Material flow design in a warehouse

The case of S:t Eriks

Beatriz del Río Tomé

MASTER´S THESIS

Packaging Logistics
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Abstract

Tittle

Material flow design in a warehouse – the case of S:t Eriks

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Goal

The main goal of this Master Thesis is the suggestion of a new layout that will help the company to store in a more time efficient way.

Design/Approach

It is going to be presented as a case study, which includes a theoretical framework from warehousing science and a case implementation that is going to be carried out at S:t Eriks warehouse in Staffanstorp.

Value

The solution provided in this thesis will allow managers in S:t Erik Staffanstorp study the strengths and weaknesses of the new layout proposed and implement it in case it is convenient. The report will also include an analysis of their current layout and its strengths and weaknesses found by the author. Besides this thesis will include a theoretical research of the main aspects in warehousing (re)design, that could become useful documentation for future researchers.

Limitations

The scope of this thesis is limited to S:t Eriks Staffanstorp stockyard.

Findings

The proposed evaluation process concluded with providing some suggestions for the stockyard that helps S:t Eriks Staffanstorp to work in a more time efficient way, to achieve a better customer service related to shipping times. The solution is divided into two different ideas: storing according the ABC analysis assigning the areas close to the shipping area the A products, and the second one is focus on the implementation of a pre-order area next to the shipping positions.

Keywords

Warehousing, layout, ABC analysis, dependency, pick, “hot product”, order, order line, article.

Acknowledgements

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Firstly, I want to thank Petteri Suhonen and Mats Nilsson for giving me the opportunity of writing the master thesis at S:t Eriks. I also want to thank Dr. Henrik Pålsson for the support given, the constructive feedback provided and helping me to implement my ideas in a feasible way. In addition, I would like to thank Dr. Ruth Carrasco for helping me in the distance and giving me continuously feedback and guiding me to keep on the right track, in order to reach the objective proposed.

Finally, I would also want to thank my family and friends, who have helped me with their support and faith during these five years, encouraging me and do not letting me give up in the worst moments.

Beatriz del Río Tomé.

Lund, June 2014

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1 Introduction

In this first chapter, the reader will be introduced to the background, company description, problem discussion, purpose and delimitations.

1.1 Background

Warehouse management is one of the oldest activities related to production. But in the last years it has increased in relevance[1], transforming it into a science with mathematical and computer models. Nowadays, it is a key factor for different companies to improve their activities in a more efficient way. Its optimization is both related to customer service and demand variability[2]. All this is possible with the introduction of warehouse management system (WMS) software that assists supervisors in tracking and tracing products all along the storage and distribution process.[3]

This project is going to be focused on S:t Eriks' warehouse, located in Staffanstorp (Skåne, Sweden); which is one of the biggest production plants of the company. Nowadays, this warehouse has to deal with some problems. The most relevant one is the lack of space in their facilities. It is due to the increase of production and the rise of the number of products in their portfolio, they have to offer the new products and the old ones in case a customer needs a spare piece. In their aim to continuous improvement, the company has introduced some changes, taking advantage of the available technology in this area. For instance, the company bought one and a half years ago a new WMS to make easier the put away and picking strategy in the warehouse, that helped them to reduce the shipping times in more than a half. In this spirit, S:t Eriks wants to analyse if there is any opportunity of improvement in their current layout configuration that helps them to store in a more efficient way and also reduce the picking times if it is possible.

Currently their facilities are divided in different sections. Each area stores a different range of products, and this classification is made according to family product (surfaces, walls, cylinders, etc.).

1.2 Company description

S:t Eriks AB is a Swedish company that has been manufacturing floor for private and public settings since the late 1800's. It is a leading supplier in Sweden of its industry, with around 400 employees. S:t Eriks AB manufactures and markets concrete products for land, water, and sewage systems applications. It offers paving stone, roofing, drainage, and water supply systems. The company provides precast concrete products, including pavers/tiles, pipes and manholes, curbstones, retaining walls, tiles, water supply and sewage systems, water and wastewater stations, and other plant products. Its customers include large and small contractors in the construction industry and municipalities, government agencies, and retailers in Sweden, Norway,

[1] Ackerman (1997)
[2] Accorsi, Manzini, & Maranesi (2014)
[3] Management (2014)

and Finland. S:t Eriks AB was formerly known as Nordform AB and changed its name to S:t Eriks AB in April 2009. The company is based in Staffanstorp, Sweden.[4]

The company has 10 production plants and the most important ones are located in Uppsala and Staffanstorp.

1.3 Problem discussion

S:t Eriks' warehouse has limited capacity and it has to store a large number of different articles, some of them are big and difficult to stack, like walls or cylinders. The warehouse capacity is even more problematic when they produce to stock in order to satisfy the demand during the high season. S:t Eriks' high season coincides with the spring and summer term, from April to September, when most of the reforms take place. During this season they are not able to produce at the same rhythm as they ship their products. So the highest inventory stock is in March when they are ready to start this high season. This is a difficult situation to deal with due to the lack of space in the warehouse.

In the high season they have more problems related with the shipping area. They have six loading trucks positions, however it is not enough. This is due to the loading times, that go from 15 minutes to 90 minutes when they have to ship lot of different products; consequently, the waiting period for incoming trucks increases. This problem usually takes place three times a day: early in the morning, at midday and one more in the afternoon.[5] This problem has increased in the last years due to the return of the cylinder production to Staffanstorp and the increase of the number of articles they store. They have to store the new products and keep the old pavements designs in case a customer needs some spare units.

This problem solving will give the needed knowledge to deal with the activities of everyday life in a warehouse. Specially, the difficulties when deciding to redesign a warehouse layout were different trade-offs can arise and influence its operations[6].

According to the literature available on this topic, most of the articles focus their attention on distribution warehouses, whose function is to store products and fulfil external customer orders[7]. There is large number of different products and the number of articles per order line is usually small.

This thesis is going to be developed in a production warehouse, whose aim is to store raw materials and finished products, associated with a manufacturing process. Furthermore, these products may be stored for long periods[8]. Even concepts as Lean manufacturing or Just-In-Time systems are increasing in relevance, production warehouses play an important role[9]. They perform critical functions, particularly in industries with a seasonal demand. The main differences when it comes to

[4] S:t Eriks (2014)
[5] Suhonen (2014)
[6] Wang & Adams (2011)
[7] Rouwenhorst, Reuter, Stockrahm, van Houtum, Mantel, & Zijm (1999)
[8] Rouwenhorst, Reuter, Stockrahm, van Houtum, Mantel, & Zijm (1999)
[9] DHL (2008)

(re)designing a production warehouse compared with a distribution warehouse, is the need of dealing with a highest degree of flexibility, in order to meet the production plan and make to stock (MTS) policies.

Flexibility in warehouses has increased in relevance due to changes in management concepts, the most important of which are an efficient consumer response, just-in-time (JIT) and vendor-managed inventories[10]. The way to accomplish these goals is through a flexible warehouse, and this characteristic should be designed into every function of the warehouse and its degree should be determined according to the warehouse's purpose. Several trade-offs can appear[11], like dedicated assigning policies versus flexibility in the amount of products stored.

1.4 Goal and purpose

This study has a double purpose. Firstly, a theoretical purpose that consists on a review on the state of the art technologies on warehousing science, that includes an analysis on the different activities performed in a warehouse and the current trends on this science. This study will identify the factors that will lead to a warehouse optimization. The second purpose is to implement these acquired knowledge in a real case, at S:t Eriks Staffanstorp, in order to identify potential improvements.

The main goal of this Master Thesis is the suggestion of a new layout that will help the company to store in a more time efficient way. This goal could also affect other activities in the warehouse, like the loading capacity and loading time.

For reaching this goal some research questions are going to be defined. They should be clear, focused, concise, complex and arguable questions around this goal. They should help the writer to focus her research by providing a path through it[12]. The research questions for this thesis are:

- How could products be located in the warehouse in order to minimize picking time?
- How can the number of trucks in the warehouse be reduced?

1.5 Delimitation

The study time is not enough to complete the implementation of the new layout and test its benefits.

Due to the complexity of the data collected and some missing information in the data, some assumptions have been made:

- One order is associated to a single truck.
- Some trucks print the order list the day before, so in these cases the truck stays in the system for more than 24 hours. To avoid this situation the printing date and time has been modified and has been replaced for the average waiting time for that day.

[10] Brockmann & Godin (1997)
[11] Marín & Carrasco-Gallego (2013)
[12] George Mason University (2012)

- Some trucks do not print the dispatch list, so in this case the time assigned is the day's average of the time the drivers take to secure the load and leave the warehouse.
- It is assumed that one order line is one pick due to the difficulty of calculating the number of pallets per order line.

2 Methodological Framework

This chapter will introduce the requirements of a case study, how it should be presented and the steps that should be followed. Then the method used in this thesis is exposed. Finally, a framework for warehouse designing followed to reach the goal of this master thesis is presented.

2.1 Case study methodology

The case study method allows investigators to retain the holistic and meaningful characteristics of real-life events. Cases studies are often used in investigations that refer to one or more cases, which are studied in more detail. Cases studies are developed with the purpose of:

- Formulate hypothesis
- Develop theories
- Exemplify and illustrate

The path should begin with a thorough literature review and the careful positioning of research question and objectives.[13] The data analysis never starts from scratch. A theoretical framework is needed to know where to place the provisional hypothesis of the detected problem solution and to ensure that the problem follows the right track. The theory is also required in study research to contrast a theory or develop a new one.

The procedure of the case study is the same in all different situations. The data obtained should be compared with the theory gathered. The investigation will depend more on the deduction if the available theoretical bases are not enough developed.

When developing a case study the following steps should be followed:[14]

- Determine and define the research questions
- Select the cases and determine data gathering and analysis techniques
- Prepare to collect the data
- Collect data in the field
- Evaluate and analyse the data
- Prepare the report

[13] Yin (2009)
[14] Yin (2009)

2.2 Method used in Thesis

This thesis will identified a more time efficient layout for a production warehouse. This topic was chosen due to the interest of the researcher on the warehousing activity and the different features that can be analysed in this science. Since it is one of the critical steps in a supply chain.

It is presented as a case study, which includes a theoretical framework and a case implementation carried out at S:t Eriks. For that is going to be used the representative or typical case study, were the objective is to capture the circumstances and conditions of an everyday or commonplace situation.[15] This case is considered to be a typical one as this problem can be found in different industries that store big products in their warehouses. The thinking reasoning can be widely implemented, although the final recommendations were built up for this practical case.

This thesis was developed using a deductive method, which works moving from a theory review to a practical problem. It started through some possible improvements observed by managers at S:t Eriks and from these observations the thesis has been developed. Due to the high amount of research and available information in this field, a previous theoretical research was carried out to get the warehouse knowledge needed to go through this problem solving.

Data collection

As this project was built up from different kind of resources, different sorts of data are going to be used. For the theory, secondary data was collected through publications, journals and newspapers. For the practical case primary data was gathered first-hand by the researcher through interviews, available information at the company and observations.

Interviews were performed to three relevant people, two of the warehouse responsible and IT manager. These interviews were semi-standardized, the researcher took a list of questions but they were changed according to the answers, to get more into detail. The duration of the interviews were in average 30 minutes.

Observations were performed with the purpose of understanding the current warehouse layout and the picking process. They were performed in the warehouse all along the spring semester. Firstly, the researcher walked around the stockyard and took notes of the different areas to expand the knowledge beyond the map and observe the different processes in the warehouse. Secondly, a field study was performed to observe how an order is shipped (see chapter 4.1.3.2).

The advantages and drawbacks of these data collection techniques can be found in Appendix A. The reliability of the data obtained through interviews is going to be checked through analysis with the excel files in case there is information for that (i.e. if one person says that the loading time is in average one hour and a half, this information can be checked with the excel files).

[15] Yin (2009)

Data analysis

The data analysis can be divided into two different groups:

- Analyses with the aim of characterize the current warehouse (number of orders, seasonality, etc.)
- Analyses with the purpose of reaching the goal (ABC analysis, dependency analyses and number of trucks in the warehouse).

The analyses were performed in Excel and Matlab, the use of the last one is due to its high processing capacity. It helped the researcher to work with a huge amount of data, designing some programs to reach the purpose of the different analysis.

Validity and Reliability

To create validity and reliability, a literature review was performed in order to acquire the knowledge of the different analysis and the steps that should be followed, as they are widely spread and investigated. Also, the final results where compared with the ones usually obtained from these analyses (i.e. from an ABC analysis is usually expected a 80-20 result, and in this thesis the result obtained is 80-26 what is close to the preferred result).

In order to have a better picture of this thesis method, a five steps research framework was developed (see Table 1). It was also used for the study plan development.

Main phases	Steps
Pre-assessment	Project plan (background, problem discussion, goal and purpose) Methodological framework
Research	Theoretical research Data collection
Analysis	Based on warehouse framework development (see 2.3) ABC Analysis Excel analysis SWOT Analysis
Results and discussion	Data output analysis Discussion related to RQs
Conclusion and future research	Draw the conclusion based both on theory and practice Next steps

Table 1: Research framework

2.3 Proposed framework for warehouse design

Normally, a warehouse design starts with a functional description, and runs through a technical specification, then to equipment selection and determination of a layout.[16]

All these requirements have been divided by Baker & Canessa (2007) into eleven steps, getting more in detail, they give in their article a general framework of steps, with specific tools and techniques that can be used for each step, as can be seen in Table 2.

Step	Tools
1. Define system requirement	Business and supply chain strategy and scenario planning Role checklist
2. Define and obtain data	Checklists and spreadsheet, or database, models are used
3. Analyse data	Database and spreadsheet models are used Activity profiling techniques Planning base, planning horizon and warehouse flow charts
4. Establish unit loads to be used	Analytic and simulation approaches
5. Determine operating procedures and methods	A wide variety of techniques are used. Shipping strategies.
6. Consider possible equipment types and characteristics	Spreadsheet models and decision trees tend to be used Heuristic, analytic and simulation methods. Decision tree.
7. Calculate equipment capacities and quantities	Spreadsheet models, as well as historic performance measures, are used The analytic and simulation methods.
8. Define services and ancillary operations	Checklists are used by some practitioners
9. Prepare possible layouts	CAD software is generally used by practitioners Outline steps and methods A warehouse relationship activity chart
10. Evaluate and assess	Simulation software is useful at this step

[16] Rouwenhorst, Reuter, Stockrahm, van Houtum, Mantel, & Zijm (1999)

	Analytic models are also used by practitioners
11. Identify the preferred design	Quantitative (e.g. financial business case) and qualitative (e.g. SWOT analysis) methods are used

Table 2: Proposed framework, tools and key references [17]

The first step is the system requirement's definition that refers to the overall system within which the warehouse operates, and therefore includes business strategy requirements and relevant constraints.[18] A useful way to present this information is analysing a typical day in the warehouse using a flow diagram, which can represent the activity in terms of flow and inventory quantities. This diagram does not include the warehouse layout but it includes some zoning considerations, in terms of separating the bulk storage and the picking storage[19], one example is shown in Figure 1.

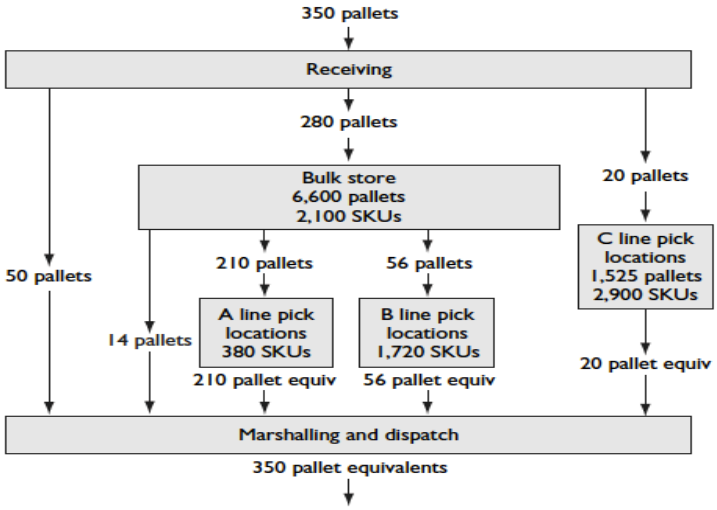

Figure 1: Warehouse flow diagram[20]

Once the strategy aspects and the warehouses needs are known, the next step is the data definition and collection. For that, the expert designer has a prespecified list of data to be collected, to which others may add depending on the project.[21] Rushton et al. (2010) propose a list of typical data required for warehouse design, see Appendix B.

This data should be collected and for that multiple techniques are used, due to the lack of structured information in the companies. These methods include extracting

[17] Baker & Canessa (2007)
[18] Baker & Canessa (2007)
[19] Rushton, Croucher, & Baker (2010)
[20] Rushton, Croucher, & Baker (2010)
[21] Bodner, Govindaraj, Karathur, Zerangue, & McGinnis (2002)

data from computer and paper records, surveying existing operations, projections based on forecasts, interviews with customers, site drawings, information from equipment and information technology suppliers and input from management and staff. Assumptions often have to be made based on informed opinion and experience, and these should be clearly highlighted and agreed upon with the people involved in the project.[22]

To analyse the data, database and spreadsheets models are normally used.[23] The analysis will depend on the project and the main areas in which it is going to be focused on and on the way the information is needed to draw some conclusion about the current situation.

Once the main analysis is done, it is time to make some decisions:

- The unit load to be used. It is not a decision that can be taken only from the warehouse point of view, focusing on the size and storage cost; it should take into account the whole supply chain, specially supplier and customer considerations.[24]
- Determine operating procedures and methods. It includes the decision of how many zones the warehouse should be divided into (e.g. zones for different product groups, temperature regimes, or Pareto classifications). Again, this appears to be left to the experience of the warehouse designer.[25] This section will include all the restrictions that the new layout will include as the activity relationship (i.e. importance of certain functions being located nears other functions) or the product family division.
- Equipment types and characteristics. There is a wide range of equipment available to warehouse designers. Some of them may be well suited to a particular operation and some very badly suited. It is very important to choose the right equipment because changes could be extremely expensive.[26] When making this decision there are some activities that can be carried out:[27]
    - The degree of automation that the warehouse would require. This decision should be made based on factors as the scale of the operation and the flexibility required. Flexibility is one of the drivers in the warehousing design; due to continuously changing customer requirements while parallely demanding low cost and high-rate service in quality and time terms.[28] It may be possible to take the decision of discarding automation in an early stage.
    - Attribute assessment. Some possible equipment could be discarded based on their attributes. It should be selected only the equipment that is suitable for the specific warehouse activities and strategies.

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[22] Rushton, Croucher, & Baker (2010)
[23] Baker & Canessa (2007)
[24] Baker & Canessa (2007)
[25] Baker & Canessa (2007)
[26] Rushton, Croucher, & Baker (2010)
[27] Rushton, Croucher, & Baker (2010)
[28] Marín & Carrasco-Gallego (2013)

    - Decision trees. With the different options that are suitable for the warehouse a decision tree can be developed to help the designer take the decision. After this process only two or three equipment option should be left.
    - Cost comparison. In this stage a cost evaluation of the different solution should be developed.
    - Equipment choice. When the preferred equipment has been chosen for each activity, and overall map should be done with the equipment mix and the flexibility provided.
- Equipment capacities and quantities. This stage includes calculation of the number of equipment required for each activity selected in the previous stage. Another decision to be made is if all the equipment is going to be bought or rented to adapt to the demand.
- Services and ancillary operations need. It could include roads, parking areas, vehicle wash, maintenance facilities, etc. It is commonly used a requirement checklist.

Once the previous decisions have been phased out, a critical part in the design process starts that is the preparation of possible layouts. However, it is important to make differences between the internal and external layout. On one hand, the external layout will show where the warehouse area is going to be located and the relevant roadways and parking areas. One important decision is to determine the traffic around the warehouse area.[29]On the other hand, the internal layout includes the different areas in which it is going to be divided, the dock area location and number of docks needed. This will include the classification between the areas with fewer distances for the greatest flows. The internal layout should meet the following objectives:[30]

- Throughput efficiency
- Building utilization
- Safety
- Environmental aspects

After drawing the possible layouts, they should be validated. This validation should be made according an operational and a technical feasibility point of view, checking that the layouts meets the requirements proposed in the first step of the framework.

Finally, the preferred layout should be chosen. For that, all the possible layouts are going to be put together and different conclusions are going to be drawn, both quantitative (e.g. financial costs) and qualitative (e.g. SWOT analysis). After all this it is possible to choose the design that best meet the company activity and expectative.[31]

[29] Rushton, Croucher, & Baker (2010)
[30] Rushton, Croucher, & Baker (2010)
[31] Baker & Canessa (2007)

3 Frame of reference

This chapter sums up the existing theory that is relevant for this thesis. First the warehousing activity is going to be analysed and the different factors that affect it and should be taken into account when (re)designing it. Secondly, the different analysis models that are going to be implemented will be described.

3.1 Warehousing

3.1.1 Importance of warehouses

Warehouses are as important as ever. New technology combined with consumer demand has driven companies to expand their range of products while at the same time focusing on manufacturing and distribution efficiencies, seeking ways to reduce costs.

Warehouse requires expensive requirements, such as labour, capital and information systems. But this expense is necessary in the supply chain in order to[32]:

- Better match supply with customer demand: A warehouse allows a company to adapt to a quickly change in the demand, not linking it to the supply that takes longer in changing. The most important change in the demand that a warehouse has to deal with is the seasonality.
- To consolidate product, to reduce transportation costs and to provide customer service.

In order to meet the previous requirements the main driver in a warehouse is its flexibility degree. Flexibility means being easily adaptable to changes and customer demand is the most changeable factor in the supply chain. To succeed with the degree of flexibility required is important to include it in every function of the warehouse: receiving, material handling, storage picking and sortation, shipping, labelling and packing, the warehouse management system (WMS) and employees. Not adding flexibility into a warehouse can lead to a lost of competitive edge in the warehouse.[33]

3.1.2 Types of warehouses

It is important to divide into different types of warehouses when studying the different criteria that would affect the re-design, due to the importance of each criterion would vary depending if we are talking about a *distribution warehouse* or a *production warehouse*.[34]

The function of a *distribution warehouse* is to store products and to fulfil external customer orders typically composed of a large number of order lines. These warehouses are often optimized for cost-efficient order picking. The main design

[32] Bartholdi & Hackman (2010)
[33] Brockmann & Godin (1997)
[34] Rouwenhorst, Reuter, Stockrahm, van Houtum, Mantel, & Zijm (1999)

criterion is the *maximum throughput*, to be reached with minimum investment and operational costs.[35]

The function of a *production warehouse* is to store raw materials, work-in-process and finished products, linked to a manufacturing and/or assembly process.[36] These warehouses are created as a result of insufficient coordination between the different steps in the supply chain[37]. Raw materials and finished products may be stored for long periods, this situation increases when the incoming goods of raw materials is much larger than the production rate, or when the production rate exceeds the customer order quantity of finished products. The prominent design criterion for these warehouses is the *storage capacity*. The main design objectives are low investment and operational cost.

3.1.3 Warehouse operations

Each warehouse has its own operations or different steps depending on their industry and product requirements. But there are some basic steps that can be found on the warehousing literature, see Figure 2.

Figure 2: Warehouse operations

Receiving

Receiving may begin with advance notification of the arrival of goods. This allows the warehouse to schedule receipt and unloading to coordinate efficiently with other activities within the warehouse.[38]

In a distribution warehouse, when goods arrive to the warehouse they should be scanned and staged for put away. It is also needed to scan the products to register its arrival so that the ownership is assumed and it is available to fulfil customer demand. Another auxiliary activity that should be done in this step is the inspection, both of quality and quantity.[39]

In a production warehouse, these activities are less important as, when it is produced the ownership of the product is assumed and the warehouse is not responsible of the incoming goods quality.

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[35] Rouwenhorst, Reuter, Stockrahm, van Houtum, Mantel, & Zijm (1999)
[36] Rouwenhorst, Reuter, Stockrahm, van Houtum, Mantel, & Zijm (1999)
[37] DHL (2008)
[38] Bartholdi & Hackman (2010)
[39] Bartholdi & Hackman (2010)

Put away

Products are assigned a location in the warehouse. These locations in the warehouse will determine how quickly and at what cost you later retrieve it for a customer. This activity requires a warehouse location inventory, with the purpose of knowing which locations are available, how large they are and how much weight they can bear.

When the product is put away, the storage location should be scanned to record where the product is placed and to include this information into the picking lists.[40]

Storage

Storage is the main activity in a warehouse. Three major decision drive the storage activity:

- How much inventory should be stored for an SKU.
- The replenishment time for each SKU.
- Where should the SKU be stored in the warehouse.

The two first decisions belong to the inventory control and are not going to be relevant for this thesis. The third decision is led by the storage efficiency and access efficiency, which refers to the resources consumed by put away and order picking activities.[41] The last point refers to slotting process: the activity of organizing how articles are physically positioned within the warehouse for order picking activities[42]. A well-slotted warehouse will outperform one that has limited effort put on this important process. The majority of distribution centres do not dedicate enough resources to manage slotting and nowadays it is one of the greatest sources to improve order picking[43]. The purpose of slotting is to warrantee:

- Products are assigned to the most convenient storage equipment type.
- Products are assigned to storage locations throughout the warehouse to optimize total labour work.
- To ensure good ergonomics for product handling.
- To reduce product losses due to damages associated with a bad position choice.

The first decision in the slotting process is to determine assignment policies. They set the rules used to assign an SKU to a given storage position. Two different policies can be implemented:

- Dedicated assignment policy. In which each storage location is assigned to a product and only for that product. The benefit of this policy is that more popular articles can be located in more convenient locations and the workers can learn the layout, what makes the order-picking more efficient. The drawback of this policy is that space utilization is far away from the optimal point. It problem increases with the lane depth. On average the storage

[40] Bartholdi & Hackman (2010)
[41] Gu, Goetschalckx, & McGinnis (2006)
[42] MWPVL International Inc.
[43] MWPVL International Inc.

location in a warehouse with a dedicated assignment policy is about 50% utilization.[44]

- Random assignment policy. It is frequently used when high space utilization is needed. A product is assigned to more than one storage location. When one storage location becomes empty is available for storing a product, it can be the one that was stored previously or a new one. One disadvantages of this policy is that the warehouse becomes more dependent on a software support, because workers cannot learn where a product is located. Another disadvantage is that if a product is located in different zones within the warehouse the workers would prefer to pick the product from the most convenient location, which could generate an inefficient use of this policy because two storage locations are being used. So that this policy require more strict warehouse processes. On average this policy has a rate of 66% space utilization.[45]

Order-picking

When a customer order is received, a checking process should be performed to verify that the products are available for the customer. Then a picking list guide is produced to help the pickers in their activities. These activities are normally accomplished by a *warehouse management system* (WMS). [46]

There are different classical picking policies that determine how many orders should be grouped to be picked together:[47]

- Strict-order picking. A picker completes a tour through the warehouse in order to retrieve all the SKU for a single order.
- Batch picking. A picker completes several orders at the same time. The goal when applying this policy is to reduce picker's travel time, as it enables the picker to retrieve more products in the same tour.
- Zone picking. This policy consists on dividing the picking area in several zones, each one assigned to a group of pickers. Zone picking also aims to reduce picker's travel time, as it limits the number of picking addresses that a picker should visit.
- Wave picking. This policy is used when a shipping schedule exists. All the orders included in the same shipment will be prepared together. Picking orders are released simultaneously in several zones of the warehouse, taking into consideration that batch size should be adapted to the available picking time. The following wave is not launched until the current wave has been completed.

It should be remarked that these policies are the classical ones or theoretical. In the practice a combination of some policies is possible. And it should be chosen

[44] Bartholdi & Hackman (2010)
[45] Bartholdi & Hackman (2010)
[46] Bartholdi & Hackman (2010)
[47] Bartholdi & Hackman (2010)

according to the company shipping strategy, the product characteristics (size, weight, high…), the warehouse layout, etc.

Bartholdi & Hackman (2010) recommend the use of these policies according to the activity volume and the truck capacity:

- If the total work to pick and load a truck is small, a strict- order picking strategy is more suitable.
- If the orders are large or span several regions of the warehouse, the work should be shared between several pickers. For this case the most suitable picking policies are wave picking or batch picking, if the products are small and several orders can be filled at the same time.
- If the warehouse moves a lot of small products the best strategy is the zone picking.

Checking, packing and shipping

Packing is a labor-intensive activity because each article should be handled, but there is not traveling time needed. As all the articles should be handled it is the perfect moment to check that the customer order is completed. This activity is needed in order to improve the customer service.

Packaged products are ready to be shipped into fewer containers (cases, pallets). After that the trailers are filled. This activity should not include high travel distance as packing should be done near the shipping docks. Before a trailer leaves the warehouse it should be scanned to register its departure and an updated order customer should be send to the customer.[48]

3.1.4 Warehouse design

When it comes to warehousing design a wide range of issues and decisions should be considered. These decisions are not only critical for a wide range of customer service activities, there are also important from a cost perspective.[49] This chapter contains the strategic issues affecting warehousing and the major decisions that should be taken.

3.1.4.1 Strategic issues affecting warehousing

There is a wide range of factors that should be considered prior to the detailed design of the warehouse:[50]

- Market/industry trends. Almost all industries have seen dramatic changes in their marketplaces, as well as in the technology available to them.
- Corporate objectives. The warehouse needs to fit with the particular objectives of the company.
- Business plan. It should include new markets and sales projections. This feature is important in order to incorporate the flexibility required.

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[48] Bartholdi & Hackman (2010)
[49] Baker & Canessa (2007)
[50] Rushton, Croucher, & Baker (2010)

- Supply chain strategy. This strategy will determine factors such as role, location and size of the warehouse.
- Other related strategies. These strategies will include factors like incoming batch sizes from production or suppliers, customer order characteristics, available information technology, and financial restrictions.
- Customer service levels. The previous strategies will define the service level and it is the key for a warehouse design.
- External factors. These factors are regulations, in different areas like construction, health and safety, equipment, manual handling, working hours, etc.

3.1.4.2 Warehouse design problems

The design of a warehouse concerns a large number of interrelated decisions. These decisions are done at a strategic, tactical or operational level. At each level, multiple decisions are interrelated and therefore it is necessary to cluster relevant problems that are to be solved simultaneously.[51]

Each individual decision on the highest level introduces a constraint and additional requirements at decisions on lower levels. However a higher-level decision must be revised if it is infeasible for a lower-lever decision.[52]

Strategic level

At the strategic level, high investment and long term impact decisions are found. These decisions are made for at least a five year time horizon, in order to be able to amortize the huge investment. Two big categories of decisions are identified:[53]

- Decisions concerning the design of the product flow.
- Decisions concerning the selection of the types of warehousing systems.

The design of the product flow defines the required processes in the warehouse. The typical flow includes the stages of receiving, storage, order-picking and shipment. Additional processes can be included which have an impact on the warehouse design. For example, using a zone or a wave picking a packing zone is needed, or the introduction of a forward picking area requires having bulk storage and picking area.

The selection of the warehouse system types includes the choice of an IT system that could handle the storage and sorting system.

These two relevant decisions should be decomposed on two decision problems, based on the technical capabilities and based on economic requirements, due to the huge investment that these decisions will require.[54]

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[51] Rouwenhorst, Reuter, Stockrahm, van Houtum, Mantel, & Zijm (1999)
[52] Rouwenhorst, Reuter, Stockrahm, van Houtum, Mantel, & Zijm (1999)
[53] Rouwenhorst, Reuter, Stockrahm, van Houtum, Mantel, & Zijm (1999)
[54] Rouwenhorst, Reuter, Stockrahm, van Houtum, Mantel, & Zijm (1999)

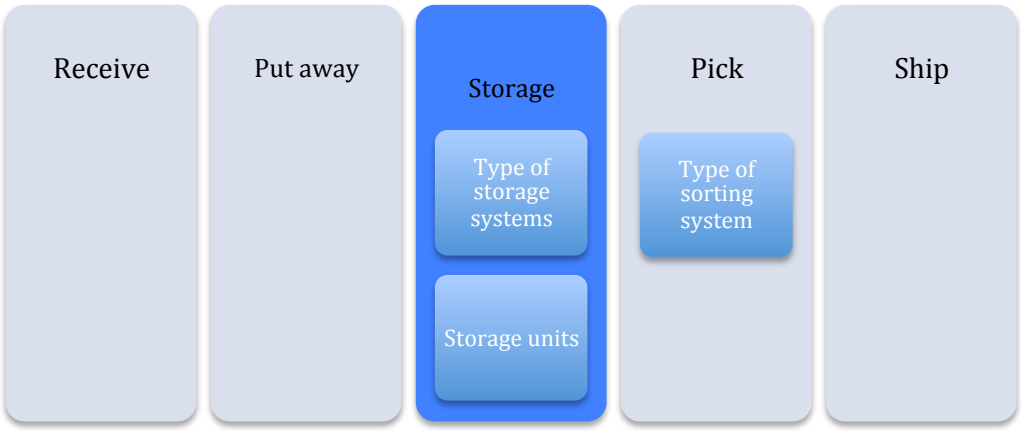


Figure 3: Decisions at the strategic level

Tactical level

At the tactical level, medium term decisions are made, based on the strategic decisions outcomes. Tactical decisions have a lower impact than the strategic ones, however they require some investments and should not be considered too often.[55]

Tactical decisions usually concern the dimension of resources (storage sizes and number of employees), the determination of a layout and a number of organizational issues, see Figure 4.

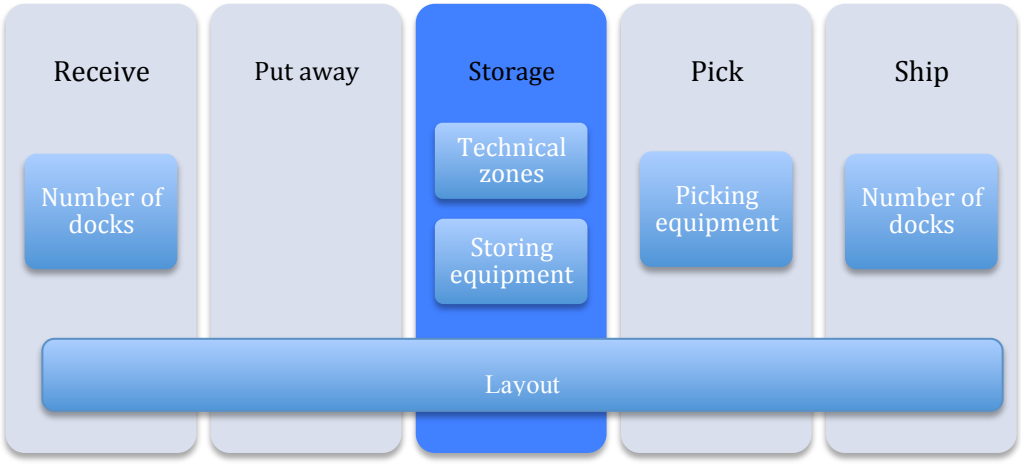


Figure 4: Decisions at the tactical level

The problems that could arise at this level are:[56]

- Organizational problems including the size of the picking zones and the ABC zones, the choice of replenishment policies, batch sizes and a selection of a storage concept (random, dedicated).

[55] Rouwenhorst, Reuter, Stockrahm, van Houtum, Mantel, & Zijm (1999)
[56] Rouwenhorst, Reuter, Stockrahm, van Houtum, Mantel, & Zijm (1999)

- Determining the dimensions of the storage system.
- Dimensions of the dock areas.
- Determining the number of material handling equipment.
- Establishing a layout of the overall system.
- Determining the number of personnel.

All these problems aim at optimizing performance criteria; like throughput, response times and storage capacities.

Operational level

At the operational level, decisions have to be taken within the constraints set by the strategic and tactical decisions. These decisions are made continuously; the period time is one day or maybe hours.

The decisions at this level are related to assignment and control problems, both people and equipment. At this level processes have less interaction and can be analysed independently.[57] The main activities at this level are visualized in Figure 5.

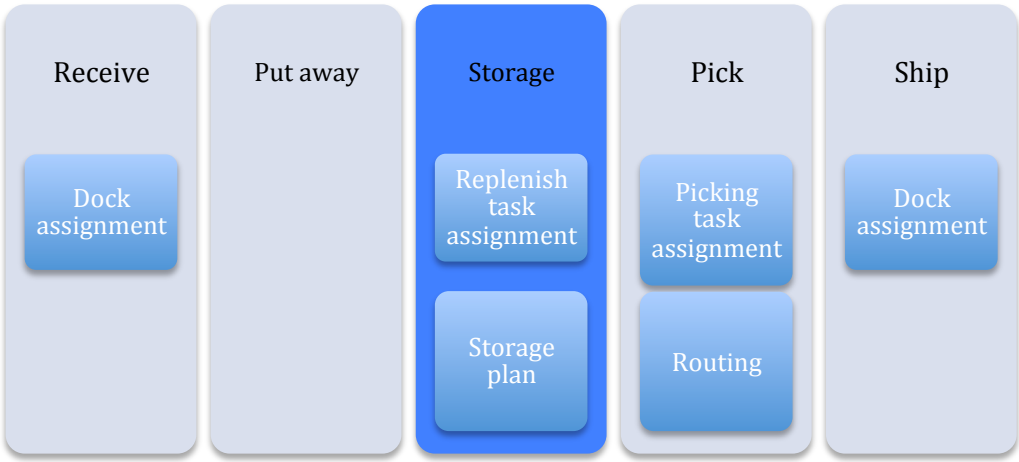


Figure 5: Decisions at the operational level

When trying to model or analyse issues in different decision levels, it could be found that the most existing quantitative analysis addresses tactical and operational decisions. For strategic level decisions is hard to formally model or analyse the issues due to three factors: underlying problem complexity, intangible nature of the criteria (e.g. flexibility) and the trade-off between minimizing cost and meeting technical and performance constraints.[58]

[57] Rouwenhorst, Reuter, Stockrahm, van Houtum, Mantel, & Zijm (1999)
[58] MHI (2005)

3.2 ABC Analysis

One of the first things to know about a warehouse is what SKUs are relevant.[59] The ABC analysis of inventory states that inventories have not an equal value to a firm.[60] Consequently, all the inventories should not be managed in the same way. The ABC classification allows organizations to separate inventory items into three classes:

- A – products with the highest criticality
- B – products with moderate criticality
- C – product with low critically

It is remarkable that most of the labour in a warehouse operation is due to order picking and so it is useful to rank SKUs by the number of pickings during some recent period time.[61] However there are other criteria that represent important considerations for management; lead time, consumption rate, demand and critically of items are the considerations that may need management's utmost attention.[62]

In order to perform an ABC classification on one parameter the following steps should be taken:

1. Sort the articles from largest to smallest of the interesting parameter. E.g. volume, frequency or profit.
2. Calculate each article percentage of the total volume for the interesting parameter.
3. Calculate each article accumulated parameter starting with the articles with the highest value.
4. Classify articles into classes based on the Paretos principle.
5. Draw a chart to help visualize the group of articles.

3.3 Warehouse Optimization

"The optimal operation of a warehouse is achieved when each customer is satisfied completely according to his order, in due time and when all warehouse and logistic processes are done in the shortest possible time, with minimal cost and optimal utilization of resources under dynamically changing conditions"[63].

Warehouse effectiveness is key to the success of any company that stores products and ships orders[64]. However there are a lot of paths that lead to the final purpose, which is customer service. This is why optimization has become more and more important in the last years. Optimization is about reaching the final objective with the most efficient solution possible. When it comes to warehousing the main reasons to optimize are to increase the company's performance regarding the demand-driven production, minimize the stock along the supply chain, reduce transportation cost and

[59] Bartholdi & Hackman (2010)
[60] Lun, Lai, & Cheng (2010)
[61] Bartholdi & Hackman (2010)
[62] Bhattacharya, Sarkar, & Mukherjee (2006)
[63] Karásek (2013)
[64] Ruriani (2013)

ensure production[65]. Given that warehouses are affected by several different activities and decisions, it is hard trying to optimize a warehouse at once. Consequently, the warehouse optimization task can be divided into three different activity groups[66]:

- The basic technical structure of warehouse.
- The operational and organizational framework.
- The coordinating and controlling systems for warehouse operations.

Optimization of technical structure

The technical structure involves *layout design* and *warehouse equipment*, this includes both the choice and dimensioning of the storage equipment and the technology needed, as conveyors, carrousels or scanning technology[67].

The layout design of a warehouse is a key aspect of others optimization aspects, due to its impact on order-picking and traveling distances. The total travel distance is affected in more than a 60% by the layout design[68]. The warehouse equipment is designed in order to reduce labour cost and increase its utilization[69].

Optimization of operational structure

The operational framework combines several areas related with the organization, such as business, inventory, organization and transportation management.

The optimization of this operational structure is based on different strategies regarding different activities in the warehouse:

- *Slotting strategy*: random or dedicated policies (see Page 14).
- *Rotting policies*. This policies should ensure an optimal travel path around the warehouse for order-picking: S-shape, Return policy, Mid-point strategy, Largest gap strategy, Composite heuristic, Optimal routing[70]; see Figure 6.
- *Picking policies*: Strict-order picking, Batch picking, Zone picking and Wave picking (see Page 15).

[65] Karásek (2013)
[66] Hompel & Schmidt (2007)
[67] Karásek (2013)
[68] Caron, Marchet, & Perego (2010)
[69] Karásek (2013)
[70] Roodbergen & De Koster (2001)

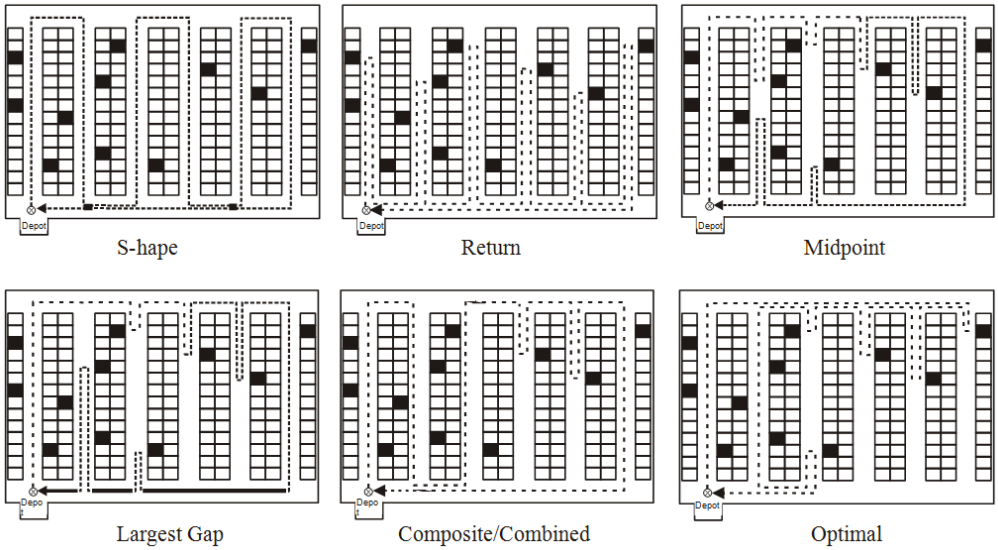


Figure 6: Rotting policies[71]

Optimization of warehouse management

Warehouse Management Systems (WMS) are used to optimize and control all warehouse operations[72]. Its objective is to provide a set of computerized processes for management of warehouse inventory with the goal of minimizing cost and fulfilment times[73].

At least, a Warehouse Management System (WMS) database is composed by the skus and their storage locations, to manage the inventory of skus and storage locations. However there are significant opportunities to save labour costs when the system is extended to different activities in the warehouse; receiving, put away, or order-picking.[74] For these reasons, implementing it on these activities would allow managers to control the flow of goods, people and machines in the warehouse.[75] Nevertheless, not everything is advantages, the initial investment and training costs are the main drawbacks. Following is a summary of the main benefits and drawbacks of implementing a Warehouse Management System (WMS)[76].

Benefits of a Warehouse Management System (WMS)

- High return on investment:
  - Reduce labour costs by 20-30%
  - Reduce or eliminate costs due to errors
  - Reduce operating expenses

[71] Iggniting Worls Markets for Growing Businesses (2013)
[72] Karásek (2013)
[73] Iggniting World Markets for Growing Businesses (2013)
[74] Bartholdi & Hackman (2010)
[75] Karásek (2013)
[76] Friedman (2006)

    - Reduce forklift travel time
    - Reduce inventory costs due to inaccuracy
    - Reduce overall inventory requirements
    - Increase space utilization
    - Re-deployment of excess resources
    - Usually complete payback within a year from implementation
- Improved customer service levels:
    - A WMS enhances the overall warehouse operation.
    - Data accuracy and inventory accuracy both improve and mistakes are pushed to an absolute minimum.
    - Deliveries are timely, shipments are accurate and customers stay satisfied.

Drawbacks of a Warehouse Management System (WMS)

- High implementation costs
- Time-intensive
    - Implementation of new system takes several months
    - Lost of testing and man-power training needed
    - Continuous evaluation needed
- Increased master data maintenance
- Additional processes step for receipt and picking
- Requires expert knowledge to configure for maximum benefit
- More complex to resolve problems caused by incorrect processing
- More maintenance and process discipline required

It is important to review the benefits and drawbacks that implementing a Warehouse Management System (WMS) has. On one hand, it allows managers to check the inventory and could reduce labour cost managing personal in a most efficient way, as the main benefits. On the other hand, the huge investment that it requires and organizational problems, like the difficulty of adapting to changes or problems with the information gathered, could not be justified with the benefits found with the implementation.

3.4 SWOT analysis

The SWOT analysis is a business tool used for understanding and decision-making different situations in a company. The SWOT analysis provides a framework to review a company or business proposition.[77]

This method approach was developed in the 1960's by Albert Humphrey. The SWOT analysis came from a research funded by the Fortune 500 companies to investigate the problems with corporate planning, as a result the SWOT analysis emerged as a new system for managing changes in the companies.[78]

[77] Chapman (2007)
[78] Humphrey (2005)

The SWOT analysis is usually represented as a 2x2 matrix, which each quadrant represent the Strengths, Weaknesses, Opportunities and Threats. Strengths and Weaknesses are internal factors; whereas Opportunities and Threats are external factors, related to the market, industry or country where the company is placed. This format helps presenting the analysis in a way that will make easy the discussion and decision-making of a proposition or an idea.[79]

Table 3 shows a list of issues and questions that can be addressed in a SWOT analysis.

Strengths *Internal attributes that are helpful to the organization to achieve its objective.* Advantages of proposition? Capabilities? Competitive advantages? Resources, Assets, People? Experience, knowledge, data? Innovative aspects? Location and geographical? Price, value, quality? Accreditations, qualifications, certifications?	**Weaknesses** *Internal attributes that are harmful to the organization to achieve its objective.* Disadvantages of proposition? Gaps in capabilities? Lack of competitive strength? Reputation, presence and reach? Own known vulnerabilities? Timescales, deadlines and pressures? Cash flow, start-up cash-drain? Continuity, supply chain robustness? Effects on core activities, distraction? Reliability of data, plan predictability? Morale, commitment, leadership?
Opportunities *External factors that help the organization to achieve its objective.* Market developments? Competitors' vulnerabilities? Industry or lifestyle trends? Technology development and innovation? Global influences? New markets, vertical, horizontal? Geographical, export, import? Market need for new USP's? Market response to tactics, e.g., surprise? Business and product development? Information and research? Market volume demand trends?	**Threats** *External factors that are harmful to the organisation to achieve its objective.* Political effects? Legislative effects? Environmental effects? IT developments? Competitor intentions - various? Market demand? New technologies, services, ideas?

Table 3: Issues and questions that can be addressed in a SWOT analysis.[80]

[79] Chapman (2007)
[80] Chapman (2007)

4 Warehouse characterization

This chapter present the information gathered at the company and the analysis performed in order to re-design the warehouse. Firstly, a qualitative warehouse characterization, that includes a mapping of the warehouse, processes, products and equipment can be found. Followed by a quantitative characterization, based on the number of orders and seasonality.

4.1 Qualitative warehouse characterization

4.1.1 Mapping of the warehouse

In this section, the different areas in the warehouse will be explained. The stockyard is divided into three different zones: the production centre, the warehouse and the facility offices. It has a radial configuration around the production centre that is located in the middle of the plot.

The current warehouse layout was designed years ago with the perspective and requirements that they had in those days. But those requirements are not the same as the ones today, due to changes in production level, number of orders and number of products stored in the warehouse. The warehouse layout was designed to take the most from the available space and with the production facility restrictions. It is divided into different areas, adapting each area and size to the production centre facilities, as there must be an aisle that communicates each production door with the road around the warehouse. The road around the warehouse is designed drawing the shell of the production centre; which minimizes the road's dimension.

The storage area is divided into different zones, designed with different letters and grouped according to the different products that are supposed to be stored in these areas. However due to the lack of space, the products end up where there is free space for them.

There are also three areas in the warehouse: Förplock fram, förplock framsidan and förplock gavel (see Figure 8), where they store next morning orders, in order to ship trucks faster in the first hours of activity in the warehouse.

Trucks are shipped in two different areas, at the top the layout, which is only used in the high season, and the other one is located on the left side (but they have moved it to the long road that is between areas F and H). These areas are also used to unload trucks that come from other production centres.

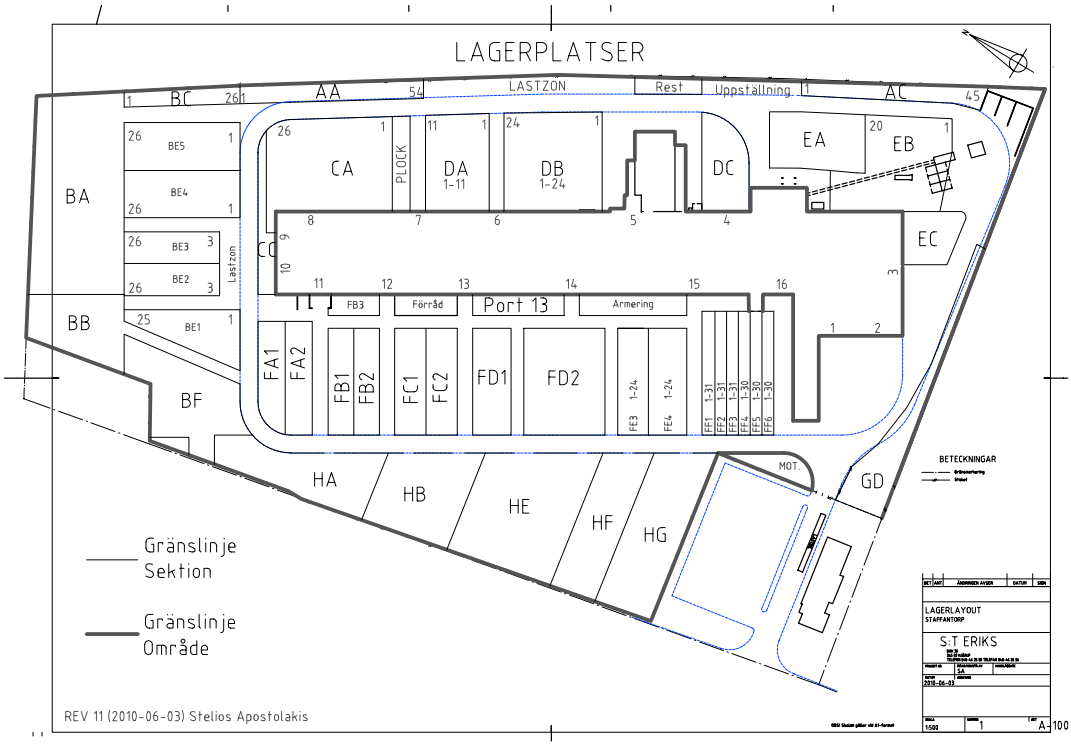


Figure 7: S:t Eriks Staffanstorp map

4.1.2 Mapping of Products

S:t Eriks' warehouse is storing approximately 1350 different products. These products are divided into four main categories (see Figure 8):

- Pavements
- Retaining walls
- Water supply systems: cylinders, sewerage systems
- Stones bags

Figure 8: Product stored in the warehouse; top left pavements, top right cylinders, bottom left retaining walls and bottom right stone bags. (S:t Eriks Staffanstorp)

Pavements have a big variety of models, sizes and colours; it is the same for the stones. Regarding retaining walls, there are different sizes, shapes (T-walls and L-walls) and there are also special walls that are made to order. For the cylinders there are different size and shapes (cylindrical, conical, etc.).

Most products are made in Staffanstorp production centre, although there are some products that come from other factories in order to fulfil customer orders.

4.1.3 Mapping of warehouse processes

The following sections will describe the warehouse processes in S:t Eriks Staffanstorp, with the aim of discussing different methods used in the different processes. At the end a field study can be found in order to allow the researcher to have a real experience of how the company works in the warehouse.

4.1.3.1 Processes description

Receiving processes

As said in the theoretical framework receiving process should begin with goods advance notification. In S:t Eriks this notification is one week before, when the production manager decides what and how much is going to be produced the next week. Thus the warehouse manager will decide which storage locations to book for next week production. Sometimes a redistribution of products stored is needed to free up more space. The assignment activity is done manually every week.

Put away processes

Put away is the process of moving the goods from the production centre to the warehouse. This activity is done with the two forklifts the company owns for this activity, which have a capacity of two pallets. The drivers have a list to know where products should be stored. This is a routine activity as there are only produced approximately 20 different products per week, in the three different machines the company owns.

Storing processes

The stockyard is divided into different areas and there is a family grouped locating system. There are different areas for retaining walls, cylinders, pavements and bags; being bigger the space booked for pavements. But sometimes there is not sufficient space for the new production articles and they have to mix products from different families into the same area. Inside each family group there is a random assignment policy, because the amount of products stored is not the same all the weeks. Besides, there is not enough space to leave pallets location empty until the article is produced. The time products are stored in the warehouse should not exceed six months due to humidity that affects the plastic protection of the products. If the storage time exceeds the six months they should change the plastic film because mould will grow on it. Normally, the time products stay in the warehouse is in average four months.

Nowadays, products are not stored with the purpose of warranting the most optimal location to reduce labour work, as it is recommended in the frame of reference. The products are stored in free pallets positions due to the undercapacity of the warehouse.

Order picking and shipping processes

Once a truck arrives at S:t Eriks warehouse the driver prints out a list at the office that contains the products that are going to be shipped, the amount and where the products are located (see Appendix D to see how a order list looks like). Where products are going to be picked from is decided by the IT manager that approximately each hour reviews the pallet storage location to verify that the same product is not going to be picked from two different lines. Then he assigns a preferred location to pick a product, in order to free up pallet lines faster.[81]

When an order list is processed it includes the article number, the quantity and where the product is located. The order list can contain products from one of the warehouses or both of them. If it only contains products from the main warehouse one forklift, or maybe two, is assigned to that order. If it only contains products from VA1 and MAX the truck goes directly to that warehouse and one forklift has to go from the main warehouse to VA or MAX and fulfil the order. If the order contains products from both warehouses the truck goes first to the main warehouse and when all products from the main warehouse are shipped, the truck and one forklift go to the other warehouse to complete the order.

Normally one picker is assigned to one order,[82] however in the data it can be found that more than one picker is assigned to one order. So it is a strict-order picking, a picker fulfils a whole order. The tablet that they have in the truck guides them to pick the products and the amount he has to pick. Normally the amount requested are pallets, but if the SKU is pieces of pavement, if the order contains less than a pallet he

[81] Wasseng (2014)

[82] Wasseng (2014)

has to get out of the forklift and pick the number of units requested. When he picks the products he goes directly to the truck and load the products for shipment.

When the order is completed the driver checks with his list that all the products are shipped, he secures the load and goes to the office where he prints the dispatch list for the customer, see Figure 9.

Figure 9: Stamps registered in the warehouse

This process is the most labour consuming in all warehouses, but is even more in this case because of the dimensions of the warehouse.

It is also remarkable that the order picking and shipping processes are done together. This is not common in warehouses were they do not have enough dock or an area for the trucks to wait such a long time, it is also one of the problems in S:t Eriks warehouse that there are peaks when they have more than 15 trucks in the warehouse.

In Figure 10 the logistic processes flow is represented to have a better picture.

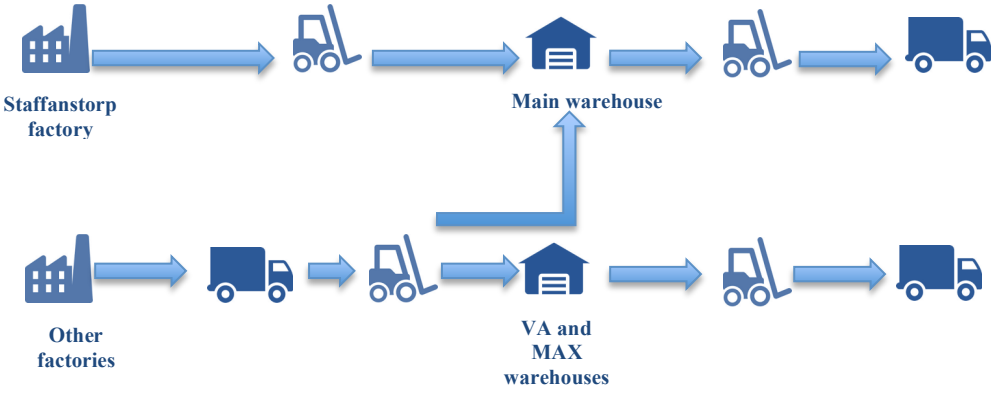


Figure 10: The logistic process flow in S:t Eriks warehouse

4.1.3.2 Field study of one order

This field study was carried out on the 5th of May of 2014 at 14:00, with the purpose of allowing the researcher to have a real experience of how the company works in the warehouse, and check some information about how they ship the products.

The shipment selected contained three orders in the same truck, these orders are 846071,845915 and 845499 as can be seen in Appendix D. The truck was located in *Lastzon* 2 (shipping area).

First order, 846071, contained 10 pallets from the same product stored in FE4 that was stored near the shipping area. It was divided in five picks with 2 pallets per pick, it took the picker 8 minutes.

The next order was 845915 that contained 10 pallets of the same article that was stored in *Upp*, which is in the other side of the warehouse. The picker took all the pallets in groups of two and left them near the truck and afterwards the ten pallets were placed in the truck. For the whole order he took 9 minutes.

Finally, the picker started with order number 845499 it was composed by two different products, 4,25 pallets of *Munksten* stored in CA and 8 pallets of *Windsor* stored in DB. Firstly he picked 4 pallets of Munksten and after that he picked one pallet of Munksten, got down from the forklift and started filling the others pallets to complete the 0,25 pallet (see Figure 11) and when he finished he put away the rest of the pallet in its original place. He then continued with the 8 pallets stored in DB. This order took 18 minutes in being fulfilled. In this order is relevant that in completing the 0,25 of a pallet it took one and a half minute.

Figure 11: The picker and the truck driver completing the 0,25 pallet (S:t Eriks Staffanstorp)

This field study has been useful since it gave the researcher a real vision of how they ship products. And get some valuable insights, like they use four pallets capacity forklifts but they pick two pallets each trip or how they pick products when less than one pallet is requested. Unfortunately, the analysis was carried out from the shipping area due to security measures in the warehouse, it did not allow getting best time measures and the time a picker spends traveling and the one spend loading the forklift.

4.1.4 Description of equipment used

In a warehouse, products are received, put away, stored and picked up. But in between these processes there are other activities, like handling these products and the information flow. For this case is important to study the equipment and personnel used for handling products.

S:t Eriks fleet of forklifts is listened below (see Appendix D)

- Six forklifts with four pallets capacity, used to ship the products (model Dantruck 7009).
- One forklift is used as reserve (model Dantruck 6009), with four pallets capacity.
- Two forklifts with two pallets capacity are used to put away products from the production centre to the warehouse (model Toyota 7FDA50).
- One forklift with four pallets capacity is both used for shipping and put away.
- One of the forklifts is used to carry the big walls and has one wall capacity (model Dantruck 9680).
- In the high season they rent four more forklifts with four pallets capacity.

It is worth mentioning that in the low season they pick the products with six forklifts. In the high season they use these six forklifts, plus four more rented ones and if it is necessary they use the shared one, so a total of 11 forklifts are used for shipment.

4.2 Quantitative warehouse characterization

This section will include some analysis related to the total number of orders and seasonality. They are done to have a better knowledge of the daily activity in the warehouse.

In Table 4 there are some of the most important figures. The total amount of orders shipped in 2013 is 9558, with an average of 38 orders per day. But this figure is not representative due to the warehouse seasonality, as can be seen in Figure 12, that represent the total number of order lines per month. As stated before, the high season goes from April to September. In this period they ship daily two or even three times more products than in the low season, see Table 4. This forces the warehouse to have a high flexibility degree to adapt to market demand.

Number of orders in 2013	**9558**
Number of order lines	29623
Average number of order lines per order	3,10
Average number of orders per day	38
Average number of orders per day between January and march	14
Average number of orders per day between April and September	50
Average number of orders per day between October and December	38

Table 4: Some important figures of the activity in 2013

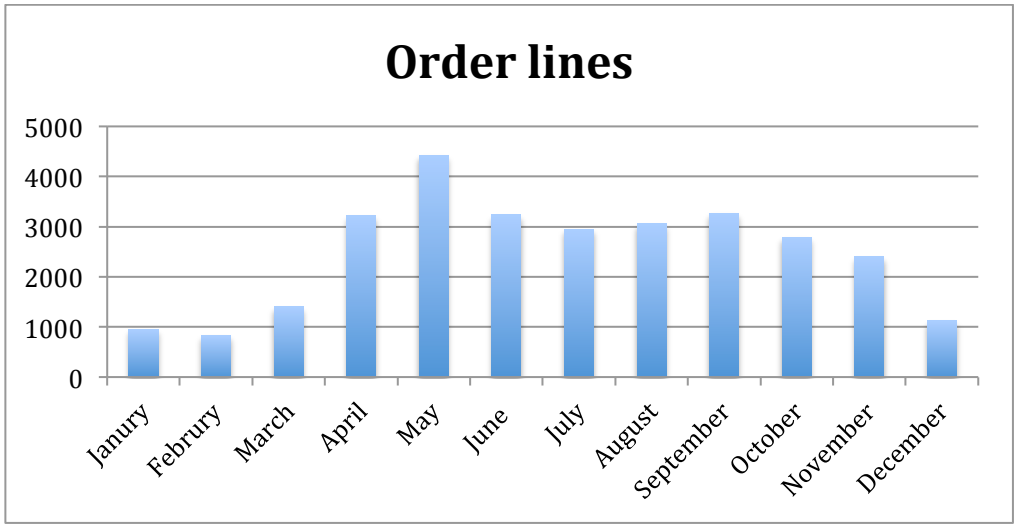


Figure 12: Number of order lines per month

Going into detail, the average number of order lines per order is 3,10. However this number is not representative because there are a couple of orders with more than 100 order lines that increase the average. It is easy to analyse the average of different products asked in one order in Figure 13, where it can be observed that almost the 45% of the orders contain one article. The 75% of the order lines contain no more than three different products, see Appendix F, which explains once more that the average number of order lines per order should be between one and two.

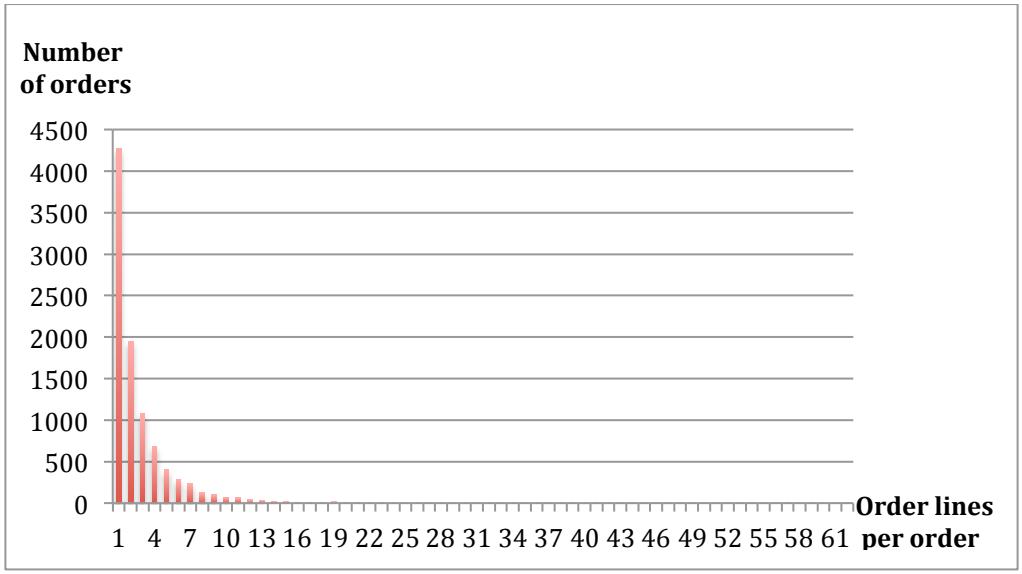


Figure 13: Number of order lines per order

5 Analysis

This section includes the analysis performed in order to reach the goal. Firstly, an ABC analysis is done to categorize products. With the ranking obtained, a dependency analysis between the ten most requested products ("hot products") and the ones they are asked with is performed. A second dependency analysis is done between the secondary warehouse the company owns and the main one. Finally, a four random days analysis is performed in order to analyse the number of trucks in the warehouse.

5.1 ABC analysis

As said in chapter 3.2, most of labour in a warehouse is due to order picking. This analysis will categorize product in terms of frequency, choosing as interesting parameter the number of order lines in 2013. Products are divided into three different groups: A articles that represent the 80% of the pickings; B articles that represent a 10% of the pickings; and C articles that represent the remaining 10% of pickings.

It can be observed in Table 5 that 80% of the picks affect only a 26% of the different products shipped in 2013. That means that the warehouse has a list of most demanded products that should be taken into account when storing products and store them in a more convenient place, close to the shipping area. Getting deeper into the analysis, as can be seen in Appendix G, there are 53 products with more than one hundred picks per year, meaning 3,7% of the articles a 32,5% of the picks. Showing that this analysis is useful when deciding where to store products.

% order lines	Article type	Number of articles	% articles	Number of order lines
80%	A	373	26%	23698
90%	B	218	15%	2953
100%	C	849	59%	2972
		1440	**100%**	**29623**

Table 5: ABC analysis

With this information a zone analysis is done, to have a better picture of where are the A products stored. It refers to the warehouse areas in which it is divided (see Figure 8). This analysis is represented in Figure 14 and the most remarkable information is that products type A are picked from three main areas: Förplock framsidan, MAX1 and VA1. Förplock framsidan is the pre-order area where they prepare next day orders, and MAX1 and VA1 are the two areas in the other warehouse. Analysing the storage areas in the main warehouse the most visited ones are CA, DB, FB2, FD2 and FE4. These areas are close to the two shipping areas. But grouping the areas for a more general analysis, it can be seen in Figure 15 that the area near the bottom

shipping zone has more activity that the one at the top. This figure is only analysing the storage areas (excluding the förplocks). The areas near the bottom shipping, store the 40% of the A products, four times more than the area next to the top shipping area.

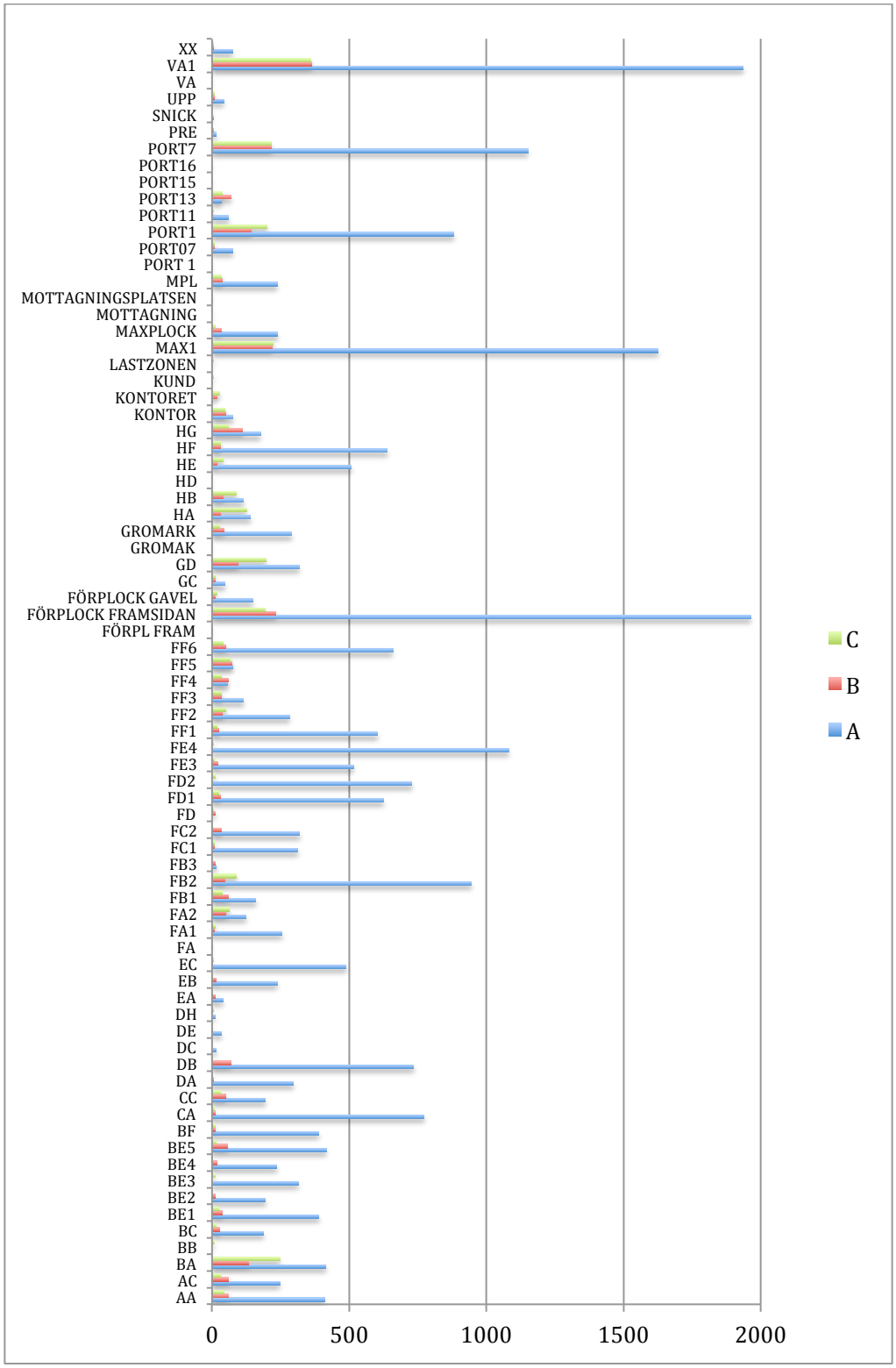


Figure 14: Number of order lines picked from each area divided in ABC products

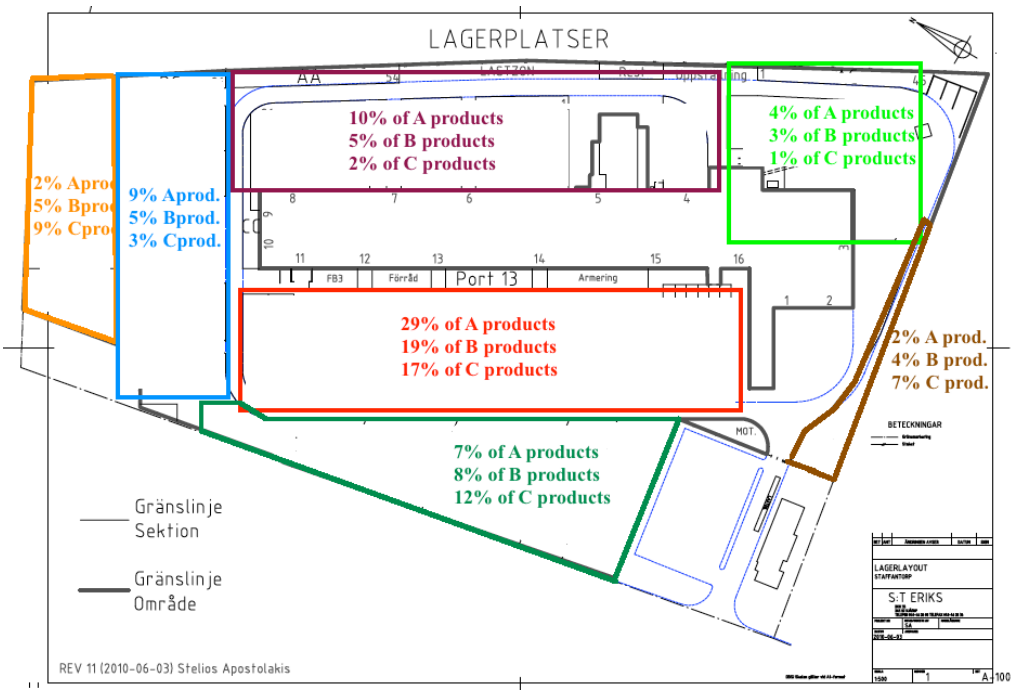


Figure 15: S:t Eriks Staffanstorp map with the percentage of order lines per area

The ABC analysis classified the products into three different categories, being remarkable that the 26% of the articles account for 80% of the order lines, which must be taken into account when addressing the new distribution of products around the warehouse. This analysis also highlighted that areas close to the bottom shipping zone store the 40% of A articles, a number four times bigger than the A products stored close to the top shipping area; that can be due to the priority usage of the bottom shipping area. But, in order to get a more efficient warehouse utilization and avoid bottlenecks the proportion of A articles should be divided between both areas.

5.2 Dependency analysis of 10 most shipped products

The ABC analysis ranked the product according to the number of times that a product was asked in 2013. However, there are 373 A articles which is a large number to work with. This analysis will be focused on the most requested products, those with a frequency higher than one order per day. In this classification ten products can be found (see Table 6), “hot products”, and are going to be analysed according to four different criteria:

- Quantity requested and number of times per day, the number of pallets shipped per day and the number of order lines that are requested per day, see Table 6.
- Number of times that it is requested as a single product in an order.
- If it is asked together with other products, which ones are asked with it more than the 20% of the times.

- Once the dependent products are identified, the locations of the products are going to be analysed to know if there is possibility for improvement storing the products in closest areas.

This analysis is done with the aim of distributing "hot products" in the warehouse in a more time efficient way, together with the products they are usually asked.

Product	Demand (pallets/day)	Frequency (orders/day)
9610-05060027	176,81	2,83
9531-05050027	10,91	2,10
9730-39000027	8,11	2,05
9610-06060027	15,83	2,05
9712-70000027	45,20	1,69
9531-05050727	3,14	0,85
9611-04060027	3,16	1,07
9610-04060027	4,78	1,07
9910-10000139	0,89	1,01
9510-07060027	7,56	1

Table 6: Demand and frequency of the 10 most shipped products

Three different graphs are given for each product, an example can be seen in figures 15, 16 and 17 for product 9531-05050027, the rest of the graphs are in Appendix I. The first one shows the percentage of times it is asked alone and with other products; the second one portrays the articles that are demanded more than 20% of the times together with the product under study and the third one represent where the products are stored in the warehouse, to analyse if there is room for improvement allocating products in closer areas.

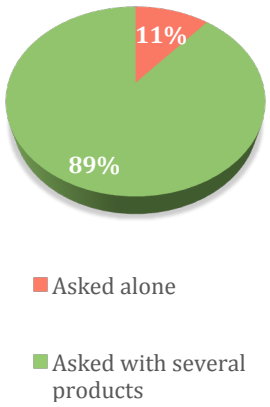


Figure 16: Percentage of times product 9531-05050027 is asked alone and with other products

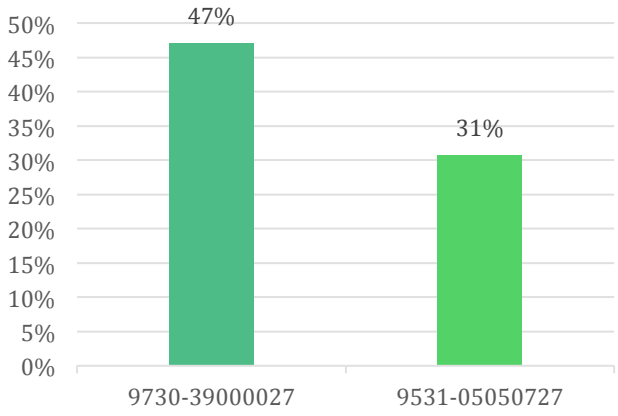


Figure 17: Product 9531-05050027 dependent products

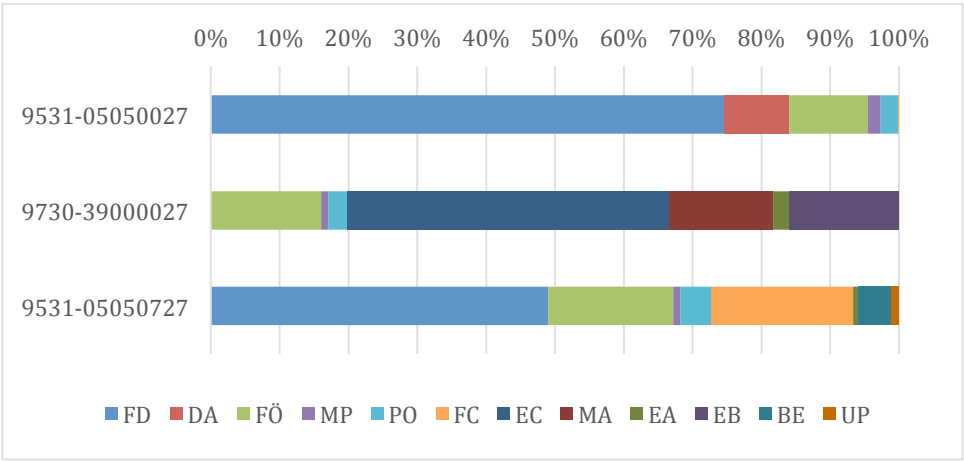


Figure 18: Most frequent location for product 9531-05050027 and its dependent products.

Before deciding where to allocate products with its dependent products, it is important to keep in mind that some products appear more than once in the analysis. Consequently, they have to be stored thinking on the dependent products and if their dependent products have another dependency. This relation is represented in Table 7 were the same products are represented with an equal colour (cells in white means that those products only appear once in the analysis). For example, "hot product 2" (green) should be stored in the same area as hot product 3, 6 and 7. Being most important to store it near "hot product 3", because it is more critical in the analysis.

To simplify and not repeat each time the article number it will be mentioned in the following form: HPX, being X the "hot product" number and HPX.Y, being Y the dependent product, it will start with one for the article that has a highest dependency percentage.

Hot product 1	HP1	9610-05060027	Hot product 7	HP7	9611-04060027
	HP1.1	9610-05050027		HP7.1	9730-39000027
Hot product 2	HP2	9531-05050027		HP7.2	9531-05050027
	HP2.1	9730-39000027	Hot product 8	HP8	9610-04060027
	HP2.2	9531-05050727		HP8.1	9730-39000027
Hot product 3	HP3	9730-39000027	Hot product 9	HP9	9910-10000139
	HP3.3	9531-05050027		HP9.1	9910-10001139
Hot product 4	HP4	9610-06060027		HP9.2	9920-000004
	HP4.1	9610-06050027		HP9.3	9910-10010439
	HP4.2	9510-10400027		HP9.4	9910-10009439
Hot product 5	HP5	9712-70000027	Hot product 10	HP10	9510-07060027
	HP5.1	9712-35000027		HP10.1	9510-10060027
	HP5.2	9510-07060027		HP10.2	9510-07040027
Hot product 6	HP6	9531-05050727		HP10.3	9610-06060027
	HP6.1	9531-05050027			
	HP6.2	9730-39000027			
	HP6.3	9730-39000727			
	HP6.4	9611-04060027			

Table 7: Products analysed in the dependency analysis

Analysing HP1 it can be observed that 20% of the time it is asked with HP1.1, in other words more than 100 times. Now they are stored in FE and FD respectively, in the area next to the bottom shipping area. These products do not have any dependency relation with the other products studied in this chapter.

HP2 is usually asked with more products and it has one of the highest dependencies in the analysis with HP2.1 (dependency relation: 47%), almost half the time it is ordered with other product it is HP2.1. Nowadays these products are stored in different areas, HP2 is stored in FD2 while HP2.1 is usually stored in EC, in the right side of the warehouse. When analysing HP2 and its dependent products, it should be taken into account that all products have dependency with other ones in the list. HP2 should be stored in the same area as HP3, HP6, HP7 and HP8.

The two products in HP3's dependency analysis are contained in HP2's analysis so it is unnecessary to comment it.

HP4 is requested 82% of the time with other products and it is remarkable a dependency relation of 29% with HP4.1 and 22% with HP4.2. HP4 is usually stored in area FE and HP4.1 is located in areas FE and FD, so nowadays it is located in a convenient place with it dependent products. However HP4.2 is located at the top of the warehouse in zone BF. Also, it should be considered that HP4 is a dependent product of HP10.

HP5 is demanded 83% of the time with other products, especially with HP5.1 with a dependency relation of 40%. HP5.1 is usually found in BC that is not far away from DB where HP5 is stored, but they could be stored closer due to their high dependency coefficient. HP5 is also requested together with HP5.2 a 21% of the time, but in this case the storing place is favourable, because it is stored in DA which is near DB. This group depends on group 10 because HP5.2 is also HP10.

HP6 and HP7 groups are highly dependent on other groups as can be seen in Table 7. All products in HP7 group are contained in HP6. And both have articles contained in HP2 and HP3, so as said before these four groups should be stored together due to their high dependency.

It is noteworthy that HP8 is asked alone 24% of the time, meaning 63 orders out of 259 in which it has been requested. When it is requested with other products 24% of the time is with HP8.1 (which is also HP3, as can be seen in Table 7), in spite of this dependency rate they are stored in different areas in the warehouse, HP8 is located at the bottom of the warehouse while HP8.1 is stored in EC in the right side of the warehouse.

HP9 group seems to have their dependency studied in advance, because HP9 and its dependent products are all stored in the same area in the warehouse and they do not have any other dependency on other products on the list.

Finally, HP10 is contained in group HP5, so it should be stored in that group, however it also has a dependency relation of 39% with HP10.1 and 32% with HP10.2. Nowadays they are stored in CA and DA, areas that are close one from the other. There is a third product HP10.3 with a 28% of dependency rate and is stored in the other side of the warehouse, this rate means 65 orders in which both products have been requested together, that is not as critical as other dependency relations, but if it is possible it should be taken into account.

When deciding where to store the products, it is also important to spread up products around the warehouse, to avoid bottlenecks in the aisles.

Summing up, this analysis shows that at least the “hot products” have a high dependency with other products. This information can be used when redistributing products in the warehouse in order to reduce picking times and to divide groups of products in different areas within the warehouse. There are four groups that according to the analysis should be stored together and they are: HP2, HP3, HP6, HP7 and HP8. There is also another small group that may be stored together and it is composed by HP4, HP5 and HP10. Finally, groups HP1 and HP9 do not have any relation with other groups in the analysis.

5.3 Dependency analysis between the main warehouse and VA and MAX warehouse

Due to the lack of the space in the main warehouse S:t Eriks owns two warehouse close to the main one. This analysis will study which products are usually demanded from the main warehouse when a customer orders products that are stored in VA or MAX (drainage and water supply products are usually stored in these warehouses).

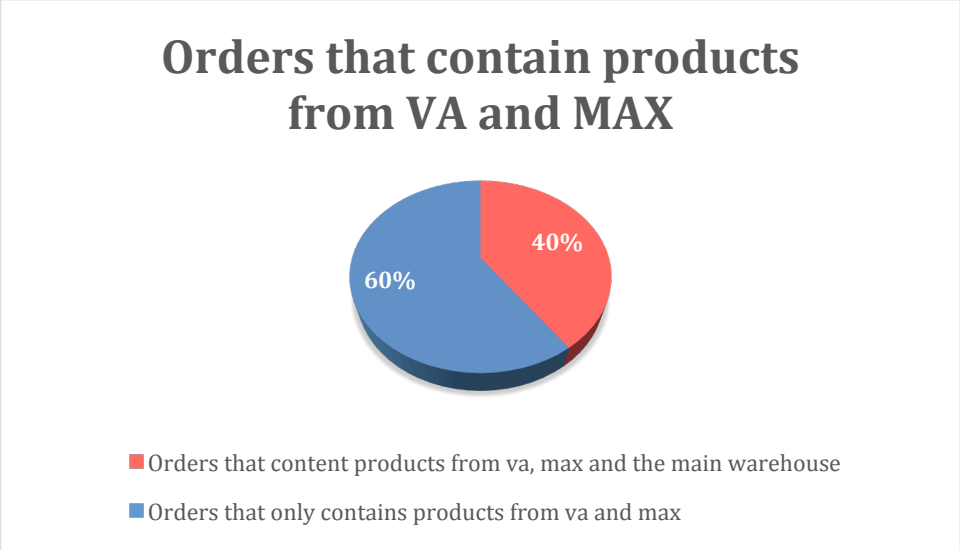


Figure 19: Orders that contain products stored in VA and MAX

Figure 19 shows that 60% of the orders only contain products from these warehouses, so to analyse if there is any dependency with some products stored in the main warehouse, a dependency analysis is going to be performed in order to know if there is any product with a high dependency that could be stored in these warehouses to avoid the double shipping and if possible reduce shipping times.

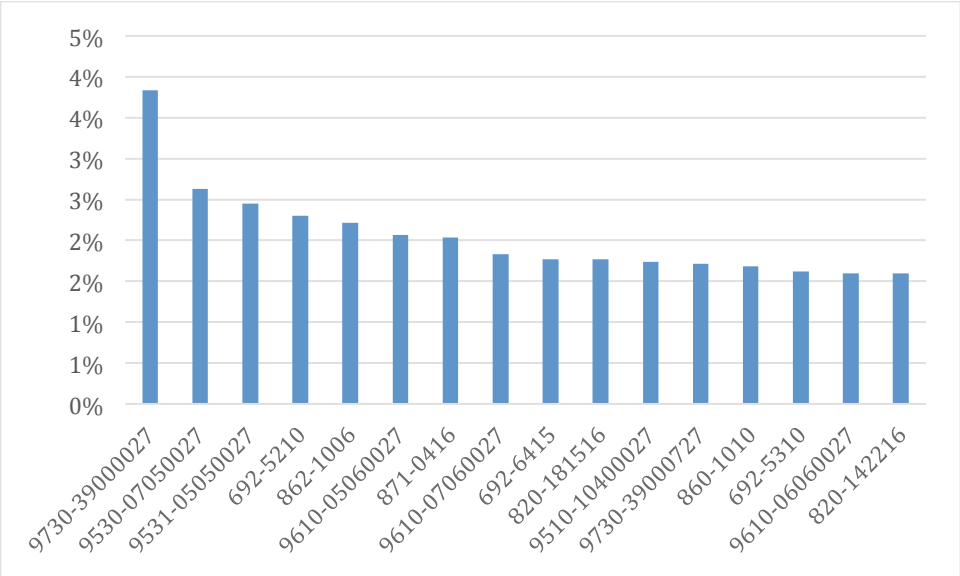


Figure 20: Products from the main warehouse ordered with products stored in VA and MAX.

This analysis shows that the products stored in VA and MAX are the correct ones because of the low dependency with products stored in the main warehouse. Due to the column chart in Figure 20 does not show a high dependency between any product stored in the main warehouse that is asked together with articles in VA or MAX.

Furthermore, some of the products shown in Figure 20 are already stored both in the main warehouse and in MAX, as can be observed in the inventory file, in particular these articles are: 9730-39000027, 9530-07050027, 692-5210, 862-1006, 692-6415 and 9730-39000727. So the company could study the advantages and drawbacks of storing the products in the list in MAX warehouse.

5.4 Number of trucks in the warehouse

This analysis is performed to know the number of trucks in the warehouse (it is assumed that each order is loaded in a truck, but as seen in the analysis above it is not always true). Four random days are chosen: one during the low season at the beginning of the year, two during the high season and the last one during the low season at the end of the year, continuing with the year division made in Table 4.

It is considered as shipping time the time that a truck is in the stockyard, since it is registered in the office until it leaves the stockyard. In this time the truck has to wait until there is a free shipping position and the loading time.

The loading time depends on several variables that could increase significantly shipping time:

- If the order contains a whole pallet or not. In that case the picker should get a new pallet, go to the product location, get out of the forklift and prepare a new pallet manually with the requested amount of the product.
- The amount of forklifts and trucks circulating around the stockyard. This variable depends on the seasonality, as can be seen in the different graphs represented below in Figure 21, 22, 23 and 24.

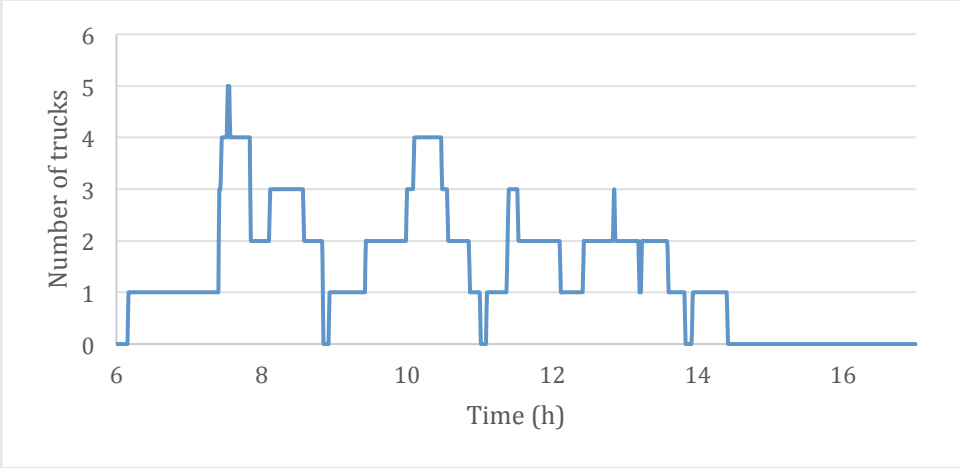


Figure 21: Number of trucks in the warehouse 2013/02/18

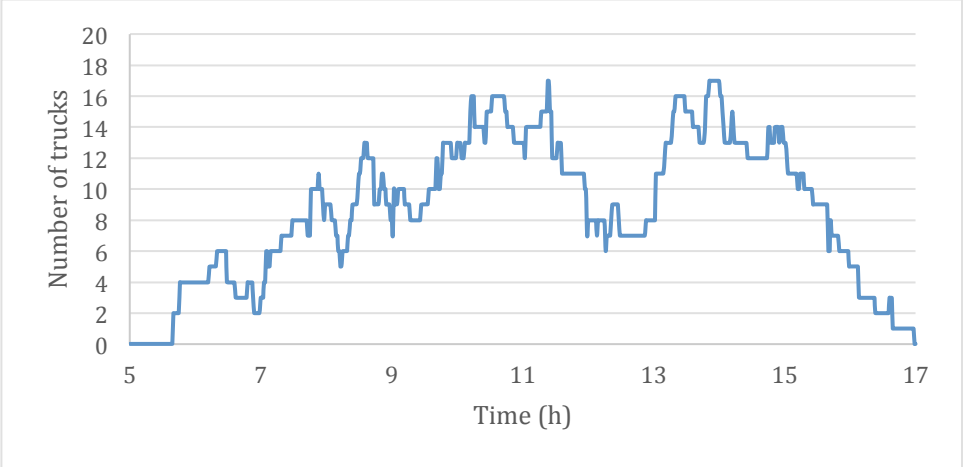


Figure 22: Number of trucks in the warehouse 2013/05/15

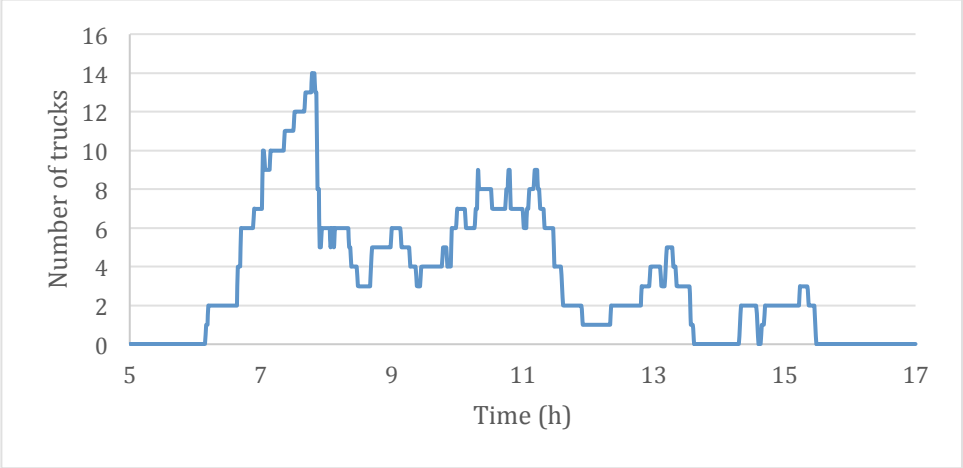


Figure 23: Number of trucks in the warehouse 2013/09/18

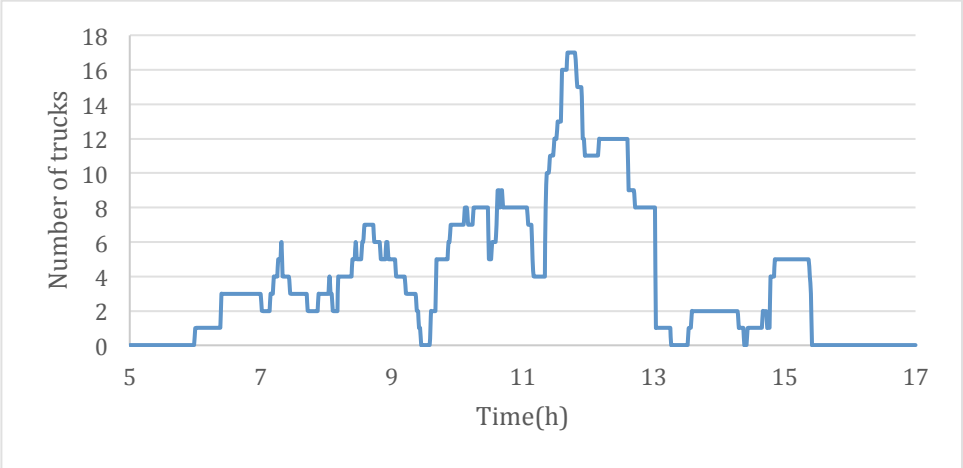


Figure 24: Number of trucks in the warehouse 2013/11/15

It is remarkable the high number of trucks on the analysis performed in May and September. There are twice as many trucks as shipping positions, and sometimes this situation is even worst as can be seen in Figure 22 where there is a peak with 17 trucks, meaning that the truck drivers have to wait for more than one hour before being assigned to a shipping area. Three peaks can be identified in the graphs: one early in the morning, another one before lunch at around 11 and the last one after lunch at 13.

Even though waiting times for truck drivers have improved in the last two years it is still significant the truck driver's need to wait one hour until they can get into the shipping area. This information was obtained first hand while discussing with a truck driver. This will be one of the points to discuss when all the analyses are done.

5.5 Summary analysis

From the first analysis, the ABC analysis, it can be observed that there is a small amount of products that represent a high number of picks, 373 articles (26% articles) account for 80% of the picks. The results obtained from the dependency analysis can be compared with the ones in the ABC analysis, as can be seen in Table 8, the articles studied in the dependency analysis represent 18 % of the total number of order lines. When developing a solution it should be given priority to the dependency analysis, since there are the most critical articles in the ABC analysis. Secondly, the ABC analysis should be taken into account to redistribute products in the warehouse.

	Number of articles	Percentage of order lines
A products	373	80%
More than 100 picks	53	32,5%
"Hot products"	10	13%
"Hot products" + their dependent products	21	18%

Table 8: Comparative study between ABC analysis and the dependency analysis

From the ABC analysis it could also be highlighted that the activity in the bottom side of the warehouse is bigger than in the top side, it could be explained as the preference of use of the bottom shipping area. However, if the company wants to get the most of the warehouse they should consider use both shipping areas. And designing one or the other shipping area will be done according the products requested in order of preference.

Finally, in the truck analysis the warehouse seasonality and the increase of the number of trucks during the high season can be observed, when the total amount of trucks in the warehouse is twice or three times the number of docks. So this analysis helped the researcher to prioritize the solution in order to reduce the number of trucks in the warehouse.

6 Results and discussion

This chapter extends the summary analysis in the previous section 5.5, presenting the suggestions for the company and their possible improvements. This suggestions will be made as the same time at the research question are answered.

Having performed all the analysis needed to suggest some changes in the warehouse, the main findings are:

- The higher utilization of the bottom area in the warehouse, not taking advantage of the favourable position of the top storage locations close to the shipping area.
- The ABC analysis shows that there is an small amount of products that represent the most part of the picks.
- Remarkable dependency between "hot products" and the ones they are usually asked with.
- High number of trucks in the warehouse, specially during the high season.

In order to find a solution for these problems, or take advantage of the findings in the analysis some possible solutions will be studied. These suggestions are focused on two different strategies that will answer the research questions proposed for this thesis.

6.1 RQ1: How could products be located in the warehouse in order to minimize picking time?

Firstly, the areas close to the bottom shipping area have four times as much activity as the top one. It could be interesting to spread up products around the warehouse and take the best of the top storage locations that are really favourable due to their proximity to the top shipping area. It is going to be relevant when deciding where to store the "hot products" and their dependent products.

If purple, red and dark green areas are prioritized for A products, due to their proximity to the shipping area, the number of picks in these areas will increase as a maximum of 3388 picks for the purple area, 14939 picks for the red one and 6144 picks for the dark green one (these calculations are in Appendix J). Obviously, these numbers will be not reached as they are done assuming that all the products stored in these area are A products, and this could not be true because some products are usually stored with products from their families that do not have to be A products. For example, the retaining walls will be better stored if they are all together in the same area, but giving the A walls the most accessible allocations. For B products the more convenient areas would be the blue and green areas. Finally, for C products it would be reserved the orange area.

This storing policy will increase the number of picks in a maximum of 1,40 times for the purple area, 2,17 for the red area and 3,70 for the dark green area. This will be translated into a reduction of the traveling time around the warehouse.

In this new reallocation system, a bigger emphasis on the "hot products" should be made. As a result of the ten most demanded products analysis, see chapter 5.2, there are four main groups to be stored in the warehouse:

- HP2, HP3, HP6, HP7 and HP8.
- HP4, HP5 and HP10.
- HP1.
- HP9.

As all the products in this analysis are A products, see Appendix I, they should be stored in the areas designed for A articles. Observing the current allocation of the products and how they should be stored according to the groups from the dependency analysis it is recommended that:

- The first group of products should be stored in the red area, and if it is possible in FC or FD, because they are more centred and approximately they have equal distance to the four shipping positions in the bottom area.
- For the second group, it is recommended that they are stored in the purple area, near the top shipping area. This is a good area for these products since it is a bulk area with the deepest lines in the warehouse and the amount of pallets of these articles is big enough to fill a whole line.
- HP1 group is now stored in FE and FC, but it could be better to store them in the purple area. In order to have an equal distribution of products in the top and the bottom of the warehouse.
- HP9 group is now stored in FF and it is recommended to keep their current positions, since they are stored all together and the amount of pallets stored is not enough (average 2 pallets of each product) to complete a line in other part of the warehouse.

In order to validate this suggestion a test was performed in order to quantify the possible improvements implementing this suggestion. The test followed the next steps:

1. Measure the zones distance in S:t Eriks Staffanstorp measures.
2. Choose a random day.
3. Consider only the orders that contains products stored in the main warehouse.
4. Calculate the current distances covered with the current distribution of products.
5. Reallocate products according the “hot product” and ABC classification.
6. Assign a shipping area.
7. Recalculate distances with the new positions.
8. Compare results.

As can be seen in Appendix K the new reallocation of products could lead to a 38,68% reduction of travelling distance in one day. Validating the distance optimization and consequently the time efficiency of the solution proposed.

Finally, in order to identify the strengths, weaknesses, opportunities and threats of this ABC storing policy a SWOT analysis will be performed. As commented in the theory, the SWOT analysis will provide a framework to review a company proposition.

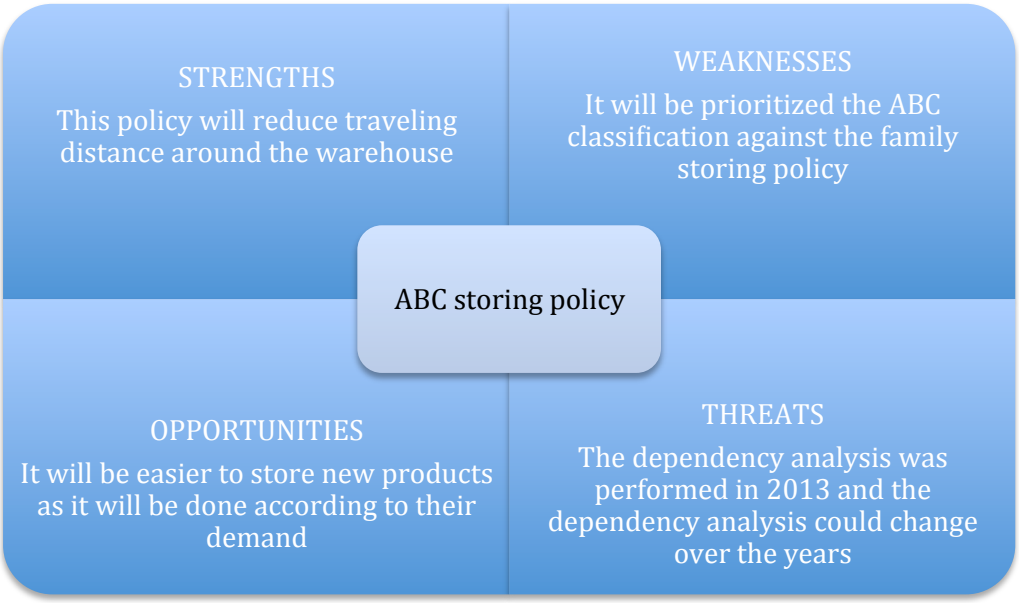


Figure 25: ABC storing policy SWOT analysis

Figure 25 shows the internal (strengths and weaknesses) and external (opportunities and threats) attributes that could affect the proposed storing policy. Together with the reduction of the traveling distances should be analysed the possible effects that could affect the implementation of this suggestion. However in this case the future improvements outweigh the possible drawbacks.

This measure is oriented to an optimization of operational structure, as it is one of the three possible optimization activity groups, see chapter 3.3. Since this ABC storing policy will affect the warehouse slotting strategic, not using the most common ones (random or dedicated policies) but assigning a storage location depending on three different groups.

6.2 RQ2: How can the number of trucks in the warehouse be reduced?

As commented in the number of trucks analysis (chapter 5.4), waiting times should be reduced to improve customer service. The previous ABC storing policy would contribute to the number of trucks reduction, as traveling distances will be reduced which affects shipping times.

Furthermore, a small area close to the shipping zone can be included in the warehouse, so orders can be picked before the trucks arrives to the shipping area. Hence once the truck arrives the requested articles are next to the truck and the loading times can be reduced. It should be done dividing the task into picking and shipping. Consequently the pickers will receive two different types of orders: a picking order or a loading order, see Figure 26. And they will receive a new order when they finish the previous one. First of all, a picking order is launched and when it is completed in a certain percentage (approximately a 75%) the loading order can be launched for the next available picker, to start loading the truck. In the meantime the truck will come to the shipping area. This policy can be implemented both in the high

and low season. Reducing the number of docks in the low season by adapting it to the number of forklifts available.

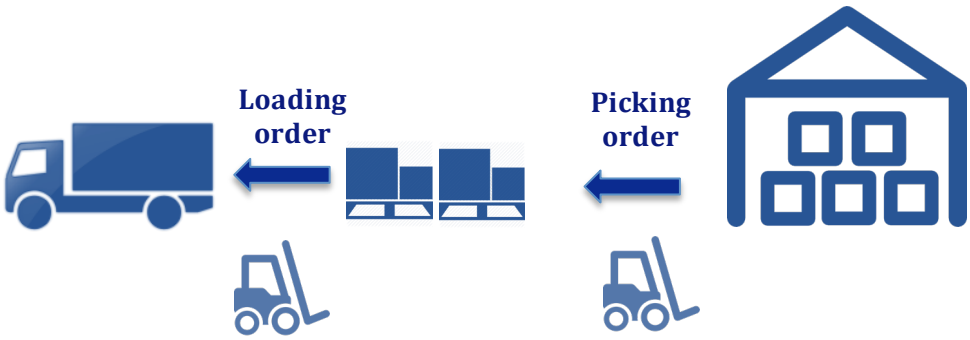


Figure 26: Product flow with the introduction of the loading area

The implementation would follow the next process:

- When a truck arrives to the warehouse it will be assigned a dock. This dock can be full or empty, if it is empty the truck can go to that dock. If it is full the truck should wait until the previous truck leaves the warehouse.
- Once the picker fulfils the previous order he should be assigned to the next task in the list and while the truck driver is securing the load and closing the truck another picker will start picking the products around the warehouse for the next truck and leaving them in the pre-order area.
- In the meanwhile the truck will arrive to the dock and when the picking order is fulfilled with the selected percentage, other picker will start loading the truck.

Regarding the task lists for the pickers, they would be processed in the WMS to different kind of orders: picking or loading orders that would be assigned in a preference order to the next available picker.

With this simple policy loading times will be reduced. As a preliminary analysis it can be observed that loading times will be reduced, since the products will be in an area close to the shipping area and it will take approximately 8 seconds to load the trucks from the pre-order area (as was measured in the field study of one order when the forklift left one pallet next to the truck and then he loaded it into the truck). With this change the time the truck driver takes to secure the load and close the truck (approximately 5 minutes) will not be lost, so products for next orders can be picked and left in the pre-order area. All that speeds up the work order processing, but some calculations in the near future should be done to corroborate this idea. In addition, a simulation test or a real test should be performed in order to decide if implementing this policy will improve significantly the waiting times.

This measure is also oriented to an optimization of operational structure. However it is focused on the rotting policies, trying to find the optimal travel path around the warehouse for order-picking, in order to reduce the number of trucks in the warehouse.

7 Conclusion and future research

This chapter presents the conclusions of the study and the future research.

Regarding theory, one of the purpose of this thesis was to identify the factors that could lead to a warehouse optimization. These factors are explained in section 3.3, and are grouped in three different areas:

- Optimization of the technical structure, that includes the layout design and the warehouse equipment choice.
- Optimization of operational structure, related to the organizational factors, as slotting strategies, rotting policies and picking policies.
- Optimization of warehouse management, basically based on Warehouse Management Systems (WMS).

These factors were used in the case study to identify the best option for the warehouse optimization and it was decided to go through the warehouse's operational structure.

Regarding practice, the analyses performed are based on the tactical decisions that should be taken on warehouse design, that are the ones that concerns the layout, the technical zones in which a warehouse should be divided. Specifically, the suggestions proposed to the company regards the reallocation of products within the warehouse according to the ABC analysis and a dependency analysis between the most demanded products; there are 21 products that should have a dedicated area in the warehouse as they are included in the dependency analysis (see section 6.1) and the rest of the products will be stored according to the ABC classification: where A products will be allocated in purple, red and dark green areas; B products, in the blue and green areas and C products, in the orange area. The second suggestion consists on the introduction of a pre-order area next to the shipping positions to reduce the number of trucks waiting in the warehouse. To confirm the validity of the pre-order area the next step will be a simulation test and a real test before implementing this policy.

The first suggestion would need a new product redistribution but these changes are justified with the increased activity in the A that would lead to a 38% of traveling distance reduction. Additionally, the second suggestion implementing the pre-order area would lead to a shipping times reduction and consequently would decrease the number of trucks in the warehouse.

As said in the theory, the main difference between a distribution and a production warehouse is the need of dealing with a highest degree of flexibility, in order to meet the production plan. This new measures will help to have a highest degree of flexibility since products are stored according to an ABC classification and only 21 products will have a dedicated space.

If the company wants to increase its storage efficiency they may review the strategic decisions that are the ones that affects the type of storage system and the storage units. These decisions according to the theory should be taken each five years, so they should check if the warehouse is able to absorb the increment in production. Besides, they can check the number of trucks needed in the high season and reconsider if the

number of trucks rented is enough to follow the high season's demand; which is part of the tactical decisions that should be reviewed every two or three years.

Regarding future theory research, it would be interesting to investigate and calculate the optimal solution or where to allocate the docks in a warehouse with radial configuration. Because all the theory found is based on rectangular warehouses, that are the most common ones. For the practical analyses, the next step would be a simulation test in order to validate the possible improvements that could be reached.

8 Recommendations to S:t Eriks

This final chapter will sum up the final recommendations for S:t Eriks in order to improve their activities and store in a more time efficient way.

As has been proposed in the results, there are some points that could help the company to store in a more efficient way, these measures are collected in the following points:

- Reallocate products according the ABC analysis, making special emphasis on the hot products. This changes could mean a reduction on the travelling distance for the pickers of a 38% (see Figure 27.
- Implement the pre-order area. However this point requires a simulation analysis before deciding it implementation. It could be a great idea to do a test in the low season and calculate the possible improving times before implementing this policy in the six shipping area, but the calculations show that there is room to save times.
- Check the VA and MAX list to include all the products in MAX (see Figure 20), the products do not represent a high percentage in the global, but it could help to reduce the number of trucks in the warehouse.

These are the areas where the researcher found room for improving, as said in the previous section if the company wants to improve their storage efficiency they will review the strategic decisions, presented in the frame of reference (chapter 3.1.4.2).

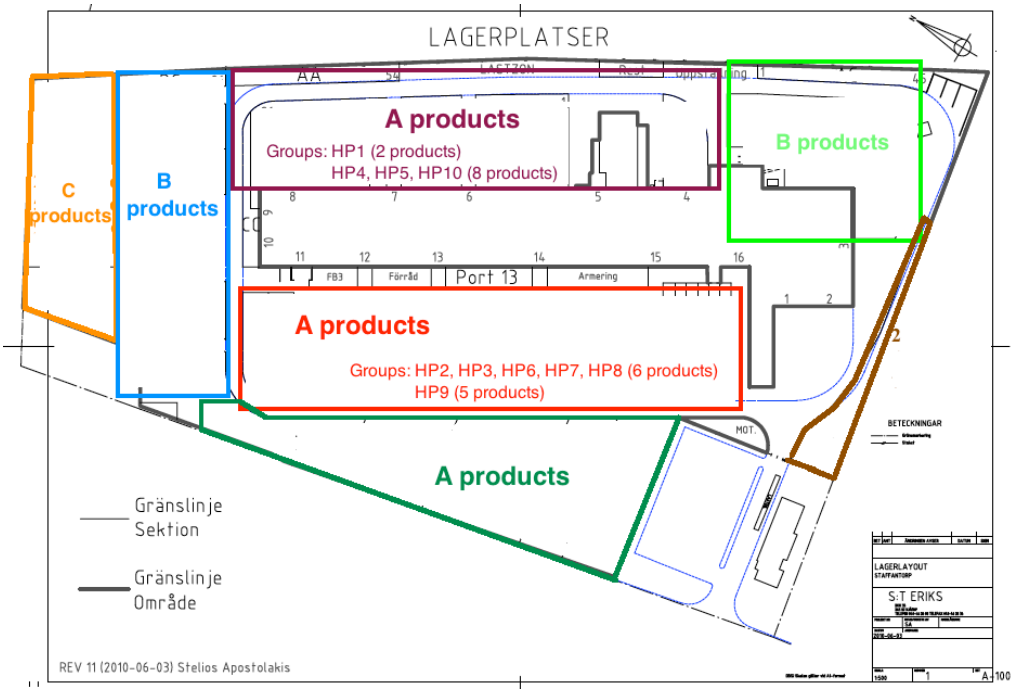


Figure 27: Layout suggestion

The researcher also found some areas that could be analysed in the company to improve their efficiency and continue improving. With this aim S:t Eriks should review:

- The number of forklifts needed in each season. Implementing simulation once picking times are collected keeping the same criterion (decide if the picker should register the stamp when he picks the product or when he load the product in the truck).
- The picking policies. It could be interesting to compare a strict order picking, zone picking or wave picking (see Page 15). Analysing the benefits and drawbacks of these policies.

9 Reflections

Once the thesis is close to the end is time for a self-evaluation of the work done in this period to take the most of this experience. This projects started at the end of January with a meeting with the company in order to establish the priority in the problem solving among the possible improvements they found, this meeting included one interview to get information about how they work and the most important numbers in the warehouse. This was followed by the project plan definition. When the purpose was settled, the theoretical review began emphasizing in the warehousing science and its design, it also contained a review of the most used analysis and methods in this areas. Parallel to the theoretical review the researcher started to visit the company, in order to have a better picture of the company and how the knowledge acquired could be implemented in the case study. After that, the researcher asked for the data needed to carry out the analysis planned: a map of the warehouse, an order file from 2013, the inventory and the production plan.

After a first period that consisted on the theoretical researcher and the information gathering. It started the second period, focused on the data analyses, the analysis evaluation and final conclusions. It was decided to start with an ABC analysis and complement it with other studies once the study was moving forward. The analyses were the critical part due to the complexity of working with a large amount of data. After running into limitations with Excel, the researcher decided to complement it with Matlab, due to its high processing capacity. Analysing the ABC and complementing it with the visits to the company, it was decided to perform some dependency analysis between the products in the warehouse. Which supposed the end of the analyses, with all the information the preliminary conclusions were drawn and the research questions answered. This thesis ended with the final conclusions presentation and recommendations to S:t Eriks. This thesis was presented to the company and they were satisfied with the problem solving and how they can improve shipping times through a product redistribution in the warehouse.

This project provided the researcher a new point of view about the complexity of working with real data, that most times it is not obtained as it is wished or it is uncompleted. This was the main difficulty found in the project. Besides this, it was a great opportunity to get in contact with a company and get used to work without ideal cases planned at the university.

Bibliography

Accorsi, R., Manzini, R., & Maranesi, F. (2014, January). A decision-support system for the design and management of warehousing systems. *Computers in Industry* .

Ackerman, K. B. (1997). *Practical Handbook of Warehousing* (4th ed.). Chapman & Hall.

Anylogic. (n.d.). *Anylogic*. Retrieved May 19, 2014 from Consulting- Warehouse Operations and Layout Optimization: http://www.anylogic.com/consulting/warehouse-operations-and-layout-optimization

Baker, P., & Canessa, M. (2007). Warehouse design: A structured approach. *European Journal of Operational Research* .

Bartholdi, J., & Hackman, S. (2010). *Warehousing & Distribution Science.* Atlanta.

Bhattacharya, A., Sarkar, B., & Mukherjee, S. (2006). Distance-based consensus method for ABC analysis. *International Journal of Production Research* .

Bodner, D., Govindaraj, T., Karathur, K., Zerangue, N., & McGinnis, L. (2002). A Process Model and Support Tools for Warehouse Design. *Proceedings of the 2002 NFS Design, Service and Manufacturing Grantees and Research Conference.*

Brockmann, T., & Godin, P. (1997). Flexibility for the future in warehouse design. *IIE Solutions , 29*.

Caron, F., Marchet, G., & Perego, A. (2010). Optimal layout in low-level picker-to-part systems. *International Journal of Production Research* .

Chaleunvong, K. (2009, September 25). Data Collection Techniques. *[PowerPoint slides]. Retrieved from: http://www.gfmer.ch/Activites_internationales_Fr/Laos/PDF/Data_collection_tecniques_Chaleunvong_Laos_2009.pdf* . Vientiane.

Chapman, A. (2007). *Businessballs*. Retrieved April 23, 2014 from http://www.businessballs.com/swotanalysisfreetemplate.htm

DHL. (2008). *DHL*. Retrieved May 15, 2014 from DHL-discover logistics: http://www.dhl-discoverlogistics.com/cms/en/course/processes/production_logistics/production.jsp

Friedman, D. (2006, September). WMS Pos and Cons. *Electrical Wholesailing* , pp. 46-47.

Gagliardi, J. P., Renaud, J., & Ruiz, A. (2007). A simulation model to improve warehouse operations. *Proceedings of the 2007 Winter Simulation Conference*, (pp. 2012-2018).

George Mason University. (2012, March 18). *The Writing Center*. Retrieved May 19, 2014 from How to Write a Research Question: https://writingcenter.gmu.edu/how-to-write-a-research-question/

Gu, J., Goetschalckx, M., & McGinnis, L. (2006). Research on warehouse operation: A comprehensive review. *European Journal of Operational Research* .

Hompel, M., & Schmidt, T. (2007). *Warehouse Management - Automation and Organisation of Warehouse and Order Picking.* Springer.

Humphrey, A. (2005). SWOT analysis for Management consulting. *SRI Alumni Newsletter* .

Iggniting World Markets for Growing Businesses. (2013). *Iggnition*. Retrieved May 19, 2014 from Warehouse Management: http://iggnition.com/product/logistics-product/warehouse-management/wms/

Iggniting Worls Markets for Growing Businesses. (2013). *Iggnition*. Retrieved May 20, 2014 from Pick and Pack: http://iggnition.com/product/logistics-product/pick-n-pack/pick_pack/

Karásek, J. (2013). An Overview of Warehouse Optimization. *International Journal of Advances in Telecommunications, Electrotechnics, Signals and Systems* , 7.

Kong, C., & Masell, D. (2008). Methods for Designing and Management of a Fast-Pick Area in a Warehouse. *Proceedings of the 2008 Industrial Engineering Research Conference*, (pp. 1367-1372).

Lun, Y., Lai, K., & Cheng, T. (2010). *Shipping and Logistics Management.* London: Springer.

management, W. a. (2014). *Reference for Business.* Retrieved May 12, 2014 from http://www.referenceforbusiness.com/management/Tr-Z/Warehousing-and-Warehouse-Management.html#b

Marín, L., & Carrasco-Gallego , R. (2013). A Design Framework for Flexible Automated Warehouses. In *Book of Proceeding of the 7th International Conference on Industrial Engineering and Industrial Management.*

MHI. (2005). Retrieved April 15, 2014 from The Warehouse Design and Control Problem - MHI: http://www.mhi.org/downloads/learning/cicmhe/lectures/whdesigncontrol.ppt

MWPVL International Inc. (n.d.). *MWPVL International Supply Chain Experience*. Retrieved May 14, 2014 from The Art and Science of Warehousing Slotting Optimization: http://www.mwpvl.com/html/warehouse_slotting_optimization.html

Roodbergen, K., & De Koster, R. (2001). Routing order pickers in a warehouse with a middle aisle. *European Journal of Operation Research* , 32-43.

Rouwenhorst, B., Reuter, B., Stockrahm, V., van Houtum, G., Mantel, R., & Zijm, W. (1999). Warehouse design and control: Framework and literature review. *European Journal of Operation Research* .

Ruriani, D. C. (2013, June). *Inbound Logistics*. Retrieved May 15, 2014 from Optimizing Warehouse Operations: http://www.inboundlogistics.com/cms/article/optimizing-warehouse-operations/

Rushton, A., Croucher, P., & Baker, P. (2010). *The handbook of logistics & distribution management.* Koganpage.

S:t Eriks. (2014). Retrieved May 12, 2014 from http://www.steriks.se

Suhonen, P. (2014, January 10). Personal interview.

Wang, B., & Adams, T. (2011). Warehousing and Distribution Centers. In *Intermodal Transportation: Moving Freight in a Global Economy*. Eno Foundation for Transportation.

Wasseng, J. (2014, March 05).

Yin, R. (2009). *Case Study Research: Design and Methods* (Fourth ed.). SAGE.

Appendix

Appendix A Advantages and constraints of the data collection techniques

Techniques	Advantages	Possible constraints
Using available information *Data that has been previously collected or is available in the company.*	Is inexpensive, because data is already there. Allows examination of trends over the past.	Data is not always easily accessible. Ethnical issues concerning confidentiality can arise. Information could be imprecise or incomplete.
Observations *Technique that includes systematically selecting, watching and recording behaviour and characteristics of living phenomena.*	Gives more detailed and context-related data. Allows collection of information on facts not mentioned in an interview. Allows tests of reliability of responses to questionnaire.	Ethnical issues concerning confidentiality or privacy may arise. The presence of the data collector can influence the situation observed. Thorough training of research assistants is required.
Interviews *Technique that involves an oral questioning and it could be done either individually or in group.*	Permits clarification of questions. Has higher response rate than written questionnaires.	The interviewer's presence can influence responses. Reports of events may be less complete than information gained through observations.
Written questionnaires *They are answered by respondents in a written form.*	Is less expensive. Permits anonymity and may result in more honest responses. Does not require research assistants.	Require extra training of researches.

Table 9: Advantages and constraints of the data collection techniques[83]

[83] Chaleunvong (2009)

Appendix B Rushton, Croucher, & Baker (2010) list of required data for warehousing design.

- Products:

  For each product line, information is required concerning:

  - product group;
  - quantity throughput (e.g. by item, case, pallet or cubic metre);
  - value throughput (to reconcile to business financial figures);
  - seasonality;
  - inventory turn (at average and peak);
  - characteristics (e.g. unit load weight/dimensions);
  - number of order lines.
- Order characteristics:
  - order profile (e.g. lines per order and units per order line);
  - order frequency (by season, week, day and time);
  - number of order lines for each SKU (to identify pick frequency);
  - time profile (e.g. percentage of orders received by week, by day, by hour);
  - unit load and packing requirements;
  - service levels (e.g. cut-off times, order lead times, and order fi l target).
- Intake and dispatch patterns:
  - number of vehicles per day and by hour;
  - types of vehicle (e.g. bed-height and end- or side-loaded);
  - unit load types and profiles (e.g. SKUs per pallet and need for re-palletizing);
  - volumes per dispatch route;
  - own vehicles or third-party;
  - cross-docking profiles (e.g. quantities, timing and sortation requirements).
- Warehouse operations:
  - basic operations to be undertaken;
  - ancillary functions, e.g. packing, returns, quality control, battery charging, offices, warehouse cleaning, maintenance workshop, services, stand-by generator, restaurant, locker rooms.
- External area requirements:
  - security facilities, including gatehouse;
  - truck parking and manoeuvring areas, car parking;
  - vehicle wash and fuelling points.
- Site and building details (for redesign of existing facilities):
  - location, access and ground conditions;
  - drawing to show building dimensions, columns, gradients, etc.;
  - drawing to show external area, roadways and adjacent facilities;
  - services (e.g. electricity supply).
- Cost data:
  - rent (or land and building costs) and rates;

  - building maintenance and security;
  - heat, light and power;
  - wage rates and shift premiums;
  - equipment costs, depreciation rules, maintenance costs.
- Any existing facilities or equipment that may be used:
  - size, condition, numbers.

Appendix C Interviews

Interview (Petteri Suhonan, 10/01/2014)

What are your main problems?

Limited capacity

Loading times, that go from 15-20 minutes to 1-1,5 hours if they have to ship different products.

Main focus for the project.

1. Optimize flows during the storage of products, placement of stockyard.
2. Loading capacity.
3. Pallet handling.

Do the warehouse have any seasonality?

Yes, during S:t Eriks high season that goes from April to September. During this season there are usually 6 trucks in the shipping docks and 6 more waiting to be loaded.

In this season, is there any peak during the day?

Yes, there are three peaks. Because the trucks can do three shipments all along the day.

In average how many pallets do you produce per day?

Nowadays it is between 500 and 600 pallets/day.

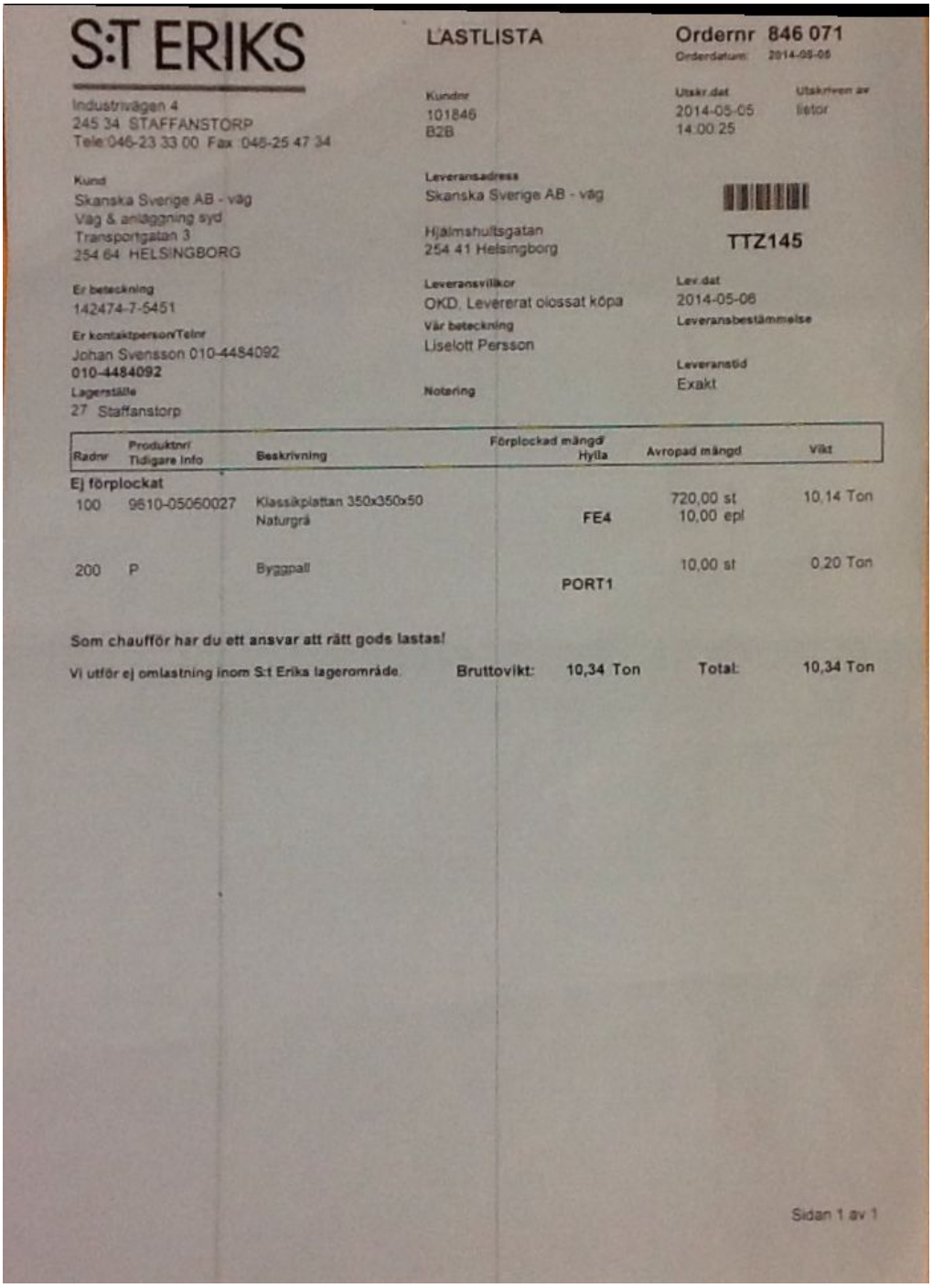
Do you store products that are not produced in Staffanstorp?

Yes, there are stored products from others factories in Sweden and products that are returned by customers. But they are not relevant compared to the production in the factory.

When is the highest stock stored in the stockyard?

In March just when we start the high season.

Appendix D Order templates



S:T ERIKS

Industrivägen 4
245 34 STAFFANSTORP
Tele:046-23 33 00 Fax 046-25 47 34

LASTLISTA

Ordernr 846 071
Orderdatum: 2014-05-05

Kundnr
101846
B2B

Utskr.dat
2014-05-05
14.00.25

Utskriven av
lietor

Kund
Skanska Sverige AB - väg
Väg & anläggning syd
Transportgatan 3
254 64 HELSINGBORG

Leveransadress
Skanska Sverige AB - väg

Hjälmshultsgatan
254 41 Helsingborg

TTZ145

Er beteckning
142474-7-5451

Er kontaktperson/Telnr
Johan Svensson 010-4484092
010-4484092

Lagerställe
27 Staffanstorp

Leveransvillkor
OKD. Levererat olossat köpa

Vår beteckning
Liselott Persson

Notering

Lev.dat
2014-05-06

Leveransbestämmelse

Leveranstid
Exakt

Radnr	Produktnr/ Tidigare info	Beskrivning	Förplockad mängd/ Hylla	Avropad mängd	Vikt
Ej förplockat					
100	9610-05060027	Klassikplattan 350x350x50 Naturgrå	**FE4**	720,00 st 10,00 epl	10,14 Ton
200	P	Byggpall	**PORT1**	10,00 st	0,20 Ton

Som chaufför har du ett ansvar att rätt gods lastas!

Vi utför ej omlastning inom S:t Eriks lagerområde.

Bruttovikt: 10,34 Ton **Total: 10,34 Ton**

Sidan 1 av 1

S:T ERIKS

LASTLISTA

Ordernr 845 915
Orderdatum: 2014-05-05

Industrivägen 4
245 34 STAFFANSTORP
Tele 046-23 33 00 Fax 046-25 47 34

Kundnr
101661
B2C

Utskr.dat
2014-05-05
14:00:18

Utskriven av
mongus

Kund
Beijer Byggmaterial AB Ängelholm
Filial 039
Box 1256
262 23 ÄNGELHOLM

Leveransadress
Beijer Byggmaterial AB Ängelholm
Lager
Klippanvägen
262 71 ÄNGELHOLM

TTZ145

Er beteckning

Leveransvillkor
LOK Levererat olossat köpar

Lev.dat
2014-05-07

Er kontaktperson/Telnr
Mats
-

Vår beteckning
Mona Gustafsson

Leveransbestämmelse

Lagerställe
27 Staffanstorp

Notering

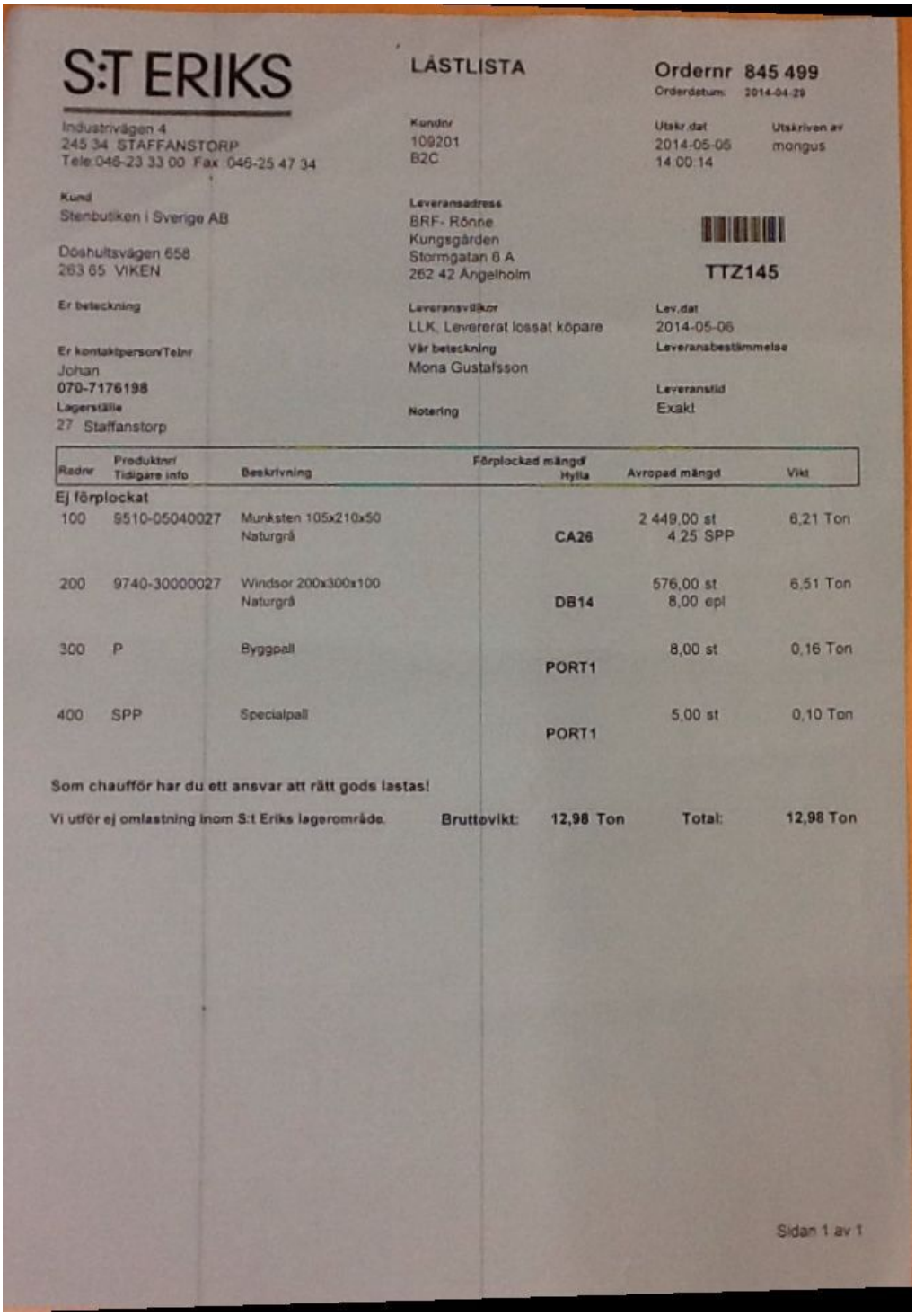
Leveranstid
Senast

Radnr	Produktnr/ Tidigare info	Beskrivning	Förplockad mängd/ Hylla	Avropad mängd	Vikt
Ej förplockat					
100	9531-05050027	Rustik 133x200x50 Naturgrå	UPP	4 320,00 st 10,00 epl	13,22 Ton
200	P	Byggpall	PORT1	10,00 st	0,20 Ton

Som chaufför har du ett ansvar att rätt gods lastas!

Vi utför ej omlastning inom S:t Eriks lagerområde. **Bruttovikt: 13,42 Ton** **Total: 13,42 Ton**

Sidan 1 av 1



S:T ERIKS

Industrivägen 4
245 34 STAFFANSTORP
Tele:046-23 33 00 Fax 046-25 47 34

LÅSTLISTA

Ordernr 845 499
Orderdatum: 2014-04-29

Kundnr
109201
B2C

Utskr.dat
2014-05-05
14:00:14

Utskriven av
mongus

Kund
Stenbutiken i Sverige AB

Döshultsvägen 658
263 65 VIKEN

Er beteckning

Er kontaktperson/Telnr
Johan
070-7176198

Lagerställe
27 Staffanstorp

Leveransadress
BRF- Rönne
Kungsgården
Stormgatan 6 A
262 42 Ängelholm

TTZ145

Leveransvillkor
LLK, Levererat lossat köpare

Vår beteckning
Mona Gustafsson

Notering

Lev.dat
2014-05-06

Leveransbestämmelse

Leveranstid
Exakt

Radnr	Produktnr/ Tidigare info	Beskrivning	Förplockad mängd Hylla	Avropad mängd	Vikt
Ej förplockat					
100	9510-05040027	Muriksten 105x210x50 Naturgrå	**CA26**	2 449,00 st 4 25 SPP	6,21 Ton
200	9740-30000027	Windsor 200x300x100 Naturgrå	**DB14**	576,00 st 8,00 epl	6,51 Ton
300	P	Byggpall	**PORT1**	8,00 st	0,16 Ton
400	SPP	Specialpall	**PORT1**	5,00 st	0,10 Ton

Som chaufför har du ett ansvar att rätt gods lastas!

Vi utför ej omlastning inom S:t Eriks lagerområde.

Bruttovikt: 12,98 Ton **Total: 12,98 Ton**

Sidan 1 av 1

Appendix E S:t Eriks Staffanstorp equipment

Equipment that S:t Eriks owns.

Modell	Year model	Fabricant	Function	Shifts number
DANTRUCK 6009	2003	Dantruck	Reserve	
DANTRUCK 7009	2008	Dantruck	Loading	1
DANTRUCK 7009	2008	Dantruck	Loading	1
DANTRUCK 7009	2008	Dantruck	Loading	1
DANTRUCK 7009	2008	Dantruck	Loading	1
DANTRUCK 7009	2008	Dantruck	Loading	1
DANTRUCK 7009	2008	Dantruck	Loading	1
DANTRUCK 7009	2008	Dantruck	Production and loading	1
7FDA50	2010	Toyota	Production	2
7FDA50	2010	Toyota	Production	2
Traktor med Släp	1997	FENDT	Intern use	1
9680	2004	Dantruck	T-walls	1

Forklifts rented by S:t Eriks Staffanstorp.

Model	Year model	Fabricant	Function	Start date	Finish date
Kalmar 5ton		Dantruck	Loading	01/04	
Kalmar 5ton		Dantruck	Loading	01/04	31/08
DANTRUCK 7009	2008	Dantruck	Loading	01/03	
DANTRUCK 7009	2008	Dantruck	Loading	01/03	

Appendix F Analysis of the number of order lines per order

Number of orders in 2013	**9558**	
Number of order lines	29623	
Average number of order lines per order	3,10	
Maximum number of order lines	261	**% Total number of orders**
Order with 1 order line	4269	45%
Order with 2 order lines	1948	20%
Order with 3 order lines	1076	11%
Order with 4 order lines	686	7%
Order with 5 order lines	400	4%
Order with between 5 and 10 order lines	823	9%
Order with between 10 and 20 order lines	250	3%
Order with between 20 and 40 order lines	76	1%
Order with between 40 and 60 order lines	20	0%
Order with between 60 and 80 order lines	6	0%
Order with between 80 and 100 order lines	2	0%
Order with between 100 and 120 order lines	1	0%
Order with more 120 order lines	1	0%

Appendix G ABC analysis: article numbers, number of order lines and accumulate percentage

Article number	order lines	%accum
9610-05060027	718	2%
9531-05050027	532	4%
9730-39000027	519	6%
9610-06060027	428	7%
9712-70000027	296	8%
9531-05050727	271	9%
9611-04060027	271	10%
9610-04060027	259	11%
9910-10000139	255	12%
9510-07060027	252	13%
9730-39000727	247	14%
9410-50000027	235	14%
9920-000004	221	15%
9610-07060027	219	16%
9510-10400027	176	17%
9411-70000027	171	17%
871-0416	166	18%
9610-05050027	164	18%
9510-07040027	160	19%
9412-101000	158	19%
692-6415	149	20%
9714-50000727	148	20%
7115-10200499	142	21%
9530-07050027	140	21%
862-1006	136	22%
7114-12202027	134	22%
692-5210	134	23%
9714-50000027	133	23%
7114-06200427	133	24%
9610-06050027	130	24%
9610-08060027	129	24%
875-2410	126	25%
9520-05050027	125	25%
9740-30000027	123	26%
682-7801	119	26%
3414-001525	117	26%
7114-10200427	116	27%
A610-05060027	115	27%
9531-05030027	114	28%
9650-10000027	112	28%
9671-04066012	111	28%
7115-08200499	111	29%
9520-07050027	110	29%
7115-12202099	109	29%
9526-08000027	108	30%
9715-39000027	106	30%
A730-39000027	104	31%
9910-10001139	103	31%
9611-04050027	103	31%
9510-07070027	102	32%
9522-06120727	102	32%
7114-08200427	102	32%
9510-10060027	100	33%
9912-08000139	99	33%
9531-05050627	98	33%
9610-07050027	96	34%
9531-05051227	96	34%
a519-04050027	95	34%
9710-50000027	95	35%
3412-170025	95	35%
9510-07020027	94	35%
9715-39000727	93	36%
7114-10202027	93	36%
A530-05050027	92	36%
860-1010	92	36%
875-2405	92	37%
3412-100025	92	37%
3111-161000	91	37%
9611-04060727	90	38%
A410-50000027	89	38%
9612-05060011	89	38%
9750-43110027	86	39%
9513-10140027	86	39%
9712-35000027	85	39%
692-5310	85	39%
9532-05051427	84	40%
895-0664	83	40%
9910-10009439	81	40%
9914-10000139	81	41%
7115-06200499	81	41%
9610-07040027	79	41%
7115-10202099	79	41%
820-181516	79	42%
9910-10010439	78	42%
9520-07060027	78	42%
9911-12000139	76	42%
7115-14202099	76	43%
699-0000	74	43%
9610-08070027	73	43%
9530-07050727	73	43%
7115-08202099	73	44%
9510-05040027	72	44%
A730-39000727	71	44%
9510-05060027	71	44%
7115-12200499	71	45%
A739-30000027	70	45%
895-0662	70	45%
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822-0610	7	93%	9910-10004339	5	95%	S999-00004027	4	96%
875-6502	7	93%	9912-08000539	5	95%	9631-06030012	4	96%
824-0405	7	93%	9750-43000011	5	95%	9914-10000239	4	96%
7214-20202027	7	93%	9912-08000639	5	95%	9917-06000139	4	96%
3101-500025	7	93%	9730-19031227	5	95%	9913-16001439	4	96%
3411-171000	7	93%	9715-19170027	5	95%	9712-78600727	4	96%
692-5322	7	93%	9911-12000111	5	95%	9914-10000639	4	96%
3216-030654	7	93%	9752-36020027	5	95%	9640-05052012	4	96%
3226-750000	7	93%	9914-10000439	5	95%	9913-16007539	4	96%
3216-030503	7	93%	A116-110025	5	95%	9752-36020727	4	96%
3416-000100	7	93%	9673-06063212	5	95%	9911-12001539	4	96%
3416-100007	7	93%	9412-781315	5	95%	9715-39000627	4	96%
3218-600003	7	93%	9610-05050627	5	95%	9695-05060011	4	96%
3211-030603	7	93%	896-2010	5	95%	9911-12009739	4	96%
3111-080250	7	93%	896-1005	5	95%	9631-05020012	4	96%
3412-150025	7	93%	881-0505	5	95%	9913-16001239	4	96%
9695-05053311	6	93%	9530-07031427	5	95%	9673-04063012	4	96%
9911-12000539	6	93%	9510-05060727	5	95%	S017361	4	96%
9680-07020011	6	93%	895-1171	5	95%	9631-05010012	4	96%
9913-16000739	6	93%	9526-08200727	5	95%	9911-12001111	4	96%
9920-110120	6	93%	9530-07051227	5	95%	9630-06030011	4	96%
9660-05060012	6	93%	9517-08000027	5	95%	9752-36090027	4	96%
V850001	6	93%	9523-05030711	5	95%	9680-07021011	4	96%
9911-12000439	6	94%	9526-10200527	5	95%	9913-16009739	4	96%
9914-10000839	6	94%	9610-06050727	5	95%	9750-43020727	4	96%
9662-07050012	6	94%	896-1012	5	95%	9517-10000727	4	96%
9517-10001227	6	94%	7214-36202027	5	95%	9530-07050627	4	96%
881-1002	6	94%	692-8655	5	95%	9512-07120027	4	96%
899-3202	6	94%	692-8715	5	95%	895-1271	4	96%
9410-50002012	6	94%	803-4005	5	95%	895-0306	4	96%
9610-12060011	6	94%	7115-12206227	5	95%	896-5012	4	96%
9610-12070011	6	94%	7114-20102027	5	95%	9510-10090727	4	96%
9410-50002112	6	94%	7214-40200427	5	95%	9510-07020527	4	96%
9513-10141027	6	94%	805-2020	5	95%	9412-781310	4	96%

882-1006	4	96%	9695-06060011	3	97%	3219-036070	3	98%
9412-781330	4	96%	9661-04060012	3	97%	3414-100007	3	98%
881-2003	4	96%	9695-06060711	3	97%	3410-001000	3	98%
9510-07061011	4	96%	9661-04060712	3	97%	3222-120045	3	98%
9510-10080727	4	96%	9911-12000339	3	97%	3213-030003	3	98%
826-0510	4	96%	9913-16010739	3	97%	3415-200025	3	98%
805-2015	4	96%	9661-06050012	3	97%	3413-100001	3	98%
7214-26200427	4	96%	9730-19031427	3	97%	3416-100005	3	98%
806-2007	4	96%	S035901	3	97%	692-5342	3	98%
692-87111	4	96%	9695-05060711	3	97%	3416-200002	3	98%
806-3007	4	96%	9680-06010011	3	97%	3215-210754	3	98%
7115-10206727	4	96%	9920-000002	3	97%	3416-400060	3	98%
806-4007	4	96%	9523-05000011	3	97%	682-7816	3	98%
7115-12207227	4	96%	930-1087	3	97%	3215-121054	3	98%
7215-22200499	4	96%	876-6721	3	97%	3212-142084	3	98%
7115-14102099	4	96%	9530-05050511	3	97%	5112-10000034	3	98%
808-5040	4	96%	882-0906	3	97%	3412-101000	3	98%
7215-44200499	4	96%	896-6009	3	97%	5112-15010034	3	98%
7115-08206227	4	96%	895-0674	3	97%	3218-600103	3	98%
7114-18100427	4	97%	9412-781305	3	97%	5125-10000134	3	98%
7115-08206727	4	97%	9510-07020627	3	97%	692-5325	3	98%
7115-12102099	4	97%	896-6010	3	97%	5126-49010035	3	98%
7115-16206727	4	97%	9520-07130727	3	97%	692-5334	3	98%
865-6022	4	97%	896-6015	3	97%	5212-09000034	3	98%
7114-20100427	4	97%	881-0510	3	97%	3215-100041	3	98%
871-1416	4	97%	9441-70070034	3	97%	630-5311	3	98%
822-0405	4	97%	9510-07200627	3	97%	9820-40450745	2	98%
7215-36200499	4	97%	9441-78101034	3	97%	9640-05062012	2	98%
7115-20102099	4	97%	9412-781215	3	98%	S959-10140027	2	98%
3215-140854	4	97%	9530-05030727	3	98%	9913-16001539	2	98%
5112-05020034	4	97%	9412-781250	3	98%	9715-19170727	2	98%
3215-120954	4	97%	9441-78201034	3	98%	9641-04052112	2	98%
3118-400025	4	97%	806-4010	3	98%	9640-07062212	2	98%
692-5344	4	97%	865-1612	3	98%	9825-10120729	2	98%
3413-130000	4	97%	806-3022	3	98%	9751-30000711	2	98%
3414-006010	4	97%	7115-18206727	3	98%	9827-000001	2	98%
3411-161000	4	97%	7115-16207227	3	98%	9750-21080727	2	98%
3500-050503	4	97%	7115-18207727	3	98%	9917-06000939	2	98%
5212-10000734	4	97%	820-12221699	3	98%	9810-18000045	2	98%
3104-151000	4	97%	7214-42200427	3	98%	9917-06001039	2	98%
3410-500000	4	97%	7214-22200427	3	98%	9661-07060712	2	98%
3120-200250	4	97%	808-2015	3	98%	9917-06200139	2	98%
3410-500500	4	97%	806-2045	3	98%	9821-06200729	2	98%
3111-080025	4	97%	875-5410	3	98%	9920-000001	2	98%
3107-111000	4	97%	820-102211	3	98%	9912-08000739	2	98%
3500-050421	4	97%	7215-20202099	3	98%	9825-10020029	2	98%
630-5405	4	97%	803-5010	3	98%	9660-04060712	2	98%
3219-036071	4	97%	806-1545	3	98%	9827-140000	2	98%
3224-100075	4	97%	694-0000	3	98%	9671-04056112	2	98%
5212-20000034	4	97%	824-0510	3	98%	9750-43100727	2	98%
682-7875	4	97%	7214-18202027	3	98%	A530-05059227	2	98%
3414-100005	4	97%	806-3010	3	98%	9910-10100139	2	98%
3412-171000	4	97%	802-1505	3	98%	9674-040650	2	98%
630-5830	4	97%	824-2007	3	98%	9920-100020	2	98%
3214-030041	4	97%	806-4005	3	98%	9813-17090034	2	98%
3109-060250	4	97%	826-0505	3	98%	9827-150000	2	98%
3214-170041	4	97%	865-6021	3	98%	9820-60670745	2	98%
3224-100100	4	97%	809-1511	3	98%	9661-05050712	2	98%
682-7820	4	97%	802-5010	3	98%	9820-800200	2	98%
692-8648	4	97%	826-0515	3	98%	9671-06066112	2	98%
3222-120010	4	97%	871-0420	3	98%	9751-30000011	2	98%
3102-061000	4	97%	7115-16102099	3	98%	9642-05052012	2	98%
100106	4	97%	7115-06206727	3	98%	9821-06200745	2	98%
9712-78300727	3	97%	829-0321	3	98%	9680-06001012	2	98%
9822-12480745	3	97%	805-1515	3	98%	9821-18300045	2	98%
9672-06063212	3	97%	7115-04100499	3	98%	9631-06010012	2	99%
9913-16000239	3	97%	7114-04102027	3	98%	9910-10005339	2	99%
9730-19170627	3	97%	7115-20207227	3	98%	9825-10120745	2	99%
9913-16000439	3	97%	876-6713	3	98%	9914-10000539	2	99%
9911-12000211	3	97%	7215-38200499	3	98%	9750-43020027	2	99%
9913-16000639	3	97%	876-6717	3	98%	895-0675	2	99%
9911-12010739	3	97%	630-5312	3	98%	9412-100310	2	99%
9750-43020711	3	97%	692-1516	3	98%	9523-05000711	2	99%
9730-19170527	3	97%	682-7850	3	98%	9441-40060034	2	99%
9671-05060027	3	97%	3220-050754	3	98%	9510-07200727	2	99%

9530-05050627	2	99%	3410-000500	2	99%	930-1487	1	99%
9412-781350	2	99%	3103-151000	2	99%	9530-05050711	1	99%
895-0105	2	99%	3416-000106	2	99%	882-0603	1	99%
896-1026	2	99%	3214-035041	2	99%	9510-10070627	1	99%
9441-78105034	2	99%	3110-301000	2	99%	9530-07050813	1	99%
9412-781207	2	99%	692-1511	2	99%	953-070208	1	99%
9441-78200534	2	99%	682-7800	2	99%	9517-08200027	1	99%
9526-08300727	2	99%	3214-160003	2	99%	895-0671	1	99%
895-0104	2	99%	3410-700500	2	99%	9517-08300027	1	99%
9520-05030727	2	99%	3414-100011	2	99%	9520-07050627	1	99%
9530-05050811	2	99%	3115-110250	2	99%	9510-07041513	1	99%
9412-781392	2	99%	5126-00000134	2	99%	961-0006	1	99%
896-6012	2	99%	3117-401000	2	99%	9610-07040611	1	99%
883-1509	2	99%	3224-100045	2	99%	9511-10040511	1	99%
895-0408	2	99%	3126-500250	2	99%	895-1571	1	99%
896-2009	2	99%	5150-10001434	2	99%	9530-07051413	1	99%
899-9999	2	99%	3417-200001	2	99%	9412-781380	1	99%
895-0672	2	99%	692-5354	2	99%	9611-04060011	1	99%
930-0887	2	99%	3411-170250	2	99%	895-1761	1	99%
9517-10200727	2	99%	3215-150041	2	99%	952-070407	1	99%
9512-07120727	2	99%	3215-100054	2	99%	896-1015	1	99%
9412-781395	2	99%	S999-00004127	1	99%	9441-12000034	1	99%
896-5015	2	99%	9821-18300729	1	99%	9520-07050511	1	99%
9517-10300727	2	99%	x752-30100027	1	99%	9520-07080713	1	99%
882-1206	2	99%	9661-08050012	1	99%	9610-07200027	1	99%
9510-10070727	2	99%	9642-05062112	1	99%	9412-781292	1	99%
895-0406	2	99%	9695-04060011	1	99%	896-1066	1	99%
9441-12101034	2	99%	9660-06050012	1	99%	9520-07050527	1	99%
9610-06060627	2	99%	9640-05052112	1	99%	9630-06010011	1	99%
895-2112	2	99%	9660-06050712	1	99%	896-1003	1	99%
871-1411	2	99%	9712-10120029	1	99%	9610-04060627	1	100%
876-6709	2	99%	S017921	1	99%	866-2028	1	100%
875-3410	2	99%	9662-05050712	1	99%	7215-46200499	1	100%
876-6715	2	99%	9917-06202639	1	99%	826-0622	1	100%
7115-16100499	2	99%	9672-04053012	1	99%	7115-08207227	1	100%
7115-18100499	2	99%	9750-21080011	1	99%	856-6021	1	100%
7215-42200499	2	99%	9672-04053212	1	99%	7414-12900034	1	100%
829-0211	2	99%	x750-43110027	1	99%	7214-32200427	1	100%
7115-06207727	2	99%	9641-04052012	1	99%	7414-16900034	1	100%
807-6000	2	99%	x752-30110027	1	99%	875-1410	1	100%
7214-40202027	2	99%	9632-09040045	1	99%	806-2005	1	100%
829-0521	2	99%	9673-06063112	1	99%	851-2022	1	100%
865-6040	2	99%	9911-12007539	1	99%	826-0522	1	100%
851-0001	2	99%	9822-12480045	1	99%	803-1010	1	100%
7115-20206227	2	99%	9642-05052112	1	99%	806-3015	1	100%
7215-48200499	2	99%	9640-07062112	1	99%	803-1502	1	100%
7115-16206227	2	99%	9810-18000745	1	99%	7112-06300435	1	100%
876-6719	2	99%	9676-050671	1	99%	826-0615	1	100%
805-3015	2	99%	9672-06063012	1	99%	826-0605	1	100%
820-122216	2	99%	9913-16000339	1	99%	803-6010	1	100%
805-3020	2	99%	a530-05059027	1	99%	861-1022	1	100%
806-4015	2	99%	s999-00004227	1	99%	7111-18200411	1	100%
863-1203	2	99%	9660-04060012	1	99%	692-8714	1	100%
692-87011	2	99%	9913-16000539	1	99%	7112-08200434	1	100%
3218-600054	2	99%	9661-05060512	1	99%	808-6050	1	100%
3222-120705	2	99%	x750-21080027	1	99%	856-5021	1	100%
3416-200001	2	99%	9640-07052212	1	99%	700-0822	1	100%
3414-100001	2	99%	x752-10000027	1	99%	7111-18100411	1	100%
692-1203	2	99%	9660-05050712	1	99%	829-0220	1	100%
5212-25000735	2	99%	x752-30100727	1	99%	829-0320	1	100%
5126-00000135	2	99%	9711-28040011	1	99%	863-1603	1	100%
6111-35000041	2	99%	x752-32040027	1	99%	869-1282	1	100%
3104-251000	2	99%	9914-10007539	1	99%	820-062211	1	100%
630-5204	2	99%	9661-06050712	1	99%	822-121099	1	100%
682-7914	2	99%	9530-07050511	1	99%	865-1514	1	100%
3214-200041	2	99%	896-2015	1	99%	692-87411	1	100%
2040-47400520	2	99%	930-1277	1	99%	809-1115	1	100%
3224-100060	2	99%	9511-10041227	1	99%	7215-16200499	1	100%
3218-600203	2	99%	9530-05031427	1	99%	829-0221	1	100%
3215-200041	2	99%	9610-05060711	1	99%	829-410313	1	100%
692-5332	2	99%	896-5009	1	99%	700-1222	1	100%
3222-120015	2	99%	882-1506	1	99%	826-0810	1	100%
5212-09000734	2	99%	896-2012	1	99%	829-0311	1	100%
3324-100015	2	99%	9520-10050727	1	99%	824-1410	1	100%
3213-050003	2	99%	899-3152	1	99%	807-1500	1	100%

875-3405	1	100%	3211-030604	1	100%	3224-100707	1	100%
7111-04100411	1	100%	5212-25000035	1	100%	100306	1	100%
824-1807	1	100%	3228-100000	1	100%	3410-000700	1	100%
7111-14100411	1	100%	5212-25000734	1	100%	3222-120030	1	100%
826-0822	1	100%	3412-140025	1	100%	3222-120005	1	100%
7111-16200411	1	100%	3416-200250	1	100%	260-510270	1	100%
7215-50200499	1	100%	3254-100007	1	100%	3215-280754	1	100%
7214-48200427	1	100%	5213-10040034	1	100%	5126-25010034	1	100%
7112-06100435	1	100%	692-52121	1	100%	3114-500250	1	100%
822-1010	1	100%	3416-400032	1	100%	3413-100000	1	100%
822-1210	1	100%	3222-120707	1	100%	3114-501000	1	100%
863-1613	1	100%	620-5240	1	100%	5130-18040034	1	100%
827-0800	1	100%	5132-16200034	1	100%	3224-100030	1	100%
829-0210	1	100%	630-5202	1	100%	3218-600254	1	100%
7411-18000411	1	100%	5153-07000034	1	100%	632-5301	1	100%
5126-00000434	1	100%	630-5203	1	100%	5152-18000034	1	100%
5112-15020034	1	100%	692-5362	1	100%	3410-50180011	1	100%
3413-150000	1	100%	850000	1	100%	5155-14000034	1	100%
3416-200201	1	100%	692-85121	1	100%	3227-121015	1	100%
692-1202	1	100%	3416-400061	1	100%	5211-06020034	1	100%
5212-09040034	1	100%	5212-09000035	1	100%	3500-050502	1	100%
3416-200007	1	100%	3224-100010	1	100%	692-5364	1	100%
3254-100015	1	100%	260-510220	1	100%	3227-121030	1	100%
3410-901200	1	100%	3215-120903	1	100%	3416-200008	1	100%
3254-100020	1	100%	3416-100102	1	100%	3227-121060	1	100%
5121-10030034	1	100%	3110-300250	1	100%	3414-000025	1	100%
3254-100030	1	100%	3227-122045	1	100%	3227-121100	1	100%
3214-120041	1	100%	3311-093010	1	100%	3215-071003	1	100%
3416-200205	1	100%	3229-170000	1	100%	3105-700025	1	100%
692-5323	1	100%	3311-094000	1	100%	3222-120100	1	100%
692-86491	1	100%	3416-100110	1	100%	5212-15000035	1	100%
3214-170054	1	100%	3224-100020	1	100%	3215-120041	1	100%
3113-061000	1	100%	5125-10000234	1	100%	5212-15000734	1	100%
692-85141	1	100%	3224-100705	1	100%	3412-120020	1	100%
3300-100101	1	100%	3229-171020	1	100%			

Appendix H Number of order lines per zone divided into the ABC classification of products

	Type of article		
Zone	**A**	**B**	**C**
AA	410	60	44
AC	247	61	30
BA	414	133	247
BB	0	0	8
BC	187	26	14
BE1	390	37	24
BE2	194	12	0
BE3	315	0	10
BE4	236	19	2
BE5	417	55	16
BF	389	12	11
CA	773	13	7
CC	195	50	30
DA	297	6	0
DB	734	68	1
DC	16	0	2
DE	33	3	3
DH	10	0	4
EA	39	13	3
EB	237	16	1
EC	488	1	4
FA	0	1	1
FA1	256	8	13
FA2	123	51	62
FB1	159	60	38
FB2	946	48	89
FB3	15	11	0
FC1	312	9	9
FC2	319	35	2
FD	0	13	4
FD1	624	30	24
FD2	728	0	12
FE3	515	22	8
FE4	1082	0	6
FF1	604	23	19
FF2	282	38	50
FF3	114	35	35
FF4	56	59	35
FF5	75	73	66
FF6	659	51	40
FÖRPL FRAM	3	1	0
FÖRPLOCK FRAMSIDAN	1964	232	194
FÖRPLOCK GAVEL	149	11	17
GC	48	12	13
GD	317	95	196
GROMAK	0	0	1
GROMARK	291	43	29
HA	140	30	125
HB	114	40	89
HD	0	0	2
HE	508	18	39
HF	639	30	31
HG	177	112	59
KONTOR	77	51	46
KONTORET	1	17	27
KUND	0	0	6
LASTZONEN	0	0	6
MAX1	1625	218	222
MAXPLOCK	240	33	11
MOTTAGNING	0	0	3
MOTTAGNINGSPLATSEN	1	0	0
MPL	237	38	35
PORT 1	1	0	1
PORT07	76	9	7
PORT1	880	141	201
PORT11	61	1	5
PORT13	34	70	38
PORT15	0	1	2
PORT16	2	0	1
PORT7	1151	217	215
PRE	15	6	2
SNICK	4	0	0
UPP	42	7	9
VA	0	0	1
VA1	1936	362	359
XX	75	6	5

Percentage of order lines picked from the pre order area (förplock):

((3+1+0+1964+232+194+149+11+17)/29623)*100= 9%

Appendix I "Hot products" dependency analysis graphs

"Hot product" table that include the calculations for the graphs

In this table is represented the number of orders in which the "hot products" appears and the number of orders it is requested with their dependent products.

			Number of orders	
HP1	Asked alone		141	19%
9610-05060027	Asked with several products		577	81%
	HP1.1	9610-05050027	134	23%
HP2	Asked alone		60	11%
9531-05050027	Asked with several products		472	89%
	HP2.1	9730-39000027	222	47%
	HP2.2	9531-05050727	145	31%
	HP2.3	9611-04060027	81	17%
	HP2.4	9730-39000727	74	16%
	HP2.5	9531-05030027	77	16%
	HP2.6	9610-05060027	60	13%
HP3	Asked alone		52	10%
9730-39000027	Asked with several products		467	90%
	HP3.1	9531-05050027	224	48%
	HP3.2	9611-04060027	90	19%
	HP3.3	9531-05050727	84	18%
	HP3.4	9730-39000727	86	18%
	HP3.5	9610-05060027	72	15%
	HP3.6	9531-05030027	50	11%
HP4	Asked alone		87	18%
9610-06060027	Asked with several products		341	82%
	HP4.1	9610-06050027	100	29%
	HP4.2	9510-10400027	75	22%
	HP4.3	9510-10060027	51	15%
HP5	Asked alone		53	17%
9712-70000027	Asked with several products		164	83%
	HP5.1	9712-35000027	65	40%
	HP5.2	9510-07060027	35	21%
HP6	Asked alone		14	5%
9531-05050727	Asked with several products		257	95%
	HP6.1	9531-05050027	150	58%
	HP6.2	9730-39000027	87	34%
	HP6.3	9730-39000727	79	31%
	HP6.4	9611-04060027	54	21%

HP7	Asked alone		38	14%
9611-04060027	Asked with several products		233	86%
	HP7.1	9730-39000027	96	41%
	HP7.2	9531-05050027	87	37%
HP8	Asked alone		63	24%
9610-04060027	Asked with several products		196	76%
	HP8.1	9730-390000027	47	24%
HP9	Asked alone		31	12%
9910-10000139	Asked with several products		224	88%
	HP9.1	9910-10001139	76	34%
	HP9.2	9920000004	65	29%
	HP9.3	9910-10010439	58	26%
	HP9.4	9910-10009439	55	25%
HP10	Asked alone		18	6%
9510-07060027	Asked with several products		234	94%
	HP10.1	9510-10060027	92	39%
	HP10.2	9510-07040027	75	32%
	HP10.3	9610-06060027	65	28%

Graphs for "hot products" and their dependent products

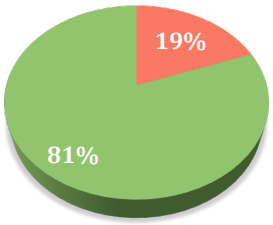
For each "hot product" is given:

- The product description.
- A pie graph with the percentage that the product is requested alone.
- A bar graph with the products that have been ordered with the studied product and with a percentage higher than 20%.
- A bar graph that represents the locations where the product was stored.

Article 1: 9610-05060027

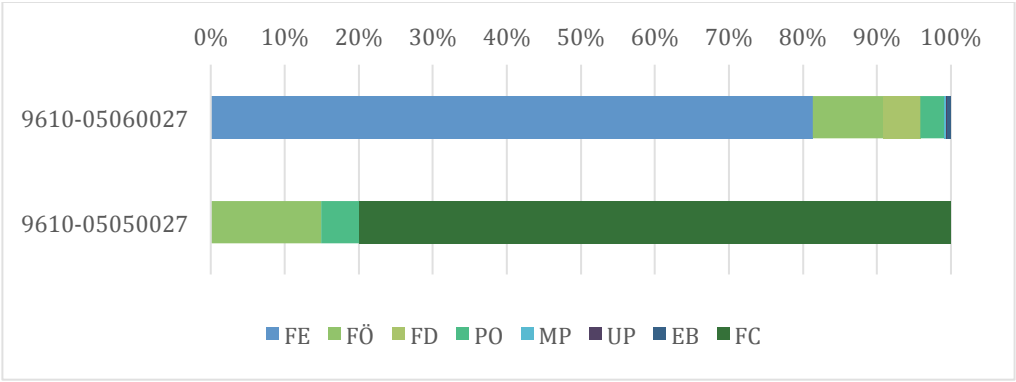
Products specifications:

9610-05060027: Klassikplattan 350x350x50 // Naturgrå
9610-05050027: Klassikplattan 175x350x50 //Naturgrå



Asked alone

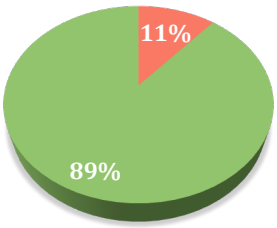
Asked with several products

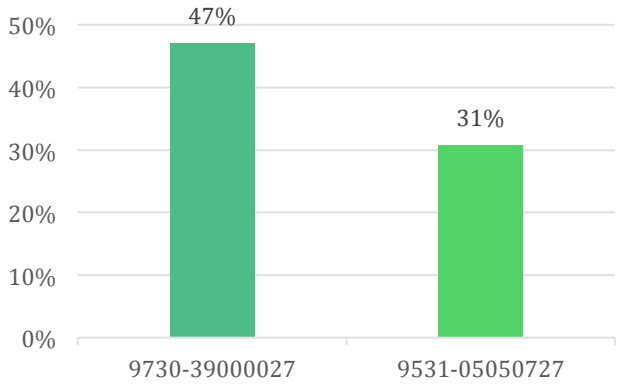


Article 2: 9531-05050027

Product specifications:

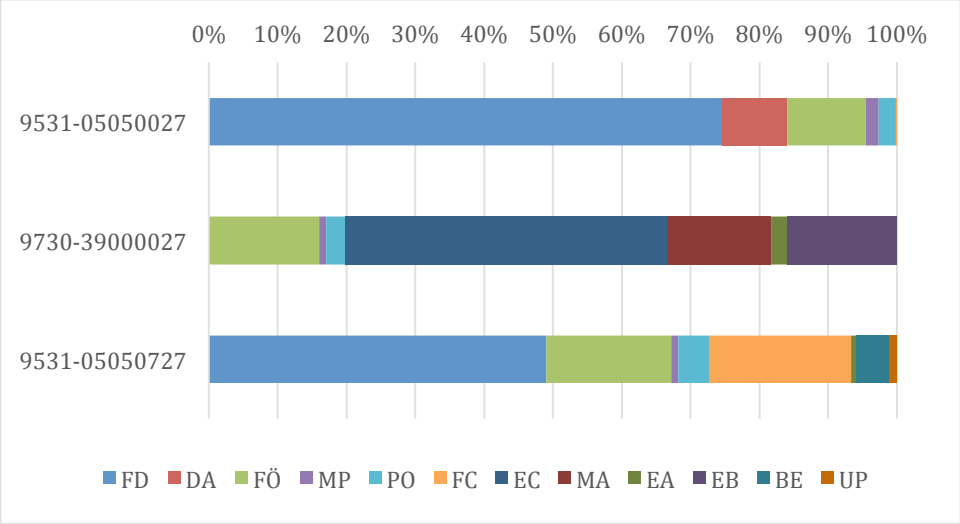
9531-05050027: Rustik 133x200x50 // Naturgrå
9730-39000027: Rustik normalblock 190x390x138// Naturgrå
9531-05050727: Rustik 133x200x50 // Antracit





Asked alone

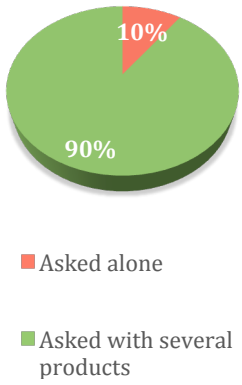
Asked with several products

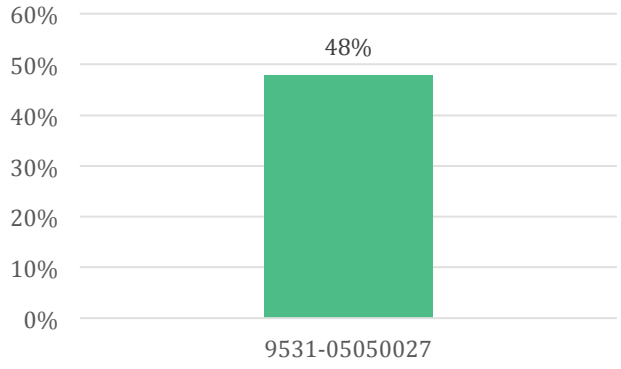


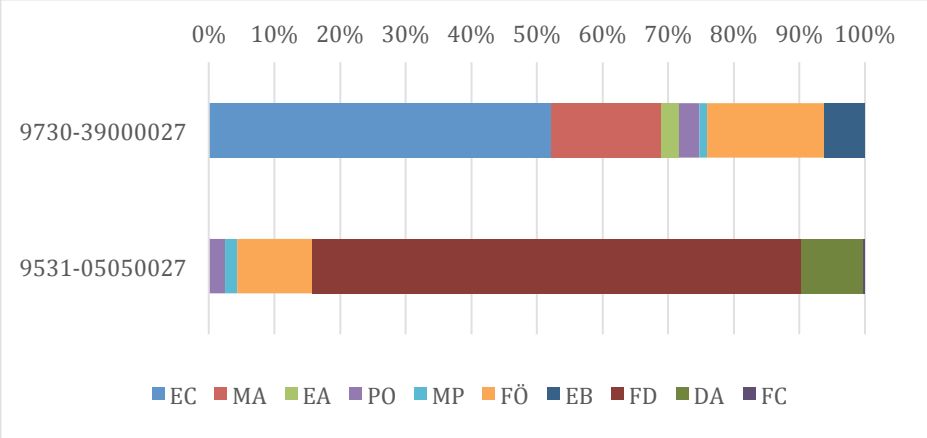
Article 3: 9730-39000027

Product specifications:

9730-39000027: Rustik normalblock 190x390x138// Naturgrå
9531-05050027:Rustik 133x200x50//Naturgrå



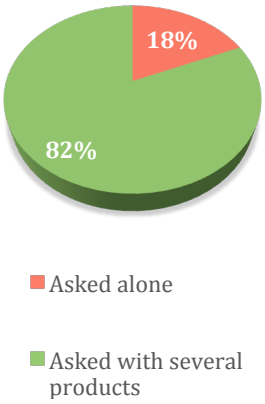


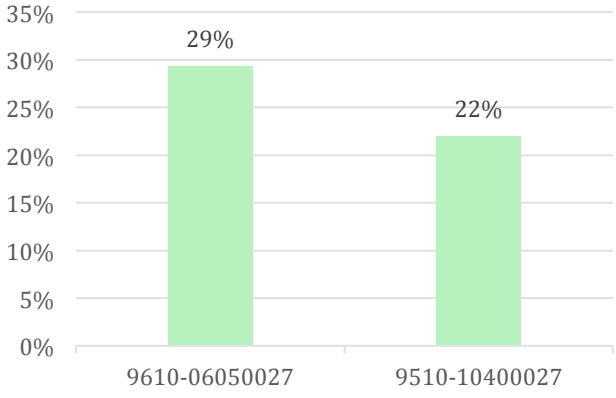


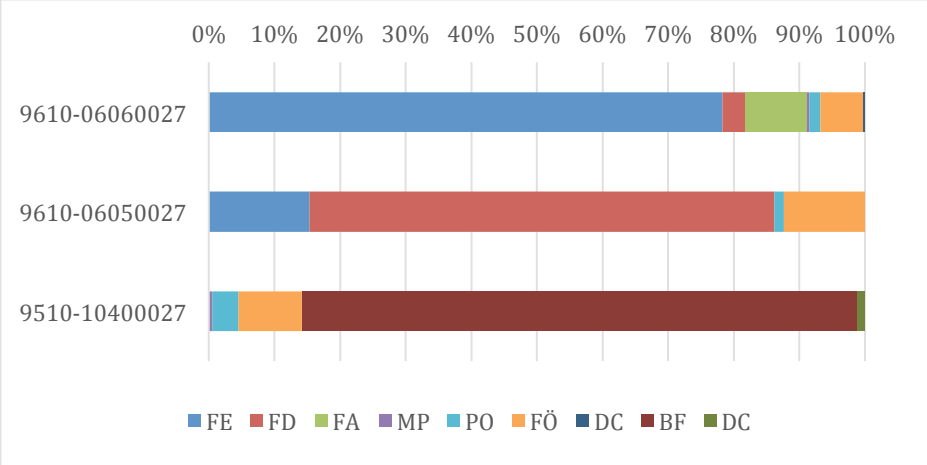
Article 4: 9610-06060027

Product specifications:

9610-06060027: Klassikplattan 350x350x60//Naturgrå
9610-06050027: Klassikplattan 175x350x60//Naturgrå
9510-10400027: Munksten gräsmunk 210x210x100//Naturgrå



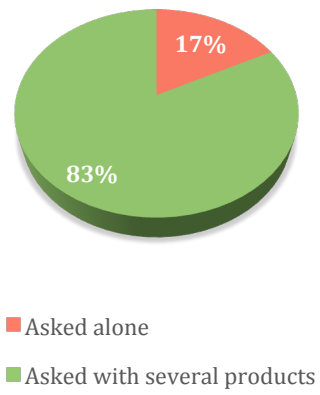


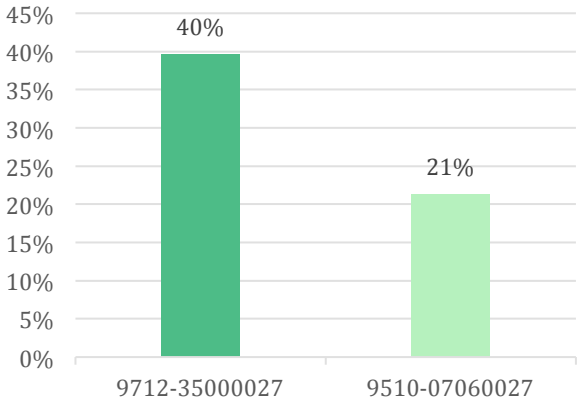


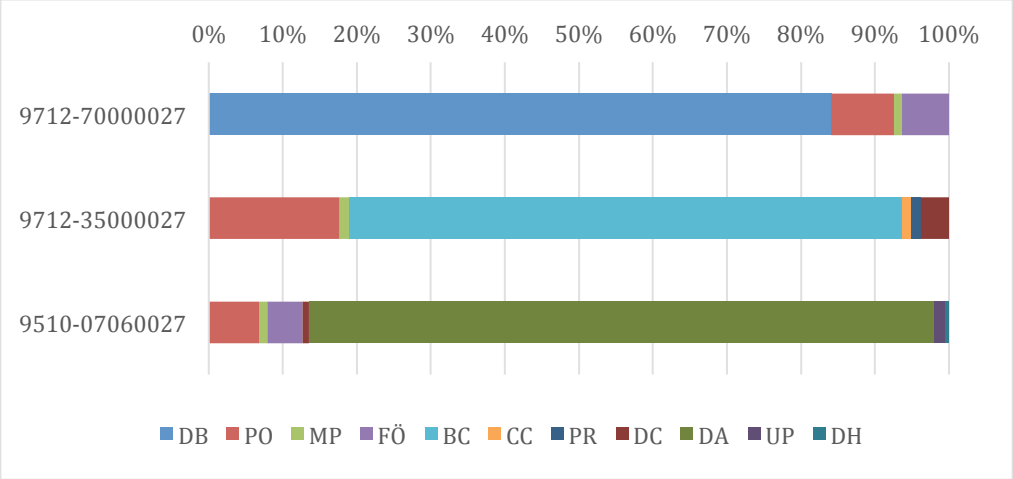
Article 5: 9712-70000027

Product specifications:

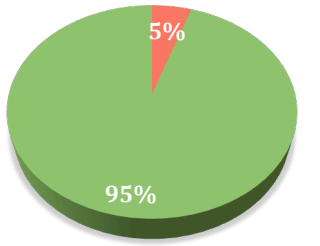
9712-70000027: Campus 350x700x175//Naturgrå
9712-35000027: Campus 350x350x175//Naturgrå
9510-07060027: Munksten 210x210x70//Naturgrå

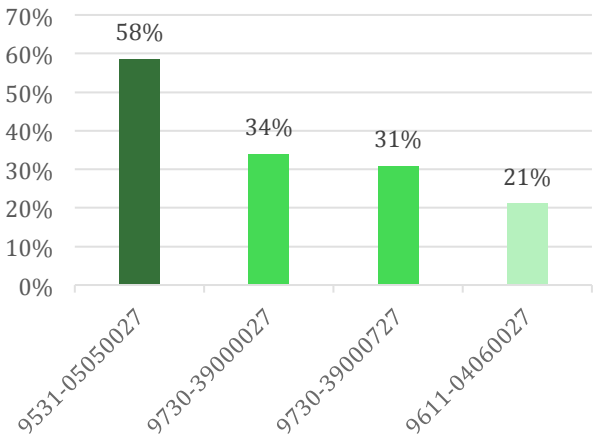


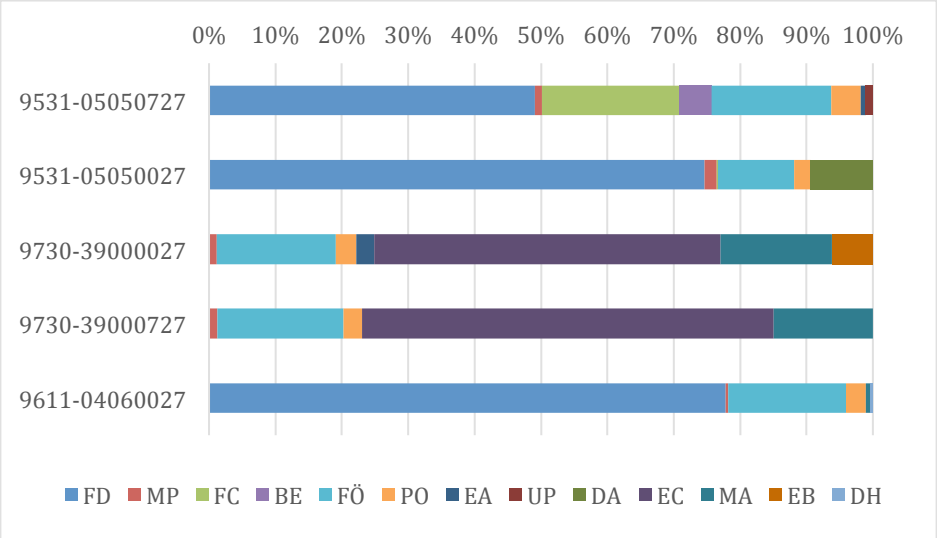




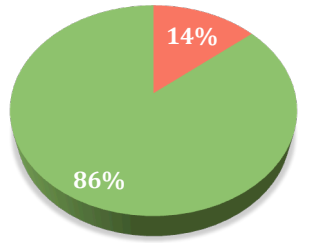
Article 6: 9531-05050727

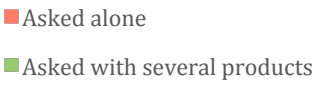


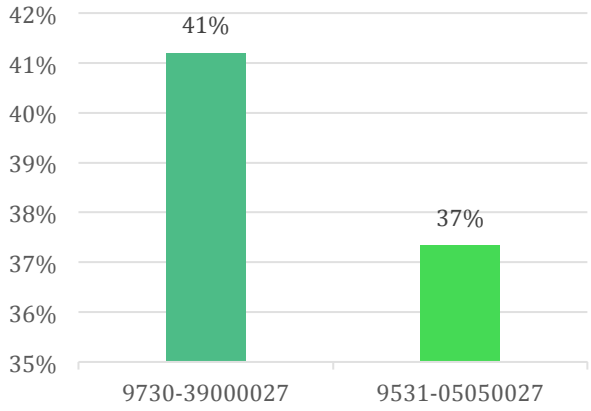


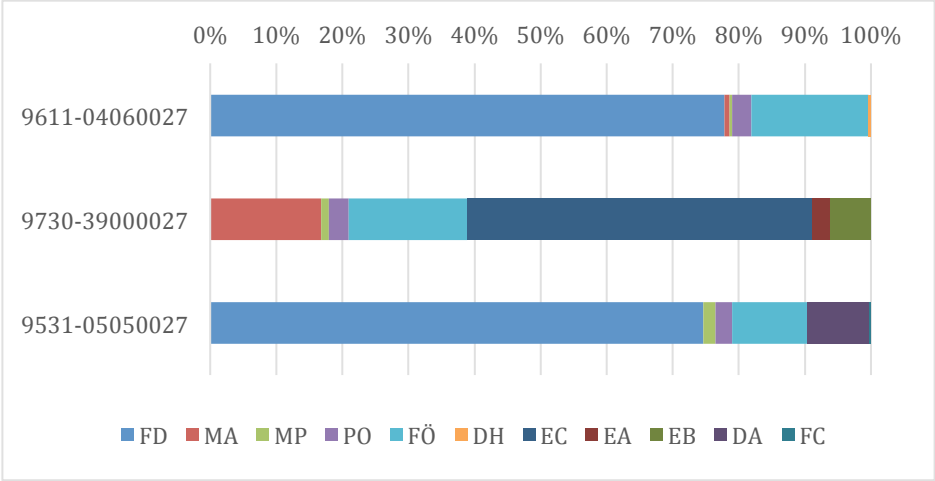


Article 7: 9611-04060027

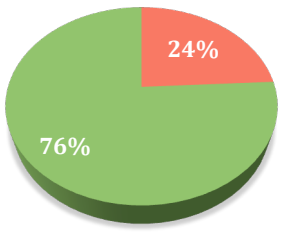


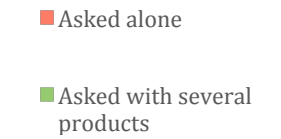


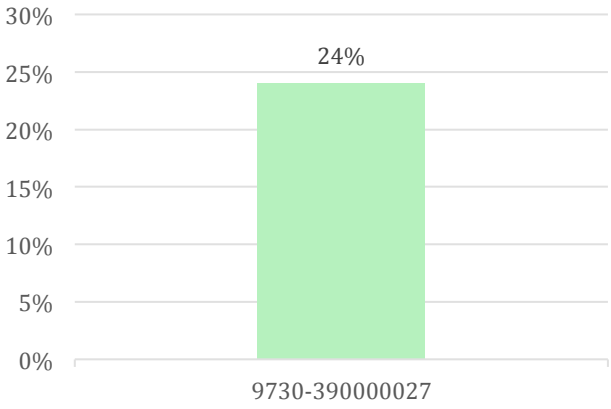


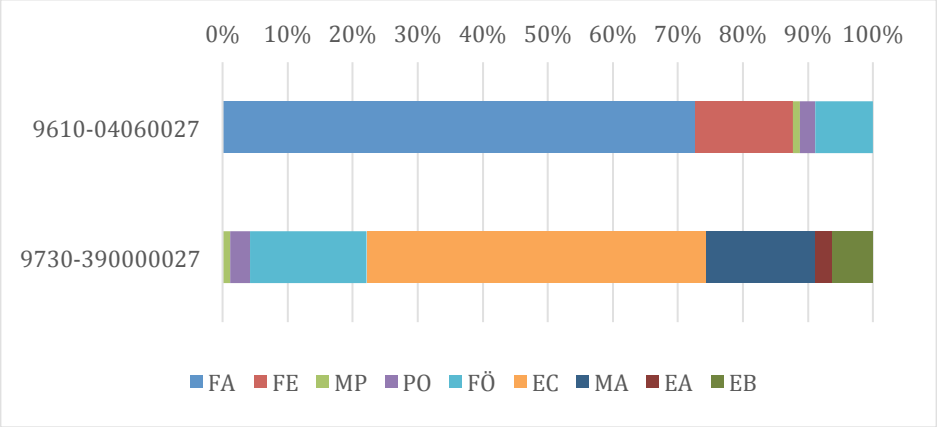


Article 8: 9610-05060027

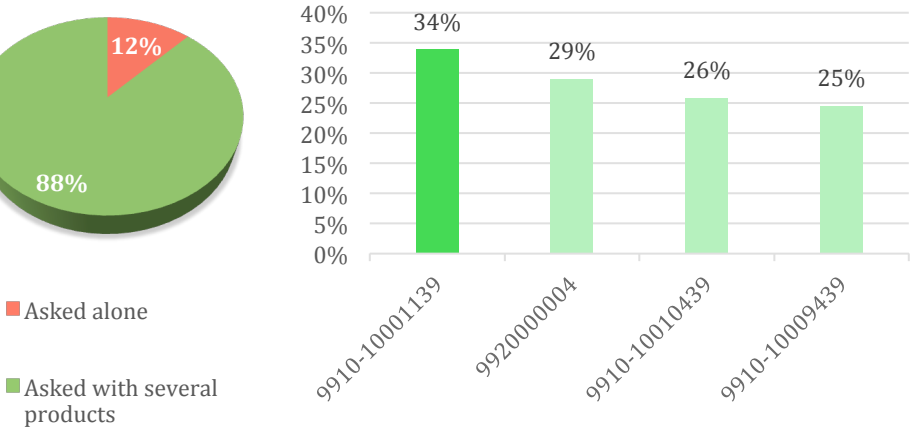


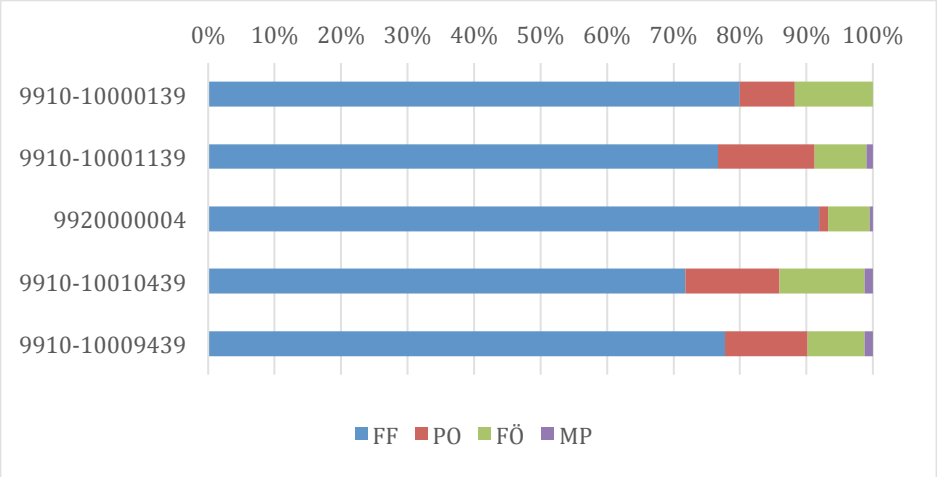




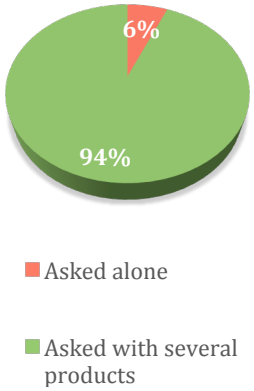


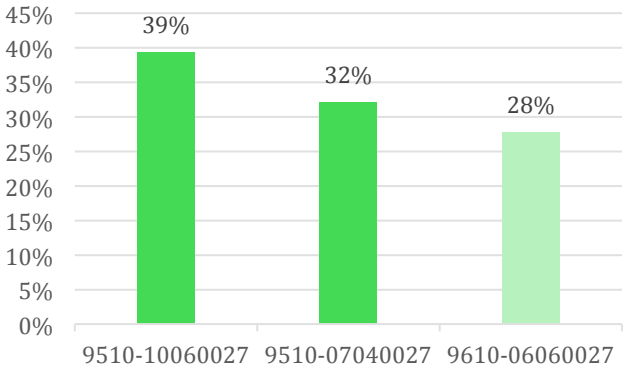
Article 9: 9910-10000139





Article 10: 9510-07060027





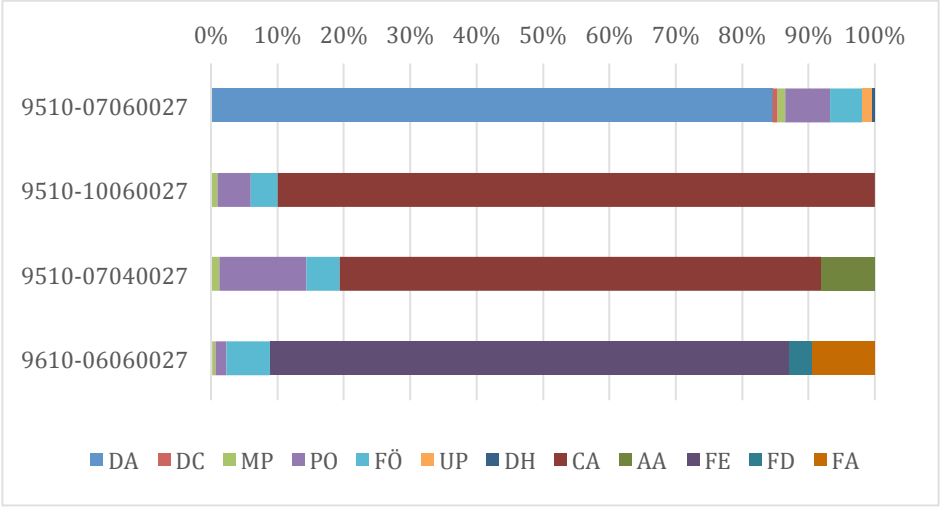
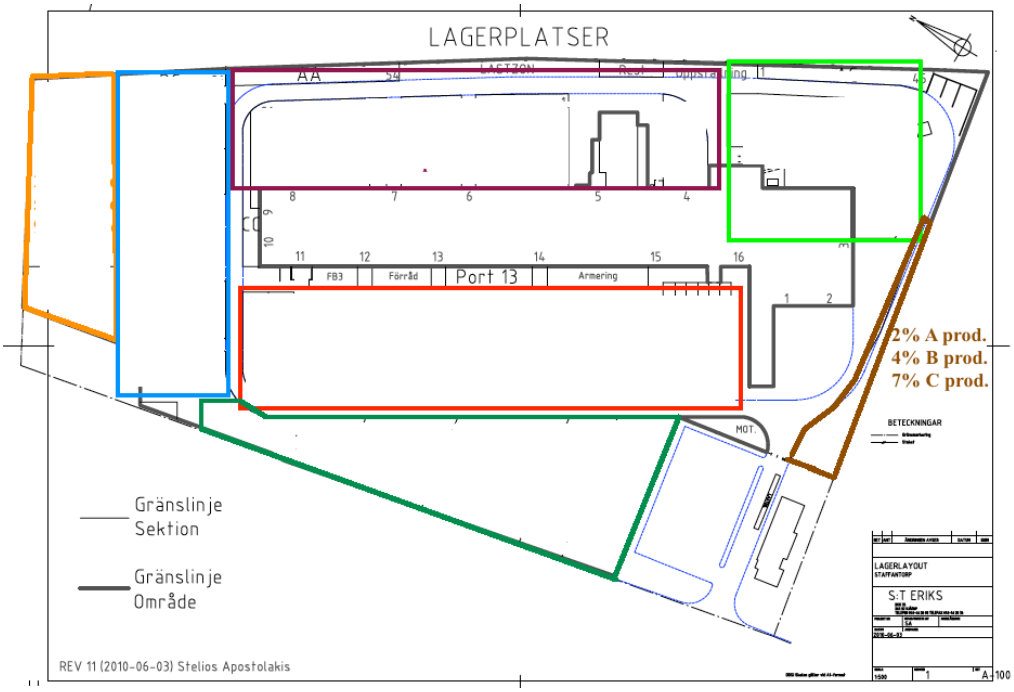


Table with all the products studied in the ABC analysis and the number of time they have been requested (not together with other products)

	Number of order lines	Percentage of total order lines	ABC classification
9610-05060027	718	2,42%	A
9531-05050027	532	1,80%	A
9730-39000027	519	1,75%	A
9610-06060027	428	1,44%	A
9712-70000027	296	1,00%	A
9531-05050727	271	0,91%	A
9611-04060027	271	0,91%	A
9610-04060027	259	0,87%	A
9910-10000139	255	0,86%	A
9510-07060027	252	0,85%	A

9610-05050027	164	0,55%	A
9610-06050027	130	0,44%	A
9510-10400027	176	0,59%	A
9712-35000027	85	0,29%	A
9730-39000727	247	0,83%	A
9910-10001139	103	0,35%	A
9920-000004	221	0,75%	A
9910-10010439	78	0,26%	A
9910-10009439	81	0,27%	A
9510-10060027	100	0,34%	A
9510-07040027	160	0,54%	A
		18,05%	



The following values are calculated in number of lines that allocates different types of products, but in some cases it has not been possible and an approximation has been made.

		Inventory		Picks	
Area	**ABC products**	**Number of lines**	**% total space**	**Number of picks**	**% number of picks**
Purple	A	71	71%	2370	10%
	B	15	15%	148	5%
	C	14	14%	59	2%
Red	A	175	46%	6872	29%
	B	46	12%	561	19%
	C	128	42%	505	17%
Dark green	A	48	27%	1659	7%
	B	26	15%	236	8%
	C	101	58%	357	12%
Blue	A	105	73%	2133	9%
	B	21	15%	148	5%
	C	18	13%	89	3%
Orange	A	16	12%	474	2%
	B	10	8%	148	5%
	C	105	80%	267	9%

Green	A	27	44%	948	4%
	B	10	16%	89	3%
	C	25	40%	30	1%
Brown	A	7	10%	474	2%
	B	8	12%	118	4%
	C	53	78%	208	7%

If the areas next to the shipping areas are prioritized, it will implies that the number of picks in these areas will increase, to determinate that increment a simple calculations are done. The areas that are going to be prioritized are for A products: purple, red and dark green. For B products area blue and green will be designed and orange area will be designed for C products.

Purple area: 71%products → 2370 picks X=1*2370/0,71=3338 picks

100%products→ X

Increased activity=$\frac{|2370-3338|}{2370} * 100 = 40\%$

Red area: 46%products→6872 picks X=1*6872/0,46=14939picks

100%products→ X

Increased activity=$\frac{|6872-14939|}{6872} * 100 = 117\%$

Dark green area: 27%products→1659 picks X=1*1659/0,27=6144 picks

100%products→X

Increased activity=$\frac{|1659-6144|}{1659} * 100 = 270\%$

Appendix K ABC storing policy test

This table provides the analysis performed in order to verify the reallocations of products according to the ABC and the "hot products" classifications. The test is done for a random day, in this case is the 18th of September 2013, and it only considers the articles stored in the main warehouse. It id calculated the approximated distances with the current distribution of products and with the proposed one.

S1: distances for top shipping area

S2: distances for bottom shipping area

S: shipping area: 1 for top shipping area and 2 for the bottom shipping area

D: distance for the selected shipping area

Distance reduction=$\frac{517-317}{517} * 100 = 38{,}68\%$

Order	Article		Current location	S1	S2	S	D	New loc.	S1	S2	S	D
418426	9411-70000027	A	FE3	24	5	2	5	FE3	24	5	2	5
418426	9531-04050027	A	BE	9.5	17	2	17	AA	6	17.5	2	17.
418426	9410-50000027	A	FE3	24	5	2	5	FE3	24	5	2	5
418426	3215-121003	C	BA	13	17	2	17	BA	13	17	2	17
791985	9526-08000027	A	BE5	9.5	17	1	9.5	AA	6	17.5	1	6
791985	9526-08000027	A	BE5	9.5	17	1	9.5	AA	6	17.5	1	6
804921	9526-08000027	A	BE5	9.5	17	1	9.5	AA	6	17.5	1	6
804921	9526-08000527	A	BE5	9.5	17	1	9.5	AA	6	17.5	1	6
818212	7114-12202027	A	FA2	18.	6.5	2	6.5	FA2	18.5	6.5	2	6.5
818995	9714-50000027	A	DB	0.5	22.5	1	0.5	DB	0.5	22.5	1	0.5
818995	9510-10100727	B	DB	0.5	22.5	1	0.5	EA	7.5	22.5	1	7.5
819096	899-0001	B	FD1	22	3	2	3	BE1	14	12	2	12
819204	9526-08000027	A	BE5	9.5	17	1	9.5	BE5	9.5	17	1	9.5
819962	3500-050420	B	BA	13	17	1	13	BE3	12	14	2	14
820214	9610-07060027	A	FD2	24	3	2	3	DB	0.5	22.5	1	0.5
820214	9510-07060027	A	DA	2.5	20	2	20	DA	2.5	20	1	2.5
820214	9510-10400027	A	BF	16	10	2	10	CA	6	17.5	1	6
820309	9730-39000027	A	EB	10	20	1	10	DB	0.5	22.5	1	0.5
820337	9740-30000027	A	DB	0.5	22.5	1	0.5	FD2	24	3	2	3
820343	7114-04200427	A	HE	22	2	2	2	HE	22	2	2	2
820370	9612-05060011	A	FF2	25	6.5	2	6.5	DB	0.5	22.5	1	0.5
820534	9612-05060011	A	FF2	25	6.5	2	6.5	DB	0.5	22.5	1	0.5
820534	9714-50000027	A	DB	0.5	22.5	2	22.	DB	0.5	22.5	1	0.5
820563	9412-101000	A	FE4	25	7	2	7	FE4	25	7	2	7
820585	9714-50000727	A	DB	0,5	22,5	2	22,	DB	0,5	22,5	2	22,

820585	9752-30110727	B	FB1	18.	6.5	2	6.5	FD2	24	3	2	3
820585	9752-24010727	B	FB1	18.	6.5	2	6.5	FD2	24	3	2	3
820585	9531-05050727	A	FD1	22	3	2	3	FC2	22	3	2	3
820585	9531-05050627	A	FC2	22	3	2	3	FC2	22	3	2	3
820620	9671-04066012	A	FF1	24	5.5	2	5.5	DB	0.5	22.5	1	0.5
820620	9531-05030027	A	AC	10	20	2	20	AA	6	17.5	1	6
820620	9531-05050027	A	FD1	22	3	2	3	FC2	22	3	1	22
820632	9714-50000727	A	DB	0.5	22.5	2	22.	DB	0.5	22.5	1	0.5
820632	9672-06063212	C	FF6	23	9	2	9	DB	0.5	22.5	1	0.5
820641	9910-10009439	A	FF6	23	9	2	9	FF6	23	9	2	9
820641	9910-10010439	A	FF6	23	9	2	9	DB	0.5	22.5	2	22.
820641	9910-10000239	A	FF6	23	9	2	9	FD2	24	3	2	3
820689	9730-19030027	A	AC	10	20	1	10	DB	0.5	22.5	1	0.5
820783	9641-04062212	A	HA	17	5	2	5	DB	0.5	22.5	1	0.5
820783	9611-04060027	A	FD2	24	3	2	3	DB	0.5	22.5	1	0.5
820783	9611-04050027	A	FE3	24	5	2	5	DB	0.5	22.5	1	0.5
820793	9912-08001139	A	FF4	23	7	2	7	DB	0.5	22.5	1	0.5
820793	9914-10001139	A	FF4	23	7	2	7	DB	0.5	22.5	1	0.5
820793	9912-08000239	B	FF4	23	7	2	7	DB	0.5	22.5	1	0.5
820793	9912-08000239	B	FF4	23	7	2	7	DB	0.5	22.5	1	0.5
820805	7114-06200427	A	HE	22	2	2	2	HE	22	2	2	2
820809	3218-600003	C	BA	13	17	1	13	BA	13	17	1	13
820841	9610-05060027	A	FE4	25	7	2	7	DB	0.5	22.5	1	0.5
820846	9610-05060027	A	FE4	25	7	2	7	DB	0.5	22.5	1	0.5
820846	9610-05050027	A	FC1	20	4.5	2	4.5	DA	2.5	20	1	2.5
820863	9531-05050527	A	BA	13	17	2	17	FC2	22	3	2	3
820863	9531-05050727	A	FD1	22	3	2	3	FC2	22	3	2	3
820863	9531-05051427	A	FC2	22	3	2	3	FC2	22	3	2	3
820863	9531-05030527	B	AC	10	20	2	20	AC	10	20	2	20
820869	9520-07060027	A	BE3	12	14	2	14	CA	6	17.5	1	6
820904	9912-08000939	B	FF4	23	7	2	7	DB	0.5	22.5	1	0.5
820904	9912-08000439	B	FF4	23	7	2	7	DB	0.5	22.5	1	0.5
820904	9912-08000239	B	FF4	23	7	2	7	DB	0.5	22.5	1	0.5
820963	9412-781205	A	HG	28	6	2	6	HG	28	6	2	6
820967	9531-05050727	A	FD1	22	3	2	3	FC2	22	3	2	3
820967	9531-05051227	A	FD2	24	3	2	3	FC2	22	3	2	3
820967	9531-05050627	A	FC2	22	3	2	3	FC2	22	3	2	3
820970	9610-04060027	A	FA1	14	8	2	8	FC2	22	3	2	3
							517					**317**