
# Designing warehousing Principles for Volvo Car Parts Central distribution center

Bachelor's thesis in mechanical engineering

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Designing warehousing principles for Volvo Car Parts Central distribution center.
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## Abstract

The aftermarket sector is one of the most profitable parts of the automotive industry, which has led to more attention and investments. Due to them being highly profitable, the organizations are constantly looking for ways to improve in order to provide a higher level of service in the most efficient way.

Recently there has been a major adaptation of Toyotas lean principles in the automotive industry which has showed to help boost productivity and efficiency. Due to its inarguable benefits Volvo Cars has decided to use parts of the lean principles and compile a documented framework, purposely created to help assist with standardization within their processes.

The purpose of this thesis has consisted of investigating and documenting the various processes and barriers that exist within the operation. Alongside documentation, the thesis has consisted of conducting studies on how the various processes can be improved with the help of supporting principles. The principles have been established with the support of engineers and fundamentals from the lean philosophy.

The conclusion drawn from the analysis is that the organization should focus on optimizing the storage methods, frequency classifications and housekeeping to set the proper grounds in their operations. The principles recommended are established to help create a more structured and effective way of work and providing a more proactive approach to dealing with other barriers that may be stumbled across.

Keywords: Lean, Distribution center, warehouse, principles, standardization, 5S.

## Acknowledgements

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First and foremost, we would like to thank everyone that has supported us throughout the course of work. We would like to especially thank our supervisor Sture Simonsson at Volvo Cars Central Distribution Center for his support, invaluable experience and guidance during the extensive thesis. Despite the unfortunate situation with the Covid-19 pandemic, Sture has made himself fully available during the entire process. He has been a vital part of making our bachelor's thesis possible by providing us with necessary resources in the form of data, interviews, and unlimited access to the organization.

We would also like to thank all employees that has been there to take part in the interviews, answering our questions and sharing their valuable knowledge with us. The people that attended our interviews were able to aid us in our field studies have been the main contributors that has helped us reach our result.

We hope that the document constructed proves to be a beneficial tool for the organization to work with continuous improvements and help create more standardized work.

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# 1. Introduction

*In this chapter an overview of the thesis is presented. The first section includes the background to the problem, the purpose, and the research questions which the background and purpose defines. The second section presents the limitations of the thesis, the sustainability aspects, and the thesis outline.*

## 1.1 Background

Volvo Car parts central distribution center provides spare parts to Volvo car owners all over the world. They supply spare parts to approximately 2500 workshops around the world, serving around 60.000 cars and customers daily. Their service vow says that spare parts should be available for cars up to 15 years old. This creates fluctuations due to the big variations and has led the warehouse operation towards stockpiling articles. Resulting in a low warehouse utilization and at the same time, the company is going through an expansive phase. Thus, measures are required to be made to reach the desired outcome.

CDC is currently operating in a very tough and competitive environment which has created a demand to be as efficient as possible. To be able to secure the top position for spare parts distribution in a luxury vehicle category as Volvo it requires them to be ahead of multiple aspects. The operation must be more efficient and streamlined, meaning that robust warehousing principles are implemented and used by everyone in the operation. Therefore, the employees must know what these principles are in order to reach the joint goal of continuous improvements and increased efficiency. This is possible by having a document containing these guidelines, standards and principles that enables the possibility of standardized work. This document is also useful as an assurance that what is being developed or created is within the company's realms and in full compliance.

There are few main prerequisites that are particularly important to achieving a successful and streamlined way of work within warehousing. These prerequisites contain of being as flow efficient as possible whilst using the limited resources to their maximum potential. Another point is the market perspective, this entails the ability to being flexible enough where changes in the market leads to changes in their business strategy to stay ahead. To be able to properly balance these aspects in a manageable way requires a structured and standardized organization.

## 1.2 Purpose

The aim is to evaluate which warehousing principles would be most beneficial for Volvo Car parts Central distribution center. The principles should align with lean principles such as “the right thing at the right place” and better flow. Including the assurance of continuous improvements to minimize unevenness, overburden, and different types of operational waste.

## 1.3 Research questions

- Where are the major challenges within the warehouse that prevents the company from a successful lean implementation?
- What principles are suited to reach the wanted state?
- What are the benefits with a flow-oriented warehouse?

## 1.4 Limitations

The scope will not include the following:

- Testing the result of the study regarding the framework, it will only include evaluation made with the tools we have available.
- Total costs for implementation of the solution will not be calculated, since it is highly dependent on the solution chosen and may also vary over time.
- Unfortunately, we live under a global pandemic and the spread of Covid-19 will limit the work in some ways. A much greater part of the interactions will be digital and therefore the communication will be suffering.

## 1.5 Sustainability

This thesis will also be based on a sustainability purpose. The United nations has global goals for a more sustainable world. Our thesis will mostly encounter the goal of sustainable production and industry, but also the term of sustainable working conditions. Our aim clearly states that we want the operation to achieve more flow and reduce waste. By reducing waste, internal transport distances should be minimized. The workload should be less uneven, and maintenance increased. The sustainability aspect of this means that less energy will be required to keep the business going, it will also require less wear on both tools, and workforce.

## 1.6 Thesis outline

The thesis is divided into different chapters, these are briefly described below.

*Chapter 1 Introduction* - In this chapter an overview of the thesis is presented. The first section includes the background to the problem, the purpose, and the research questions which the background and purpose defines. The second section presents the limitations of the thesis, the sustainability aspects, and the thesis outline

*Chapter 2 Theoretical Framework* - This chapter describes the theoretical foundation that is used to form the study plan. It is also used as a base for analysing the result in terms of how well it answers the stated problems. The chapter includes the theoretical processes used within warehousing, planning and control in combination with parts of the lean philosophy.

*Chapter 3 Methodology* - This chapter entails the approach and methodological approach used to research and gather information for the project. A focal point in this process has been the reliability and validity of the chosen methods used to collect data for the presented result.

*Chapter 4 Result* - This chapter presents the resulting findings gathered within the operation at Volvo Car Parts. The findings will be presented as a Current and Wanted state. The current state is information based on interviews and field studies, and the wanted state is based what the engineers and the management shared with us.

*Chapter 5 Analysis & discussion* - In this section an analysis of the research questions and based on the answers, the analysis follows with suggested principals. The principals analysed through comparing how well they meet the utilized theories in combination with the wanted state.

*Chapter 6 Conclusion and recommendation* - This section presents a summary of what conclusions can be drawn from the thesis analysis. It also includes recommendations on how the company can further develop these principles in the future.

# 2. Theoretical framework

*This chapter describes the theoretical foundation that is used to form the study plan. It is also used as a base for analysing the result in terms of how well it answers the stated problems. The chapter includes the theoretical processes used within warehousing, planning and control in combination with parts of the lean philosophy.*

## 2.1 Warehouse and distribution center

Warehouses and distribution centers are a core element, it enables goods flows that connects supplier and consumer. Warehouses and distribution center are often associated with tied up capital and non-value adding operation, but fact states that almost all business needs storage to be able to keep a high level of service.

The basic processes in a warehouse of distribution center is simple. Articles that are not used immediately requires storage and will be put away until the demand for the article occurs. When an order is places it will be retrieved and transferred. The main steps in this process contains goods receiving, storage, replenishment, picking, and cross-docking (Hompel & Schmidt, 2007).

***Goods Receiving***
Goods receiving is the inspection process of goods being delivered to the business, it includes inspection of quantity and a description check towards the placed order. Afterwards the quality and condition of the product is made before its logged and processed into the system.

***Storage***
The storage process can be referred to as a stationary process where the material is not moving through the flow but at the same time tied up in the flow itself. The size of the stocked material is dependent on the size and speed of flow. The Storage is also a connection between the inbound flow connected to the supply chain and the outbound flow which is the distribution system (Jonsson & Mattsson, 2020).

***Replenishment***
The material replenishment is part of the material handling in the warehouse. Its fundamental cause it to hyperlink processes together to ensure that the goods needed are available for next processes. The goal with material replenishment is to keep stock levels are a balanced level that correspond to the demand to prevent overstocking. A way to work with material replenishment is through re-order point systems. It is a method that helps synchronize orders and stock with the demand in order to promote a balanced material flow (Jonsson & Mattson, 2016). It works by having the system replenish materials once stock levels fall below given reference quantity (Jonsson & Mattson, 2016). The re-order system is one of the most effective and commonly used systems for material replenishing in the aftermarket business.

***Picking***
Order picking can be defined as “the process of retrieving products from storage or buffer areas in response to a specific customer request” (Koster & Le-Duc, 2007). It is a process that is carried out where goods are extracted from a storage in response to a customer order. There are

two types of picking systems used in warehouses, manual picking done by humans and machine picking.

Human picking is done by a picker to parts system where the picker travels within the warehouse to the picking destination to retrieve the requested items. A picking route can consist of multiple parts being picked in batches along the way or the retrieval of a specific item.

Machine picking is an automated system where the machine collects the items from a automation prepared section of the warehouse, usually created so that both the process of storing and collecting of a part are automated (Koster & Le-Duc, 2007).

***Cross-docking***

Cross-docking is a distribution process in which goods from a retailer or production facility are delivered directly to a buyer or distribution chain with little or no processing or storage time (Hulshof, 2019). Cross docking usually occurs in a warehouse docking port, which normally has trailers and dock entrances on two sides (inbound and outbound) and no storage space. The method of receiving goods from an incoming dock and then moving them through the dock to an outbound shipping dock is known as cross docking.

In basic terms, incoming goods arrive via transport trucks and are assigned to a receiving area on one sides of the warehouse. If the inbound transportation has been received, the goods can be transported to outbound destinations either directly or indirectly; they can be unloaded, sorted, and inspected to determine their final destinations. Once the final destination has been determined, the goods can be loaded on the mean of transportation and be sent for delivery (Gerini & Sciomachen, 2019).

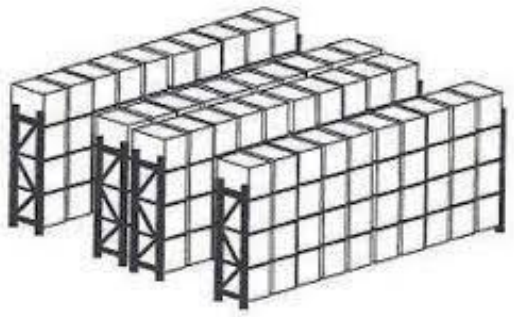
Since cross docking would not meet all warehouse's needs, it is critical to make an educated decision on whether it would boost efficiency, lower prices, and improve customer satisfaction. Cross docking will help to speed up the supply chain for a range of items. Additionally, cross docking will make transporting already packaged and sorted goods to a specific customer a quicker and more reliable operation.

### 2.1.1 Material storage

Depending on what type of material that needs to be stored, there are different storing methods that is suitable. Storage consists of storage equipment like shelving or rack with the function to store units between transports and processes (Zandin, 2001). The storage equipment must be compatible with the physical form of the unit that is to be stored (Zandin, 2001). Due to high costs of storing it requires cost effective storage solutions within the warehouse to prevent unnecessary costs. The most cost-effective storage equipment depends on the quantity of held materials and materials flow intensity (Zandin, 2001). (Lumsden, 2007) presents the most suitable storing methods within a warehouse with low automation.

***Pallet racking***

Pallet racking is the most used method of storage due to its space and cost-efficient solution for storing palletised goods. It is used for storing pallets in a single or multi-level system and allows for easy accessibility. Pallet racking is especially practical due to them being customizable where goods that are not stored in standard-sized pallets can still be stored just as easily.

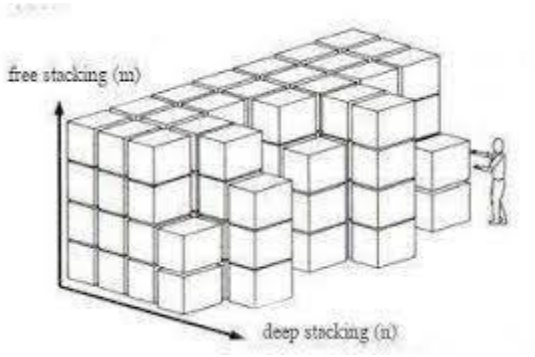


High/Pallet racking figure attained from (Jonsson & Mattson, 2016, ss. 73-74)

***Ground storage***

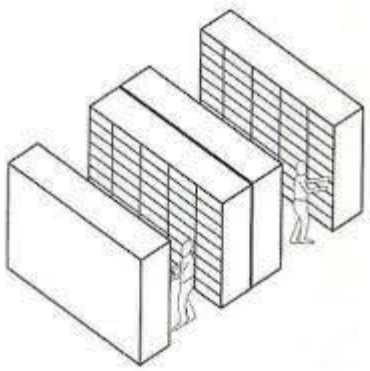
Ground storage is a storing method where larger goods a stored or stacked directly on the floor. The stacking depth or height are dependent on what type of characteristics the goods have, which can be the pallets load strength or weight. The method is a simple form of storage and therefore only requires little investment costs. It is also a flexible method that can be constructed as long as the aisle are wide enough. This type of warehouse storage functions best when being operated mainly manual.

There are two very common types of ground storage which is deep stacking and block stacking. Block stacking means having goods arranged directly upon another, side by side and one after the other. Making the storage space highly utilized but leading to low access when picking only can be performed at the front row. Deep stacking is another variant of block stacking where pallets are stored in depth in the desired quantity. It is a safe and effective method for storing goods that are fragile or to unstable to be block stacked. The ground storage methods only allows the pallet stored last to be accessed which makes it only suitable for last in first out (LIFO) (Hompel & Schmidt, 2007).




Block stacking figure attained from (Jonsson & Mattson, 2016, ss. 73-74)

***Shelving***
Shelving is practical for storing smaller and lighter goods, usually suitable for material that are picked by hand. This method makes it easy for the workers to quickly access goods due to the large number of articles stored in a smaller area. It is suitable for low to medium frequency articles due to the limited storage space in the shelves.



Shelving figure attained from (Jonsson & Mattson, 2016, ss. 73-74),

***Automated storage and retrieval system (ASRS)***
The system operates under computerized control, which determines where in the storage an item can be retrieved, schedules the retrieval, and also directs the machine whilst it gathers the material. Automation always include the benefit of reduced labor, but it also saves space. The ASRS gives the possibility to store material more dens and in higher racks (Hompel & Schmidt, 2007).

***Fist in First out (FIFO)***
FIFO is a storing and picking principle used to achieve a flow of stock (Lumsden, 2007). It entails that the material stored first is also picked first as the name suggests, it prevents material from going obsolete. Obsolete material will cause waste for the company in form of scrap.

## 2.2 Planning and control

### 2.2.1 Process design

Processes are defined as arrangement of resources and activities that transform inputs into outputs in a way that satisfies customer needs, transformed resources flow between each process. Therefore, process design has an important role, it defines the blocks that founds the operation. It is important that the performance or the output matches the performance of the process. To help judge the process performance there are several factors that defines such as, quality, speed, dependability, flexibility, cost, and sustainability (Slack, 2019).

Besides these factors there are “micro” process objectives listed below (Slack & Alistair, 2013).

- *Flow rate*
  Flow rate is the number of flow units that goes through a business/process per unit time. The flow rate in most scenarios is the average rate.

- *Cycle time*

Cycle time or takt time is the reciprocal of throughput rate. It is the time between items emerging from the process. The term “takt” time is the same but is normally applied to “paced” processes like moving belt assembly lines. It is the “beat” or tempo of working required to meet demand.

- *Throughput time*

Throughput time is the average elapsed time taken for inputs to move through the process and become outputs.

- *Work in progress*

The number of items in the process (also called the “work in progress”, or in-process inventory), as an average over a period of time.

- *Utilization*

The utilization of process resources is the proportion of available time that the resources within the processes are performing useful work.

### 2.2.2 Frequency Classification

How frequently an article is picked defines their classification and the classification can be used as a tool for planning. The frequency classification helps establish suitable limit values for the article, such as safety stock and run-out time which defines the inventory turnover rate. A way of defining frequency is through annual value classification, sometimes referred to as ABC-classification. The annual value classification is built on Pareto’s minority principles, it states that there is a small proportion which accounts for a large part of the effect. The principle can also be referred to as 80/20 rule where 20% of the articles account for 80% of the effect. Since the small proportion of articles defines such a big share, most resources and time should be spent on these because they are so significant for the operation (Jonsson & Mattsson, 2020).

### 2.2.3 Material planning

There are two ways to trigger order start, a push or a pull system. The push type is applied through having central planning or supplying unit initiating the process without a consuming unit that authorizes the plans. The pull type is applied when materials movement is initiated and authorized by the consuming unit. The difference between the two can be summarized as, the pull systems activities does not take place at all if there is no demand which does not apply for push. The pull system is also a concept based on small batches which will create direct and immediate material flow, this helps avoid unnecessary overprocessing. Both systems can be used in most material planning methods but it is how they are applied that defines the state. (Jonsson & Mattsson, 2020).

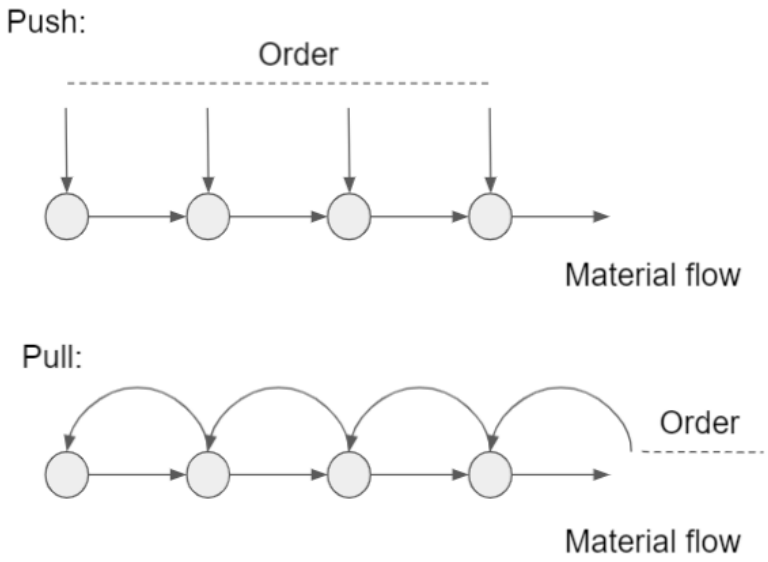



*Figure 1, Pull vs. Push illustration*

### 2.2.4 Kanban

Kanban is a Japanese word for card or signal, with the foundation from Lean the use of Kanban's is one method of operationalizing the pull system. In a simple form, it is a method used by a consumer or customer to signal for the supplier to deliver more items. The common principle used is that the receipt of a Kanban triggers the moment, production or supply of one unit or standard container of units (Slack & Alistair, Operations Management, 2013). (Jonsson & Mattson, 2016) states that Kanban is most suited for operations with a stable demand and predictable forecast, meaning a warehouse with a high variation of parts will not have much success with the implementation of Kanban.

It is a method used to manage workflow for establishing, managing, and improving services, this is done through six different practices that include:

Visualizing workflow, Limit WIP (Work In Progress), Manage Flow, Make Process Policies Explicit, Feedback loops and improving collaboratively.

***Two-bin system***

Two-bin systems is a type of Kanban that uses pull and is easily applied for small material. The system is based on having two bins of the same article available at the picking location. The picking will be performed at one bin at a time, when the first bins is empty it will be replenished, and the picker can continue picking from the second bin. When both bins are full, they should represent a maximum quantity for that article in that workspace (Ortiz, 2016).

## 2.3 Lean

The Lean movement is based on the Toyota production system (TPS) which has a unique approach to manufacturing. Toyota's performance has been synonymous to operational excellence because of their outstanding results (Liker, 2004). According to Slack (2019) Lean can be viewed as three things: a philosophy, a method of planning and control, and a set of improvement tools. The goal is to have material, information and customers flowing smooth though the operations, process, and supply network (Slack, Operations management , 2019).

### 2.3.1 Toyota's 14 management principles

In the book The Toyota way: 14 management principles from the world's greatest manufacturer, the fundamental business strategy of Toyota is described. The strategy is visualized through the 4P's which includes for Philosophy, Process, People and Partners, and Problem Solving. The approach of the 4P's is hierarchical, where Philosophy is the foundation and Problem solving is at the top. Each principle belongs to different steps in the hierarchy (Liker, 2004).

The 14 principles are:

*Philosophy*

1. Base management decisions on a long-term philosophy, even at the expense of short-term financial goals

*Process*

2. Create process "flow" to surface problems
3. Use pull systems to avoid overproduction
4. Level out the workload
5. Stop when there is a quality problem
6. Standardize tasks for continuous improvements
7. Use visual control so no problems are hidden
8. Use only reliable, thoroughly tested technology

*People and Partners*

9. Grow leaders who live the philosophy
10. Respect, develop, and challenge your people and teams
11. Respect, challenge, and help your suppliers

*Problem Solving*

12. Continual organisational learning through continuous improvements
13. Go see for yourself to thoroughly understand the situation
14. Make decisions slowly by consensus, thoroughly considering all options; implementing rapidly

### 2.3.2 The 7+1 wastes

All non-value adding operations is referred to as waste according to Lean, waste is a type of barrier that prevents streamlined flow. Value-adding operations can be defined as something that the customer is willing to pay for. There are three causes for waste, in Japanese they are called Muda, Mura and Muri (3M) which means Waste, Unevenness and Overburden (Slack, Operations management , 2019).

Depending on the operation there are different types of waste, Liker (2004) describes them as following:

1. *Overproduction*
   Production should be triggered by demand otherwise its overproduction. Producing without demand causes unnecessary overstaffing, storage, and transportations costs.

2. *Waiting (time on hand)*
   Employees waiting before they can start their process is waste. The waiting can be caused by bottlenecks, stockouts or a machine downtime.

3. *Unnecessary transport or conveyance*
   Moving material between stations unnecessarily many times or unnecessarily long distances is inefficient.

4. *Overprocessing or incorrect processing*
   All process steps should be value-adding for the customer. Poor product design can be a cause for overprocessing a part. When producing higher quality than needed, waste is generated.

5. *Excess inventory*
   This makes it harder to keep problems at surface, but also causes longer lead times, damaged goods, and unnecessary aged stock. Besides, total costs increase due to large amount of capital tied up.

6. *Unnecessary movement*
   All motion that the does not add value is waste, that motion could be stacking parts or tools, but also walking.

7. *Defects*
   Producing parts that needs rework, inspection or generates scrap, causes waste in form of time, handling, and effort.

8. *Unused employee creativity*
   Meaning losing skills, time, ideas, improvements from competence employees. But also missing learning opportunities that causes the company's development to stagnate.

### 2.3.3 5S

The 5S lean tool is used to create workplace organization and standardization. It helps create a well-organized work environment where there is "a place for everything and everything in its place, when you need it". The 5S's are Sort, Set in order, Shine, Standardize and Sustain. The good effects of 5S usually result in, fewer accidents, improved efficiency, a visual workplace and a foundation for all other improvement activities (Myerson, 2012).

1. Sort - Items locations are checked and evaluated. Removal of unnecessary articles or equipment
2. Set in order – Arrange workstations and necessary equipment in a way that enhances workflow
3. Shine – Inspection of the workplace while cleaning
4. Standardize – Implement procedures that enables the first the S's
5. Sustain – Organize follow ups on all S's and implement improvement

All steps are performed in the following order and when a cycle is complete it should be done again to keep the continuous improvements alive (see figure 2).

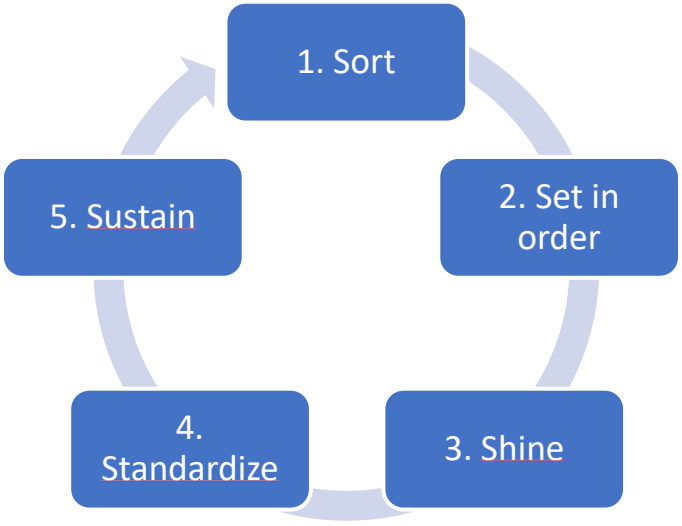



*Figure 2, 5S*

### 2.3.4 The 7 Storage Techniques

The 7 storage techniques is a Toyota lean philosophy designed for warehouses to ensure safety while maintaining quality and improving productivity (Toyota, 2020).

1. *Store by Product*
   The integrated storage plan should consider and address the specific characteristics of each product. Store parts of same type and shape together into specific zones.

2. *Store by Movement Rate*
   High frequent parts should be stored in a location that minimizes the distance it is moved, such as near primary aisles, shipping area and in low storage racks (no need for extended lifting) or for some super frequent parts an open floor space.

3. *Store Long and Thin parts Vertically*
   Vertical storage should be applied when suitable to gain high storage utilization.

4. *Store Within Easy Reach*
   Parts should be stored within easy reach for the picker to be able to pick them in an ergonomically way to avoid injuries.

5. *Store Heavy Parts Lower Down*
   Heavy parts should be assigned to locations low to the ground to minimize the effort and risk of heavy lifting. Visual irregularity movement control should be used to be able to act on deviations i.e., excess material for a specific part number should be stored at an extra location and not at the standard location dimensioned for this part.

6. *Store 1 Part Number 1 in Location*
   All parts should be stored in separated locations for the picker to be able to identify the part in a simple way and reduce picking errors.

7. *Irregularities*
   Visual irregularity movement control should be used to be able to act on deviations i.e., excess material for a specific part number should be stored at an extra location and not at the standard location dimensioned for this part.

### 2.3.5 Flow efficiency and Resource efficiency

Liker (2004) states that “Flow is at the heart of the lean message that shortening the elapsed time from raw materials to finished goods will lead to the best quality, lowest cost, and shortest delivery time”. How flow achieves this is through constantly driving waste out of the processes. A good example of this is the reduction of inventory, by reducing inventory the process will be more sensitive which makes the processes depend on each other. if continuous flow is not maintained it will cause the process to stop, making it easier to identify waste (Liker & Meier, 2006).

Lean promotes efficiency and there are two different ways of categorizing efficiency. The first one is resource efficiency and the second one is flow efficiency. The relationship between flow efficiency and resource efficiency is called the efficiency paradox because it is very hard to reach both types of efficiency. Resource efficiency measures how efficient one available resource is, meaning how much time the resource spends on value-adding time. Resource efficiency from a costs perspective is very justifiable, and it is commonly the focus in an organisation because utilization of resources is so valuable that it is seen as the most important factor (Modig & Åhlström, 2015). Flow efficiency does not focus on resource, it focuses on the flowing unit and can be defined by how much value-added time the flowing unit receives through the total lead time. According to Lean it is the customers' needs in focus, therefore the definition of the process value and demand is more important than high utilization.

There are three laws that defines the process of the flowing unit, Little´s law, the law of bottlenecks, and the law of the effect of variations on the process (Modig & Åhlström, 2015).

*Little´s law*
The law states according to Equation 1 that throughput time increases if the number of flowing units or cycle time increases.

$$\text{Throughput time} = \text{Flowing units in process} \times \text{Cycle time} \qquad \text{[Equation 1]}$$

*The law on bottlenecks*
Bottlenecks occur when one or several processes are slower than the rest. Queuing will start before the bottleneck, causing a clog that will starve the next process in line. The effect of bottlenecks will prolong the throughput time and limit process flow. The law on bottlenecks states that the process throughput time is constrained by the slowest process, with other words the identified bottleneck.

*The law of the effect of variations on the process*
The law of the effect of variations on the process states that throughput time will increase if the variation increases. Variation can be divided into three categories which includes resources, flowing units, and external factors. Resource variation can mean that needed tools availability vary. Flowing units' variation can be varying specifications for a product and external factors mean that demand can vary.

# 3. Methodology

*This chapter entails the approach and methodological approach used to research and gather information for the project. A focal point in this process has been the reliability and validity of the chosen methods used to collect data for the presented result.*

## 3.1 Research study design

The research study utilized a design that helped to acquire crucial data for use in analysing the strategies, principles and standards applied in Volvo Cars Parts Supply and Logistics. In order to propose principles that can be used in establishing guidelines for attaining maximum effectiveness while running a business in warehouse and logistics. This has been conducted as a case study focused on qualitative combined with quantitative research with the aim to investigate and document. The qualitative research entailed interviewing the warehouse operators and conducting field studies that included guidance through the warehouse processes with the team leaders. In addition, some secondary sources of information were also engaged in this research study for acquiring of secondary data.

This research design was particularly used because it brings the researchers close to their primary sources of information which allows for an easy and accurate gathering of information.

### 3.1.1 Quantitative research

The quantitative approach consists of gathering of data through observation, collection of measurements and statistical data collected through polls. The aim of the quantitative method is to determine whether the predictive generalisations of the proposed research questions hold through (Habib, 2014). The most used purpose of quantitative research is to examine the relationship between two variables within a population. The studies made are either experimental or descriptive. Quantitative research is mainly focused on numeric and unchanging data, that is convergent reasoning rather than divergent. The method is carried out to the technical components of the thesis as its most applicable to use for evaluating quantifiable metrical performance.

### 3.1.2 Qualitative research

A qualitative research is based on information that is acquired through unrestricted and conversational communication. This is often done by conducting interviews, on spot questions and different types of observation. The larger part of the information gathering for this thesis was done by qualitative research. This is because it is the better way of achieving a deep understanding of a subject within a business and management aspect (Bryman & Bell, 2018). By having open ended and flexible conversational communication with workers it increases the chances of gathering unexpected information that could be crucial. The qualitative types of

research also allow for understanding of opinions and motivations, it gives a proper insight to the different problem or ideas that the respondent has.

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## 3.2 Interview selection process

The interview selection process consisted of assessing the topics together with the supervisor, by going through the different areas and processes we were able to establish 15 people who would be the most suitable to interview. The relevant topics within warehousing strategy, engineering, housekeeping and storing management were observed and matched with the most experienced and knowledgeable person within the area, thus a interview request was made.

## 3.3 Data collection

### 3.3.1 Semi-structured interviews

The interviews that were conducted were less structured; meaning that the individuals were asked different questions linked to their working areas and expertise. Both primary and secondary data were collected and used in this research study. Interviews were carried and conducted as the primary means of obtaining primary data for this study. The interviews were answered by supervisors and team leaders from different departments within the various processes of the Central distribution center for Volvo Cars. It was answered by 15 respondents including the supervisors, engineers, technicians, and other employees operating in the warehouse.

The interview questions were semi-structured (less structured); meaning that the individuals from different sections of the warehouse were asked different questions which linked to their working area and operations. The ambiguity of the research questions was adjusted in accordance with the competence and professional position of the responding person. However, for the employees who worked in the same areas, the interview questions were structured; meaning that they had uniform questions. By having uniformed questions within the same areas, it allowed for a clear view of what actually was a working practice contrary to things that were wanted states.

The semi-structured interview method was essential for this research because it provided specific details about the types of documentation and information that exists and how they've been preserved. Furthermore, the extensive dialogue with participants gave them the freedom to express their thoughts and input about their practices and current guidelines at Volvo Car Parts, which generated valuable feedback. Using this technique, the participant was allowed more flexibility to comment and expand on the areas of discussion that he/she deemed most relevant or valuable.
In the interviews, the researchers asked the questions, and the respondents answered the questions using facts from general knowledge and documentation of how their specific area operates. We took notes to capture first-hand information from the interviews in combination with the use of current documents that existed. The interviews sessions became increasingly communicative, as more questions were being continually posed. During the interviews, the participants were able to elaborate more and explain various company practices and activities.

### 3.3.2 Field study

Field studies were conducted within the distribution center by visiting different sections of the warehouse, analysing their processes, and seeking more knowledge from workers who discussed the different processes taking place at each area. The field studies were particularly beneficial because they helped with understanding the processes easier by being able to view it live, this helped us get a better insight to the problems and be able to draw our own conclusions.

## 3.4 Literature and Procedural analysis

Literature analysis was carried out by a thorough research on similar past scholarly work in combination with taking advantage of books and other reading material. The secondary data collection is preferred where experiences and capacities are constrained; nevertheless, the content provider must be objectively analysed and linked to other sources. Some of the details were gleaned from other existing records and relevant studies.

## 3.5 Data Analysis

The interview questions included more open questions addressing how different functions at Volvo Car Parts are working to make their operations effective and efficient. The questions also aimed at working with documentation handling were focused on mapping current and principial needs. The deliverables of this research can be summarized as finding common work procedures that can be applicable, stored and distributed to the entire organization. Whereas in areas where common work procedures and guidelines were not set, we had to examine for a wanted state that were deemed necessary and beneficial, they were then presented and discussed to reach a

common result. In order to reach a desired outcome, the data and theories are developed and revised throughout the entire study. When the interview notes were transcribed and analyzed, the finding was summarized to get an overview of their current strategies, principles and standards of operation that increase efficiency and effectiveness in operations.

The data collected in the field studies was interpreted and analyzed, then matched with the information obtained from the interviews to check for accuracy and reliability of the data. The comparisons were then presented in comparison tables for illustrations and to help in picking the matches. This was aligned with the secondary data obtained from historical records of the company's operations and also the research work from the past researches. The analyzed data was then presented as the finding of the qualitative research study.

## 3.6 Reliability & Validity

Reliability and validity are ways of assessing and illustrating the accuracy and thoroughness of testing procedures, as well as the consistency of study results, based on a variety of considerations such as that of the relevant literature, how data were obtained, how data will be evaluated, and how findings will be obtained (Mohajan, 2017). Reliability indicates how effective a theoretical framework is in achieving comparable outcomes under a number of conditions, while validity explains how efficient a procedure is in assessing what is meant to be tested in a more nuanced manner (Hayashi Jr, 2019). In quantitative analysis, reliability and validity are essential aspects for maintaining and assessing consistency. These metrics play no part in qualitative analysis, as is inferred in this study, and therefore validity can appear to be meaningless for such kinds of studies upon first glimpse. There are, nevertheless, strategies for adjusting reliability and authenticity to the requirements of qualitative analysis by mitigating the emphasis on measure problems (Mcdonald, Schoenebeck, & Forte, 2019).

### 3.6.1 Reliability

Reliability can be defined as a measurement of the truthfulness of tests performed and evidence based on the research questions. Moreover, reliability reflects the degree to which the result of an analysis is verifiable under varying circumstances (Cypress, 2017). As a result, in order to ensure consistency in this analysis, the very same structure and formality was used in the interviews. Useful and informative notes were made during analysis phase. Throughout the data analysis, the working practice was to go back and forth through the details and our understanding to establish a strong relation between the evidence and our perceptions.

### 3.6.2 Validity

Validity assesses how accurately a test procedure measures what it is intended to measure. Any scholars argue that the work “validity” is ineffective in qualitative studies. However, several people have found that there would be a need for validity measures and test in qualitative testing as well. (Sherif, 2018). A possible pitfall in attempting to achieve authenticity in qualitative studies is the possibility of being influenced by individual opinions while collecting or analyzing evidence, which may contribute to bias. While conducting qualitative interviews, the authenticity of interview results must be considered to reduce the possibility of losing out on any elements of evidence. The observational results were primarily collected via semi-structured interviews, a technique that allowed for detailed responses while also allowing for clarifying and additional questions. Responses and interpretations were checked with informants to reduce the potential of selection bias.

# 4 Result

*This chapter presents the resulting findings gathered within the operation at Volvo Car Parts. The findings will be presented as a Current and Wanted state. The current state is information based on interviews and field studies, and the wanted state is based what the engineers and the management shared with us.*

## 4.1 Current state

The Central distribution center is built on a concept of three product families that include Small, Medium, and Large where each product family is divided into separate areas in the warehouse. Each product family is a gathering of parts that are stored, picked, and managed in similar ways with the same types of equipment, racks, and forklifts. Each specific part is assigned to a product family based on their size, weight, and shape.

The product families are sectioned into business areas (VO's) based on part properties and frequency along with its necessary equipment and tools, this helps reduce lead times and more effectively make use of existing equipment. The business areas are made in a way that promotes the work environment and efficiency. Each business area is then maintained by a team that is responsible for the different processes which include receival of goods, storing, picking and internal distribution. The business areas create their own standardized working methods and work continuously to improve the working methods within the various processes.

The business areas are defined as:

| | |
|---|---|
| VOS | Small parts (Placed on the mezzanine floor) |
| VOS HF | High frequent small parts |
| VOM | Medium parts |
| VOL | Large parts |
| HL | ASRS for small and medium parts |

Besides the different business areas there are buffer storage placed outside the CDC which are referred to as the RD-halls. The CDC also has an external warehouse in Lammhult used for old material that has very low demand.

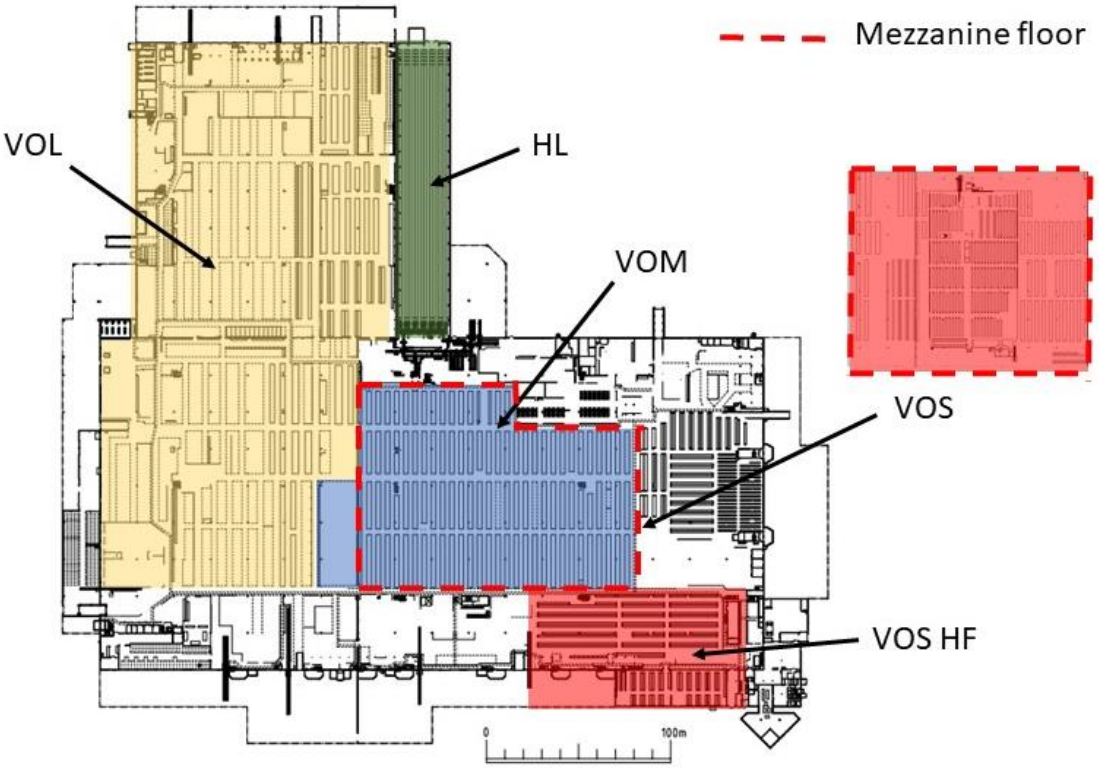


*Figure 3, Product family sectioning at CDC*

### 4.1.1 Frequency Classification

How frequent an article is ordered defines the classification and is used as an indicator of their placement in the warehouse. CDC has defined frequency classifications according to the chart below.

| Frequency classification | Number of picks |
|---|---|
| Obsolete | Last 3 years = 0 |
| Super slow | Last 3 years ≤ 3, and current year = 0 |
| Slow | Last year < 12 |
| Medium | Last year < 50 |
| Fast | Last year > 50 |

*Figure 4, CDC frequency classifications*

From a summary of our research and interview questions it was clear that the operation did not have a standardized and systematic approach to their frequency classification. It was established that each business area had its own team which took care of relocating parts, the parts that needed to be relocated were discovered by going through the frequency demand daily and manually changing its position depending on if its demand increased or decreased.
Since the CDC have the promise to provide spare parts to cars up to 15 years old, there is overall a big variation in demand and a very big percentage of the older articles that has a very low demand. The older articles are therefore hard to identify in the current relocating process, since they their demand do not move at all. Leading to a reactive process where pickers or replenishment identify the articles incorrect placement.

One of the methods CDC uses to approach their frequency classification is by positioning the most frequent material close to the worker, making it easier and faster to fulfil orders. They also make use of a system that works with repositioning parts that have their frequency or demand lowered, these articles are often positioned in an area further away.

When a part is repositioned it often has its space reoccupied by another more frequent part. This system works for parts both decreasing and increasing in demand and frequency. The repositioning process is dependent on the teams knowledge since there are no defined areas for the frequency classes, meaning that the placement is up to the induvial to decide. Since there are three teams that works individually from for each business area (Small, Medium and Large) the relocating process differs a lot.

### 4.1.2 Housekeeping

Housekeeping assures the warehouse's productivity and safety. It includes working with tools such as maintenance of stock keeping rules, consolidation of empty spaces, and trigger-points. The tools help the warehouse to regularly turn its inventory and keeping the "right thing at the right place at the right time".

When the housekeeping topic was brought up with the property manager, we were told that they previously had a position known as a stockkeeper who was responsible for the housekeeping questions. But that position had been removed and the responsibilities were split up between the supervisors of the different areas of the warehouse. This had led to a loss of housekeeping management which has over time became lackluster. Currently there are some departments that actively work with housekeeping and some not. We were told that CDC is at this time not efficiently working with housekeeping in general, the only implemented method they are using is a lack-luster trigger-point system. The system is programmed to give a trigger once an articles lifespan reaches 13 years. It is referred to as "Volvo Car Parts stock holding policy" which says that towards the end of a part numbers life they create a final order which is supposed to cover for the remaining time and that final order quantity is stored at CDC.

While conducting the field study, observations were made at the CDC storage. A lot of empty picking and buffer positions were identified without a clear reason. When questioning the warehouse engineering team about this, their response was that they would rather define the warehouse as overstocked.

### 4.1.3 Storage technique

The storage techniques used within the CDC vary depending on the material that needs to be stored. Currently, Volvo uses pallet-racking, ASRS, deep and block stacking, and shelving systems. The shelving system is used for small parts with low to medium frequency. Pallet-racking is used for small, medium and large parts. Deep and block stacking is used for Medium and Large articles, and the ASRS is used for small and medium parts.

From our observations in the warehouse we noticed that single quantity pallets were stacked on the ground, especially in the VOL area. This unsystematic way of storing gives a poor warehouse utilization and makes it hard for new employees to learn both picking and replenishment. Management and engineers have described that since the new employees have a long learning curve, they use extra personnel to assure quality.

We were informed from the part locating managers that the same problems exist within the storing process of parts where specific individuals place parts wherever they feel fits and not after a standard. The way of unstructured work and low standardization has been a repeating topic that has been brought up in multiple interviews that were conducted and is obviously an underlying issue to many of their problems.

The stock managers also informed us that the automatic high-bay storage lacked a clear purpose, currently it is being used for all types of parts. Everything from obsolete and dead parts to parts with medium frequency are placed in the high-bay storage. We were informed that they are in need of clear guidelines for what should be stored there.

It was made very clear that their fill rate within the warehouse is extremely uneven due to large fluctuations of incoming goods, currently they receive large batches of goods weekly. This has led to unevenness in the warehouse where some days they are forced to work over capacity whilst some days there is barely anything to do. This prevents them from having a balanced inventory and flow of goods which prevents them from using the FIFO principle.

## 4.2 Wanted State

From the conducted interviews and observations, a collocation of their operational wanted state was made together with the property manager, engineers and supervisors.

To be able to ensure an efficient and streamlined operation within CDC they strive to have robust warehousing standards and principles in place. The main subject that everyone agreed on were that they would like more standardization with clear documentation and guidelines within the

various processes. By applying and using The Lean philosophy is one of the topics that was they believe would help them improve their productivity and reach the joint goal of continuous improvement. A list of processes/topics which they strive to implement/improve is presented.

- Being more flow oriented by keeping less stock in combination with a more frequent supply of smaller batches.
- A system that sets guidelines for how and where a part is stored based on its size and characteristics
- Inventory management system which helps with parts storing.
- Minimize reactive methods and be more proactive with stock keeping.
- Implementation of the 7 storage techniques.
- Clear storage structure of the different product families and established frequency zones within each product family.
- Having the picker in focus in order to reduce picking times.
- Handling of campaign parts & season selling.
- Reducing the amount of waste and strive to implement the lean philosophy.

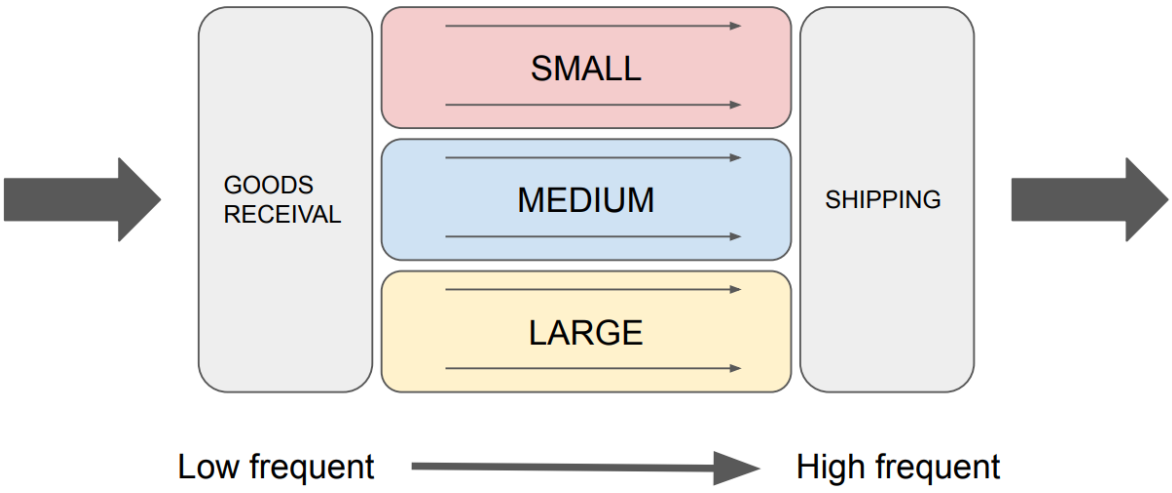


*Figure 5, flow oriented warehouse*

# 5 Analysis

*In this section an analysis of the research questions and based on the answers, the analysis follows with suggested principals. The principals analysed through comparing how well they meet the utilized theories in combination with the wanted state.*

## 5.2 Answers to research questions

This section presents answers to the research questions which are presented in Chapter 1. Each research question is answered individually.

### Where are the major flaws within the warehouse that prevents them from a successful lean implementation?

To be able to determine a successful lean implementation we need to first define what a Lean organization entails. The main concept of lean is described by (Motwani, 2003), its focus is to reduce waste on all aspects of the organizations operations. This is made possible by removing inconsistencies and overburden from the various processes and focusing on processes that add value for the customer.

To achieve the lean philosophy an operation must work towards elimination of waste. CDC has previously attempted the lean implementation to no avail. The main cause that has prevented them from a successful implementation has been due to not having a plan for the implementation. The attempts have been made without setting the proper foundations to implement parts of lean, which has resulted in uncertainty and resistance from management and warehouse operators.

A lean implementation requires that certain steps and challenges are made in a progressive way, level by level. The following implementation stair-step model has been constructed by (Elshennawy & Sisson) that helps with a transition to a lean adapted organization.

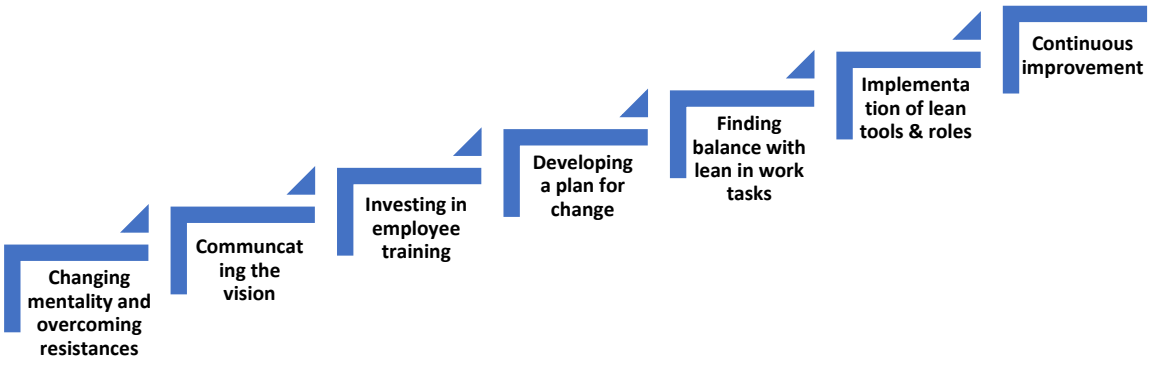


*Figure 6, Steps of implementing Lean*

The barriers that currently exist within CDC that prevents the possibility of a successful lean implementation is their way of work. The different areas of the warehouse work in various ways with low to no standardization, this already causes poor quality and unevenness. It requires a large amount of effort from management in order to set proper fundamentals within the operations in order to promote a healthy lean implementation.

Another major barrier is the mentality of a majority of employees in the organization, they are comfortable with the old ways and are have a negative mindset to change. The importance in successfully motivating change opposed to mandating it is explained by Katzenbach (2008), he motivates that change should never be forced onto an organization but instead present the benefits and communicate the vision for change. A way to motivate the implementation of lean could consist of sharing the possibilities which it generates. It will allow employees to share responsibility and gain more freedom, also allowing for more growth potential for employees by being able to present their ideas and work.

### What principles are suited to reach the wanted state?

The principles that are suited to reach the wanted state must work as a foundation for the operation. These principals are designed to help set a structure and create standardization. They must also lead the operation towards proactive working methods. Based on this, we think that there are a few areas that would be beneficial to highlight and further analyze, which are the storage methods, the frequency classifications, and the housekeeping methods. By defining principles for the CDC storage methods, they can properly use the storage areas without overprocessing, unnecessary movement and waiting time. It is also highly suitable with more general storage principles for an operation with a high product variation, creating a common basis without generating silos. The frequency classification principles purpose is to first and foremost minimize the waste in form on motion. The articles that have a higher demand must be correctly placed, thus close to the picker. The order fulfilment is handled by the picker which means that the placement according to frequency, indirectly will determine how high the level of service can be. The housekeeping principles create conditions for being able to provide a good frequency classification and good storage principles, therefore it is a good tool for working proactively. It determines what tools that should be included in the systematic processes towards a more efficient warehouse, continuously creating prerequisites and improvements.
Through covering these three areas the warehouse should gain sufficient documented guidelines for taking the lean implementation to the next step.

### What are the benefits to having a flow-oriented warehouse?

A fully optimized and well-designed warehouse enhances traffic efficiency, reduces product waste, and boosts overall efficiency. The aim is to maximize the movement of merchandise, material and staff into the warehouse in relation to the amount of incoming and outgoing goods.

Flow is a key concept that ensures the current state is reliable and predictable by maintaining processes aligned and maximizing value-added time. It provides both customer satisfaction and

flow quality when used together. Furthermore, flow-oriented warehousing is mostly concerned with the reconfiguration of smaller pallets and the handling of regular smaller orders. Smaller orders require shorter processing and shipping time, resulting in shorter lead times.

Flow reliability decreases processing costs, supplies, and inventory while optimizing inventory management and handling through frequent deliveries. Which optimizes activities and operations, resulting in lower storage costs, shorter lead times, and less inventory accumulation, as opposed to resource productivity. Which results in slower processes due to lengthy job lines, longer lead times, and merchandise accumulation in the warehouse.

By having a focus on flow efficiency and having a flexible resource utilization it increases the possibility to combine a higher service level and lower total cost.

## 5.3 Principial proposals

Within this section the different principles that were established and recommend for the different processes of the warehouse are presented. Based on the Result in Chapter 4, the flawed warehousing areas can be improved by establishing guidelines and principles. The covered areas are, how to use storage methods in a systematic way, how to implement a frequency classification technique and how to work with housekeeping. The areas covered are specifically chosen because they set the foundations for a healthy operating warehouse that will aid them towards reaching their wanted state. The storage principles are based on the storage methods the CDC have available, by guiding the operation towards a more efficient way of working with the already existing methods they can streamline the operation without any need for investment. The principles regarding the frequency classifications are there to support the operation in relocating parts, keeping the flow at its most efficient way. The purpose of the housekeeping principles is to make sure that continuous improvements will be maintained.

All three suggested principles are related and the good effects of applying them together would enhance the effects of the total outcome.

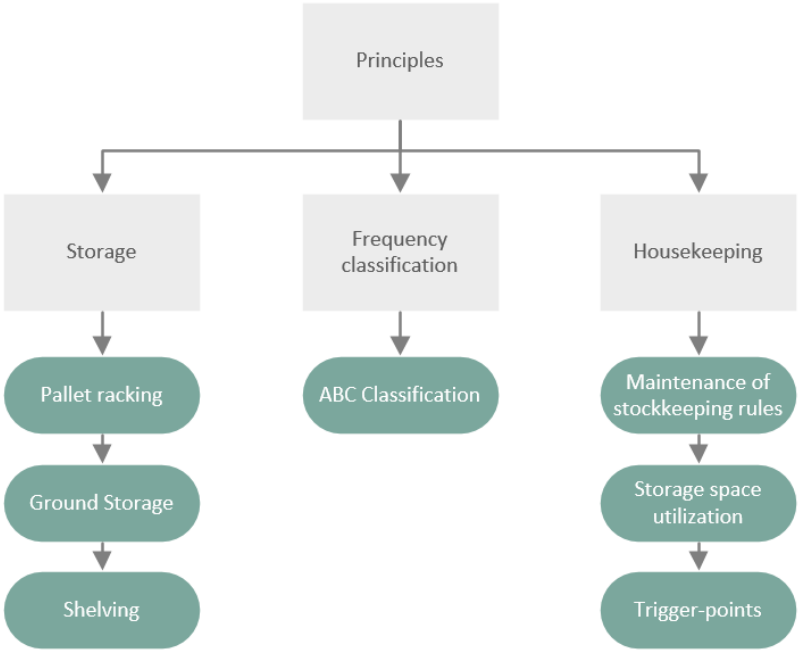


*Figure 7, WBS of suggested principles*

### 5.3.1 Warehouse Storing Principles

One of the most crucial processes within a warehouse is optimizing the warehouse storage. If not done correctly it could lead to consequences such as, unnecessary costs, low productivity, blocked aisles, and other operational waste. The proper storage management process entails that goods are placed in the most optimized and appropriate space while making full use of all available space. Having a solid warehouse storage system also helps to prevents from running out of space in the case of unexpected growth or when large sale fluctuations occurs.

#### *Pallet racking*

The CDC uses a high amount of pallet racking, and to properly use them the most effective way the following principles should be followed.

- ***Pallet racking is used to store goods with lower frequency***

This is due to the pallets not being as accessible in pallet racking which makes it time consuming, therefore pallet racking is best used for articles with low frequency. Since the CDC is required to carry a large amount of articles, pallet racking is one of the most space effective solutions for storing.

- ***The first and second level should be used as pick face and the other levels as buffers***

Since the order picking forklifts are designed to be able to pick from certain heights, it only allows the pickers to reach the first and second level of the pallet rack. Therefore, the upper levels are used as buffers that refill the first and second level once they run out.

### *Ground storage*

Larger and bulky items are ground stored by either block or deep stacking, the benefit of these storage methods is that they allow for easy accessibility and it is easy to implement. The warehouse is getting new articles every day and with these methods they can easily be flexible without needing any investment. Block stacking is a more used method due to it being quite space effective, this is because parts can be stacked on top of each other. The depth of the block stacked articles should be according to their demand to assure inventory turnover but still avoid stockout.

- ***Deep stacking is extremely space intensive and should therefore only be used once deemed necessary***

  When deep stacking you are using a large amount of space for each item, especially when shortage of space is one of the main issues in the warehouse it should be used as little as possible. Only specific goods that are fragile and unstable should be deep stacked to avoid damage. All other possible storage methods must be eliminated before making the choice of deep stacking an article.

- ***Ground storage should only be used for goods with higher turnover rates because of the limited possibilities of using FIFO***

  When you block & deep stack material you're placing the incoming material in front of the previous material, this makes it hard to follow the FIFO principle since you are not able to reach the material which was stored first due to the rest being placed in front.
  By only ground storing articles with higher turnover rates eliminates the possibilities of goods not being used.

### *Shelving*

It is a good way to utilize space, it helps with organizing things more precisely and providing good visibility. Shelving is especially effective to use in a warehouse environment due to the fact that it can store parts with many different shapes and sizes, this is because the shelves are easily customizable and versatile.

- ***Small goods with low to medium frequency should be stored in shelves***

  There is limited space in a shelving storing system and to minimize the risk of stock-out they should store goods with low to medium frequency. Another factor is that the material replenishment process should be interfering with the pickers and risk elongate lead times.

- ***Lighter and smaller goods are best stored in the middle to upper section of the shelf to provide visibility***

  This is particularly beneficial when there is a large amount of light and small goods since you're able to view the entirety of the shelf when in eye view. If they had been placed in the lower levels it would increase the possibility of not seeing the material which could lead to unnecessary replenishment or scrapping if it stays obsolete for too long.

- ***Heavier and larger goods are best stored in the lower to middle sections of the shelf, because of ergonomic and safety reasons***

The heavier goods do not put the same amount of strain on the body as if you were to grab an item from a waist level compared to head level. When working at the waist level you are able to have your arms close to your body, when working at a head level you're raising your arms away from your core which leads to additional strain. High storage for heavier articles also increases the risk of injury.

### 5.3.2 Frequency Classification

A frequency/inventory classification is an essential part of a well-functioning warehouse, it is a simple method of classifying items used to optimize the warehouse layout. It assists with organizing stock to enable accessibility for workers to retrieve stock. By creating classifications for the parts, the more frequently needed parts can be classified and stored accordingly and vice versa with the lower frequent parts. An ABC-classification has been suggested to use in order to help create a systematic approach and create classification zones in the warehouse. It makes the job easier for both the pickers and person responsible for storing goods.

- ***Utilizing ABC classifications within all storage areas***

The purpose of ABC classification is to place articles according to their frequency. Class A has the highest frequency and Class C the lowest, what frequency that defines each class is up to the business to decide. The goal is to minimize picking distances which reduces waste in form of transportation, this is achieved through placing Class A closest to the workstations. The most frequently used parts should be placed in the most optimized position that requires minimum time and effort to retrieve, otherwise it will result in a waste of time (Lumsden, 2007).
The distance that the picker must travel in order to collect a part is quite significant when it comes to productivity. Meaning that the further away the parts are positioned from the pickers workstation the longer it will take the picker to finish the job. As mentioned, CDC is not using ABC correctly to its full potential. This is mostly caused by lack of space due to the overwhelming amount of parts stored in an inefficient way within the warehouse. This has led to parts not being positioned according to ABC-classification and are placed wherever suitable

empty space is found.

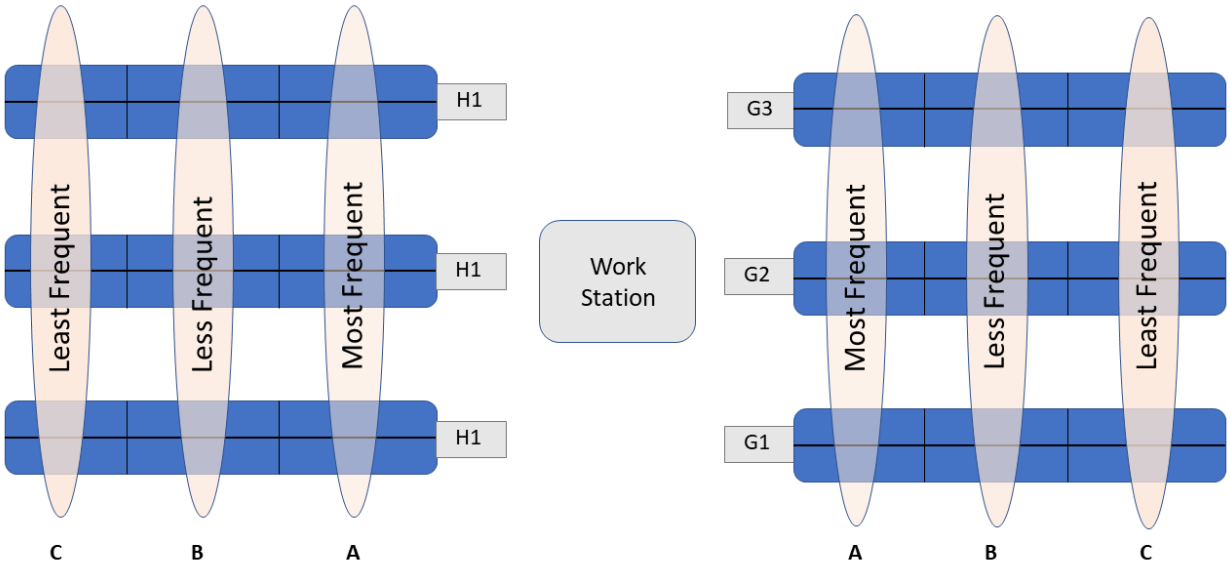


*Figure 8, Illustration of ABC-classifications*

In order to properly apply ABC-Classifications it is suggested that the organization re-examines their version of the ABC analysis and constructs storage areas designed for ABC-classification to be properly utilized. In combination with moving infrequent parts to the high bay storage or placing them in the C section. By having designated areas enables for a systematic approach where sections of the storing area are divided into A/B/C where parts are assigned based on the already established parameters.

With a functioning ABC Classification within the warehouse, the travel and driving distances for picking and put away would be reduced significantly and boost their productivity. It will also shorten the process for the relocating teams because they will have a higher amount of control. The process where they will have to find a suitable position will be minimized or reduced completely. A beneficial solution that aids both the picker and the person responsible for storing goods.

### 5.3.3 Housekeeping

Since the role as stockkeeper was removed by the company and the responsibilities were spread out to multiple instances the company need a common way of working with housekeeping. A good way to implement this is to make use of the 5S methodology from Lean because housekeeping is an integral to 5S. It is used to create a prerequisite so that work can be performed efficiently, safe and organized. The 5S's makes is possible for all areas in the warehouse to work with housekeeping even though the material and quantities varies.

How the housekeeping should be managed have been divided into three categories, Maintenance of stock keeping rules, storage space utilization and trigger-points.

### *Maintenance of stock keeping rules*

To assure that articles are correctly placed and frequently updated, the warehouse needs maintenance of stock keeping rules but also to shorten lead times and utilize the capacity of the warehouse. It should be done frequently otherwise the good effects of frequency classification will not be achieved. It is all about balancing a high level of service but still avoid stockout which leads to backorders. The maintenance of stock keeping rules are aligned with the first, second and third S, which are Sort, Set in order and Shine.

### *Storage space utilization*

The CDC storage space must have the capability to store all types of material to assure a high level of service. The materials size and volume vary and even though that a correct storage method is used, some extended measures can be made to make the warehouse fully utilized. The storage space utilization should be at a level where it still can handle new articles and campaign sales without having to relocate other articles.

- ***Apply the 7 storage techniques***

Through applying some of the 7 storage techniques from the Lean the CDC storage space will be more utilized. When using the first technique, store by product, articles that are of the same characteristics will be stored together in a specific zone. The third technique suggests that, when suitable long and thin parts should be stored vertically. Another useful technique is last one that states that visual irregularity movement control can be performed through storing overflow of an article in an extra location, not the standard location for the part. The techniques will mean that the surfaces within the warehouse will be consolidated. When you consolidate, it also means that other surfaces will be freed which would be beneficial for the company if they continue to expand.

- ***Regular checking of the warehouse fill rate should be done frequently***

The warehouse fill rate plays an important role in order to manage a clean, function and efficient warehouse. A good way to handle the fill rate is to have an ongoing analysis on how many unused picking positions there are, and where they are located. If there are too many empty picking positions in one area the positions slot size might not be correct and should be modified after the actual demand. Since there are fluctuations it is very important that this analysis stays as an ongoing process. A frequent use of these principles will eventually lead to more empty areas, when that is recognized it should be reported to the responsible supervisor/engineer. The space should be utilized by assigning a new function or reconstructing the area for a new project. If on the other hand the fill rate is too high after an analysis is made off-site locations should be used to manage the high demand.

### *Trigger Points*

To be able to work with housekeeping in a systematic way, there must be indicators on how and when a housekeeping process should start. Trigger-points enables a systematic way of creating these indicators. Working with trigger-points aligns with the fourth S, which is standardize.

- **Implement trigger-point when an article is moving through to the next phase in the products life cycle**

If the operation implements trigger-points throughout the whole product life cycle they can start working more proactively with how they store their material. As the product starts to decline as it moves in the cycle, modification to safety stock and incoming packages should be made. By identifying when the demand drops and with how much the supplier can be informed that the incoming packaging should be of a smaller size. This will result in less overstocked articles and more accurate safety stock.

- **Implement in different business areas for parts to be relocated according to frequency**

This principle is combined with the frequency classifications but also with the part characteristics. Creating triggers that will create an action towards the relocating team, both ABC-zone and type of storage. An article that has previously been a high frequent article might not be needing a whole picking position when the demand decreases. Pairing the characteristics (which includes weight and volume) and frequency as parameters when developing triggers for relocating will be very helpful for both storage utilization and lead times. It provides a solution for storing obsolete or low frequent articles without unnecessary stockpiling. The trigger also includes a possibility to be more process-oriented rather than having to rely on the team members experience in the area, a more automated process.

# 6 Conclusion & Recommendation

*This section presents a summary of what conclusions can be drawn from the thesis analysis. It also includes recommendations on how the company can further develop these principles in the future.*

## 6.1 Conclusions

The aim of this research was to examine and evaluate where the underlying reason for their flaws within the warehouse operations and how they work more effectively with the flow of material and components through the warehouse. This can be done with evaluating the current situation and ideal wanted state of the operations in order to propose guidelines and principals within various processes.

A description of the current state has been constructed to give an understanding of how material and information flows through the warehouse. The foundation for our investigation consisted of three processes within their operations that consist of Storage techniques, frequency classification and housekeeping. The extensive work has mainly consisted of conducting interviews, field studies and observations where the result of the investigations has been presented under chapter 4.1 “Current state”. The result has generated a clear overview of the flaws and poor techniques used within their operations.

The extensive work has showed that the remaining challenge within their operation is mainly due to an unsustainable way of work with low guidelines, principles, and systematic way of work. The current set up in the organization does not help eliminate unevenness and overburden which in turn contributes to operational waste.

By analyzing the organizations wanted state we were able to establish and propose principles within the processes based on observations and theoretical foundations in order to create more efficiency within the warehouse. These principles are a proposal for a better approach on how different types of implementation are beneficial in order to raise productivity and secure quality.

## 6.2 Recommendations

After the execution of this study there are possibilities to further develop the warehousing principles, we specifically recommend this due to the upcoming changes in the new projects. It is important to keep the defined principles as a foundation for continuous improvements to assure the company’s vision towards a more lean business.

What important areas that we recommend the company to further develop are:

- Work more consistently with trigger-points, the operation must identify all stages of the product life cycle to create a systematic support for their triggers. By implementing more triggers, the operation will also gather data that is vital for managing forecast of lower stock quantities.

- Lower stock quantities to reduce stockpiling, this also to assure less tied up capital and better utilization of space which would result in better flow. It is also a requirement if the operations should seize to expand in the future.
- Communicate the developed principles to all instances of the operation to assure that the operation will go towards more process control, which is a prerequisite if the business is to eliminate silos and increase their overall value-adding processes.

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