
y	A39350.0100	FÄST PLÅT	39	AMJ	9705	B	4
y	A35622.0100	TRAPP VÄ SVEP (SVETS)	32	AMJ	9094	B	4
y	A35627.0100	BAKRE SVEP VÄ	32	AMJ	9094	B	4
y	922593.0023				0000000,00		
y	A36288.0100	HJUL GAFFEL	10	JAA		B	2
y	921797.0009	BATTERI XXXAH 12V	64	MSO	35	B	4
y	A35995.010G				0000000,00		
y	A35606.0100	HYTTLYFTSFÄSTE VÄ (SVETS)	10	JAA		B	4
y	A35656.0100	TAPP	20	CSN	1530	B	4
y	A39344.0100	SKYDDSPLÅT BRÄNNARE	39	AMJ	7196	B	4
y	A36288.0100	HJUL GAFFEL	10	JAA		B	2
y	38137.010G				0000000,00		
y	36016.010G				0000000,00		
CA	A23357.0100	SVEPKÅPA VÄ	36	AMJ	7714	B	4
CA	A23357.0300	SVEPKÅPA VÄ	36	AMJ	7714	B	4
CA	A41594.0300	KÅPA	33	AMJ	7714	B	4
CA	A23436.0300	PLÅT	34	AMJ	7714	B	4
CA	A41594.0200	KÅPA	33	AMJ	7714	B	4
CA	A41419.0100	RÄCKE SKÄRM	37	AMJ	1248	B	4
CA	A39407.0300	BERÖRINGSSKYDD	33	AMJ	7714	B	4
CA	A41594.0100	KÅPA	33	AMJ	7714	B	4
CA	A12270.0100	BALK HYTTUNDERBYGGNAD	80	LJA	5333	B	4
CA	A41577.0100	TÄCKPLÅT MOTOR	33	AMJ	7714	B	4
CA	A41167.0200	TÄCKPLÅT	33	AMJ	7714	B	4
CA	37259.0100				0000005,00		
GA	A04356.0100	SPÄNNRING	76	HPN	5418	B	6
FA	A41722.0100	SKENA HYTTUNDERBYGGNAD HÖ	80	LJA	5333	B	5
XA1	A41517.0100	HYTTUNDERBYGGNAD	33	AMJ	7714	B	4
XA1	A39201.0100	HYTTUNDERBYGGNAD	34	AMJ	1285	B	4
XA1	A27463.0300	TIPPRAM ,HYTTIPP	32	AMJ	5074	B	4
XA2	A39202.0100	FÄSTE FÖR HYTT VÄNSTER	34	AMJ	1248	B	4
XA2	A39202.0200	FÄSTE FÖR HYTT HÖGER	30	AMJ	1248	B	4
XA2	A39308.0100	FÖRSTÄRKNINGSBALK	32	AMJ	1285	B	4
SF	A25819.0200	STYRAXELBRYGGA 42-45	20	CSN	35	B	3

LF2	A23302.1100	CYLINDER 250/180 SL 2800	86	LJA	9639	B	4
LF2	A03967.0005				0000343,00		
LF2	923967.0007	CYLINDER 160/ 63 SL 198	86	LJA	9639	B	5
LF2	923562.0059	DRIVAXEL KESS 26.35 B3033	33	AMJ	9248	B	8
LF2	923562.0016	DRIVAXEL KESSL 29,5	34	AMJ	9248	A	16
LF2	922473.0047	DRIVAXEL MERIT.26.62(119)	32	AMJ	5155	A	8
LF2	A25965.0200	STYRAXELVAGGA DRD	20	CSN	35	A	4
LF2	A02304.0100	MOTVIKT STYRAXEL	54	NSS	505	B	8
LF2	923562.0056	DRIVAXEL KESS 14,57 B3234	32	AMJ	9248	A	6
LF2	922473.0049	DRIVAXEL MERIT.32,08 (96)	32	AMJ	5155	A	8
X21	A42365.0100	FÄSTE LJUDFÄLLA	37	AMJ	7196	B	4
X21	A41536.0200	GUIDE SKENA VÄ	33	AMJ	7714	B	4
X21	A42365.0600	FÄSTE LJUDFÄLLA	34	AMJ	7196	B	4
X21	A41534.0100	GUIDE SKENA HÖ	33	AMJ	7714	B	4
X22	A41685.0200	STEG HÖ	33	AMJ	7714	B	4
X22	A41685.0100	STEG HÖ	33	AMJ	7714	B	4
X22	A25626.0800	STEG VÄ	37	AMJ	7714	B	4
X22	A25626.0700	STEG HÖ	37	AMJ	7714	B	4
X22	A25626.1800	STEG VÄ	37	AMJ	7714	B	4
X22	A25626.1700	STEG HÖ	37	AMJ	7714	B	4
X22	A25626.1600	STEG VÄ	37	AMJ	7714	B	0
X22	A25626.1500	STEG HÖ	37	AMJ	7714	B	0
X22	A25626.1200	STEG VÄ	37	AMJ	7714	B	4
X22	A25626.1100	STEG HÖ	37	AMJ	7714	B	4
X22	A25626.1000	STEG VÄ	37	AMJ	7714	B	4
X22	A25626.0900	STEG HÖ	37	AMJ	7714	B	4
X22	A24580.0200	STEG FRAM	37	AMJ	7714	B	4
X22	A41697.0100	STEG FRAM VÄ	33	AMJ	7714	B	4
X22	A41698.0100	STEG BAK VÄ	33	AMJ	7714	B	4
X22	A41698.0200	STEG BAK VÄ	33	AMJ	7714	B	4
X22	A41696.0100	PLATTFORM	33	AMJ	7714	B	4
X22	A11360.0100	BALK HYTTUNDERBYGGNAD	34	AMJ	1248	B	4
X22	A11360.0200	BALK HYTTUNDERBYGGNAD	34	AMJ	1248	B	4
X22	A29079.0100	SKENA HÖ	80	LJA	5333	B	5
X22	A29079.0200	SKENA VÄ	80	LJA	5333	B	5
X22	A24580.0300	STEG NEDRE	37	AMJ	7714	B	4
X22	A39299.0100	GOLVPLATTA	37	AMJ	7714	B	4
X22	A41035.0400	FOTSTEG NEDRE VÄ	34	AMJ	7714	B	4
X22	A41035.0300	FOTSTEG NEDRE HÖ	34	AMJ	7714	B	4
X22	A41035.0200	FOTSTEG NEDRE VÄ	32	AMJ	7714	B	4
X22	A41698.0400	STEG BAK VÄ	33	AMJ	7714	B	4
X22	A41698.0300	STEG BAK VÄ	33	AMJ	7714	B	4
X22	A24580.0100	STEG FRAM	37	AMJ	7714	B	4
X22	A41685.0400	STEG HÖ	33	AMJ	7714	B	4
X22	A41685.0300	STEG HÖ	33	AMJ	7714	B	4
X22	A41685.0100	STEG HÖ	33	AMJ	7714	B	4

X22	A41684.0100	STEG FRAM	33	AMJ	7714	B	4
X23	A41722.0100	SKENA HYTTUNDERBYGGNAD HÖ	80	LJA	5333	B	5
X23	A41722.022				0000109,00		
D	A11256.0400	PLÅT	20	CSN	35	B	3
D	A39202.0100	FÄSTE FÖR HYTT VÄNSTER	34	AMJ	1248	B	4
D	A11243.0100	BALK HYTTUNDERBYGGNAD	34	AMJ	1285	B	4
D	A25042.0300	LAMPFÄSTE BAK	34	AMJ	7714	B	4
D	A35457.010G						
D	A35448.0100	CYLINDER 180/125 SL 2550	9	AMG	35	A	6
D	A32201.0100						
D	A39380.0100	RAM TRA SVETS	10	JAA		B	4
D	A41722.0200	SKENA HYTTUNDERBYGGNAD VÄ	80	LJA	5333	B	5
D	A923892.000						

Appendix 9: Article data sorted according to their storage location.

Storage Area	Company	Article Name	Meter	Meter/Year
LB1	KCH	INNERVAGN	265	0
LB1	KCH	TRUCK DCD420-12CSG	265	0
LB1	KCH	LYFTVAGN SF	265	53000
LB1	KCH	GAFFELTRUCK DCD320-12	265	0
LA1	KCH	MOTVIKT BAK	239	13384
LA1	KCH	MOTVIKT	239	3824
LA2	KCH	AGGREGAT SID 20-40	239	40630
LA2	KCH	AGGREGAT SID 20-40	239	5258
LA2	KCH	AGGREGAT TOPP 20-40	239	0
LA3	KCH	MOTVIKT BALJA	239	58794
LA3	KCH	MOTVIKT BALJA	239	138620
LA3	KCH	DRIVAXEL KESS 30.19 B3094	239	0
LA4	KCH	MOTVIKT	140	32200
LA4	KCH	MOTVIKT,ÖVRE	140	31640
LA4	KCH	MOTVIKT DC 38000-45000	140	16240
LA4	KCH	MOTVIKT DC2 ÖVRE	140	5040
LA4	KCH	MOTVIKT BAKRE DC 28-42	140	43960
LA4	KCH	MOTVIKT BAKRE	140	32200
LA4	KCH	MOTVIKT	140	1960
LA4	KCH	RAM DCE 70/90-45E	140	32480
KA	KRTC	LYFTBOM KOMPLETT	215	15910
JA	KRTC	GAFFEL DC RULLE 28-32	294	5880
JA	KRTC	RAMBALK HÖ	294	0
JA	KRTC	RAMBALK VÄ	294	0
JA	KRTC	RAMBALK DC2 LB HÖ	294	0
JA	KRTC	RAMBALK DC2 LB VÄ	294	0
JA	KRTC	RAMBALK VÄ	294	0
JA	KRTC	RAMBALK HÖ	294	0
JA	KRTC	RAMBALK VÄ	294	0
JA	KRTC	RAMBALK HÖ	294	0
JA	KRTC	BALK	294	0
JA	KRTC	BALK	294	0
JA	KRTC	RAMBALK DC2 HB HÖ	294	0
JA	KRTC	RAMBALK DC2 HB VÄ	294	0
JA	KRTC	RAMBALK HÖ	294	0
JA	KRTC	RAMBALK VÄ	294	0
JA	KRTC	RAMBALK HÖ	294	0
JA	KRTC	RAMBALK VÄ	294	0
JA	KRTC	RAMBALK VÄ	294	0
JA	KRTC	RAMBALK HÖ	294	0
WD	KRTC	CYLINDER 160/125 SL 4750	239	0
LF2	KCH	SKÄRM FRAM VÄ	167	18370
LF2	KCH	YTTERSKÄRM VÄ	167	17702
LF2	KCH	YTTERSKÄRM HÖ	167	17702
LF2	KCH	SKÄRMBREDDARE HÖGER	167	5010
LF2	KCH	SKÄRMBREDDARE VÄNSTER	167	5010

LF2	KCH	SKÄRM, FRAM HÖ	167	2004
LF2	KCH	LOCK	167	0
LF2	KCH	SKÄRM, BAK HÖ	167	2004
XB	KCH	RÄCKE FRONT 1300	228	912
XB	KCH	RÄCKE SIDA L=1200	228	912
XB	KCH	RÄCKE, SIDA 1600	228	912
XB	KCH	RÄCKE INSTEG VÄ	228	50616
XB	KCH	RÄCKE BAK	228	456
X	KCH	CLAMP DUBBEL	228	427728
X	KCH	BATTERI 140AH 12V	228	344280
X	KCH	MOTOR,DIESEL CUM. QSM11	228	1824
X	KCH	VÄXELLÅDA 15.7TE32418-??	228	3192
X	KCH	CYLINDER 160/ 80 SL 1275	228	912
X	KCH	VÄXELLÅDA EL.VÄXLING	228	52896
X	KCH	PLÅT	228	0
X	KCH	PLÅT	228	456
X	KCH	KÅPA MOTVIKT	228	456
X	KCH	PLÅT	228	1824
X	KCH	VÄXELLÅDA EL.VXL.FÖRB.AUT	228	52896
X	KCH	FÖRSTÄRKNINGSBALK	228	36480
X	KCH	KÅPA,LJUDISOLERING	228	0
X	KCH	KÅPA,LJUDISOLERING	228	3648
X	KCH	FÄSTE,VIKTINDIKATOR	228	11400
X	KCH	MOTOR,DIESEL TWD 731 VE	228	35112
X	KCH	MOTOR,DIESEL TWD1031 VE	228	48336
X	KCH	LJUDDÄMPNINGSPLÅT FRONT	228	5928
X	KCH	KÅPA,LJUDISOLERING	228	11856
X	KCH	ISOLPLÅT FRONT UNDRE	228	5928
X	KCH	FÖRVARINGSLÅDA	228	2280
X	KCH	KYLARE RSD 2T5519810B SJT	228	7752
X	KCH	MOTOR,DIESEL TAD 720 VE	228	22800
X	KCH	MOTOR,DIESEL TWD1240 VE	228	32376
X	KCH	MOTOR,DIESEL CUMMINS	228	1368
X	KCH	VÄXELLÅDA EL.VXL.FÖRB.AUT	228	7752
X	KCH	BRÄNSLETANK	228	50616
X	KCH	BRÄNSLETANK	228	3192
X	KCH	BRÄNSLETANK	228	37848
X	KCH	KYLARE,VÄTSKA VATTEN/OLJA	228	912
X	KCH	KYLARE,VÄTSKA VATTEN/OLJA	228	36480
X	KCH	KYLARE,VÄTSKA VATTEN/OLJA	228	16872
X	KCH	CLAMP	228	2830848
y	KRTC	LJUDDÄMPARE ANSL.115/110	262	0
y	KRTC	SÄKERHETSFILTER	262	1048
y	KRTC	SPEGEL,BACK UTV.	262	9956
y	KRTC	MOTOR OCH VÄXELLÅDSF. H.	262	0
y	KRTC	MOTOR OCH VÄXELLÅDSF. V	262	0
y	KRTC	KYLARE,VATTEN/LUFT/OLJA	262	0
y	KRTC	FÄSTE,SPEGEL	262	0
y	KRTC	PUMP,2 VÖ 60/VÖ 60	262	0
y	KRTC	KABEL RKKB 2X1,5 SVART	262	0

y	KRTC	NIPPEL,HYDR.00 04-08	262	0
y	KRTC	MOTORFÄSTE, FRAM	262	0
y	KRTC	HUV LUFTFILTER D=179,5	262	94844
y	KRTC	LUCKA BAKRE KPL.	262	0
y	KRTC	KÅPA	262	13624
y	KRTC	INSUGNINGSRÖR	262	0
y	KRTC	AXEL	262	0
y	KRTC	HJUL GAFFEL	262	0
y	KRTC	SLÄPKEDJA RK=200 36L	262	0
y	KRTC	FILTERINSATS	262	1048
y	KRTC	KYLARE,VÄTSKA VATTEN	262	52924
y	KRTC	FÄST PLÅT	262	0
y	KRTC	TRAPP VÄ SVEP (SVETS)	262	0
y	KRTC	BAKRE SVEP VÄ	262	0
y	KRTC	BATTERI XXXAH 12V	262	0
y	KRTC	HYTTLYFTSFÄSTE VÄ (SVETS)	262	0
y	KRTC	TAPP	262	0
y	KRTC	SKYDDSPLÅT BRÄNNARE	262	0
CA	KCH	SVEPKÅPA VÄ	160	1600
CA	KCH	SVEPKÅPA VÄ	160	0
CA	KCH	KÅPA	160	4160
CA	KCH	KÅPA	160	8320
CA	KCH	PLÅT	160	0
CA	KCH	RÄCKE SKÄRM	160	11840
CA	KCH	BERÖRINGSSKYDD	160	35200
CA	KCH	KÅPA	160	22080
CA	KCH	BALK HYTTUNDERBYGGNAD	160	2880
CA	KCH	TÄCKPLÅT MOTOR	160	0
CA	KCH	TÄCKPLÅT	160	1600
GA	KCH	SPÄNNRING	25	3900
XZ3	KCH	SKENA HYTTUNDERBYGGNAD HÖ	262	57116
FA	KCH	SKENA HYTTUNDERBYGGNAD HÖ	10	2180
XA1	KCH	HYTTUNDERBYGGNAD	228	49704
XA1	KCH	HYTTUNDERBYGGNAD	228	37392
XA1	KCH	TIPPRAM ,HYTTIPP	228	1368
XA2	KCH	FÄSTE FÖR HYTT VÄNSTER	228	36024
XA2	KCH	FÄSTE FÖR HYTT HÖGER	228	36024
XA2	KCH	FÖRSTÄRKNINGSBALK	228	36480
SF	KCH/ KRTC	STYRAXELBRYGGA 42-45	228	0
LF2	KCH	CYLINDER 250/180 SL 2800	167	114562
LF2	KCH	CYLINDER 160/ 63 SL 198	167	48096
LF2	KCH	DRIVAXEL KESS 26.35 B3033	167	668
LF2	KCH	DRIVAXEL KESSL 29,5	167	668
LF2	KCH	DRIVAXEL MERIT.26.62(119)	167	31062
LF2	KCH	STYRAXELVAGGA DRD	167	53774
LF2	KCH	MOTVIKT STYRAXEL	167	63460
LF2	KCH	DRIVAXEL KESS 14,57 B3234	167	40080
LF2	KCH	DRIVAXEL MERIT.32,08 (96)	167	9352
XZ1	KCH	FÄSTE LJUDFÄLLA	262	23056
XZ1	KCH	GUIDE SKENA VÄ	262	57116

XZ1	KCH	FÄSTE LJUDFÄLLA	262	7336
XZ1	KCH	GUIDE SKENA HÖ	262	57116
XZ2	KCH	STEG HÖ	262	13100
XZ2	KCH	STEG VÄ	262	524
XZ2	KCH	STEG HÖ	262	0
XZ2	KCH	STEG VÄ	262	3144
XZ2	KCH	STEG HÖ	262	3668
XZ2	KCH	STEG VÄ	262	9432
XZ2	KCH	STEG HÖ	262	10480
XZ2	KCH	STEG VÄ	262	3668
XZ2	KCH	STEG HÖ	262	3668
XZ2	KCH	STEG VÄ	262	13624
XZ2	KCH	STEG HÖ	262	12052
XZ2	KCH	STEG FRAM	262	16768
XZ2	KCH	STEG FRAM VÄ	262	58688
XZ2	KCH	STEG BAK VÄ	262	36680
XZ2	KCH	STEG BAK VÄ	262	14148
XZ2	KCH	PLATTFORM	262	58164
XZ2	KCH	BALK HYTTUNDERBYGGNAD	262	8908
XZ2	KCH	BALK HYTTUNDERBYGGNAD	262	6288
XZ2	KCH	SKENA HÖ	262	8384
XZ2	KCH	SKENA VÄ	262	8384
XZ2	KCH	STEG NEDRE	262	105848
XZ2	KCH	GOLVPLATTA	262	104800
XZ2	KCH	FOTSTEG NEDRE VÄ	262	1048
XZ2	KCH	FOTSTEG NEDRE HÖ	262	1572
XZ2	KCH	FOTSTEG NEDRE VÄ	262	1048
XZ2	KCH	STEG BAK VÄ	262	2620
XZ2	KCH	STEG BAK VÄ	262	6288
XZ2	KCH	STEG FRAM	262	94844
XZ2	KCH	STEG HÖ	262	2620
XZ2	KCH	STEG HÖ	262	5240
XZ2	KCH	STEG HÖ	262	37204
XZ2	KCH	STEG FRAM	262	58164
D	KCH	PLÅT	262	0
D	KCH	FÄSTE FÖR HYTT VÄNSTER	262	41396
D	KCH	BALK HYTTUNDERBYGGNAD	262	10480
D	KCH	LAMPFÄSTE BAK	262	53448
D	KCH	CYLINDER 180/125 SL 2550	262	0
D	KCH	RAM TRA SVETS	262	0
D	KCH	SKENA HYTTUNDERBYGGNAD VÄ	262	57116
LE	KCH	Hyttar	120	93600
				6743644

Appendix 10. Articles sorted according to how frequent they are used

Storage Area	Article Name	Meter	Meter/ Year
X	CLAMP	228	2830848
X	CLAMP DUBBEL	228	427728
X	BATTERI 140AH 12V	228	344280
LF2	CYLINDER 250/180 SL 2800	167	114562
LA3	MOTVIKT BALJA	239	138620
XZ2	STEG NEDRE	262	105848
XZ2	GOLVPLATTA	262	104800
LF2	MOTVIKT STYRAXEL	167	63460
XZ2	STEG FRAM	262	94844
y	HUV LUFTFILTER D=179,5	262	94844
LF2	STYRAXELVAGGA DRD	167	53774
LA4	MOTVIKT BAKRE DC 28-42	140	43960
LF2	CYLINDER 160/ 63 SL 198	167	48096
LA3	MOTVIKT BALJA	239	58794
LF2	DRIVAXEL KESS 14,57 B3234	167	40080
LA4	RAM DCE 70/90-45E	140	32480
X	VÄXELLÅDA EL.VÄXLING	228	52896
X	VÄXELLÅDA EL.VXL.FÖRB.AUT	228	52896
LA4	MOTVIKT	140	32200
LA4	MOTVIKT BAKRE	140	32200
LA4	MOTVIKT,ÖVRE	140	31640
XZ2	STEG FRAM VÄ	262	58688
XZ2	PLATTFORM	262	58164
XZ2	STEG FRAM	262	58164
XB	RÄCKE INSTEG VÄ	228	50616
X	BRÄNSLETANK	228	50616
CA	BERÖRINGSSKYDD	160	35200
FA	SKENA HYTTUNDERBYG	10	2180
XZ1	GUIDE SKENA VÄ	262	57116
XZ1	GUIDE SKENA HÖ	262	57116
XZ3	SKENA HYTTUNDERBYGGNAD HÖ	262	57116
XA1	HYTTUNDERBYGGNAD	228	49704
D	SKENA HYTTUNDERBYGGNAD VÄ	262	57116
X	MOTOR,DIESEL TWD1031 VE	228	48336
D	LAMPFÄSTE BAK	262	53448
y	KYLARE,VÄTSKA VATTEN	262	52924
LB1	LYFTVAGN SF	265	53000
LF2	DRIVAXEL MERIT.26.62(119)	167	31062
LA2	AGGREGAT SID 20-40	239	40630
X	BRÄNSLETANK	228	37848
XA1	HYTTUNDERBYGGNAD	228	37392
XA2	FÖRSTÄRKNINGSBALK	228	36480
X	FÖRSTÄRKNINGSBALK	228	36480
X	KYLARE,VÄTSKA VATTEN/OLJA	228	36480
XA2	FÄSTE FÖR HYTT VÄNSTER	228	36024
XA2	FÄSTE FÖR HYTT HÖGER	228	36024

D	FÄSTE FÖR HYTT VÄNSTER	262	41396
GA	SPÄNNRING	25	3900
X	MOTOR,DIESEL TWD 731 VE	228	35112
XZ2	STEG HÖ	262	37204
X	MOTOR,DIESEL TWD1240 VE	228	32376
XZ2	STEG BAK VÄ	262	36680
CA	KÅPA	160	22080
LA4	MOTVIKT DC 38000-45000	140	16240
LF2	SKÄRM FRAM VÄ	167	18370
LF2	YTTERSKÄRM VÄ	167	17702
LF2	YTTERSKÄRM HÖ	167	17702
X	MOTOR,DIESEL TAD 720 VE	228	22800
XZ1	FÄSTE LJUDFÄLLA	262	23056
CA	RÄCKE SKÄRM	160	11840
KA	LYFTBOM KOMPLETT	215	15910
X	KYLARE,VÄTSKA VATTEN/OLJA	228	16872
XZ2	STEG FRAM	262	16768
LA1	MOTVIKT BAK	239	13384
LF2	DRIVAXEL MERIT.32,08 (96)	167	9352
XZ2	STEG BAK VÄ	262	14148
CA	KÅPA	160	8320
XZ2	STEG VÄ	262	13624
X	KÅPA,LJUDISOLERING	228	11856
y	KÅPA	262	13624
XZ2	STEG HÖ	262	13100
X	FÄSTE,VIKTINDIKATOR	228	11400
XZ2	STEG HÖ	262	12052
XZ2	STEG HÖ	262	10480
D	BALK HYTTUNDERBYGGNAD	262	10480
y	SPEGEL,BACK UTV.	262	9956
LA4	MOTVIKT DC2 ÖVRE	140	5040
XZ2	STEG VÄ	262	9432
XZ2	BALK HYTTUNDERBYGGNAD	262	8908
X	KYLARE RSD 2T5519810B SJT	228	7752
X	VÄXELLÅDA EL.VXL.FÖRB.AUT	228	7752
XZ2	SKENA HÖ	262	8384
XZ2	SKENA VÄ	262	8384
LF2	SKÄRMBREDDARE HÖGER	167	5010
LF2	SKÄRMBREDDARE VÄNSTER	167	5010
XZ1	FÄSTE LJUDFÄLLA	262	7336
CA	KÅPA	160	4160
X	LJUDDÄMPNINGSPLÅT FRONT	228	5928
X	ISOLPLÅT FRONT UNDRE	228	5928
XZ2	BALK HYTTUNDERBYGGNAD	262	6288
XZ2	STEG BAK VÄ	262	6288
LA2	AGGREGAT SID 20-40	239	5258
JA	GAFFEL DC RULLE 28-32	294	5880
XZ2	STEG HÖ	262	5240
CA	BALK HYTTUNDERBYGGNAD	160	2880
LA1	MOTVIKT	239	3824

X	KÅPA,LJUDISOLERING	228	3648
LA4	MOTVIKT	140	1960
XZ2	STEG HÖ	262	3668
XZ2	STEG VÄ	262	3668
XZ2	STEG HÖ	262	3668
X	VÄXELLÅDA 15.7TE32418-??	228	3192
X	BRÄNSLETANK	228	3192
LF2	SKÄRM, FRAM HÖ	167	2004
LF2	SKÄRM, BAK HÖ	167	2004
XZ2	STEG VÄ	262	3144
CA	SVEPKÅPA VÄ	160	1600
CA	TÄCKPLÅT	160	1600
XZ2	STEG BAK VÄ	262	2620
XZ2	STEG HÖ	262	2620
X	FÖRVARINGSLÅDA	228	2280
X	MOTOR,DIESEL CUM. QSM11	228	1824
X	PLÅT	228	1824
XZ2	FOTSTEG NEDRE HÖ	262	1572
XA1	TIPPRAM ,HYTTIPP	228	1368
X	MOTOR,DIESEL CUMMINS	228	1368
LF2	DRIVAXEL KESS 26.35 B3033	167	668
LF2	DRIVAXEL KESSL 29,5	167	668
XZ2	FOTSTEG NEDRE VÄ	262	1048
XZ2	FOTSTEG NEDRE VÄ	262	1048
XB	RÄCKE FRONT 1300	228	912
XB	RÄCKE SIDA L=1200	228	912
XB	RÄCKE, SIDA 1600	228	912
X	CYLINDER 160/ 80 SL 1275	228	912
X	KYLARE,VÄTSKA VATTEN/OLJA	228	912
y	SÄKERHETSFILTER	262	1048
y	FILTERINSATS	262	1048
XZ2	STEG VÄ	262	524
XB	RÄCKE BAK	228	456
X	PLÅT	228	456
X	KÅPA MOTVIKT	228	456
LE	Hyttar	120	93600
			6743644

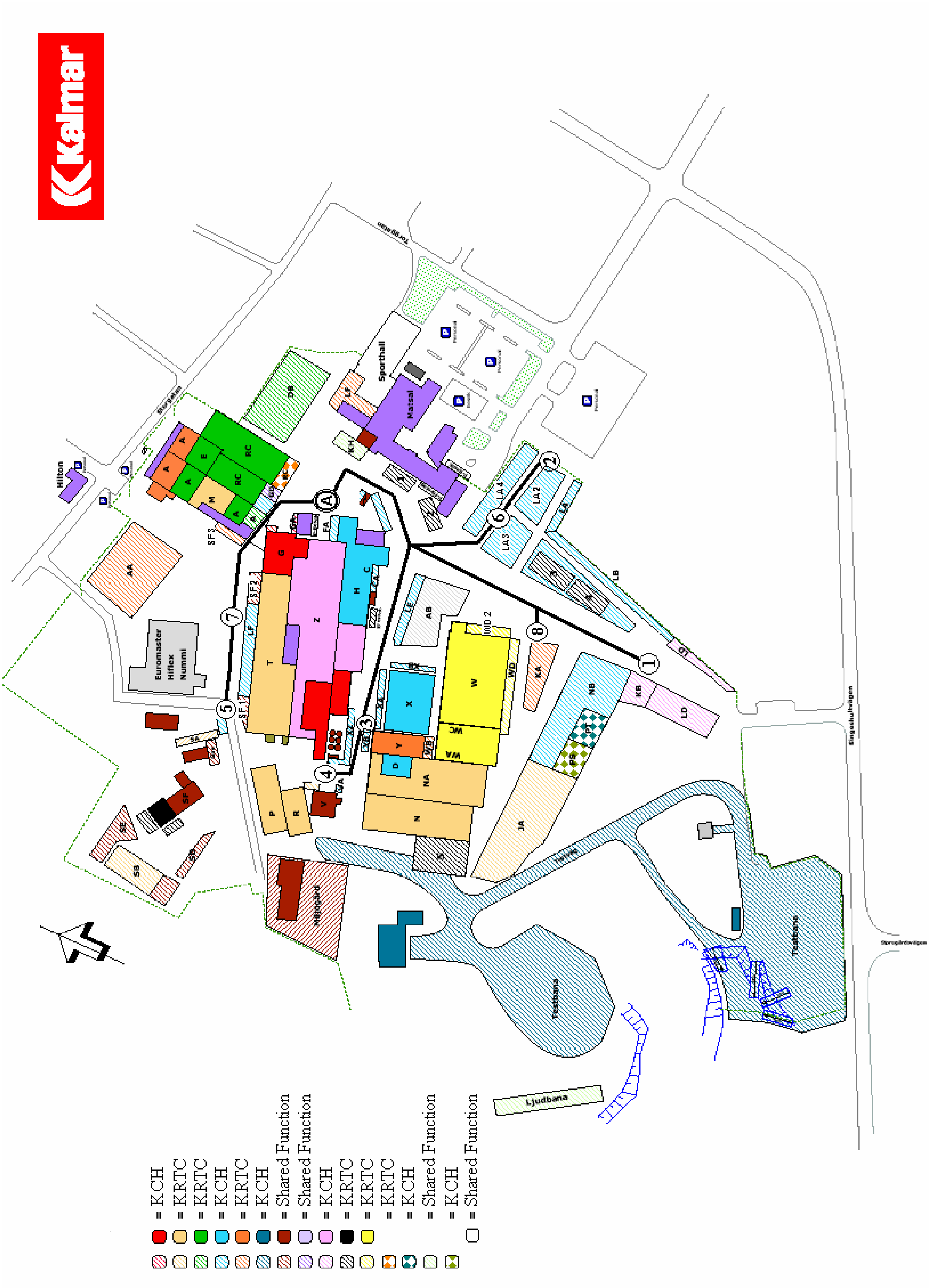
Appendix 11: Articles sorted according to their product family

Product Families	Storage Area	Meter	Meter/ year
MOTVIKT BAK	LA1	239	13384
MOTVIKT	LA1	239	3824
MOTVIKT BALJA	LA3	239	58794
MOTVIKT BALJA	LA3	239	138620
MOTVIKT	LA4	140	32200
MOTVIKT,ÖVRE	LA4	140	31640
MOTVIKT DC 38000-45000	LA4	140	16240
MOTVIKT DC2 ÖVRE	LA4	140	5040
MOTVIKT BAKRE DC 28-42	LA4	140	43960
MOTVIKT BAKRE	LA4	140	32200
MOTVIKT	LA4	140	1960
MOTVIKT STYRAXEL	LF2	167	63460
AGGREGAT SID 20-40	LA2	239	40630
AGGREGAT SID 20-40	LA2	239	5258
LYFTVAGN SF	LB1	265	53000
DRIVAXEL KESS 26.35 B3033	LF2	167	668
DRIVAXEL KESSL 29,5	LF2	167	668
DRIVAXEL MERIT.26.62(119)	LF2	167	31062
STYRAXELVAGGA DRD	LF2	167	53774
DRIVAXEL KESS 14,57 B3234	LF2	167	40080
DRIVAXEL MERIT.32,08 (96)	LF2	167	9352
BALK HYTTUNDERBYGGNAD	CA	160	2880
BALK HYTTUNDERBYGGNAD	XZ2	262	8908
BALK HYTTUNDERBYGGNAD	XZ2	262	6288
BALK HYTTUNDERBYGGNAD	D	262	10480
FÖRSTÄRKNINGSBALK	X	228	36480
FÖRSTÄRKNINGSBALK	XA2	228	36480
BATTERI 140AH 12V	X	228	344280
BERÖRINGSSKYDD	CA	160	35200
BRÄNSLETANK	X	228	50616
BRÄNSLETANK	X	228	3192
BRÄNSLETANK	X	228	37848
CLAMP	X	228	2830848
CLAMP DUBBEL	X	228	427728
CYLINDER 160/ 63 SL 198	LF2	167	48096
CYLINDER 250/180 SL 2800	LF2	167	114562
CYLINDER 160/ 80 SL 1275	X	228	912
FILTERINSATS	Y	262	1048
FOTSTEG NEDRE HÖ	XZ2	262	1572
FOTSTEG NEDRE VÄ	XZ2	262	1048
FOTSTEG NEDRE VÄ	XZ2	262	1048
STEG HÖ	XZ2	262	13100
STEG VÄ	XZ2	262	524
STEG VÄ	XZ2	262	3144
STEG HÖ	XZ2	262	3668
STEG VÄ	XZ2	262	9432

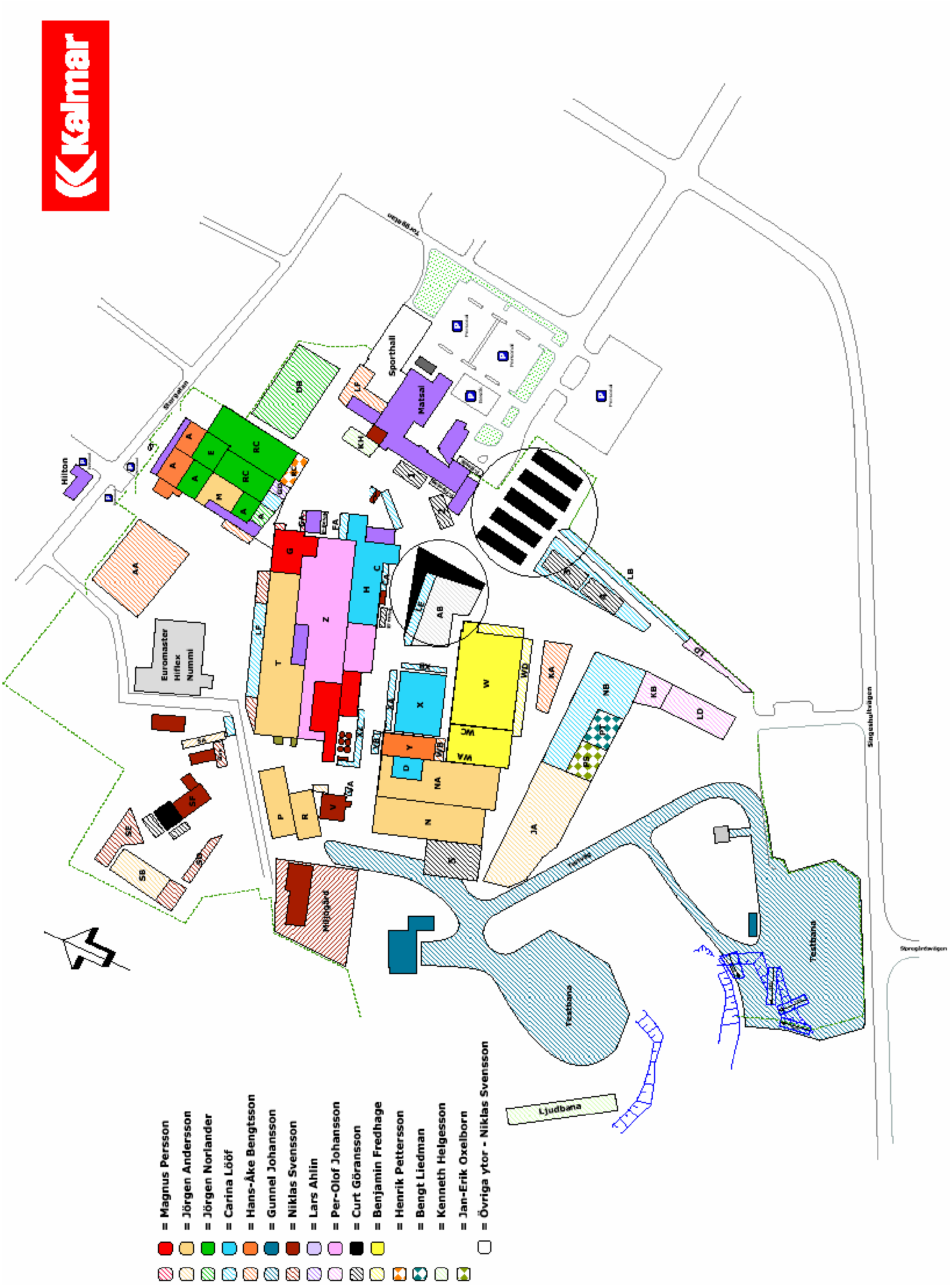
STEG HÖ	XZ2	262	10480
STEG VÄ	XZ2	262	3668
STEG HÖ	XZ2	262	3668
STEG VÄ	XZ2	262	13624
STEG HÖ	XZ2	262	12052
STEG FRAM	XZ2	262	16768
STEG FRAM VÄ	XZ2	262	58688
STEG NEDRE	XZ2	262	105848
STEG BAK VÄ	XZ2	262	36680
STEG BAK VÄ	XZ2	262	14148
STEG BAK VÄ	XZ2	262	2620
STEG BAK VÄ	XZ2	262	6288
STEG FRAM	XZ2	262	94844
STEG HÖ	XZ2	262	2620
STEG HÖ	XZ2	262	5240
STEG HÖ	XZ2	262	37204
STEG FRAM	XZ2	262	58164
FÄSTE FÖR HYTT VÄNSTER	XA2	228	36024
FÄSTE,VIKTINDIKATOR	X	228	11400
FÄSTE FÖR HYTT HÖGER	XA2	228	36024
FÄSTE LJUDFÄLLA	XZ1	262	23056
FÄSTE LJUDFÄLLA	XZ1	262	7336
FÄSTE FÖR HYTT VÄNSTER	D	262	41396
FÖRVARINGSLÅDA	X	228	2280
GAFFEL DC RULLE 28-32	JA	294	5880
GOLVPLATTA	XZ2	262	104800
HUV LUFTFILTER D=179,5	y	262	94844
HYTTUNDERBYGGNAD	XA1	228	49704
HYTTUNDERBYGGNAD	XA1	228	37392
ISOLPLÅT FRONT UNDRE	X	228	5928
KYLARE RSD 2T5519810B SJT	X	228	7752
KYLARE,VÄTSKA VATTEN	y	262	52924
KYLARE,VÄTSKA VATTEN/OLJA	X	228	16872
KYLARE,VÄTSKA VATTEN/OLJA	X	228	912
KYLARE,VÄTSKA VATTEN/OLJA	X	228	36480
KÅPA	y	262	13624
KÅPA	CA	160	4160
KÅPA	CA	160	8320
KÅPA	CA	160	22080
KÅPA MOTVIKT	X	228	456
KÅPA,LJUDISOLERING	X	228	3648
KÅPA,LJUDISOLERING	X	228	11856
SVEPKÅPA VÄ	CA	160	1600
LAMPFÄSTE BAK	D	262	53448
LJUDDÄMPNINGSPLÅT FRONT	X	228	5928
LYFTBOM KOMPLETT	KA	215	15910
MOTOR,DIESEL TAD 720 VE	X	228	22800
MOTOR,DIESEL TWD 731 VE	X	228	35112
MOTOR,DIESEL TWD1031 VE	X	228	48336
MOTOR,DIESEL TWD1240 VE	X	228	32376

MOTOR,DIESEL CUM. QSM11	X	228	1824
MOTOR,DIESEL CUMMINS	X	228	1368
PLATTFORM	XZ2	262	58164
PLÅT	X	228	456
PLÅT	X	228	1824
RAM DCE 70/90-45E	LA4	140	32480
TIPPRAM ,HYTTIPP	XA1	228	1368
RÄCKE BAK	XB	228	456
RÄCKE FRONT 1300	XB	228	912
RÄCKE INSTEG VÄ	XB	228	50616
RÄCKE SIDA L=1200	XB	228	912
RÄCKE SKÄRM	CA	160	11840
RÄCKE, SIDA 1600	XB	228	912
SKENA HYTTUNDERBYGGNAD	FA	10	2180
SKENA HYTTUNDERBYGGNAD	XZ3	262	57116
SKENA HYTTUNDERBYGGNAD	D	262	57116
SKENA HÖ	XZ2	262	8384
SKENA VÄ	XZ2	262	8384
GUIDE SKENA HÖ	XZ1	262	57116
GUIDE SKENA VÄ	XZ1	262	57116
SKÄRM FRAM VÄ	LF2	167	18370
SKÄRM, BAK HÖ	LF2	167	2004
SKÄRM, FRAM HÖ	LF2	167	2004
SKÄRMBREDDARE HÖGER	LF2	167	5010
SKÄRMBREDDARE VÄNSTER	LF2	167	5010
YTTERSKÄRM HÖ	LF2	167	17702
YTTERSKÄRM VÄ	LF2	167	17702
SPEGEL,BACK UTV.	y	262	9956
SPÄNNRING	GA	25	3900
SÄKERHETSFILTER	y	262	1048
TÄCKPLÅT	CA	160	1600
VÄXELLÅDA 15.7TE32418-??	X	228	3192
VÄXELLÅDA EL.VXL.FÖRB.AUT	X	228	7752
VÄXELLÅDA EL.VÄXLING	X	228	52896
VÄXELLÅDA EL.VXL.FÖRB.AUT	X	228	52896
Hyttar	LE	120	93600
			6743644

Appendix 12: Storage Area Map with Material Flow



Appendix 13: Changed layout at the LA-Area



Appendix 14: Results of Changing the Storage Layout when locating the Articles based on their frequency.

Storage Area	Article Name	Meter	Meter/ Year	New Location	New Meter	New Meter/Year
X	CLAMP	228	2830848	AB	152	1887232
X	CLAMP DUBBEL	228	427728	AB	152	285152
X	BATTERI 140AH 12V	228	344280	X	228	344280
LF2	CYLINDER 250/180 SL 2800	167	114562	AB	152	104272
LA3	MOTVIKT BALJA	239	138620	AB	152	88160
XZ2	STEG NEDRE	262	105848	LE	120	48480
XZ2	GOLVPLATTA	262	104800	LE	120	48000
LF2	MOTVIKT STYRAXEL	167	63460	AB	152	57760
XZ2	STEG FRAM	262	94844	LE	120	43440
y	HUV LUFTFILTER D=179,5	262	94844	Y	262	94844
LF2	STYRAXELVAGGA DRD	167	53774	LF2	167	53774
LA4	MOTVIKT BAKRE DC 28-42	140	43960	AB	152	47728
LF2	CYLINDER 160/ 63 SL 198	167	48096	AB	152	43776
LA3	MOTVIKT BALJA	239	58794	AB	152	37392
LF2	DRIVAXEL KESS 14,57 B3234	167	40080	LF2	167	40080
LA4	RAM DCE 70/90-45E	140	32480	LA4	140	32480
X	VÄXELLÅDA EL.VÄXLING	228	52896	X	228	52896
X	VÄXELLÅDA EL.VXL.FÖRB.AUT	228	52896	X	228	52896
LA4	MOTVIKT	140	32200	AB	152	34960
LA4	MOTVIKT BAKRE	140	32200	AB	152	34960
LA4	MOTVIKT,ÖVRE	140	31640	AB	152	34352
XZ2	STEG FRAM VÄ	262	58688	LE	120	26880
XZ2	PLATTFORM	262	58164	LE	120	26640
XZ2	STEG FRAM	262	58164	LE	120	26640
XB	RÄCKE INSTEG VÄ	228	50616	LE	120	26640
X	BRÄNSLETANK	228	50616	X	228	50616
CA	BERÖRINGSSKYDD	160	35200	CA	160	35200
FA	SKENA HYTTUNDERBYG	10	2180	LD	294	64092
XZ1	GUIDE SKENA VÄ	262	57116	LE	120	26160
XZ1	GUIDE SKENA HÖ	262	57116	LE	120	26160
XZ3	SKENA HYTTUNDERBYGGNAD HÖ	262	57116	LE	120	26160
XA1	HYTTUNDERBYGGNAD	228	49704	XA1	228	49704
D	SKENA HYTTUNDERBYGGNAD VÄ	262	57116	LE	120	26160
X	MOTOR,DIESEL TWD1031 VE	228	48336	X	228	48336
D	LAMPFÄSTE BAK	262	53448	AB	152	31008
y	KYLARE,VÄTSKA VATTEN	262	52924	Y	262	52924
LB1	LYFTVAGN SF	265	53000	LB1	265	53000
LF2	DRIVAXEL MERIT.26.62(119)	167	31062	AB	152	28272
LA2	AGGREGAT SID 20-40	239	40630	LA2	239	40630
X	BRÄNSLETANK	228	37848	X	228	37848
XA1	HYTTUNDERBYGGNAD	228	37392	AB	152	24928
XA2	FÖRSTÄRKNINGSBALK	228	36480	AB	152	24320
X	FÖRSTÄRKNINGSBALK	228	36480	AB	152	24320
X	KYLARE,VÄTSKA VATTEN/OLJA	228	36480	X	228	36480
XA2	FÄSTE FÖR HYTT VÄNSTER	228	36024	LA4	140	22120

XA2	FÄSTE FÖR HYTT HÖGER	228	36024	LA4	140	22120
D	FÄSTE FÖR HYTT VÄNSTER	262	41396	LA4	140	22120
GA	SPÄNNRING	25	3900	LA4	140	21840
X	MOTOR,DIESEL TWD 731 VE	228	35112	X	228	35112
XZ2	STEG HÖ	262	37204	LE	120	17040
X	MOTOR,DIESEL TWD1240 VE	228	32376	X	228	32376
XZ2	STEG BAK VÄ	262	36680	LE	120	16800
CA	KÅPA	160	22080	LF2	167	23046
LA4	MOTVIKT DC 38000-45000	140	16240	LF2	167	19372
LF2	SKÄRM FRAM VÄ	167	18370	LF2	167	18370
LF2	YTTERSKÄRM VÄ	167	17702	LA4	140	14840
LF2	YTTERSKÄRM HÖ	167	17702	LA4	140	14840
X	MOTOR,DIESEL TAD 720 VE	228	22800	X	228	22800
XZ1	FÄSTE LJUDFÄLLA	262	23056	LA4	140	12320
CA	RÄCKE SKÄRM	160	11840	LA4	140	10360
KA	LYFTBOM KOMPLETT	215	15910	KA	215	15910
X	KYLARE,VÄTSKA VATTEN/OLJA	228	16872	X	228	16872
XZ2	STEG FRAM	262	16768	LA1	239	15296
LA1	MOTVIKT BAK	239	13384	AB	152	8512
LF2	DRIVAXEL MERIT.32,08 (96)	167	9352	LF2	167	9352
XZ2	STEG BAK VÄ	262	14148	LF2	167	9018
CA	KÅPA	160	8320	CA	160	8320
XZ2	STEG VÄ	262	13624	LF2	167	8684
X	KÅPA,LJUDISOLERING	228	11856	X	228	11856
y	KÅPA	262	13624	Y	262	13624
XZ2	STEG HÖ	262	13100	LF2	167	8350
X	FÄSTE,VIKTINDIKATOR	228	11400	X	228	11400
XZ2	STEG HÖ	262	12052	LF2	167	7682
XZ2	STEG HÖ	262	10480	LF2	167	6680
D	BALK HYTTUNDERBYGGNAD	262	10480	D	262	10480
y	SPEGEL,BACK UTV.	262	9956	Y	262	9956
LA4	MOTVIKT DC2 ÖVRE	140	5040	LA4	140	5040
XZ2	STEG VÄ	262	9432	LF2	167	6012
XZ2	BALK HYTTUNDERBYGGNAD	262	8908	XA2	228	7752
X	KYLARE RSD 2T5519810B SJT	228	7752	XA2	228	7752
X	VÄXELLÅDA EL.VXL.FÖRB.AUT	228	7752	X	228	7752
XZ2	SKENA HÖ	262	8384	LE	120	3840
XZ2	SKENA VÄ	262	8384	LE	120	3840
LF2	SKÄRMBREDDARE HÖGER	167	5010	LF2	167	5010
LF2	SKÄRMBREDDARE VÄNSTER	167	5010	LF2	167	5010
XZ1	FÄSTE LJUDFÄLLA	262	7336	XZ1	262	7336
CA	KÅPA	160	4160	CA	160	4160
X	LJUDDÄMPNINGSPLÅT FRONT	228	5928	X	228	5928
X	ISOLPLÅT FRONT UNDRE	228	5928	X	228	5928
XZ2	BALK HYTTUNDERBYGGNAD	262	6288	LF1	228	5472
XZ2	STEG BAK VÄ	262	6288	LF1	228	5472
LA2	AGGREGAT SID 20-40	239	5258	LA2	239	5258
JA	GAFFEL DC RULLE 28-32	294	5880	JA	294	5880
XZ2	STEG HÖ	262	5240	JA	294	5880
CA	BALK HYTTUNDERBYGGNAD	160	2880	CA	160	2880
LA1	MOTVIKT	239	3824	LA1	239	3824

X	KÅPA,LJUDISOLERING	228	3648	X	228	3648
LA4	MOTVIKT	140	1960	LA4	140	1960
XZ2	STEG HÖ	262	3668	JA	294	4116
XZ2	STEG VÄ	262	3668	JA	294	4116
XZ2	STEG HÖ	262	3668	JA	294	4116
X	VÄXELLÅDA 15.7TE32418-??	228	3192	X	228	3192
X	BRÄNSLETANK	228	3192	X	228	3192
LF2	SKÄRM, FRAM HÖ	167	2004	XZ1	262	3144
LF2	SKÄRM, BAK HÖ	167	2004	XZ1	262	3144
XZ2	STEG VÄ	262	3144	XZ1	262	3144
CA	SVEPKÅPA VÄ	160	1600	XZ2	262	2620
CA	TÄCKPLÅT	160	1600	XZ2	262	2620
XZ2	STEG BAK VÄ	262	2620	XZ2	262	2620
XZ2	STEG HÖ	262	2620	XZ2	262	2620
X	FÖRVARINGSLÅDA	228	2280	X	228	2280
X	MOTOR,DIESEL CUM. QSM11	228	1824	X	228	1824
X	PLÅT	228	1824	X	228	1824
XZ2	FOTSTEG NEDRE HÖ	262	1572	KB	294	1764
XA1	TIPPRAM ,HYTTIPP	228	1368	KB	294	1764
X	MOTOR,DIESEL CUMMINS	228	1368	X	228	1368
LF2	DRIVAXEL KESS 26.35 B3033	167	668	LF2	167	668
LF2	DRIVAXEL KESSL 29,5	167	668	LF2	167	668
XZ2	FOTSTEG NEDRE VÄ	262	1048	KB	294	1176
XZ2	FOTSTEG NEDRE VÄ	262	1048	KB	294	1176
XB	RÄCKE FRONT 1300	228	912	XB	228	912
XB	RÄCKE SIDA L=1200	228	912	XB	228	912
XB	RÄCKE, SIDA 1600	228	912	XB	228	912
X	CYLINDER 160/ 80 SL 1275	228	912	KB	294	1176
X	KYLARE,VÄTSKA VATTEN/OLJA	228	912	X	228	912
y	SÄKERHETSFILTER	262	1048	Y	262	1048
y	FILTERINSATS	262	1048	Y	262	1048
XZ2	STEG VÄ	262	524	KB	294	588
XB	RÄCKE BAK	228	456	KB	294	588
X	PLÅT	228	456	KB	294	588
X	KÅPA MOTVIKT	228	456	KB	294	588
LE	Hyttar	120	93600	LD	294	229320
			6743644			**5184882**

Appendix 15: Result of Changing the Storage Layout when grouping the Articles in Product Families.

Product Families	Storage Area	Meter	Meter/ year	New Location	New Meter	New Meter/ Year
MOTVIKT BAK	LA1	239	13384	LA	140	7840
MOTVIKT	LA1	239	3824	LA	140	2240
MOTVIKT BALJA	LA3	239	58794	LA	140	34440
MOTVIKT BALJA	LA3	239	138620	LA	140	81200
MOTVIKT	LA4	140	32200	LA	140	32200
MOTVIKT,ÖVRE	LA4	140	31640	LA	140	31640
MOTVIKT DC 38000-45000	LA4	140	16240	LA	140	16240
MOTVIKT DC2 ÖVRE	LA4	140	5040	LA	140	5040
MOTVIKT BAKRE DC 28-42	LA4	140	43960	LA	140	43960
MOTVIKT BAKRE	LA4	140	32200	LA	140	32200
MOTVIKT	LA4	140	1960	LA	140	1960
MOTVIKT STYRAXEL	LF2	167	63460	LA	140	53200
AGGREGAT SID 20-40	LA2	239	40630	LA	140	23800
AGGREGAT SID 20-40	LA2	239	5258	LA	140	3080
LYFTVAGN SF	LB1	265	53000	LB1	265	53000
DRIVAXEL KESS 26.35 B3033	LF2	167	668	LF2	167	668
DRIVAXEL KESSL 29,5	LF2	167	668	LF2	167	668
DRIVAXEL MERIT.26.62(119)	LF2	167	31062	LF2	167	31062
STYRAXELVAGGA DRD	LF2	167	53774	LF2	167	53774
DRIVAXEL KESS 14,57 B3234	LF2	167	40080	LF2	167	40080
DRIVAXEL MERIT.32,08 (96)	LF2	167	9352	LF2	167	9352
BALK HYTTUNDERBYGGNAD	CA	160	2880	LD	294	5292
BALK HYTTUNDERBYGGNAD	XZ2	262	8908	LD	294	9996
BALK HYTTUNDERBYGGNAD	XZ2	262	6288	LD	294	7056
BALK HYTTUNDERBYGGNAD	D	262	10480	LD	294	11760
FÖRSTÄRKNINGSBALK	X	228	36480	LD	294	47040
FÖRSTÄRKNINGSBALK	XA2	228	36480	LD	294	47040
BATTERI 140AH 12V	X	228	344280	X	228	344280
BERÖRINGSSKYDD	CA	160	35200	X	228	50160
BRÄNSLETANK	X	228	50616	X	228	50616
BRÄNSLETANK	X	228	3192	X	228	3192
BRÄNSLETANK	X	228	37848	X	228	37848
CLAMP	X	228	2830848	AB	152	1887232
CLAMP DUBBEL	X	228	427728	AB	152	285152
CYLINDER 160/ 63 SL 198	LF2	167	48096	AB	152	43776
CYLINDER 250/180 SL 2800	LF2	167	114562	AB	152	104272
CYLINDER 160/ 80 SL 1275	X	228	912	AB	152	608
FILTERINSATS	Y	262	1048	Y	262	1048
FOTSTEG NEDRE HÖ	XZ2	262	1572	LE	120	720
FOTSTEG NEDRE VÄ	XZ2	262	1048	LE	120	480
FOTSTEG NEDRE VÄ	XZ2	262	1048	LE	120	480
STEG HÖ	XZ2	262	13100	LE	120	6000
STEG VÄ	XZ2	262	524	LE	120	240
STEG VÄ	XZ2	262	3144	LE	120	1440

STEG HÖ	XZ2	262	3668	LE	120	1680
STEG VÄ	XZ2	262	9432	LE	120	4320
STEG HÖ	XZ2	262	10480	LE	120	4800
STEG VÄ	XZ2	262	3668	LE	120	1680
STEG HÖ	XZ2	262	3668	LE	120	1680
STEG VÄ	XZ2	262	13624	LE	120	6240
STEG HÖ	XZ2	262	12052	LE	120	5520
STEG FRAM	XZ2	262	16768	LE	120	7680
STEG FRAM VÄ	XZ2	262	58688	LE	120	26880
STEG NEDRE	XZ2	262	105848	LE	120	48480
STEG BAK VÄ	XZ2	262	36680	LE	120	16800
STEG BAK VÄ	XZ2	262	14148	LE	120	6480
STEG BAK VÄ	XZ2	262	2620	LE	120	1200
STEG BAK VÄ	XZ2	262	6288	LE	120	2880
STEG FRAM	XZ2	262	94844	LE	120	43440
STEG HÖ	XZ2	262	2620	LE	120	1200
STEG HÖ	XZ2	262	5240	LE	120	2400
STEG HÖ	XZ2	262	37204	LE	120	17040
STEG FRAM	XZ2	262	58164	LE	120	26640
FÄSTE FÖR HYTT VÄNSTER	XA2	228	36024	XZ2	228	36024
FÄSTE,VIKTINDIKATOR	X	228	11400	XZ2	228	11400
FÄSTE FÖR HYTT HÖGER	XA2	228	36024	XZ2	228	36024
FÄSTE LJUDFÄLLA	XZ1	262	23056	XZ2	228	20064
FÄSTE LJUDFÄLLA	XZ1	262	7336	XZ2	228	6384
FÄSTE FÖR HYTT VÄNSTER	D	262	41396	XZ2	228	36024
FÖRVARINGSLÅDA	X	228	2280	X	228	2280
GAFFEL DC RULLE 28-32	JA	294	5880	JA	294	5880
GOLVPLATTA	XZ2	262	104800	AB	152	60800
HUV LUFTFILTER D=179,5	y	262	94844	Y	262	94844
HYTTUNDERBYGGNAD	XA1	228	49704	XA1	228	49704
HYTTUNDERBYGGNAD	XA1	228	37392	XA1	228	37392
ISOLPLÅT FRONT UNDRE	X	228	5928	X	228	5928
KYLARE RSD 2T5519810B SJT	X	228	7752	X	228	7752
KYLARE,VÄTSKA VATTEN	y	262	52924	Y	262	52924
KYLARE,VÄTSKA VATTEN/OLJA	X	228	16872	X	228	16872
KYLARE,VÄTSKA VATTEN/OLJA	X	228	912	X	228	912
KYLARE,VÄTSKA VATTEN/OLJA	X	228	36480	X	228	36480
KÅPA	y	262	13624	Y	262	13624
KÅPA	CA	160	4160	KB	294	7644
KÅPA	CA	160	8320	KB	294	15288
KÅPA	CA	160	22080	KB	294	40572
KÅPA MOTVIKT	X	228	456	KB	294	588
KÅPA,LJUDISOLERING	X	228	3648	KB	294	4704
KÅPA,LJUDISOLERING	X	228	11856	KB	294	15288
SVEPKÅPA VÄ	CA	160	1600	KB	294	2940
LAMPFÄSTE BAK	D	262	53448	D	262	53448
LJUDDÄMPNINGSPLÅT FRONT	X	228	5928	X	228	5928
LYFTBOM KOMPLETT	KA	215	15910	AB	152	11248
MOTOR,DIESEL TAD 720 VE	X	228	22800	X	228	22800
MOTOR,DIESEL TWD 731 VE	X	228	35112	X	228	35112
MOTOR,DIESEL TWD1031 VE	X	228	48336	X	228	48336

MOTOR,DIESEL TWD1240 VE	X	228	32376	X	228	32376
MOTOR,DIESEL CUM. QSM11	X	228	1824	X	228	1824
MOTOR,DIESEL CUMMINS	X	228	1368	X	228	1368
PLATTFORM	XZ2	262	58164	AB	152	33744
PLÅT	X	228	456	X	228	456
PLÅT	X	228	1824	X	228	1824
RAM DCE 70/90-45E	LA4	140	32480	JA	262	60784
TIPPRAM ,HYTTIPP	XA1	228	1368	XA1	228	1368
RÄCKE BAK	XB	228	456	NB	294	588
RÄCKE FRONT 1300	XB	228	912	NB	294	1176
RÄCKE INSTEG VÄ	XB	228	50616	NB	294	65268
RÄCKE SIDA L=1200	XB	228	912	NB	294	1176
RÄCKE SKÄRM	CA	160	11840	NB	294	21756
RÄCKE, SIDA 1600	XB	228	912	NB	294	1176
SKENA HYTTUNDERBYGGNAD	FA	10	2180	XZ	262	57116
SKENA HYTTUNDERBYGGNAD	XZ3	262	57116	XZ	262	57116
SKENA HYTTUNDERBYGGNAD	D	262	57116	XZ	262	57116
SKENA HÖ	XZ2	262	8384	XZ	262	8384
SKENA VÄ	XZ2	262	8384	XZ	262	8384
GUIDE SKENA HÖ	XZ1	262	57116	XZ	262	57116
GUIDE SKENA VÄ	XZ1	262	57116	XZ	262	57116
SKÄRM FRAM VÄ	LF2	167	18370	XB	228	25080
SKÄRM, BAK HÖ	LF2	167	2004	XB	228	2736
SKÄRM, FRAM HÖ	LF2	167	2004	XB	228	2736
SKÄRMBREDDARE HÖGER	LF2	167	5010	XB	228	6840
SKÄRMBREDDARE VÄNSTER	LF2	167	5010	XB	228	6840
YTTERSKÄRM HÖ	LF2	167	17702	XB	228	24168
YTTERSKÄRM VÄ	LF2	167	17702	XB	228	24168
SPEGEL,BACK UTV.	y	262	9956	Y	262	9956
SPÄNNRING	GA	25	3900	GA	25	3900
SÄKERHETSFILTER	y	262	1048	Y	262	1048
TÄCKPLÅT	CA	160	1600	NB	294	2940
VÄXELLÅDA 15.7TE32418-??	X	228	3192	X	228	3192
VÄXELLÅDA EL.VXL.FÖRB.AUT	X	228	7752	X	228	7752
VÄXELLÅDA EL.VÄXLING	X	228	52896	X	228	52896
VÄXELLÅDA EL.VXL.FÖRB.AUT	X	228	52896	X	228	52896
Hyttar	LE	120	93600	LD	294	229320
			6743644			**5280000**

Appendix 16: Results of the Internal Transportation Calculations

Results of the Internal Transportation Calculations			
	Today	**Alternative 1: Frequency**	**Alternative 2: Product Group**
Total meter	6743644	5184882	5280000
Meter reduction		1558762	1463644
Cost in SEK	269746	207395	211200
Saving in SEK		62350	58546
% Saving		23%	22%