LUNDS UNIVERSITET
Lunds Tekniska Högskola

Department of Industrial Management and Logistics
Division of Engineering Logistics

Material supply to assembly stations

- A study at Nederman, Helsingborg

Authors: Karl Fredriksson
Charlotte Sallmén

Supervisors: Professor Andreas Norrman
Lunds University, Faculty of Engineering

Björn Tideman
Nederman

PREFACE

This thesis was written during the autumn 2010 as a final part of the authors' degree at the Industrial Engineering and Management program at Lund University. The study has been carried out at Nederman Helsingborg.

The study would not exist without all generosity from all involved people at Nederman that shared their thoughts and answered all questions. It has been a great pleasure for the authors to be working as a part of the Nederman team. A special thanks to the supervisor at Nederman, Björn Tideman, for all his dedicated time and great guidance in this study. The authors will also send special thanks to our supervisor, Professor Andreas Norrman at Division of Engineering Logistics, Department of Industrial Management and Logistics, Lund University, Faculty of Engineering. His guidance and mentorship had a great influence and contributed to a better result of this study.

Helsingborg 2011-01-29

____________________________ ____________________________

Karl Fredriksson Charlotte Sallmén

ABSTRACT

Title: Material supply to assembly stations – A study at Nederman, Helsingborg

Authors: Karl Fredriksson and Charlotte Sallmén

Supervisors: Professor Andreas Norrman, Division of Engineering Logistics, Department of Industrial Management and Logistics, Lund University, Faculty of Engineering
Björn Tideman, Quality Engineer, Nederman

Purpose: The purpose of this study is to improve the material supply to assembly stations at Nedermans and identify parameters and principles that determine if the components should be stored at the assembly station or in the warehouse. The improvement should reduce the floor space used for assembly, increase the assembly utilization rate and reduce waste of time in the material handling.

Method: The study has been accomplished with a system approach, which fits the task where the holistic environment is of greatest importance. An abductive research method has been used, due to the authors' wandering between theory and empirics. The study has both a qualitative and quantitative focus. Interviews, company visit and observations compose the main qualitative data collection. Quantitative data from the enterprise resource program and theoretical studies has also been of greatest importance. The authors have mapped the ordering process at three assembly stations at Nederman. Data about demand variability, picking frequency and number of transportation orders was collected. From this data, the distribution of transportation orders was plotted. The demand variability and picking frequency are two of the fundamental decision variables for Kanban. The inventory turnover and picking frequency were also plotted in a developed framework. These plots are together the foundation of the analysis.

Theory The report includes several theory sections used as a base for the study. A high share of the theory covers parts from Lean production such as Kanban, Two-bin Kanban, standardized working methods, stabilize the load of work and mapping of waste. Theory about warehousing is also included like inventory turnover, inventory carrying cost and location of articles in an inventory.

Conclusions: The authors suggest that Nederman should start using Kanban for an improved component ordering process. Kanban should only be used for components with a high picking frequency and a low variability. The study provides a framework that Nederman can use as a guideline in the identification of Kanban components. The authors have identified three possible Kanban areas, Kanban-A, Kanban-B and Kanban-C. Nederman should start with the Kanban-A components. The Kanban-A components have a variability factor of demand between 0 to 0.6 and a picking frequency that is at least 125 times per year. The Kanban solution reduces the inventory at the assembly stations and increases the assembly utilization rate. A Kanban solution will stabilize the work load for the warehouse personnel. The number of pallet locations in the station buffer will be reduced up to 25% due to the Kanban implementation. A Kanban solution will also reduce the component ordering time by 73 hours per year at the detail studied assembly stations at Nederman in Helsingborg. To facilitate an implementation of Kanban and take care of all ideas from the involved personnel, the authors suggest that quality circles should be started. Quality circles also encourage and motivate the involved personnel to contribute in process improvements.

The study has also identified a potential improvement in the material handling from the warehouse to the assembly station. By investing in a conveyer with a sensor, unnecessary movements and waiting time can be eliminated and correct picking order can be ensured. A conveyer solution would reduce the internal logistics circulating time with 133 hours per year.

By standardizing the load carrier where cartons are replaced by bins, a reduction floor space can be achieved. The bins can be placed in shelves which will optimize the allocated floor space and improves the visualization of the station buffer.

The study also provides Nederman with a framework that identifies components in the station buffer with a low inventory turnover. For the components within the Kanban-A area with a turnover less than 50 should change order quantity according to the framework. By reducing the component order quantity for these components the inventory will decrease and hence release floor space.

Keywords: Material supply, Lean, Assembly, Inventory turnover, Kanban, Lead time, Stabilize the load of work

SAMMANFATTNING

Titel: Materialförsörjning till monteringsstationer – En studie på Nederman, Helsingborg

Författare: Karl Fredriksson, Charlotte Sallmén

Handledare: Professor Andreas Norrman, Institutionen för Teknisk ekonomi och logistik, Lunds Universitet, LTH
Björn Tideman, Quality Engineer, Nederman

Syfte: Syftet med studien är att förbättra materialförsörjningen på Nederman, genom att identifiera parametrar och principer som avgör om en komponent skall förvaras vid stationen eller på lagret. Förbättringarna skall reducera yta vid monteringsstationerna, öka nyttjandegranden i monteringsprocessen samt reducera slöseri i materialhanteringen.

Metod: Studien är genomförd med ett systemsynsätt, vilket lämpar sig i en miljö där det holistiska perspektivet ej får förbises. En abduktiv forskninsmetod har används då författarna valt att vandra mellan teori och empiri. Studien har både ett kvalitativt och kvantitativt fokus. Intervjuer, studiebesök och observationer utgör den huvudsakliga kvalitativa datainhämtningen. Kvantitativ data från affärsdatasystemet och teoretisk inhämtning har också varit av stor vikt. Författarna har kartlagt beordringsprocessen i tre monteringsstationer på Nederman. Data om efterfrågevariabilitet, plockfrekvens och antalet transportuppdrag har också samlats in. Från dessa data det varit möjligt att pricka in fördelningen av transportuppdrag, efterfrågevariabiliteten mot plockfrekvensen, volymbaserat förvaringstest och lageromsättningshastigheten mot plockfrekvensen i diagram. De diagram har används som grund för analysen.

Teori Rapporten innehåller flera teoridelar som används som bas för studien. En stor del av teorin täcker delar från Lean så som Kanban, två-bings Kanban, standardiserat arbetssätt, stabilisering av arbetsbörda samt kartläggning av slöseri. Teori om lagerhållning är också inkluderat där lageromsättningshastighet, lagerhållningskostnader och placering av artiklar i ett lager bidrar med en teoretisk bas i studien.

Slutsatser: Författarna föreslår att Nederman bör använda Kanban för att förbättra sin beordringsprocess av komponenter. Kanban ska endast användas för komponenter med en hög plockfrekvens och låg variabilitet. Studien ger ett ramverk som Nederman kan använda som riktlinje för att identifiera Kanbankomponenter. Författarna har identifierat tre möjliga Kanbanområden, Kanban-A, Kanban-B och Kanban-C. Nederman bör starta med Kanban-A komponenter där variabilitetsfaktorn för efterfrågan är mellan 0 och 0.6 samt har en plockfrekvens mer än 125 gånger per år. Kanbanlösningen reducerar lagret i monteringsstationerna och ökar nyttjandegraden i monteringsprocessen. Kanbanlösningen stabiliserar arbetsbördan för lagerpersonalen och reducerar upp till 25 % av pallplatserna i stationslagret. En Kanbanlösning kommer att minska beordringstiden med 73 timmar per år på de tre detaljstuderade monteringsstationerna hos Nederman i Helsingborg. Författarna föreslår att kvalitetscirklar bör startas för att underlätta implementeringen av Kanban samt för att ta vara på idéer från den involverade personalen. Kvalitetscirklar uppmuntrar och motiverar personalen att medverka till förbättringar i processen.

Studien har även identifierat potentiella förbättringar i materialförsörjningen från lager till monteringsstation. Genom att investera i ett transportband utrustad med en sensor kan onödiga förflyttningar och väntetider elimineras, samt rätt plockordning kan garanteras. En rullbandslösning reducerar den interna logistikens onödiga cirkulerande med 133 timmar per år.

Genom att standardisera lastbärare och därmed ersätta kartonger med lådor kan golvyta i monteringen frigöras. Lådorna bör placeras i hyllor och på så vis kan den allokerade golvytan optimeras och även ge en tydligare visualisering av stationslagret.

Studien ger även ett ramverk för att identifiera komponenter i stationslagret med låg lageromsättningshastighet. För komponenter inom Kanban-A området som har en lageromsättningshastighet mindre än 50 bör orderkvantiteten ändras enligt ramverket. En minskad orderkvantitet för dessa komponenter bidrar till minskning av lager och frigöra därmed även golvyta.

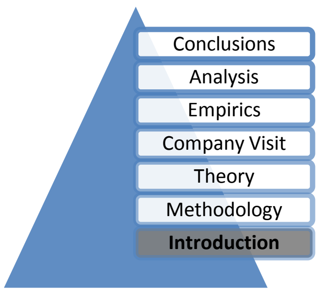
Nyckelord: Materialförsörjning, Lean, Montering, Lageromsättningshastighet, Kanban, Ledtid, Stabilisering av arbetsbördan

TABLE OF CONTENTS

FIGURES

TABLES

1 INTRODUCTION



This chapter will introduce and give the reader a background to the problem and the studied company. The authors will also present a problem discussion, the purpose and delimitations of the thesis.

1.1 Background

Nederman is one of the world's leading companies within industrial air filtration. Their products create a clean and safe working environment by focus on air and recycling. The company has subsidiaries in 26 countries and has sales agents in over 30 countries. Nederman had 2009 in average 672 employees. The net sale was 1052 SEK m.[1]

Nederman has a wide range of products. The two main business areas are *Extraction & filter systems* and *Hose & cable reels.* The popular Filtermax DF40 product is illustrated below, Figure 1. FilterMax DF take care of the air pollution from metal industries as well as non-explosive dust from other industries.

Figure 1 - Nederman Filtermax DF40

The business concept of Nederman is stated as followed; *Through products, systems and application expertise to provide solutions that safeguard a clean working environment, efficient and safe production and eco-friendly recycling.*[2]

The Swedish industrial production is now days driven by a strong international demand and companies like Nederman are highly affected by the global economic situation. The Swedish economy has recently recovered from the financial crisis and it is now growing again. Globally is it still a problem and financial dips are still expected to happen. Big nations and economies tighten their budgets and cuts are expected. Due to the global disturbance, the Swedish recovery will be lower in a short term perspective. But the structural changes that currently are made will increase the economy in a long term.[3] The current financial situation and Nederman's global competition are forces that affect them and create a need of staying competitive in every process.

Nederman's site in Helsingborg assembles, mainly manually by operators, components into finished products for shipping to end customers. To be able to be competitive with labor intensive assembly

[1] Nederman, *Annual report 2009*, retrieved 2010-12-01, <http://www.nederman.com/Financial/Financial/~/media/Nederman_Group/Financial/Nederman_Annual_report_2009%20pdf.ashx>, p. 1

[2] Nederman, *Annual report 2009,* retrieved 2010-12-07, <http://www.nederman.com/Financial/Financial/~/media/Nederman_Group/Financial/Nederman_Annual_report_2009%20pdf.ashx>, p. 5

[3] N Grahn et al. Svenskt näringsliv*, Efterskalv, Det ekonomiska läget, Augusti 2010*, retrieved 2010-11-02, <http://www.svensktnaringsliv.se/material/rapporter/efterskalv-det-ekonomiska-laget-augusti-2010_115950.html>, p. 7

operations, high utilization rates of the assemblers are necessary. This is especially due to the relative high total labor costs in Sweden.[4]

In a long term perspective the goal is to increase the number of products assembled in Helsingborg. An increase of the number of assembly stations is therefore needed. The site in Helsingborg has today almost reached its limits due to lack of free floor space. A significant amount of the floor space is today allocated to store components. By reducing the components stored in the assembly area, an increased floor space can be achieved, which enables future expansion.

1.2 Problem Discussion

Nederman in Helsingborg face some challenges to their future expansion. To be able to expand, space for new assembly stations is needed. At this moment, a lot of the goods that should be stored in the warehouse are placed at the assembly floor space, due to limited storage space. One challenge is to find ways where the material supply can reduce the inventory and release floor space.

A current problem at Nederman is the high amount of time used for non assembling activities, such as material ordering, material supply or search for components. The non assembling time can be considered as waste, which needs to be eliminated in a competitive environment.

Another problem is the lack of method of how to determine if components should be stored at the assembly station or at the warehouse. Today no standardized procedures exist for the material supply. As a result, the inventory at the assembly stations is high and ordered without further consideration. Nederman aims to reduce inaccurate inventory and find the components that should be stored in the assembly area.

Those problems can be summarized as;

- How can the waste of time be reduced in the material supply?
- How can the utilization rate at the assembly stations be increased?
- What ways exist to release floor space at the assembly stations?
- Which parameters determine where a component should be stored?
- How can suggested solutions be financially prioritized?

The studied system is illustrated in Figure 2. The material flow at the assembly site in Helsingborg starts with reception of components that will be stored in the warehouse. Through the ERP system IFS the assembly operator places an order when new material is needed at the station. The internal logistics team delivers the components from warehouse to the station buffer by forklifts. The assembler then places the pallet or the bin where he or she wants it to be. Both fixed and floating station buffers are used. When an order is fulfilled the operator puts the finished goods outside its station and the next forklift that is passing picks it up and deliver it to the area where goods are loaded for the finished goods inventory.

---

[4] K B Andersson, Svenskt Näringsliv, *Internationell utblick Löner och arbetskraftskostnader*, retrieved 2010-11-02, <http://www.svensktnaringsliv.se/material/rapporter/internationell-utblick-loner-och-arbetskraftskostnader-internatio_28149.html>, p. 5

The studied system, see Figure 2 is affected by a number of components that has to be taken into consideration: the structure of material flow, the processes within the system and the management components that are controlling the system.

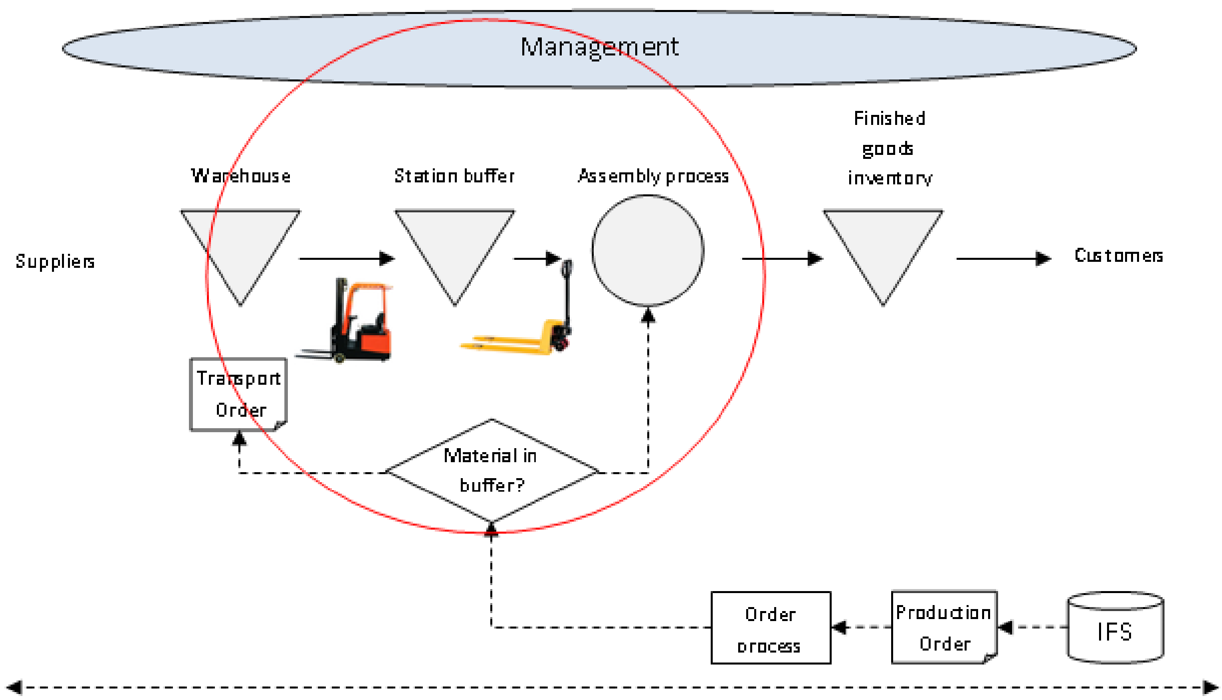


Figure 2 - The studied system

1.3 Purpose

The purpose of this study is to improve the material supply to assembly stations at Nedermans and identify parameters and principles that determine if the components should be stored at the assembly station or in the warehouse. The improvement should reduce the floor space used for assembly, increase the assembly utilization rate and reduce waste of time in the material handling.

1.4 Objectives

The objective of the thesis is to present material for decision basis that contain information of which components that should be stored at the assembly stations. The main objective parameters are; decreased floor space, increase utilization rate and reduced waste of time in the material supply[5].

[5] These parameters are identified by Nederman

1.5 Delimitations and focus

The focus of this study is illustrated by the big weighted circle in Figure 2. It is the internal material supply to the assembly stations that the authors aim to study. The material and information flow before and after this border is not a part of this study.

Due to time delimitations, the study cannot map, analyze and construct solutions for all assembly stations. The study will only perform detailed studies at the three assembly stations, referred to as 189, 166 and 152, see 3.4.5 for further discussion about chosen stations.

1.6 The target group

The key target group of this study is the decision makers at Nederman in Helsingborg. The study also has an academic target group, researchers and students within the area of logistics.

1.7 Report structure

The report is divided into seven main chapters: Introduction, Methodology, Theory, Company visit, Empirics, Analysis and Conclusions. The introduction will also contain a chapter about Nederman. The report will finally also contain references followed by appendix. To visualize the structure and create an understanding of how the report, as it reaches closer to the conclusions and narrows its content into specific areas, a report structure pyramid is introduced, see Figure 3. Every chapter is introduced by this pyramid and gives the reader an organized way to understand each chapter in a holistic perspective.

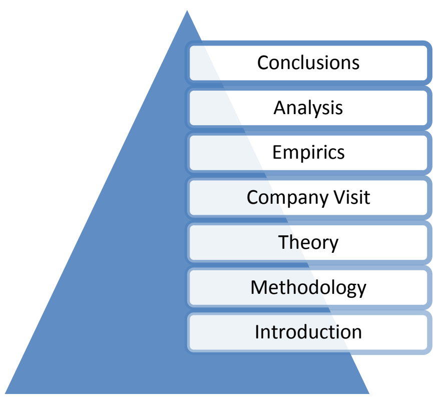


Figure 3 - Report structure

Introduction - This chapter will introduce and give the reader a background to the problem and the studied company. The authors will also present a problem discussion, purpose and delimitations of the thesis. The introduction will also contain chapter 2, a brief introduction to Nederman.

Methodology - This chapter describes scientific approaches, methodologies, data gathering methods and finally critique of sources. After each section a discussion about the authors' standpoint and choices are given. This chapter declares the authors way to the final result.

Theory - This chapter gives a presentation of relevant theories used in the thesis. The theories are essential in the analysis of collected empirical data. The theories are chosen to fit the actual problem and purpose, but also to correspond to the methodology.

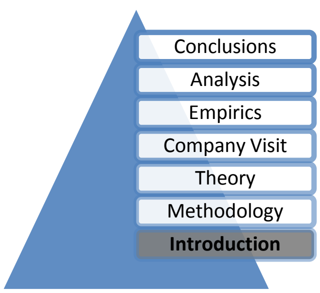
Company visit – This chapter describes the company visits at Thorn Lighting in Landskrona. The company has made massive changes to adopt the Lean philosophy. The chapter will be a reference for the authors and readers of how a company can translate theory into successful reality.

Empirics - This chapter describes the material supply to assembly stations at Nederman Helsingborg. The processes are described by mapped information and material flow, description of ordering processes and data collection of the component buffer.

Analysis - In this chapter the presented empirics will be analyzed by using the framework developed in the theory and inputs from the company visit. The following conclusion and recommendation will be based on the analysis.

Conclusion – This chapter will present the authors' conclusions based on the previous analysis. The chapter will also provide priorities of the suggested improvements.

2 NEDERMAN



This chapter introduces Nederman to the reader, how it all started and what kind of products they are manufacturing today. Nederman's market and ownership will also be described.

2.1 History

Nederman was founded 1944 by Philip Nederman in Helsingborg, Sweden. From early eighties until today, the Nederman history has taken many turns. Nederman was 1983 for the first time listed on the Swedish stock exchange. Two years later the company *Active* bought it back from the stock market. 1991 was Nederman acquired by *Esab*, that later was acquired by *Charter*. The venture capital company *EQT* acquires Nederman 1999 and launches a series of rationalizations. 2007 was Nederman back on the stock market, the Swedish OMX small cap list.[6]

Today Nederman has assembly facilities in Sweden, Norway, Canada and China. The company has subsidiaries in 25 countries and agents in about 30 countries. The group employs 650 people worldwide and has a turnover of 1052 million MSEK.[7]

2.2 Products

One of the most traditional application areas for Nedermans products is within metal fabrication. Toxic smoke from welding machines is affecting millions of people and can cause neurological damage, cancer and allergies. Nedermans products, both mobile and fixed installations, ensure that individual workstations and systems are having a good working environment. The products extract the smoke and a filter takes care of harmful particles. Figure 4 below illustrates FilterCart, a mobile filter system for welding.[8]

Figure 4 - FilterCart[9]

When metals are drilled, milled or cut, metal shavings and cutting fluids are generated. Nederman provides products that collects waste products and separates the metal from fluids. The metal waste can be sold and the fluid reused, the products are hence both environmental friendly and profitable.

---

[6] Nederman, *Nederman company presentation 201* retrieved 2010-12-01, <http://www.nederman.com/Nederman%20Group/Related_documents/Nederman_company_presentation_2010.aspx>, p.4-5

[7] Nederman, *Nederman company presentation 2010, retrieved 2010-12-01,* <http://www.nederman.com/Nederman%20Group/Related_documents/Nederman_company_presentation_2010.aspx>, p. 8

[8] Nederman, *Nederman Annual report 2009,* retrieved 2010-12-01, <http://www.nederman.com/Financial/Financial/~/media/Nederman_Group/Financial/Nederman_Annual_report_2009%20pdf.ashx>, p. 11

[9] Nederman, retrieved 2010-12-01, http://www.nederman.com/sitecore/content/Product%20Database/Products/Low%20Vacuum%20Filters/Mobiles%20-%20Portables/FilterCart/FC%20Carbon.aspx

Nederman also provides a range of products that makes workshops safe and ergonomic. Figure 5 illustrates to the left a balancer that provides an ergonomic solution that makes operator tools weightless. The cable reel below to the right is a product that takes care of cables in the workshop by making the cable management easy and safe.[10]

Figure 5 - Balancer series 810 and Cable Reel Series C20[11]

Nederman's products are often of great importance for the customer's production. Without sufficient air quality, the plant is not allowed to produce and has to stand still. As a result, the aftermarket is growing every year and Nederman provide services such as maintenance and storage of critical components.

2.3 Market

Nederman has today 73% of its sales outside the Nordic region. Nederman has during recent years been focusing on geographic expansion and opened 2008 a logistics and assembly plant in Shanghai. The geographic division of net sales is illustrated in Figure 6.[12]

---

[10] Nederman, *Nederman Annual report 2009, retrieved 2010-12-01,* <http://www.nederman.com/Financial/Financial/~/media/Nederman_Group/Financial/Nederman_Annual_report _2009%20pdf.ashx> p. 6

[11] Nederman, 2010-12-01, http://www.nederman.com/sitecore/content/Product%20Database/Products/Hose%20and%20Cable%20Reels.as px

[12] Nederman, *Nederman Annual report 2009, retrieved 2010-12-01,* <http://www.nederman.com/Financial/Financial/~/media/Nederman_Group/Financial/Nederman_Annual_report _2009%20pdf.ashx>, p.8

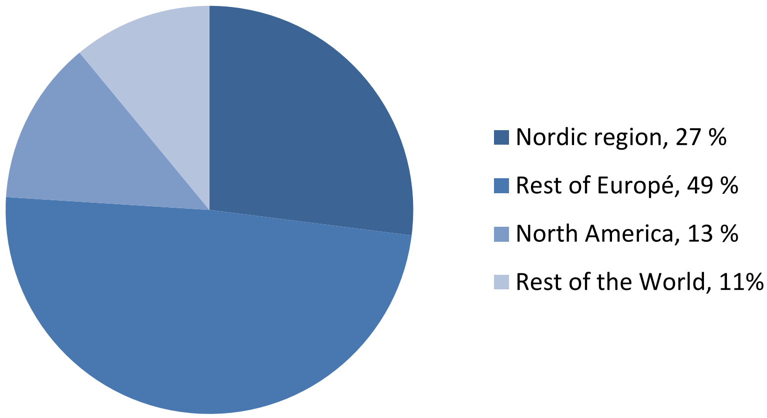


Figure 6 - The geographic division of net sales[13]

Nederman has an operational objective to identify new application areas and geographic markets with significant growth potential. Nederman's strategy for its sales organization is to adapt business to the local markets. The product areas they are focusing on in different regions in the world therefore follows the industrial development in each country. The sales organization is global and Nederman uses a global network of distributors and importers.

Nederman has a strong market competition and are mainly facing small local competitors. But global competition exists. One of the former big global competitors Dantherm Filtration was acquired by Nederman in April 2010.

The European market is the home market of Nederman and it is served with an extensive network of own sales companies. The market reported 2008 a sales record, just before the financial crisis. The recovery from the crisis in Europe is slower than the recovery at the global growth markets and Nederman expects just further growth in Europe to be in composite materials, machining and automotive services. Still though, Eastern Europe has according to Nederman a potential of being more like Western Europe. Nederman's international business area is responsible for all sales outside Europe. Today their focuses are at the well developed North America and the growing markets in China, India and Brazil.[14]

[13] Nederman, *Nederman Annual report 2009, retrieved 2010-12-01,* <http://www.nederman.com/Financial/Financial/~/media/Nederman_Group/Financial/Nederman_Annual_report_2009%20pdf.ashx>, p.8

[14] Nederman, *Nederman Annual report 2009, retrieved 2010-12-01,* <http://www.nederman.com/Financial/Financial/~/media/Nederman_Group/Financial/Nederman_Annual_report_2009%20pdf.ashx>, p. 9s

2.4 Ownership

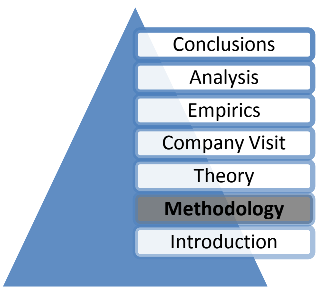
Nederman is today listed at the Swedish stock market, OMX small cap. At the end of year 2009 Nederman had 3429 shareholders. The ten major shareholders are listed in Table 1.[15]

Major shareholders 31 December 2009	Share %
Investment AB Latour	26,5
Ernström Finans	10
IF Skadeförsäkringar	9,9
Lannebo MicroCap	9,1
Handelsbankens fonder	5,9
JP Morgan UK	3,5
Robur småbolagsfonder	3
United Nation Staff Pension Fund UK	2,9
BNP/Henderson Pan European	2,3
Sven Kristensson	1,4
Ten largest total:	**74,5**

Table 1 – Nederman's major shareholders 2009

[15] Nederman, *Nederman Annual report 2009, retrieved 2010-12-01,* <http://www.nederman.com/Financial/Financial/~/media/Nederman_Group/Financial/Nederman_Annual_report_2009%20pdf.ashx>, p.18

3 METHODOLOGY



This chapter discusses the scientific approaches, methodologies, data gathering methods and analysis used in the study. After each section a discussion about the authors' standpoint and choices are given. Finally this chapter describes the study research plan, which tells how the purpose of the study was fulfilled. This chapter hence declares the authors way to get the final result.

3.1 Scientific approaches

To understand the surrounding area of which a scientist choose standpoint is of greatest importance for the interpretation of a scientific report. The scientist's view of science, reality, believes and definitions, all matters and contributes to the authors scientific paradigm. The scientific theorist Törnebohm (1975) describes that a paradigm consist of four major components: Conception of reality, conception of science, scientific ideals and ethical/aesthetical aspects.[16] Arbnor and Bjerke (1994) believe that the selected approach has to fit the problem, but also that the author's scientific paradigm mirror his/her chosen approach.[17] Solving identical problems with different approaches will result in different answers. It is therefore crucial to be aware of and select the right kind of method to suit a specific problem. Arbnor and Bjerke describe three approaches that dominate the scientific methodology in management studies today: *Analytical approach*, *System approach* and *Actors approach*.[18]

All three approaches differ from each other by a diverse view of looking at knowledge. There is a significant difference between those who want to understand, and those who want to explain knowledge. The three scientific approaches can graphical be illustrated together with explanatory and understanding knowledge, see Figure 7. To get a perspective and to understand the differences between those three approaches, a brief explanation regarding the axis of the graphical context is necessary.

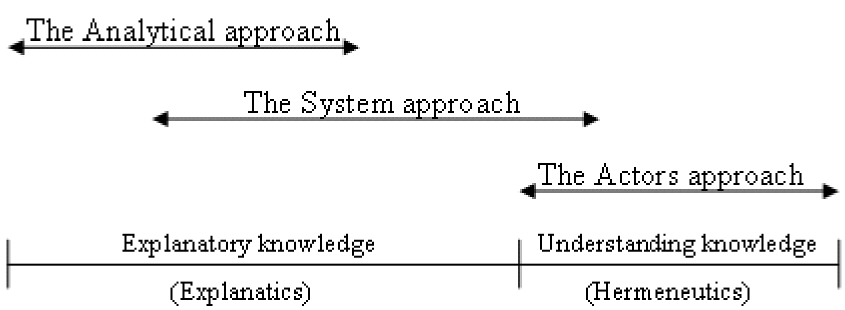


Figure 7 - The boundary between explanatics and hermeneutics[19]

3.1.1 Hermeneutics

Hermeneutics is all about understanding and interpreting meanings of texts, symbols, actions and experiences.[20] Hermeneutics also make a significant difference between methods from natural sciences and social sciences. A classical natural science method is not suitable to a social science study not even if it is modified.[21] During interpretation, alternations between a holistic and a detailed perspective are done to be able to understand and see problems. The knowledge outcome from a hermeneutic study is subjective and highly dependent on the individual, because of the high level of personal interpretation.[22]

---

[16] I Abnor & B Bjerke, *Företagsekonomisk metodlära*, 1994, p. 30
[17] Ibid., p. 26
[18] Ibid., p. 65
[19] Bid., p. 62
[20] G Wallén, *Vetenskapsteori och forskningsmetodik*, 1996, p. 33
[21] Ibid., p. 33
[22] Ibid., p. 33-34

3.1.2 Explanatics

Contrary to the distinction between social and natural science studies, *explanatics* states that there are no differences between the sciences. They argue that methods developed and proved within natural science are valid for social science as well.[23] The explanatics also see the social reality as a complex world that needs to be simplified. This is the opposite of hermeneutics, who try to obtain further problematization and a holistic perspective. According to explanatics, the reality should be objective and not depended on time, place, feelings, people or ideals.[24]

3.1.3 Analytical approach

The analytical approach is deep rooted in the western culture with a strong connection from the classic analytical philosophy. In the past, the analytical approach has been the most common approach.[25] The basic idea is that the subjective reality should be avoided, instead should the objective reality be observed. Knowledge developed from an analytical study is individual independent and the characteristics of the author are unimportant.

Logical and mathematical models have a central function when the objective reality is defined. The reality is described by causal relations, where deterministic relations are sufficient for describing cause-effect-relations. The reality can also be described by stochastically relations, these relationships does not necessarily describe effects. Instead these relationships can be uncertain or difficult to define.

One of the basic assumptions of the analytical approach is that the reality can be decomposed into sub parts, where each part can explain local cause-effect relations. In the analytical approach the reality can be described as the sum of all sub parts.[26] The basic assumption is that a closer and wider view of the problem results in a better solution. As a result it is important to have access to a wide range of data and statistics.

3.1.4 System approach

The system approach became popular during the 1950s as a reaction of the limited holistic view in the analytical approach. Because of its today dominating position in business it will be explained more detailed.[27]

In contrast to the analytical approach, the system approach assumes that the sum of the whole reality do not necessary have to be equal to the sum of the sub parts. The system approach has a holistic perspective and can be explained by synergy effects and bilateral interactions between sub parts. The scientific result is not always applicable in other studies; the outcome is individual independent but can be depending on a certain system.[28]

A system is defined by sub parts with linked relations among each other. To understand the whole, all factors in the system have to be explained. Instead of time based cause-effect-relations, interaction between parts are observed. With a system approach, a single sub part cannot just be taken away

[23] I Abnor & B Bjerke, *Företagsekonomisk metodlära*, 1994, p. 62
[24] G Wallén, *Vetenskapsteori och forskningsmetodik*, 1996, p. 26-27
[25] I Abnor & B Bjerke, *Företagsekonomisk metodlära*, 1994, p. 65
[26] Ibid., p. 78
[27] Ibid., p. 66
[28] Ibid., p. 67

without further considerations of the system. It can easily be illustrated by the following scenario, see Figure 8.

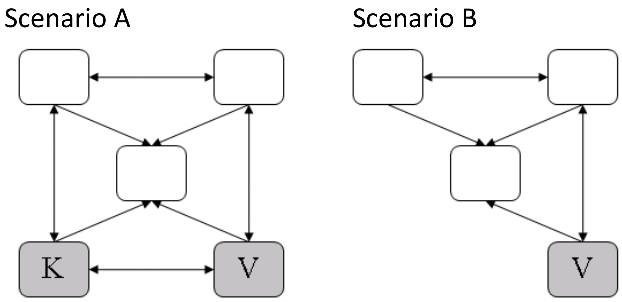


Figure 8 - The holistic perspective in a system approach[29]

V is a component explained in scenario A by the whole sum of iterations and connections from the surrounding reality. In scenario B the component K is removed. The explanation of V from scenario A is now inaccurate in scenario B because of the changing connections. As a result, the system has to be explained by a holistic perspective that is greater than the sum of each component.[30]

Different constellations and forces in a system can result in various outcomes; these kinds of forces are called system structures. Goals and active behaviors by individuals can also be forces that affect the systems. Instead of searching for causal relations, forces and components' adaption to its actually purpose are of greater interest. The relations are instead called indicator-effect-connections. An indicator distinguishes from the cause by its more complex relation structure. Instead of being followed by an effect, the indicator can be a result of an effect. It can also result in many effects with a various time delay.[31]

A system can either be a *real system* or a *model of a system*. By using a model the scientist has to be aware of its limitations. A model reflects just one possible solution of a real system, the intended use of the model and its level of detail is therefore important to consider during a research.[32]

A scientist can have different interest in a system approach. Abnor and Bjerke (1994) describe three different results of the knowledge, *system analysis*, *system construction* and *system theory*. By doing a *system analysis* a real system is described. The internal and external factors that are affecting the system are mapped. A system analysis has therefore an explaining and describing purpose. *System construction* is a construction of a system model. The purpose can be a construction of model that is going to be the base for a new real system. The need for a new system construction can be identified during a system analysis. *System theory* results in models with indicator-effect connections where the results are valid for more than one real system. The theory can then be applied in new analysis or constructions.[33]

[29] I Abnor & B Bjerke, *Företagsekonomisk metodlära*, 1994, p. 81
[30] Ibid.
[31] Ibid., p. 81-82
[32] I Abnor & B Bjerke, *Methodology for Creating Business knowledge*, 1997, p. 112-114
[33] I Abnor & B Bjerke, *Företagsekonomisk metodlära*, 1994, p. 164-166

3.1.5 Actors approach

The actors approach is considerably different according to the other two mentioned approaches. The reality is seen as a result of sprawling social constructions depending on the characters creating it. The result is a non objective reality where the viewer creates an individual dependent reality. For people, groups or companies this reality can be more or less similar. According to this, e.g. structural changes have to be implemented in different ways in different organizations according to their social construction.

The actors approach considers the reality as produced where the actor is producing. To create knowledge about social acts, understanding of reality pictures created by other individuals are necessary. A central act by the actor is to create understanding of how the own picture of reality interacts with other individual realities, which is defined as dialectical connections.[34]

3.1.6 The authors' scientific approach

As Arbnor and Bjerke describe, the selected approach has to fit the problem, but the authors' scientific paradigm also reflect the choice of approach. By reading, writing and evaluating the different approaches the authors have decided that this study will have a system approach. This approach fits this specific problem best, it also mirror the author's scientific paradigm.

The purpose of this study is to improve the material supply at Nederman by identifying parameters that determines if the components should be stored at the assembly station or in the warehouse. By evaluating the three different approaches according to the purpose, the standpoint became clear. The analytical approach neglects the holistic perspective, which is a significant part for this report to be able to understand the flows and actions within the plant. The authors are not comfortable with the actors approach since it is focusing on qualitative data and on individuals. This individual dependency is too strong for a general solution that is applicably at Nederman.

The problem at Nederman is not just a single sub part problem. To solve the problem, synergy effects and bilateral interactions between sub parts with indicator-effect-connections have to be considered. The system approach supports this thinking and the authors feel comfortable in its wide approach of explanatory and understanding knowledge. A wide data gathering approach will result in that the authors have to process both hermeneutical and explanatics in the view of knowledge. The system approach is by the authors' point of view the far best option for the study.

3.2 Methodics

Because of the chosen system approach, this chapter will only contain methodics for the system approach. There are two main methodics for system studies, *goal-means orientation* and *trial-and-error orientation*.[35]

When using a goal-mean orientation the goal for both the study and the system are set at an early stage. The scientist can therefore approach the study with a more extensive planning. Problems are defined as lack of target achievements.[36]

---

[34] I Abnor & B Bjerke, *Företagsekonomisk metodlära*, 1994, p. 86-95

[35] Ibid., p. 319

The goal-mean orientation starts with an identification of a problem in a real system. By doing a system analysis the problem can be formulated. The system analysis contains mapping of internal and external factors that are affecting the system. The phase is usually extensive because of the time consuming data collection and understanding stage. When the analysis is done a new system are to be created, referred as system construction. The last phase is implementation of the constructed system.[37] Figure 9 indicates the working process of a goal-mean orientation.

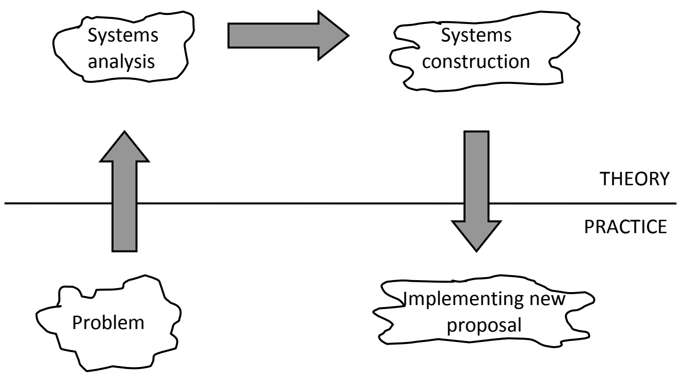


Figure 9 - A general plan for a study with a goal-means orientation[38]

The *Trial-and-Error* orientation aims for an interaction between the real system and development of solutions. The start point has not a defined problem, instead a continuous flow of sub problems are to be solved during the process. An important factor for success is the involvement of strategic positioned individuals from the beginning. Figure 10 below is an illustration of the continuous and dynamic process where the orientation is based on a "walk" between the theory and the real system. [39]

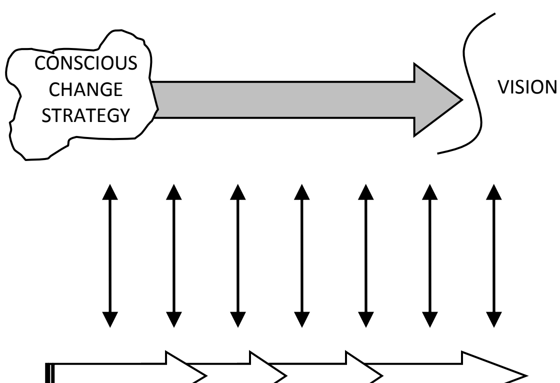


Figure 10- One example of trial-and-error systems study[40]

[36] I Abnor & B Bjerke, *Företagsekonomisk metodlära*, 1994, p. 321
[37] Ibid., p. 321-322
[38] Ibid., p. 321
[39] Ibid., p. 325-326
[40] Ibid., p. 326

3.2.1 The authors' methodics

The goal-mean orientation fit the master thesis' problem very well. The supervisor at Nederman, Björn Tideman, gave a pre-defined problem at the start. The task at Nederman is to solve the defined problem and it will be solved with a goal-mean orientation by an extensive system analysis. A daily placement at the facility in Helsingborg will be the launch of the analysis by learning the system and its environment from the inside. The authors need a holistic perspective over the material flow at the beginning to understand factors that influences the work at the assembly stations.

The system mapping phase will start with the pre-defined problem and the thesis purpose as borders when the system is to be mapped. With a mapped system with distinct boarders an analysis of the system can be carried out. Data collection, interviews and observations will be the base of the analysis. Further on, the system approach can continue with a system construction. The system construction phase needs a strong interaction between theory and empirics, the actors within the system as well as the studied theory have an important role in the construction phase. To succeed with this interaction between theory and empirics, the authors believe that a matching research method has to be chosen, see chapter 3.3.3.

3.3 Research Methods

The research methods are the scientist direct actions for acquiring knowledge and analyze its context. There are many ways to analyze and gather data to achieve knowledge. When choosing method it is important to be aware of the consequences. The method must fit the task.

3.3.1 Induction, deduction, abduction

There are three main approaches about how to use theories and empirical data that has to be considered when performing a study.

Induction starts with empirical data without knowledge about the theory, the data collection should be unprejudiced. From the empirics, theories and conclusions can be made. E.g. the report tells us that this certain train always arrives at eight, therefore the train will probably arrive at eight tomorrow as well. The approach is useful when theories are missing or less developed. The approach has been blamed by criticizers that the conclusions do not contain more relevant facts than then material from the empirics.[41]

Within *deduction* the theory has an important central function from which predictions about the empirics are made.[42] The predictions are later verified by the collected data, which are resulting in a debate about increased or decreased trust for the theory. By adding verified variables to the theory a more accurate picture about the empirics is created, which can be a great improvement for future studies.[43]

The third approach *abduction* is a combination between induction and deduction. According to Holme and Solvang it is often during an abductive approach new innovative knowledge take place.[44] An abductive approach is a wandering back and forth between theories and empirics for finding

[41] G Wallén, *Vetenskapsteori och forskningsmetodik*, 1996, p. 47
[42] M Björklund & U Paulsson, *Seminarieboken – att skriva, presentera och opponera*, 2003, p. 62
[43] I M Holme & B K Solvagn, *Forskningsmetodik Om kvalitativa och kvantitativa metoder*, 1997, p. 51
[44] Ibid.

connections and making conclusions. The research methods and their differences can be illustrated together, see Figure 11.

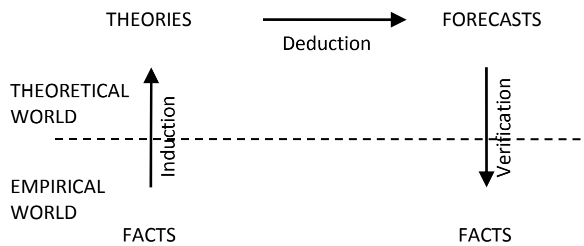


Figure 11 - Cyclical nature of the analytical approaches procedures[45]

3.3.2 Quantitative and Qualitative methods

Scientific research methods can be divided into two general categories, the quantitative method and the qualitative method.[46] The most significant difference between these two methods is the use of numbers and statistics.

A quantitative research is made by scientific methods when information and data can be measured, shown in numbers and valued. The collected empirical data can be summarized into statistics.[47] The researcher is trying to obtain a precise reflection of the quantitative data where the information is gathered from a wide research. Variables, averages and representative data are of greatest importance when the researcher is trying to describe and explain. A significant characteristic for the quantitative research is that the researcher has a non interacting position, more like an observer. A common problem is that the researcher has to be certain about the relevance of questions and following answers in e.g. surveys, otherwise the interpretations of collected data will be incorrect. This is almost like the analytic approach.[48]

A qualitative method aims to achieve understanding by deep studies. The researcher is trying to obtain a research based by understandings of connections and structures. To achieve deeper understanding, data collection is often made by participation, observation or interviews by the researcher. The researcher in a qualitative study has a more interacting part by observing the study from the inside. As a result of the method, criticism about objectives is a returning question. This is almost the same as the actors approach.[49]

3.3.3 The authors' research methods

The narrow theory limits the verification in a deductive approach, as a result, the deductive approach was not chosen. To understand and be successful during the empirical phase with an inductive approach, the researcher needs experiences to be able to collect the right kind of material, which the authors do not posses. Instead the authors believe that they need a wandering between induction and deduction, to be able to see, find and make connections between theory and empirics. As a result, the abduction research method was chosen.

---

[45] I Abnor & B Bjerke, *Företagsekonomisk metodlära*, 1994, p. 107
[46] M Björklund & U Paulsson, *Seminarieboken – att skriva, presentera och opponera*, 2003, p. 63
[47] I M Holme & B K Solvagn, *Forskningsmetodik Om kvalitativa och kvantitativa metoder*, 1997, p. 76
[48] Ibid., p. 77
[49] Ibid., p. 78-81

The study will mainly have a qualitative focus were deeper understanding will be acquired through case studies, interviews and participation. But collected data will also be described and explained to understand, thus a quantitative focus will also be used. The study will therefore have a *System approach* since the study will be based on both qualitative and quantitative studies.

3.4 Data gathering

There are two common terms for collected data. By gathering new data the term is referred as primary data. Already known knowledge and material is referred to as secondary data. According to Arbnor and Bjerke (1994), new data referred to as primary data can be collected in three different ways: observations, interviews and experiments.[50] The three different scientific approaches have their own view on gathering data. The analytical approach uses all three methods for collecting data while experiments in system approach are not guilty. The reason that experiments in a system approach are not guilty is the need in an experiment of two identical situations where causal connections are to be found. The system approach denies causal connections and believes that every situation is unique.[51]

3.4.1 Primary information - Interviews

An interview can be made in a various forms. Personal interviews, surveys and telephone interviews are the general categories of interviews. The outcome of an interview is referred to as primary information. The interview can be done by one or many interviewers. Time and number of questions can also be of various ranges.

There are several ways to perform an interview. The same questions can be asked to everyone interviewed, referred to as a standardized interview. Semi structured interviews have the same areas that has to be covered but new questions can be brought up during the interview. An interview can also be more or less like a conversation where the interviewer asks questions regarding of the situation, referred as a non structured interview.[52]

Questions during the interview can also be open or closed. An open question is a defined question where the respondent can answer free and spontaneously. The closed questions have pre made answers which the respondent has to choose between.[53]

The advantages of an interview are the ability to develop specific questions during interviews, but also that feelings and reactions can be interpreted. The respondent can also ask questions, and misunderstandings can be avoided. On the other hand, an interview consumes a lot of money and time. Interviews have to be prepared and they are also connected with increased travel, to get in touch with interview objects.

---

[50] I Abnor & B Bjerke, *Företagsekonomisk metodlära*, 1994, p. 241
[51] Ibid., p. 245
[52] M Björklund & U Paulsson, *Seminarieboken – att skriva, presentera och opponera*, 2003, p. 68
[53] I Abnor & B Bjerke, *Företagsekonomisk metodlära*, 1994, p. 243

3.4.2 Primary information - Observations

As an observer you have to look, listen and ask to discover what is going on. It is all about catching the system of actions and reactions to understand. During the observation the observer is located within or close to a group of people. The close relation requires an ethical perspective due to observation of not just professional actions but also social behaviors and private demands. This perspective is closely connected to two different observation methods, the open and the hidden observation.[54]

An open observation is known by the ones targeted in the observation, while a hidden observation is more of an undercover operation. A hidden observation can be made from a distance where the observer has no contact with the observed group. It can also be an observation where the group is not aware about a member with an observing role inside the group.

It is hard to define advantages or disadvantages of observations because of the many ways to perform a study. In general, an observation gives objective information, but it is time consuming.[55]

3.4.3 Secondary information

A common source for secondary information is literature. Books, articles, reports and thesis' are all examples of literature that is common to use in the search for related secondary information.

Literature studies have a great advantage in time and expenses. Gathering a large amount of accurate information can be done immediately with tiny expenses.[56] Especially today when libraries are searchable through the web and electronic published articles can be downloaded instantly.

During a literature study it is of greatest importance to be sure about the purpose and its approaching methodology of the former study. A different purpose or a non objective research will create an underlying source of error.[57]

3.4.4 Best practice

Best practice can be defined as methods and techniques that according to experts in a specific area are the most efficient for the moment.[58] The specific best practice is not best for every company in every situation, but it can in general be used as an inspiration source and something to strive for. By comparing specific aspects in companies processes with the best practice case, knowledge and new ideas can be discovered. The best practice case will change over the time, since new best practice cases will be developed.[59] The great advantage with the best practice method is that it is not heavily time consuming. Instead of reinventing already existing methods and techniques, a best practice case can be studied.

The first step is to define which business process to improve and then decide one metric to measure, e.g. late shipments. The next step is to find best practice companies, within and outside the industry.

---

[54] I M Holme & B K Solvagn, *Forskningsmetodik Om kvalitativa och kvantitativa metoder*, 1997, p.111
[55] M Björklund & U Paulsson, *Seminarieboken – att skriva, presentera och opponera*, 2003, p.71
[56] Ibid., p. 70
[57] M Björklund & U Paulsson, *Seminarieboken – att skriva, presentera och opponera*, 2003, p. 67
[58] ItSMF Sweden, retrieved 2010-10-15, <www.itsmf.se>
[59] BusinessDictionary.com, search word: *best practice*, retrieved 2010-10-15,< www.businessdictionary.com >

When the information is gathered, the solution should be modified to suit the company. The last step is to implement the new methods and techniques, and then measure the result.[60]

3.4.5 The authors' data collection

A system approach strives for a holistic perspective and the authors believe that a mix of data gathering methods is necessary to achieve understanding between the parts in the system. Data collection within the system and data collection outside the system has to be done to understand, and further on construct a new system that is fulfilling the purpose of the thesis.

To achieve knowledge about material supply, secondary information will have a significant impact. The Electronic Library Information Navigator, ELIN, hosted by Lund University, was an input in the search of scientific articles regarding the subject. The authors were also building up a small collection of books that addresses the areas of this study.

Initially the secondary information was used to achieve knowledge within the field of material supply. To get a deeper understanding and basic knowledge about Nederman's processes, observations and interviews were made. These initially interviews was opened and semi structured to avoid wrong directions set by the authors. Later on in the study, when the targeted area was specified, more specific interviews were made. See Appendix A, Appendix B and Appendix C for interview guides.

The authors' have also visited and observed a best practice assembly process to gather information and data regarding successful solutions of material supply. By signing up a membership in the Swedish logistics association, PLAN, the authors were invited to a company visit hosted by Thorn Lighting. Thorn Lighting has the last year successfully been introducing Lean in their assembly plant and offered PLAN members a guided tour in their plant. The authors' have been using this gathered data as a best practice in the analysis. The company did not want to reveal any numbers about the changes, but the company event has a high credibility since it was hosted by PLAN.

Initially a meeting with involved people at Nederman was booked to find out potential assembly stations for the study. The authors then continued to distinguish the stations by their volume and number of different finished product. The authors' aimed to search for assembly stations with different characters. As a result assembly station 189, 166 and 152 were decided to be observed. A plot of the three chosen stations by their characteristics can be seen in Figure 12. These stations reflect a various spread of assembly stations at Nederman. These assembly stations were observed by the authors to catch the system of actions, processes and actors. The chosen assembly stations were mainly observed by three different perspectives that are within the focus of the report, the component ordering process, the buffer inventory and the management process.

[60] Small business information, retrieved 2010-10-15, <www.sbinformation.about.com>

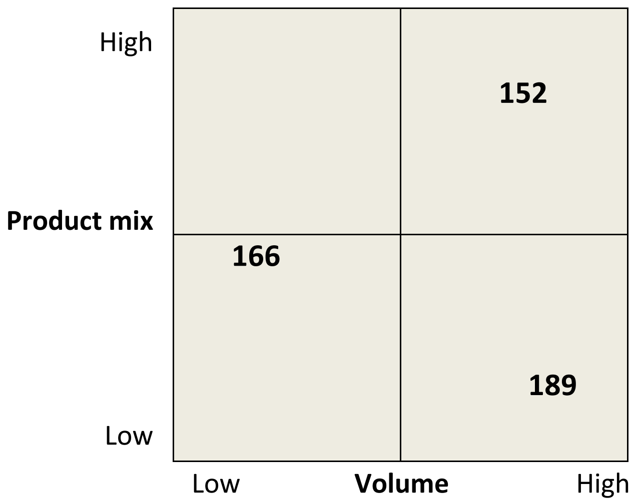


Figure 12- Characteristics of chosen assembly stations

The authors did not just look and listen during the observations; questions about the system were of greatest importance. The observations were of an open kind where they were well known by the personal at the stations. To understand the surrounding area of the assembly stations, interviews and observations were also made with production planers, internal logistics team, team leaders and production manager.

The study has also been using a large amount of quantitative data from the enterprise resource program. Data about demand, transportation orders and picking frequency for components at the three detail studied stations have been gathered. The data covers a time horizon of one year, 2009-2010. The data has been exported to Microsoft Excel and cleaned by removing outliers. Missing data has been treated by a list wise deletion, which means that when any of the variables are missing, the entire observation row is omitted from the analysis

3.5 Research plan and analysis

The study followed the established goal-mean orientation. The study started at an early stage to clarify and understand the problem, but also to identify the system. How it worked and interacted with the surrounding area. Initial interviews with production managers were made to get basic knowledge about the studied system. The authors were also interviewing personal at different levels to achieve an objective holistic view at the problem.

To be able to perform a system analysis the authors were studying theories and aimed to find a company which could be targeted as a best practice within material supply. The theory was secondary information from books, articles and reports, the theory was qualitative. During a system analysis it is important to understand the holistic system and how the sub parts interact with each other. Hence, a material and information flow mapping were made to get this perspective. The authors also aimed to search for quantitative data. The quantitative data had a significant impact in the identification of transportation times, buffer size and component ordering process. To be sure about the credibility of the data, triangulation was made. The mapping and data collection was complemented by interacting observations and interviews, where the authors participated in the assembly process. The empirical phase was highly depended of presence and tight schedules for achieving data and other system analysis characteristics. The data collection from the enterprise resource program was time consuming and needed a time table. From the system analysis and its empirical information a system construction was made.

The system construction phase started with a pre phase of analysis of the identified problems and collected data. The collected empirical data was considered and compared to theories and best practices. The quantitative data were also analyzed by statistically operations where problem areas were identified. The study aimed to analyze following questions;

- How can the waste of time be reduced in the material supply?
- How can the utilization rate at the assembly stations be increased?
- What ways exist to release floor space at the assembly stations?
- Which parameters determine where a component should be stored?
- How can suggested solutions be financially prioritized?

The analyze phase had to combine empirical principles and theoretical tools. To perform a carefully prepared analysis the interaction between these principles and tools had to be defined.[61] The tools are presented in the theory chapter and the principles are defined in the beginning of the analysis chapter. The principles and tools framework were the guideline for the analysis phase in this study, see Figure 13. The established principles have been analyzed one at the time by the defined tools. To achieve a holistic view, the authors had to analyze the sum of the principles and present consequences of potential conclusions. The outcomes were deliberated and a holistic picture of the analysis phase was created in the final sub chapter of the analysis. Read about principles in chapter 4.4.

Principles Tools	Stockless production	Location of articles	MRP	Kanban	Standardized working methods	Stabilize the load of work
Simplify structures, systems and processes	●	●		●	●	
Reduce waste of time in material supply		●			●	●
Reduce waste of time in assembly processes	●	●		●	●	
Optimize buffer inventory	●	●	●			

Figure 13- Principles and tools framework

The purpose to improve the material supply at Nederman by identifying parameters that determines if the components should be stored at the station or in the warehouse has to be fulfilled. During the system construction phase an intensified communication with the supervisor took place. The

[61] A Norrman, *Lecture Notes – Logistik i försörjningskedjor (MTT240),* 2009, p.12-15

conclusions and recommendations had to be realistic and economical sustainable. The authors' arranged workshops with the supervisor at Nederman to validate the accuracy of the analysis. Due to the abduction approach, a wandering between theory and empirics was made and during the final conclusion the authors sometimes needed to go backwards in the goal mean orientation. The goal mean orientation can be seen in Figure 14

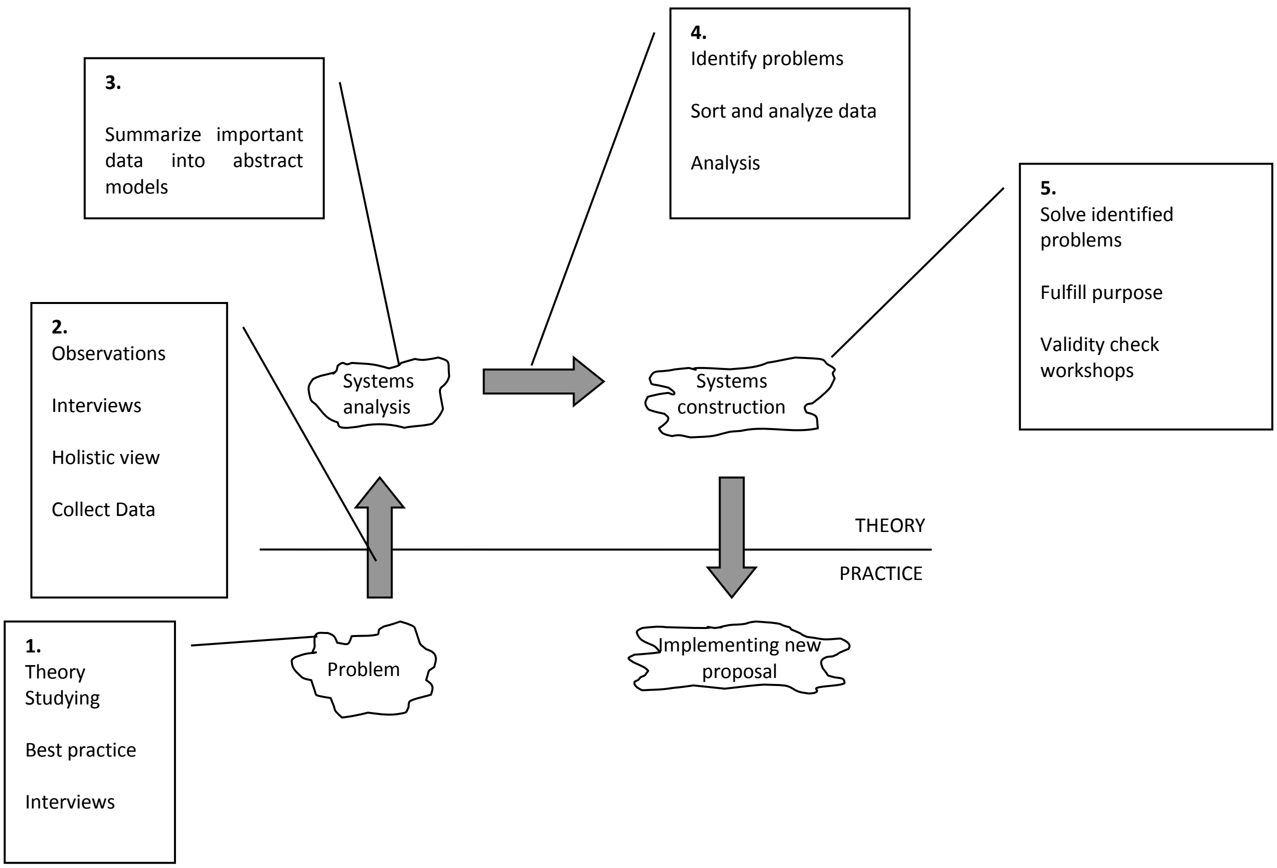


Figure 14- Research plan with a goal mean orientation approach

3.6 Validity and reliability

Validity can be defined as to what extent you measure what you are supposed to measure.[62] To achieve a high level of validity can be difficult. Fundamental parameters have to be included and systematic errors needs to be eliminated.

The validity in a system approach does not have a great focus on the connections between theories and reality. Instead the validity check consist questions like; Are the results likely? To check and increase the validity it is important to be in the system and talk with people in it. A report with high validity can be

[62] M Björklund & U Paulsson, *Seminarieboken – att skriva, presentera och opponera*, 2003, p. 59

used as a guide.[63] High validity can be achieved by non subjective and clarified questions.[64] Triangulation can also be method to increase validity by using different investigations methods to study same object.[65]

Reliability can be defined as to what extent the outcome of the results will be the same with repeated trials.[66] The result in a system approach is not precise in the same way as e.g. an analytical approach, where it is valued to control the reliability as often as possible. As a result reliability is not of greatest interest in a system approach report.[67] Higher reliability can be achieved by using question to control already responded answers. Triangulation can also be used to increase the reliability.[68]

3.7 Credibility of the study

The credibility of the study depends on the authors methods of continuously maintain validity and reliability. To achieve a high degree of validity and reliability the authors considered a number of different aspects: Data about certain areas were collected from different types of sources, referred as triangulation. The interviews were recorded and compiled into data that was going to be verified by the respondent. Chosen interview objects and assembly station observations were selected to obtain a holistic perspective. All collected data were discussed with the supervisor at Nederman. Through the study the authors were continuously asking themselves, Are the results likely?

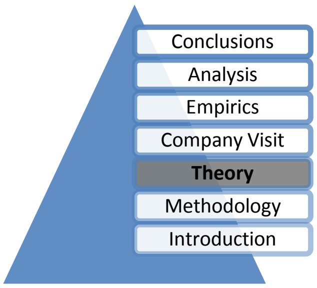
To achieve an increased credibility and enable the reader to follow the study all interview guides and respondents positions are placed in the Appendix A, Appendix B and Appendix C. During the study some previously made studies at Nederman has been used as input data in the empirics. In those cases the data has been verified by personal at Nederman, to check that it is accurate and up to date.

After each phase of the study a workshop with the supervisor at Nederman has been taken place to ensure high reliability. The authors' ideas and gathered data have been discussed and validated. In complex areas such as the component ordering process in the ERP system, workshops with the production planner has also been carried out to ensure high credibility. To ensure useful conclusions for Nederman, the analysis phase has been followed by meetings to evaluate the analysis and identify areas of importance. The final presentation of the study at Nederman was also followed by a workshop where all involved personnel helped the authors' to point out obscurities and contribute to a higher credibility of the study. This workshop did also include a discussion about the economical potential and the complexity factor of each proposed solution. The workshop after the final presentation at Nederman involved warehouse personnel, internal logistics, team leaders, purchasers, production planners, site manager, quality engineers and the authors supervisor at Nederman.

---

[63] I Abnor & B Bjerke, *Företagsekonomisk metodlära*, 1994, p. 250
[64] M Björklund & U Paulsson, *Seminarieboken – att skriva, presentera och opponera*, 2003, p. 60
[65] Ibid., p. 76
[66] Ibid., p. 59
[67] I Abnor & B Bjerke, *Företagsekonomisk metodlära*, 1994, p. 248-249
[68] M Björklund & U Paulsson, *Seminarieboken – att skriva, presentera och opponera*, 2003, p. 60

4 THEORY



This chapter gives a presentation of relevant theories used in the study. The theories are essential in the analysis of collected empirical data. There are four subchapters in the Theory chapter; concepts and terms, improvement tools and mapping tools. The chapter structure of the theory will follow the order of the tools in the principle and tool framework.

4.1 Concepts and terms

This subchapter briefly describes important concepts and terms used in the study. These concepts and terms are basic knowledge in logistics and therefore necessary to understand.

4.1.1 Inventory turnover

The inventory turnover is a performance indicator for a company. A high turnover rate implies that the inventory is sold many times a year and the company has relatively low stock levels. The opposite, a low inventory turnover indicates that the inventory is not sold out many times during a year. A low inventory turnover can be a result of buying too many components at each time or that the demand for bought components is low. The inventory turnover can be calculated according to the following formulas:[69]

$$Inventory\ turnover = \frac{Demand\ (quantity)}{Average\ stock\ level}$$

$$Inventory\ turnover = \frac{Demand\ (value)}{Avarage\ stock\ value}$$

By reducing the investments in the inventory, the inventory turnover will increase and the tied capital will decrease, with a higher profit as a result. A reduction of inventory levels is always desirable as long as stock shortage can be avoided.[70]

4.1.2 Lead-time

The lead-time is defined as the time from that a customer places an order until the time the customer receives the order. The lead-time includes several activities, such as reception of order, order handling, planning, manufacturing and distribution. Most of these activities are not value adding for the customer; only the total lead-time is in the focus for the customer. The lead time is a supply service element and companies that manage to keep shorter lead times than their competitors, has a competitive advantage.[71]

According to Persson (1995) there are three ways of reducing the Lead time; Change from sequence to parallel activities, reduce waiting time by synchronization and simplifying activities for reduced time. In a reduction of Lead time it is usually easiest to find potential reductions in the administrative part. A reduction of Lead time can also easily be achieved by increased cooperation with suppliers or customers.[72]

4.1.3 Inventory carrying cost

The inventory carrying cost can be described as all costs related to holding an inventory. The inventory cost depends on the quantity of components stored in the inventory. The cost is mainly split into three costs; the capital cost, the storage space cost and uncertainty cost.[73] The capital cost is the interest of

[69] B Oskarsson, et al. *Modern Logistik- för ökad lönsamhet,* 2004 p.190
[70] JJ Vogt, et al. *Business Logistics Management,* 2006, p.97
[71] K Lumsden, *Logistikens grunder, 2006,* p.261
[72] G Persson, *Logistics Process Redesign: Some Useful Insights,* 1995, p.20-21
[73] P Jonsson, et al. *Logistik- Läran om effektiva materialflöden, p.131*

the money used to buy the inventory. It can also be described as the interest lost from other possible investments.[74] The storage space cost includes costs for the warehouse building and costs for all the activities related to storing components. It includes costs for: the warehouse staff, inventory administration, depreciation of the warehouse building, storage and handling equipment, inventory administration, as well as internal logistics and energy.[75] Storing components is associated to uncertainty and endangerment. The final cost, the uncertainty cost is related to obsolescence, shrinkage and damage of components. A high inventory level can cause long storage times which can lead to a higher risk of obsolete components. These products will be rejected or sold to a reduced price. The cost for obsolete components is usually high in many companies. High inventory levels can also cause defected components due to the increased handling of components. Some components disappear from the inventory even if no sale has been done, due to less control over high inventory levels. The shrinkage usually depends on stealing but in some cases is the shrinkage a cause of an inadequate ordering system. If wrong articles or wrong number of articles are delivered to a custom an extra cost will occur since the fault needs to be corrected, this is also included in the uncertainty cost. The insurance cost is also one of the cost included in the uncertainty cost, this cost is usually easy to determine compare to the other costs in the uncertainty cost.[76]

The management at the company is responsible for the inventory. With high inventory levels the holding cost will increase but the ordering cost will be lower due to less order placements.[77]

4.1.4 Variability of demand

The demand of components in a company can differ a lot. The demand can be stable, varying or very unstable. Figure 15 illustrates three graphs with stable demand (X), varying demand (Y) and very unstable demand (Z). The x-axis represents the time and the y-axis the demand.

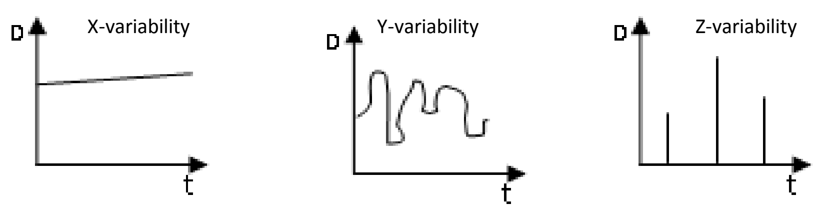


Figure 15- Variability of demand[78]

The variability factor makes it possible to compare different component's uncertainty of demand with each other. The variability factor for a component can be calculated according to the formula:

$$Variability\ factor = \frac{\sigma_w}{\emptyset D_w}$$

σ_w is the standard deviation of demand per component, per week.

[74] JJ Vogt, et al. *Business Logistics Management,* 2006, p.98
[75] P Jonsson, et al. *Logistik- Läran om effektiva materialflöden, p.132*
[76] Ibid.*, p.132-133*
[77] B Oskarsson, et al. *Modern Logistik- för ökad lönsamhet,* 2004 p.106
[78] A Norrman, Lecture Notes – Logistik i försörjningskedjor (MTT240), 2009 p.49

$\varnothing D_w$ is the average demand per component, per week[79]

The variability of demand can be used as an axis in a classification matrix. If the variability factor of a product is plotted against the demand, principles of how to treat the product can be found. See Figure 16 for an example.[80]

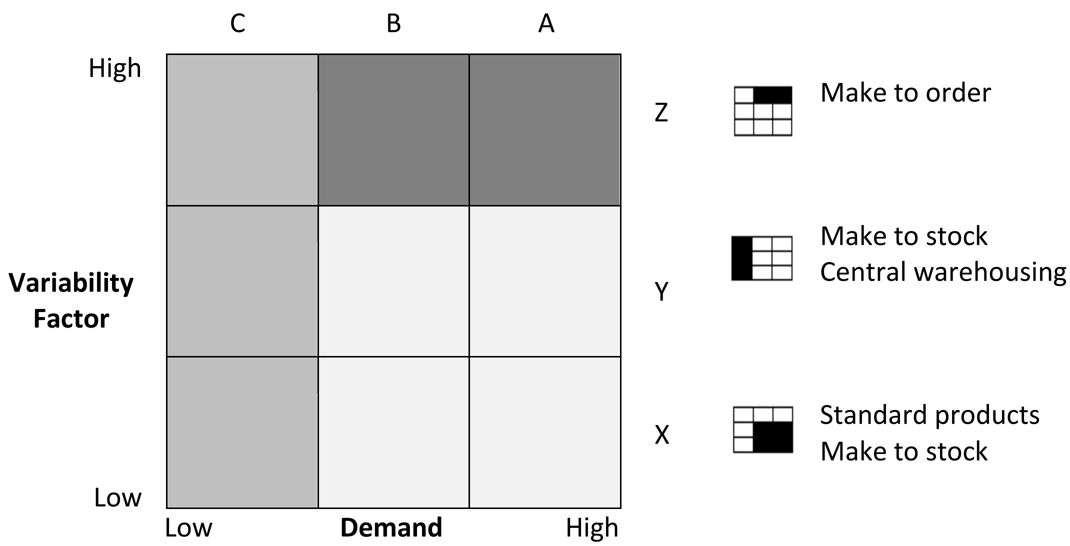


Figure 16 – Classification of products[81]

4.1.5 Priority matrix

According to Bjørnland, et al (2003), an organization is not able to manage too many projects at the same time that are transforming the business. As a result, the potential improvements have to be prioritized. A prioritization list can be achieved by plotting potential improvements in a framework. An organization and the people involved in an improvement project often need early success stories. Projects with high economical potential with low complex factor should have 1st priority according to Persson (2003). A prioritization framework can be illustrated by following matrix, Figure 17.[82]

[79] A Norrman, Lecture Notes – Logistik i försörjningskedjor (MTT240), 2009 p. 49-52
[80] Ibid., p.51
[81] Ibid., p.50
[82] D Bjørnland, et al, *Logistik för konkurrenskraft – Ett ledaransvar,* 2003, p. 338-339

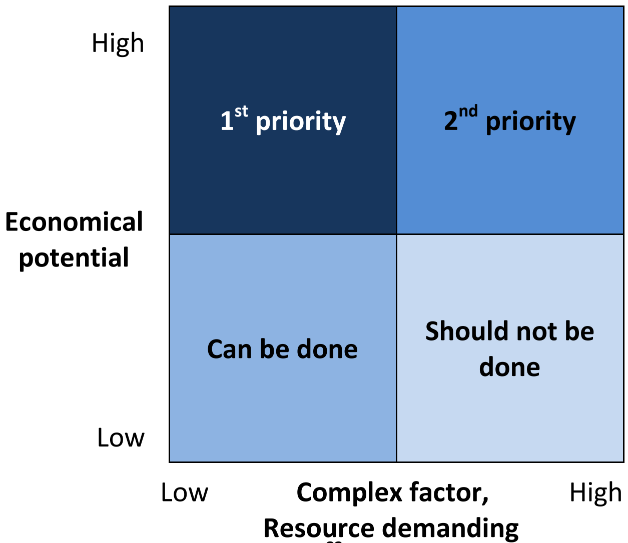


Figure 17- Priority matrix[83]

4.2 Improvement tools

The following subchapters discuss different improvement tools that can be useful at Nederman. Most of the improvement tools are found within Lean production.

4.2.1 Quality circles

Quality circles are a Japanese invention and started around 1962. The quality circles were from the beginning a study group for factory workers. These study groups were later developed into groups that were working with solving problems and generating new ideas. Nowadays quality circles are including a small group of volunteers of employees in the company. The volunteers discuss and analyze the quality and productivity of the company. Quality circles are group-oriented and usually formally organized in the company. What is discussed in the circle and how it is discussed is usually structured. In Japan the method and quality goals are important and therefore the circles are discussing working methods and quality. New ideas about well-being and comfort are also legitimate subjects, for example coffee machines or repainting of canteen.

The main purposes of quality circles are to increase the work ethic and motivation for the employees. Many of the production plants Schonberger had visit in Japan had vigorous quality circles and he was impressed of the quality circles obvious contribution to better quality, methods, working ethics and motivations. Schonberger was convinced that quality circles had a great impact of the early Japanese quality improvements. [84]

4.2.2 Stockless production

A continuous attempt to decrease the inventory level in an organization can result in great advantages. The function of production buffers is to avoid disturbance in the flow. When the buffer level decreases,

---

[83] D Bjørnland, et al, *Logistik för konkurrenskraft – Ett ledaransvar,* 2003, p. 339

[84] R J Schonberger, *Japansk kvalitet och produktivitet, 1983, p161-166*

disturbances will occur and problems will be visualized. The outcome is that the company needs to adjust the visualized problems to be able to continue the production.[85] The *Japanese sea* illustrates problems hidden by high inventory levels, see Figure 18. The water in the sea is representing the amount of material in the system. Under the surface there are several problems hidden. By decreasing the water level (inventory level) in the sea (inventory), hidden problem will be visualized. The idea with the illustration is to gradually drain the sea to find and solve all disturbances.[86] A common problem in Lean production is that when disturbance occurs in one station, most of the other stations will be affected as well. As a result there are incentives for everyone in the production that every station is processing all the time. If a problem occurs time after time, the management can solve the situation by e.g. educate the personnel in maintenance to be able to eliminate the problem.[87] There are in general three reasons for striving towards stockless production *visualization*, *priority* and *incitement*. As mentioned before, reduced inventory *visualizes* disturbance. A visualized disturbance can more easily be *prioritized* by its harmfulness. Without buffers there are strong *incentives* to solve and get rid of the disturbance. During the reduction phase, the system will be more sensitive to disturbance in short terms, but it will be stronger and more profitable in long terms.[88]

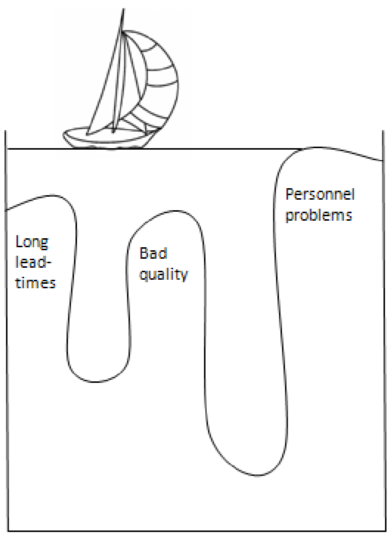


Figure 18- The Japanese sea[89]

4.2.3 Location of articles

The location of articles in an inventory is critical to be efficient and competitive. Bad placement of articles will cause inefficiency, which is costly for a company in a competitive industry.[90] By making the picking process more efficient, the inventory cost can be decreased.[91] There is not any general method

[85] J-E Ståhl, *Industriella tillverkningssystem – länken mellan teknik och ekonomi*, 2008, p.263
[86] S Shingo, *Den nya japanska produktions filosofin,* 1989, p. 181
[87] J Liker, *The Toyota way- Lean för världsklass,* 2009, p. 56
[88] J-E Ståhl, *Industriella tillverkningssystem – länken mellan teknik och ekonomi*, 2008, p.264
[89] Ibid.
[90] JJ Vogt, et al. *Business Logistics Management,* 2006, p.144
[91] C G petersen & G R Aase, *Improving order-picking performance through the implementation of class-based storage,* 2004, p. 534

to find the optimal location for an article. The best way to find a good solution is to start with some location principles of articles and restriction on where the article can be located.[92]

4.2.3.1 *Volume based storage*

In volume based storage the articles storage location is based on handled volume or picking frequency. Since the demand usually is uncertain the location is based on expected volume. Articles with a high frequent demand should be located close to the assembly process to be able to decrease the travel time and distance. It is the opposite for articles with an expected low frequency demand.[93] The articles can be classified based on frequency and be plot in a graph with accumulated demand on the y-axis and the share of articles on the x-axis, see Figure 19. The slope in the plot indicates if the location of articles according to frequency can be successful. A flat plot shows that there is a relative high amount of articles with a high frequency. With a flat plot, volume based storage is not really easy to manage.[94]

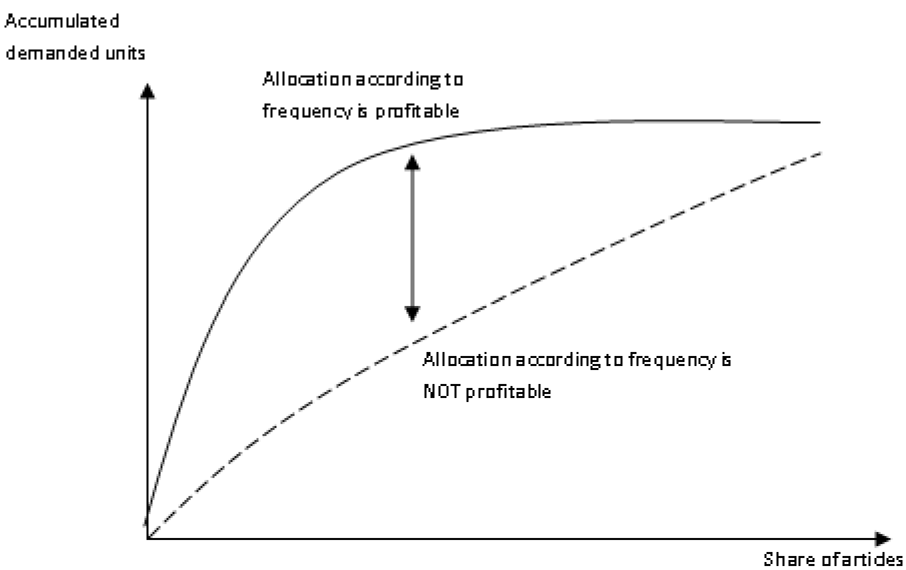


Figure 19- Volume based storage test[95]

This type of classification requires that the demand is stable. Therefore, the picking frequency of the articles should be investigated continuously when using locating storage according to this classification.[96]

4.2.3.2 *Size-based storage*

According to the size-based principle, articles that are big, heavy or difficult to handle should be located close to its use. The reason for this is that the costs of handling this type of articles are generally higher than for other articles. These types of articles should also be stored as low as possible in the inventory due to difficulty to handle the articles. [97]

---

[92] K Lumsden, *Logistikens grunder, 2006,* p.459
[93] C G Petersen, The impact of routing and storage policies on warehouse efficiency, 1999, p. 1054
[94] K Lumsden, *Logistikens grunder, 2006,* p.460-461
[95] Ibid., p.461
[96] Ibid., p.460-461
[97] Ibid.,, p.462

4.2.4 Ordering process

The purpose of an ordering process is to determine how much and when to order. Components have different characteristics and there is not just one specific ordering process that suits for all components. Below are three different systems discussed; Material requirements planning, Kanban and two-bin Kanban.

4.2.4.1 *Material requirements planning*

The material requirements planning (MRP) system is used in several companies, it is especially used in companies that are assembling final products. MRP is a method to plan backwards in time. When the demand of the final product is set the system calculates which components and how many components that are going to be needed. The calculations are based on current inventory level for each component. The missing components are ordered in the specific missing amount.[98] Since the MRP-system only orders the specific amount that is needed, the system is most suitable for products with an uncertain demand or with a low frequency demand. [99]

4.2.4.2 *Kanban*

In production is it common to use forecasts and push components to manufacturing. The Kanban system "pulls" the components from the warehouse to the manufacturing. Kanban systems are useful for standard products where the demand of components is frequent, predictable and stable.[100] The idea of Kanban came from grocery stores where the customer picks its products and the personnel fill up the shelves continuously.[101] With Kanban the purpose is to bring materials and components to the right place at the right time when they should be used, in a quantity to match the production schedule. With Kanban it is possible to reduce inventory levels and therefore inventory space. But the method has some disadvantages; if the material is not delivered in time it will be a risk of interruption in the production.[102] Kanban does not solve any problems itself, it is a visualization tool to fast and continuously serve the production with components.[103] When an article is finished or the buffer has decreased to a specific level in an assembly station, a Kanban card with information is send to the warehouse. The card includes information about which product, when and how much to deliver, and from where to where the product should be delivered. It does not necessary have to be a card, it can be a pallet, a light or some other type of visualization tool as long as the forklift driver know what, how much and where to collect.[104] Since the production is repetitive, the Kanban card can be used several times.[105]

As mentioned before, Kanban suits components with a stable and predictable demand. However, components that can hold safety stock to a low cost can still be considered for Kanban. By using the variability of demand ratio mentioned in 4.1.4 potential Kanban components can be identified.

[98] K Lumsden, *Logistikens grunder, 2006,* p.429
[99] Ibid.*, p. 425*
[100] S Shingo, *Den nya japanska produktions filosofin,* 1984, p.167
[101] Ibid., p.172
[102] P Chary & T Skjøtt-Larsen, *Managing the global supply chain,* 2003, p.166
[103] S Shingo, *Den nya japanska produktions filosofin,* 1984, p.182
[104] K Lumsden, *Logistikens grunder, 2006,* p.427
[105] S Shingo, *Den nya japanska produktions filosofin,* 1984, p.172

According to Cimorelli (2005) products with a low variability factor are good candidates for Kanban. With a moderate safety stock even moderate and high variability components with a factor of 0.5-1 are suitable for Kanban as long a safety stock exist.[106]

Two-bin Kanban

Two-bin system is a type of Kanban system that is useful for small components stored in bins. The bin represents the Kanban card but do also work as the transportation bin for the components. The production buffer has two bins. When one of the bins is empty it is placed at a refill location. The forklift driver collects the bin, refills it and puts it back at the specific place for the article in the production buffer. The amount of components in bin one has to be enough so the lead-time for refilling bin number two do not exceeds the time to consume the components in bin number two.[107]

4.2.5 Standardized working methods

A standardized working method is one of the cornerstones in Lean production. It enables constant improvements, innovations and employee development. Without a standardization of the work, the process will be unstable. The process needs to be stable before any improvements can be done. The goal with standardized work is repetitiveness and efficient work tasks for the workers.[108] Implementing a standardized working method is almost pointless if the volume is unknown, varies day to day or if the work sequence varies due to a wide product mix. [109]

If a workers work task is standardized, it should not be possible to do a process wrong; standardization is a way to guarantee the quality the company aiming for. However there is a critical path between a strict procedure and the liberty for the worker. The key to success is depending on how the standards are written and by whom. If someone outside the production writes the standards, it will be very difficult to implement the work and force the worker to follow the rules. To be able to succeed with the implementation, the worker and the team-leader should together describe and develop the standardized process. In that way the operators feel accessorial in the development towards a more effective production.[110]

To develop a standardized working method, an instruction should be created. The purpose is to minimize waste by combining worker, machine and equipment. All activities in a process should be specified in a way so no matter whom performs the activity; it should always be performed exactly in the same way.[111] The team-leader controls that the standardized working method is followed correctly, by checking the instruction.[112]

The standardized working method is updated by continuously improvements.[113] If problem occurs even while the instruction was followed, the team-leader and the worker should inspect all steps in the instruction. Together it should be possible to find where in the instruction some changes needs to be

---

[106] S Cimorelli, *Kanban for the supply chain - Fundamental practices for manufacturing management,* 2005,p. 64-65
[107] B Oskarsson, et al. *Modern Logistik- för ökad lönsamhet,* 2004 p.96
[108] J Liker, *The Toyota way- Lean för världsklass,* 2009, p.*179*
[109]http://www.gembapantarei.com/2008/02/three_essential_supervisor_skills_for_standard_wor.html
[110] J Liker, *The Toyota way- Lean för världsklass,* 2009, p. *176-179*
[111] S Shingo, *Den nya japanska produktions filosofin,* 1989, p. 149
[112] J Liker, *The Toyota way- Lean för världsklass,* 2009, p. *179*
[113] S Shingo, *Den nya japanska produktions filosofin,* 1989, p. 152

done for avoiding the problem.[114] The chosen standardized working method is the best solution at the moment, but there will always be place for improvements. Thus, the standardized working method should always be challenged and improved.[115]

According to Persson (1995) is simplification of structures, systems and processes one of the principles in reaching an improved process performance. Standardization of methods and processes are of two ways of simplifying the work. With an increased simplification, the complexity of the control task decreases and improvements of the performance can easily be made.[116]

4.2.6 Stabilize the load of work

Mura is one term in Lean Production and means irregularity in the production. In production systems there are usually problems with too much work, or as an opposite, shortage of work. Irregularity is a cause of varying production utilization or production volumes. These variations arise because of internal problems like slack, defect or missing components. Waste is a consequence of irregularity. [117]

The common way to start to use Lean production is by concentrating on elimination of waste. Although the hardest step to implement Lean for companies is the elimination of irregularities. An elimination of irregularities is fundamental to be able to reduce waste and overstress. It is better to do activities in a slow and even rate instead of a high production rate with many breaks.[118]

In manufacturing different ordering systems are used, for example Kanban or computer systems such as MRP. In Kanban systems orders are placed when a component is needed. If the demand of components in the production is unstable, this will lead to even higher fluctuating load of work in the internal logistics. To be able to avoid the problem with irregularity should routines be introduced to stabilize the load of work.[119]

4.3 Mapping tools

To be able to succeed with improvements and identify problems in an organization all activities needs to be clarified. With knowledge about the process it is possible to draw some conclusions and to create proposal for solutions. The first step in a description of current situation is to map the material and information flow. [120] The material and information flow are connected and can therefore not be studied totally separate from each other. [121]

4.3.1 Mapping of the material flow and information flow

When mapping the material flow in an organization the material, goods and services needs to be studied.[122] The map can be very detailed or more general, depending on time and purpose of the study. Usually is a more briefly flow mapping to prefer because it is very time consuming and most of the work

---

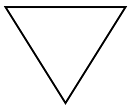
[114] J Liker, *The Toyota way- Lean för världsklass,* 2009, p*. 176-179*
[115] http://www.imit.se/presentations/pres_96.pdf
[116] G Persson, *Logistics Process Redesign: Some Useful Insights,* 1995, p.22
[117] J Liker, *The Toyota way- Lean för världsklass,* 2009, p*.* 148
[118] Ibid., p*.* 147
[119] S Shingo, *Den nya japanska produktions filosofin,* 1984, p.138
[120] B Oskarsson, et al. *Modern Logistik- för ökad lönsamhet,* 2004 p.175
[121] K Lumsden, *Logistikens grunder, 2006,* p.249
[122] N Storhagen, *Logistik-Grunder och möjligheter,* 2003, p.20

might be done in vain. Initially to avoid that too much effort is put in the mapping, it can be described briefly and be refined in the parts of the flow that is extra interesting for the study.[123]

When mapping, some well established symbols are usually used to illustrate the process.[124]

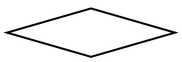
Operation/ Activity/ Department

The rectangle in a flow chart stands for some activity in the process. It can be a value adding activity like assembling, or a non-value adding activity like transportation of components to a assembly station.[125]



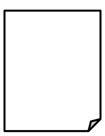
Inventory

The rectangle represents some type of inventory in the process. It can be a warehouse, station buffer or finished goods inventory. [126]



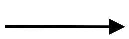
Decision point

The quadrangle illustrates some type of decision point in the process. The point can show different alternatives for the material or information flow.[127]



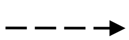
Document

Some specific information or documents can be important for the process and should therefore be included in the flow mapping.[128]



Material flow

All movement of the material in the process is marked with an arrow. [129]



Information flow

The information flow includes all communications and data processing in the organization.[130]

[123] B Oskarsson, et al. *Modern Logistik- för ökad lönsamhet,* 2004 p.176-177
[124] Ibid., p.175
[125] Ibid., p.176
[126] Ibid.
[127] Ibid.
[128] Ibid.
[129] Ibid.
[130] N Storhagen, *Logistik-Grunder och möjligheter,* 2003, p.20

4.3.2 Mapping of waste

When mapping a process, waste is one important aspect. The main purpose is to eliminate all kind of waste and create value for the customers.

One important step in the Lean process is to identify the flow of activities; all activities that do not create value for the customers are potential waste.[131] According to Liker (2009) there are eight types of waste.[132]

- *Overproduction.* There are two types of overproduction. The first one is waste created by unnecessary big sizes of production quantities. As a result, the products will be kept in stock until they are demanded. Having products waiting for a customer is expensive, due to the inventory cost. The second one is to produce at an early stage. To avoid late customer deliveries, an extra time buffer is added. The produced products will be finished before the determined date, which means that the products will be kept in stock until delivery date.[133]
- *Wait.* Different types of wait can occur in a production. It can be when an operator is waiting for a machine, spare parts or just waiting because of material shortage. All types of wait related to machines, operators or resources are waste since it is not creating any extra value for the customers.[134]
- *Unnecessary movements and transportations.* The movement of products does not create value for the customers. It can for example be unnecessary movements between inventory and production. Thus, transportations and movements should be eliminated to the greatest possible extent.[135]
- *Over- or incorrect processing.* Products should be produced without any superfluous operations or movements. Poor working tools or bad designed products might be the source to this kind of waste. Waste is also created when the product quality is higher than required.[136]
- *Excess inventory.* Unnecessary high inventory level of incoming material, processing products or finished goods affects the waste. It increases throughput time, risk of obsolete products and damaged goods. It is also creating unneeded extra transportations, inventory costs and delays. This type of excess inventory usually cover up for bad production planning, late supplier deliveries, incorrect products or long set-up times[137]
- *Pointless working activity.* Every working movement that does not contribute to the value for the customer is classified as waste. It can be movements such as stretching, searching or walking to the warehouse for a component.[138]
- *Defects.* Reparations or rejections of defect products results in waste of handling time and energy.[139]
- *Unused creativity.* If a company does not listen to advises from its employees, ideas and smart solutions will be wasted which will result in waste of time, skills, improvements and ability to learn.[140]

---

[131] B Bergman & B Klefsjö, *Kvalitet från behov till användning,* 2009, p.622
[132] J Liker, *The Toyota way- Lean för världsklass,* 2009, p. *50*
[133] S Shingo, *Den nya japanska produktions filosofin,* 1989, p. 92
[134] J Liker, *The Toyota way- Lean för världsklass,* 2009, p. *50-51*
[135] Ibid.
[136] Ibid.
[137] Ibid.
[138] Ibid.
[139] Ibid.
[140] Ibid.

A way to visualize value adding and waste activities is to map all the activities in a process, see Figure 20. A block represents each activity; the size of the block depends on the required activity time. Each block that represents a value adding activity is marked with a color, the waste activities are marked with another color.[141]

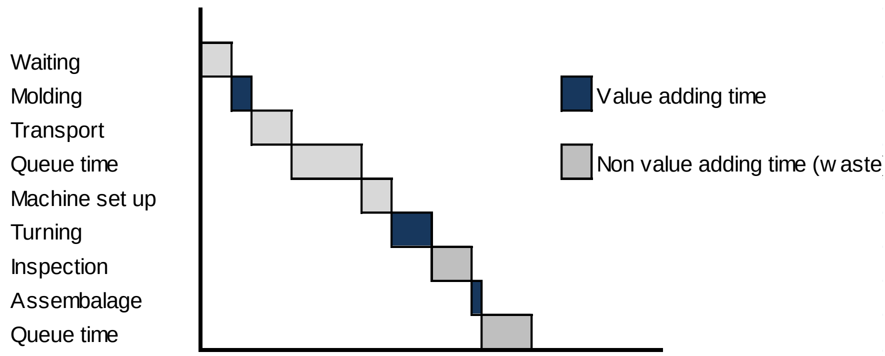


Figure 20- Waste within a value system

4.4 The Principle and Tool framework

By using a Principle and Tool framework, the analysis in a study can be performed in a structured and illustrative way. An example of a Principle and Tool framework are seen in Figure 21**.** The tools are corresponding to the chosen theory of the study. The principles are developed by a step process. Mapping of the value chain should be the first step in an analysis to achieve an understanding of the activities. The mapped flow should then be described by its features, such as lead times, uncertainties, complexity and organization. By describing the mapped flow, principles for achieving an increased efficiency can be written down. The principles can e.g. be *Reduce Lead Times, Postpone, Increase frequency* or *Simplify structures*.[142]

Principles / Tools	Flow mapping	MRP	Japanese sea	Kanban
Reduce lead-times				
Postpone				
Increase frequency				
Simplify structures				

Figure 21- The principle and tool framework

When the Principles and Tools are decided and placed in to the framework, it is just to identify and combine which tool that can be a solution for each principle.

[141] J Liker, *The Toyota way- Lean för världsklass,* 2009, p. *52*
[142] A Norrman, Lecture Notes – Logistik i försörjningskedjor (MTT240), 2009 p.9-15

4.5 Summary of chosen theories

Stockless production, Location of articles, MRP, Kanban, Standardized working methods and Stabilize the load of work have all been chosen as tools in the principle and tool framework. The framework is later used to provide an easy and structural approach in the analysis phase. The following brief theory addresses the purpose of the study and is well suited to fulfill an analysis of the principles.

The stockless production theory addresses the issues of that a continuous attempt to decrease the inventory level in an organization can result in great advantages. The location of articles in an inventory is critical to be competitive; a bad placement of articles will cause inefficiency.

MRP is establish in assembly processes and well suited for products with an uncertain demand or with a low frequency demand. As an opposite can Kanban be useful for components with predicted and frequent demand.

Simplifying structures, systems and processes are necessary in reaching an improved process performance. Irregularity is also causing problems in the process performance. The varying production utilization or production volumes creates too much work, or as an opposite, shortage of. To be able to avoid the problem with irregularity should routines be introduced to stabilize the load of work.

The theories are gathered in Figure 22.

Theories →

Principles / Tools	Stockless production	Location of articles	MRP	Kanban	Standardized working methods	Stabilize the load of work
Simplify structures, systems and processes						
Reduce waste of time in material supply						
Reduce waste of time in assembly processes						
Optimize buffer inventory						

Figure 22- The principle and tool framework in the study

To be able to perform a mapping of the material supply, several parameters have to be studied. The parameters are the following:

Inventory turnover - In the detailed study, the inventory turnover for each component will be studied. The inventory turnover can be an indication of that a component is stored over a long time in the station buffer.

Lead-times – To be able to understand the material supply from the ordering to the delivery of components, the authors measure the average time for the following activities

- Ordering time
- Picking time
- Waiting time
- Transportation time

- Buffer placement time

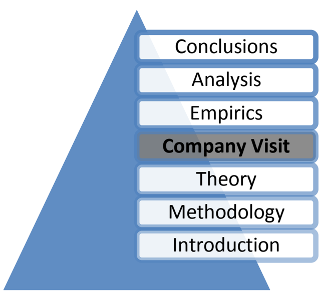
Variability factor of demand – To determine the variability factor of demand for a component, the authors need to gather data about demand volume to be able to calculate:

- The standard deviation of demand per component
- Average demand per component

The variability factor will make the comparison between the components easier.

Picking frequency - The authors needs to gather data about the picking frequency of each component. With the picking frequency it is possible to see which components that are picked the most and also see if the components are stored at the right location according to the picking frequency.

5 COMPANY VISIT AT THORN LIGHTING



This chapter describes the company visits at Thorn Lighting in Landskrona. The presentation was held by the Lean consultant Markus Breuer from Kiendl LeanConsultant. The company has made massive changes to adopt the Lean philosophy. The chapter is an experienced reference for the authors and readers in how a company can translate theory into successful reality.

5.1 Thorn Lighting

Thorn Lighting is a part of the Zumtobel Group and it is a global brand for indoor and outdoor lighting. The company is competing in over 100 markets around the world and it has established market leadership in the UK. Thorn Lighting has also strong positions in France and the Nordic region and is a leading supplier in the Australian and Hong Kong market.

The company delivers lightning indoors solutions to:

- Office and Education
- Industry and Technology
- Hospital and Healthcare
- Retail and Supermarkets

Figure 23 illustrates one indoor product from Thorn Lighting.

Figure 23 Indoor product from Thorn Lighting[143]

The outdoor market segments are road, urban and sports (indoor and outdoor). Figure 24 illustrates one of the outdoor solutions.[144]

Figure 24 Outdoor product from Thorn Lighting[145]

[143] Thorn Lighting, retrieved 2011-01-13, <www.thornlighting.se/PDB/Ressource/photo/TLG_FAMO_F_SU1.jpg>
[144] Thorn Lighting, retrieved 2011-01-13, < www.thornlighting.se/se/sv/aboutus_about_thorn_f.htm>
[145] Thorn Lighting, retrieved 2011-01-13, <www.thornlighting.se/PDB/Ressource/photo/TLG_VCTA_F_PTA.jpg>

5.2 The company visit

The second of November 2010 Thorn Lighting in Landskrona was hosting an event where persons interested in Lean Production were invited to their assembly plant. The company has performed huge changes the last year for adopting the Japanese philosophy, Lean. The changes have lead to good results, but they did not want to reveal any numbers. The Lean consultant Markus Breuer from Kiendl LeanConsultant was the one behind the big changes. The changes were among others performed in the internal logistics were the company invested in automotive trucks. According to Thorn Lighting it was several key factors that lead to the big success in the assembly plant.

A key to the success was the *go gemba* watchword, which means; all problems should be visualized. After visualizing problems in the assembly plant, the company is able to find solutions and improvements. Thorn Lighting points out that team-work is very important to be able to improve. The knowledge from personnel working at the assembly stations is invaluable. This knowledge should be used to continuously identifying and reduce all types of waste. Here is where the company's next watchword comes in, *just do it*. When problems are visualized new ideas about how to solve the problems will be generated. This watchword refers to that all new good ideas should be considered without managers having several meetings about the idea. The company points out that meetings about new ideas, how to implement the ideas, when to do it and all problems related to it, is just waste of time. New ideas should instead be tried in the assembly process and if it does not suit the assembly process the company should skip the idea. It can for example be ideas concerning the replenishment of a component or location of the component in the station. The company believes that the speed is more important than the accuracy in the replenishment of components.

5.2.1 Storage categories

The work towards Lean at Thorn Lighting includes assembling small batches and using small containers to store the components. The company does not use any pallets at all in the internal logistics. The company uses small bins or special designed load carriers on wheels in the internal logistics. There is one special division in the company responsible for develop new load carriers for the components that is too big to be stored in a bin. These load carriers are replacements for the traditional pallets that were used in the assembly plant before. The load carriers are equipped with small wheels so the load carriers can be dragged behind the new trucks. The load carriers are designed to facilitate the picking of components for the assembler. For example, instead of using traditional pallets where the assembler needs to reach down for the last components in the bottom of the pallet, the new load carriers are designed to facilitate the picking of components. The smaller components are stored in bins. The company uses several sizes of the bins but the largest bin has a size of a shoe box.

5.3 Warehouse and Internal Logistics

Thorn Lighting has a receiving area for goods from its supplier. This receiving area is located next to the central warehouse in the company. The incoming goods are transported into the warehouse on a conveyor. The goods are therefore picked in the order they were received. The goods are controlled in the receiving area before the pallets are put in the warehouse. The components in the central warehouse are delivered from the central warehouse to assembly stations and "supermarkets".

5.3.1 Supermarkets

Instead of only using the central warehouse several “supermarkets” are spread all over the assembly plant. The supermarkets are shelves with bins that are storing components. Each supermarket supply one or several stations. The replenishment of the bins is done by a 2 bin Kanban system where each bin represented a Kanban card. The location of the bins in the supermarkets is based on a numerical sequence which facilitates the replenishment of the bins.

Low frequency or expensive components are not stored in the supermarkets. The assembler fills in a paper with information about the component if these types of components are needed. This paper is placed on a notice board next to the supermarkets and works like a Kanban card. When someone from internal logistics passes by to replenish components in the supermarket the Kanban card on the notice board is collected as well. Components with a bigger size are also replenished the same way as low frequency and expensive components, with a Kanban card.

5.3.2 The internal logistics

The company stress that the internal logistics is the supplier of the production and the production should have as low waste as possible. The assemblers should be able to assemble as much as possible during a working day and not do other things. Activities that not include assembling are classified as waste.

To be able to make the material supply as effective as possible a specific plan on how to replenish each component in every station should be done. The components can be classified in groups which makes it possible to replenish similar components the same way.

The company has invested in two new types of trucks to transport components to assembly stations. One of the new trucks is automated and does not need a forklift driver; the company calls this truck the turtle, see Figure 25. Tape is pasted on the plant floor for the truck to follow. This route can easily be changed if the company wants to; it is just to move the tape. The truck has a specific route to follow into some of the assembling stations or out to the warehouse. It is possible to connect a load carrier on wheel to it. When the assembler wants to replenish a component he just puts the empty bins in a load carrier and connects it to the truck. After pushing a button the turtle follows the tape out from the assembly area into the warehouse. The turtle is received by the personnel in the warehouse. The personnel replenish the bins and put them back in the load carriers. The warehouse personnel push the button on the turtle and it follows the tape back into the assembly area.

Figure 25 – Turtle truck[146]

[146] Helge Nyberg AB, retrieved 2010-11-29, <http://www.helge-nyberg.com/web/Products.aspx>

The second type of truck has almost the characteristics of a train. One person is driving the truck and components stored in several load carriers on wheels are dragged behind the truck. The “train” has its fixed routes and stop during the day. Figure 26 illustrates this new truck.

Figure 26 – “Train”[147]

The advantage with these two new trucks is the decreased transportation distance due to a number of components can be delivered to several stations in the same route. Before, traditional forklifts were used but with the new trucks the internal logistics’ personnel could focus on replenishing bins and load carriers instead of driving the forklifts. The traditional forklift can only transport one pallet at the time which implies a higher transportation frequency to each assembly station.

5.4 The assembly stations

Thorn Lighting has several assembly stations in the site in Landskrona. Every station has the same ordering process and restriction of the station buffer. The ordering process and the station buffers will be described separately below.

5.4.1 Ordering components

Thorn Lighting does not use any computer systems when ordering components. The company is working with visualization so all orders are done either with two-bin Kanban or by Kanban cards placed on notice boards. Simplifying is one of the watchwords at the company and to visualize the demand of components by a Kanban card instead of using computer systems is one of the steps towards simplification.

Since the routes for internal logistics are fixed, the assemblers know when the trucks are going to pass by. The components that need to be replenished should therefore be prepared by the assembler and when the “train” passes by, bins and Kanban cards are collected from each station.

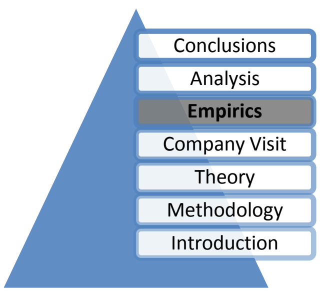
5.4.2 The buffer

The assembly stations at Thorn Lighting are not storing many components in the buffer. Most of the stations do only have the components required for that specific order. Other stations have some components stored close to the station because of the big size of the components. The company has focused on how to make it easier for the assembler to perform the daily work. Instead of using pallets are components stored in bins and other load carriers, which makes it much easier for the assembler to handle the components. These changes have saved a lot of space in the station buffer. Each component

[147] Helge Nyberg AB, retrieved 2010-11-29, <http://www.helge-nyberg.com/web/Trucks_3.aspx >

has a fixed location in the buffer during and a maximum space to use. Each location is visible marked so the internal logistics team easily can put the components at the location.

6 EMPIRICS



This chapter describes the assembly process at Nederman in Helsingborg. The processes are described by mapped information and material flow, description of ordering processes and data collection of the component buffer. The chapter structure of the empirics will follow the order of the principles in the principle and tool framework.

6.1 *Structures, systems and processes*

To be able to follow and understand, chapter 6.1 gives the reader an introduction of Nederman's material supply and its activities.

6.1.1 The site in Helsingborg

The two Nederman facilities in Helsingborg facilitate many company functions, such as assembly, warehouse, finished goods inventory, Nederman group´s corporate functions and research & development. The study has taken place at the assembly building in Helsingborg.

The assembly site in Helsingborg consists of 22 assembly stations, warehouse and supporting office buildings. The assembly area and the warehouse can been seen in Figure 27. The assembly personal at the site in Helsingborg starts at 06:45 and ends at 15:30.

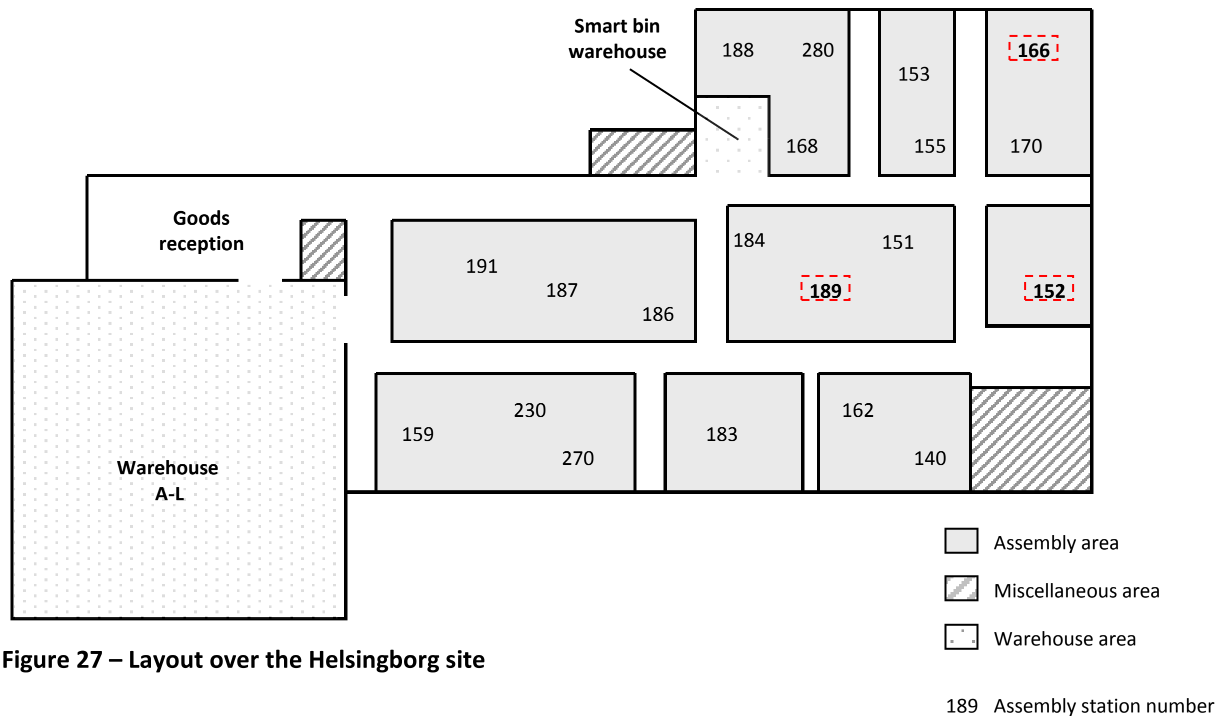


Figure 27 – Layout over the Helsingborg site

The stations have a three digit identification number that addresses stations in processes, such as material orders in IFS. Around the assembly areas pallet storage allocated to the warehouse are placed. A pallet that arrives to the goods reception are usually placed in the main warehouse, but can also be placed at the pallet locations close to the assembly area.

6.1.2 The ERP system

IFS is the enterprise resource program (ERP) that is used by Nederman. The program is used by all assembly personal to access production orders and order material from the warehouse. Every station has its own account in IFS. The assembly personal uses IFS to time stamp orders. IFS has also been used by the authors to access and gather data about time, components and transportation orders.

IFS is illustrated in Figure 28, the figure gives an overview about upcoming production orders at assembly station 189.

Prioritets-kategori	Parti-storlek	Färdig kvant	Artikelnr	Artikel-beskrivning	Order-nr	Status	Färdig datum
	1	0	AVB_189	X Avbrott TO 189H	189_AVBROT	Påbörjad	2006-12-
	30	0	30700230	With 17m3G1,5-230V-BI-Ned	350270	Påbörjad	2010-11-
	5	0	30700620	With 12m3G2,5-230V-BI-Ned	350054	Frisläppt	2010-11-
	1	0	30700630	With 17m3G2,5-230V-BI-Ned	350557	Frisläppt	2010-11-
	30	0	30800220	With 12m1/4"-BI-Lp-Ned	350930	Frisläppt	2010-11-
	30	0	30700220	With 12m3G1,5-230V-BI-Ned	351096	Frisläppt	2010-11-
	30	0	30700220	With 12m3G1,5-230V-BI-Ned	351247	Frisläppt	2010-11-
	30	0	30720120	For 12m3G1,5-230V-BI-Neutral	351450	Frisläppt	2010-11-
INFO	30	0	30700420	With 12m3G1,5+socket-230V-BI-Ned	350034	Fast planerad	2010-11-
	30	0	30800430	With 10m3/8"-BI-Lp-Ned	350738	Frisläppt	2010-11-
	30	0	30800230	With 12m5/16"-BI-Lp-Ned	350932	Frisläppt	2010-11-
	30	0	30800420	With 8m5/16"-BI-Lp-Ned	351095	Frisläppt	2010-11-
	12	0	36200	Hose cmpl 6mm 12 m	351278	Frisläppt	2010-11-
	12	0	36202	Hose cmpl 8mm 12m	351248	Frisläppt	2010-11-
	30	0	30800430	With 10m3/8"-BI-Lp-Ned	351420	Fast planerad	2010-11-
	30	0	30800420	With 8m5/16"-BI-Lp-Ned	351573	Fast planerad	2010-11-
	12	0	36203	Hose cmpl 10mm 10 m	351575	Fast planerad	2010-11-

Figure 28 – IFS example

6.1.3 Storage categories

Nederman's site in Helsingborg mainly uses 4 types of storage categories: Pallets, small blue bins, large blue bins and cartons.

6.1.3.1 *Pallet*

A large amount of the inbound goods are delivered on pallets. From the warehouse to the assembly stations, most of the components are delivered on pallets. The finished assembled products are also packed and delivered on pallets. Due to lack of storage space, pallets and their pallet location can contain more than one type of component, referred to as a mix pallet, see Figure 29.

Figure 29 – Mix pallet

6.1.3.2 *Small blue bin*

Storage of components from the smartbin system, see 6.2.1 is often stored in small blue bins. The small blue bins are handled manually by the assembly operators and is not ordered through IFS. The bins are moved manually by an operator and often inserted in shelves or vertical back panels. They are often containing screws, mutters and fasteners and therefore placed with advantage in a vertical back panel to the assembly tables, see Figure 30.

Figure 30 – Small blue bins

6.1.3.3 *Large blue bin*

The large blue bins are easy to use in the assembly process. The bins can easily be moved back and forth. A few suppliers deliver directly in blue bins, the bins are supplied by Nederman and they are used to make the material supply in the assembly easier. More common is that components in cartons are moved into bins for easier handling in the assembly process. The bins are often placed close to the assembly area when the actual component is needed. When the large bin is not needed, it is often placed in a shelf or at a mixed pallet. The large blue bin has two different sizes. The left one in Figure 31 is referred to as a Volvo bin and the one to the right as a Norway bin.

Figure 31 – Large blue bins

6.1.3.4 *Cartons*

Cartons are often delivered at pallets to the warehouse. Cartons can be taken off the pallet and delivered separately to the stations. The cartons are also delivered by pallet to the station, where the operator then uses one carton in a time. The cartons are often emptied into a large blue bin for easier handling for the operator.

6.1.4 The material and information flow

The material flow at Nederman's site in Helsingborg starts when the components arrive to the goods reception. At the goods reception the material gets controlled and is then transported to the warehouse. As described in previous section, the site has pallet locations at the assembly stations as well. Some of the goods therefore get a pallet location close to the assembly station. This warehouse is referred to as Warehouse V. Small quantities like single cartons can be placed at mixed pallet locations. A mixed pallet location can store multiple components at the same pallet. Due to floating location storage, a pallet has no fixed place and is placed by the system at the first free storage location.

The components are stored in the warehouse until the assembly personal places an order for transport of demanded component to a specific station. The internal logistics team (IL) delivers the component to the assembly station. Usually the assembly personal takes care of the component by using a forklift, but the assembler can also show the IL transport where the goods should be placed. Few stations has fixed buffer locations, due to working personal and type of product in process, the buffer layout and placement of components can differ.

The flow between buffer and assembly process various a lots. Due to order amount, working personal and station, different kind of flow can be identified. A small order amount often results in a pre picking phase where the assembly personal takes the specific number of needed components from the buffer. While a large order often results in that cartons or pallets from the buffer often are placed close to the assembly table. Different personal assembly patters also mirror the placement and flow of components close to the assembly table.

Finished goods are placed at pallets and placed in the passages outside the station area. No transportation orders are placed for transports to the finished goods inventory. Instead when a forklift driver is passing and sees a finished goods pallet, he or she picks it up and deliver it to the area of which transports to the finished goods inventory taking place.

The phases of the material handling can be summarized into:

1. Arriving and goods inspection
2. Warehousing of components
3. Component ordering process
4. Transportation between warehouse and assembly stations, Internal logistics
5. Buffer storage
6. Buffer material handling
7. Assembly process
8. Transportation between assembly stations and finished goods inventory, Internal logistics
9. Warehousing of finished goods
10. Shipping from the finished goods inventory

The mapped material and information flow can be visualized through the following map, see Figure 32.

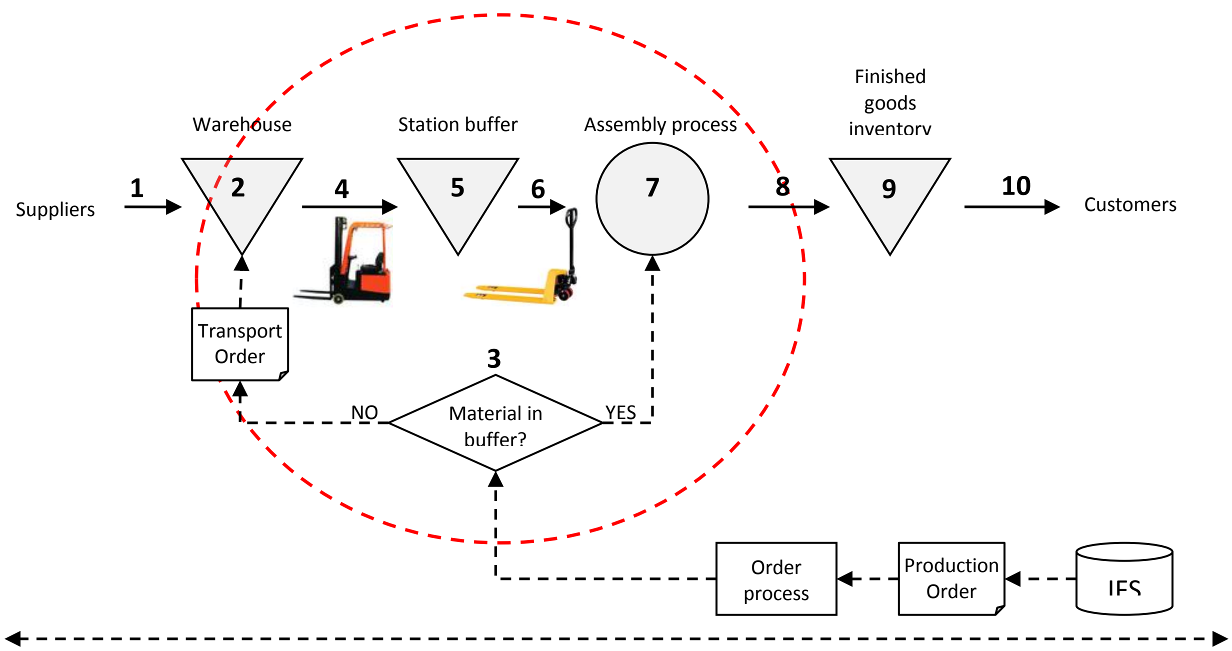


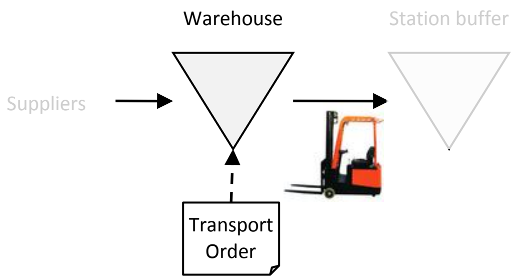
Figure 32 - Mapped material and information flow

As seen in Figure 32 the dotted circle defines the studied system. The activities outside the system are not a part of the studied system, but they are still affecting it and have parts that are within the studied system. The assembly process is within in the system, but it is not in focus because it is not affecting the flow of material handling. The activities of interest are;

2. Warehousing of components
3. Component ordering process
4. Transportation between warehouse and stations, Internal logistics
5. Buffer storage
6. Buffer material handling
7. Assembly process

The component ordering process, buffer storage and buffer material handling will be described individually in each station chapter. The internal logistics does not differ between the stations and will therefore be described in one section, covering all internal logistics activity.

6.2 The material supply



The warehouse at the site in Helsingborg can be divided into three different locations, the main warehouse (Warehouse A-L), the warehouse locations in the assembly area (Warehouse V, Figure 34) and the Smart bin warehouse. The Smart bin warehouse will be described in next section, Smart bin 6.2.1. Warehouse A-L consists of around 3000 pallet locations and a smaller picking shelf. The pallet location in the assembly area consists of around 800 pallet places. The global inventory turnover at the site in Helsingborg is 5.

The warehouse A-L is staffed by one forklift and its operator. Time to time there is also extra personal from a staffing company and an extra forklift is then in use.

In Figure 33 the flow within the warehouse are illustrated. The arriving goods get a pallet location at the goods reception by IFS. It is either a location in Warehouse A-L or in Warehouse V. The arriving goods can be placed at the ramp (B) where ingoing goods for the warehouse A-L are placed. It can also be placed at the location (C), where arriving goods with a pallet location in Warehouse V are placed.

From the arriving goods ramp (B) the warehouse forklift driver places the pallets or bins at the pre defined pallet location in Warehouse A-L. When the assembly station demands components by a transportation order, the ordered material are picked from the warehouse and placed at the delivery ramp (A). The warehouse forklift driver usually puts the pallets or bins from the left side to the right of the ramp. The last pallet put on the ramp is therefore placed closest to the assembly area. After putting the pallet on the ramp the forklift driver in the warehouse A-L finish the transportation order in IFS. The system therefore believes that the order is fulfilled. Due to that the order is fulfilled the forklift driver has to mark the goods with a pen where it is going; otherwise it is impossible for the internal logistics forklift drivers to know which station to deliver it to.

The two forklifts that operate in the assembly area cross the warehouse continuously and identify goods that are waiting at the ramp (A) or at waiting area (C). If goods are waiting at the delivery ramp (A) the internal logistics forklift driver picks the closest pallet, i.e. the latest pallet placed on the ramp. The space between the ramp and the pallet rack in warehouse A-L is very limited. When someone from internal logistics comes to pick a pallet at the ramp it happens that either the warehouse forklift driver or the internal logistics forklift driver has to wait for the other one due to the limited space. According to the forklift drivers, the waiting time is one minute and it occurs 2-3 times a day. The internal logistics forklift drivers then deliver from the ramp to the assembly station and the transportation order is also fulfilled in reality, not just in the system.

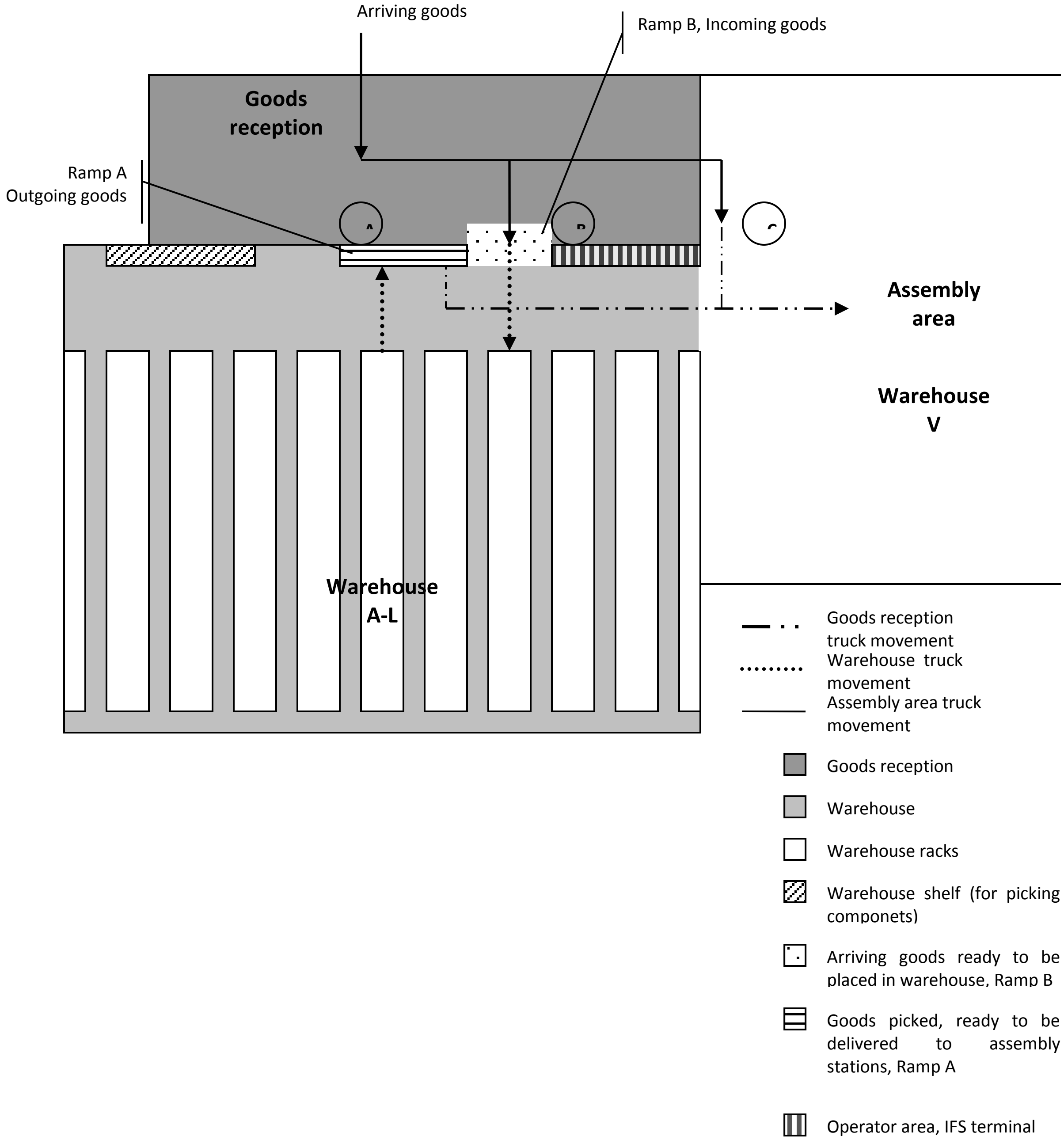


Figure 33 – Warehouse material flow

As seen in Figure 33 a small picking shelf area exists for smaller components that can be stored in blue bins. Still though, the bins can only be accessed by forklifts, due to the height of the shelf. Figure 34 illustrates Warehouse V in the assembly area.

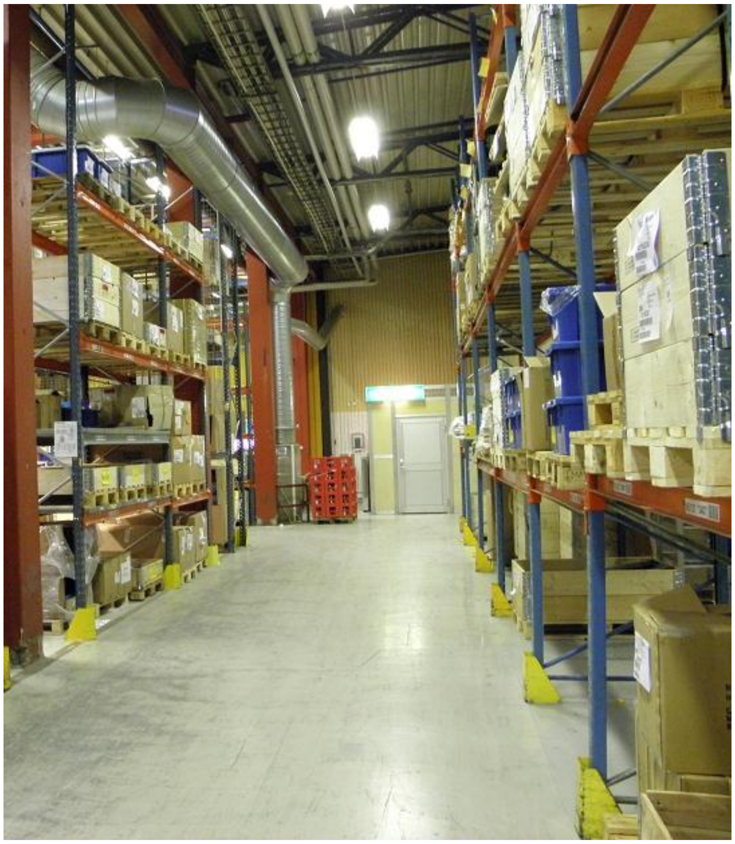


Figure 34 – Warehouse pallet locations in the assembly area (Warehouse V)

The long picking time can be described by the warehouse layout and system. The warehouse is constructed to handle whole pallets with forklift access. To pick few components from the fourth height in the pallet rack takes time. The operator has to use the forklift to take the pallet down, then leave the forklift and by hand take out the components into a bin and then back into the forklift and put in the pallet in the rack again.

According to the warehouse personnel, transportation orders that requires picking generates problem in the Warehouse A-L. The warehouse personnel also claims that an ordered amount of components that usually matches carton quantities can sometimes be wrong due to different delivery quantities per carton.

The sum of all transportation orders per station during the latest year (2009.10.31 – 2010.10.30) are gathered from the IFS system and shown in Table 2.

Assembly station	Number of transportation orders
140	1251
151	686
152	**902**
153	929
155	195
159	2101
162	194
166	**862**
168	966
170	1027
183	2565
184	1352
186	518
187	1590
188	1719
189	**1723**
191	4792
230	1394
270	350
280	1008

Table 2 - Sum of transportation orders per station

6.2.1 Smart bin warehouse

Smart bin is the warehouse solution for screws, mutters and fasteners. The components are stored in easy accessible boxes, see Figure 35. The system has information about the weight of every single component. The boxes stands on scales and every night the Smart bin system calculates the actual stock level for each component. When the stock level reaches the order point, the system automatically sends an order to the supplier. The components are then delivered within 24 hours.

To access and pick components from the Smart bin warehouse, no transportation order is needed. When Smart bin components are needed, the assembly personal just has to walk to the warehouse with a small blue box and pick needed amount. The Smart bin location is close to the assembly stations; see the map in Figure 27.

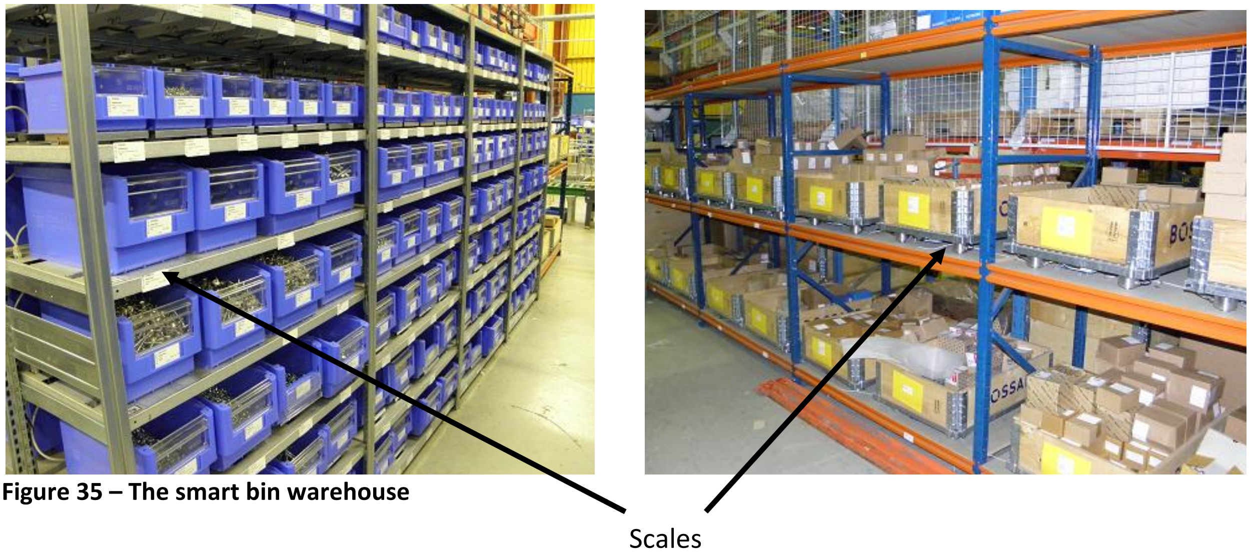


Figure 35 – The smart bin warehouse

6.2.2 The internal logistics team

The internal logistics team is responsible for all component movements within the site. The team that takes care of the transportation between the warehouse and assembly stations consists of two persons with two forklifts. The internal logistics team is connected to IFS by handhelds, where they get information about transportation orders.

As described in the warehouse section, the team crosses warehouse A-L continuously and identify goods that are waiting at the ramp for delivery. They are not able to see these movements in IFS, because of that the transportation order is already fulfilled by the warehouse personal. Instead they identify where it is going by manual written pen marks at the goods. According to the forklift drivers they cross Warehouse A-L four times per hour and it takes about 30 seconds to pass by. With two forklift drivers the total circulating time per day will be 32 minutes.

Goods that are ordered from the pallet locations within the assembly area (Warehouse V) are treated differently. The internal logistics team takes care of these orders without involvement from the Warehouse A-L personal. As a result, these orders are fulfilled by the internal logistics team when they deliveries it to the stations.

Components that are ordered either from warehouse A-L or warehouse V to the stations are only addressed with the assembly station number, e.g. 189. Hence, the forklift driver either just puts the components at the station or asks the assembly operator where to put it. The internal logistics team is unable to get the pallet placement at the assembly station. Even if there are fixed pallet locations at the stations they are not addressed in IFS.

Transportation orders for year 100101-101118, are gathered by IFS. In Figure 36 the average delivery time for transportation orders from Warehouse A-L and Warehouse V are plotted against the time of the day. The average delivery time for components in Warehouse A-L is 42 minutes and for Warehouse V 21 minutes.

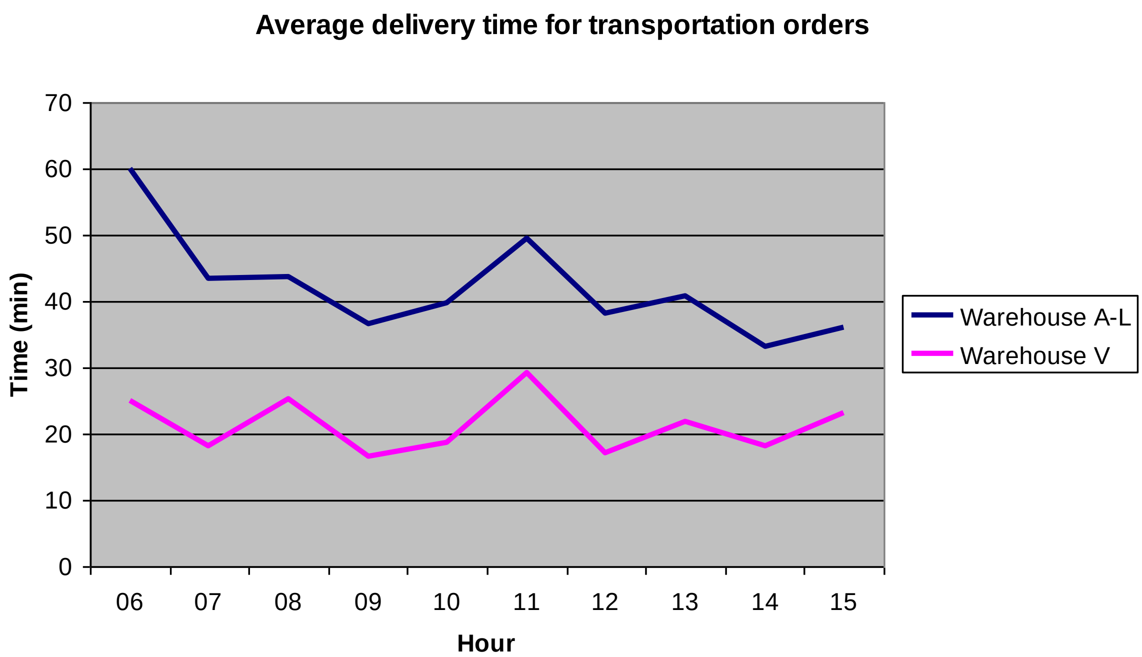


Figure 36 – Average delivery time for transportation orders, Warehouse A-L, Warehouse V

The number of transportation orders per hour from Warehouse A-L and Warehouse V are plotted against the time of the day, Figure 37.

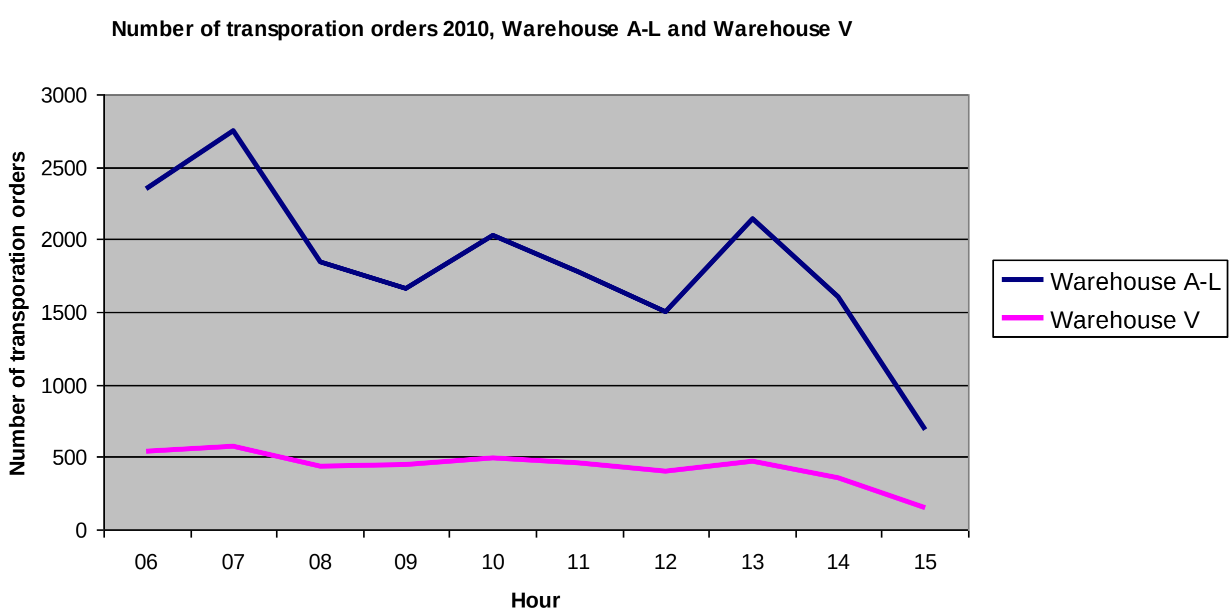


Figure 37 – Number of transportation orders 2010, Warehouse A-L and Warehouse V

6.2.3 Lead time

To be able to measure lead time, the way of transport components had to be mapped. From warehouse A-L to the station, the following activities has been mapped and measured, see Table 3. The time is represented by its average time.

Warehouse A-L	Average (min)
Ordering time	2,0
Waiting time for transportation order, warehouse A-L	39,8
Warehouse A-L picking time	2,2
Waiting time at the ramp	3,4
IL time (Ramp-Station)	0,9
Buffer placement time	2,4
Total	**50,7**

Table 3 – Average lead time, Warehouse A-L

The ordering time has been collected from a previous made study by the PPQA manager, Jan Meng and Industrial Engineer technician, Dick Johansson and during this study verified by team leader Johan Leckström. The waiting time for transportation orders has been calculated by collected data in IFS. The waiting time is based on 22 000 transportation orders. The warehouse A-L picking time has been measured by the authors. The time has been collected by timekeeping in the warehouse and is based on 45 samplings. The waiting time at the ramp and the IL time from the ramp have been collected in the same way it is based on 20 samplings. The buffer placement time has been taken from the previous study by Jan Meng.

The total lead time from Warehouse A-L to the stations can be illustrated in a mapped time diagram, Figure 38. The total lead time is in average 50 minutes.

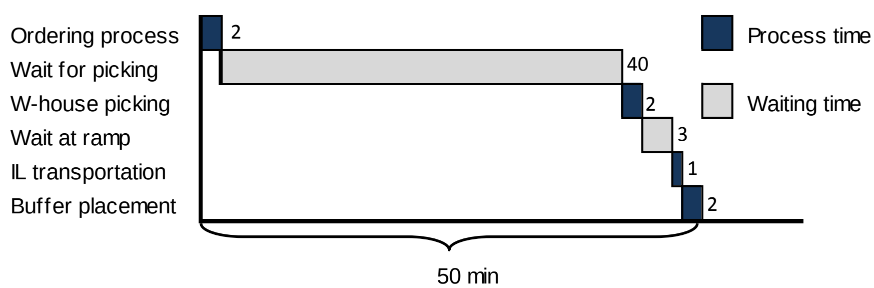


Figure 38- Lead time diagram, Warehouse A-L to assembly station buffer

Components from Warehouse V have fewer handling activities in the way from the warehouse to the station. The following activities has been mapped and measured; the time is represented by its average time, Table 4.

Warehouse V	Average (min)
Ordering time	2,0
Waiting time for transportation order, warehouse V	20,5
IL time (Warehouse V-Station)	0,5
Buffer placement time	2,4
Total	**25,4**

Table 4- Average lead time, Warehouse V

The ordering and buffer placement time are the same as when a component is ordered and delivered from warehouse A-L. The waiting time for a warehouse V order has been collected from IFS. The IL time from warehouse V to the assembly station has been observed by the authors.

The total lead time from warehouse V to the assembly stations can be illustrated in a mapped time diagram. The total lead time is in average 25 minutes, see Figure 39.

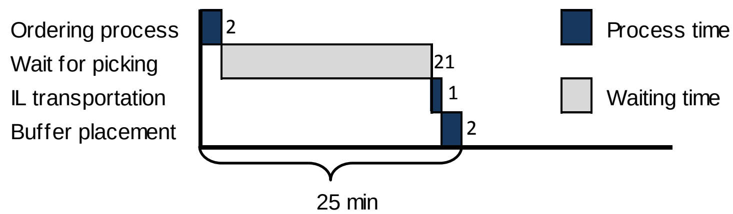
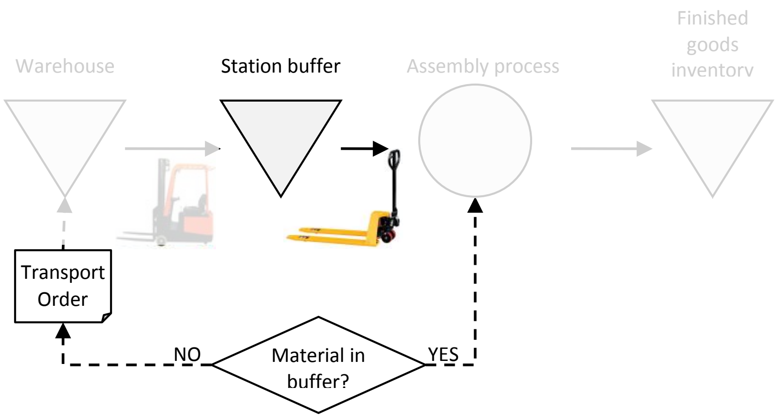


Figure 39- Lead time diagram, Warehouse V to assembly station buffer

6.3 The component ordering process



The component ordering process starts when the assembly personnel check upcoming production orders. There are two ways to control that there are enough components in the buffer, automatic calculation with release of picking quantities, or manual component ordering based on observations and empty pallet places.

The automatic calculation compares the needed components for upcoming production orders with the actual inventory in the buffer at the station and places an order for the difference. This is a function that is built in IFS. The function works similar to a MRP function, where only needed material is ordered. The problem is that it does not consider quantities of boxes or pallets. As a result the system generates heavy picking lists that do not consider production ahead of chosen orders and quantities that do not match box quantities.

The assembly personnel's IFS screen view where they start or stops orders and order components are illustrated in Figure 40.

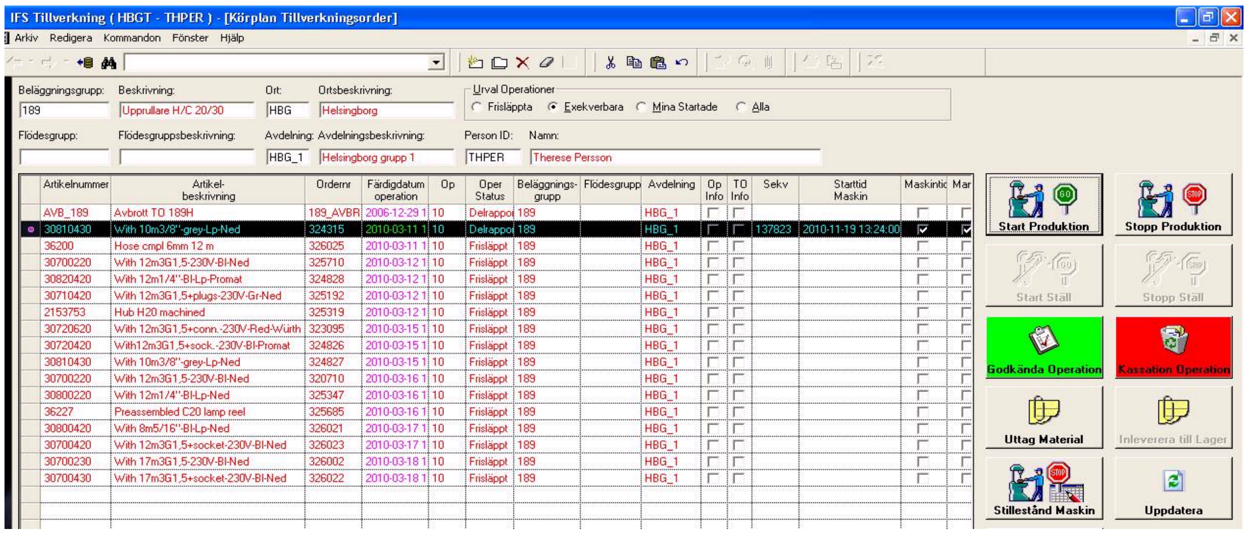


Figure 40- IFS, a production order plan view for assembly operators

The more common way of ordering material is to order components manually and specify the order quantity. The assembly operator goes through the list of production orders and does a check to see if all needed components are at the station. The check is usually fast and brief; the operator goes through the list and visually checks if the components are at the station. An operator explained, *from this desk where the computer is I see all the pallets, e.g., this certain component is at the pallet over there, I know the pallet is almost full, I ordered it yesterday. It is therefore no need of ordering new material.* It is first when an unknown component appears at the list an operator has to search for it.

If a component is missing or needed an order has to be fulfilled. From the material list the component number has to be copied and pasted into the order sheet. The quantity has to be specified as well as where the operator wants to order it from. E.g. the actual component can be stored at two different locations within the building. When the order sheet is fulfilled it is just to send it and the internal logistics team will deliver it within ½ - 4 hours, depending on the work load for internal logistics, according to the assembly personal. Collected data shows different result, see Figure 36**.**

The assembly operator has to remember the quantities or look at the old bin to see the order quantity. Sometimes the internal logistics team delivers a different quantity according to the ordered one. The reason can be that it is not enough time for picking the specific quantity or that they deliver a full box with a quantity that closely matches the ordered quantity.

Kanban has previously been used with bad experiences. A couple of years ago a Kanban project started, but the project leader quitted his employment before the project was finished and it was never implemented. Nederman has also tried another Kanban project at a specific assembly station. One of the team leaders describes the project as a big failure. "*When we were using Kanban, material that was not supposed to be used within the next 4 months could be arriving".*

To achieve a deeper understanding and be able to perform a general study for the site in Helsingborg, the author's detailed study is limited to assembly station 189, 166 and 152. See 3.4.5 for the authors' choice of assembly stations for detail studies. As mention in 3.4.5 the component ordering process and the buffer inventory are detailed studied. In the assembly process the component ordering process at the three assembly stations will be studied. The detail study of the buffer inventories are covered in next chapter, see 6.4.

The gathered data is collected from IFS. Due to the large amount of data rows it is not possible to put all data in appendix.

6.3.1 Assembly station 189

In station 189 are various types of hose reels and cable reels assembled; Figure 41 illustrates one type of end product from the station. This product is one of the most common in station 189. The hoses can have different length, diameter, color and medium depending on what the customers are asking for. There are about 30 different types of reels made in the station. The station can be described as a high frequency station, where some of the products are made every day. Some of the products are low frequency products and are made to order. The high frequency products are assembled to stock inventory.

Figure 41 – A standard assembled product at assembly station 189

The station consists of one preassembly station and one main assembly station. At the preassembly station employees from Samhall are working. This preassembly station prepares the hoses that are going to be used later in the main assembling station. A whiteboard is placed at the preassembling station. All orders that should be prepared are written on the whiteboard, so it is possible for the person at the preassembling station to know which hoses that needs to be prepared. After each finished order the person at the preassembling station writes finish after each finished order on the white board. The workers at the main assembly stations will therefore know which hoses that are prepared. The workers at the main assembly station are responsible for writing the information at the whiteboard for the Samhall worker. Usually the Samhall workers are rotating so the same workers are not there every day. Lately the same person has been at the preassembling station and therefore learned the computer system to check out which orders to prepare. Even though, the whiteboard is still used as a visualization tool for the assembling process. In the end of each day the preassembly station prepare the first order that is going to be assembled the next morning in the main assembly station. This preparation eliminates the risk of starting the day in the main assembly station with waiting for hoses. The preassembly station is not manned all day long so the person working there is usually responsible for controlling the end product as well as the packaging of the end product. The main assembly station is designed to have two persons assembling at the same time. The same persons are usually working at the stations and rotation of the personnel is not common. The assembly of the end product requires many steps and it takes some time to learn all steps. Assembled reels are placed on a conveyer to the packaging. Packed reels are placed on a pallet in the end of the main assembly station.

The production orders for tomorrow's assembly at station 189 are released at 1 pm. The station has one client with IFS where the operators enter each production order and where the needed components are listed.

The ordering process at 1pm is quite fast due to a continuous material ordering during the day. If the operator takes the last component or notice that it's just a few components left, they place an order. The order of the material process is therefore highly individual in terms of the timing for placing an order. The quantity of ordered material at the station is often equal to the number of components in a pallet or a box. Most of the components are delivered in pallets.

The ordering process at 1pm has been a routine since the 1st of August 2010. Before this date there were no established routines when a component should be ordered. In Figure 42 the number of transportation orders during the day is shown for assembly station 189 between the 1st of January 2010 and 31st of July 2010. After the routines were established the transported orders during the day can be illustrated by Figure 43.

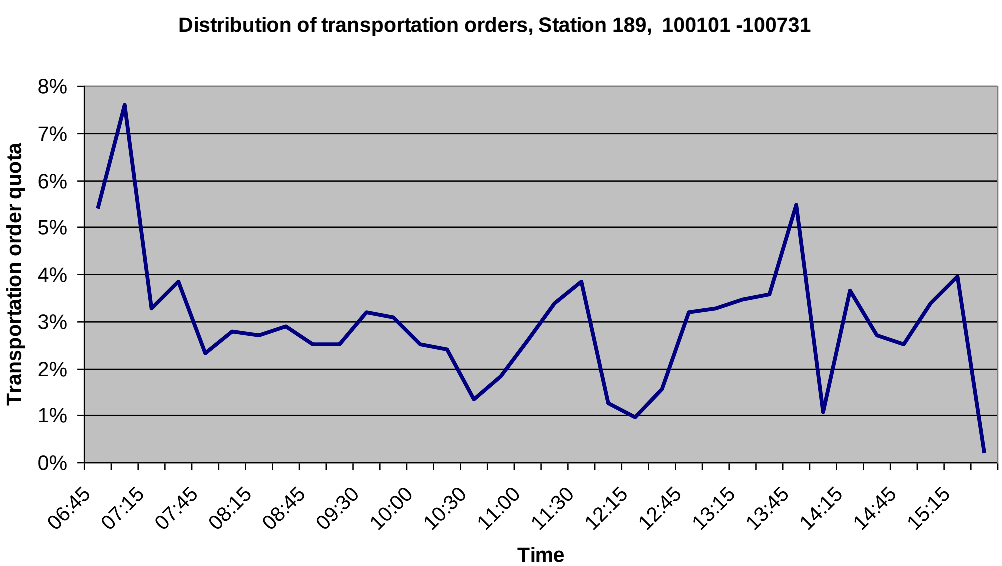


Figure 42 – Assembly station 189, Distribution of transportation orders, 100101-100731

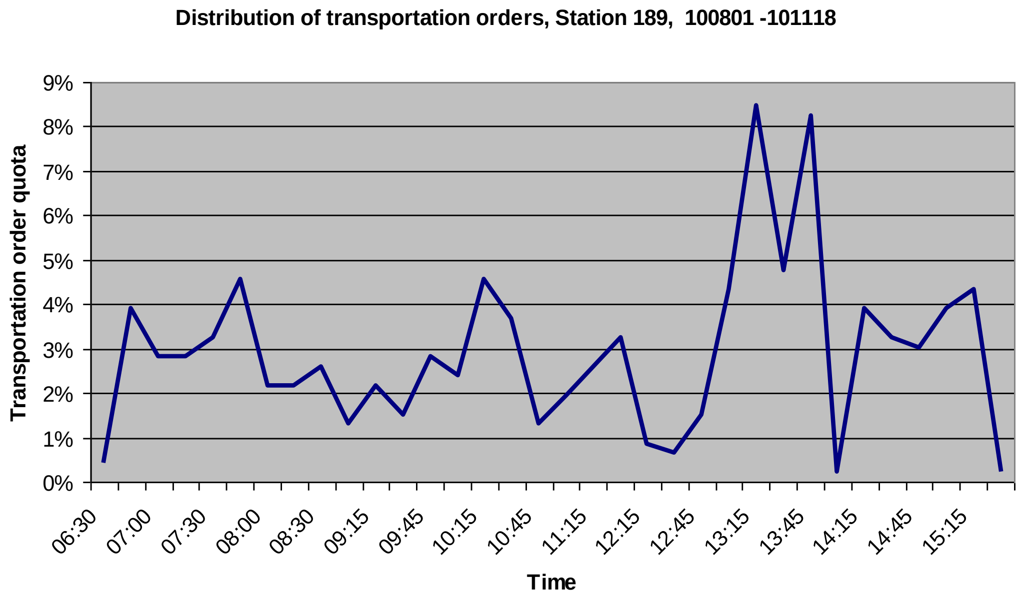


Figure 43 - Assembly station 189, Distribution of transportation orders, 100801-101118

As seen in the figures, the peak of the disturbance of transportation orders has moved from the morning to after 1pm. This is a result of the new established routines.

6.3.2 Assembly station 166

It is only one person working at station 166. This person is responsible for assembling the product, ordering components and controlling the end-product. Figure 44 illustrates a typical product from station 166. The products in this station have a quite long assembly time, between two and four hours depending on which model of FilterBox that is assembled. The models do not differ a lot; the models have the same shape and size. The FilterBox can be stationary or mobile. The stationary FilterBoxes have two models either wall fixed or floor fixed. The stationary models have a faster assembly time, around two hours. The shorter time depends on if the fastening is done by the customer. The mobile models are assembled ready to use for the end customers. The assembly time is therefore longer for the mobile model due to the extra assembly steps. Assembling a mobile FilterBox takes about four hours.

Some other things that differentiate between the FilterBoxes models are the color and the cable terminal boxes. The colors are either Nederman blue or white. The blue once is more common of the two colors and the white is mostly bought and used by bakeries. The different cable terminal boxes depend on where the customer is situated. All countries do not have the same standard restriction when it comes to electricity. Most of the products are made to order and only the most common are made to stock. The most common product is the wall fixed model.

Figure 44 - A standard assembled product at station 166, FilterBox

At this station the personal does not have to order components at a specific time. The time horizon which the assembly personal checks upcoming production orders, are several days. The assembly personal can therefore order the components at any given time. The operator describes that he choose to order when a specific component buffer is about to be finished. He is not using the automatic IFS application to calculate needed material; instead he checks the orders for the rest of the week and he continuously checks the components in the buffer. It is first when an unknown product is to be assembled he does check in the component list. The personal at the assembly station complains about the uncertainty about the size and number of component in each box. Sometimes the component will arrive in blue boxes with a certain quantity and time to time in a cartoon with a different number of components. The correct ordering quantity that will fit the amount in the cartoon therefore changes as the size of the box changes.

From collected data the total numbers of transportation orders 2010 are placed as follows, see Figure 45.

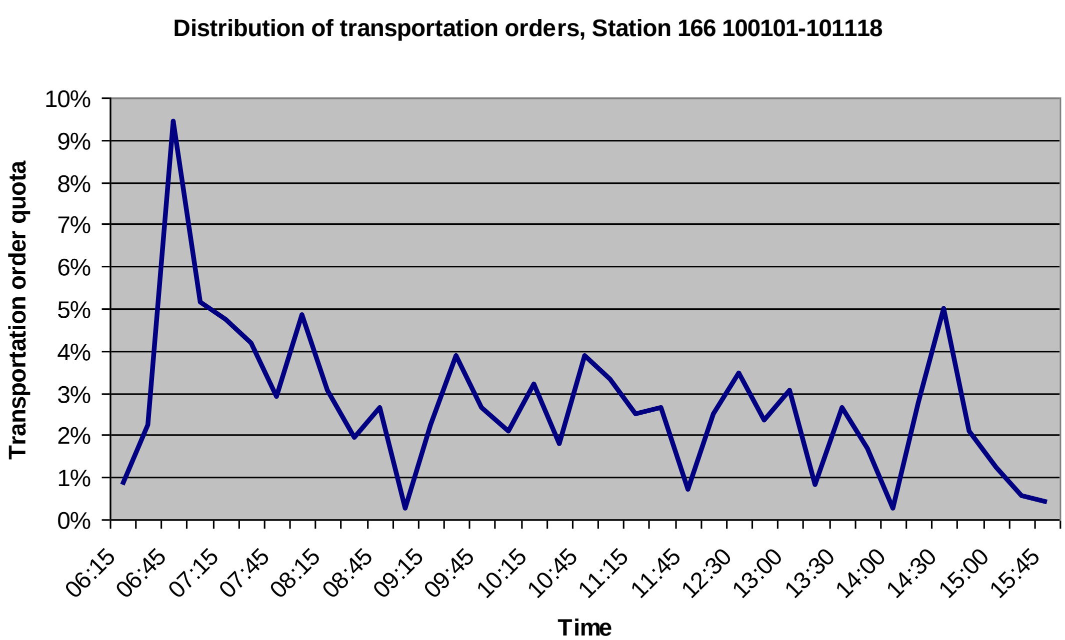


Figure 45 - Assembly station 166, number of transportation orders during the day, 100101-101118

The assembly personal explains that the ordering process can be quite fast, around 2-3 minutes per transportation order. But if the ordering person is unfamiliar with the station, it takes time to check up the standard quantity and article number. The station has a lot of pallet places and it can therefore be problems when the system tells the operator that it is enough components at the station. If the operator has no clue where to find them it takes time to control if they really are in the station buffer.

6.3.3 Assembly station 152

At station 152 fans are assembled. There are about 90 different types of fans assembled at the station; the difference is the motor and impeller. The fans can either be produced to order, stock or as semi-finished goods used in other products at Nederman. The fans are assembled on a gantry; this gantry can be on wheels or without wheels depending on what the customer is asking for. Figure 46 illustrates one fan with a gantry on wheels.

The station is manned everyday during the year. Usually is only one person working at the station but lately there has been a lot to do so two persons are working at the station. The assembly time for the products varies a little bit but the average time is around 20 minutes per product.

Figure 46 – Nederman portable fan

The station has a component ordering process that is similar to station 166. The station does not order at a specific time and the assembly personal can see the production plan for a couple of days ahead. As a result the operator orders material when boxes are empty or when he or she has the time for material ordering. The station often orders whole pallets from the warehouse. Figure 47 illustrates the distribution of transportation orders during a day.

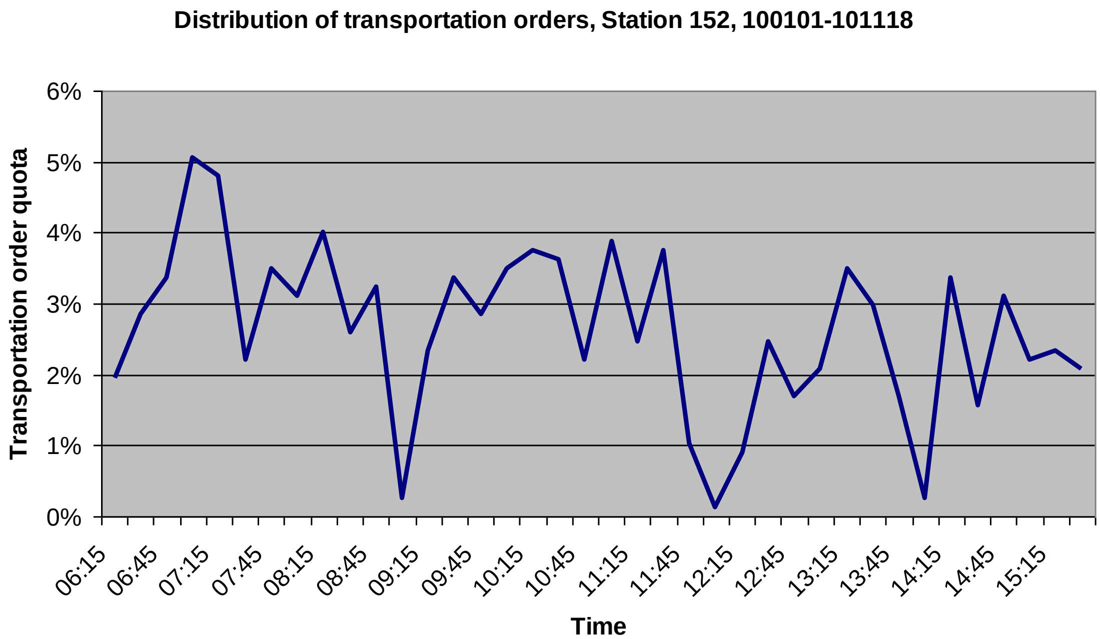


Figure 47 - Assembly station 152, number of transportation orders during the day, 100101-101118

6.4 The buffer inventory

To be able to perform analysis of the buffer inventory turnover and frequency analysis, large amount of data has been gathered. The data has been collected from IFS and measures one year, the time between 2009-10-31 and 2010-10-30. The data is gathered for assembly station 189, 166 and 152, see 3.4.5 for criteria's for chosen stations. The following component data has been collected for all components, see Table 5. The gathered data is about 24000 rows, due to the large amount of data it will not be attached in an appendix.

Component number	**Demand**	**Assembly picking frequency**	**Transported Quantity**	**Average transportation Quantity**	**Transportation Frequency**	**Standard deviation of demand**
22162	1728	195	1735	116	15	5

Table 5 – Gathered component data

6.4.1 Assembly station 189

The majority of the components for the assembling in station 189 are stored in the station buffer, this because most of the end products uses the same components, see Figure 48. Only a few rarely used components are stored in the Warehouse V. There are 39 pallets stored at the station and three shelves filled with blue bins containing components. The Figure 48 illustrates station 189 and where each component is stored at the station. The black colored figures are the assembly tables in the assembly station. The station has pallet locations at third and fourth levels in the pallet racks. Time to time, the assembly operators has to call a forklift driver to bring down components from the racks to the floor. The reason for using these pallet locations is that the station has been in a project recently. The goal with the project was to optimize the station buffer. After the project, components with a high frequency where placed at the third and the fourth level in the pallet rack.

Four of the pallet locations are mixed pallets, which contain cartons and bins with different components. The rest of the pallets are only containing one specific component. All fasteners used in the assembling are gathered in small blue bins from the smart bin system. The component at the mixed pallet with article number: 218515241 is not used at the station anymore but are stilled stored in the station buffer. Due to high inventory levels, problems with obsolescence components occur.

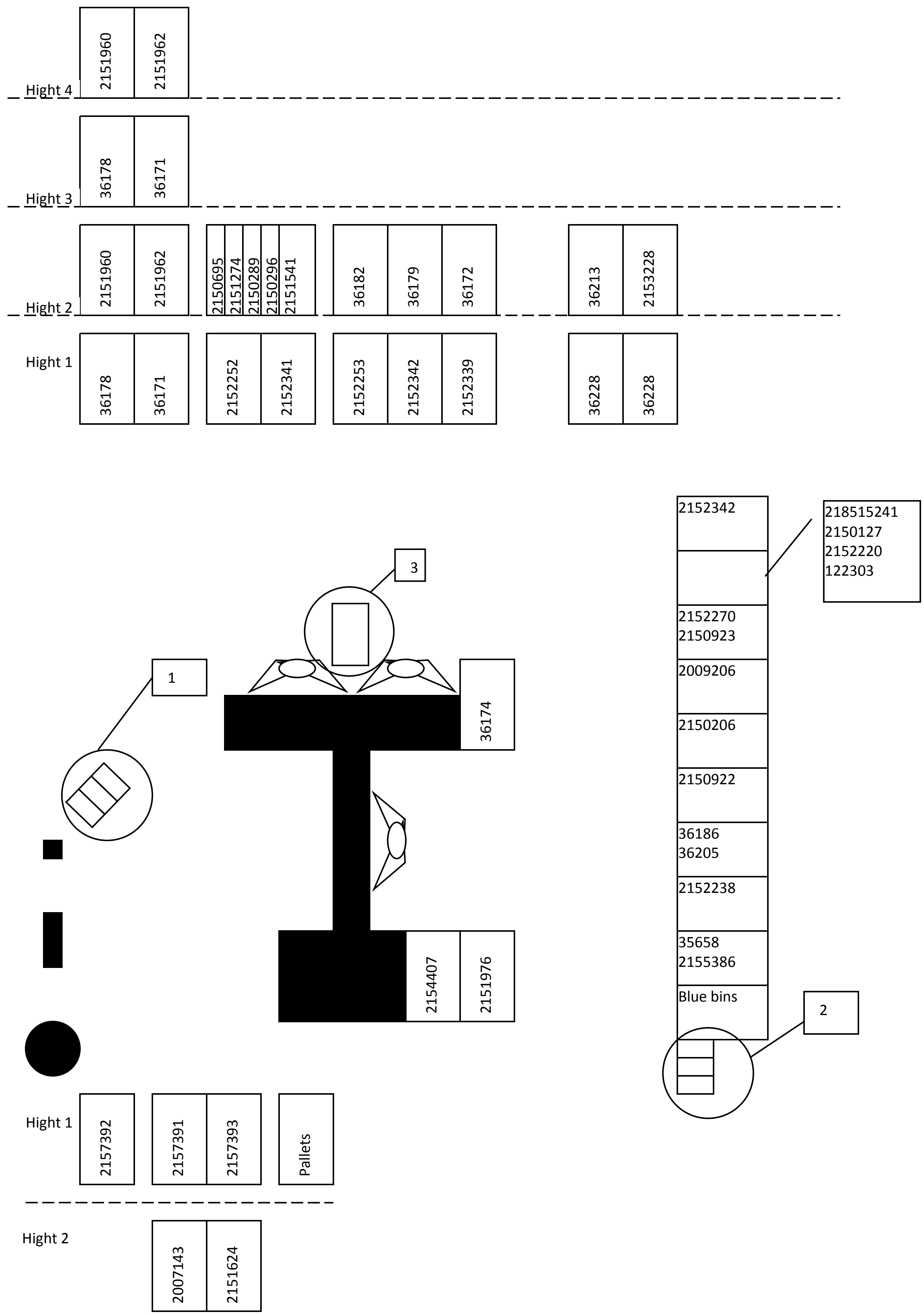


Figure 48- Assembly station 189

Shelf 1:
In this shelf the components are stored in big and small blue bins. The small bins are logical placed closed to the assembly station to facilitate the assembling. The small bins are refilled from the big bins that are also placed in the shelf. The following components are stored in the shelf:

2151099	2006889	2006888
2150701	2150702	2151099
2002307	2151521	
2002306	2151520	
2002305		

Shelf 2:
This shelf has enough space for five big blue bins. A printer for tags is placed in the shelf. The articles stored in the rack are the following:

36229	36214	36221	36215

Shelf 3:
This shelf is placed between the assemblers. The shelf is logical placed close to facilitate the assembling. The following articles are stored in the shelf:

36205	2000237	45947	36174
45943	45942	45946	2000238

6.4.2 Assembly station 166

Since the assembling time is quite long, the components in the buffer are not consumed in such a high speed as the components in station 189. The search for components in assembly station 166 can sometimes be time consuming because the storage location of a component can be changed in the station buffer. Figure 49 illustrates where each article is stored in the buffer. The black colored figures are the assembly tables in the assembly station. Some of the stored components in the station buffer are used in every FilterBox but the components are delivered to the station in such a big amount that it takes weeks before the pallet is empty. The station buffer has space for 47 pallets.

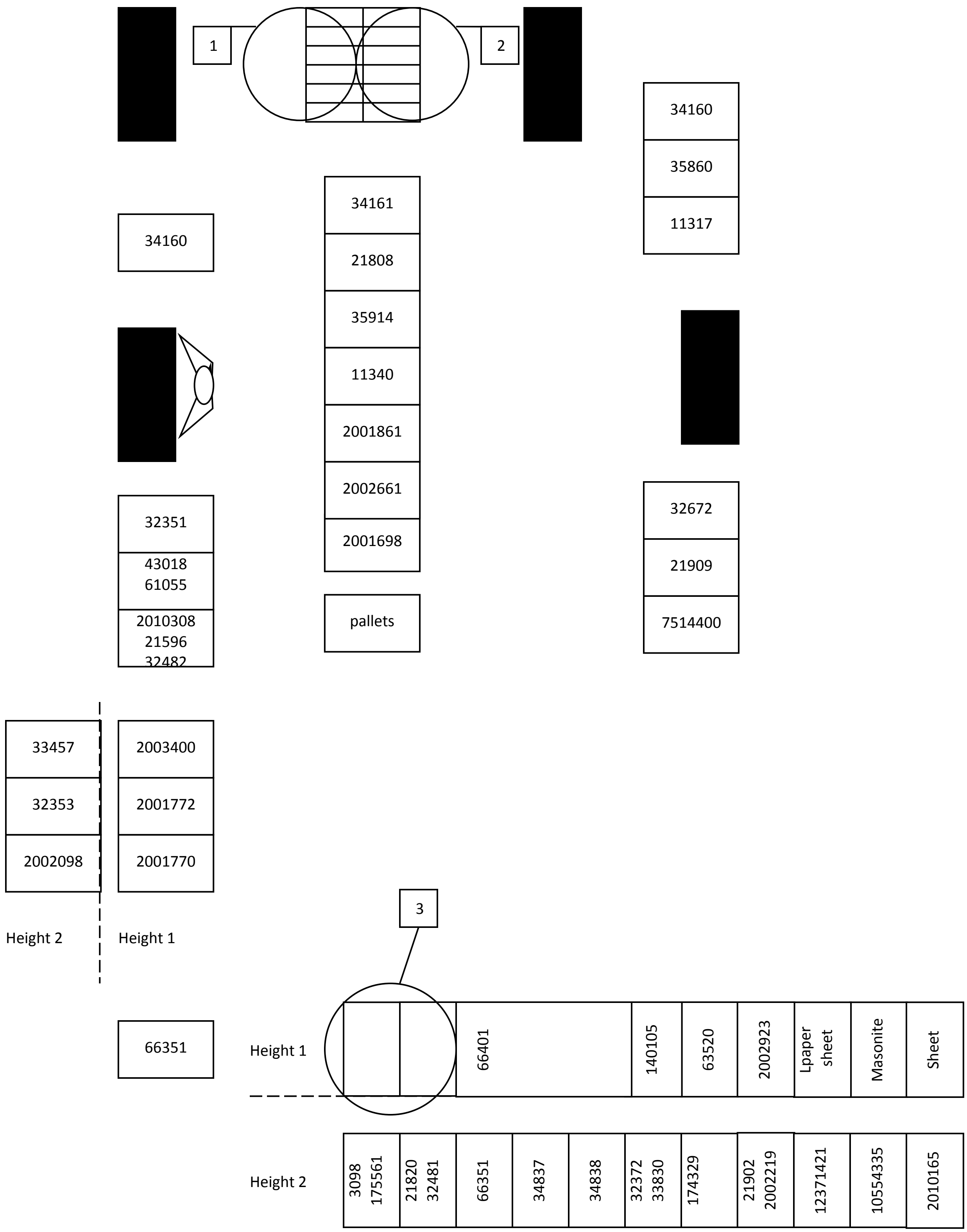


Figure 49 – Assembly station 166

Shelf 1:
This shelf has the following articles:

2002219	32481	46545	46526	21823	2002684
46580	2010165	2010189	2002098	2001772	2001770
63455	2005021	63407	21902	2005022	32353
	2001990	2001991	32482		

Shelf 2:
This shelf has the following articles:

2002098	21823	46526	46545	62388	2002219
2010189	2010165	46580	21902	32481	2005021
2001770	2001772		63407		32353
2001991	32482			2153746	2153745

Area 3:
At Area 3 four pallets are stored. The pallets have half the height of a standard pallet. Two pallets are stored directly on the floor with the following components:

2003320	46580

At the upper half are several cartons placed on the two pallet locations with the following components:

32481	14502237	2155271	35863	35865	32318	63282	2000497	10551235

6.4.3 Assembly station 152

The station buffer at assembly station 152 has space for 57 pallets. Several of these pallet locations are for pallets with a height of a half standard pallet. In Figure 50 the small squares are representing a pallet with half height. The black colored figures are the assembly tables in the assembly station. The pallets marked as free in the figure does not have any specified components stored at this location, these can be used when needed for any component. To clarify the figure, the pallet racks in station 152 is turned away from the station. So if the person working at the stations wants a pallet from one of the pallet racks he/she needs to walk out in the forklift passage.

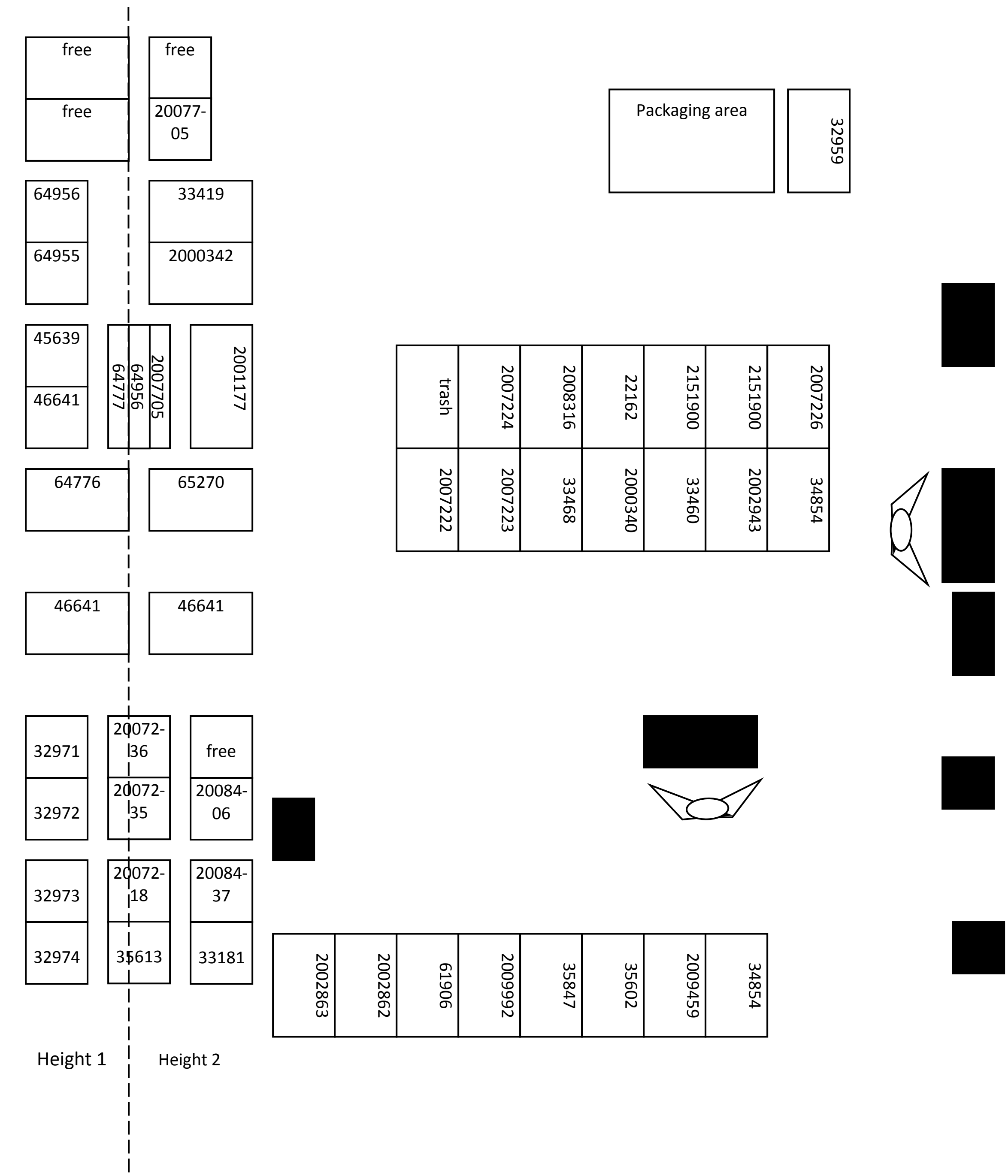
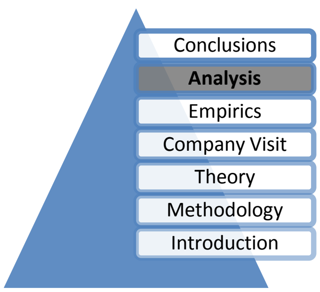


Figure 50- Assembly station 152

7 ANALYSIS



In this chapter the presented empirical data will be analyzed by using the framework in the theory and inputs from the company visit. The conclusion and recommendation in the final chapter will be based on the analysis.

7.1 The principle and tool framework

The authors have been using a principle and tool framework that combine presented theories and discussed problems into a simple framework that is easy to follow through the study. The framework has been used in the analysis to achieve a structure in the study.

The tools are as mentioned before the presented theory. The princples are those actions that will improve the process performance. By acquired understanding of the studied system, the authors' in chapter 1.2 provided a problem discussion that can be stated into following questions;

- How can the waste of time be reduced in the material supply?
- How can the utilization rate at the assembly stations be increased?
- What ways exist to release floor space at the assembly stations?
- Which parameters determine where a component should be stored?
- How can suggested solutions be financially prioritized?

By the problem discussion two princples are identified, *Reduce waste of time in material supply* and *Reduce waste of time in assembly processes.* To succesfullly improve process performance within material supply, a structural principle about the inventory is needed, *Optimize buffer inventory.* The authors have during the phase of mapping, observations and data collection, realized that the structures, system and processes at Nederman are complex and hard to review. According to Persson (1995), see 4.2.5, simplification is needed for a succesful improvement of the performance. The principle *Simplify structures, systems and processes* was therefore chosen.

The authors have then combined the presented theories and the stated princples into following framework, see Figure 51. The framework also provides the plot how the authors decided to carry out the analysis of the study.

Principles / Tools	Stockless production	Location of articles	MRP	Kanban	Standardized working methods	Stabilize the load of work
Simplify structures, systems and processes	●	●		●	●	
Reduce waste of time in material supply		●			●	●
Reduce waste of time in assembly processes	●	●		●	●	
Optimize buffer inventory	●	●	●			

Figure 51 – The chosen principle and tool framework

7.2 Structures, systems and processes

To be able to transform to Lean and towards continuously improvements the structure to handle ideas and solve problems has to be clear. At Thorn Lighting these problems are solved by the personnel working in the assembly process without unnecessary management involvement. During the Lean transformation they introduced the watchword *just do it*, which means that upcoming problems are solved without managers having several meetings about it. The company believes that the speed is most important. If the solution is not working it is replaced with another one.

At Nederman, structures about how to handle new ideas are vague. New ideas are hard to implement, they have to be processed in meetings with managers. As a result the ideas might be wasted or outdated. According to Lean in 4.3.2 all unused creativity is seen as waste. At Thorn Lighting they believe that the knowledge from the personnel working in the processes is invaluable.

A way to ensure that new ideas will not be waste is to start using quality circles. According to the theory in 4.2.1, Quality circle supports the creativity and motivation for the employees. The employees discuss and analyze the working methods and it enables a forum for expression of their opinions.

7.2.1 The ERP system

Nederman is using IFS as the ERP system. The IFS is also used by the assembly personal to order components, see inventory levels and print manufacturing orders. An ERP system is a fast, effective and an accurate way of controlling and review the flow. As described in the component ordering process, the IFS automatic release function in IFS calculates the needed material and creates a transportation order. Still though, problems occur. The auto release function creates big problems when the inventory levels are inaccurate. The complex calculations become a problem when wrong order quantities are ordered. The assembly personnel first discover it when the components are missing in the assembly process. The ERP system can therefore also be seen as a narrowing of the visibility in a process and add complexity to the structure.

At Thorn Lighting they were trying to minimize the computer system dependency. They believed that the systems were hard to follow, it decreased the visibility and that problems within the system could not be visualized. *Go gemba,* which means that all problems should be visualized, could not be followed as long as the material supply was depended on an ERP system.

According to the Lean theory unused creativity is classified as waste. Due to the ERP system complexity it is difficult, time consuming and expensive to create new smart solutions. Therefore are structures set by the system almost impossible to change and new creativity could not be adopted.

Still though, an ERP system is necessary for a company and a significant part of the material supply needs an efficient ERP system. Eliminating the system is therefore not an option. Problems with implementing continuously improvements can be olved by working closer to the system administrators of IFS. Areas such as the component ordering process that is changing continuously can also use non ERP dependent solutions such as Kanban to enable a visualized and fast changeable material supply.

7.2.2 Storage categories

Nederman uses pallets, cartons and three types of blue bins to store components. The advantage of store components in bins instead of cartons is that the bins have a standard size compare to the cartons where the size can differ. With standardized measures of the bins it is easier for the assembler to plan the inventory space. Some other advantages are that the design of the bins makes it easy to put on a pile and the grips make the bins easy to lift and handle.

A problem that turns up at Nederman is that the storage categories can differ from time to time. As a result, a component that always has been stored in a bin can suddenly be stored in a carton. Since the assembler chooses the ordering quantity for each component a change of box will also change the order quantity. Usually the assembler is trying to order a quantity that does not create picking activity in the warehouse. Instead the assemblers try to order quantities that match full boxes or pallets. A problem with IFS is that it cannot provide e.g. the quantity of a full box, instead the order quantity has to be remembered, which means that *tacit knowledge* is important. This problem is related to the delimitations of the ERP system that Nederman uses.

At Thorn Lighting only two different sizes of bins are used, which makes it easier to design the material supply. The company's transformation towards Lean includes assembling in small batches and therefore also using small containers to store components. The bins are stored in shelves, also called super markets. Storing bins in shelves with many heights saves floor space at the assembly stations.

At the assembly station 166, shelves are positioned beside the assembly process which saves floor space at the station. At assembly station 189, four mixed pallets are stored in the buffer, containing both bins and cartons. If all these components instead were stored in bins a supermarketcould replace the pallets, which would save floor space. Storing the blue bins in shelves instead of pallets would also decrease the searching time for components, since all bins are stored at the same place. Storing components in smaller bins instead of cartons can also increase the inventory turnover for the station buffer. Storing components in bins can increase the material handling in the warehouse since the components have to be moved from cartons to bins. Since bins are easier to handle it is possible for the internal logistics team to transport several bins in the same route which can reduce the number of transportations.

7.2.3 The material and information flow

Station 189, 166 and 152 have a lot of pallet locations in the station buffer inventory. As a result during the buffer placement, the internal logistics personnel have to ask the assembler where to put the components or hand over the material to the assembler. In both cases the assembly process will be interrupted. This interruption is classified as a pointless working activity in Lean. Every movement that does not contribute to the value for the customer is classified as waste. The assembling activity is the value adding activity for Nederman so it is critical that the utilization rate at every assembling station is as high as possible. Thorn Lighting does not store many components in the station buffers and each component has a visible marked location in the station buffer. Fixed and marked pallet locations make it easier for the internal logistics team to replenish the components. The components stored in the supermarkets are located according to a system to decrease the searching time to find the right location for the component. By storing components by a system at Nederman, for example in a numerical sequence in supermarkets, the internal logistics personnel can more easily find where to put the components in the station buffer. Another way to visualize the locations of components could be to draw a map of the pallet locations in the station and place it next to the station.

7.3 The material supply

After the forklift driver has picked a pallet from Warehouse A-L he/she puts the pallet at the waiting ramp. The forklift driver usually places the pallet to the left at the ramp. The pallets wait at the ramp until one person in the internal logistics team picks it up. The internal logistics forklift driver usually picks the closest pallet, the one to the right at the ramp. The pallet with the lowest waiting time will therefore be picked. The problem is that the first pallet placed at the ramp is the first one that was ordered from the assembly, and probably the first needed. At Thorn Lighting they solved this kind of problem with a conveyer that ensures picking pallets in the right order.

Another problem in Warehouse A-L is the space in the outgoing goods area, the area between the waiting ramp and the pallet racks. The area is very narrow and it happens that the warehouse forklift driver or the internal logistics forklift driver has to wait for each other. Wait is classified as waste according to the Lean theory and should be eliminated. The waiting time is one minute and it happens 2-3 times a day. During a year the total waiting time is 13 hours. According to the theory 4.2.5, it can be useful with standardized working methods for these problems. A standard of where the warehouse forklift driver should place the pallets and from where the internal logistics forklift driver should pick the pallets has to be established. The standard working method should also be structured in a way that the waiting time in the outgoing area is avoided. Thorn Lighting uses conveyors in the goods receiving area. The conveyor rolls the pallets to the right and ensures that the pallets are handled in the correct order.

A forklift driver in Warehouse A-L finishes a transportation order in IFS by placing a pallet at the ramp and writes the station number on the pallet. Otherwise the internal logistics team has no information about where to transport the pallet. It happens that the written number on the pallet is wrong or difficult to read, which can result in that the pallet is transported to wrong station. The solution with writing station number on the pallet is due to the computer system Nederman is using, the hand over activity between two forklifts is not possible to handle in IFS.

Thorn Lighting is working with visualization. When ordering components either a two-bin Kanban system or a Kanban is card used. The cards and bins from the assembly process follows the material through the flow, the warehouse personnel knows how much to pick and the internal logistics know where to transport it. The visualization of demand and avoiding complex computer systems is are ways of simplifying the component ordering process.

The number of transportation orders is seen in Table 2 in 6.2. This table is then sorted from the station with the lowest number of transportation orders to the station with the highest number of transportation orders, see Table 6. The table was sorted to facilitate the comparing of numbers of transportation orders at Nederman. The authors divided the number of transportation orders in three groups to distinguish the stations. The components with less than 1000 transportation orders per year are colored with a light color. These stations order less than 4 times a day (with 250 working days per year). The medium colored stations are the stations that orders between 4 to 8 times per day. The dark colored stations are the stations that order more than 8 times a day.

Assembly station	Number of transportation orders	Class
162	194	Light
155	195	Light
270	350	Light
186	518	Light
151	686	Light
166	862	Light
152	902	Light
153	929	Light
168	966	Light
280	1008	Medium
170	1027	Medium
140	1251	Medium
184	1352	Medium
230	1394	Medium
187	1590	Medium
188	1719	Medium
189	1723	Medium
159	2101	Dark
183	2565	Dark
191	4792	Dark
Total	**26124**	

Table 6 – Number of transportation orders per station

In Figure 52 are the stations are colored according to Table 6. . According to the theory in 4.2.3.1 should stations with a high frequency of transport orders be located close to the place where the components are stored. In this case the stations marked with a darker color should be located closer to the warehouse. With the dark colored stations located close to the warehouse is it possible to keep a low transportation time due to short transportation distance.

Table 6 shows that the stations 191 and 159, are two of the three stations with the highest number of transportation orders. Both these two stations are located closest to the warehouse, where they should be located according to the theory in 4.2.3.1, see Figure 52. Assembly station 183 is also one of the three stations with the highest number of transportation orders; it is placed a little bit further away from the warehouse. If this station would placed closer to the warehouse the traveling distance and time would decrease. Assembly station 188 is placed far away from the Warehouse A-L and behind the smart bin warehouse, the station has the fifth highest number of transportation orders and a lot of time could be saved by replacement. Placement of a station depends on the characteristics of the station. The number of transportation orders is not the only factor to consider, the characteristics of the station affects the decision making as well. For example if the station requires a lot of space it might be difficult to place close to the warehouse. This map can be used as a future guideline for Nederman.

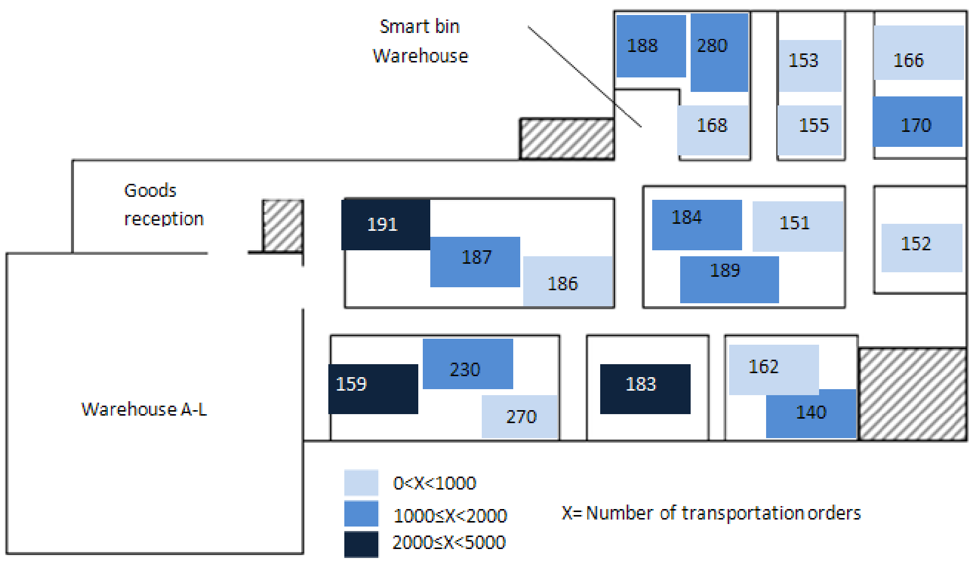


Figure 52 –Assembly station map per number of transportation orders

7.3.1 The internal logistics team

The internal logistics team is responsible for the transportations between the warehouse and assembly stations. Goods that have been placed at the ramp in the Warehouse A-L are not possible to find in IFS for the forklift drivers. The internal logistics forklift drivers instead have to cross Warehouse A-L continuously to identify goods that are waiting at the ramp, this is not efficient. If the ramp is empty the forklift driver drives back in to the assembly area. This circulating time is 32 minutes a day and the total time per year is 133 hours. These movements are unnecessary and classified as waste in Lean. Since unnecessary movements and transportations do not create any value they should be eliminated to the greatest possible extent. Thorn Lighting uses Kanban-cards and two-bin Kanban to visualize that component should be replenished. To eliminate unnecessary movements for the internal logistics team at Nederman a simple visualization signal can be used to inform the forklifts drivers. A simple light sensor could easily notify the internal logistics when a pallet is placed at the ramp.

The number of transportation orders per hour from Warehouse A-L and Warehouse V are plotted in Figure 37 in the Empirics chapter. The plot shows that most of the transportation orders are made in the morning. It is likely that the first thing the assembler does in the morning is to see if some components need to be ordered. It is also possible to see that a lot of orders are placed after the morning break and after the lunch break. The high number of transportation orders at specific times during the day affects the work load for the forklift drivers.

Mura means irregularity and is one of the terms in Lean. Irregularity is caused by varying volume of work. According to the theory in 4.2.6 is better to have a slow an even rate than a high rate with many breaks. Standardized working methods should be introduced to be able to avoid problems related to irregularity and to stabilize the load of work. Thorn Lighting solved the problem with irregularities with fixed routes during the day. Thorn Lighting has created a timetable for the internal logistics, when to gather empty bins and Kanban cards as well as replenish the supermarkets. With a timetable it is possible for the internal logistics team to help picking components in the warehouse instead of driving forklifts. Several routes a day makes the work load more stable in the warehouse.

When the internal logistics at Nederman deliver components to the assembly stations traditional forklifts are used. The forklifts can only transport one pallet a time, which means that only one station can be served each time. Thorn Lighting's investments in new trucks that could deliver both pallets and bins lead to a lower number of transportation tasks. With these new trucks it was possible to serve several stations in every transportation task, instead of just serving one station.

7.3.2 Lead time

The average delivery time for a transportation order can differ depending on which time during the day the order is placed. Figure 36 in 6.2.2 shows the differences. The average delivery time is longer in the beginning of the day. The high delivery time is a consequence of the unstable load of work which occurs due to peaks in the component ordering process. In Figure 53 it is possible to indentify one of these peaks in the components ordering process that affecting the load of work for the internal logistics and warehouse personnel.

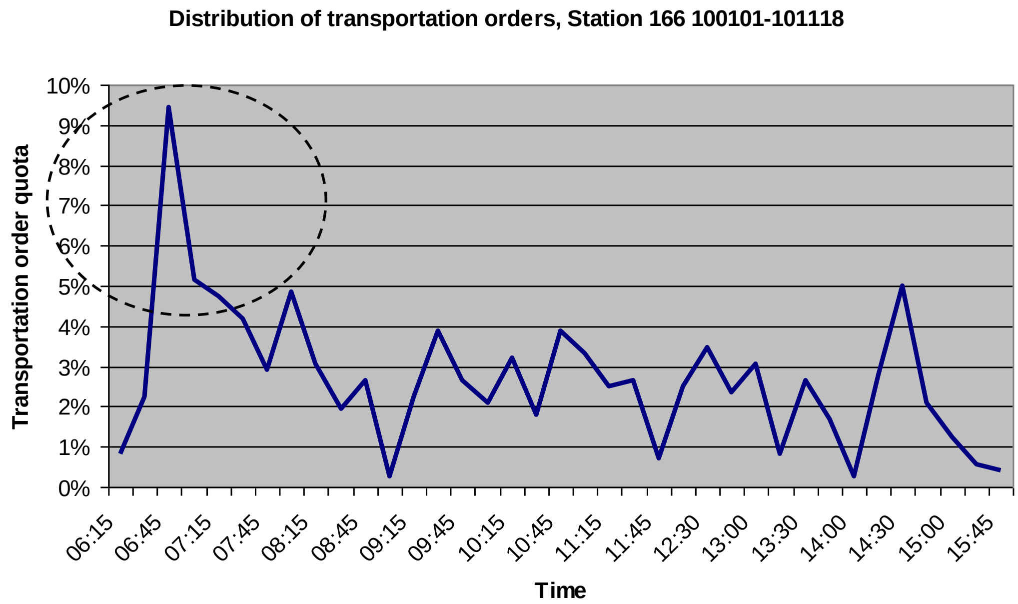


Figure 53 - Assembly station 166, Distribution of transportation orders

The average delivery time from Warehouse A-L is higher than the average delivery time from Warehouse V, 50 minutes in average from Warehouse A-L versus 25 minutes in average form Warehouse V. When a component is picked from Warehouse V is it delivered directly to the station by the internal logistics. The components picked in Warehouse A-L is first placed at the ramp where it stays until someone in the internal logistics team picks it up and deliver it to the station. Warehouse A-L has a higher number of transportation orders than Warehouse V, due to the higher number of pallet locations. Only one person is working at Warehouse A-L while in Warehouse V two persons are working, the internal logistics team. Since Warehouse A-L only has one forklift driver and receives much more orders, the waiting time for each order to be handled is longer in Warehouse A-L. Figure 36 shows that the total waiting time for picking is on average 40 minutes for Warehouse A-L and only 21 minutes Warehouse V. The waiting time at the ramp in Warehouse A-L is the time that mostly influences the average delivery time.

In 6.2.3 is the total lead time from Warehouse A-L and Warehouse V illustrated in two diagrams. The total lead time for a transportation order from Warehouse A-L is 50 minutes and a transportation order from Warehouse V 25 minutes, see Figure 38 and Figure 39. Warehouse V is located very close to the stations. The shorter lead time for Warehouse V and the close locations to the stations should be used to improve the material supply. According to the theory in 4.2.3.1 should articles with a high picking frequency or a high handled volume be placed close to the assembly process to be able to decrease the traveling time and distance. By storing components with a high frequency close to the station, the advantages of a short lead time can be used more often. This decrease the work load in Warehouse A-L since the internal logistics team is responsible for picking components in Warehouse V. To be able to utilize the pallet locations at Warehouse V, IFS has to be configured, which can only be done by someone at IFS.

The ordering process and the buffer placement are the two activities that interrupt the assembling. These two activities take four minutes per transportation order. With 26000 transportation orders per year the total interruption time of the assembling is 1700 hours per year.

The assembler usually has to place the ingoing components delivered by the internal logistics to a specific location in the station buffer. As a result, the assembly process will be interrupted. With a structured layout of the station, the internal logistics would be able to place the components without interrupting the assembly process. A map of the pallet locations could be placed next to the station.

7.4 The component ordering process

Today the component ordering process is characterized by a complex system where tacit knowledge is required. The process is characterized by the assemblers' ability to know how long a certain box will last, how many components a pallet can store for a certain component and when it is time to order it. The embedded function in IFS for automatic release of components and transportation orders is not working properly due to the inaccurate buffer inventory. There is also a problem for the warehouse personnel, they are not able to pick all quantities generated by the IFS function, instead are deliveries made by full pallets or boxes.

As written before, the ordering process is highly depended on the assembler's tacit knowledge. The large assembly area also works as a trigger for the assembler to order more material than needed. As a result the inventories are high and many components have a low inventory turnover, see Appendix I, Appendix J and Appendix K. With higher inventories the visualization decreases and the component ordering process becomes time consuming.

As seen in Figure 37 the component ordering process creates a peek of transportation orders during the first hour. With peeks irregularity occurs, referred as *Mura* in the theory. Irregularities create waste due to the problem to both handle high working peeks with hours of shortage of work. To eliminate irregularities due to the component ordering process, routines for stabilization of the process could be established.

The perceived problem with a lot of disturbances in the assembly process can partially be addressed to the component ordering process. As seen in Table 6, assembly station 183 has during a year placed 2565 transportation orders, which are about 10 orders per day. The actual component ordering process is time consuming, but it also important to add assembly start up and stop time to get an objective picture. Reducing the number of orders that are placed manually will decrease the disturbances and increase the assembly utilization rate.

Kanban has successfully been implemented at many companies to get rid of the time consuming component ordering process. Many companies have also been implementing a two-bin Kanban for even higher degree of visualization and simplified structure. An example of a successful implementation of Kanban is Thorn Lighting. At Thorn Lighting they were using a two-bin Kanban for the most frequent components and Kanban cards for low frequent and big components. Empty bins were placed at a certain area and when the train stopped, the bins were picked up by the train and delivered in next round. At Thorn Lighting Kanban is one of the fundamental implementations for reaching a simplified and visualized structure with increased assembly utilization rate.

Nederman has tried Kanban but failed in the implementation. Deliveries of components that are not going to be used in months are just a consequence of badly Kanban usage. The idea is not just to send away new Kanban cards every time the box is empty and use this procedure for all components. Kanban should still be used to pull components from the warehouse to the buffer only when material is needed.

7.4.1 A framework for analyzing the ordering process

To determine which components that can be suitable for Kanban and MRP, the authors have decided to develop a framework by combining the theory of MRP and Kanban. The framework is plotting the variability factor of components versus the picking frequency. This framework is developed where the plotted components can be addressed to a certain ordering process, see Figure 54. The authors' choice of using either MRP or Kanban can be addressed to the fact that a MRP in IFS is an existing function and Kanban has successfully been implemented in similar industries.

The variability factor calculations are introduced in 4.1.4. The picking frequency is the number of times a component during a year has been picked per assembly station. Due to the five days working week the number of working days is set to 250, a yearly picking frequency of 250 is therefore interpret as one picking per day.

To be able to use Kanban efficiently the demand has to be stable and high frequent. A Kanban solution is therefore found in the lower right quadrangle in the framework. There are two important questions that have to be considered; At which level of the variability factor could the demand be considered as stable? How many component picks per year is equal a high frequency?

The authors have considered Cimorellies' (2005) conclusion regarding the variability factor and which products to put on Kanban. Still though, floor space at the assembly stations has to be minimized and building safety stock for high variability components is not an option. Therefore the authors have chosen a relative low accepted variability factor for Kanban-A, 0.6. A component with a high picking frequency is by the authors defined as a component that is picked every second day over a one year period. With 250 working days the Kanban-A frequency boarder is set to 125. The boarder is set by the authors to narrowing the search for the most suitable components that could be tried in a pilot study. The area of those components is marked by the crosshatched Kanban-A area in Figure 54.

With an organization and a material supply that is working with Kanban, a yearly picking frequency of one per week would be more realistic, which is marked by the crosshatched Kanban B area in Figure 54. A possible third area of accepted Kanban components is the Kanban-C area. The Kanban-C area accepts components with a higher variability and lower demand frequency.

The demand variability factor is the components standard deviation of demand, divided by its average demand. The standard deviation and corresponding average demand is per day. The data used for calculations of the variability factor are gathered by IFS. The data covers one year of the component demand per assembly station. The picking frequency is the number of times a component has been requested at each assembly station per year. If the assembler visits the box of a component and takes 10 components, the demand is 10 but the picking frequency is just one.

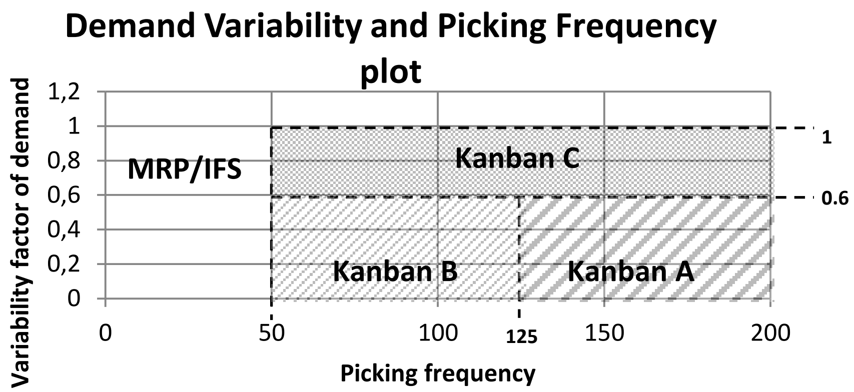


Figure 54- Variability and Frequency framework

7.4.2 Assembly station 189

Assembly station 189 has during a one year period handled about 100 different components. Those components variability factor and their picking frequency have been plotted in to the variability and frequency plot for identification of potential Kanban use. As seen in Figure 55 about 45 of the 100 components fit the requirements of a Kanban-A component ordering process.

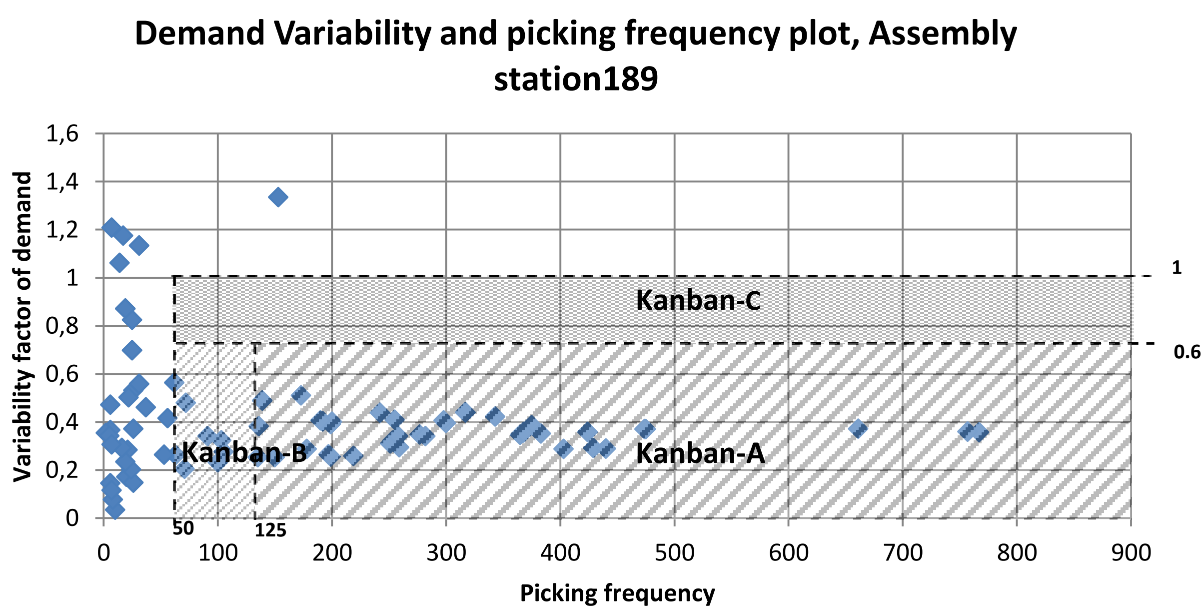


Figure 55 - Variability and demand frequency framework, Assembly station 189

The components that fit the requirements of a Kanban-A component ordering process are seen in Table 7. The table also provides the number of transportation orders made per component during one year. The total number of transportation orders to assembly station 189 is 1723, see Table 6. The potential Kanban-A components during one year have been transported 1384 times to assembly station 189, see Table 7. By dividing 1384 with 1723 it is noticed that a potential Kanban-A system could handle about 80 % of all components transportation orders.

$$\frac{1384}{1723} = 80\ \%$$

Article number	Article description	Number of Transportation orders, 2010	Assembly Picking frequency, 2010
36182	Drum 30 (0,8x7000)	91	178
36205	Attached details H20/H30 Nederman	40	403
2150695	X Hub H30	40	219
2152340	Drum cover hose ass.	20	440
2152341	Cable stand female 12m	25	135
2000238	Cable stop half under	18	259
4901071	Strap 270x4,7 mm black	8	429
2009206	Cable stand male	13	150
2150084	O-ring 13.1x2.62	6	440
2002305	Pressure bush 6mm lt	6	199
2006888	Brake cover 6mm	5	197
36179	Drum 20 (0,7x7500)	153	475
36178	Cover assembly Ser. 20 Blue	148	424
36171	Cover assembly Ser. 30 Blue	118	253
2151960	Cover CH20 service side. Blue	110	424
2151962	Cover CH30 service side. Blue	97	251
2154407	Box CH 20 332x342x159 Nederman KLIP	46	383
2150923	Outlet protection	40	757
2152270	Bearing bar	37	757
2150922	Bracket CH20	35	474
2150206	Bracket CH30	29	282
2151976	Box CH30 383x387x165	25	258
2000237	Cable stop half upper	19	277
2151202	Label Nederman 78X13	8	661
2151521	Banjo 10mm brass	17	199
2002307	Pressure bush 10mm lt	14	365
2151524	Hub lock	15	767
45947	Hosestop 10 lower right black	14	199
45946	Hosestop 10 upper right black	14	199
2006889	Brake cover 8mm	9	368
2151099	Spring guard 3/8"	11	375
2002306	Pressure bush 8mm lt	9	368
36186	Attached details C20/C30 Nederman	24	242
36174	Current collector complete 3-pole	16	298
2151541	Hub C20	15	255
45944	Hosestop 8 upper right black	14	192
45945	Hosestop 8 lower right black	15	192
2152339	Drum cover cable ass.	16	317
2155351	Hose nipple 8mm-1/4	6	200
2150289	Sealing drum	8	317
45942	Hosestop 6 upper right black	7	139
45943	Hosestop 6 lower right black	8	139
2150127	Cover thermo switch	3	317
64753	Connection terminal	7	317
2152220	Sealing connection cover	5	317
Total		**1384**	

Table 7 – Potential Kanban-A components, Assembly station 189

The potential Kanban-B components are attached in Appendix D, no potential Kanban-C components exists for assembly station 189. The components at assembly station 189 that would be ordered through the automatic function in IFS are seen in Table 8. As seen in the same table, those components correspond to 171 transportation orders.

Article number	Article description	Number of Transportation orders, 2010	Assembly Picking frequency, 2010	Variability Factor
2150767	X Hose 3/8" TF	7	153	1,3
36229	Attached details C20/C30 Würth	3	26	0,1
36228	Cover assy. Ser 20. Red (Würth)	10	26	0,1
36222	Attached details H20/H30 Promat	3	20	0,2
2153951	Cover CH20 serices. Red Würth	7	26	0,1
2152342	Cable stand female 17m	5	21	0,3
2007143	Hose 8mm black	4	24	0,2
2151864	Rotation lock CH30	4	10	0,0
2153354	Cable 3G1,5 H07RN-F 12m yellow	3	6	0,1
2154405	Box CH 20 332x342x159 Promat	3	19	0,2
2151975	Box neutral 383x387x165	2	16	0,3
33210	Pipe angle 8mm	1	8	0,1
32525	X Pipe angle 6mm	1	7	0,1
36215	Attached details C20/C30 neutral.	4	26	0,4
33211	Pipe angle 10mm	1	6	0,4
2153355	Cable 3G1,5 H07RN-F 17m yellow	2	2	0,4
65377	X Nipple for hose 10mm-1/4"	2	5	0,3
2154406	Box CH30 383x387x165 Promat	1	7	0,3
36232	Cover assembly Ser. 30 Grey	11	31	0,6
36214	Attached details H20/H30 Neutral	2	26	0,5
2154378	Cover CH30 Service side grey	9	31	0,6
36221	Attached details C20/C30 Promat	2	6	0,5
2150765	X Hose 1/4" TF	5	37	0,5
2152253	Cable 3G1,5 H07RN-F 17m	4	22	0,5
2151274	X Hub H20	9	25	0,8
2153879	Cable lamp 2x1mm2 12 m	7	19	0,9
36213	Cover assembly Ser. 20 Grey	7	25	0,7
2153739	Transformer 110-230V/24V in box	4	19	0,9
2153228	Cover CH20 service side. Grey	5	25	0,7
2153708	Slip ring unit 24V cmpl.	5	19	0,9
2153960	Cable 3G2,5 H07RN-F 12m	13	17	1,2
2153961	Cable 3G2,5 H07RN-F 17m	10	14	1,1
66457	Socket 3-pin UK	7	7	1,2
2155386	Socket 230V IP44	5	31	1,1
35658	Cable 3G2,5 H07 RNF 1m	3	31	1,1
Total		**171**		

Table 8 – Components that should be ordered by IFS, Assembly station 189

The component ordering process at assembly station 189 with heavy amount of transportation orders after 1pm create peaks in the material supply, see Figure 43. The change from placing orders in the morning towards placing orders after 1pm has just moved the peak. To achieve a stabilized material supply, the component ordering process has to be spread out during the day. A problem with increased number of times when the assembler places transportation orders is the declining assembly time. At Thorn Lighting the two-bin Kanban system stabilized the component ordering process during the day. The empty bins were picked up by the train and delivered next round. The assemblers do not need to interrupt their assembly process, the component ordering process serves the station with components automatically.

7.4.3 Assembly station 166

Assembly station 166 has during a one year period handled about 90 different components. Those components variability factor and their picking frequency have been plotted in to the variability and frequency plot for identification of potential Kanban use. As seen in Figure 56, 34 of the 90 components fit the requirements of a Kanban-A component ordering process.

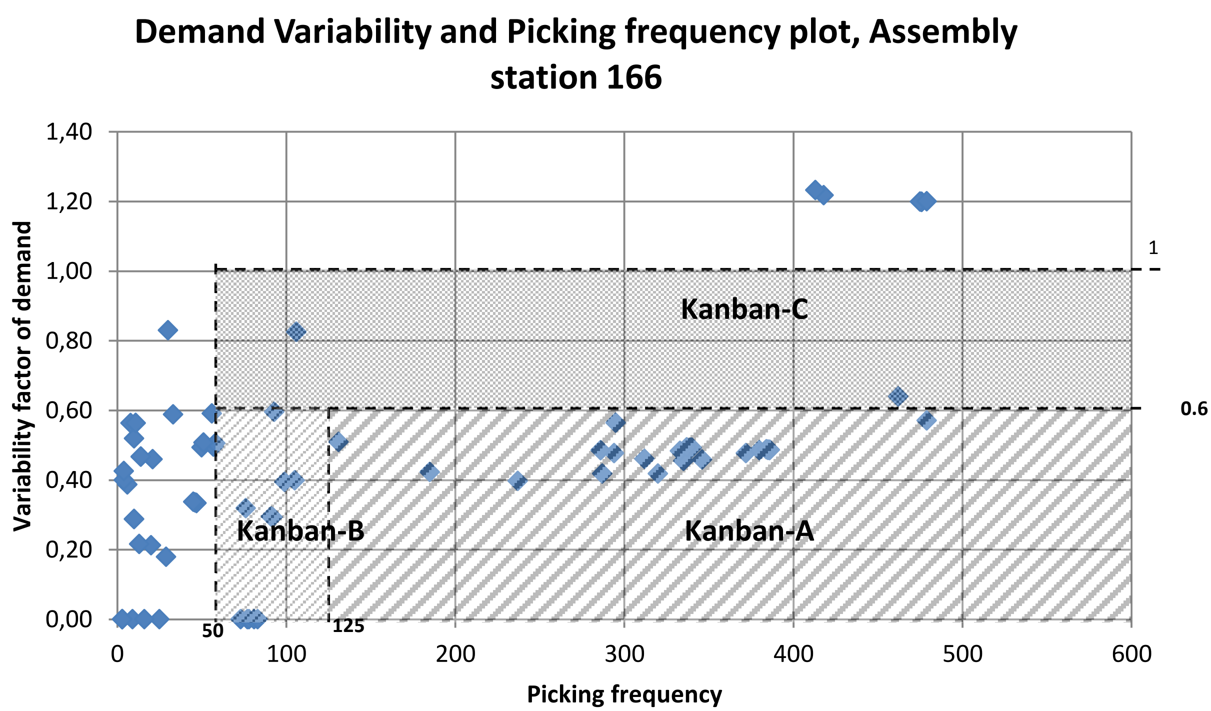


Figure 56 - Variability and demand frequency framework, Assembly station 166

The components that fit the requirements of a Kanban component ordering process are seen in Table 9. The table also provides the number of transportation orders made per component during one year. As seen in Table 6 the total number of transportation orders to assembly station 166 is 862. The potential Kanban-A components during one year have been transported 271 times to assembly station 166, see Table 9. By dividing 271 with 862 it is noticed that a potential Kanban-A system could handle about 31 % of all components' transportation orders.

$$\frac{271}{862} = 31\ \%$$

Article number	Article description	Transportation orders
35866	Control box IEC 3P 400V timer	19
2151206	Label Nederman 330X51	4
35914	Motor complete 400V 3P 50Hz	12
144023	Instr.Manual FilterBox Standard	7
2010189	Bracket lower	4
2010165	Bracket upper	4
147788	Label Instruction	1
148766	X CE-deklaration FilterBox	1
2001861	Edge protection 60x60x5x 670	1
21596	Sleeve connection	4
33457	Hose vent 160/ 450 blue	4
2002316	Spacer d=22x30	3
46580	Sleeve coupling Ø160	4
2002098	Handle	10
32481	Quick coupling	7
32352	Cleaning flap	15
21808	Display panel	11
11340	Collar	9
2000753	Quick clamp	3
32351	Cleaning bar	3
2001770	Bracket	2
2001772	Bracket	2
2002219	Gasket r265.5/251.5	3
2001991	Washer sealing	2
63407	Damper	1
32353	Handle	1
2001990	Gasket 50/ 77	2
21820	Rod	28
34160	Kit panel in/out blue ii	51
2003400	Bucket 10L black	4
34161	Kit panel side blue ii	33
2001101	Pilloflex	2
2005021	Cable guide	6
61055	Hose clamp 130-165	8
Total		**271**

Table 9 - Potential Kanban-A components, Assembly station 166

The potential Kanban-B components are attached in Appendix E and potential Kanban-C components in Appendix F. Components at assembly station 166 that would be ordered through the automatic function in IFS are seen in Table 10. As seen in the table, those components correspond to 420 transportation orders.

Article number	Article description	Number of Transportation orders	Assembly Picking frequency	Variability factor
32318	Bearing swivel	10	476	1,2
63282	V-ring 170	10	476	1,2
63340	V-ring 85 a	3	476	1,2
21909	Bearing	9	475	1,2
21902	Bush bearing	6	479	1,2
11317	Gear ring	8	418	1,2
35868	Control box IEC 3P 400V monitor	16	25	0,0
35863	Control box IEC 1P 110V timer	8	9	0,0
12371422	Stand 522/529 floor for fan	6	16	0,0
36383	Fan N29 1.5kW unpacked	3	3	0,0
2009400	Electronic Siren 2,9kHz	1	3	0,0
12333354	Compressed air cleaning 24V	3	3	0,0
2005022	Fuel filter	1	29	0,2
144022	Instr.Manual FilterBox Monitor	2	20	0,2
32958	Cartons 595x375x320neut	1	13	0,2
35864	Control box IEC 1P 230V timer	6	10	0,3
35910	Motor complete 230V 1P 50Hz	2	10	0,3
34837	Kit panel in/out space blue	6	47	0,3
34838	Kit panel side space blue	6	47	0,3
2002654	Hose vent 160mm 2.2m white	5	46	0,3
2002668	Bucket 10L space blue	12	45	0,3
2002684	Washer cover space blue	2	6	0,4
32672	Filter-PW-FB-13	182	413	1,2
2155271	Control box 220/380/440V monitor	3	4	0,4
66493	Wooden box, FilterBox	3	4	0,4
2155270	Control box 220/380/440 timer	16	21	0,5
35865	Control box IEC 3P 230V timer	12	14	0,5
35913	Motor complete 230V 3P 50/60Hz	2	14	0,5
22166	Inlet connection	2	10	0,5
2002215	Extension tube fan	6	8	0,6
36022	Fan N24 0.9kw without package	3	11	0,6
14502237	Manual fan starter FMS 1.6 -2.5	2	11	0,6
2001263	Filter cartridge compl.	33	33	0,6
2150311	Filter antistatic	30	30	0,8
Total		**420**		

Table 10 - Components that should be ordered by IFS, Assembly station 166

In contrast to assembly station 189, assembly station 166 has no restrictions regarding the time of order. As seen in Figure 45, the component ordering process has today a significant peak in the morning. The station is therefore one of the stations that is creating a morning peak for the material supply and internal logistics, which is contradictory according to theory 4.2.6 of stabilize the load of work.

7.4.4 Assembly station 152

Assembly station 152 has during a one year period handled about 48 different components. Those components variability factor and their frequency of demand have been plotted in to the variability and frequency plot for identification of potential Kanban use. As seen in Figure 57, 9 of the 48 components fit the requirements of a Kanban-A component ordering process.

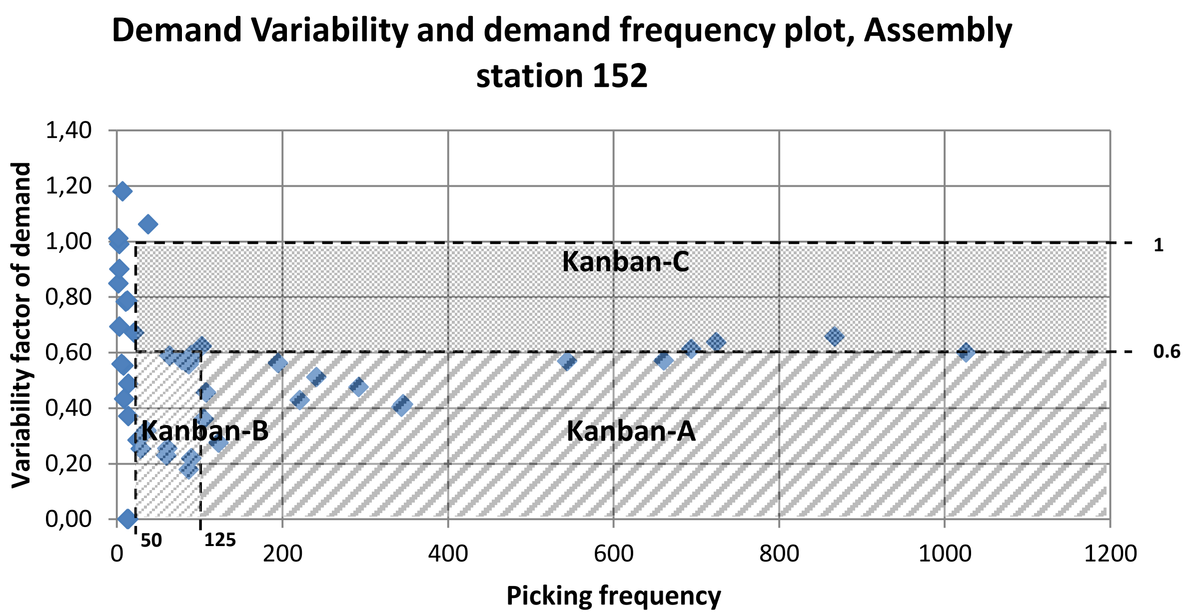


Figure 57 - Variability and picking frequency framework, Assembly station 152

The components that fit the requirements of a Kanban component ordering process are seen in Table 11. The table also provides the number of transportation orders made per component during one year. The total number of transportation orders to assembly station 152 is 929, see Table 6. The potential Kanban-A components during one year have been transported 428 times to assembly station 152, see Table 11. By dividing 428 with 929 it is noticed that a potential Kanban-A system could handle about 46% of all components transportation orders at assembly station 152.

$$\frac{428}{929} = 46\ \%$$

Article number	Article description	Transportation orders
32959	Cartons 524x514x380mm	3
2151900	Impeller N24 50Hz	28
22162	Impeller N16 50Hz	15
33181	Guard net	10
33419	Attached paper N10/N16/N24	4
61055	Hose clamp 130-165	9
2151203	Label Nederman 175X27,9 Blue	3
147553	Label caution	1
34854	Fan casing pair space blue	355
Total		**428**

Table 11- Potential Kanban-A components, Assembly station 152

The potential Kanban-B components are attached in Appendix G and potential Kanban-C components in Appendix H. The components at assembly station 166 that would be ordered through the automatic function in IFS are seen in Table 12, these components correspond to 126 transportation orders.

Article number	Article description	Number of Transportation orders	Assembly Picking frequency	Variability factor
2008142	Impeller Ø310 10-fanblades	3	14	0,21
64777	Motor w. Switch	10	25	0,40
64776	Motor w. Switch	8	29	0,28
2007222	Motor 2.2kW 230/400V 3~ 50/60Hz	22	14	1,57
2007236	Motor 7AA80M02, 1,1/1,3 kw 3Ph50/	1	13	0,08
32973	Fan housing impeller f.60Hz 2,2	13	14	0,93
64968	Motor with switch	3	8	0,38
64969	Motor with switch	5	9	0,56
2007216	Motor 0.9kW 200V ±10 3~50/60Hz	1	6	0,17
32972	Fan housing impeller 50Hz 1.5kW	28	36	0,78
64955	Motor w. Switch	7	11	0,64
2007235	Motor 7AA80MO2K, 0,75/0,86kw 3Ph5	3	21	0,14
65003	Motor with switch 60Hz USA	3	3	1,00
22171	Impeller N16 60Hz	4	13	0,31
46592	Reducer Ø160-150	2	2	1,00
2155348	X Motor 1,1kW/1,5hp 220/380/440V	2	3	0,67
2007706	Fan wheel Ø227 60Hz	2	3	0,67
2007705	Impeller N10 50Hz	4	38	0,11
64956	Motor w. Switch	4	7	0,57
2007218	Motor 3,0Hp 230/460V 3~60Hz UL/CSA	1	2	0,50
Total		**126**		

Table 12 - Components that should be ordered by IFS, Assembly station 152

Assembly station 152 has a more stabilized flow of the component ordering process, see Figure 47. Still though, a smaller peak in the morning can be identified. But in comparison with station 189 and 166 the ordering process is quite stable during the day, which is desirable according to the Lean theory of stabilize the load of work, 4.2.6.

7.4.5 Kanban ordering process

As seen in the detailed study of three assembly stations the number of suitable components for Kanban can differ. Assembly station 189 seems to have the highest share of suitable components. It is important to understand that this identification framework of Kanban or ERP is not providing a final decision for each component. E.g. component 147553, Label caution, see Table 11, has been transported to the station one time during a one year period. Many components similar to this one can be found the tables. The reason is that these kinds of products are often used, but stored in a big quantity. The label caution, 147553 is demanded about 600 times a year with a total demand of 5711 items, the box has during the year been delivered one time, in a box of 10000 items.

Due to the chosen variability factor a lot of components that seems to be suitable for Kanban are rejected in the Kanban-A area. In the variability and frequency plots for both 166 and 152, it is possible to identify components with high frequency that are not within Kanban-A area. Just by accepting a higher safety stock for those components the problem with variability can be solved. But it is still important to see frameworks like the variability and frequency plot as a guideline in the finding of the best component ordering activity, see Figure 58.

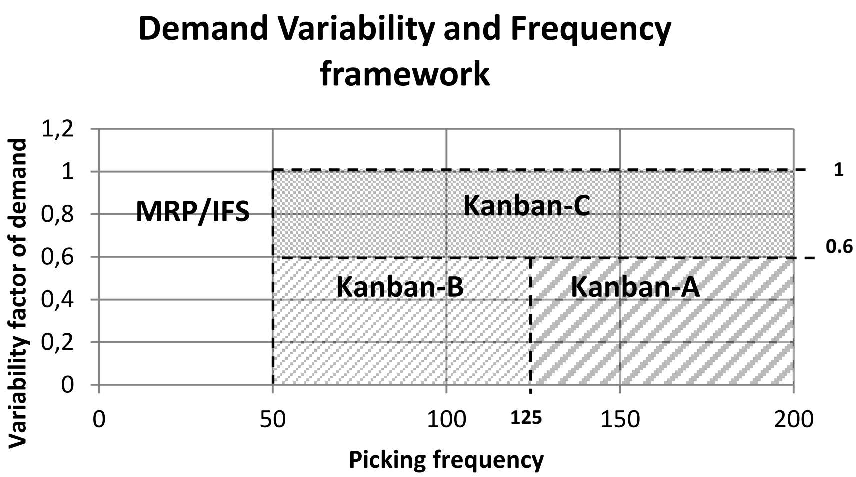


Figure 58 - Variability and Frequency framework, Kanban A-C

It is also important to decide standards for the components that are not considered for Kanban. The problems with those components are that they have either a high variability or are used with a low frequency. It seems that Nederman has solved the high variability problem with building up inventory buffers and as a result the variability is not a problem, maybe not even known.

In IFS it is possible to use the automatic release function to calculate an order picking lists for components. Due to the problems in the warehouse with handling a large number of picking activities the number of picking lists has to be limited. Today these problems are solved by the assembler that only ordering components with a quantity that matches a full pallet or carton. According to the developed framework, the non Kanban components should be ordered through IFS when needed. The order quantity matches the demanded quantity and the components should not be seen as a part of the inventory. With no inventory of those products, the automatic release function would just order demanded quantity.

With a reduced or eliminated inventory of low picking frequency components, it is of greatest importance to establish routines for the ordering process, so that the assembly process is not interrupted by component shortage. Component shortage can be seen as one of the disturbances that occur in the *Japanese sea* when the inventory decreases. Therefore is it important to establish routines where the assembler at a certain time places an order for e.g. the next day production.

By using a Kanban solution that is refilling material continually and usage of the auto release function, the time spend in component ordering will decrease rapidly and the assembly utilization rate will increase.

7.4.6 Implementation of Kanban

Nederman has bad experience of implementing Kanban, the previous attempt did not work because it was implemented with wrong components. Components that should not be used until six months later could be ordered and delivered. The overall opinion of Kanban is that it is not suitable at Nederman. An implementation of Kanban can therefore be complicated due to the bad experiences. A better understanding of Kanban would facilitate the implementation of Kanban. In quality circles are improvements and problems related to the process discussed. If these quality circles were used at Nederman, an implementation of Kanban could be facilitated. The quality circles can include an introduction of Kanban and the main purpose of implementing it at Nederman. When starting implementing Kanban, the quality circles can be used to discuss which problems that have been occurring because of the Kanban-system. With these quality circles the implemented Kanban can continuously be improved so it will suit Nederman and its material supply.

An introduction of Kanban needs to be successful initially, the doubters have to be convinced that Kanban is useful. The implementation should therefore initially start with a few components that are perfect suited for Kanban. The identified components in the Kanban–A area in the variability and picking frequency framework matches the ideal Kanban criteria's and would be perfect to start with in a first implementation step. The implementation of Kanban should also be done step by step to be successful. Start the implementation at one station and then include more and more station could make the implementation successful. Station 189 has made some changes in the station buffer lately. Starting the implementation in this station might be easier since the assembly personnel have experienced changes before and might be more open-minded to new changes.

A component ordering process by Kanban requires a new way of notifying the internal logistics that a component needs to be replenished. The Kanban cards do not create transportation orders in IFS and the internal logistics will therefore not be notified.

At Thorn Lighting it was two options to notify the internal logistics, either by placing the Kanban bin in a certain area or put a Kanban-card at a white-board. When the internal logistics at Thorn Lightning passed by with the train they picked up the empty Kanban bins and took down the Kanban cards.

At Nederman a notification system could be implemented due to the fact that no scheduled visits occur. A notification system can be connected to the handhelds but Lean strives for simplicity and a regular lamp could be a solution. When the operator places a Kanban order, the bin or the card are placed at a certain area where the operator turns on a lamp which notifies the internal logistics. When the internal logistics sees the light they pick up the Kanban-card or the bin and turn off the light. The price for a notification system with cables, switches, lamps and installation will approximately be 2500 SEK per assembly station.[148]

The Kanban-card can be placed in a plastic pocket on the pallet rim and when the number of components in the pallet decrease to a certain level the Kanban-card could be placed on a white-board and the light should be turned on. The Kanban-cards should include which component, the number of components and which station the components should be delivered to.

The use of Kanban will reduce the time to order a component. The reduction can be calculated by multiplying the time to order a component by the number of transportation orders placed for Kanban A-C components. The component ordering time in IFS is measured to two minutes, see Figure 38. The component ordering time for Kanban products has been estimated to 20 seconds, the time it takes to take the Kanban card and walk with it to the area where the cards are placed. The time reduction can therefore be seen as 100 seconds per placed order. In Table 13 the number of transportation orders per station is compiled. By implementing Kanban A-C the time reduction in the assembly process would be 73 hours per year for assembly station 189,166 and 152.

$$Time\ reduction, assembly\ station\ 189, 166\ and\ 152 = (1728 + 818 + 64) \times \frac{100}{3600} = 73\ hour$$

The identified components at the three stations are distributed as follows;

	Assembly station			
	189	**166**	**152**	**Total**
Kanban A	1384	271	73	1728
Kanban B	153	149	516	818
Kanban C	0	14	50	64
MRP/IFS	171	420	126	717
Total	1708	854	765	
Total Kanban share	90 %	51 %	84 %	

Table 13 - Number of Transportation orders 2009.10.31 - 2010.11.01 per station and category

A consequence of a Kanban solution is the increased number of transportations, the forklift driver has to visit each station and collect empty bins and Kanban cards before a component delivery. But with an increased usage of blue bins and decreased order quantities, the forklift driver is able to deliver several boxes at the same time. A successful Kanban solution is therefore highly dependent on integration between stations, internal logistics and the warehouse to make up for the extra transportations. With a less complex structure and a higher degree of visualization, the operators working within the system have a high responsibility to solve upcoming problems and continuously improve the material supply. Pre defined timetables for collecting Kanban orders such as the case at Thorn Lighting could be a way for

[148] Expressel, retrieved 2011-01-12,< http://www.expressel.se/index.html>

decreasing the number of transportations. A higher degree of integration between the warehouse personnel and the internal logistics could also be a solution for stabilize the work load in the warehouse at Nederman.

7.5 The buffer inventory

Every assembly station at Nederman has a large number of pallet locations. The studied stations: 189, 166 and 152 have 39, 47 and 57 pallet locations each. To be able to assemble and handle the material supply, the assembler and internal logistics personnel requires *tacit knowledge*. Due the number of pallet locations at the station, the searching for components will be very time consuming if the assembler is inexperienced. In station 189, four of the pallet locations are mixed pallets; these pallets are mixed with both cartons and blue bins. The mixed pallet locations make it even more difficult to find components. The searching for components in the inventory buffer does not create any value. In Lean is searching classified as waste see theory 4.3.2, pointless working activities, and should be avoided.

The inventory buffers at each station can be compared to the Japanese sea where the high inventory levels hide disturbances and problems. As an observer it is very difficult to identify and understand the structure of the material supply at Nederman. The company wants to reduce the assembly floor space that is allocated at the assembly station. To be able to release floor space in the assembly area, the inventory level needs to be decreased. This reduction of inventory level will visualize problems that occur due to reduced inventory levels. At Thorn Lighting the Lean watchword *Go Gemba* is used, which means, all problems should be visualized. It is first when a problem is visualized it can be solved. According to the theory 4.2.2, low inventory levels will lead to strong incentives to solve and get rid of disturbances. The system will be more sensitive of disturbances in short terms but on the other hand the system will be stronger and more profitable in long terms.

7.5.1 Ordering quantities

The assembler does not have any restriction about which quantity that is allowed to order. This mean that each assembler orders a suitable quantity based on *tacit knowledge*. Without any restriction about the ordering process there is a risk that too many components will be ordered. Storing too many components in the inventory buffer is classified as the waste excess inventory according to the theory 4.3.2. Without any restrictions the assembler can choose to order components a long time before it is going to be used. When a delivery of components arrives too early to the station, it has to wait a long time before it is going to be used. Early receiving of components can be identified as over production, which is a waste in Lean. Over production refers to activities executed before determined date, which will lead to wait.

As mentioned before, Nederman wants to reduce the occupied assembly floor space. Thorn Lighting's solution to reduce floor space and to facilitate the assembling for the assemblers was to stop using traditional pallets. The company replaced the pallets with other load carriers with wheels on and small bins. The bins are placed in the supermarkets around the assembly area. A supermarket can store approximately 24 bins which are about four pallets with bins. The supermarket allocates the floor space of one pallet location. When using supermarkets the bins could be stored on the height in the shelves, which saves floor space. The stations at Thorn Lighting do only have the components required for that specific order placed in the buffer at the assembly station. Each component has a fixed location in the station inventory buffer and a maximum space to use.

The assembly station inventory can be analyzed by its inventory turnover. A low inventory turnover indicates that components allocate unnecessary floor space. Reduction of floor space is an important area of this study. In previous chapter, the Variability and Frequency framework was introduced, see Figure 54. By replacing the variability factor with the inventory turnover a framework for identification of wrong ordering quantities are introduced, see Figure 59. The Kanban areas are kept in the framework for an easy identification of components.

One of the questions in the problem discussion is; *What ways exist to release floor at the assembly stations?* In the discussion about the lowest accepted inventory turnover, this question has been in mind. By reducing the accepted limit of inventory turnover, the buffer inventory has to be reduced and floor space will be released. In the presented Inventory turnover and demand frequency framework, Figure 59, the limit is set to 50 by the authors. An inventory turnover of 50 corresponds to a replacement of the inventory 50 times a year, which is once a week, with 250 working days. The picking frequency border is the same as in previous section with 50 and 125 for Kanban-A and Kanban-B areas, see 7.4 for further details.

Inventory turnover for components within the area of MRP/IFS are not of interest when these components could use the automatic order release function in IFS, described in 7.4.5. These components should not be stored in the buffer inventory since they are only ordered when they are going to be used. An analysis of these components is hence not necessary. These components can be found in Table 8, Table 10 and Table 12 for assembly station 189, 166 and 152.

The detailed analysis with the Inventory turnover and picking frequency framework will only be carried out for the Kanban-A area, which means for components with a yearly picking frequency higher than 125.

The yearly frequency of demand is the same axis as in the described Variability and Frequency framework, see 6.3. The inventory turnover has due to insufficient data of average inventory at each station been calculated by an approximated formula;

$$Inventory\ turnover = \frac{Component\ demand\ (per\ year\ and\ station)}{\left(\frac{Average\ delivery\ quantity}{2}\right)}$$

The inventory turnover formula has been since no safety stock exists at the station buffers. The components have fixed buffer placements and that the components are demanded regularly.

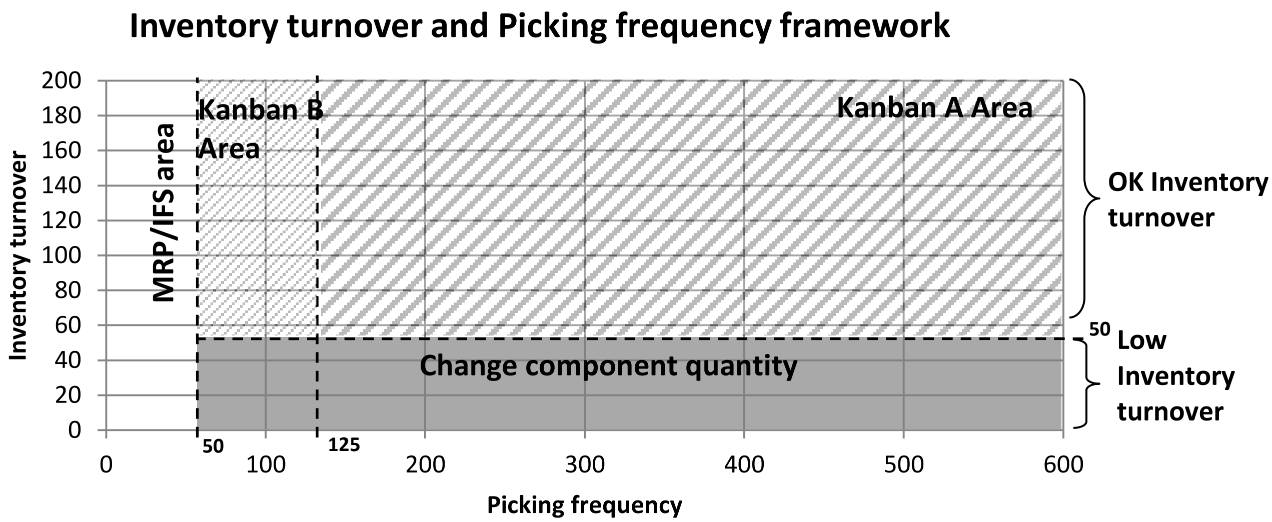


Figure 59 – Inventory turnover and Picking frequency framework

7.5.2 Location of articles

Good location of articles in an inventory is critical for a company to be efficient and competitive. There is not any general solution to find the optimal location of articles in an inventory. The location of articles can be based on picking frequency, according to 4.2.3.1 Volume based storage. Articles with a high picking frequency could be located close to the assembly process. The accumulated demand and share of articles should be plotted in a graph to check if location of articles according to picking frequency can be successful, see Figure 60.

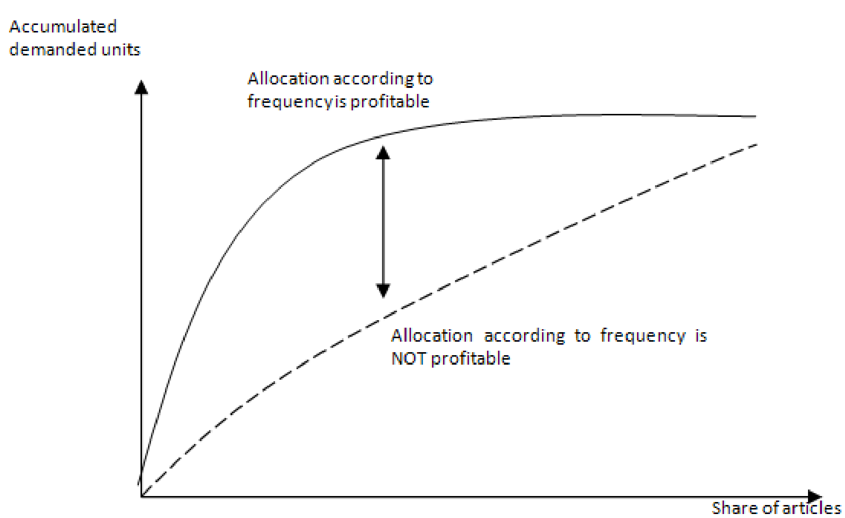


Figure 60 – Volume based storage test

7.5.3 Assembly station 189

7.5.3.1 *Inventory turnover at assembly station 189*

The inventory at assembly station 189 handles about 100 different components. These components inventory turnover in the buffer inventory and their picking frequency have been plotted in Figure 61, for identification of components with a low inventory turnover. As seen in Figure 61, 35 of the 100 components are identified as components with a low inventory turnover, see Appendix for a table of identified components. The identified components are those within the grey box in Figure 61.

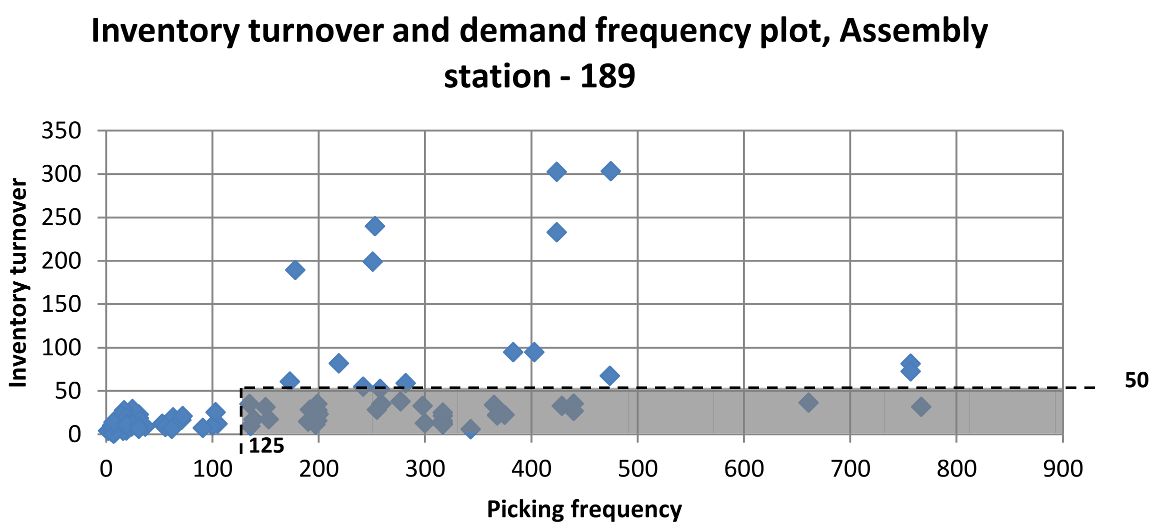


Figure 61 - Inventory turnover and demand frequency plot, Assembly station - 189

7.5.3.2 *Picking frequency at assembly station 189*

The authors have gathered data about the picking frequency for each component at station 189. The accumulated demand and share of articles for the stations is illustrated in Figure 62. The slope of the plot indicates that volume based storage is probably not suitable since the slope is quite flat and it misses a distinct bend. A high share of the components has a high demand at assembly station 189.

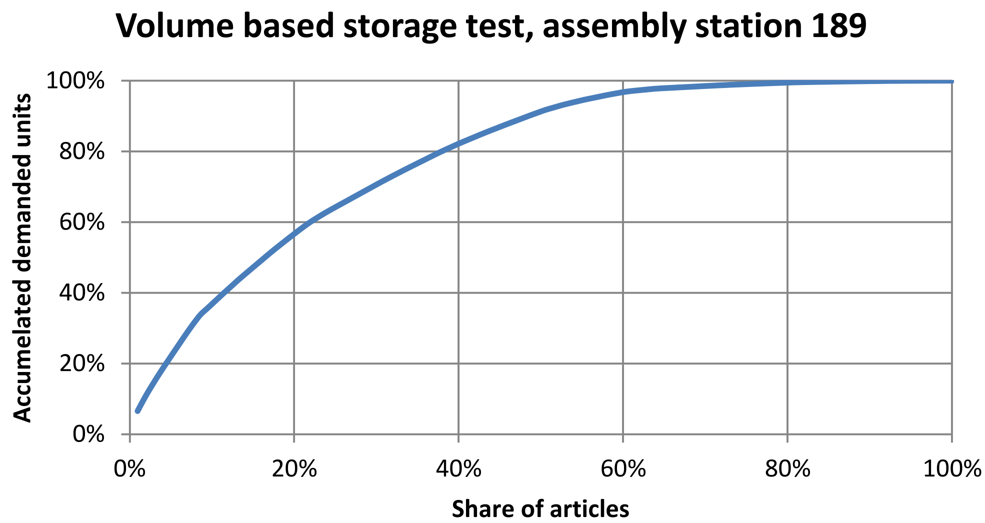


Figure 62 - Volume based storage test, assembly station 189

Figure 63 was created by using the picking frequency data and the map of assembly station 189. The data has been gathered from IFS. The dark colored components are picked once or more per day. The medium colored are the once picked once a week but less than once a day. Components picked at least once a month but less than once a week are white colored. The diagonal lined components, is the components picked less than once a month.

The figure shows that almost all dark colored components are located closest to the assembly station. What also can be seen is that components colored with white and with diagonal lines are located in the station inventory buffer although they are used less than once a week. Four of the most picked components are placed at height three and four. The forklift at the station can only reach to height two. This means that when the assembler needs the component stored at height three or four, he needs to call for someone in the internal logistics. This can be identified as the waste, *pointless working activity* and should be avoided according to the theory 4.3.2. If the internal logistics forklift driver is busy the assembler needs to wait for the forklift driver to bring the pallet down from the pallet rack. *Wait* should be eliminated according to the theory 4.3.2. A better location of these four pallets could reduce *pointless working activities* and *wait,* this could increase the assembly utilization rate.

At station 189 four of the pallet locations are mixed pallets. The mixed pallets contain small bins and cartons. Even if it is a small quantity it requires a whole pallet location. Thorn Lighting uses supermarkets were different components are stored in bins. These supermarkets have saved floor space at the station buffers. The supermarkets are located close to the assembly station and the assembler picks demanded quantity from the bins.

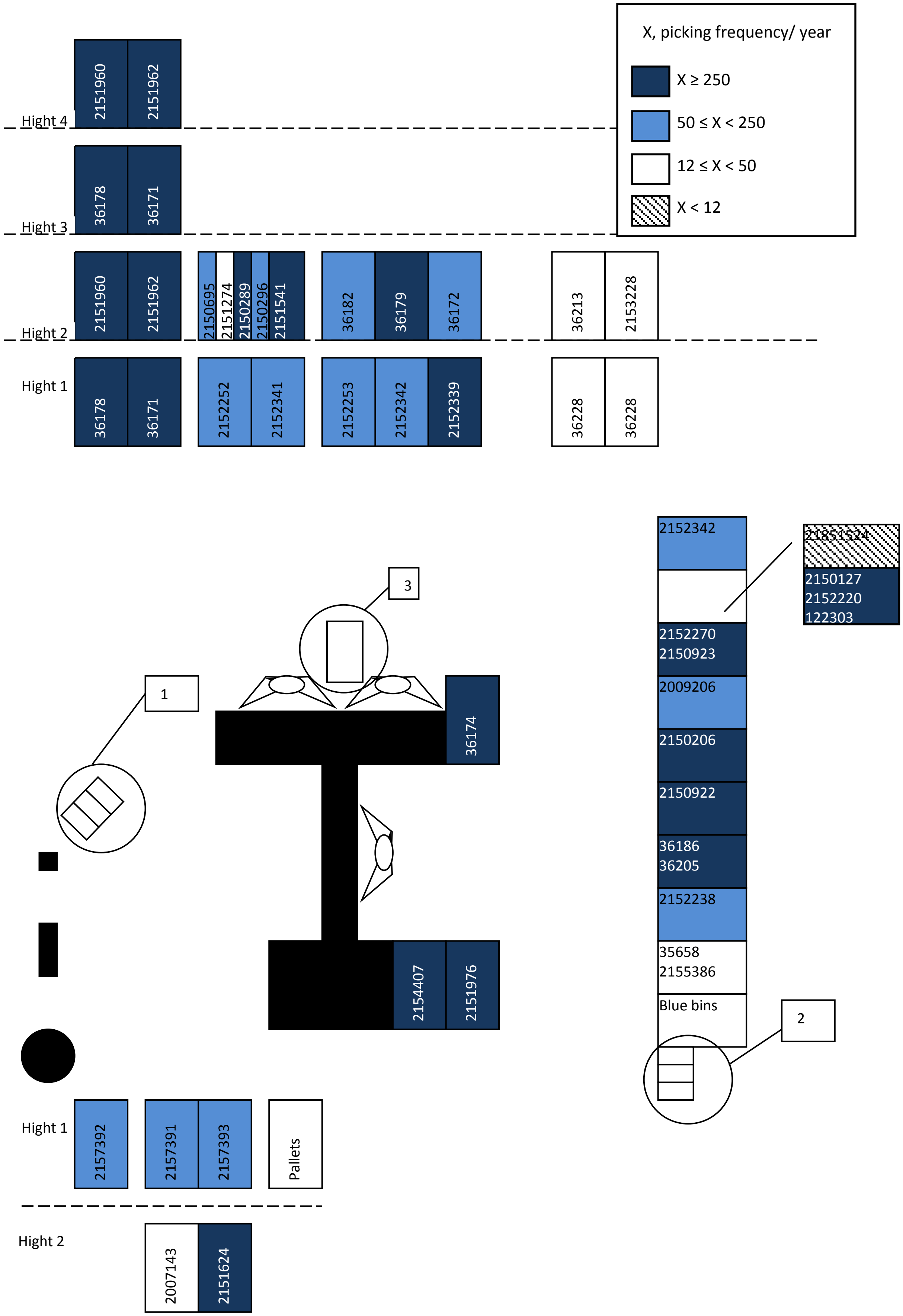


Figure 63- Picking frequency, Assembly station 189

Shelf 1:

2151099	2006889	2006888
2150701	2150702	2151099
2002307	2151521	
2002306	2151520	
2002305		

Shelf 2:

Many of the components in Shelf 2 are not picked very often. Component 36221 is picked less than once a month.

36229	36214	36221	36215

Shelf 3:

36205	2000237	45947	36174
45943	45942	45946	2000238

7.5.3.3 ***Kanban at assembly station 189***

In Figure 64 the components are colored by the classification of Kanban. The dark colored components are the Kanban-A components, gathered from Table 7. The medium colored components are the Kanban-B components, gathered from Appendix D. There are not any Kanban-C components in station 189. There is one component that is marked with a black cross, this component is handled a different way in IFS. Therefore is data about the components missing in the IFS-system and can therefore not be classified. The components in Table 8 are the ones that should not be ordered with Kanban. The components that are not ordered with Kanban do not need to be stored in the station buffer because they are only ordered when needed. These pallet locations are marked with diagonal lines. At assembly station 189, nine whole pallet locations could be saved. One of the mixed pallets includes a component that is not used in the assembly process any more, this space can be released when moving the component from the station buffer.

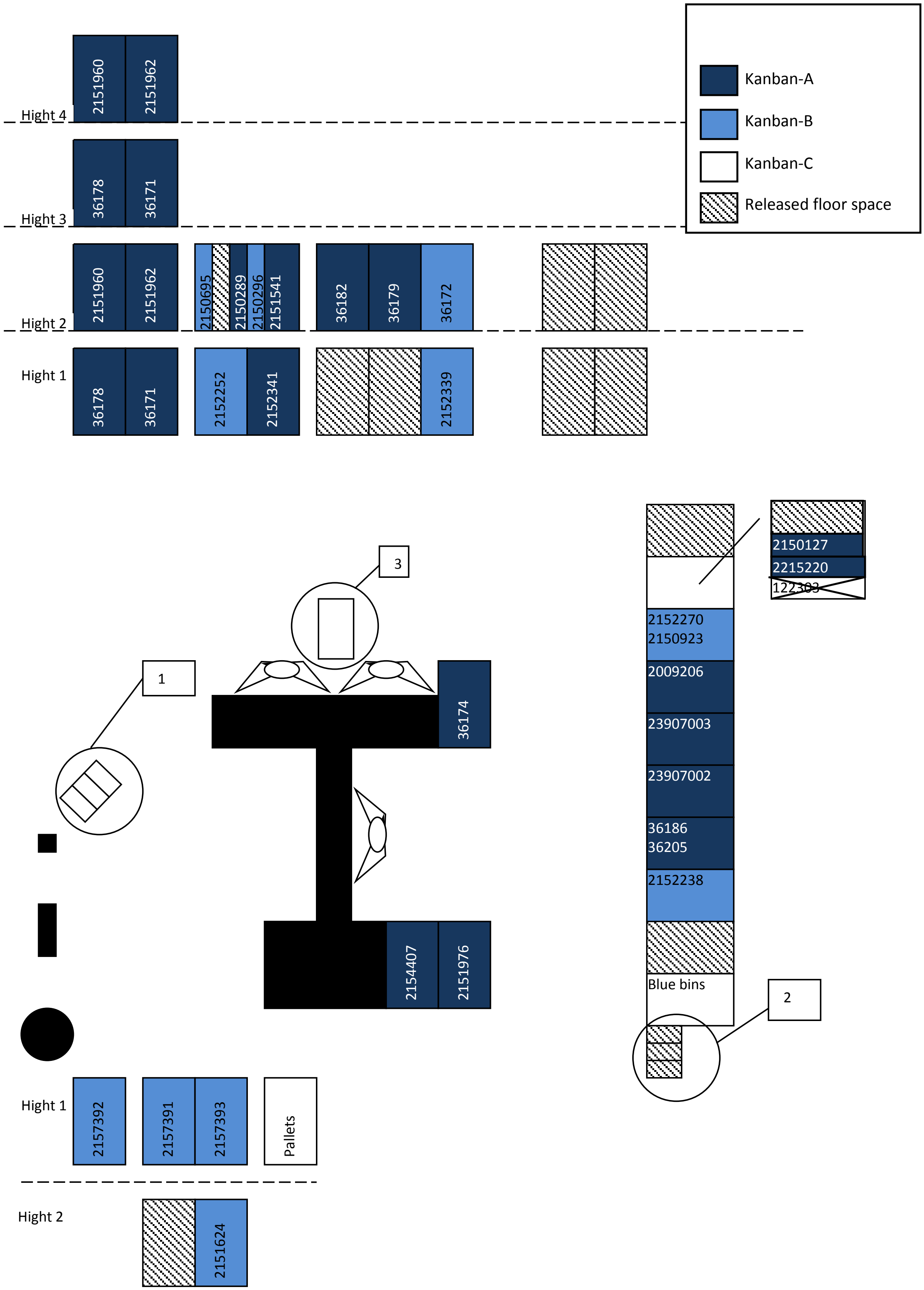


Figure 64 - Kanban, assembly station 189

Shelf 1:

Most of the components stored in Shelf 1 are classified as Kanban-A components, only three of the bins in the shelf are Kanban-B. The bins in the shelf are refilled from bigger bins that also are placed in the shelf. The shelf should not include two or more bins with the same components, instead it should only include one bin of each component. According to the theory in 4.3.2 is *Excess inventory* classified as waste.

2151099	2006889	2006888
2150701	2150702	2151099
2002307	2151521	
2002306	2151520	
2002305		

Shelf 2:

After introducing Kanban at station 189 should it be possible to use all the space this shelf is occupying.

Shelf 3:

All components in shelf 3 are suitable for Kanban-A. In Shelf 3 it is possible to find components that also are stored in mixed pallets in Figure 64. *Excess inventory* is classified as waste.

36205	2000237	45947	36174
45943	45942	45946	2000238

7.5.4 Assembly station 166

7.5.4.1 *Inventory turnover at assembly station 166*

The buffer inventory at assembly station 166 handles about 90 different components. These components inventory turnover at the assembly station and their yearly picking frequency have been plotted in Figure 65, for identification of components with a low inventory turnover. As seen in Figure 65, 37 of the 90 components are identified as components with a low inventory turnover, see Appendix J for a table of identified components. The identified components are those within the grey box, see Figure 65.

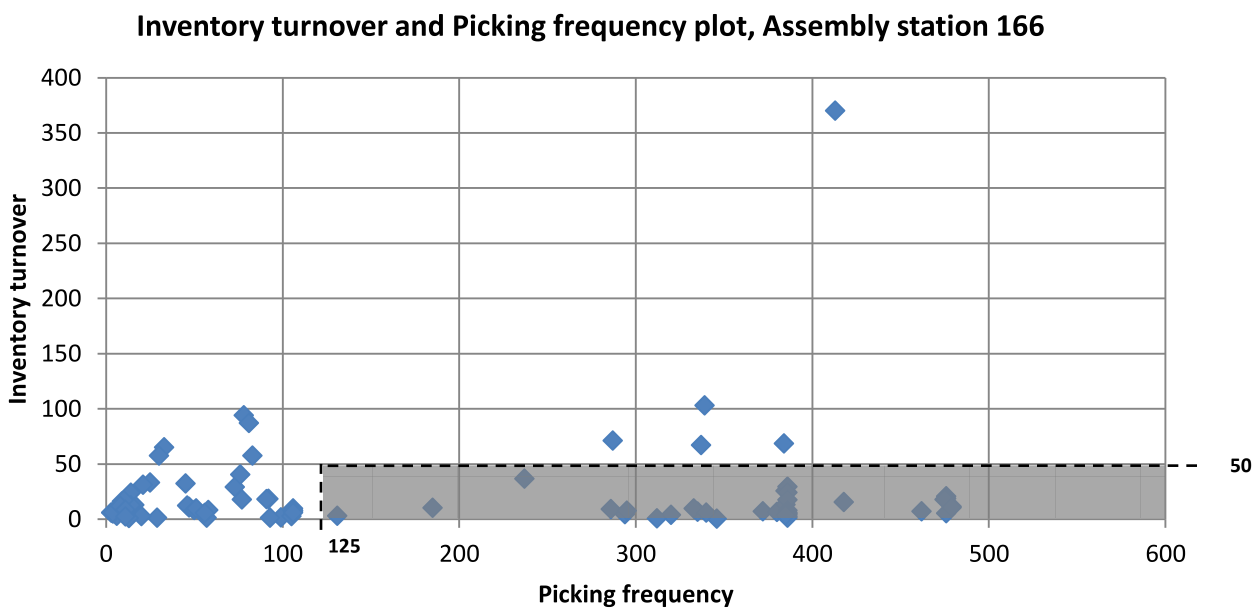


Figure 65 - Inventory turnover and Picking frequency plot, Assembly station - 166

7.5.4.2 *Picking frequency at assembly station 166*

The accumulated demand and share of articles for the stations is illustrated in Figure 66. The slope is not an obvious case for volume based storage, the plot indicates that volume based storage could be suitable since the slope is not flat. Still tough, the slope is missing a distinct bend. Station 166 will probably be more suitable for volume based storage than assembly station 189.

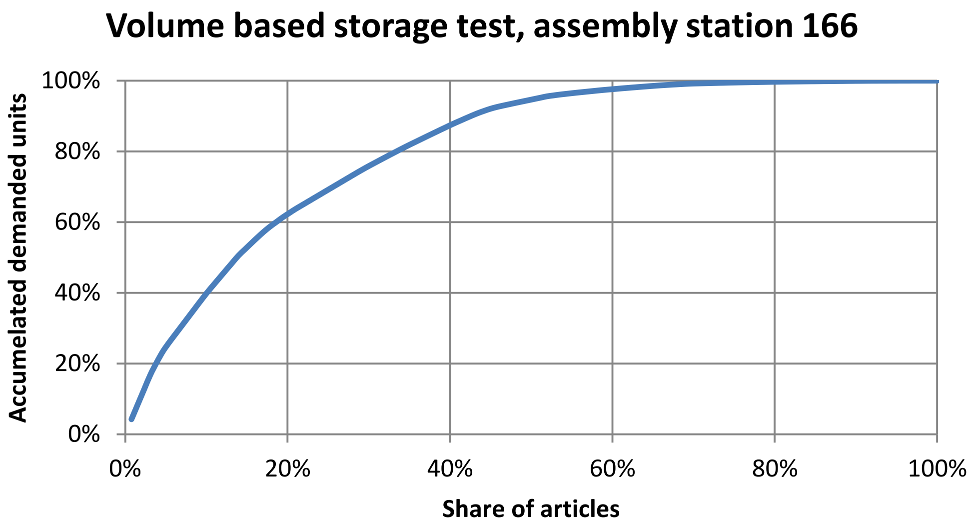


Figure 66 – Volume based storage test, assembly station 166

Figure 67 was created by using the picking frequency data and the map of station 166. The dark colored components are picked once or more per day. The medium colored are the once picked once a week but less than once a day. Components picked at least once a month but less than once a week are white colored. The diagonal lined components, is the components picked less than once a month.

Several pallet locations are marked with the darker color, which means that they have a high picking frequency. Only one pallet location is marked with diagonal lines which means picked less than once a month. Station 166 uses two shelves that can be compared to the supermarket at Thorn Lighting. Floor space at the station is saved due to the storing of components in shelves. The bins stored in the two shelves are replenished by the assembler from the pallet locations in the station buffer.

Station 166 has several mixed pallets. In area 3 many cartons are placed on the two pallet locations. Four components, marked with diagonal lines, stored at this location are picked less than once a month.

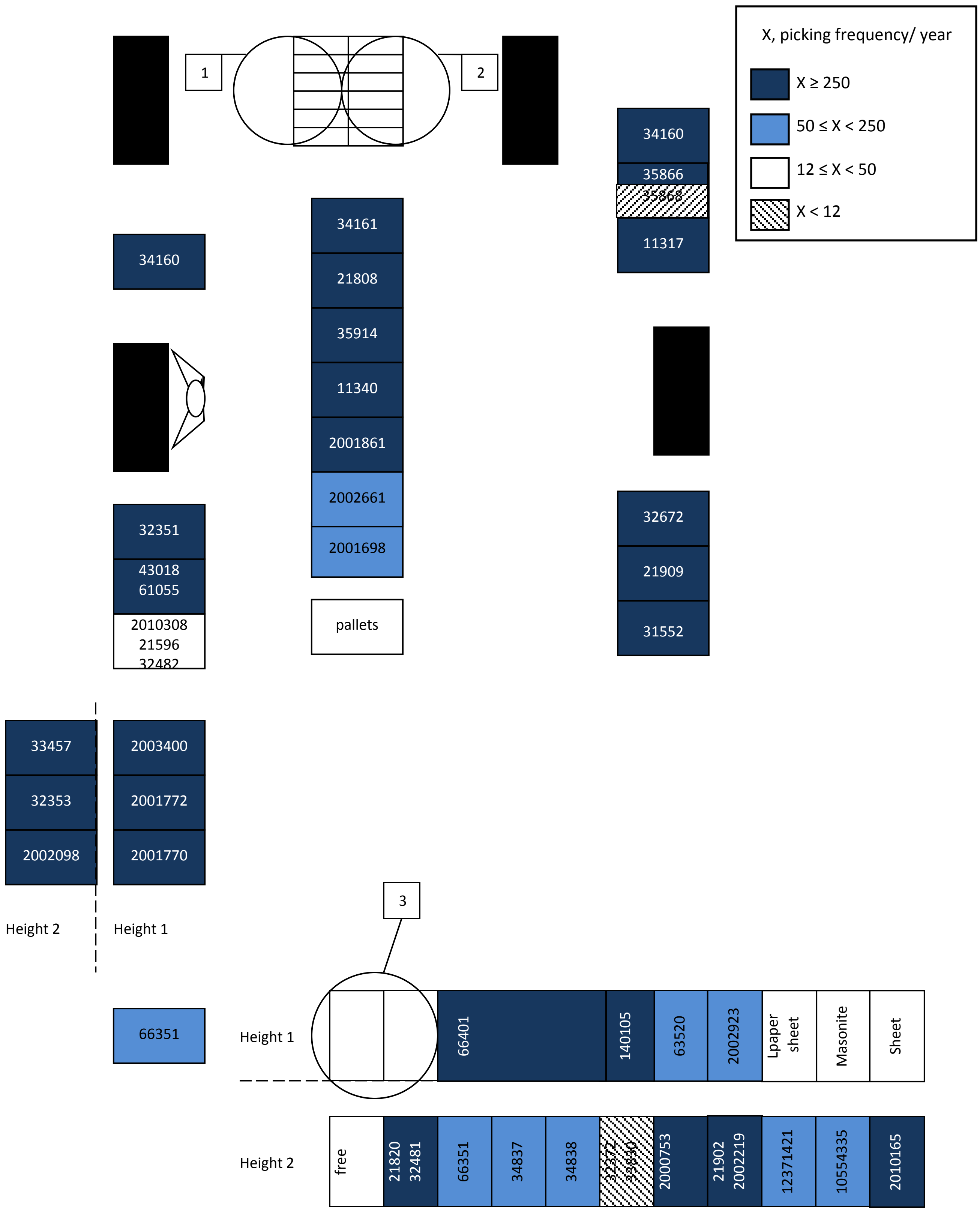


Figure 67- Picking frequency, assembly station 166

Shelf 1:

2002219	32481	46545	46526	21823	2002684
46580	2010165	2010189	2002098	2001772	2001770
63455	2005021	63407	21902	2005022	32353
	2001990	2001991	32482		

Shelf 2:

2002098	21823	46526	46545	62388	2002219
2010189	2010165	46580	21902	32481	2005021
2001770	2001772		63407		32353
2001991	32482			2153746	2153745

Area 3: The two pallets stored on the floor have the following picking frequency:

2003320	46580

Over the two previous components two pallets locations with the half height of a standard pallet are storing the components with the following picking frequency:

32481	14502237	2155271	35863	35865	32318	63282	2000497	10551235

7.5.4.3 *Kanban at assembly station 166*

In Figure 68 the components are colored by the classification of Kanban. The dark colored components are the Kanban-A components, gathered from Table 9. The medium colored components are the Kanban-B components, gathered from Appendix E. The white colored components are the Kanban-C components, gathered from Appendix F. There are components marked with a black cross, these components are handled a different way in IFS. Therefore is data about these components missing in the IFS-system and can therefore not be classified. The components in Table 10 are the ones that should not be ordered with Kanban. Some of the components in Figure 68 are marked with diagonal lines. This means that Kanban is not really suitable for these components. Even if some components in Figure 67 are dark colored, i.e. have a high picking frequency, they are not suitable for Kanban, for example component 32672 and 21909. The reason for this is that they have a variability factor 1,2, see Table 10, which is not suitable for Kanban. The components that should not be ordered with Kanban do not have to be stored in the station buffer; six pallet locations would be released.

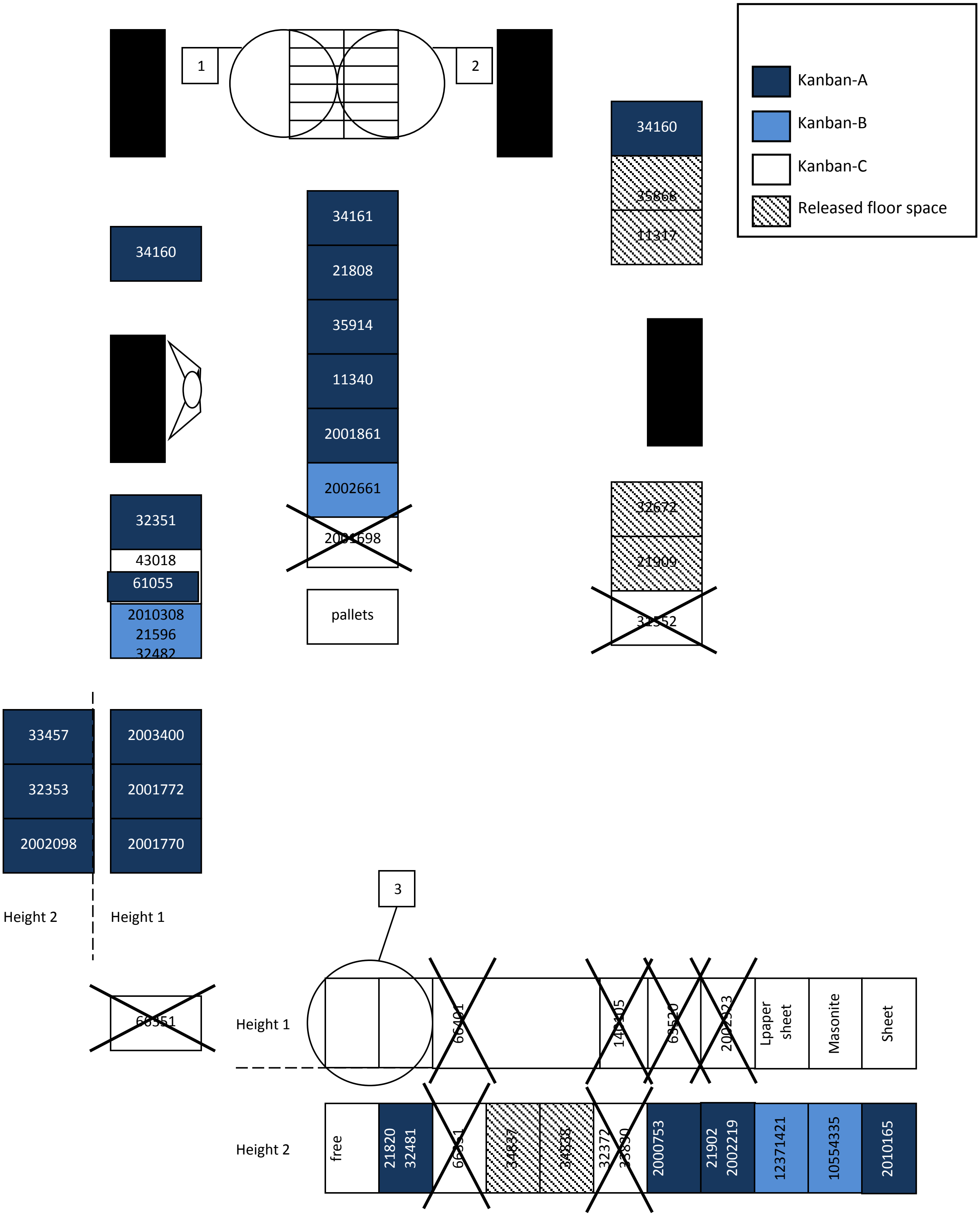


Figure 68- Kanban, assembly station 166

Shelf 1

2002219	32481	~~46545~~	46526	21823	2002684
46580	2010165	2010189	2002098	2001772	2001770
63455	2005021	63407	21902	2005022	32353
	2001990	2001991	32482		

Shelf 2

2002098	21823	46526	~~46545~~	~~62388~~	2002219
2010189	2010165	46580	21902	32481	2005021
2001770	2001772		63407		32353
2001991	32482			2153746	2153745

Area 3: Here are two pallets stored at the floor with the half high of a normal pallet with the following components:

2003320	46580

The following components are stored on the upper half:

32481	14502237	2155271	35863	35865	32318	63282	~~2000497~~	10551235

All components in shelf 1 and 2 are stored in bins and most of them are stored in both of the shelves. Since the components are stored in bins and occupying two bin locations, a two-bin Kanban might be suitable for these components. The components 32481 and 46580 are stored in both shelves as well as in area three. According to the theory 4.3.2, *Excess inventory* is classified as waste. There is also a higher risk for wasting time since the assembler needs to look for the components when it is stored at several places at the station. There are several components stored in area 3 that should not be ordered by Kanban. These components are not necessary to store in the station buffer.

7.5.5 Assembly station 152

7.5.5.1 *Inventory turnover at assembly station 152*

The inventory at assembly station 152 handles about 50 different components. These components inventory turnover at the assembly station and their yearly picking frequency have been plotted in Figure 69, for identification of components with a low inventory turnover. As seen in Figure 69, 9 of the 50 components are identified as components with a low inventory turnover, see Appendix K of identified components. The identified components are those within the grey box, see Figure 69.

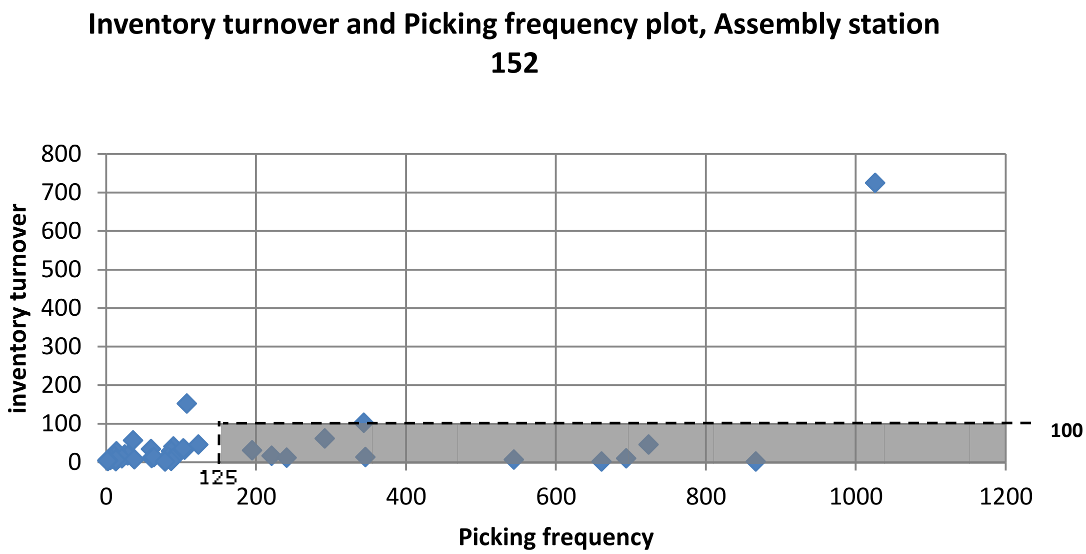


Figure 69 - Inventory turnover and Picking frequency plot, Assembly station - 152

7.5.5.2 *Picking frequency a assembly station 152*

The accumulated demand and share of articles for the assembly stations is illustrated in Figure 70. The slope of the plot indicates that volume based storage is suitable since the slope is not flat and it has a distinct bend. 20% of the components have more than 80% of the accumulated demand.

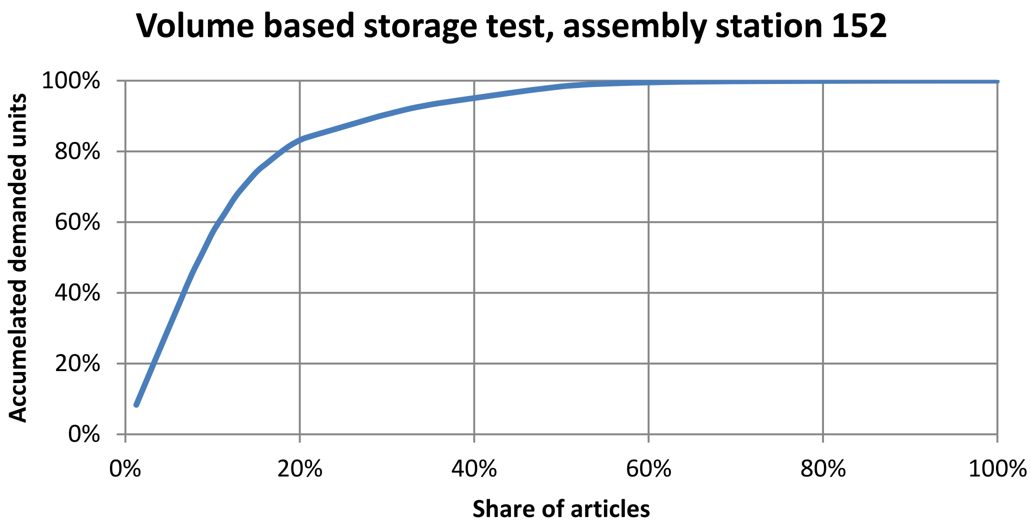


Figure 70 – Volume based storage test, assembly station 152

Figure 71 was created by using the picking frequency data and the map of station 152. The dark colored components are picked once or more per day. The medium colored are the once picked once a week but less than once a day. Components picked at least once a month but less than once a week are white colored. The diagonal lined components are the components picked less than once a month.

The station buffer has 57 pallets locations. Due to the high number of pallet locations in the station, four pallet locations are empty. Several of the pallet locations are in the pallet rack. Picking from this pallet rack cannot be done from the inside of the station, only from the outside, in the forklift passage. As seen in Figure 71, four pallets locations are marked with a dark color, which mean that these components are picked at least once a day. Two pallets are placed in the middle of the station. These two pallets are marked with white since these components are picked less than once a week. According to the theory 4.2.3.1 should components with a high picking frequency be located close to the assembly process, the opposite for components with a low picking frequency. The components marked with a black cross are components handled differently in the ordering process. Data for these components could therefore not be gathered from IFS.

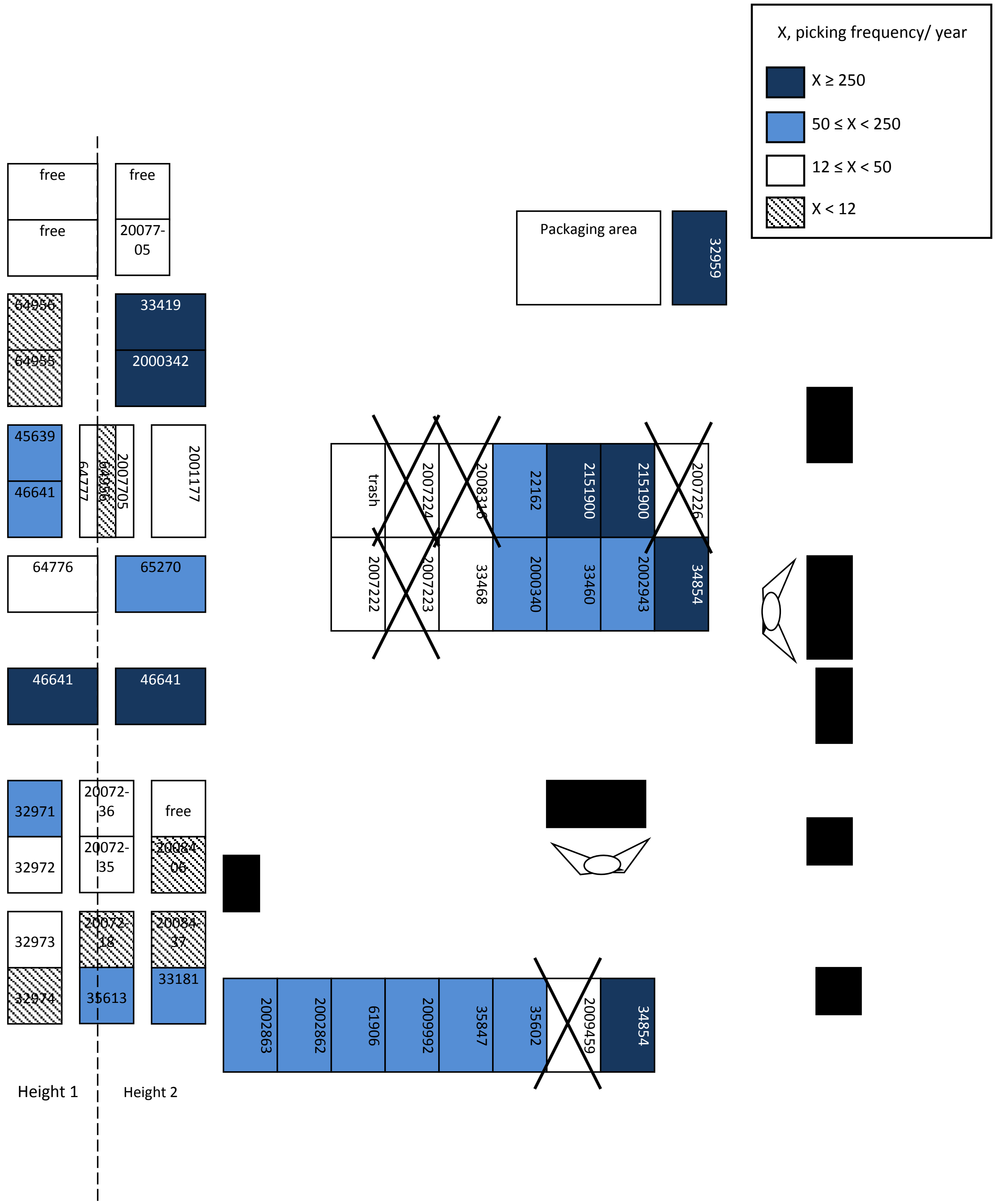


Figure 71- Picking frequency, assembly station 152

7.5.5.3 ***Kanban at assembly station 152***

In Figure 72 the components are colored by the classification of Kanban. The dark colored components are the Kanban-A components, gathered from Table 11. The medium colored components are the Kanban-B components, gathered from Appendix G. The white colored components are the Kanban-C components, gathered from Appendix H. There are components marked with a black cross, these components are handled a different way in IFS. Therefore is data about these components missing in the IFS-system and can therefore not be classified. The components in Table 12 are the ones that should not be ordered with Kanban. Some of the components in Figure 72 are marked with diagonal lines. This means that Kanban is not really suitable for these components. By moving these components to the warehouse instead of storing them in the station buffer 14 pallet locations would be released. Eleven of these pallet locations have a half height of a standard pallet and the remaining three locations have a standard height of a pallet.

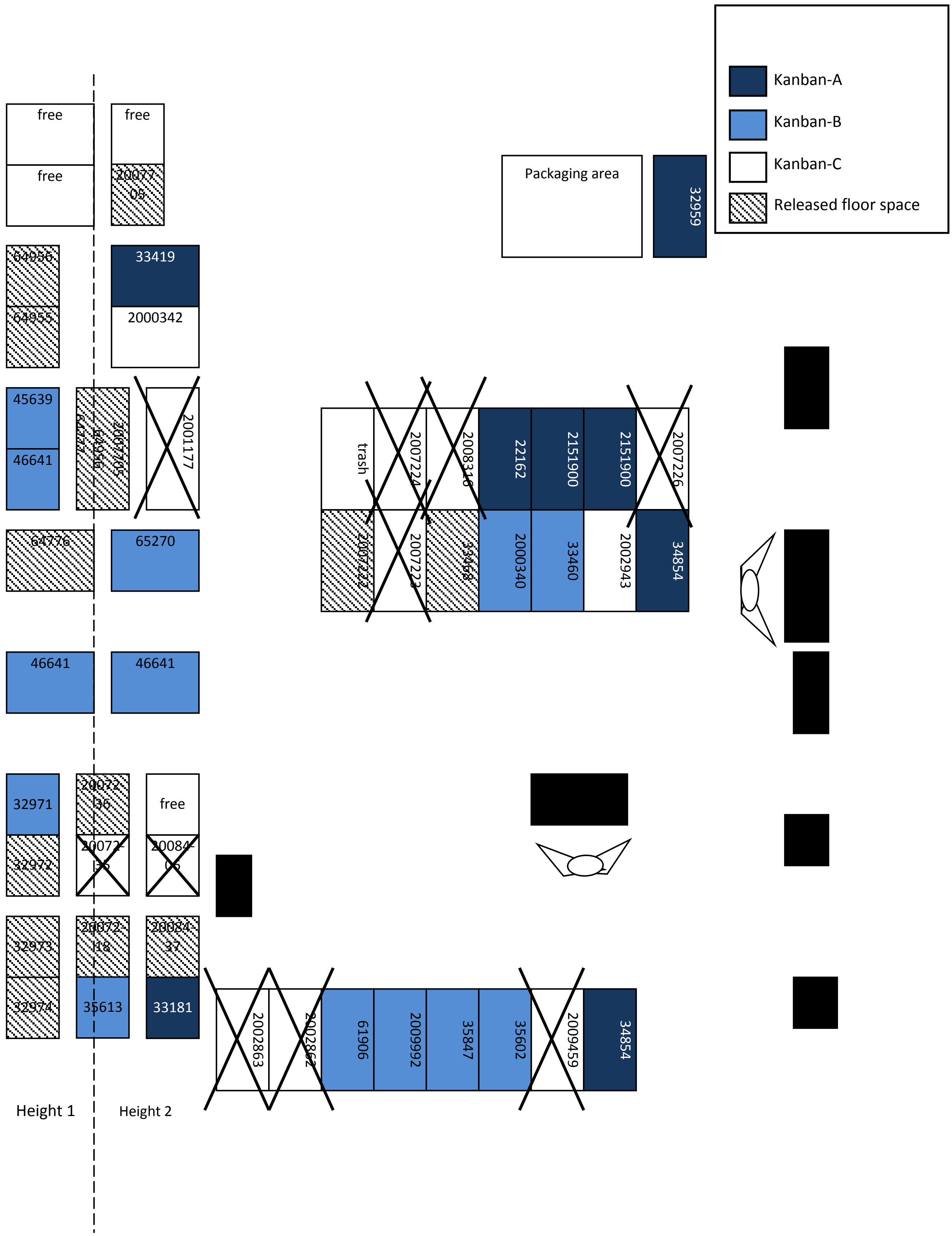


Figure 72- Kanban, assembly station 152

7.5.6 Reduction of the station buffer

By implementing Kanban A-C the number of pallet locations could be reduced up to 25 %. The number of released pallet locations at the detailed assembly stations due to Kanban A-C is summarized into Table 14;

	Assembly station		
	189	**166**	**152**
Pallet locations:			
Before	39	47	57
After	30	41	43
Reduction	9	6	14
Reduction (%)	23%	13%	25%

Table 14 – Reduction of pallet locations due to Kanban A-C

By replacing the mixed pallets with supermarkets the floor space could be decreased. The number of released pallet locations due to supermarkets can be summarized into Table 15;

	Assembly station		
	189	**166**	**152**
Number of mixed pallets	4	6	0
Required number of supermarkets	1	2	0
Reduction of pallet locations	3	4	0

Table 15 - Reduction of pallet locations due to Supermarkets

7.6 The priority matrix for Nederman

To be able to prioritize possible solutions, the solutions have to be placed into a context. According to Bjørnland et. al.(2003) the possible solutions could be compared against each other by plotting them into a framework that considers the complexity factor and the economical potential. The possible solutions with a low complexity and a high economical potential should be implemented first. The analyzed possibilities are briefly explained below;

Introduce segmented Kanban/MRP approach - The components identified as potential Kanban in the variability and picking frequency framework could be stored at the assembly station and non Kanban components could be ordered by the MRP function in IFS. A Kanban solution would reduce the buffer inventory and increase the assembly utilization rate.

Station inventory map – A map could be placed next to the stations so that the internal logistics forklift drivers more easily can see where to place the component in the station buffer. With these changes the assemblers do not need to interrupt the assembly process and the assembly utilization rate would increase.

Reduce components order quantity – By reducing the accepted limit of inventory turnover, the buffer inventory will be reduced and floor space will be released. The inventory turnover and picking frequency plot provides a framework that identifies components with a low inventory turnover.

Conveyer with a sensor - A conveyor will eliminate the problem with picking the first pallet placed at the ramp, but also the problem that the forklift drivers have to wait for each other. With a conveyer they do not have to cross each other's paths. A simple sensor with a light indicator could be installed at the conveyor. The light sensor will easily notify the internal logistics when a pallet is placed at the conveyor which will eliminate the circulating time for the internal logistics team.

Quality circles - The creativity and knowledge from the assembly personnel is invaluable. Even if this study provides a framework of how to identify potential Kanban components, the personnel have the experience and *tacit knowledge* that can explain and solve single component problems. The quality circles are a perfect way to facilitate projects such as a Kanban implementation.

Supermarkets - Standardized bins can be stored in supermarkets and since all bins have the same size the supermarket could be fully utilized. When replenish components from the Warehouse in bins, it is possible to deliver bins to several assembly stations in each route. Replenishing several stations in the same route will decrease the total transportation distance. Storing the bins in the supermarkets will decrease the searching time since the assembler will know where in the station the bins are stored.

Usage of Warehouse V - Storing high frequency components in Warehouse V will result in a reduction of total traveled distance by the forklift drivers. With less distances traveled, the occupied time will be reduced.

Location of components in the station buffer – By performing a volume based storage test, assembly stations can be identified for an optimization of the buffer inventory. Less distance to highly demanded components would increase the assembly utilization rate.

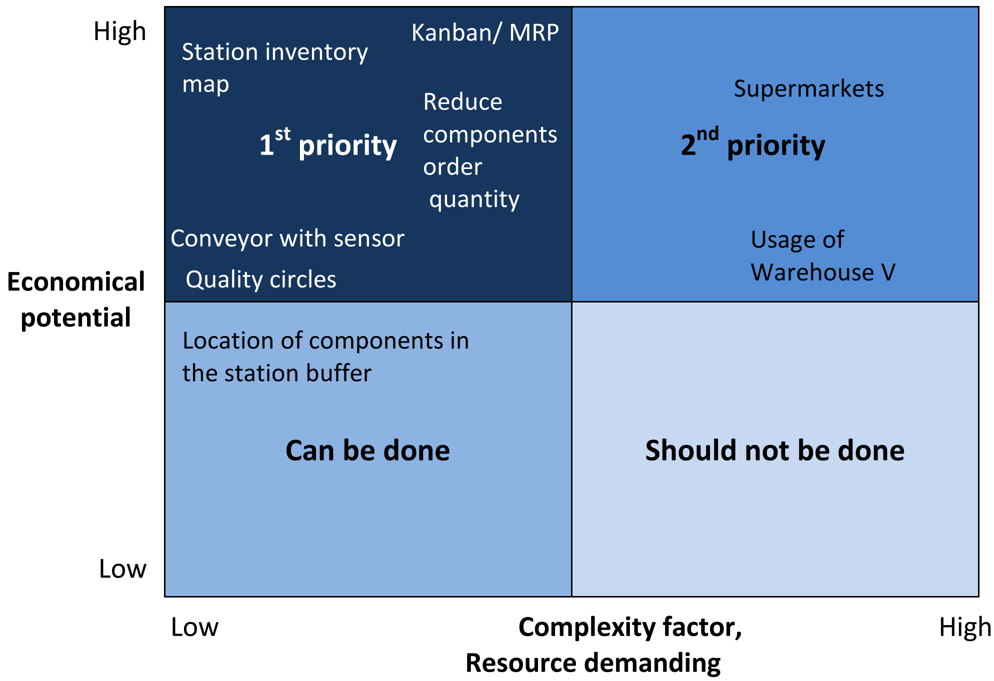


Figure 73 - The priority matrix for Nederman

The priority matrix was created in connection with the workshops at Nederman. The workshops were a way to validate the solutions complexity factor and economical potential. The final result is illustrated in

Figure **73**. The final priority matrix was discussed and validated at the last presentation at Nederman.

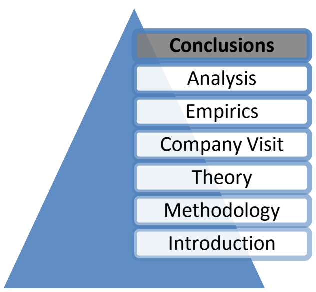
The authors find Kanban as the solution with the highest economical potential since Kanban will increase the assembling time, stabilizes the load of work and reduce floor space. The problem with Kanban is that it is difficult to implement and it increase the material handling. The implementation has to be done step by step to make it successful. Another aspect to consider being able to make Kanban successful is to start with quality circles at Nederman. Quality circles facilitate the implementation of Kanban without any investments.

An investment in a conveyor and a light sensor is small and not complex to implement, but still it improves the material supply by reducing the waste of time in the material supply. By placing a map at each assembly station the buffer placement time can be eliminated without complex solutions. The station buffer inventory can be decreased by changing the order quantity. It can be achieved by either changing supplier agreement or by changing the quantity in the station order quantity. The solution is quite difficult to implement when new contracts has to be negotiated.

Supermarkets have a high economical potential due to the reduction of floor space. The problem with supermarkets is that they demand standardized size of bins. To be able to carry out a standardization of bins, all purchased components have to be delivered in bins otherwise the material handling will increase when the warehouse personnel have to change load carrier. Optimized usage of Warehouse V can reduce the transportation distance of components. The problem is that the configuration in IFS has to be changed every time the demand changes. The configuration has to be done by a programmer at IFS, which makes the changes complex.

The location of components in the assembly station buffer can increase the utilization rate at the assembly station if a small share of the components has a high share of the demand. The study shows that only one of three stations is suited for volume based storage. The changes of the pallet locations is not complex, it can easily be done by the assemblers at each station.

8 CONCLUSIONS



This chapter will present the authors' conclusions. The chapter will also provide a priority of the suggested improvements. It ends with a discussion of future studies.

8.1 Introduction

Nederman in Helsingborg face some challenges to their future expansion. To be able to expand, space for new assembly stations is needed. One challenge is to find ways where the material supply can reduce the inventory and release floor space. A current problem at Nederman is the high amount of time used for non assembling activities, such as material ordering, material supply or search for components. The assembly utilization rate has to be increased. Another problem is the lack of method of how to determine if components should be stored at the assembly station or at the warehouse. Today no standardized procedures exist for the material supply. The purpose of this study is hence:

To improve the material supply to assembly stations at Nedermans and identify parameters and principles that determine if the components should be stored at the assembly station or in the warehouse. The improvement should reduce the floor space used for assembly and reduce waste of time in the material handling.

To be able to fulfill the purpose of the study, the identified problems in the problem discussion have to be solved. The conclusion will fulfill the purpose of the study by answering following questions;

- How can the waste of time be reduced in the material supply?
- How can the utilization rate at the assembly stations be increased?
- What ways exist to release floor space at the assembly stations?
- Which parameters determine where a component should be stored?
- How can suggested solutions be financially prioritized?

In Chapter 7.6 eight suggested solutions for Nederman are presented. The eight solutions are combined with the four early presented principles, see Chapter 7.1. From discussion in chapter 7 the author where able to plot which solution that affects which principle, see Figure 74 .

Principles / Tools	Kanban/MRP	Station inventory map	Reduce components order quantity	Conveyor with sensor	Quality circles	Supermarkets	Usage of Warehoue V	Location of articles in the station buffer
Simplify structures, systems and processes	●	●		●	●			
Reduce waste of time in material supply				●			●	
Reduce waste of time in assembly processes	●	●				●		●
Optimize buffer inventory	●		●			●		

Figure 74 – The principle and tool framework for suggested solutions

In Chapter 7.6, The priority matrix for Nederman was introduced. This subchapter summarizes the eight solutions the authors propose to Nederman. The solutions are classified by their complexity factor and economical potential, see Figure 75.

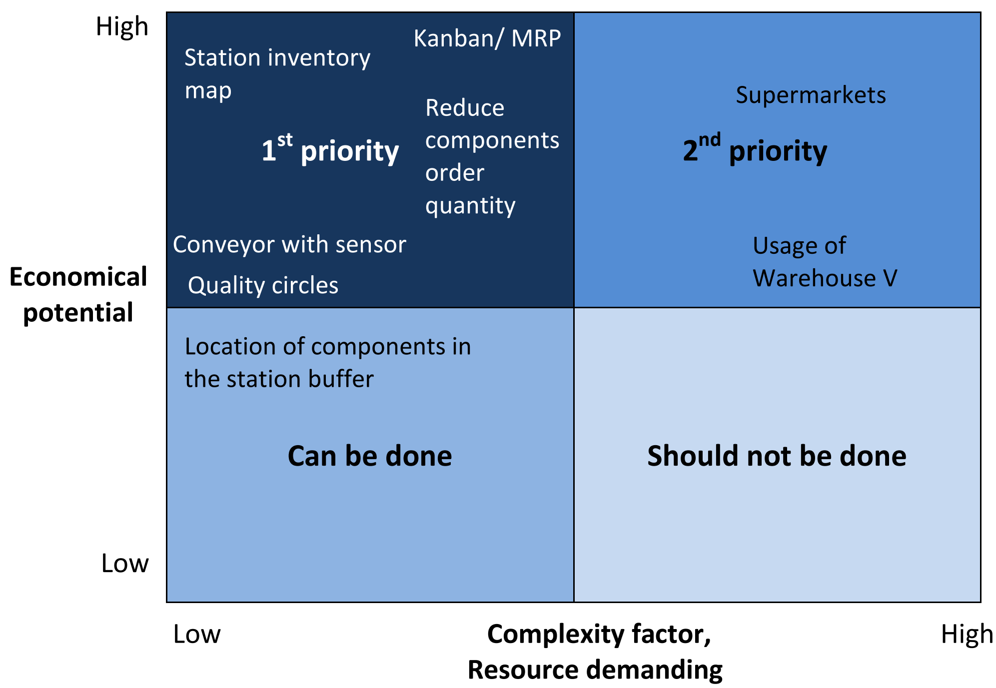


Figure 75 – The priority matrix for suggested solutions at Nederman

The following subchapters in the Conclusions will present the solutions according to the priority matrix. The solutions classified as 1st priority are the first to be presented. The 1st classified solutions will be followed by the 2nd priority solutions. Finally will the solution classified as a *Can be done* solution be presented. The eight solutions are;

- Introduce segmented Kanban/MRP approach
- Station inventory map
- Reduce components order quantity
- Conveyor with sensor
- Quality circles
- Supermarkets
- Usage of Warehouse V
- Location of components in the station buffer

8.2 Introduce segmented Kanban/MRP approach

The components identified as potential Kanban should be stored at the assembly station. Non Kanban components should be ordered by the MRP function in IFS and just be ordered in demanded quantities.

As a result, non Kanban components should not be stored at the assembly station. The variability and picking frequency framework should be used to determine where a component should be stored. Components in the Kanban area should be stored in the station buffer. Components in the MRP/IFS area should be stored in the Warehouse and only be ordered when needed, see Figure 76. The parameters that determine where a component should be store is the variability factor of demand and the picking frequency of the component.

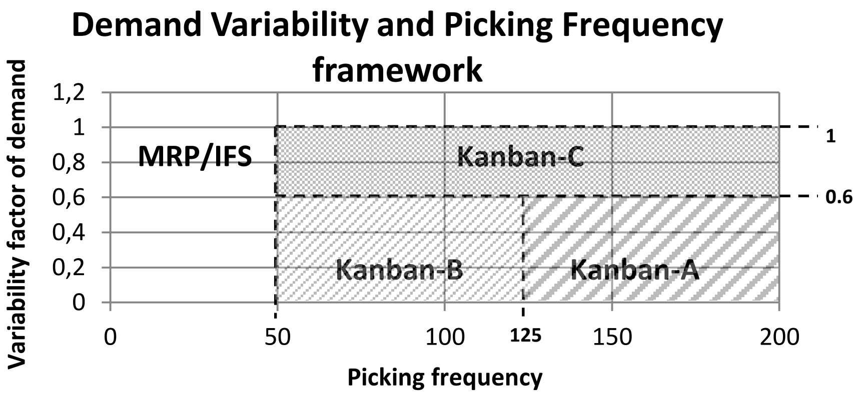


Figure 76 - Variability and Picking Frequency Framework

It is still important to see frameworks like the variability and frequency plot as a guideline in the searching of decision parameters for where a component should be stored. Size of the components and special treatment arrangements can be other factors that also have to be considered.

With Kanban cards and two-bin Kanban the writing on the pallets should be eliminated for the Kanban components. With this solution, the time waste on writing numbers on the pallet and the wrong deliveries can be eliminated.

To achieve a stabilized material supply, the component ordering process has to be spread out during the day. When implementing Kanban the ordering will not be done at a specific time during the day, instead it will be done continuously. This will reduce a significant amount of the irregularities due to the fact that most of the components can be ordered by Kanban.

Kanban will reduce the number of orders that are placed manually which will decrease the disturbances and increase the assembly utilization rate. By using a Kanban solution that is refilling material continuously and usage of the MRP function in IFS, the time spend in the component ordering process will decrease rapidly and the assembly utilization rate will increase. The authors believe that the visualization of new Kanban orders should be done by turning on a light. The price for a notification system would approximately cost 2500 SEK per assembly station.

By implementing Kanban A-C the time reduction in the assembly process would be 73 hours per year for assembly station 189, 166 and 152.[149] As a result of the time reduction, the utilization rate at the assembly station will increase.

[149] See Chapter 7.4.1 for description of Kanban- A, Kanban-B and Kanban-C

The study shows that implementing Kanban at the three studied assembling stations will release 29 pallet locations, see Table 16

	Assembly station		
	189	**166**	**152**
Pallet locations			
Before	39	47	57
After	30	41	43
Reduction	9	6	14
Reduction (%)	23%	13%	25%

Table 16 - Released pallet locations in the studied assembly stations

The authors propose that Nederman should start with the Kanban implementation at assembly station 189. One reason of starting the project in a small scale is to avoid big problems that create disturbances in the assembly process. Another important reason is to establish early success stories of the Kanban project. Due to the past Kanban experiences, an implementation of Kanban today cannot afford early failures. With a suitable assembly station chosen it is important to start with a component that perfectly matches the criteria for Kanban, e.g. Kanban-A components. Further on when the procedures of treating the Kanban components are established, an expansion of number of components at the chosen station can be made.[150]

8.3 Station inventory map

A way to facilitate the placement for the internal logistics could be to draw a map of the pallet locations. This map should be placed next to the stations so the internal logistics truck operator easily can see where to place the component. With these changes the assemblers do not need to interrupt the assembly process and the assembly utilization rate would increase.[151]

8.4 Reduce components order quantity

The authors believe that an inventory turnover higher than 50, which corresponds to a replacement of the inventory once a week, is an accepted inventory turnover. Components with an inventory turnover less than 50 should reduce the component quantity per load carrier. By reducing the accepted limit of inventory turnover, the buffer inventory has to be reduced and floor space will be released. Figure 77 illustrates this framework.

[150] See Chapter 7.4.5for a further discussion

[151] See Chapter 7.2.3 for a further discussion about station inventory map

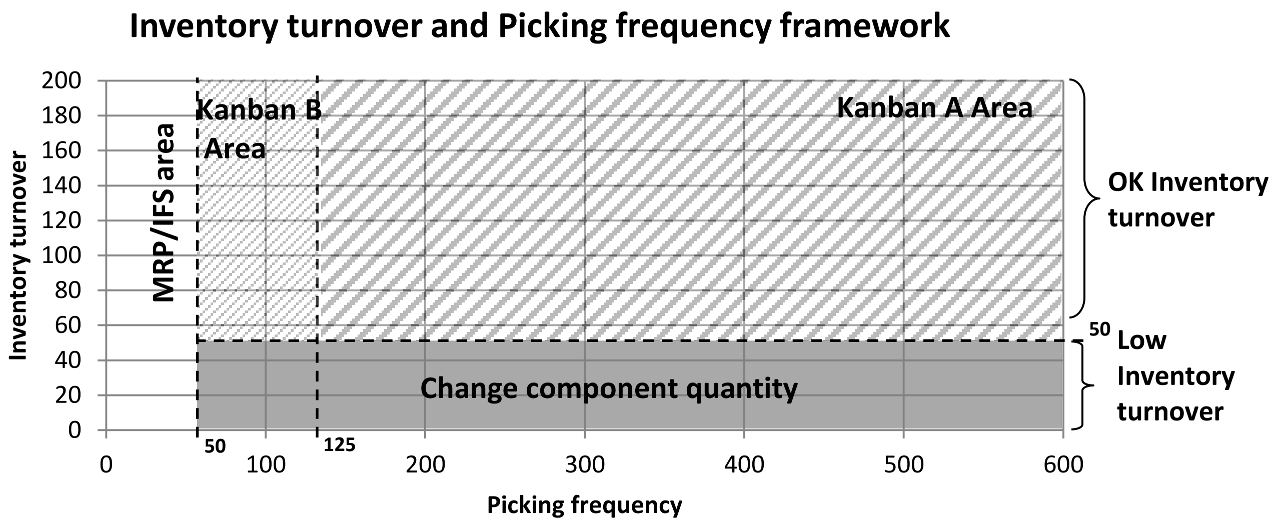


Figure 77- Inventory turnover and Picking frequency framework

If the components are delivered in high quantities from the suppliers, new supplier contracts with less quantity per delivery could be interesting. If the components are delivered in big quantities from the warehouse, bins are more suitable to use. [152]

8.5 Conveyor with sensor

Nederman should invest in a conveyor in warehouse A-L. A conveyor will eliminate the problem with picking the first pallet placed at the ramp, but also the problem that the forklift drivers have to wait for each other. With a conveyer they do not have to cross each other's paths.[153]

A simple sensor with a light indicator could be installed at the conveyor. The light sensor will easily notify the internal logistics when a pallet is placed at the conveyor. The unnecessary movements that occur when the internal logistics team continuously passes Warehouse A-L to find new transportation orders can be eliminated. The solution will save 133 hours per year.[154]

8.6 Quality circles

The authors believe that quality circles should be started coincident with the implementation of Kanban. The quality circles are a perfect way to start up a Kanban process with involvement of employees. The creativity and knowledge from the assembly personnel is invaluable. Even if this study provides a framework of how to identify potential Kanban components, the personnel have the experience and *tacit knowledge* that can explain and solve single component problems. There are also these quality circles that have to reevaluate the implementations and continuously improve them.[155]

[152] See Chapter 7.5.1 for a further discussion about ordering quantities
[153] See Chapter 7.3 for a further discussion about the conveyor
[154] See Chapter 7.3.1 for a further discussion about the light sensor
[155] See Chapter 7.2 for a further discussion

8.7 Supermarkets

The authors have by the study concluded that bins should be standardized at Nederman. When replenish components from the Warehouse in bins, it is possible to deliver bins to several assembly stations in each route. Replenishing several stations in the same route will decrease the total transportation distance, which will decrease the total transportation time as well. The bins have grips which makes them easier to carry compare to cartons. The bins can be stored in supermarkets[156] and since all bins have the same height the supermarkets space could be fully utilized. A supermarket can replace 4 mixed pallet.

The bin can be used as a Kanban card by using two-bin Kanban. When storing the bins in the supermarket, the time spending on searching for components will decrease since the assembler will know where in the station the bins are stored. When decreasing the time spend on searching for components the assembly utilization rate will increase. [157]

8.8 Usage of Warehouse V

Storing high frequency components in Warehouse V will result in increased number of transportation orders from Warehouse V but the lead time for each transportation order will be reduced. The allocation function that reserves pallet locations exists in IFS and should be used to decrease the waste of time in the material supply. By contacting the responsible for IFS this allocation can be done. The arriving components would after the change gradually be replaced and stored at a more optimal location. The internal logistics will therefore be less occupied.[158]

8.9 Location of components in the station buffer

The study shows that volume based storage can be suitable for station 152 but for the other two stations 189 and 166 will volume based storage will not be useful since a high share of the components have the same demand. [159]

To minimize the problem were assemblers at station 189 have to call for the internal logistics team to take down components at height 3 and 4 only the pallet locations at height 1 and 2 should be used in the station buffer.[160]

8.10 Parameters

There are a couple of parameters used in this study to determine where a component should be stored. As described earlier should Kanban components be stored at the assembly stations. Hence, the variability factor of demand and picking frequency are the decision parameters. Components with a high variability factor of demand and or a low picking frequency should be stored in the warehouse. The following parameters are therefore needed to determine if a component should be store in the station buffer or in the warehouse;

---

[156] See Chapter 5.3.1 for description of a supermarket

[157] See Chapter7.2.2 for a further discussion about supermarkets at Nederman

[158] See Chapter 7.3.2 for a further discussion about usage of Warehouse V

[159] See Chapter 7.5.3.2, 7.5.4.2 and 7.5.5.2 for the three stations

[160] See Chapter 7.5.3.2 for further explanation

- Picking frequency per component
- Variablilty factor of demand per component
    - Standard deviation of demand per component
    - Average demand per component

The authors did also develop a framework to determine if the components ordering quantity is too high. The framework is using the picking frequency and the inventory turnover. To be able to calculate the inventory turnover the component demand, safety stock and the average inventory parameters are needed. The assembly station buffers at Nederman do not have any safety stocks and is therefore not included. Average inventory at the station buffers could not be gathered from IFS and is therefore calculated as the half of the average delivery quantity. The following parameters are needed to determine if components are stored in a too high quantity at the assembly stations;

- Picking frequency per component (Identification of Kanban components)
- Inventory turnover per component
    - Component demand per station and year
    - Average delivery quantity per component

The authors also suggest a solution where high frequency components should be stored in Warehouse V. The decision is based on a transportation time comparison between the possible storage locations. To be able determine where to place high frequency components, following parameter is needed;

- Transportation times from the possible warehouses

8.11 Future studies

The authors have during the study identified areas that can be considered for further studies. The areas are divided into, Future studies at Nederman and Future academic studies.

8.11.1 Future studies at Nederman

Implementing Kanban is a project that has to be well established in the organization before it should be tried. This study draws conclusions that Kanban could fit for the assembly stations in the study. Probably would Kanban also be suitable for the other assembly stations at the site in Helsingborg. The developed variability and picking frequency framework could be used in a future study to identify potential Kanban components at the remaining assembly stations.

The authors have during the study also identified that the Warehouse A-L can be targeted for further studies. The warehouse is designed to handle whole pallets and is not suitable for picking components, which makes the material supply difficult to manage.

For an increased number of assembly stations at the site in Helsingborg, an arrangement of the layout is necessary to release floor space. The authors have concluded that the assembly stations can be rearranged for an optimized layout that minimizes the transportation distance. With high frequency stations located close to the warehouse it is possible to keep a low transportation time due to short transportation distance.

8.11.2 Future academic studies

The theory about Kanban is often focusing on what Kanban is and the affects of Kanban. The problem is that the theory forgets to give information about how to implement Kanban successfully. A future study about how companies implements Kanban solutions practically would therefore be of greatest interest.

The theory about Kanban did not provide any information about how to decide if a component is suitable for Kanban. The authors have therefore developed a framework to identify potential Kanban components. This framework is based on the studied theory, see Chapter 4. The authors have also developed a framework to determine if the components order quantity is too high. This framework is also based on the studied theory, see Chapter 4. The two developed frameworks have not been implemented and therefore not validated. A future academic study could analyze and validate the two developed frameworks.

REFERENCES

Literature

Abnor, I. & Bjerke, B., *Företagsekonomisk metodlära*, 2nd edition, Studentlitteratur, Lund, 1994.

Bergman, B. & Klefsjö, B., *Kvalitet från behov till användning,* 4th edition, Studentlitteratur, Lund, 2009.

Björklund, M. & Paulsson, U., *Seminarieboken – att skriva, presentera och opponera*, 1st edition, Studentlitteratur, Lund, 2003.

Chary, P. & Skjøtt-Larsen, T., *Managing the global supply chain,* 2nd edition*,* Copenhagen Business school press, Copenhagen, 2001.

Cimorelli S., *Kanban for the supply chain- fundamental practices and manufacturing management,* 1st edition, Productivity Press, New York, 2005

Holme, I. M. & B K Solvagn, *Forskningsmetodik Om kvalitativa och kvantitativa metoder*, 2nd edition, Studentlitteratur, Lund, 1997

Jonsson, P. & Matsson, S.A., *Logistik – Läran om effektiva materialflöden, 1st* edition, Studentlitteratur, Lund, 2005.

Liker, J., *The Toyota way- Lean för världsklass, 1st* edition*,* Liber*,* Malmö*,* 2009.

Lumsden, K., *Logistikens grunder,* 2nd edition, Studentlitteratur, Lund, 2006*.*

Norrman, A., Lecture Notes – Logistik i försörjningskedjor (MTT240), 2009.

Oskarsson, B., Aronsson, H. & Ekdahl, B., *Modern Logistik- för ökad lönsamhet,* 3rd edition, Liber*,* Malmö, 2006.

Persson G., Logistics Process Redesign: Some Useful Insights*, The International Journal of Logistics Management*, Volume 6 No 1, p.20-21, 1995, ELIN.

Bjørnland D., Persson G., Virum H., *Logistik för konkurrenskraft – Ett ledaransvar,* Upplaga 1, Liber, Malmö, 2003

Petersen, C.G., Aase, G.R. & Heiser, D.R., Improving order-picking performance through the implementation of class-based storage*, International Journal of Physical Distribution & Logistics Management*, Volume 34 No 7, p. 534-544, 2004, ELIN.

Petersen, II. & Charles, G., The impact of routing and storage policies on warehouse efficiency, *International Journal of Operations & Production Management*, Volume 19 No 10, p.1053-1064, 1999, ELIN.

Schonberger, R.J., *Japansk kvalitet och produktivitet,* Upplaga 1, Bröderna Ekstrands Tryckeri AB, Lund, 1983.

Shingo, S., *Den nya japanska produktions filosofin,* Upplaga 1, Svenska managementgruppen, Åre, 1989.

Storhagen, N., *Logistik - Grunder och möjligheter,* 3rd edition, Liber, Malmö, 2003.

Ståhl, J-E., *Industriella tillverkningssystem – länken mellan teknik och ekonomi, 1st* edition*,* Lunds tekniska högskola, Lund, 2008.

Vogt, J.J, Pienaar, W.J & de Wit, P.W.C., *Business Logistics Managemen: Theory and practice,* 2nd edition, Oxford University Press, Cape Town, 2002.

Wallén, G., *Vetenskapsteori och forskningsmetodik*, 2nd edition, Studentlitteratur, Lund, 1996.

Electronic sources

Expressel, <www.expressel.se>, January 2011

Gemba Panta Rei, <www.gembapantarei.com>, October 2010

Helge Nyberg AB, <www.helge-nyberg.com>, November 2010

JMAC Scandinavia, http://www.imit.se/presentations/pres_96.pdf, October 2010.

Nederman, http://www.nederman.com/Financial/Financial/~/media/Nederman_Group/Financial/Nederman_Annual_report_2009%20pdf.ashx, December 2010.

Nederman, http://www.nederman.com/Nederman%20Group/Related_documents/Nederman_company_presentation_2010.aspx, December 2010.

Svenskt Näringsliv, <www.svensktnaringsliv.se>, November 2010.
ItSMF Sweden,< www.itsmf.se>,
BusinessDictionary.com, search word: *best practice*, retrieved 2010-10-15,< www.businessdictionary.com >
Small business information, retrieved 2010-10-15, <www.sbinformation.about.com>

Oral sources

Blix, Erik, *Site manager, Supply Unit,* AB Ph. Nederman Co, Helsingborg, Interview Fall 2010

Breuer, Markus, Consultant, Kiendl LeanConsult, Landskrona, Company visit 2010-11-02

Cederlund, Anna, *Production manager, Production,* AB Ph. Nederman Co, Helsingborg, Interview Fall 2010

Eliasson, Carl, *Forkliftdriver, Warhouse A-L,* AB Ph. Nederman Co, Helsingborg, Interview 2010-12-07.

Johansson, Conny, *Assembler at station 166, Assembling,* AB Ph. Nederman Co, Helsingborg, Interview 2010-12-03.

Johansson, Dick, *Industrial Engineering technician, PPQA,* AB Ph. Nederman Co, Helsingborg, Interview Fall 2010

Knezevic, Roland, *Forklift operator, Goods reception,* AB Ph. Nederman Co, Helsingborg, Interview 2010-09-16

Leckström, Johan, *Team leader, Production,* AB Ph. Nederman Co, Helsingborg, Interview 2010-09-16.

Meng, Jan, *Manager, PPQA,* AB Ph. Nederman Co, Helsingborg, Interview Fall 2010

Persson, Therese, *Production planner, CSG,* AB Ph. Nederman Co, Helsingborg, Interview Fall 2010

Svensson, Siv, *Assembler at station 152, Assembling,* AB Ph. Nederman Co, Helsingborg, Interview 2010-12-03.

Thronée, Sara, Assembler at station 189, *Assembling*, AB Ph. Nederman Co, Helsingborg, Interview 2010-11-03.

Tideman, Björn, *Quality Engineer, Process & Product Quality Assurance*, AB Ph. Nederman Co, Helsingborg, Interview Fall 2010

Appendix A

Interview guide 1 – Assembly personal

- How does the assembly personal order components?
- What kind of components and which quantities are ordered?
- Does a point of order exist?
- How long is the lead time between ordering and delivery?
- Is it common with different ordering behaviors?
- What happens with components that are not consumed in the assembly activities?
- Do inaccurate deliveries occur?
    - Are these deliveries a problem in the assembly activities?
- Is it common that assembly personal borrows components from others stations?
- What kind of problems have you identified in the material supply today?
    - Do you have any spontaneously solutions?
- Is floor space a problem today?
- Components used at several assembly stations, do they have a common storage space? Or are they stored at several places?
- Do some of the assembly stations have more problems than others?
- How do the forklift drivers feel about the situation today?
- Do you have any suggestions on how to reduce the buffer inventory?
- Do you have any suggestions on how to increase the assembly time?

Appendix B

Interview guide 2 – Internal logistics team and warehouse personnel

- Are the pallets in the warehouse placed at specific places?
- Is it difficult to perform individual component picking?
- Is the demand of assembly stations stable during the day?
    - If not, when does peaks occur?
- Are the components always ordered in same quantities?
- Does the internal logistics team have knowledge about the placement of all components at the assembly stations?
- Does the internal logistics have to wait on the warehouse personnel or vice verse?
- Is it easier to handle bins than cartons?
- Can the internal logistics deliver to several assembly stations in the same delivery round (milkround)?
- Do you have any suggestions on how to improve the material supply?
- Do you have any suggestions on how to reduce the buffer inventory?

Appendix C

Interview guide 3 – Production planners, Quality engineers, Site manager, Team leaders, Purchasers

- What are the main problems in the material supply of the assembly stations today?
- What are the reasons of the low assembly utilization rate?
- Do any rules for the component ordering process exist?
- Have Nederman tried Kanban before?
- Are they any reasons for the high inventory levels in the buffer?
- Is IFS working desirable?
    - Which functions in IFS cause problems?
    - Can functions in IFS be changed?
- Do any previous studies of the material supply exist?

Appendix D

Components at assembly station 189 identified in the Kanban B area.

Article number	Article description	Number of Transportation orders	Assembly Picking frequency
61286	Brace cable no 704	2	343
2155352	Hose nipple 10mm-R3/8	2	190
2157393	Hose 3/8 TF perforated	28	173
2152252	Cable 3G1,5 H07RN-F 12m	12	63
2157391	Hose 1/4" TF perforated	9	71
2154408	Box CH20 332x342x159 Neutral	7	53
2155350	Hose nipple 6mm-R1/4	1	105
2150701	Banjo 6mm	2	100
2157392	Hose 5/16" TF perforated	13	103
2152238	Cable 3G1,5 H07RN-F 1m	4	91
2150768	X Hose 5/16" TF	9	72
2151520	Banjo 8mm brass	2	56
2150296	Hub C30	3	62
36172	Drum 30 (0,8x11000)	50	104
2151624	X Hose 10mm black (Merlett)	6	300
2150702	Banjo 8mm	3	136
Total		**153**	

Appendix E

Potential Kanban-B components, Assembly station 166.

Article number	Article description	Number of Transportation orders	Assembly Picking frequency
2000359	Plastic bag for 611	1	73
10551235	Spot light/fan switch for Original	11	77
2153746	Cable complete 9,5m	5	92
2153745	Cable complete 2m	2	91
12371421	Trolley filterbox generation ii	18	76
61837	Cable l=188mm strap	2	99
148764	X Instr.manual Fbox standard	1	105
32482	Sleeve connection quick coppling	1	50
63455	Holder	1	57
21823	Handle complete	4	58
46526	Washer cover blue ii	1	51
2002661	EPS-brace 900x260x40	1	56
140737	Assembly instruction	1	93
36027	Fan 2.2kw N29 wo. package	38	78
36026	Silencer 663 wo. package	36	81
10554335	Fume extractor l=3m Original	26	83
Total		**149**	

Appendix F

Potential Kanban-C components at assembly station 166

Article number	Article description	Number of Transportation orders	Assembly Picking frequency
43018	Gasket for fan flange	3	462
63918	Pipe angle	2	106
2001653	Cable complete	1	106
2003320	Pipe system complete black	4	106
2010308	Solenoid valve cpl 24V	4	106
Total		**14**	

Appendix G

Kanban B, Assembly station 152

Article number	Article description	Number of Transportation orders	Assembly Picking frequency
61906	Cartons e 2181 785x585x475mm	2	123
2009992	Stand for perm. ass. N29	17	60
46589	Part middle n40 space blue	16	105
35602	Impeller 50Hz N40	12	87
2000340	Outlet black complete	8	90
35847	Attached det. for N-Fan stand	2	61
35613	Attached details for N40	2	90
32960	Cartons 585x485x395	3	90
46641	Attached det. N16/N24 portable	4	87
45639	Tube Clamp	6	83
2152170	Impeller N24 60Hz	9	64
2002944	End Ø25	2	89
65270	Interior f portable fan	2	87
2007807	Seal.strip BIA for supp. clip W3-50	1	79
32971	Fan housing impeller 50Hz 2.2kW	75	108
Total		**161**	

Appendix H

Kanban C, Assembly station 152

Article number	Article description	Number of Transportation orders	Assembly Picking frequency
2000342	Flange inlet	24	724
64667	Rubber sponge washer 3,0mm	6	694
147558	Label motor rotation	1	867
2002943	Stand	19	103
Total		**50**	

Appendix I

High frequency components with a low inventory turnover, assembly station 189.

Article number	Article description	Inventory turnover
2152340	Drum cover hose ass.	35,1
2152341	Cable stand female 12m	34,9
2000238	Cable stop half under	34,7
4901071	Strap 270x4,7 mm black	32,5
2009206	Cable stand male	31,0
2150084	O-ring 13.1x2.62	26,7
2002305	Pressure bush 6mm lt	15,6
2006888	Brake cover 6mm	11,3
2000237	Cable stop half upper	37,6
2151202	Label Nederman 78X13	36,2
2151521	Banjo 10mm brass	34,9
2002307	Pressure bush 10mm lt	33,6
2151524	Hub lock	31,5
45947	Hosestop 10 lower right black	27,7
45946	Hosestop 10 upper right black	27,1
2006889	Brake cover 8mm	22,4
2151099	Spring guard 3/8"	22,2
2002306	Pressure bush 8mm lt	21,7
2151624	X Hose 10mm black (Merlett)	12,7
2150702	Banjo 8mm	9,3
36174	Current collector complete 3-pole	32,7
2151541	Hub C20	28,3
45944	Hosestop 8 upper right black	28,1
45945	Hosestop 8 lower right black	28,1
2152339	Drum cover cable ass.	24,8
2155351	Hose nipple 8mm-1/4	23,0
2150289	Sealing drum	21,2
45942	Hosestop 6 upper right black	17,0
45943	Hosestop 6 lower right black	16,9
2150127	Cover thermo switch	15,3
2155352	Hose nipple 10mm-R3/8	14,6
64753	Connection terminal	12,3
2152220	Sealing connection cover	11,2
61286	Brace cable no 704	5,6
2150767	X Hose 3/8" TF	17,0

Appendix J

High frequency components with a low inventory turnover, assembly station 166.

Article number	Article description	Inventory turnover
35866	Control box IEC 3P 400V timer	36,7
2151206	Label Nederman 330X51	3,9
144023	Instr.Manual FilterBox Standard	10,4
2010189	Bracket lower	6,9
2010165	Bracket upper	6,9
147788	Label Instruction	0,4
148766	X CE-deklaration FilterBox	0,8
2001861	Edge protection 60x60x5x 670	4,6
21596	Sleeve connection	7,2
33457	Hose vent 160/ 450 blue	9,7
2002316	Spacer d=22x30	6,6
46580	Sleeve coupling Ø160	9,3
2002098	Handle	25,6
32481	Quick coupling	13,2
32352	Cleaning flap	29,6
21808	Display panel	24,3
11340	Collar	17,7
2000753	Quick clamp	8,1
32351	Cleaning bar	5,8
2001770	Bracket	5,4
2001772	Bracket	4,7
2002219	Gasket r265.5/251.5	4,4
2001991	Washer sealing	2,7
63407	Damper	2,2
32353	Handle	1,5
2001990	Gasket 50/ 77	3,7
2003400	Bucket 10L black	6,1
2001101	Pilloflex	3,2
2005021	Cable guide	7,8
61055	Hose clamp 130-165	11,5
43018	Gasket for fan flange	7,3
32318	Bearing swivel	20,8
63282	V-ring 170	18,7
63340	V-ring 85 a	5,3
21909	Bearing	17,9
21902	Bush bearing	10,7
11317	Gear ring	15,5

Appendix K

High frequency components with a low inventory turnover, assembly station 152.

Article number	Article description	Inventory turnover
22162	Impeller N16 50Hz	29,87896
33181	Guard net	15,736
33419	Attached paper N10/N16/N24	12,69667
61055	Hose clamp 130-165	10,84364
2151203	Label Nederman 175X27,9 Blue	5,8524
147553	Label caution	1,1422
2000342	Flange inlet	45,15462
64667	Rubber sponge washer 3,0mm	9,638601
147558	Label motor rotation	0,871332