Volvo Group Trucks Operations
Logistics Services

Analysis of material- & tied-up capital flow in Inbound

Master Thesis

Advanced level, 30 hp

Product- and process development, Innovative production

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ABSTRACT

This master thesis is performed on behalf of Volvo Group Trucks Operations Logistics Services in Eskilstuna, which is also the final part of the Master in Engineering program – Innovation, production and logistics at Mälardalen University.

Logistics Services central warehouse in Eskilstuna ensures that parts are available all over the world, material is transported to the production facilities, packaging is available and vehicles are distributed to the dealers. The current need is to reduce costs and improve the production process at the Inbound department. The aim of this project has been to analyze the current flow of materials and tied-up capital in the inbound flow and give improvement suggestions on reducing lead times and the tied-up capital, as well as give suggestions on common performance metrics for all the sub departments at Inbound.

The report is based on theoretical and empirical study, where the theory concerns the topics; logistics, lean philosophy and supply chain management. The empirical study was carried out by data collection through time measurements in the plant and by BEAT-report, observations and discussions with the operators, and interviews with production managers and process developers. The collected data was analyzed and the products in the flow were divided into groups, where the inbound material flow was mapped by the VSM tool. Product groups were analyzed by amount of received material reports, quantity, value and lead time, and the product groups that tied the highest value were defined as well as where in the flow the value was located. For each sub department calculations on production capacity and utilization were performed to analyze the current state and be able to compare the departments with each other. The interviews contributed with knowledge to create a reliable and valid SWOT analysis for each sub department at Inbound, where common factors could be defined concerning deviations, performance metrics and other hidden problems, but also opportunities.

Finally, in this report the current state in the Inbound department has been analyzed. Products have been categorized into groups and the materials flow mapped. It has been defined where in the flow and how much value that is tied up, and by which product groups. Hidden problems and deviations have been brought up to surface. Improvement suggestions have been given concerning decreasing of lead times and the tied up value, and also suggestions on common performance metrics for all the sub departments have been given.

SAMMANFATTNING

Detta examensarbete är utfört på uppdrag av Volvo Group Trucks Operations Logistics Services i Eskilstuna, och är också det sista momentet inom Civilingenjörsprogrammet – Innovation, produktion och logistik på Mälardalens högskola.

Logistics Services centrallager I Eskilstuna försäkrar att delar är tillgängliga över hela världen, material transporteras till produktionsanläggningar, förpackning är tillgängligt och fordon distribueras till försäljarna. Det nuvarande behovet är att reducera kostnader och förbättra produktionsprocessen på Inbound avdelningen. Syftet i detta projekt har varit att analysera det nuvarande materialflödet och flödet av bundet kapital på Inbound avdelningen och ge förbättringsförslag för reduktion av ledtider och bundet kapital, samt ge förslag på gemensamma mätetal för alla underavdelningar på Inbound.

Rapporten baseras på teoretisk och empirisk studie, där teorin berör ämnena; logistik, lean filosofi och supply chain management. Den empiriska studien utfördes genom data insamling genom tidmätning i anläggningen och genom BEAT-rapport, observationer och diskussioner med operatörer, och intervjuer med produktionsledare samt processutvecklare. Den insamlade datan analyserades och produkterna i flödet delades in i grupper, där materialflödet i Inbound kartlades genom användning av VSM verktyget. Produktgrupperna analyserades efter antal inkommande material rapporter, kvantitet, värde och ledtid, och produktgrupperna som binder högst värde definierades samt var i flödet värdet befinner sig. För varje underavdelning genomfördes beräkningar på produktionskapacitet och utnyttjandegrad för att analysera nuläget och kunna jämföra avdelningarna med varandra. Intervjuerna bidrog med kunskap till att skapa en SWOT analys för varje underavdelning på Inbound, där gemensamma faktorer kunde definieras gällande avvikelser, mätetal och andra dolda problem, men även möjligheter.

Slutligen, i denna rapport har nuläget på Inbound avdelningen analyserats. Produkter har kategoriserats i grupper och materialflödet har blivit kartlagt. Det har definierats var i flödet och hur mycket värde som är bundet, samt genom vilka produktgrupper. Dolda problem och avvikelser har förts till ytan. Förbättringsförslag har getts på reduktion av ledtider och bundet värde, och även förslag på gemensamma mätetal för alla underavdelningar.

PREFACE

This master thesis is the last part in the Engineering degree of Innovation, production and logistics at Mälardalen University. The thesis work is executed on the behalf of Volvo Group Trucks Operations in Eskilstuna.

I would like to thank all the people that has been involved in this project and have been helpful by taking their time and answering questions and providing information. I would especially like to thank Björn Bohman and my supervisor Gerhard Kjellberg who has given me this opportunity to perform my master thesis at the Volvo Group, and also thank my supervisor for the guidance, Kim Gabrielson for the support, the production managers and process developers Lars Ekendahl, Andreas Sweström, Anders Eklund, Per-Eric Klingstedt, Sara Bäckman, Åsa Göhlman, Rickard Kindlund for the support and accommodating, and Rolf Possmark for assistance with the data collection. I would also like to thank all the people involved for showing great interest and optimism in this project.

Finally I would like to thank my mentor Antti Salonen at Mälardalen University for the guidance through this project.

Eskilstuna, 31 May 2013

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ABBREVIATION LIST

B	Binning
BEAT	Business Evaluation and Analysis Tool
DC	Distribution Center
DMAIC	Six Sigma tool; Define Measure Analyze Implement Control
EDI	Electronic Data Interchange
ERP	Enterprise Resource Planning
GR	Goods reception
Lean	Lean production, philosophy and tools for improvements
MR	Material Report; see Appendix 3
PC	Production Capacity
PP	Pre-pack
SCM	Supply Chain Management
SPIS	Volvo System; Spare Parts Information System
SWOT	Analysis tool; Strengths Weaknesses Opportunities Threats
VPS	Volvo Production System
VSM	Lean tool; Value Stream Mapping
VTC	Volvo Trucks Operations
WIP	Work in Process
U	Utilization

TABLE OF CONTENTS

LIST OF FIGURES

List of Tables

List of Diagrams

LIST OF APPENDICES

1. INTRODUCTION

In this report an empirical study is performed at the Volvo Group Truck Operations in Eskilstuna, where the general aim is to analyze the flow of materials and tied-up capital in the inbound flow and give improvement suggestions.

1.1. Background

Companies of today gain more and more interest in lean philosophy as it is proven to provide more advantages in increased productivity but also in the competitiveness with other companies. There is focus on making production systems more efficient by balancing material flows but also the information flows in the supply chain and within the own company. (Bellgran & Säfsen, 2005; Powell, et al., 2013) There is an increased pressure on European Union manufacturers to be more flexible and innovative as result of rapid growth of low-cost economies. Surveys performed on manufacturing improvements state that the two most important strategies for competition of sales and profits in global markets are; lean production and Enterprise Resource Planning (ERP) systems. (Powell, et al., 2013) A survey performed by Hofer, et al. (2012) states that lean practices directly contributes to improved financial performance by decreasing the operating costs, as well as improved inventory leanness. (Hofer, et al., 2012) The focus of lean is continuous flow of materials and eliminating waste, however to achieve valuable future improvements it is significant to evaluate the current state and bring all problems to the surface. (Liker, 2004)

1.2. Problem statement

Today Volvo Group has general projects with focus on reduction of tied-up capital in the supply chain. Volvo Group Truck Operations Logistic Services Eskilstuna has a need of cost reduction and better methods for following up the capital that is tied up in the chain, especially in the Inbound department. Due to the economy crises that arose in EU in the first decade of 2000 there became a need to make improvements with small means and the company is developing and improving their approach based on lean philosophy. In order to make improvements in the production process, the company needs to map and analyze the current state of materials flow. Currently the central warehouse in Eskilstuna stores 75 000 unique articles and there is a lot of value that is handled daily, which makes it important to map the flow in order to be able to reduce tied-up value.

1.3. Aim of project and research questions

The aim of the project is to analyze the material flow and tied-up capital in the inbound flow, to develop valuable measurements for daily management and monitoring of the tied-up capital. Through the measurements identify the development, deviations and suggest solutions that will reduce lead time and also the tied-up capital by 20%.

Research questions that are to be investigated in this project are following;

- What is efficient material flow and how is it achieved?
- What problems/deviations are there?
- How is improvement work operated?
- What kinds of metrics are used in the current state?
- Which product flow groups stand out in terms of value, quantity, amount of material reports and lead time?
- How is the value proportion between the three sub departments in Inbound?
- For how long is the capital tied up in the flow and where is it tied-up?

1.4. PROJECT LIMITATIONS

The project includes; from that the goods passes the gate at Distribution Center (DC) in Eskilstuna to that the article is physically in stock and reported in the system SPIS. The project is limited to 20 weeks of full-time work, which comprises 40 hours per week.

Since the warehouse in Eskilstuna handles a huge amount of different products that involves several different handling procedures such as outsourcing, control, extern warehouses etc. the project needed to be narrowed down to a more reasonable size concerning time of the project and capability. The project does not include following:

- The Procurement process
- The Outbound flow
- Third part suppliers (e.g. Pihls)
- Articles at extern warehouses
- Articles on the yard
- The transportation process
- The kit process
- The Buy back process
- Delivery notes/remarks
- Transportation damages and insurance matter

1.5. COMPANY DESCRIPTION

The company was founded by Assar Gabrielsson and Gustaf Larsson in 1927 with the vision of constructing a Swedish car that could withstand the weather and the roads in Sweden. Ever since, durability has been one important part in the design of the products. Volvo cares a lot for quality, safety and the environment, thus the vision is to be the leader in sustainable transport solutions. Today the Volvo Group is one of the largest suppliers in the world regarding buses, trucks, industrial engines, construction equipment and marine. The company has established sales and marketing channels on all continents, having 115 thousand employees in twenty countries. Figure 1 shows a world map where the Volvo Group has established production facilities.

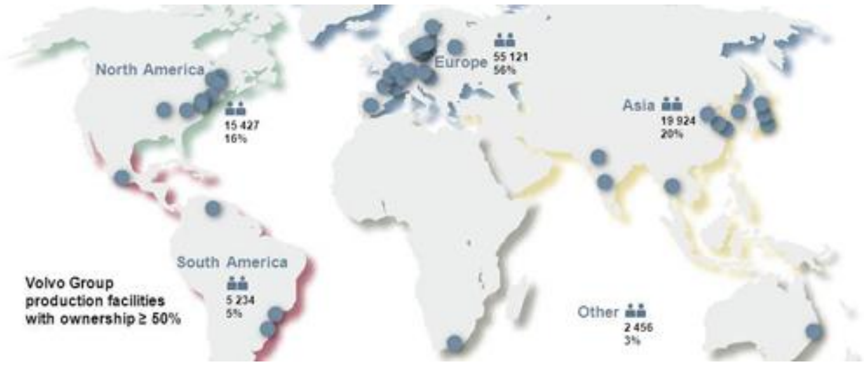


Figure 1 – Volvo Group production facilities. Volvo Group intranet

The Figure 2 shows the Volvo Group Organization. This report is based on empirical studies at the Group Trucks Operations (GTO) Logistics Services in Eskilstuna. GTO is built upon eight different units; North America Trucks Operations, Volvo Trucks Global Manufacturing, Renault Trucks Manufacturing, Asia Trucks Operations, Volvo Logistics, Volvo Powertrain Operations, Parts Logistics and Remanufacturing in Volvo Parts, Volvo Production System (VPS) and Operational Development (OD) from Volvo Technology.

Figure 2 – Volvo Group Organization. GTO Presentation 2013 ver 1.0 s.5

Figure 3 shows the function of GTO in the Volvo Group. The GTO has 81 distribution centers and 50 plants, manufactures cabs and trucks for the Volvo, Renault, Mack and UD Trucks (former Nissan Diesel) brands, produces engines and transmissions of the Group, remanufactures components, provides logistics services and spare parts management for the entire Group, and provides VPS and OD support for the entire Group.

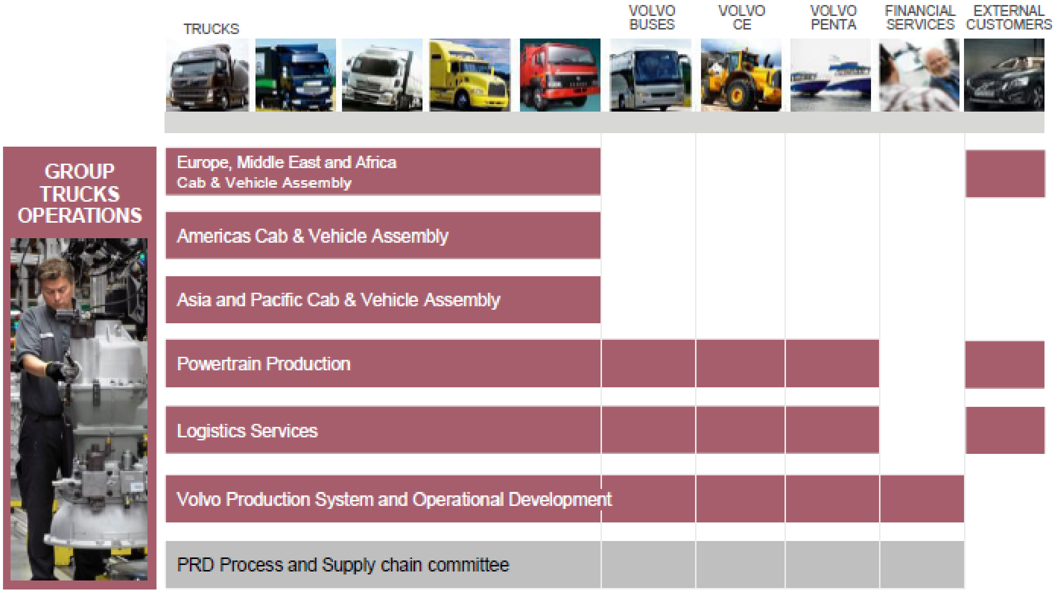


Figure 3 – Group Trucks Operations. GTO Presentation 2013 ver 1.0 s.12

The Logistics Services are world-leading supplier concerning logistics services for global vehicle-, transport- and air industry, having 5 000 employees at more than 60 locations world-wide. It is about design, handling and optimization of the supply chain concerning all brands in the Volvo Group and selected automotive industry. Logistics Services ensure that parts are available all over the world, material is transported to the production facilities, packaging is available and vehicles are distributed to the dealers. Volvo GTO has three central warehouses in Europe which are located in; Eskilstuna Sweden, Gent Belgium and Lyon France.

1.5.1. Volvo Production System (VPS)

The focus of VPS is to create customer value and eliminate waste in the processes, striving to achieve sustainable profitability and operational excellence while maintaining the values of the Volvo Way. The VPS integrates the whole value chain and involving all areas and individuals to commit to the Volvo principles, helping to contribute to Volvo Group Transformation.

The VPS are principles and practices that are customer driven and people oriented to help the company achieve their best performance. The main principles are; Built-in-Quality, continuous improvement, Just-in-Time, Process stability, teamwork and The Volvo Way. The Built-in-Quality involves having a zero-defects mindset, not tolerating bad quality and eliminating the root causes. The continuous improvement is based on standardization a desired future state vision, being a driving force in the company. Producing the right thing, in the right amount and at the right time is the vision of Just-in-Time, aiming for shortest possible lead times and minimal inventory. The Process stability is about understanding the operations and reducing waste and variations in the processes, by standardized work, production leveling and 5S. The Volvo Way is the company's values, culture and leadership.

Figure 4 - Volvo Production System Matrix. Volvo Group intranet

2. METHODOLOGY

In order to define a scientific method it is important to define the research approach of this thesis, whether it is deductive, inductive or abductive. The deductive approach focuses on theoretical study and comparing previous theories, the inductive approach bases the research on practical knowledge and the abductive focuses on completely new hypotheses and are also the one that is least common to use. Since this project aims to investigate a real problem at a real company where a lot of practical study is required before knowing what theory to search for, this thesis will follow an inductive research approach. (Kovacs & Spens, 2006)

There are several different scientific methods that can be used when writing a thesis, the chosen methods are to be described and motivated for this particular project. To ensure the scientific credibility of the research a great awareness should be put in thought when choosing the method. (Ejvegård, 2003)

2.1. CHOICE OF METHOD

A method implies to scientifically approach the subject that is chosen to be written about and how to handle it. The chosen methods will affect the whole essay. Following are four methods that has been used in this project.

2.1.1. DESCRIPTION

This method is the easiest one and simply explains how something appears or is being monitored, e.g. how an organization works or how a decision has been made. When using this method all the information that has been gathered must be categorized and sorted, and the most important information to be selected. It is important that there is a context in what is to be written, this is to be decided in the thesis object, and that the information is relevant to the subject. Often this method is empirical and being used in general issues; however it was initialized by appraising reasons. (Ejvegård, 2003)

In this case the aim of the project has been clear and all gathered information has been critically analyzed by the means of the project aim and research questions.

2.1.2. CASE STUDY

Case study aims to describe the reality by investigating a small part of multiple events. The difficulty is that one event cannot itself describe the reality and therefore it is important to be careful when drawing conclusions. The benefits of this method are that the problem statement can be unknown or be postponed to a later stage in the study, and the aim then becomes to understand rather than explain something. (Ejvegård, 2003)

In this project I have been studying the material flow at the inbound department by observations, documentation, data collections & interviews.

2.1.3. CLASSIFICATION

Classification is a method to analyze the gathered data and there are many different ways to do a classification. Examples of common classifications are genres, interests, social groups etc. To be able to analyze and draw conclusions the classification must meet certain requirements. These requirements are that the classes must be reliable, valid, collectively exhaustive, mutually exclusive and there should not exist empty classes. (Ejvegård, 2003)

The main classification has been by dividing products into different product flows, doing this by using the company's own packaging codes and by this being able to categorize and separate different products from each other, making the information more manageable.

2.1.4. Qualitative and quantitative research

There are two types of scientific approaches, quantitative and qualitative. Quantitative research investigates how much or how many of something there is. In order to define the quantity classification must be defined. Doing a quantitative research means going through a process that involves planning-, collection- and analysis phase which in their turn involves different stages with requirement of disciplinarily. (Hartman, 2004) Something that is quantified can be calculated, expressed in digits or terms corresponding digits. Quantified data is hard data and can be expressed statistically, and with help of computer programs easily be analyzed. The hard data is easily presented by diagrams and tables. (Ejvegård, 2003)

The aim of the project was very clear, based on research questions it was defined what data to investigate. The quantitative approach was collecting hard data, both primary and secondary, about lead times, products, product value etc. The qualitative approach has been interviewing the people that have been involved in the inbound department for a long time who had good knowledge, but also by observations and discussions with operators.

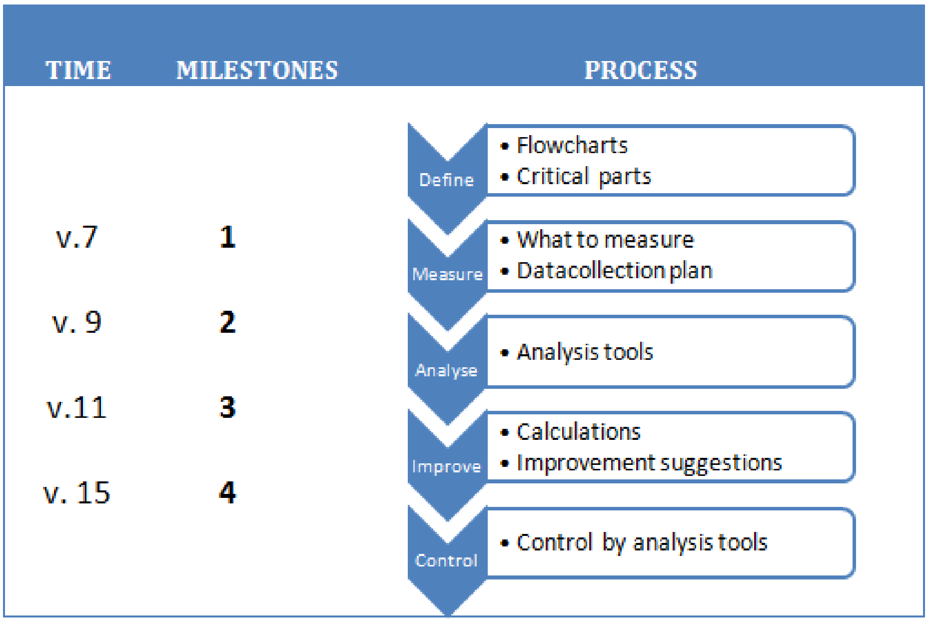
This project has involved a lot of hard data partly through; time measurements on production floor and partly through BEAT-reports where the company's system stores information about all the products such as; costs, delivery times, packaging codes etc. The measured time data has been analyzed and evaluated together with Kim Gabrielson who performs measurements for Value Stream Mapping, to state its validity. The systems data has been carefully analyzed and sorted in an excel file both manually and in some extent automatically by pivot tables, with help by Rolf Possmark and my supervisor Gerhard Kjellberg.

2.2. Approach

In combination with earlier mentioned methods it will be suitable to use the Six Sigma improvement model DMAIC, which stands for;

- **Define:** Defining the process by flowcharts and process charts and finding the critical parts in the processes output.
- **Measure**: Collecting data of the process by quantifying the work. Define what to measure and prepare a data collection plan.
- **Analyze:** Analyze the data that has been collected in order to improve the process, using different analysis tools such as Pareto charts, cause and effect diagrams etc.
- **Improve**: Adjust or redesign current methods in order to improve the process.
- **Control**: Monitor the process in order to control the new performance levels, by using the analysis tools. (Krajewski, 2007)

Following the DMAIC steps will help taking control over the project and combined with Gantt-chart planning, milestones in the project have been set to get an organized and structured project time plan.



2.3. DATA COLLECTION

There are two types of data; primary and secondary. Primary data concerns measurements and quantifications, where three typical strategies are observations, interviews and surveys. The primary aim is to gain basis for the research analysis. Secondary data implies information that has been previously collected for other purposes, but can be relevant for the current research. (Befring, 1994)

Primary data includes time measurements on the floor and BEAT reports about product information. Secondary data concerns company presentation, daily measurements data and diagrams, process maps and directives, some time measurements done by Kim Gabrielsson and previous Value stream maps.

2.3.1. LITERATURE STUDY

Literature study implies studying all written material such as books, articles, reports, essays etc. The most appropriate is to use library databases and search for information with different keywords. Researchers always use references in their works and these references may be interesting to use as well. (Ejvegård, 2003)

Literature such as books has been partly collected at the University's library and partly from previous courses included in the study program. Some books have been found by checking references in similar literatures. Scientific articles have been collected by using the university's database Discovery that searches through a wide range of other scientific databases. Main key word for finding appropriate literature has been; lean production, supply chain management, logistics, tied-up capital, logistics management, scientific thinking- and methods.

2.3.2. *INTERVIEWS*

An interview aims to find out the characteristics of what is being investigated by the knowledge of the person that is being interviewed. An interview can be quantitative by doing surveys where the answers often are yes or no, or are expressed as a value on a scale. A qualitative interview does not involve leading questions and strives for open answers. (Hartman, 2004) It is important to be careful when choosing who to interview and carefully prepare the interview, since interviews takes a lot of time to process. The best way to perform an interview is by using a recorder and then be able to calmly go through the interview afterwards. The interview can always be documented by taking notes, however it has shown to have an inhibitory impact on the interviewer. (Ejvegård, 2003)

The interviews have been documented partly by using recorder and taking notes and partly by email. The persons interviewed are all deeply involved with the inbound processes and flow as they are production managers and process developers. The questions asked are of qualitative value that encourages individual answers where there are no rights or wrongs. The aim was to find valuable information of both negative as well as positive aspects at inbound. Equalities in point of view of the processes states the importance in that specific problem or question as well as differences rises up questions that may not have had as big focus.

2.3.3. *OBSERVATIONS*

Observation can appear in two ways; either to gain knowledge of behaviors and events, or as physical measurements to investigate reactions and actions. The advantage of observations is that the reality may be different to what has been said during an interview. The memory can be deceptive and then the answers become invalid. By observing it is easier to find out how something really appears, and for example find the root cause of a problem. A negative aspect of observing is that it is time consuming. (Hartman, 2004) The researcher performs the observations by listening, watching, feeling, experiencing and registering the impressions. Since the researcher is in himself a measuring instrument he must be aware of errors, preconceptions and expectations. Using a structured observation- and assessment scheme will help the process to become systematic. (Befring, 1994)

The observations have been performed during the whole project by discussing with workers, managers, developers and when measuring times. Many times it has been obvious that some people that have worked to long with a specific task were somewhat blind to why some specific things occurred, and they did not reflect on whether it was in their favor or disadvantage. Also discussing with people sometimes only gave parts of information, while after observing the information gaps were filled. Observations are time consuming indeed, however it was a natural activity while measuring times and easily documented in the notebook.

2.3.4. *DOCUMENTATION*

Documentation data is very important for the current state analysis in the project. (Befring, 1994) During the project information from the company’s intranet and database has been used to collect secondary data such as graphs, layout maps, measured times, presentations etc. and also primary data that has been compiled for this specific project and also the measuring of production times.

2.4. REFERENCES

When gathering information through literature study it is important to be critical against the reliability of the source and the validity of the information. The information must be objective, if something seems strange it must be controlled. Critically studying information there must be a consideration if the material is; genuine, independent, recent and contemporaneous. (Ejvegård, 2003) Source criticism aims valuing the information by the relevance and usability to the current research. (Befring, 1994)

The literature used in this report has been collected carefully, by starting out with relevant course literature and then searching for literature recommended from these books. Also searching for relevant key words at the University’s library and database, and checking if the year of the book is of validity and reliability to this project.

2.5. RELIABILITY AND VALIDITY

Ejvegård describes reliability as credibility and usability of measuring instruments and unit of measurements. If a measuring tape shows different measuring units when measuring twice e.g. the same box then it is not reliable, neither is a rubber band a reliable tool for measuring. It is important to be critical concerning whether the measurements are reliable or not, if something seems strange it should be controlled. Validity refers to whether the measurements are what really need to be measured. There should be clear measurement methods and units of measurement e.g. if ranking countries by size of population or square kilometers. It is important to know what the unit stands for and if it is consistent. (Ejvegård, 2003)

Time measurements have been performed by using timekeepers, performed together with Kim Gabrielson. Before staring measuring we decided a standard of what to measure and how to do it, also using a specifically developed template. The measurements were compared to each other and also to previously measurements from another project.

The data from the company’s system were compiled from a BEAT-report by Rolf Possmark who is the IT coordinator and daily works with developing different kind of data reports. By careful analysis errors occurring was identified and adjusted easily, and data such as costs were compared to another system by Gerhard Kjellberg to state the reliability of the numbers.

3. THEORETICAL BACKGROUND

3.1. Logistics

Logistics can be described as the efficient flow of materials from raw material to end user, but also the reversed flow of material that comes with defected products, recycling etc. Figure 5 illustrates this. (Jonsson, 2008; Christopher, 2005) During the past twenty years logistics has developed from having focused on dealing with transports and storage to become an important part of a company's competitive strategy. One way of describing a modern logistics point of view quoted by Oskarsson, et al. (2006) is that "*logistics is an important factor when it comes to creating competitiveness and profitability for many companies*". The goal of logistics is to deliver the desired product to the customer at the right place and the right time at a reasonable cost. Logistics covers planning and implementing, but also controlling that the output was a desired result. (Oskarsson, et al 2006)

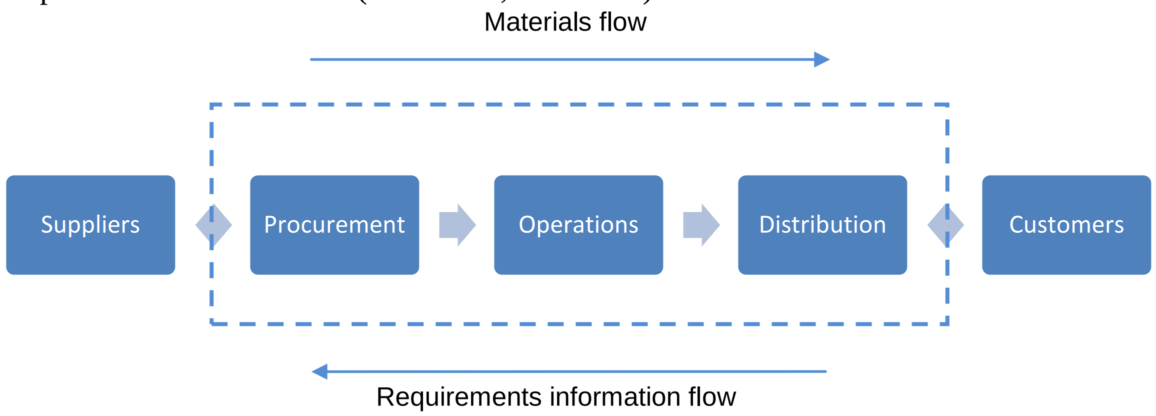


Figure 5 – Logistics management process. Christopher M, 2005. S. 15.

An important part of the logistics is the total cost, which is effected by the decisions that are made e.g. when wanting to implement a change in a process. The most general logistics costs are; transportation-, handling-, inventory-carrying- and administrative costs, these will be described further on in the report. Another important part of logistics is the delivery service which can be divided into six delivery service elements (Oskarsson, et al 2006);

1. Lead time – time from order to delivery
2. Delivery reliability - the reliability in the lead time
3. Delivery dependability – the right product at the right time with the right quality
4. Information – the importance of the information flow between all parties involved
5. Flexibility – the ability of customization
6. Stock availability - the amount of orders that can be delivered directly

(Oskarsson, et al 2006)

The link between the total logistics cost and delivery service is achieving high delivery service at low costs. (Oskarsson, et al 2006; Christopher, 2005) In practice the level of delivery service is set and the costs are reduced accordingly. However there is a limit of how high the delivery service can be, since it sometimes doesn't provide any further value to the total products profitability. There is a "highest delivery service" that is profitable that falls between 95-99%. Being able to deliver in all types of situations will lead to endless costs. (Oskarsson, et al 2006)

3.1.1. *Supply Chain Management*

Supply chain management (SCM) is a wider concept than logistics and builds on the logistics framework of creating a plan for the product and information flow, seeking a link and coordination between all the parts in the chain such as customer and supplier and the own organization. The management thinking has developed during the past two decades and in the search for new strategies of providing great customer value Michael Porter developed the concept of value chain. The value chain can be divided into two activity categories; the primary (operations, inbound logistics, outbound logistics, service, marketing and sales) and support activities (human resource management, infrastructure, procurement and technology development), illustrated in Figure 6. The competitive advantages arise depending on how these activities are organized by a company within the value chain, by performing them efficiently or uniquely a greater differentiation can be made against the rivals. (Christopher, 2005)

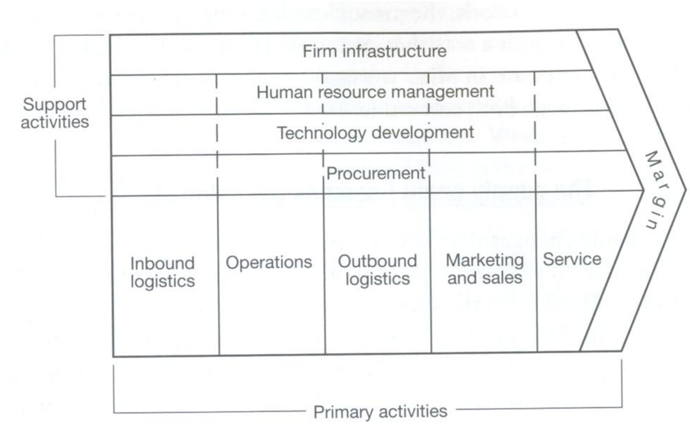


Figure 6 - The value chain. Christopher M, 2005. S. 14

According to SCM the purpose of logistics is to move and position inventory at the right time, place and cost. Until the inventory is positioned it has limited value and does not support value-added creation. To realize the maximum strategic logistics benefits there must be integration between all the functional works. A successful implementation of integrated logistics management is challenged by the interrelation of functions. Figure 7 shows the five areas of logistics work that by integration creates value capabilities are; order processing, inventory, transportation, warehousing and material handling, and facility network. (Bowersox, et al., 2005)

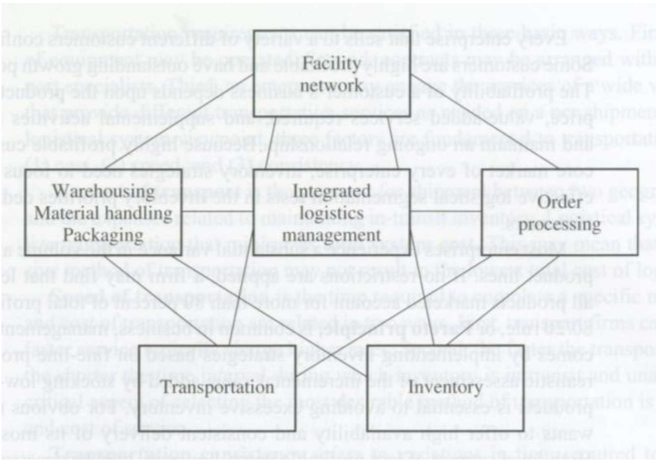


Figure 7 - Integrated logistics. Bowersox, et al., 2010. S. 27.

3.2. PROCESS MAPPING

In order to find an alternative solution and improvement a current state analysis must be done. The first step is to map the material- and information flow to clarify the amount of activities, storage etc. that is in the flow and what alternatives there is, and also departments and people that are involved. (Oskarsson, et al., 2006)

The mapping of flow can be performed in many ways. The most common symbols that are used in the mapping process are seen in Figure 8. The rectangles represent something that is being performed, which can be refined operations or activities or departments. The triangles represent stocks that are in the flow which can be material stock, output buffer or finished goods inventory. The decision points can help when describing alternative flow directions and the computer system and paper documents are sometimes necessary to show a clear picture of the information flow. It is important to use symbols and draw maps in a way that is distinct, understandable and sufficiently comprehensive to those who will use the maps. Figure 9 shows an exapmle of a simple flow chart. (Oskarsson, et al., 2006)

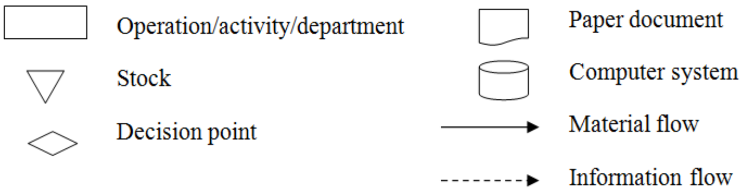


Figure 8 - Mapping symbols. Oskarsson, et al., 2011. S. 175.

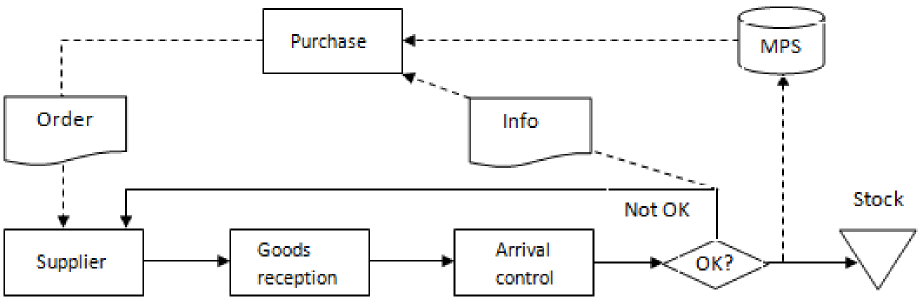


Figure 9 - Flow chart example. Oskarsson, et al ., 2011. S. 176.

Flow mapping can be more or less detailed and a lot of time is required if it is to be done thoroughly. Since time is often limited it is important to focus on the right parts. In order to avoid spending time on the wrong things a refinement of the most interesting parts in the flow is necessary, which is determined by metrics. If the aim is to decrease the time and speed up the flow then it is interesting to find the most time consuming activity and then other details are therefore less interesting in this case. (Oskarsson, et al., 2006)

3.2.1. MATERIAL FLOW MAPPING

A good way of starting analyzing tied-up capital and logistics costs is to map the materials flow, which can be done with different charts. This is a good basis for the work of reducing throughput time in order to lower the tied-up capital costs. (Jonsson, 2008) However Value

Stream Mapping can be a better way to map the material flow since it takes in account more factors in the chain. (Krajewski, et al., 2007) Figure 10 illustrates an example of a material flow chart.

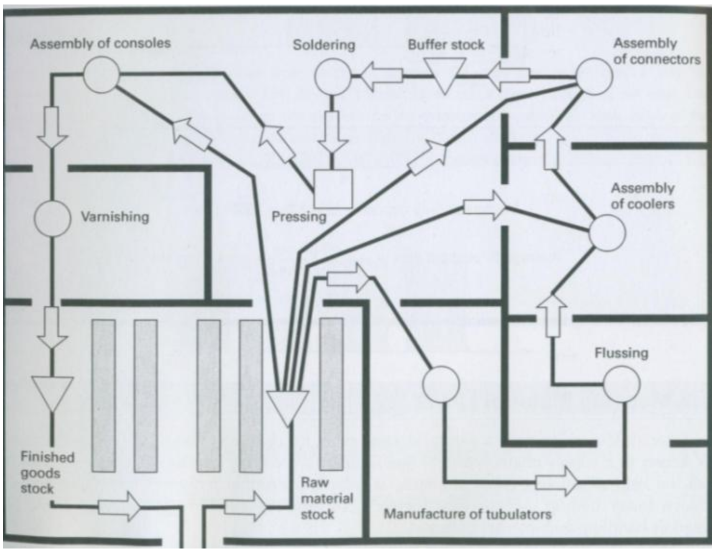


Figure 10 - Material flow chart example. Jonsson P, 2008. S.112.

3.2.2. Value Stream Mapping

Value stream mapping (VSM) is a qualitative tool that aims of eliminating waste, which sometimes can be up to 60 percent high. The tool gives a visual picture as a map of the processes involved in the material flow. The VSM shows the whole value chain from the ordering receipt to delivery of finished products. The VSM offers more information than the usual flowchart which helps identifying waste time activities. The VSM consists of current state drawing, future state drawing and an implementation plan. The information for the VSM can be collected at the shop floors such as cycle time, batch size, number of operators etc. (Krajewski, et al., 2007) The first step in value stream mapping is breaking down the full range of products into managable groups (Bicheno, 2004), Figure 11 illustrates the process of value stream mapping. An example of a value stream map is shown in Figure 12.

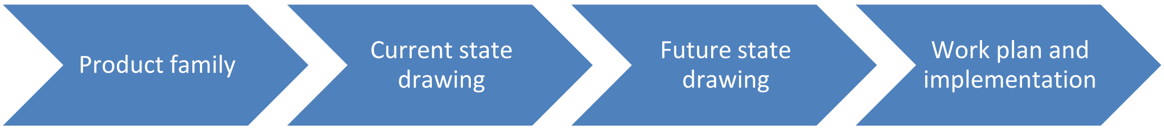


Figure 11 - VSM steps. Krajewski, et al., 2007. S. 360.

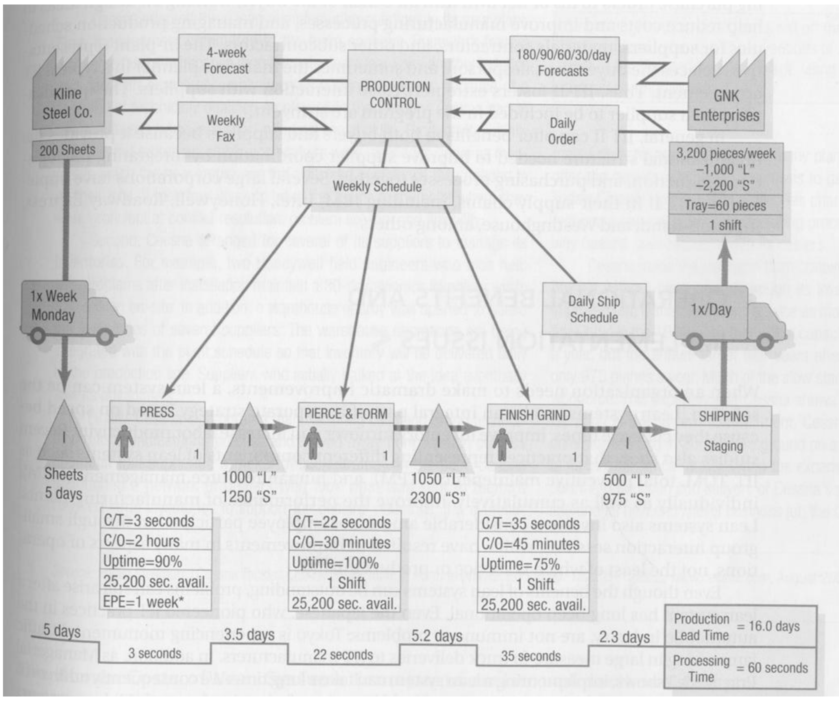


Figure 12 - VSM example. Krajewski, et al., 2007. S. 361.

3.2.3. *Spaghetti Diagram*

The spaghetti diagram is a simple tool for mapping products flow or material handling routes. Using a layout diagram of the plant and tracing the physical flow of the product, it is easy to mark storage locations and draw flow paths. The total length of the flow should be calculated including travel length. Using this tool it is easy to identify poor layout and wasteful movement. Parts are not supposed to be outspread in many locations, lean layout inventory should be grouped into supermarkets driven by pull. The spaghetti diagram is a good tool to shape type of routes. (Bicheno, 2004)

3.3. Tied-up Capital & Logistics Cost

The profitability of a company and it costs are directly affected by the tied-up capital. A supply chain or logistics system can use logistics cost and tied-up capital as performance variables. In order to measure and control the existing performance, the existing costs must be identified. It is also important to compare the logistics cost with other logistics goals. (Jonsson, 2008)

3.3.1. *Logistics Cost*

Logistics costs are linked to the logistics activities and can be divided into direct and indirect costs. Direct costs are e.g. costs of physical handling, storage and transportation of materials as well as tied-up capital and administration costs. Indirect costs are e.g. capacity and shortage costs. The logistics cost can be defined for a specific process, organization or a network of companies. The total logistics costs can be described by following (Jonsson, 2008);

- Transportation and handling costs
- Packaging costs
- Inventory-carrying costs
- Administrative costs

- Ordering costs
- Capacity-related costs
- Shortage and delay costs
- Environmental costs

Since many partial costs can be included in more than one of the eight above mentioned cost types, it is important to be careful and not to count the costs more than once. The total logistics costs size vary depending on the definition of logistics costs, which industry and what country the company operates in, but also the structure of the network and the role of the company in the logistics network. For a manufacturing company the direct logistics costs lies between 10 to 30 percent of the turnover. (Jonsson, 2008)

3.3.1.1. Transportation and handling

These costs relate to the moving of goods and are divided into internal and external transportation. The internal transportation refers to material handling activities such as packaging, picking and internal movements and these costs can be included in the inventory carrying or storage costs. The external costs refer to loading, moving, reloading and unloading goods to and from the supplier and customer or within the company's own plants. The external transportation can be handled by internal or external resources. Sometimes when delivery is free it may be hard to break down the transportation costs since they are hidden in the price of the product. The goods that are being transported represent tied-up capital and are therefore a part of total transportation costs. In general the transportation cost makes a small part of the total logistics cost, but can be higher in industries where dealing with high value goods. (Jonsson, 2008)

3.3.1.2. Packaging

These costs include all the material packaging, packing and marking costs. For reusable packages there are also costs for administration, storage, transportation and reconditioning. (Jonsson, 2008)

3.3.1.3. Inventory carrying

These costs are the costs for having goods in stock and depend on the stored quantity. They are consisting of financial, physical and uncertainty costs. The financial costs are the required return the company puts on capital which is tied up in stock. The physical are the operating costs for the storage and the uncertainty is associated with the risk of keeping materials in stock. In many companies the inventory carrying costs are the largest part in the logistics cost. To estimate inventory carrying costs there must first be an estimation done of the capital, storage- and uncertainty costs. (Jonsson, 2008)

- *Capital costs* - To evaluate the inventory carrying costs the materials in stock can be treated as investment in current assets which means it is required return for capital tied up in stock. If it would not have been tied up in stock it could have been an investment for the company in another way. (Jonsson, 2008)
- *Storage costs* - These costs are cost for personnel, energy, internal transportation, administration, equipment and depreciation. (Jonsson, 2008)

- *Uncertainty costs* - There are uncertainties and risk of keeping materials in storage. Large volumes lead often to more broken items since the handling increases, and also to longer storage times. Items that cannot be sold or are outdated must be scrapped or sold at a reduced price. Another uncertainty is missing articles that the company cannot gain money from and loss of stock may depend on poor administration and storage system. Costs will then occur due to wrong delivery of items or quantities in terms of error correction such as extra picking, freight transport and administration. Sometimes the wrong delivered items may even disappear when arrived to the customer, and never be returned. When storing in different regional warehouses shortage may occur which results in items having to be transferred between the warehouses. The most common reason for this is that demand allocation did not follow the forecasts. Re-localization is also a cost of the total uncertainty costs. (Jonsson, 2008)

3.3.1.4. Administrative

These costs refer to longtime planning material flows operative management. The primary costs are for the personnel of administration, but it also includes costs of communication systems and procurement. (Jonsson, 2008)

3.3.1.5. Ordering

These costs refers to the processing of purchase and manufacture orders. When deciding of lot sizing it is the incremental cost that is interesting, and can be divided into four parts:

- *Re-tooling set up costs* - The time it takes to change the manufacturing process from one to another.
- *Costs for capacity losses* - How large costs are depends on the utilization of capacity in the production process and purchasing organization. The time spent at full capacity leads to increased costs due to personnel and consumables, and could have been used for something more value-adding.
- *Material-handling costs* – E.g. the arrival controls, goods reception, placing in stores & transportation.
- *Order processing costs* - If it is a purchasing situation these costs involves all the costs for processing orders for the planning department, accounts department and purchasing department, transferring the order to a supplier. If it is a manufacturing situation the costs refers to the planning, order release and recalling.

(Jonsson, 2008)

3.3.1.6. Capacity-related

Capacity costs refer to the personnel, machines and plants, the costs of operation and maintenance. The costs may be influenced by the degree of utilization of the equipment and as they are fixed costs a high degree of utilization can reduce items cost price. If the utilization of capacity is high it automatically will lead to higher costs due to e.g. shifts, overtime work, more transportation and subcontracting. (Jonsson, 2008)

3.3.1.7. Shortage and delay

If a delivery cannot take place due to a customer's wishes a shortage cost arise, and it has direct connection with customer services which aims to creating value and generating revenues. The worst thing that could happen is that due to a delivery loss also the customer is lost, otherwise in a less serious situation the customer remains but sale is lost. Items that are more difficult to replace leads to more costs such as overtime work and express transportation, even extra cost due to damage may occur. (Jonsson, 2008)

3.3.1.8. Environmental

Environmental costs are hard to estimate since the effect is long term and many factors affect the environment indirectly. Selection of transportation affects the environment in different ways, but also the packaging of goods affects the choice of transportation. (Jonsson, 2008)

3.3.2. TIED-UP CAPITAL

The assets of a company consist of fixed and current assets and when doing investments the capital is tied up. This affects the cash flow of the company and its ability to pay. A part of the current assets is the material flow in the supply chain and influences affects the total tied up capital in the company. It is required to calculate the amount tied up capital in order to measure and analyze the logistics performance. The average tied up capital shows the amount of capital tied up in the material flow, work in process, stores, transportation and stocks etc. (Jonsson, 2008)

The tied up capital can be expressed in inventory turnover (ITR), absolute figures or average throughput time in current storage points. If the need is to compare tied up capital between different stocks or departments, the absolute figures is not recommended, also the same applies to comparing tied up capital over time periods. A better way is to use ITR, which is easy to measure and easily compares different measurement points. The ITR shows how many times per years the stock turn over and it shows the value of materials during a specific time period, usually a year in relation to the average capital during the same time period that was tied up in material flows. (Jonsson, 2008)

However it is more interesting to calculate the ITR for a group of items or for all items in stock. The turnover is then expressed as the outbound delivery value for a period of time and average tied-up capital. A problem when calculating the ITR is that the annual turnover often is expressed by the goods value based on the sales price, while the tied up capital is expressed as the value in stock based on the cost price. To correct this when calculating the same valuation is required for the turnover and capital tied up, which is the costs for goods sold. One way to notice if the calculation is based on different valuations is that the ITR increases if the sales price increases, despite the fact that the average stock remains the same – which is incorrect. (Jonsson, 2008)

The average ITR is calculated by:

$$\text{ITR} = \frac{annual\ turnover\ expressed\ as\ cost\ of\ goods\ sold}{average\ capital\ tied\ up\ in\ material\ flow}$$

The higher rate inventory turned over, the lower is the capital tied up.

An alternative to ITR is to calculate the average stock throughput time, if ITR increases the stock throughput will decrease and otherwise.

The average throughput time is calculated by:

$$\text{Average throughput time} = \frac{average\ tied\text{-}up\ capital\ in\ flows * 52}{delivery\ value\ peryear} = \frac{1*52}{ITR}$$

The factor 52 stands for the throughput time expressed in weeks, otherwise it will be expressed in years. (Jonsson, 2008)

3.3.2.1. Tied-up capital mapping

Tied-up capital exists along the entire flow from supplier to customer and occurs in stocks of raw material, work in process, stocks of finished goods and distribution stores. To be able to reduce the tied-up capital, mapping is required in order to study the flow in a structured way. In order to do the mapping it is needed to collect relevant information about which items that moves in which sub-flows, and in which stocks, transportations and operations. Another important information is the size of flow for each item per time period (can be measured as consumption over time), the value of items in the flow and average stock quantities. For internally produced items flows and stocks can be valued at standard costs and for purchased items at an average purchase price. (Jonsson, 2008) Figure 13 illustrates an example of value flow mapping.

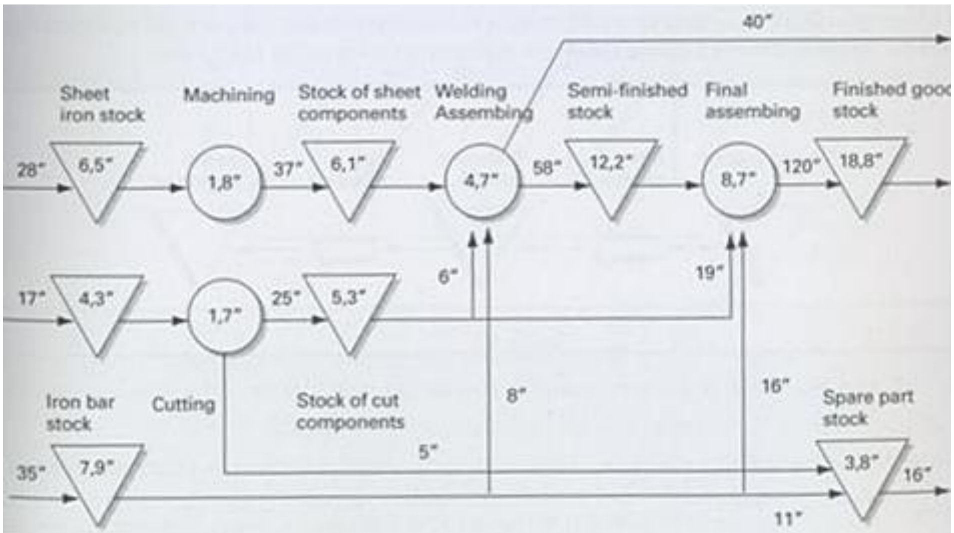


Figure 13 - Value flow example. Jonsson P., 2008. S. 113.

3.4. Materials Management

The flows of materials are initiated by different orders, which are defined by the quantity that will be transported from a supplying to a consuming unit and the time for availability. Stocks increase due to the material from inbound flows from the supplying units and decrease due to consumption. (Jonsson, 2008)

The purpose of purchasing and manufacturing orders is to initiate the flow of materials and to satisfy the current requirements. The aim of materials management is to determine the time and quantities for all items order, and the goal is to do as efficiently as possible taking in consideration the tied-up capital, utilization of resources and delivery service. Four questions materials management should be able to answer are (Jonsson, 2008);

1. Which items are the orders planned for? (item question)
2. What is the item quantity? (quantity question)
3. When must the order for each item be delivered to production, customer or stock? (delivery time question)
4. When must the order for each item be transferred to supplier or internal production? (start time question)

To understand how the materials flow are connected, being able to choose the right materials planning method it is good to separate the independent and dependant demand. Independent demand items have no connection with other items demand and are stocked for delivery to customers, usually being standard products. Dependant demand is the opposite of independent demand and means that one items demand is possible to trace from another items demand e.g. items that are input in other items production. It is very common that dependent demand items also have an independent demand, where the item is sold separately as well as a part of another product. (Jonsson, 2008)

In materials management it is important to as cost-efficiently as possible balance the materials requirements with availability. If the demand is higher than the supply then the materials flow must be increased by planning new orders, if the demand is lower than the supply then the inbound deliveries of the planned and released order must be delayed. The effect of bad balance between demand and supply results in; large stocks if the supply is too high, or poor delivery capacity and shortage if the demand is too high. (Jonsson, 2008)

The current supply is represented by the stocks while the future supply is represented by the planned inbound delivery. The demand is expressed as forecasts, customer allocations, allocations for manufacturing orders and aggregate gross requirement. Allocation represents the most certain information of future requirements while forecasts represent the least reliable and certain information. (Jonsson, 2008)

Materials management can be based on push or pull factors, illustrated by Figure 14, where pull material flow is based on the initiative of a consuming unit in the flow and push is rather based on the supplying or planning unit. Pull based planning is directly initiated by the customer orders and the quantities are small and as closely as possible correspond to direct or immediate material requirement. It is the use of material planning methods that determines whether material flows are of push or pull type, rather the method in itself.

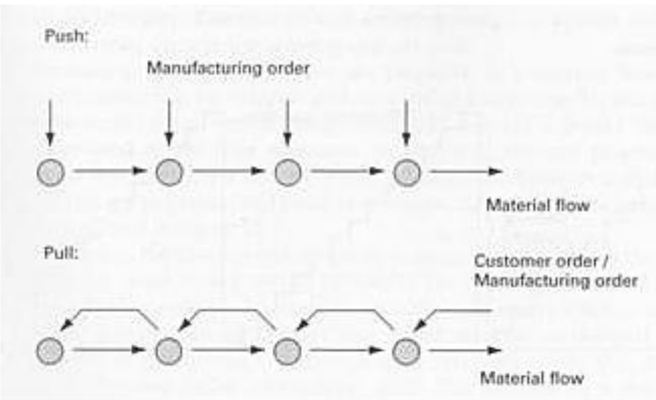


Figure 14 - Push and pull based management. Jonsson P., 2008. S. 269.

A method for re-order point can be either used by a consuming unit for replenishment of material - pull, or be used by a central materials management department to order for manufacturing to stock for future sales – push. (Jonsson, 2008)

3.4.1. STOCK TYPES

The ideal flow of materials is a continuous movement from suppliers to customers in the supply chain. However it is not possible to achieve ideal flows since the speed in sub flow parts varies in the total flow, due to the difference between supply and consumption rate. In general there are often interruptions in the movement of materials and the different sub-flows must be separated from each other to not disrupt the movement of other sub-flows. The function of different types of stocks is to help achieving this and stocks become integrated in the materials flow. The different types of stocks are following (Jonsson, 2008);

- *Cycle stocks* - These stocks arise when inbound deliveries occur at different rates and have larger quantities than the consumption. Every order, delivery and transportation is associated with ordering costs no matter the size of the quantity. The larger the order quantity the less ordering cost per unit. (Jonsson, 2008)
- *Safety stocks* - It is not possible to avoid disruptions in stock replenishment since deliveries can be delayed or the wrong amount of quantities to be received. It is also hard to predict the perfect future consumption. To avoid stocks being depleted to early if the demand may be higher than expected, safety stocks are used. (Jonsson, 2008)
- *Leveling stocks* - Sometimes the consumption of goods is dependent on seasons where there is more consumption during certain time period. However there is still in interest to have an even production flow. This type of stock is to decouple the production rate from the consumption rate, where the plan for production and sales is leveled. (Jonsson, 2008)
- *Work in process* - This stock of materials is in the process and are either being manufactured or in between two successive production resources. WIP is used to limit production disruptions and enables to separate the production rate between different parts in the production system. (Jonsson, 2008)
- *Co-ordination stocks* - This stock arise when simultaneous ordering of several items occur and when the delivery or ordering is regulated by a timetable. The purpose of this stock is to couple parallel flows of material. (Jonsson, 2008)
- *Synchronization stocks* - This stock arises due to imperfections in synchronizing demand, supply and material flows. An example is when items have to wait for other items concerning assembly. (Jonsson, 2008)
- *Speculation stocks* - This stock is a type of cycle stock, however its turnover I decoupled from expected short term consumption. The purpose with this stock is if there will be shortage of raw material or if future price increases. (Jonsson, 2008)
- *Obsolescence stocks* - This stock can be referred to as an inactive stock, where the goods in it are no longer expected to be consumed and are considered as scrap. (Jonsson, 2008)

3.5. INFORMATION FLOW

In order of making good decisions it is significant to have up-dated, complete and correct information. This is important in materials management, use of resources and generally managing industrial activities. There are four main groups of information systems that are used as tools for collecting and processing information; Planning-, communication-, identification systems and electronic marketplace. The three first mentioned are to be explained, the electronic marketplace concerns communication and transactions between purchasing and selling parties which is not included in this project. (Jonsson, 2008)

3.5.1. PLANNING SYSTEM

The planning system consists of two main types; the enterprise resource planning system (ERP) and other specialized and advanced types of systems such as; warehouse management systems (WMS), transport management systems (TMS) and advanced planning and scheduling systems (APS). The specialized systems does not have their own databases, instead they use data in a parallel ERP system. Recently the advanced and specialized types of systems have developed as integrated parts of ERP. (Jonsson, 2008)

3.5.1.1. ERP

This system provides and process information that is required for administrative management in a company as a database and a collection of software programs. The database is an integrated system; it is shared between all the program functions that give information for all business processes. (Jonsson, 2008) The value of the system is that it connects all the information flows within the company. (Fawcett et al 382) This provides every user to have access to the information that they need. (Jonsson, 2008) ERP enables organizations to view the operations as a whole instead of trying to put together pieces of different information by various functions. Figure 15 shows the functions of ERP. (Krajewski, et al., 2007)

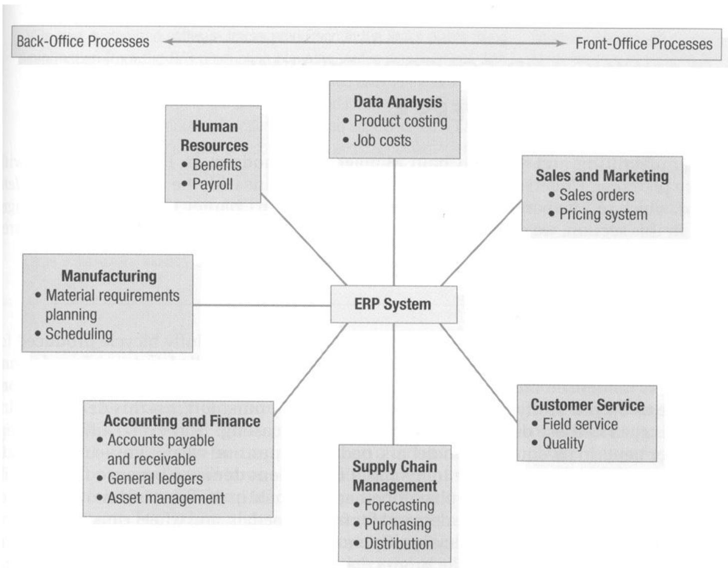


Figure 15 - ERP application modules. Krajewski, et al., 2007. S. 625.

3.5.1.2. Warehouse management system (WMS)

ERP supports planning and execution of materials flow, however sometimes some detail support is missing and therefore the system can be supplemented with a special designed system such as the WMS. The WMS contains support for storage activities, the most common functions are following (Jonsson, 2008);

- *Goods reception* – Incoming goods registration and automatic matching of purchase orders and advance shipment notice. Keeps track of whether goods should go to storage or as backorders.
- *Putting in stores* – Identification of optimal location for each product made by calculations
- *Stock management* – Updating of stock balance and enables tracking of goods
- *Order reception and order picking* – Automatic generation of picking orders and advance shipment notices when other parties signal demands
- Dispatch – picking orders generated by the system, labels and other documentation are printed for the goods that are to be delivered
- Materials management – re-order point calculations and generation of purchase orders

(Jonsson, 2008)

For optimal efficient use of WMS there are generally integration with systems for automatic data capture such as; bar codes, RFID and EDI, to be explained in the Communication system section. (Jonsson, 2008)

3.5.1.3. Transport management systems (TMS)

TMS is another type of special designed software. This system supports the transport planning with aim of optimizing total costs and delivery services. The functions in TMS are; design of transport network, transport optimization, route planning, load planning, manifesting and tracking and tracing. (Jonsson, 2008)

3.5.1.4. Advanced planning and scheduling systems (APS)

APS is a development of ERP that includes new knowledge about planning, logistics, IT etc. The aim is to support the materials flow planning through the entire supply chain. (Jonsson, 2008) The APS system includes plants, customers, warehouses, transportation etc. incorporating both temporal and spatial considerations. The major components of APS are; resource management, demand management, resource allocation and resource optimization. (Bowersox, et al., 2010) Several different terms are used to determine advanced planning and scheduling such as; advanced planning and optimization, advanced planning systems and supply chain planning. Following are the basic principles (Jonsson, 2008);

- Frequent re-planning in order to adapt to changes
- Priority and capacity planning in order to identify feasible plans
- Advanced mathematics and logical algorithms
- Optimization tools for the planning and decision making in order to identify the most feasible plans
- Business limitation consideration e.g. capacity, goals, material flow

- Scenario simulation
- Multi-site available
- Stock level and resource availability considerations during process planning in order to define the best total efficiency

3.5.1.5. Other systems

There are other systems that are used to support logistics and supply chain management, these are;

- *Labour management system (LMS)* – Demand-, capacity-, resource planning and considerations of shifts, breaks, workstations etc.
- *Supply-chain event management (SCEM*) – Targets deviations helping focus on daily planning.
- *Supply-chain visibility (SCV)* – Tools showing information of production status, stock levels, deviations etc. Usually built in to SCEM.
- *Customer relationship management (CRM)* – Supports marketing and sales processes.
- *Product content data management system (PCDM)* – Enables several business units to work with joint database

3.5.2. Communication system

There are different methods of communicating information internally and externally depending on between what parties the information is to be exchanged, if the information is processed online or offline, stationary or mobile and the quantity. (Jonsson, 2008)

3.5.2.1. EDI

EDI stands for electronic data interchange where data is transformed between different computer systems in a standardized and predefined format. (Jonsson, 2008) EDI is the most commonly used e-purchasing technology. EDI allows organizations to exchange information although they may have different software programs. Typical documents are invoices, payments information and purchase orders. (Krajewski, et al., 2007) There are different EDI standards such as (Jonsson, 2008);

- *Edifact* – A UN standard that stands for electronic data interchange for administration, commerce and transport
- *Odette* – Used within the automobile industry
- *Ansi X.12* – American EDI standard

The to-be transferred information is generated in a file in the transmitting ERP system and translated by EDI software into the Edifact standard. The file is then transferred to the receiving system by a telecommunication network where the converted file updates the ERP system register. EDI uses offline communication and the system is generally used between organizations that have a regular exchange since the introduction of EDI is expensive and the running costs are high. (Jonsson, 2008)

A combination of EDI and Internet, the so called web based EDI systems was created to facilitate the communication between the company and their smaller customers and suppliers.

With a web browser small companies are able to communicate with larger companies ERP-systems. (Jonsson, 2008)

3.5.2.2. EDA

EDA stands for electronic data access and makes some ERP system parts accessible to customers and suppliers. This provides an online communication with the company's database where the customers and suppliers can maintain their systems data about their products and companies. The customers can enter orders in the suppliers system, the suppliers can administrate the stock in the customers system and also being able to book transportation. The investments for EDA are low compared to EDI. The advantages of this method is that separate activities can be reduced in the company's resource planning leading to reduced cycle times. (Jonsson, 2008)

3.5.2.3. Internet

The availability and spread of the Internet and the communication interfaces by browsers has expanded the opportunities of information exchange between companies. The internet has quickly become the tools for exchanging forecasts, product updates, orders etc. (Bowersox, et al., 2010) Extranet are internet sites that provide limited access to certain business partners. Portals provides updated information often within the own company, but sometimes public as well. Suppliers and customers can log on to the specific portal and access stock levels, forecasts and other information of interest. Exchanging data between websites and the company's ERP system has the same character as EDA and is relatively inexpensive to establish. (Jonsson, 2008)

3.5.3. Identification system

Communication technologies are significant in the planning and operations of logistics. (Bowersox, et al., 2010)The aim is to enable automatic data capture or identifying products and transfer that data into a computer minimizing the manual handling. Advantages are less registration errors, higher speed of item registration and releasing personnel from manual registration work. The identification systems differ in the way that they are built upon different technologies, the atomization and what type of information they can transmit. (Jonsson, 2008)

3.5.3.1. Bar codes

Bar coding and electronic scanning are auto identification systems that were developed to support the exchange and collection of information. The most common purposes are tracking warehouse receipts and retail sales. This system requires large capital investment, however it decreases errors and time consuming manual paper work. Auto identification enables the communication of movement and quickly tracking of objects. (Bowersox, et al., 2010)

Bar codes are computer readable codes that are placed on items, pallets, cartons etc. The bar codes are based on line symbols that represent different numeric characters. The two most common types of bar codes are European Article Numbering (EAN), see Figure 16, and Universal Product Code (UPC). There is also a two dimensional bar code that is used for a large amount of information that handles approximately one A4 of full text information. The most commonly used, two dimensional bar code is PDF 417, see Figure 17. (Jonsson, 2008)

Figure 16 - EAN streckkod.se

Figure 17 - PDF417 streckkod.se

The scanning process which is another part within auto identification optically collects the data on the bar code into usable information. There are two types of scanners which both manage contact or noncontact technology; handheld and fixed position. The handheld are laser guns (non contact) and wands (contact), the fixed position are automatic scanners or card readers. (Bowersox, et al., 2010)

3.5.3.2. RFID

RFID stands for Radio Frequency Identification, it is a form of the radio frequency technology and uses radio waves to identify objects. (Jonsson, 2008; Bowersox, et al., 2010) The object is attached with an electronic microchip that stores the information and a reader transforms the radio waves into information in the computer. (Jonsson, 2008) RFID can be used on containers or for single products when they are being transported or moved in a facility. (Bowersox, et al., 2010) The advantage of using RFID compared to bar codes and scanners is that a microchip is able to store a lot more information and the time for reading the information is a lot shorter than for other identification systems, since RFID enables to identify a whole truck load at the same time. (Jonsson, 2008)

3.6. Lean

The Lean philosophy is basically about eliminating waste time and resources, build-in quality, building a learning culture for continuous improvement, finding low costs without compromising on the quality and perfecting the business process. (Liker, 2004) Lean originates from Toyotas Production system (TPS) and the term emerged in 1988 by Krafcik. Lean production means resource efficient production with a philosophy to eliminate everything that is not value-added in the value chain. The general idea is to reduce waste (muda) and add value. Transport, inventory, handling, wait time are all waste time. Using value analysis and other techniques to question the process adequacy is important in Lean.

Developing better layout to reduce transportation, striving to have one piece flows to reach production leveling and shortening set-up times and throughput times, all these contribute to waste reduction. (Bellgran & Säfsen, 2004)

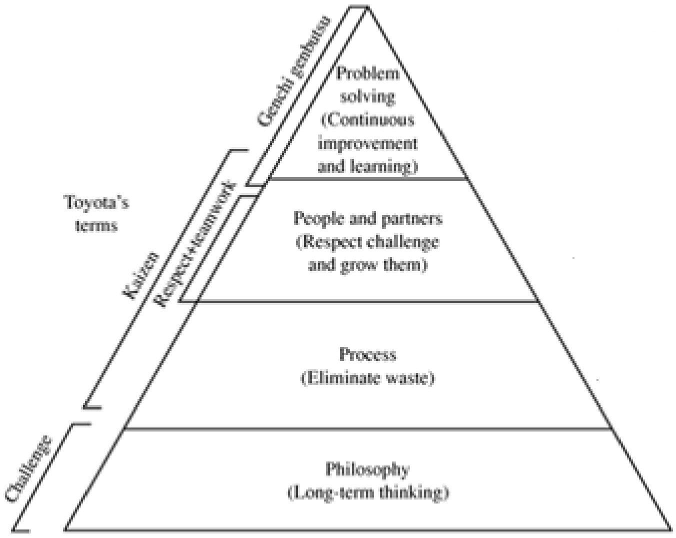


Figure 18 - The 4P model. Liker, 2004. S. 13

The advatages of using Lean is stronger profitability and competitiveness by increased flexibility and productivity. However Lean is not something that is just impelemented, it is an approach and a culture – a long term philosophy. (Petersson, et al., 2009; Liker, 2004) There are 14 Lean principles that can be divided in to the 4P model, they are the foundation of the Toyota Production System (TPS). The four main principle groups are the philosophy, process, people and partners and problem solving, Figure 18 illustrates this. (Liker, 2004)

Figure 19 - The TPS house. Liker, 2004. S. 33.

The Toyota production system (TPS) is a unique approach for manufacturing and is the basis for lean production. A simple representation of TPS was developed, a house to show the structural system. Figure 19 shows the TPS House diagram. The roof shows the goals; low costs, best quality and short lead times. The pillars are Just- in- Time (right part, right amount, right time) and Jidoka (in station quality). The foundation consists of Heijunka which stands for leveled production and also reliable, standardized and stable process. Within the house is the core; people, waste reduction and continuous improvement. The TPS is not a tool, it is a structured production system that supports the people to continuously improve the process. (Liker, 2004)

JIT is one of the pillars in the Lean house and is a number of tools, principles and techniques that helps producing small batches of products with short lead times with the aim of meeting the specific customer needs. JIT includes the continuous flow and pull systems that are to be described below. (Liker, 2004)

3.6.1. *Lean Principles*

There are 14 lean principles in the lean philosophy described by Liker (2004), however the principles described below are the ones that I find concerns this project most.

3.6.1.1. Continuous process flow

The lean principle of continuous flow aims materials and products to be in constant movement, which in reality is hard to achieve. However the goal should be to strive for a continuous flow as possible to minimize stops and the time of stopping. All time for stops are waste time and contributes to longer lead-time which in its turn leads to higher costs and decreased flexibility against the customer, stops in the production process also requires more space. To achieve as continuous flow as possible a company should strive to have; short distance between operations, small buffers, small packaging units and frequent transports. (Petersson et.al. 2009)

A buffer is a defined intermediate storage for products in work or work in process (WIP) or products in queue, and causes a stop in the flow which prolongs the lead time. Intermediate storage is necessary to compensate for losses in the flow, but should however be as small as possible. To define the cause behind the existence of a buffer it is important to define the deviations and the opportunities. An example of the need for intermediate storage is long set up times which in their turn lead to large batch sizes. The optimal continuous flow strives for one part batch size. The amount of items in one package is also an important factor, if one package contains 100 items then the first item to be packed will need to wait there until all the other items are packed. Minimizing the packing size also helps reaching a more continuous flow. Being able to reach smaller packing sizes the transportation needs to increase, if the packing size is halved but the transportation does not increase then there are no gain to the flow. In an ideal flow the items are transported one by one to the following operation e.g. on a conveyer or transporter. (Petersson et.al. 2009)

3.6.1.2. Pull systems

A pull system means that items are received based on the demand. (Liker, 2004) The production does not start until the following step in the process signals a demand. (Petersson et.al. 2009) Many companies produce products based on their own schedule and push the products on to their customers who will get a bigger inventory. Lean is not about managing inventory, it is about eliminating it. The pull system is the ideal state of JIT production, giving the customer the right product, at the right time and amount. The customer in this case can be the next step in the production process. The ultimate pull flow is one piece flow with zero inventories, however it more realistic that some breaks will occur and therefore some inventory is necessary. (Liker, 2004) A way to signal the demand between processes is by using Kanban, to be described more under the Kanban headline. A short description is that it is a visual signal – a sign, card etc. The main qualifications for the Kanban to be of advantage is; having high and even demand, short replacement times and physically small details. (Petersson et.al. 2009)

3.6.1.3. Level out the workload (Heijunka)

Heijunka is about leveling production volumes and the product mix, by taking the total orders volume during a period and leveling it out so the same mix and amount are produced each day. (Liker, 2004) In terms of planning the flow must be as even as possible over time, and by achieving that the advantages will be; effective tact time, high and even quality- and utilization of resources. In the perfect flow there are no stress factors and the work pace is smooth and harmonious. (Petersson, et al., 2009)

3.6.1.4. Stopping the process to build in quality (Jidoka)

Jidoka means building in quality to the product by securing things being done right from the first time and stopping the process if something goes wrong. It is about creating predictability of the product quality. The main principles of Jidoka are; stopping when errors occur and building in quality. (Petersson, et al., 2009) A method is needed to detect errors and to automatically stop the process (Liker, 2004), but having also the right knowledge and an established approach. (Petersson, et al., 2009) Jidoka can be compared to automation, by using intelligent equipment that stops itself when problems occur (Liker, 2004), making it possible to continuously ensure the product quality. (Petersson, et al., 2009)

3.6.1.5. Standardization

It is hard to improve a process if the tasks in it are not standardized. The process must be stabilized before making continuous improvements otherwise the improvements here and there will be just another variation. Standardization is also the key to build in quality, if standardized work is followed but errors still occur then the standards need to be changed. As written in the Toyota Way by Liker, the quality cannot be guaranteed without standard procedures and this is something a good quality manager should know. The quality procedures should be simple enough to be used on a daily basis. (Liker, 2004)

3.6.1.6. Visual control

This principle aims at making problems visual by using simple visual indicators to determine if standard is followed, design visual systems where the work is performed in order to support pull flow and reduce the amount of reports, if possible to a one piece paper. Visual control is also about having a clean and well organized work place and eliminating waste, which can be performed by using the 5S; Sort, Straighten, Shine, Standardize and Sustain, to be described under the Lean Tools chapter. (Liker, 2004)

3.6.1.7. Reliable and thoroughly tested technology

New technology should only be introduced after being well tested and thoroughly evaluated, and it should provide added value. An analysis should be done on the impact the technology will have on the processes, by analysis the current value added work and looking for new opportunities to even out the flow and eliminate waste. Before introducing new technology the company should try all possibilities to improve the process with current resources. The new technology should support the continuous flow in the process and the people working in it. (Liker, 2004)

3.6.1.8. Develop exceptional people and teams

The importance of teamwork is inevitable, however it is the individuals who create added value. Teams coordinate the work, encourage and learn from each other, and the individual performs the detailed work. There should be a balance between individual excellence and team effectiveness, creating teams by great individual performers. Making teamwork the foundation in a company will make individuals give more to reach company success. (Liker, 2004)

3.6.1.9. Go see for yourself (Genchi Genbutchu)

There is a great value in go seeing by yourself where the problems occur. This is the first step in problem solving situations. It is significant to understand all aspects of the situation. Assumptions and claims should only be made on proved and verified information, based on confirming the facts yourself and also taking advantage of others knowledge. (Liker, 2004)

3.6.2. 7 WASTES

There are seven main wastes that have been identified by Toyota that are non value adding, and there is also another eighth waste defined by Liker (2004) included in the list below.

1. *Overproduction* - Items that are not produced to order generate waste as overstaffing, storage and transportation costs due to excess inventory.
2. *Waiting (time on hand)* - Workers that have no work to do because of equipment downtime, stock-outs and bottlenecks, or workers waiting for the next process or watching an automated machine.
3. *Unnecessary transport or conveyance* - Handling work in process during long distances, moving materials in and out of storage or between processes, or creating inefficient transport.
4. *Over processing or incorrect processing* - Inefficient processing due to poor tools, unnecessary activities or producing products with higher quality than needed.
5. *Excess inventory* - Redundancy in material flow causes obsolescence, long lead times, storage costs etc. generated by late deliveries, break downs, defects and production imbalance.
6. *Unnecessary movement* - This refers to waste movement such as walking, reaching for, searching for, stacking etc.
7. *Defects* - Production of damaged parts involving scrap, rework and repair, and inspection causing waste time.
8. *Unused employee creativity* – Not listening to or engaging the employees results in loss of ideas, time, skills, improvements and learning opportunities.

(Liker, 2004)

3.6.3. *Lean Tools*

Following headlines list lean tools that are used for improving the production process and materials flow.

3.6.3.1. Data collection

One of the most important steps in improvement work is data collection and facts. The basis for decision making is important when highlighting the current issue. It is important to collect the right type of data and in the right way, and to do so it is important to know the purpose of the data collection. (Bergman & Klefsjö, 2007)

3.6.3.2. PDCA

PDCA, also called Deming Wheel, stands for Plan-Do-Check-Act and is a continuous improvement tool that is used for problem solving among teams.

- *Plan* – A process or activity that needs improving is selected by the team. The process is documented by analyzing data, then goals are set and a plan is made for achieving the goals.
- *Do* – The plan is implemented and the progress is being monitored. Improvements are measured by continuously collecting data and documenting changes in the process.
- *Check* – Data collected during the Do step is analyzed and compared to the goals set in the Plan step. If the results don't correspond to the goals the plan is reevaluated.
- *Act* – Is the results are successful the process is documented and becomes a standard procedure for those who will use it.

(Krajewski, et al., 2007; Petersson, et al., 2009)

3.6.3.3. 5S

5S is a basic tool for organizing at the company and concerns safety and quality. Sometimes this tool is compared by cleaning, however it is a mindset about working at a well organized and functional company. 5S consists of five elements;

1. *Sort* – Tools, materials etc. are sorted, the aim is to define how often the objects are used and throw away what is not used. It is good to classify the objects by frequency.
2. *Simplify* – define a place for everything, where the object is best used. This helps the daily work by avoiding to search for papers or tools and quickly being able to identify is something is missing.
3. *Sweep* – This means controlling everything is in its place and cleaning up the mess.
4. *Standardize* – This can only be performed when the three first S's are done. In this step it is decided how something should be performed e.g. how to order, location for specific objects etc. the standard should be easy to follow and understand.
5. *Sustain* – This step is about self discipline, managing to maintain the standards, always participate and make improvements.

(Bicheno, 2004; Petersson, et al., 2009)

3.6.3.4. Supermarkets and FIFO Lanes

The ideal in lean is one piece flow, but traditionally there is inventory before and after workstations waiting to be moved. To enable the material handler to visit regularly, the supermarket areas should be grouped together, by supermarket meaning the material handler goes shopping for parts. Supermarkets usually take form at the boundary between pull loops, referred to value stream mapping where the value streams meets. Having WIP between workstations is allowed as long as it is controlled by Kanban or CONWIP (Constant Work In Process) – both to be explained further down in the report. (Bicheno, 2004)

FIFO Lanes together with supermarkets requires more space, but are good for housekeeping and visibility and helps avoid date sensitive inventory problems. Inventory is brought at one end and removed at the other, and monitored by colors or dates. (Bicheno, 2004)

3.6.3.5. Kanban

Kanban is a Japanese word meaning visible record and is referring to the control of a production flow by using cards. The most basic type of Kanban is attaching a card to every container of produced items where each container has a certain percent of an items daily production. When the container is being emptied the card is removed and attached to a receiving post. The empty container is moved to a storage area and the card shows a signal that a new container needs to be produced for the specific item. (Krajewski, et al., 2007) Figure 20 illustrates a single card kanban system.

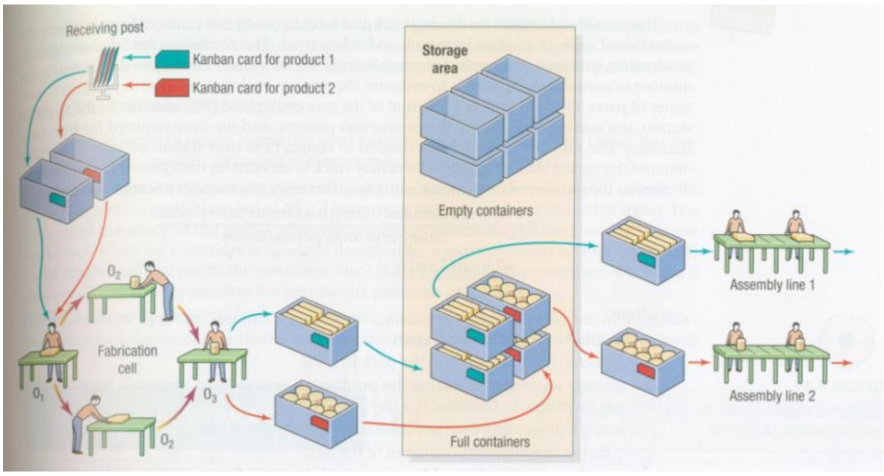


Figure 20 - Single-card Kanban system. Krajewski, et al., 2007. S. 357.

3.6.3.6. CONWIP

Constant Work In Process links the processes of a product by a multi stage signal system and it is a pull oriented production control system. Unlike Kanban where the cards operate between two stations, the cards follow the product or batch through all the stages. When the product is completed the card is sent from the last process to the first indicating start of a new product. (Bicheno, 2004)

3.7. PRODUCTION CONCEPTS AND MATHEMATICAL MODELS

A production consists of several activities such as processing, assembly operations etc. Activities between the operations are storage, material handling etc. These activities can be divided into two categories called; operations and non operations, where the non operations are simply sources of delay. Different production concepts are to be described below. The characters used in the calculations are listed (Audo, 2013);

T_o = operation time
T_{no} = non operation time
T_{su} = set up time
N_m = no of machines/operations
Q = no of units in batch
i = operation sequence
W = Work centers or operators
Sw = Shifts/Week
H = Hours
Dw = Weekly demand

3.7.1. MANUFACTURING LEAD TIME (MLT)

MLT is the total time required to process a product through the plant. This time defines in general how long it takes for the product to reach the customer and since today's business are quite competitive companies strive to keep it as low as possible by e.g. automated manufacturing. The formula for MLT is expressed as (Audo, 2013);

MLT = $\sum_{i=1}^{nm}(Tsui + QTo + Tnoi)$

If all operation times, non operation times and set up times are equal the following formula can be used;

MLT = $n_m(Tsui + QTo + Tnoi)$

3.7.2. PRODUCTION RATE (RP)

The production rate is usually expressed in hours. In automation high productivity is important and focuses on reducing all the nonoperational times such as set up, handling, processing and tool change. For batch production the following formulas are used (Audo, 2013);

Batch time/machine = Tsu+QTo

Tp (Average production time/unit) = $\frac{\text{(batch time/machine)}}{Q}$

Rp (Average production rate for the machine) =$\frac{1}{Tp}$

For job shop production if Q=1 the following formula is used;

Tp = Tsu+To

3.7.3. PLANT CAPACITY (PC)

Plant capacity (or production capacity) aims to define the maximal rate of output a plant can produce. It is related to the production rate and the operating conditions are associated with no of shifts per day, no of hours per shift, no of operators etc. the capacity is usually measured by the output of the plant, however sometimes input units may be more appropriate e.g. for job shops the capacity can be measured by available labor or machine hours. Formulas that are used for measuring the capacity are (Audo, 2013);

PC = WSwHRp

If measuring the production capacity for a batch production the formula should be divided by no of machines a product in the batch h has to go through. The capacity calculation can also be used to calculate the amount of resources to be allocated to meet a certain weekly demand rate (Audo, 2013);

$$WSwH=\frac{DwNm}{Rp}$$

By having a certain hourly production rate there are three ways to readjust the production capacity in order to meet the weekly demand (Audo, 2013);

1. Change no of work centers or operators (W) in the shop e.g. by hiring new workers or use new machines.
2. Change no of shifts per week (Sw) e.g. by establishing evening or Saturday shifts.
3. Change no of hours per shift (H) e.g. by establishing overtime.

3.7.4. UTILIZATION

Utilization is a production concept that measures the amount of output relative to the capacity, as well as how well resources are being used. If utilization is low then the facility is not operating at its full capacity and if utilization is high then the company should increase its capacity (Audo, 2013).

U = Output/Capacity

3.7.5. WORK IN PROCESS (WIP)

WIP refers to the amount of products currently being processed or being between operations. WIP is inventory that is going through change from raw material to finished product and is often a high cost for the company. There is a general focus in companies of reducing WIP often by automating their operations. Following formula is used (Audo, 2013);

$$WIP=\frac{MLT(PC*U)}{SwH}$$

3.8. FLOW RELATED METRICS

The goal of logistics is to create good delivery service at low costs, therefore it is interesting to measure costs and delivery service. There are four measurable service delivery elements; lead time, stock availability, supply availability and delivery reliability. It is also important to measure costs, however it may be difficult at an early state to know which costs are relevant for the analysis. (Oskarsson, et al., 2006)

3.8.1. TIED-UP CAPITAL RELATED METRICS

One costs element that is always affected by logistics changes is the warehousing cost, for this the tied-up capital cost needs to be known in the flow. When doing flow analysis it is the average capital tied up that is interesting and therefore the average stock needs to be known. With steady demand the order is same every time and the inventory curve is repeatedly saw-tooth shaped. Cyclic demand which represents season variations looks alike but not as quite rectilinearly. The ideal inventory curve looks like saw-teeth's and is easier to calculate by using the following formula;

ASL (Average stock level) = SS+ $\frac{Q}{2}$

SS = Safety stock

Q = Order quantity

However if it is not possible to calculate the average inventory with this formula then it is possible to use measured data of the inventory levels for a specific time period e.g. measurements for an article at the end of every week and just calculate the average.

How much capital tied up there is depends on the value of the products, given that the product value is p the average inventory value, ASV, is calculated by;

ASV = p x ASN

Materials that are in process is not called inventory, even though they may be still for a long time period. It is interesting to find out how much they are worth and are called WIP (work in process, Swedish PIA). The average WIP is defined for a specific production section, the time it takes for the product to go through the whole section. Since the value of a product increases during production an average product value (p_a) is used. (Oskarsson, et al., 2006)

Average WIP = D*TT

D = Demand

TT = Throughput time

Average WIP value = p_m * Average WIP

$p_a = \frac{Pin+Pout}{2}$

3.8.2. *TIME RELATED METRICS*

Reducing times often leads to positive costs and delivery service effects and time unit is also suitable for describing and analyzing flows.

Lead time

The time from order placement to delivery receiving is the lead time of the process. Studying more in detail there are smaller ordering and delivery processes that has their own lead times. (Oskarsson, et al., 2006)

Throughput time

Throughput time describes the time it takes for a product to go through a flow section and can be measured for both small and bigger parts in the flow. Several throughput times builds one lead time or sometimes the opposite. To measure the throughput time in stock, the formula is (Oskarsson, et al., 2006);

Throughput time = ASL/D (pcs) or ASV/D (SEK)

Inventory turnover

Inventory turnover = D(pcs)/MLN or D(kr)/MLV

If the throughput time is measured in weeks then;

Inventory turnover = 52/Throughput time (v)

The average inventory turnover can be calculated in three different ways; the total value, total amount or unweighted. (Oskarsson, et al., 2006)

3.8.3. *SERVICE RELATED METRICS*

Earlier mentioned it is important to satisfy the customer's expectations on the company's service ability and therefore it is interesting to measure this. Following three service related metrics measures the service level (Oskarsson, et al., 2006).

Inventory availability

Inventory availability described how many product that are in stock when the customer makes an order.

Inventory availability (%) = $\frac{\text{amount of delivered orders}}{total\ amount\ of\ orders} * 100$

Delivery reliability

Delivery reliability concerns the ability to deliver on time.

Delivery reliability (%) = $\frac{\text{amount of deliveries on time}}{total\ amount\ of\ deliveries} * 100$

Delivery dependability

Besides the importance of delivery on time it is also important to deliver the right amount at the right quantity and quality.

Delivery dependability (%) = $\frac{\text{amount of complete flawless deliveries}}{total\ amount\ of\ deliveries} * 100$

3.9. AUTOMATION STRATEGIES

A company can adopt certain strategies to improve their productivity concerning manufacturing operations. These strategies are often associated with automation technology. Below ten strategies are listed;

1. *Specialization of operations* - This strategy focuses on reaching highest possible efficiency level of performance for on specific operation by using special purpose equipment.
2. *Combined operations* - This strategy aims of reducing number of machines or workstations through where a product part must go through, by performing more than one operation at a machine. By doing this the set up time is reduced since each machine requires setup and also the nonoperational- and material handling time.
3. *Simultaneous operations* - This strategy aims to perform operations simultaneously on the same work part at one workstation.
4. *Integration of operations* -This strategy aims of linking several workstations together, by doing this numerous parts can be processed at the same time and increase the overall output. By linking workstations the number of machines can be decreased and automated handling equipment can be used to move parts between stations.
5. *Increased flexibility* - This strategy aims reducing the WIP and manufacturing lead-times by reducing the set up- and programming time for a machine. This is done by applying flexible automation concepts, using same equipment for several products and reaching to achieve maximum equipment utilization. The concept of increased flexibility suits well for job shop and medium volume production.
6. *Improved material handling and storage* -This strategy focus lies on reducing the WIP and manufacturing lead times by using automated material handling and storage systems.
7. *On-line inspection* - This strategy aims to increase the quality of the product and reduce scrap by establishing the inspection during the manufacturing process instead of doing it after when the products are already produced.
8. *Process control and optimization* - This strategy aims improving product quality and reducing process time by using a wide range of control schemes for the individual process.
9. *Plant operations control* - This strategy focuses on controlling the whole plant by using a high level of computer network within the factory.
10. *Computer integrated manufacturing (CIM*) - CIM implies integration between all the different business function within the company by extensive use of computer databases, applications and networks.

(Audo Sabah, 2013)

3.10. Analysis tools

The following tools are used for analyzing, in this project they have been used to analyze the current state data.

3.10.1. SWOT

SWOT is a strategic analysis tool and the aim is to find a match between the strategy and resources of the company and the business environment. It is a decision making tool that helps determining the internal factors such as Strengths and Weaknesses, and the external factors such as Opportunities and Threats. (Burns, 2007)

Figure 21 illustrates a matrix of the SWOT factors.

Figure 21 – SWOT matrix

3.10.2. Pareto chart

The Pareto chart is helpful to identify the most important set of factors among a lot of others. In quality control they show the most common source of defects, most common occurring type of defect etc. The Pareto chart helps to decide what problem is the most severe and needs to be handled first. By using this chart the problems are organized and can be systematically resolved. (Bergman & Klefsjö, 2007) Many companies experience a variance in profitability and volume across product lines. 20 percent of all products may account for 80 percent of the total profit, this is the so called Pareto principle or 80/20 rule. To avoid these companies must implement inventory strategies based on fine-line product classification. (Bowersox, et al., 2010)

4. CURRENT STATE ANALYSIS

4.1. Production planning

There are many factors involved when comes to production planning and a broad view of the whole supply chain is needed. Although this project involves the Inbound process the incoming flow of materials is at a high degree determined by the planning process.

4.1.1. The planning system

Below follows a short description of the company's system and planning process to give an understanding of the information- and incoming material flow in the warehouse.

4.1.1.1. SPIS

SPIS is the company's ERP system that stands for Spare Parts Information System and is the main frame system developed in the late seventies. Shortly described the system handles materials management, warehouse management and ordering and billing. The functions of SPIS are; the procurement system (materials management), order system (SPIS, SOI, MMI), inbound (goods receiving, quality control, binning), outbound (pick & pack, shipping), and other (stocktaking, returns etc.). SPIS contains approximately one million parts numbers, having 75 000 active parts numbers in Eskilstuna. There are also many other systems that supports the processes of SPIS such as SAP for financial transactions. (Andersson, 2013)

The systems network at the company is illustrated by Figure 22.

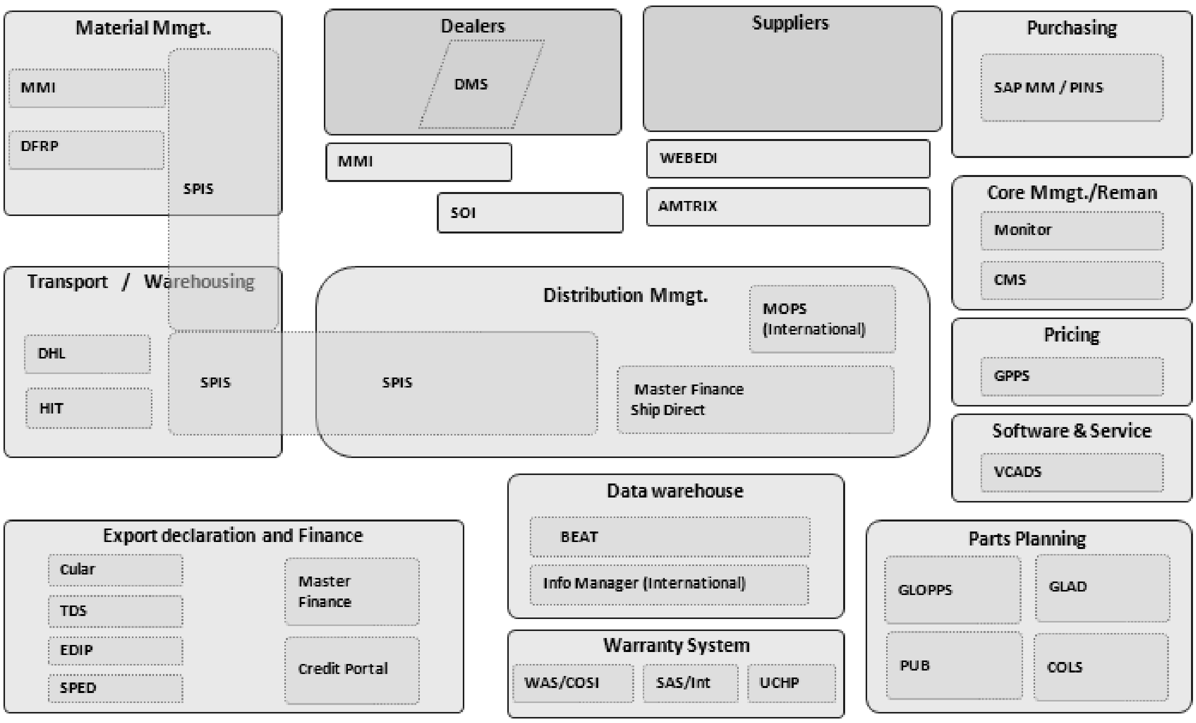


Figure 22 - IT landscape at GTO. SPIS System, 2013. Pp. 4.

4.1.1.2. Communication systems

All EDI traffic within the company goes through a software that works as a EDI-transmission that sorts the information. There are several different communication systems that are used where the main EDI traffic consists of delivery plans. There are two ways for the supplier where the supplier either uses full EDI where the EDI-file loads from SPIS into their system or by using web based EDI. (Andersson, 2013)

Figure 23 illustrates the communication system at the company.

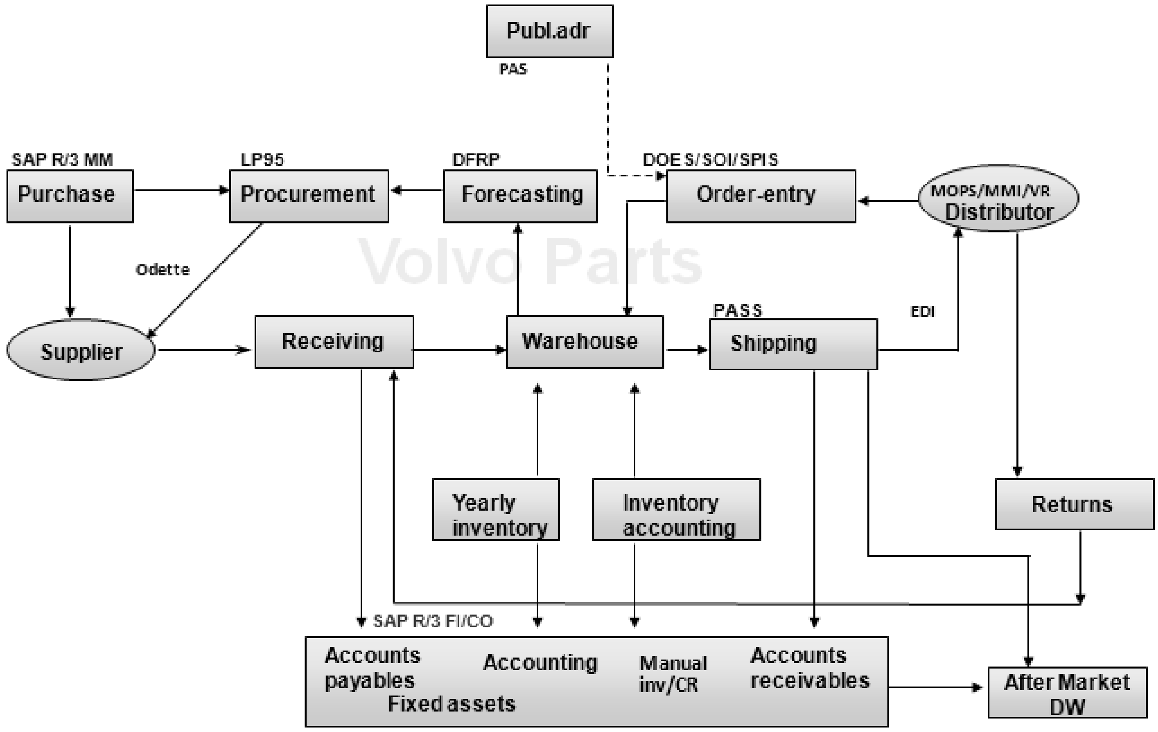


Figure 23 - System overview at GTO. SPIS system, 2013. Pp. 7.

4.1.2. *FORECASTING AND FLOW PLANNING*

The flow planning aims to plan overall material flow of spare parts to achieve the right customer service with the right mix of cost and inventory. The flow planner makes decisions based on changes in demand patterns for the central warehouse regarding forecast, sales and stock value in order to optimize stock and availability. They analyze the flow and identifies bottlenecks, making action plans to maintain the planned goal. Flow planning spans over three to six months period and is made every month, having a total supply chain visibility from demand to supply. (Jern, 2013)

4.1.3. *MATERIAL PLANNING*

The material planning order articles based on the forecasts developed by the flow planners using SPIS, but also studying the sales and the stock, looking back three periods depending on if it is regular articles or seasonally. They also study the safety stock and purchase point. They must have in mind that spare parts should be available for 10 years ahead and also "cleaning out" products that are to be replaced by new ones. The service level goal is about 94%. (Jern, Sigg & Eriksson, 2013)

4.2. INBOUND PRODUCTION PROCESS

The Inbound department consists of three sub-departments; the Goods reception, the Pre-pack and the Binning. There are roughly two general types of flows; one where articles arrive at the Goods reception and then go straight to the storage, and another where articles arrive at the Goods reception, then have to be repackaged into Volvo boxes at the Pre-pack department and then go to storage. There is also a third type of flow that concerns articles that goes to Pihls, it is excluded in this project, however these products arrive at the Goods reception so they have been defined when sorting data from the BEAT-report.

The material reports are organized in three types of statuses; the High priority (HP, “red”), the Priority and the ordinary (“green”). The high priority articles are the ones that are out of storage and the customer needs immediately, the priority articles are out of storage, but the customer doesn’t need them yet, and the ordinary has a normal flow priority since there are articles in storage. An example of a material report and reading instruction of it can be seen in Appendix 3.

Figure 24 shows the layout of the warehouse.

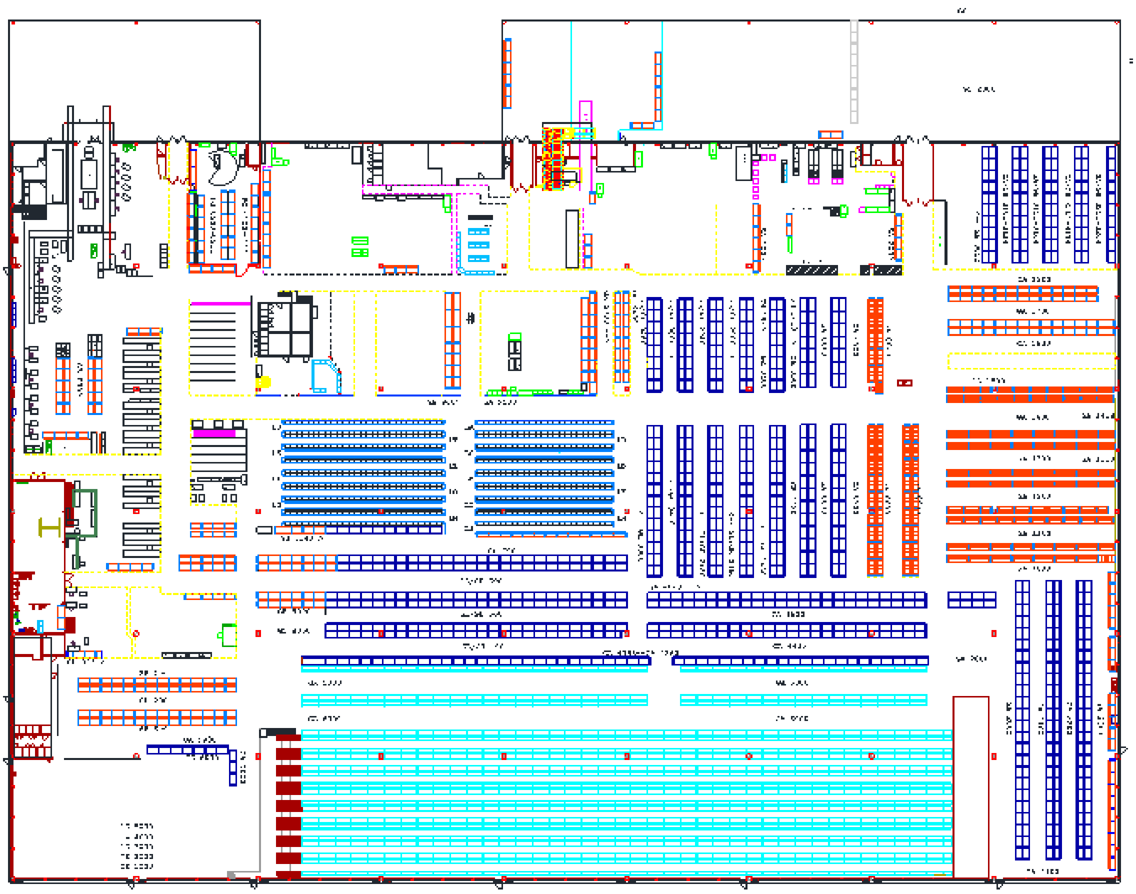


Figure 24 - Warehouse layout map, Sandell Tomas, 2013.

The Figure 25 shows a diagram over the materials flow at the Inbound department.

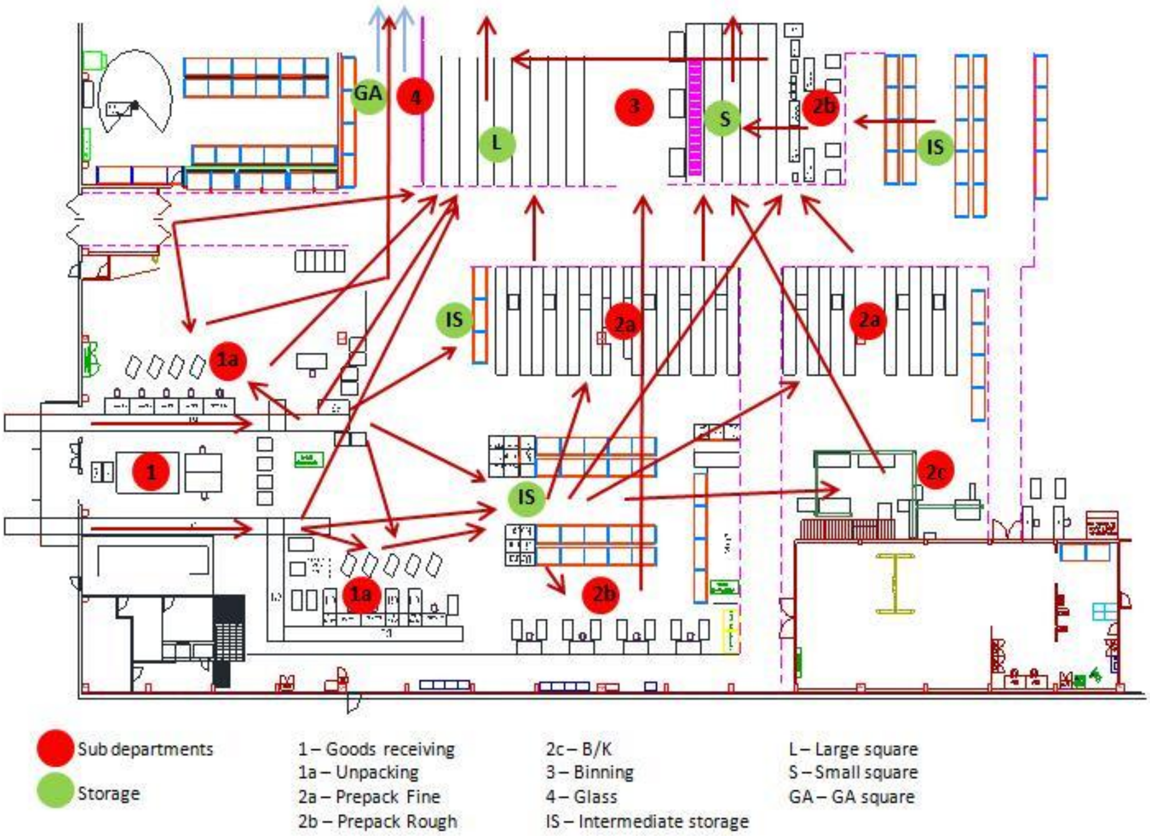


Figure 25 - Diagram of the materials flow at Inbound

4.2.1. GOODS RECEPTION

The Goods reception has four gates, where two gates have conveyers and receives relatively small goods, one gate receives bulky goods and one gate receives large goods such as engines that go straight to the storage shelf. Each gate has unpacking stations for articles that arrives in pallets with mixed MRs, where the operator sorts each MR into new pallets depending on the status of the MR, code number and bin location. The goods receiving also has a control station for articles that lack the correct type of information, this is often the case for new articles where weight, code or bin location is missing.

The Goods reception has a service forklift that keeps track on what pallets should go where, sorting them into the right places. These places are the intermediate storage (IS), the small/large/GA (S/L/GA) squares, the yard, the B-crane, control station, unpacking station. The service forklift also serves as sorting empty pallets, getting packaging material, driving away scrap etc. Frankly there is no standard on what activities there are, since the operator takes care of them himself and is very flexible on what should be done next.

Figure 26 illustrates the layout of the Goods reception department.

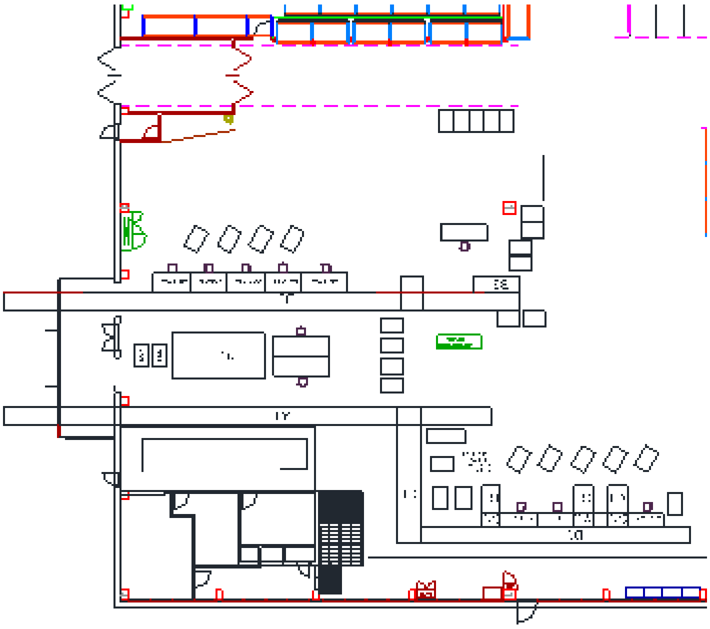


Figure 26 - Layout of Goods reception department

4.2.2. *PRE-PACK*

The Pre-pack department is roughly organized in two ways; the Fine or Line (“Banan”) that handles goods that weighs 0-3 kg, and the Rough that handles goods of 3-18 kg weight. In the Rough station the Glass pre-packing is included. The Glass station is located in the other end of the building, close to gate 4 and the GA storage. Between the Goods reception and Pre-pack there is an intermediate storage since the Goods reception department produces articles at a higher rate than the Pre-pack department.

Digging deeper into the Pre-pack department we find that the Fine line is organized into “green” and high priority (HP) benches, and also a bag station and one station called “Krympen” which handles 0-3 kg articles that needs to be packaged into brown boxes, while the other ordinary Fine articles are packed into blue boxes. There is also one bag machine that is not being used. The Fine line has 11 benches where one bench is for fast work and three for high priority MR. The Rough station in Pre-pack is organized by two ways; where the benches 6-8 handles pallets with maximum 10 items in order to produce faster, and the benches 1-5 handles all the other pallets. The operators at bench 6-8 drive the pallets by themselves to the binning squares, while the benches 1-5 leave the pallets for the service forklift to pick up. All the pallets at the Fine benches are served and picked up by the service forklift, however sometime the operators use a hand forklift and leave the pallets to the small square by themselves.

Figure 27 illustrates the layout of the Pre-pack department.

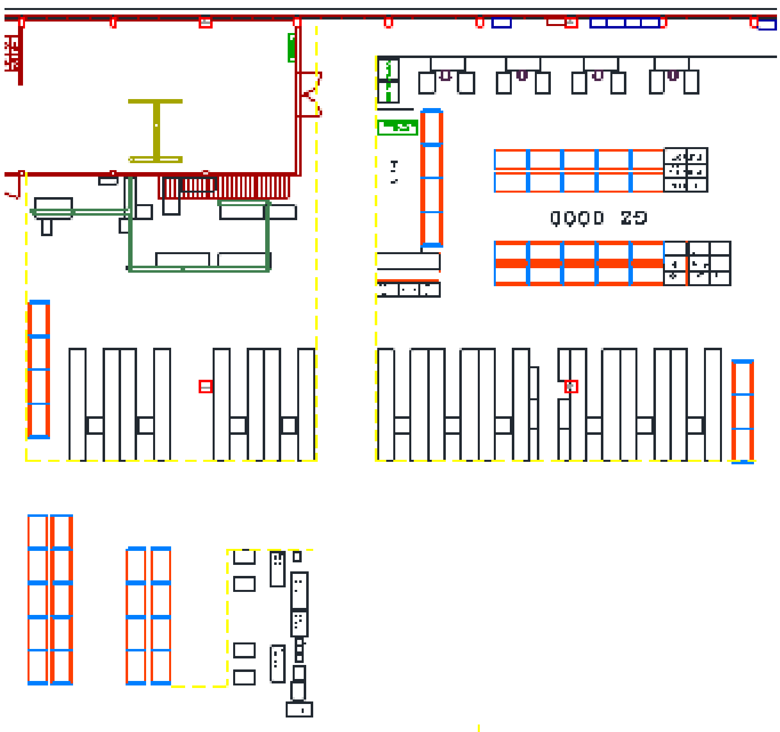


Figure 27 - Layout of Pre-pack department

4.2.3. *BINNING*

At the binning station there are two different types of forklifts that are being used; pallet stacker and picking forklift. The pallet stacker bins pallets from the L and GA square to following bin locations; GA, GH, GL, GB and XXX. The picking forklift is used for pallets with multiple articles at the S square to bin to H/L A-U storage. There is also a third forklift, a stand-on stacker that is used for sorting at the L/H area.

There is also a sorting station that has one operator who sorts the MRs in the mixed pallets from S and sometimes L square for the binning operators, into new pallets depending on the binning route. This is done for the H/L A-U storage where one pallet can contain several different MRs. This operator has a very flexible position, which means that sorting the MRs is not the only work he performs. If there is time over and there are no pallets to sort, he will act as a service forklift picking up pallets from Pre-pack and bringing them to the squares, sort empty pallets, help the service forklift at GR to bring special pallets to the control department etc.

Figure 28 illustrates the layout of the Binning department.

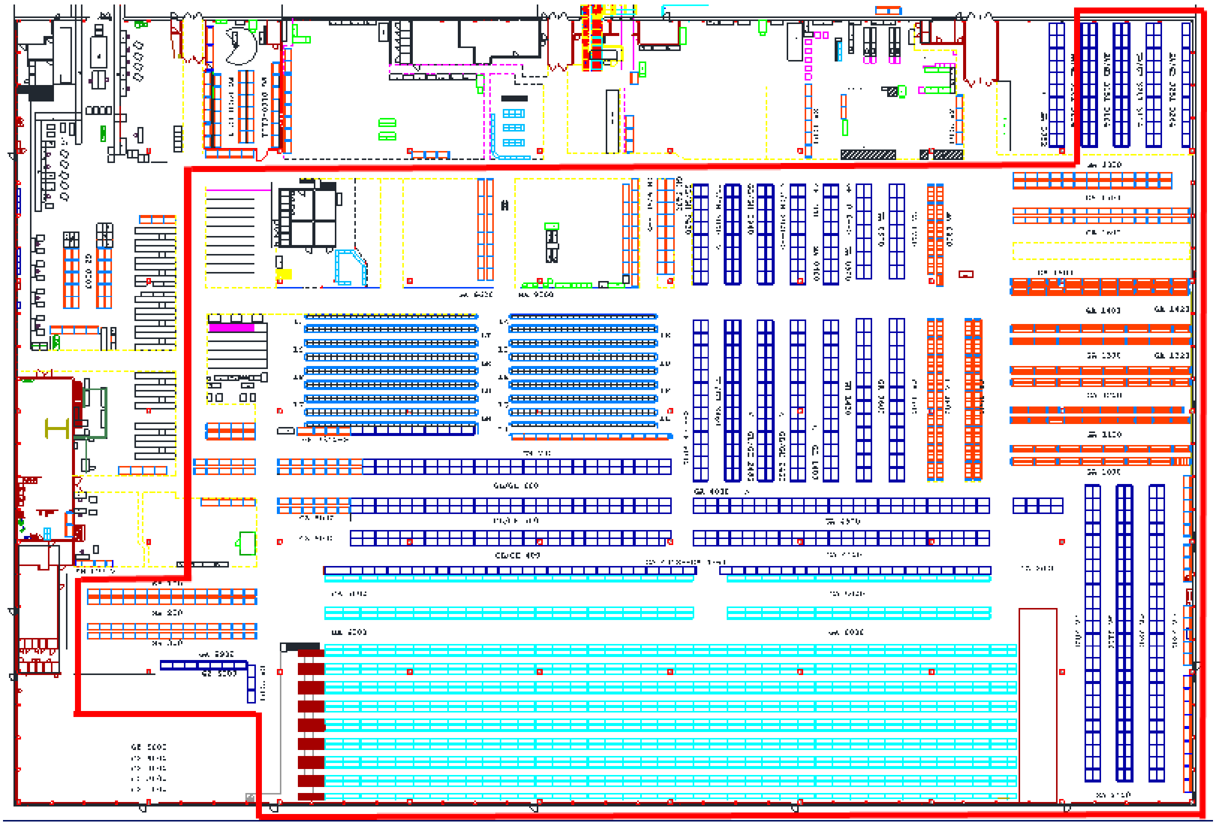


Figure 28 - Layout of Binning department

4.2.4. Intermediate storage

There is an intermediate storage (IS) between the Goods reception and the Pre-pack department that stores pallets with goods that are to be repackaged. The goods are organized by ordinary and high priority (HP) labels, where high priority pallets are to be handled first and then the ordinary pallets in date order. The pallets in the IS are controlled and handled by the Pre-pack service forklift operator who serves the Fine line operators, and moves and organizes the pallets within the IS. The IS consists of several storage points placed around the Pre-pack department. There is a vision of FIFO flow, however the high priority pallets affects this since they are prioritized first, making the "green" pallets wait.

Figure 29 illustrates pallets in the racking system in the IS.

Figure 29 – Pallets in racking in IS

4.3. VISUALIZATION TOOLS

Volvo has implemented 5S by organizing and giving a place for each item at each working bench. The pallets are labeled depending on type of article, storage point and priority, making it easier for the operators to handle. Figure 30 shows the labels that are used on the pallets, where the green are ordinary priority and the red ones are high priority.

Figure 30 - Pallet labels

Figure 31 shows another label that is used to ease the operators work by showing the date of arrival, the type of article and priority visualized by the colors red or green and also where the pallet should go.

Figure 31 - Pallet label

4.4. Product Flows

Since there are 75 000 active products at the DC in Eskilstuna it is appropriate to divide them into different groups that are more manageable. I chose to define product groups by the packaging codes since I noticed they had specific flows through the Inbound, but also had a good segmentation of the types of products in each packaging code, see Appendix 5, also shortly summarized in Table 2. Following product flows has been defined based on the packaging codes that are used, illustrated in Table 1.

	Codes					
Product flows	**Fine**	**Rough**	**Bag/K**	**Direct**	**Glass**	**Unknown/others**
	2 & 2A (wrong coded)	2G	7P(>40 pcs)	1 & 1A(wrong coded)	Product Group: 726, Glass & window:	2K
	5 & 5A (wrong coded)	5G	8P(>40 pcs)	4 & 4A (wrong coded)	Codes: 3, 3G, 4, 4A & 5G	3 & 3A (<18000g)
	7P(<40 pcs)	2B	9K		3G (ex. glass&window)	4G
	8P(<40 pcs)	5B	5K			Blanks

Table 1 - Table of packaging codes divided into product groups

Code List	
1. Article should not be packed	B. Cardboard
2. Pre pack <18 kg	G. Rough goods
3. Package externally >18kg, or Glass packaging (G)	K. "Krympen"
4. Packaged by supplier	P. Bag machine
5. Packaged by instruction	S. Kit
6. –	
7. Bag machine by instruction	
8. Pre pack in bag machine	
9. "Krympen"	

Table 2 – Table of codes

4.5. Data collection

The time has been measured together with the consultant Kim Gabrielson, using time keepers and special designed data sheets, see Appendix 2. Some times are secondary data, measured by Kim for a separate project.

Since the product flow is unpredictable, it is never certain how much of the same item will be received in how many pallets, or if the pallets will contain mixed products, therefore it was decided to measure time for one pallet regardless amount of products in it (except the Pre-pack department where it was possible to measure specific products). For detailed time data see Appendix 6. Following tables contains compiled time data for the different stations. Based on the hypothesis that 1 pallet contains 10 MR, where the times are average time for 1 MR. However at the Goods reception the hypothesis is that 1 pallet is equal to 1 MR.

In order to understand the numbers it needs to be explained that the Operation time is not the same as Value added time. The operation time at Goods reception concerns the time from when the pallet enters the conveyor (Line 1 & 2) and the preparing time (at Line 1&2 it is constantly prepared while riding the conveyor), to when the pallet is fully prepared by the operator (thus the leaving time is considered as non operation time). However there is data on the value added time which can be seen under the "*4.6. Flow mapping*" headline. For the Binning department the operation time is from that the operator picks the pallet on the square and all the driving time until it is on shelf. Concerning the Pre-pack department the Operation time can be seen as equal to Value added time.

4.5.1. Lead time study

Following times are compiled from Appendix 6 time tables. The abbreviations can be found in the Abbreviation list in the beginning of this report and also in Appendix 6, the Table 3 abbreviations can be found in the spaghetti diagram Figure 35 since it was drawn in association with time measurement of the service forklift activities.

4.5.1.1. Goods reception

The Goods reception has four gates, however the fourth one mostly handles engines, driving them by forklift directly to storage or square. Therefore time is collected on the other three stations where the operators prepare the incoming goods; Line 1, Line 2 and Bulky. Following tables shows the time for 1 pallet in minutes;

Line 1:				
	Operation time		Non operation time	
Activity	Gate->1	2,90	1->3	3,60
	Label	0,02	Leaving to storage*	3,60
	1 MR	1,60		
	Sum	4,52	Average Sum	3,60

Table 4 – GR Line 1

Leaving to storage*	
L1->IS	3,3
L1->L1b->IS	3,4
L1->S->Large square	5,7
L2->IS	3,7
L2->S-> Large square	4,8
3->IS	0,8
Average sum	3,62

Table 3 – GR leaving to storage

Line 2:				
	Operation time		Non operation time	
Activity	Gate->1	3,8	1->3	1,00
	Label	5,10	Leaving to storage*	3,60
	1 MR	0,2		
	Sum	9,1	Average Sum	2,30

Table 5 – GR Line 2

Bulky:				
	Operation time		Non operation time	
Activity	Preparation	9,8	Getting goods	1,40
	1 MR	0,4	Bulky-> L/S	0,80
			Bulky->IS	1,20
			Bulky->GA	1,40
			Bulky->Glass	1,70
			Bulky->B-crane	2,01
	Sum	10,2	Average Sum	1,70

Table 6 – GR Bulky

The non operation time here is basically leaving the products to their locations, hence the average sum since it is different locations.

4.5.1.2. Pre-pack

Following tables shows the time for 1 MR in minutes;

Fine line:						
	Set up time		Operation Time		Non operation time	
Activity	Go get packaging	0,62	Packaging	10,16	Service forklift	
	Print labels				leave to square	0,47
	& MR	0,08				
	Sum	0,7	Sum	10,16	Sum	0,47

Table 7 – PP Fine line

Rough:						
	Set up time		Operation Time		Non operation time	
Activity	Go get packaging	0,62	Packaging	13,56	Preparing etc.	7,52
	Print labels				6-8 to square	1,03
	& MR	0,08			1-5 to square	6,42
					1-5 service truck	
					leave to square	1,64
	Sum	0,7	Sum	13,56	Sum	10,55

Table 8 – PP Rough stations

The Sum in Table 8 for the Non operation time is Preparing time plus the average sum of the different square leaving times.

Preparing etc.	Bench 1- 5	Bench 6 - 8	Average
Get job	0,83	1,04	0,935
Empty pallet	1,22	0,75	0,985
MR/labels/package	2,85	3,95	3,4
Prepare	2,26	2,14	2,2
Total	7,16	7,88	7,52

Table 9 – PP Rough Preparing

Glass:						
	Set up time		Operation Time		Non operation time	
Activity	Check inventory	13,00	Packaging	12,33	Leave to GA	1,3
	Print labels				Leave to storage	2,9
	& MR *	-			Sorting	5,12
					Preparing etc.	16,48
	Sum	13,00	Sum	1,23	Average Sum	23,70

Table 10 – PP Glass station

*The glass station has different routines from the Fine line and Rough station. They might print all MR at one time. At the time when measuring they already had the MRs printed out.

Time for bag machine was not collected since it has such a small impact on the entire Inbound flow.

4.5.1.3. Binning

Following tables shows the time for 1 MR in minutes;

GH forklift:				
S square	Operation Time		Non operation time	
Activity	Driving forklift		Sorting	4,1
	SVAT	6,43	Driving forklift	
	Register MR	0,1	NVAT	3,01
	Sum	**6,53**	**Sum**	**7,11**

Table 11 – Binning GH forklift S square

GA forklift:				
L square	Operation Time		Non operation time	
Activity	Driving forklift		Driving forklift	
	SVAT	2,14	NVAT	2,52
	Register MR*			
	Sum	**2,14**	**Sum**	**2,52**

Table 12 – Binning GA forklift L square

GA forklift:				
GA square	Operation Time		Non operation time	
Activity	Driving forklift		Driving forklift	
	SVAT	2,73	NVAT	6,32
	Register MR*			
	Sum	**2,73**	**Sum**	**6,32**

Table 13 – Binning GA forklift GA square

4.5.2. Manning & Capacity

The times and calculations for Pre-pack and Binning are based on time in minutes per 1 MR, since it was the most reliable metric. The calculations for the Goods reception are based on time per 1 pallet due to the high variation since one MR can consist of several pallets or one pallet can contain several MR. Calculating on quantity would be a lot more unreliable here, assuming that 1 pallet is equal 10 MR is equal 100 pcs.

The calculation formulas are based on chapter "*3.10. Production concepts an mathematical models*".

4.5.2.1. Goods reception

The Goods reception works 1 shift per day, having 10 operators that concerns this project working 7,8 h Monday to Thursday and 7,4 h on Fridays.

Table 14 shows data of operating hours and shifts per week, and number of operators working. Table 15 shows calculations on capacity, production rate and utilization based on the data of incoming goods during the period of October (-12) to January (-13).

1 Shift per day		
Operators	10	op
Hours/shift	m-t 7,8	h
	f 7,6	h
SwH	38,8	h
WSwH	388	h
Average operation time	*7,94*	*min*
Average non operation time	*2,53*	*min*
Sum operation time	10,47	min

Table 14 – GR Available hours per week

Calculations		Value	Unit
Amount of MR:		46 447	pcs
MLT = (MR x operation time)	(46447 x 10,47)	486 300	min
	(46447 x 10,47)/60	8 105	h
	(46447 x 10,47)/24	338	days
	(46447 x 10,47)/5	68	weeks
Tp= (MLT)/Q)	(8105/46447)	0,175	h
Rp= (1/Tp)	(1/0,175)	5,73	MR/h
Available PC= (WSwHRp)	(388 x 5,73)	2 223	MR/week
Real PC = (Amount of MR/16)	(46447/16)	2 903	MR/week
W= (PC/SwHRp)	(2903/(5,73 x 38,8)	13,1	operators
WSwH= (Dw/Rp)	(2903/5,73)	507	h/week
U = (Output/Capacity)	(2903/2223)	1,3056	130,6%

Table 15 – GR Calculations

Based on number of operators, working hours per day, shifts per day and the measured operation times, the Goods reception has a weekly capacity of 2 223 MR per week. However during this period they have handled 2 903 MR, giving a utilization of 130%. This means that they have been working as if they were 13 operators instead of 10.

4.5.2.2. Pre-pack

The Pre-pack department works 2 shifts per day;

The Fine line has 16 operators working day shift 7,8 hours Monday to Thursday and 7,4 hours on Fridays. They also have one operator working 3,9 hours Monday to Thursday and 3,8 hours on Fridays. The service forklift operator is included in the day shift.

In the evening shift the Fine line has one operator working 5,9 hours Monday to Thursday and 5 hours on Fridays, and one operator working 8 hours Monday to Thursday and 6 hours on Fridays.

The Rough stations has 7 operators working day shift 7,8 hours Monday to Thursday and 7,4 hours on Fridays. Two operators from glass station are included in the day shift. In the evening 4 operators work 8 hours Monday to Thursday and 6 hour on Fridays.

Table 16 shows data of operating hours and shifts per week, and number of operators working. Table 17 shows calculations on capacity, production rate and utilization based on the data of incoming goods during the period of October (-12) to January (-13).

2 shift per day **30 operators**	Fine Day		Fine Evening		Rough Day *	Rough Evening
Operators	16 op	1 op	1 op	1 op	7 op	4 op
Hours/shift	m-t 7,8 h f 7,4 h	m-t 3,9 h f 3,8 h	m-t 5,9 h f 5 h	m-f 8 h f 6 h	m-t 7,8 h f 7,4 h	m-t 8 h f 6 h
SwH	37,53	h				
WSwH	1126	h				
Average set up time	*3,80*	*min*				
Average operation time	*12,02*	*min*				
Average non operation time	*11,57*	*min*				
Sum operation time	27,39	min				

Table 16 – PP Available hours per week

Calculations		**Value**	**Unit**
Amount of MR:		19 140	pcs
MLT = (MR x operation time)	(19140 x 28,37)	543 002	min
	(19140 x 28,37)/60	9 050	h
	(19140 x 28,37)/24	377	days
	(19140 x 28,37)/5	75	weeks
Tp= (MLT)/Q)	(8731/19140)	0,473	h
Rp= (1/Tp)	(1/0,456)	2,11	MR/h
Available PC= (WSwHRp)	(1126 x 2,19)	2 381	MR/week
Real PC = (Amount of MR/16)	(19140/16)	1 196	MR/week
W= (PC/SwHRp)	(1196/(2,19 x 37,53)	15,1	operators
WSwH= (Dw/Rp)	(1196/2,19)	566	h/week
U = (Output/Capacity)	(1196/2468)	0,5023	48,5%

Table 17 – PP Calculations

The Pre-pack department has a planned capacity of being able to handle 2 468 MR per week, however the real outcome during the period has been 1 196 M giving a utilization of 48,5% which is too low. However the low utilization number may not be as surprising since it has been known that the Pre-pack produces at a slower rate than the other two departments.

4.5.2.3. Binning

The Binning department has 2 shifts per day with 8 operators working day shift and 7 operators working evening shift. At day shift they have 4 regular workers and 4 consultant workers, and 4 regular together with 3 consultant workers at the evening shift. The regular workers works 7,8 hours per shift and the consultant staff works 7,9 hours per shift.

Table 18 shows data of operating hours and shifts per week, and number of operators working. Table 19 shows calculations on capacity, production rate and utilization based on the data of incoming goods during the period of October (-12) to January (-13).

2 shift per day **15 operators**	Day Volvo	Day consultant	Evening Volvo	Evening consultant
Operators	5 Volvo op.	3 consultants	4 Volvo op.	3 consultants
Hours/shift	7,8 h	7,9 h	7,8 h	7,9 h
SwH	30,80 h			
WSwH	462 h			
Average operation time	*3,80 min*			
Average non operation time	*5,32 min*			
Sum operation time	9,12 min			

Table 18 – Binning Available hours per week

Calculations		**Value**	**Unit**
Amount of MR:		44 256	pcs
MLT = (MR x operation time)	(44256 x 9,62)	425 743	min
	(44256 x 9,62)/60	7 096	h
	(44256 x 9,62)/24	296	d
	(44256 x 9,62)/5	59	w
Tp= (MLT)/Q)	(7096/44256)	0,160	h
Rp= (1/Tp)	(1/0,160)	6,24	MR/h
Available PC= (WSwHRp)	(462 x 6,24)	2 881	MR/week
Real PC = (Amount of MR/16)	(44256/16)	2 766	MR/week
W= (PC/SwHRp)	(2766/(6,24 x 30,8)	14,4	operators
WSwH= (Dw/Rp)	(6,24/2766)	443	h/week
U = (Output/Capacity)	(2766/2881)	0,9599	96,0%

Table 19 – Binning Calculations

The Binning department has a weekly capacity of 2 882 MR, where the real outcome during the period was 2 766 giving a utilization of 96% which is very good since the utilization level should be around 95-97 %. This utilization value was expected since the Binning department according to the daily management and interviews is reaching their performance goals.

4.5.3. *TIME & TIED-UP CAPITAL*

The following numbers are based on the BEAT-report created by Rolf Possmark, where the data is collected from the system SPIS. The data has been carefully sorted in order to fulfill the requirements of this project, see Appendix 4.

4.5.3.1. The Data

The data is based on a four months period; October (-12) to January (-13), having 83 working days with holidays excluded. The data is based on approved quantity during the period concerning articles that are registered and stored by the end of the period. Table 20 shows the incoming value during the studied period divided between the four different facilities in Eskilstuna, where G 924 concerns this project.

Total value (Std. Cost) Gate 900, 924, 936, 956	Total with control	Total percent	Total Ex. control	Value control
G 900	51 735 324,59 kr	10,23%	51 541 398,12 kr	193 926,47 kr
G 924	437 602 703,90 kr	86,52%	429 932 465,70 kr	7 670 238,20 kr
G 938	2 258 374,71 kr	0,45%	2 258 374,71 kr	- kr
G 956	14 183 416,42 kr	2,80%	14 183 416,42 kr	- kr
TOTAL	505 779 819,60 kr	100,00%	497 915 654,90 kr	7 864 164,70 kr

Table 20 – Total value during period Oct (-12) – Jan (-13)

Sorting out Pihls from the data the total received value is 505,9 milj SEK, where 437,5 milj SEK is the value coming in to the facility concerning this project and stands for 86,5% of the total value, illustrated in Diagram 1.

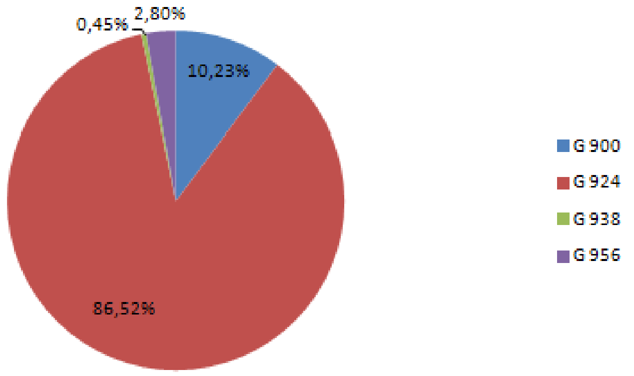


Diagram 1 - Circle diagram of total value

Total Std. Cost 2013 (Oct 2012 - Jan 2013) Max open MR 4 (Approved qty.)				**505 779 820 kr**
G 900				51 735 325 kr
G 938				2 258 375 kr
G 956				14 183 416 kr
G 924				437 602 704 kr
Control station			7 670 239 kr	
Pihls			31 708 788 kr	
Flows			398 223 677 kr	
Fine Total		57 654 109 kr		
Fine by PP	*55 891 372 kr*			
Fine Direct	*1 762 737 kr*			
Rough Total		95 457 304 kr		
Rough by PP	*91 642 798 kr*			
Rough Direct	*3 814 506 kr*			
Bag/K Total		9 197 417 kr		
Bag/K by PP	*8 989 701 kr*			
Bag/K Direct	*207 717 kr*			
Direct Total		225 721 016 kr		
Direct	*225 252 313 kr*			
Direct by PP	*468 703 kr*			
Glass Total		1 815 199 kr		
Glass by PP	*646 366 kr*			
Glass Direct	*1 168 833 kr*			
Unknown Total		8 367 721 kr		
Unknown by PP	*539 660 kr*			
Unknown Direct	*7 828 061 kr*			
Excluded (Kit) 5S	*10 910 kr*	10 910 kr		

Table 21 – Distributed value, product groups

The Table 21 shows how the total incoming value during the studied period is distributed within the different facilities in Eskilstuna and within the different product groups in this project. This table shows value distribution in a way that has not been seen previously, enabling to define the most value holding product groups, but also the Pihls products value.

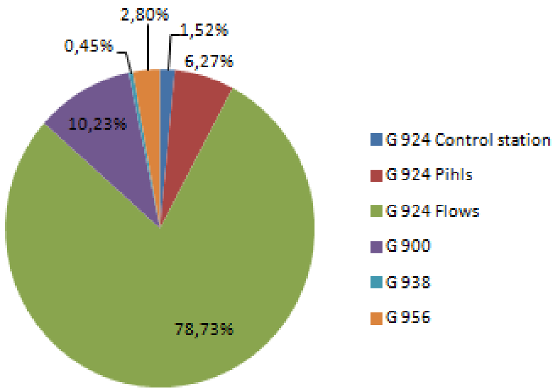


Diagram 2 - Circle diagram of total value

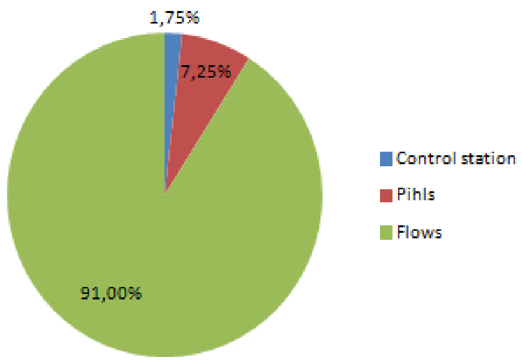


Diagram 3 - Circle diagram of value at Gate 924

The Diagram 2 and Diagram 3 shows that the product flows in this project stands for ca 79% of the total incoming value and 91% of the total incoming value concerning the G 924. The following Table 22 shows detailed data of all the product flows at G 924 divided in the previously defined product categories, containing data of lead times and value that has been produced from SPIS. Table 23 shows the products value based on the lead times at intermediate storage and the squares in detail for each product flow, showing how much value that is tied up and for how long between each department. Studying the Table 23, the most tied up value is located at the IS between the Goods reception and Pre-pack department. By studying the lead time between each department it can be defined that the material is stuck at the IS, where the Pre-pack department is not able to handle the incoming goods at the same rate as the Goods reception, and making it braking the flow.

	Oct (-12) -Jan (-13)* Max MR code 4	Amount MR (pcs)	Forecast items (pcs)	Diff. Forecast vs. Qty app.	Qty approved (pcs)	Average time 1->3 (days)	Average time 3->4 (days)	Average time 1->4 (days)	Products Value (SEK)	
FINE	*Fine 2, 2A, 5, 5A by PP*	*10 849*	*564 086*	*97 255*	*661 341*	*3,87*	*0,48*	*4,34*	*55 521 471 kr*	
	Fine 7&8 (<40 pcs)by PP	*388*	*5 633*	*1 142*	*6 775*	*4,56*	*0,49*	*5,04*	*369 901 kr*	
	Fine by PP Total	**11 237**	**569 719**	**98 397**	**668 116**	**3,89**	**0,48**	**4,36**	**55 891 372 kr**	
	Fine 2, 2A, 5, 5A Direct	*888*	*20 767*	*-5 987*	*14 780*			*0,97*	*1 720 292 kr*	
	Fine 7&8P (<40pcs) Direct	*128*	*10195*	*-9 350*	*845*			*0,19*	*42 444,49 kr*	
	Fine Direct Total	**1 016**	**30 962**	**-15 337**	**15 625**			**0,87**	**1 762 737 kr**	
ROUGH	**Rough 2B, 2G, 5B, 5G by PP**	**6 184**	**143 486**	**-31 766**	**111 720**	**4,4**	**0,49**	**4,9**	**91 642 798 kr**	*ex. glassand tube¤*
	Rough 2B, 2G, 5B, 5G Direct	**553**	**4 543**	**-1 561**	**2 982**			**1,1**	**3 814 506 kr**	
BAG/K	*Bag (>40 pcs) by PP*	*1 565*	*299 597*	*473 433*	*773 030*	*2,7*	*0,49*	*3,2*	*5 687 569 kr*	
	Krympen by PP	*831*	*11 144*	*6 982*	*18 126*	*0,4*	*0,3*	*0,8*	*3 302 131 kr*	
	Bag/K by PP Total	**2 396**	**310 741**	**480 415**	**791 156**	**1,9**	**0,4**	**2,4**	**8 989 701 kr**	
	Bag (>40pcs) Direct	*51*	*16 663*	*2 085*	*18 748*			*2*	*148 880 kr*	
	Krympen Direct	*51*	*424*	*-181*	*243*			*0,6*	*58 837 kr*	
	Bag/K Direct Total	**102**	**17 087**	**1 904**	**18 991**			**1,3**	**207 717 kr**	
DIRECT	**Direct 1, 1A, 4, 4A**	**23 172**	**2 214 764**	**-386 644**	**1 828 120**			**0,54**	**225 252 313 kr**	*ex. glass*
	Direct 1, 1A, 4, 4A by PP	**73**	**1 240**	**3 711**	**4 951**	**3,8**	**0,48**	**4,3**	**468 703 kr**	*ex. glass*
GLASS	*Glass by PP*	*153*	*2 444*	*-98*	*2 346*	*2,3*	*1,6*	*3,9*	*564 940 kr*	
	Glass 3G (ex. glass&window) by PP	*8*	*26*	*69*	*95*	*2,6*	*1*	*3,6*	*81 426 kr*	*ex. glass*
	Glass by PP Total	161	2 470	-29	2 441	2,3	1,6	3,9	646 366 kr	
	Glass Direct	*178*	*12 313*	*-8 590*	*3 723*			*2,8*	*1 138 072 kr*	
	Glass 3G (ex. glass&window) Direct	*9*	*78*	*-19*	*59*			*3,6*	*30 761 kr*	*ex. glass*
	Glass Direct Total	187	12 391	-8 609	3 782			2,8	1 168 833 kr	
	Glass Total	**348**	**14 861**	**-8 638**	**6 223**			**3,3**	**1 815 199 kr**	
OTHERS	*Unknown 2K & blank by PP*	*22*	*65*	*75*	*140*	*0,6*	*0,4*	*1*	*289 809 kr*	
	Unknown 3- & 3A (<18kg) by PP	*36*	*335*	*93*	*428*	*2,1*	*0,9*	*3*	*249 852 kr*	*ex. glass*
	Unknown by PP Total	**58**	**401**	**167**	**568**	**1,5**	**0,7**	**2,2**	**539 660 kr**	
	Unknown 2K & blank Direct	*270*	*988*	*-47*	*941*			*0,2*	*7 574 817 kr*	
	Unknown 3- & 3A (<18kg) Direct	*8*	*2*	*20*	*22*			*2,75*	*63 824 kr*	*ex. glass*
	Unknown Direct Total	**278**	**990**	**-27**	**963**			**0,3**	**7 638 641 kr**	
	Unknown 4G	**12**	**34**	**33**	**67**			**0,5**	**189 420 kr**	
EXCLUDED	**Kit 5S**	**2**	**13**	**12**	**25**			**0,0**	**10 910 kr**	
	TOTAL	**45 431**	**3 308 840**	**140 667**	**3 449 507**				**398 223 677,30 kr**	
	¤Pihls 5G Tube (m)	**1**	**0**	**720**	**720**			**19,00**	**25 546 kr**	*ex. glass*
	Pihls EC 400-899	**935**	**2 975**	**1 408**	**4 383**			**2,30**	**29 982 783 kr**	
	Pihls 3- & 3A (>18kg) (ex. EC 400-899)	**82**	**730**	**-337**	**393**			**1,80**	**1 700 460 kr**	*ex. glass*
	Pihls Total	**1 018**	**3 706**	**1 790**	**5 496**			**2,3**	**31 708 788 kr**	
	TOTAL	**46 449**	**3 312 546**	**142 457**	**3 455 003**	**3,8**	**0,5**	**0,6**	**429 932 465,64 kr**	
						Average direct + prepack time		**2,4**		

Table 22 – Product groups detailed data

	Oct (-12) -Jan (-13)* Max MR code 4	Average time 1->3 (days)	Average time 3->4 (days)	Average time 1->4 (days)	Products Value (SEK)	Value/day (SEK)	(Value/day) x lead time 1->3 (SEK)	(Value/day) x lead time 3->4 (SEK)	(Value/day) x lead time 1->4 (SEK)
FINE	*Fine 2, 2A, 5, 5A by PP*	*3,87*	*0,48*	*4,34*	*55 521 471 kr*	*668 933 kr*	*2 588 772 kr*	*321 088 kr*	*2 903 171 kr*
	Fine 7&8 (<40 pcs)by PP	*4,56*	*0,49*	*5,04*	*369 901 kr*	*4 457 kr*	*20 322 kr*	*2 184 kr*	*22 461 kr*
	Fine by PP Total	3,89	0,48	4,36	55 891 372 kr	673 390 kr	2 619 487 kr	323 227 kr	2 935 981 kr
	Fine 2, 2A, 5, 5A Direct			*0,97*	*1 720 292 kr*	*20 726 kr*	*- kr*	*- kr*	*20 105 kr*
	Fine 7&8P (<40pcs) Direct			*0,19*	*42 444,49 kr*	*511 kr*	*- kr*	*- kr*	*97 kr*
	Fine Direct Total			0,87	1 762 737 kr	21 238 kr	- kr	- kr	18 477 kr
ROUGH	Rough 2B, 2G, 5B, 5G by PP	4,4	0,49	4,9	91 642 798 kr	1 104 130 kr	4 858 172 kr	541 024 kr	5 410 237 kr
	Rough 2B, 2G, 5B, 5G Direct			1,1	3 814 506 kr	45 958 kr	- kr	- kr	50 554 kr
BAG/K	*Bag (>40 pcs) by PP*	*2,7*	*0,49*	*3,2*	*5 687 569 kr*	*68 525 kr*	*185 017 kr*	*33 577 kr*	*219 280 kr*
	Krympen by PP	*0,4*	*0,3*	*0,8*	*3 302 131 kr*	*39 785 kr*	*15 914 kr*	*11 935 kr*	*31 828 kr*
	Bag/K by PP Total	1,9	0,4	2,4	8 989 701 kr	108 310 kr	205 788 kr	43 324 kr	259 943 kr
	Bag (>40pcs) Direct			*2*	*148 880 kr*	*1 794 kr*	*- kr*	*- kr*	*3 587 kr*
	Krympen Direct			*0,6*	*58 837 kr*	*709 kr*	*- kr*	*- kr*	*425 kr*
	Bag/K Direct Total			1,3	207 717 kr	2 503 kr	- kr	- kr	3 253 kr
DIRECT	Direct 1, 1A, 4, 4A			0,54	225 252 313 kr	2 713 883 kr	- kr	- kr	1 465 497 kr
	Direct 1, 1A, 4, 4A by PP	3,8	0,48	4,3	468 703 kr	5 647 kr	21 459 kr	2 711 kr	24 282 kr
GLASS	*Glass by PP*	*2,3*	*1,6*	*3,9*	*564 940 kr*	*6 807 kr*	*15 655 kr*	*10 890 kr*	*26 545 kr*
	Glass 3G (ex. glass&window) by PP	*2,6*	*1*	*3,6*	*81 426 kr*	*981 kr*	*2 551 kr*	*981 kr*	*3 532 kr*
	Glass by PP Total	2,3	1,6	3,9	646 366 kr	7 788 kr	17 911 kr	12 460 kr	30 371 kr
	Glass Direct			*2,8*	*1 138 072 kr*	*13 712 kr*	*- kr*	*- kr*	*38 393 kr*
	Glass 3G (ex. glass&window) Direct			*3,6*	*30 761 kr*	*371 kr*	*- kr*	*- kr*	*1 334 kr*
	Glass Direct Total			2,8	1 168 833 kr	14 082 kr	- kr	- kr	39 431 kr
	Glass Total			3,3	1 815 199 kr	21 870 kr	- kr	- kr	72 171 kr
OTHERS	*Unknown 2K & blank by PP*	*0,6*	*0,4*	*1*	*289 809 kr*	*3 492 kr*	*2 095 kr*	*1 397 kr*	*3 492 kr*
	Unknown 3- & 3A (<18kg) by PP	*2,1*	*0,9*	*3*	*249 852 kr*	*3 010 kr*	*6 322 kr*	*2 709 kr*	*9 031 kr*
	Unknown by PP Total	1,5	0,7	2,2	539 660 kr	6 502 kr	9 753 kr	4 551 kr	14 304 kr
	Unknown 2K & blank Direct			*0,2*	*7 574 817 kr*	*91 263 kr*	*- kr*	*- kr*	*18 253 kr*
	Unknown 3- & 3A (<18kg) Direct			*2,75*	*63 824 kr*	*769 kr*	*- kr*	*- kr*	*2 115 kr*
	Unknown Direct Total			0,3	7 638 641 kr	92 032 kr	- kr	- kr	27 610 kr
	Unknown 4G			0,5	189 420 kr	2 282 kr	- kr	- kr	1 141 kr
EX.	Kit 5S			0,0	10 910 kr	131 kr	- kr	- kr	- kr
	TOTAL				476 883 902,49 kr	5 745 589,19 kr	10 569 218,77 kr	1 312 058,57 kr	13 656 899,92 kr

Table 23 – Product groups value data

WIP GR-PP	10 569 218,77 kr
WIP PP-B	1 312 058,57 kr
WIP GR-B	1 775 622,58 kr

4.5.3.2. Pareto charts

By using the Pareto chart tool on the gathered and compiled data in Table 22, product groups that stand for the highest amount of the given unit can be determined by descending order.

The following diagrams show the product groups that stand for the highest amount of value, material reports, quantity and longest lead time.

Value:

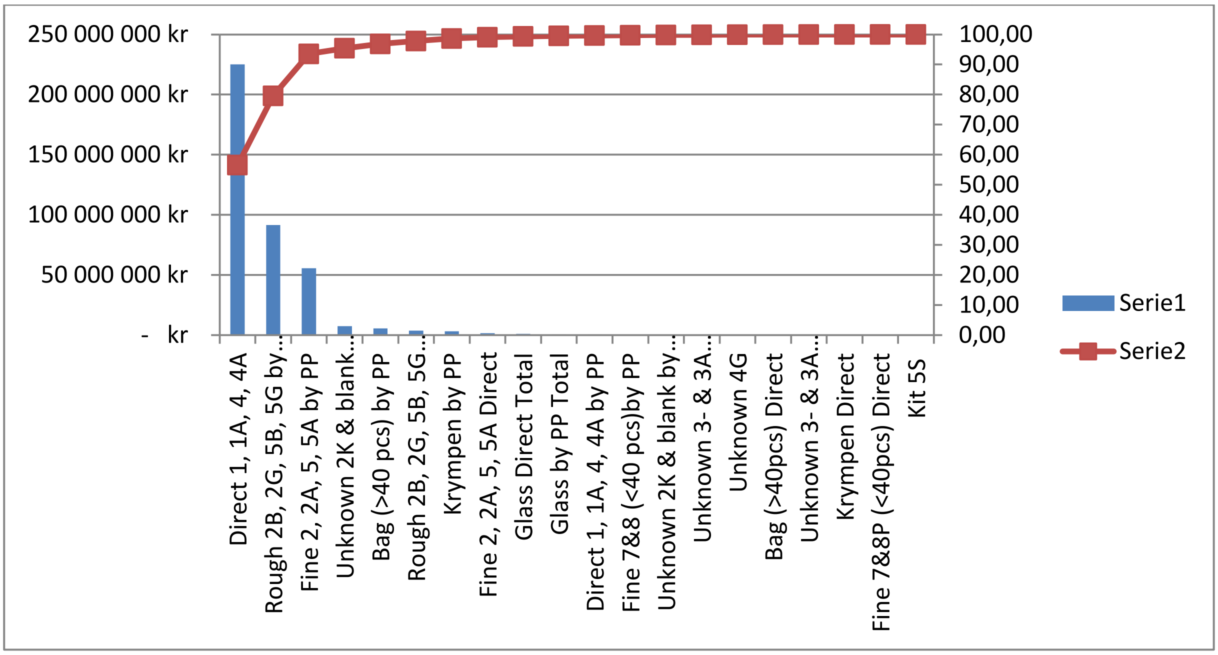


Diagram 4 – Pareto chart - Value

Studying the Diagram 4 it can be defined that the Direct-, Rough by Pre-pack- and Fine by Pre-pack product groups are the ones having the highest value standing for 80% of the total products value.

Quantity:

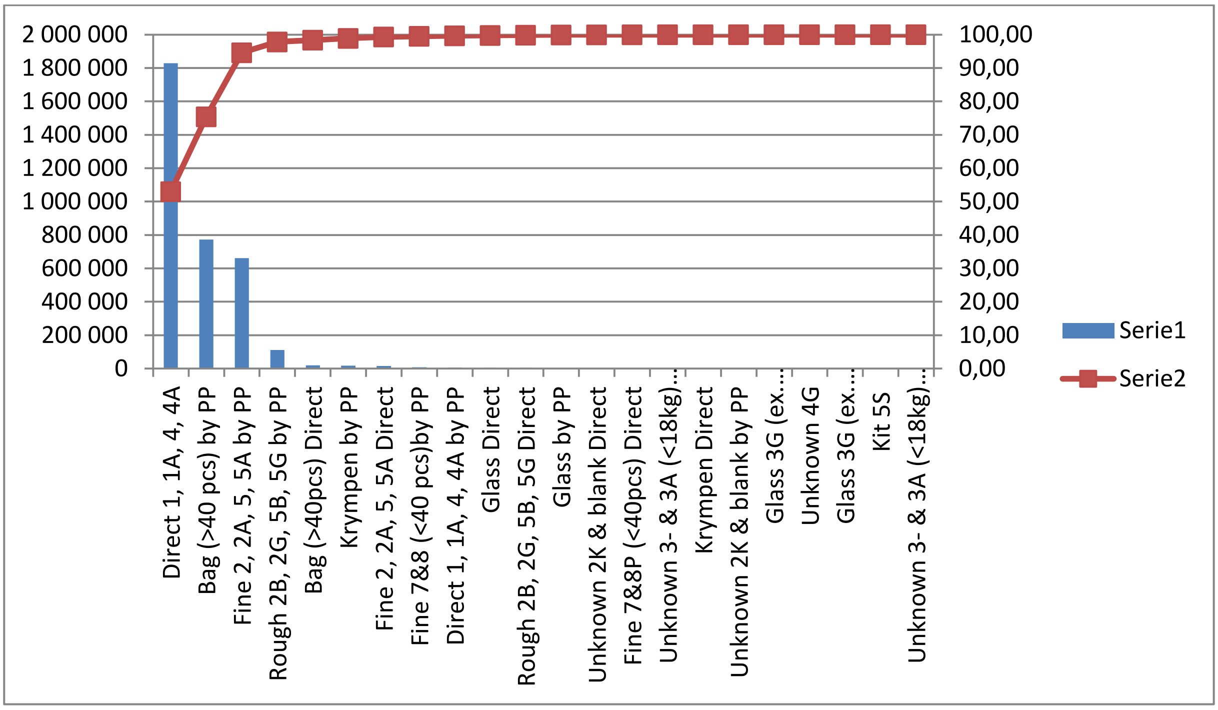


Diagram 5 – Pareto chart - Quantity

Studying the Diagram 5 it can be defined that the Direct-, Bag by Pre-pack- and Fine (2, 2A, 5, 5A) by Pre-pack product groups are the ones having the highest incoming amount of articles, standing for almost 80 % of the total amount of incoming articles.

Material reports:

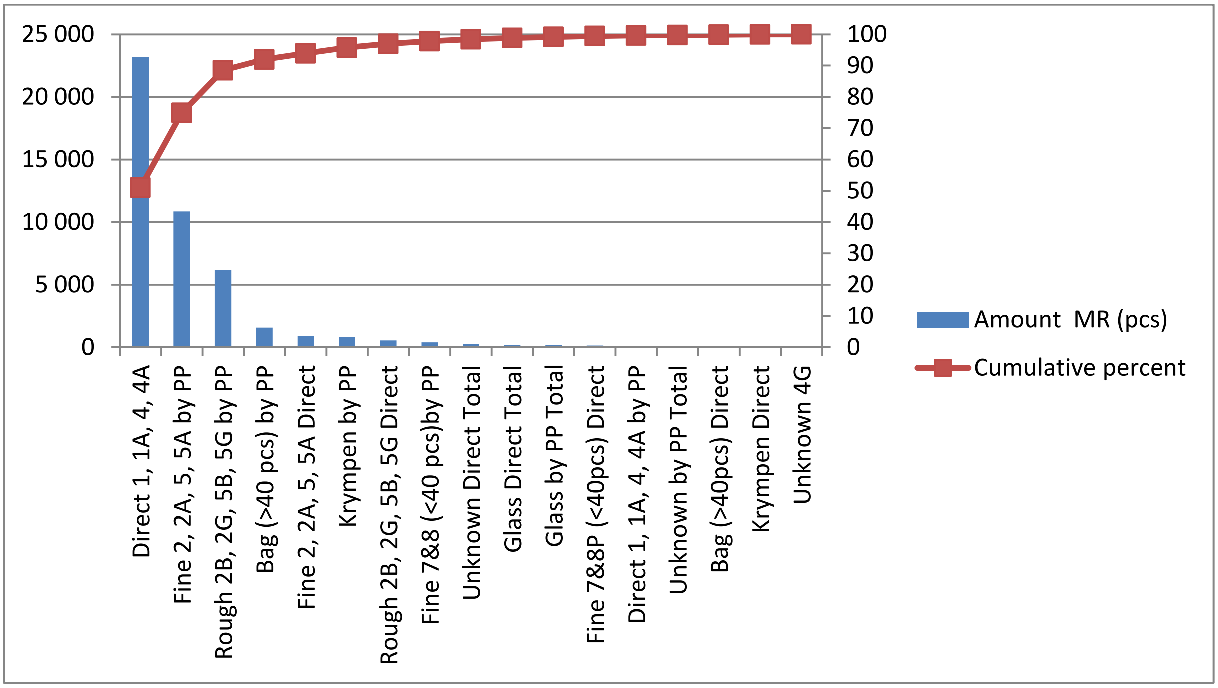


Diagram 6 – Pareto chart – Material reports

Studying the Diagrams 6 it can defined that the Direct-, Fine (2, 2A, 5, 5A)- and Rough by Pre-pack product groups are the ones handling the highest amount of material reports standing for 90% of the total amount of incoming MR.

Lead times:

In the Average time column the numbers 1, 3 and 4 stands for Goods reception, Pre-pack and Binning in following order.

DIRECT TO BINNING

Oct (-12) -Jan (-13)	Average time 1->4 (days)	Cumulative no	Cumulative percent
Glass Direct Total	2,84	2,84	38,10
Bag/K Direct Total	1,30	4,14	55,55
Rough 2B, 2G, 5B, 5G Direct	1,10	5,24	70,31
Fine Direct Total	0,87	6,11	82,01
Direct 1, 1A, 4, 4A	0,54	6,65	89,26
Unknown 4G	0,50	7,15	95,97
Unknown Direct Total	0,30	7,45	100,00
Kit 5S	0,00	7,45	100,00

Table 24 – Direct flows Lead time

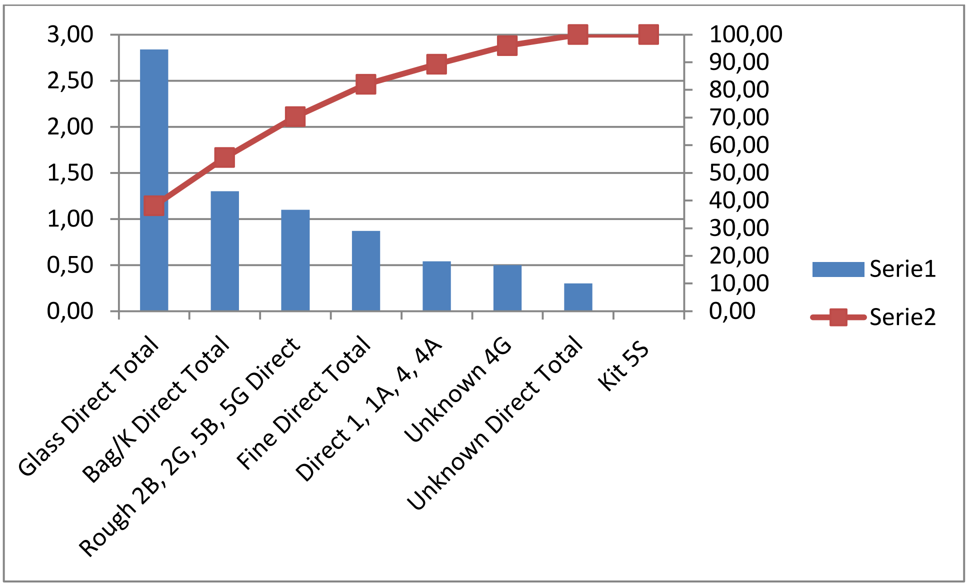


Diagram 7 – Pareto chart – Direct flows Lead time

The Diagram 7 shows that the Glass-, Bag/K-, Rough- and Fine are the direct flows product groups that have the longest lead times, where the Glass station distinguishes by taking 2,84 days from arrival to storage point.

BY PREPACK

Oct (-12) -Jan (-13)	Average time 1->4 (days)	Cumulative no	Cumulative percent
Rough 2B, 2G, 5B, 5G by PP	4,9	4,90	22,21
Fine by PP Total	4,36	9,26	42,00
Direct 1, 1A, 4, 4A by PP	4,3	13,56	61,49
Glass by PP Total	3,9	17,45	79,11
Bag/K by PP Total	2,4	19,82	89,84
Unknown by PP Total	2,2	22,06	100,00

Table 25 – Flows by Pre-pack Lead times

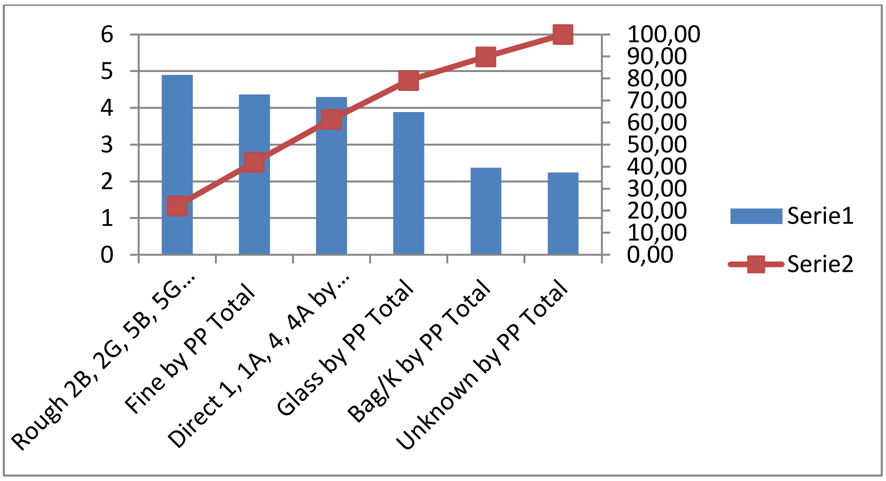


Diagram 8 – Pareto chart – Flows by Pre-pack Lead times

In the product flows that has to go by Pre-pack the ones that has the longest lead time from arrival to storage point are Rough, Fine, Direct and Glass products. Breaking down the lead time into time between Goods reception and Pre-pack, and time between Pre-pack and Binning gives the following data with the lead times at IS and the squares;

BY PREPACK

Oct (-12) -Jan (-13)	Average time 1->3 (days)	Cumulative no	Cumulative percent
Rough 2B, 2G, 5B, 5G by PP	4,4	4,40	24,66
Fine by PP Total	3,89	8,29	46,48
Direct 1, 1A, 4, 4A by PP	3,8	12,09	67,78
Glass by PP Total	2,3	14,41	80,76
Bag/K by PP Total	1,9	16,31	91,42
Unknown by PP Total	1,5	17,84	100,00

Table 26 - Flows between GR and PP Lead times

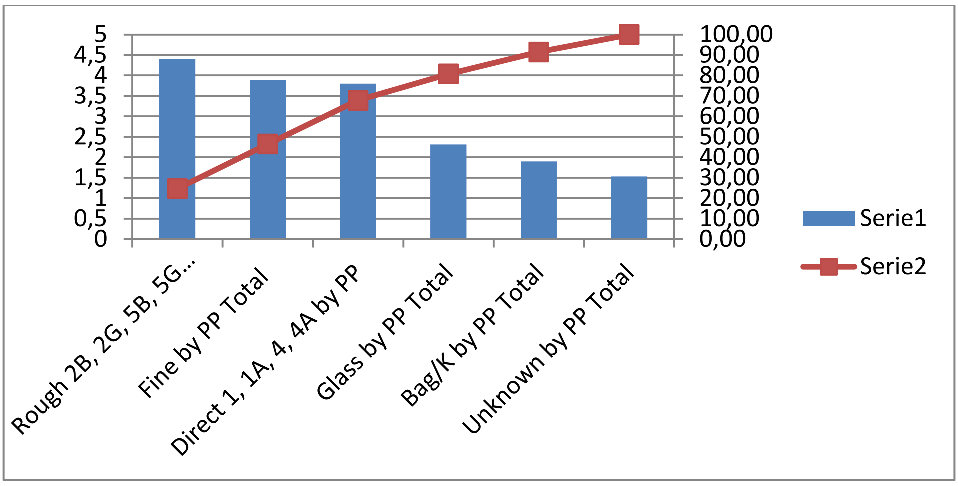


Diagram 9 – Pareto chart – Flows between GR and PP Lead times

The Diagram 9 shows that Rough-, Fine- and Direct by Pre-pack flow groups are the products that have the longest lead time in the intermediate storage between the Goods reception and Pre-pack.

BY PREPACK

Oct (-12) -Jan (-13)	Average time 3->4 (days)	Cumulative no	Cumulative percent
Glass by PP Total	1,6	1,57	37,79
Unknown by PP Total	0,7	2,28	54,89
Rough 2B, 2G, 5B, 5G by PP	0,49	2,77	66,68
Fine by PP Total	0,48	3,25	78,24
Direct 1, 1A, 4, 4A by PP	0,48	3,73	89,79
Bag/K by PP Total	0,4	4,15	100,00

Table 27 - Flows between PP and B Lead times

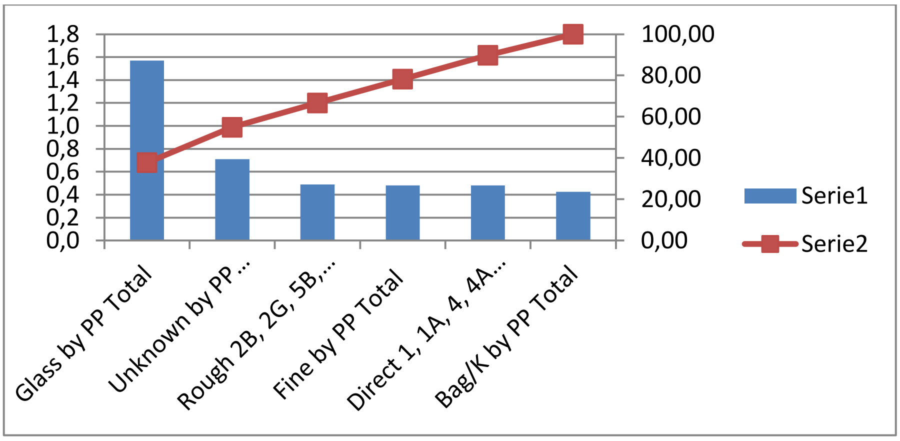


Diagram 10 – Pareto chart – Flows between PP and B Lead times

Diagram 10 shows that Glass-, Unknown-, Rough- and Fine by pre-pack flows are the ones having the longest lead times at the squares between Pre-pack and Binning, where the Glass product group has significantly longest lead time.

4.5.3.2.1. Pareto charts summary

Studying all the parameters and Pareto charts, the following product groups are identified to stand out in terms of;

Product flows that handles the highest value:

1. Direct 225 milj SEK
2. Rough by PP 91 milj SEK
3. Fine (2, 2A, 5, 5A) by PP 55 milj SEK

Product flows that handles the highest amount of quantity:

1. Direct - 1 828 120 pcs
2. Bag by PP - 773 030 pcs
3. Fine (2, 2A, 5, 5A) by PP - 661 341 pcs

Product flows that handles the highest amount of MR:

1. Direct - 23 172 MR
2. Fine (2, 2A, 5, 5A) by PP - 10 849 MR

Product flows that have the longest lead times:

1. Rough by PP – 4,9 days
2. Fine by PP – 4,36 days
3. Direct by PP – 4,3 days
4. Glass by PP – 3,9 days
5. Glass direct - 2,84 days

The listed product group flows are the ones that needs to be investigated, however not all of those are important in this project. The interest lies in the highest value flows,
Table 28 shows product groups organized in order of value from highest to lowest.

Direct	225 252 313 kr
Rough by PP	91 642 798 kr
Fine 2, 2A, 5, 5A by PP	55 891 372 kr
Rough direct	3 814 506 kr
Glass direct	1 168 833 kr
Bag direct	148 880 kr
Direct by PP	468 703 kr
Glass by PP	646 366 kr

Table 28 – Product group flows by value

4.5.3.3. Tied-up capital

The aim in this project is to identify the tied up capital so the focus should be on the product groups that has the highest value in relation to the lead time. The Table 29 shows the product groups value per day times the lead time, giving the groups that ties up the highest value. Comparing these values we see that though the Direct product group has the highest total products value it is the Rough- and Fine by Pre-pack groups that ties up the highest value.

Detailed	(Value/day) x lead time 1->4 (SEK)	Cumulative no	Cumulative percent
Rough 2B, 2G, 5B, 5G by PP	5 410 237 kr	5 410 237 kr	53
Fine 2, 2A, 5, 5A by PP	2 903 171 kr	8 313 408 kr	81
Direct 1, 1A, 4, 4A	1 465 497 kr	9 778 905 kr	95
Bag (>40 pcs) by PP	219 280 kr	9 998 185 kr	97
Rough 2B, 2G, 5B, 5G Direct	50 554 kr	10 048 739 kr	98
Glass Direct	38 393 kr	10 087 132 kr	98
Krympen by PP	31 828 kr	10 118 960 kr	99
Glass by PP	26 545 kr	10 145 505 kr	99
Direct 1, 1A, 4, 4A by PP	24 282 kr	10 169 787 kr	99
Fine 7&8 (<40 pcs)by PP	22 461 kr	10 192 248 kr	99
Fine 2, 2A, 5, 5A Direct	20 105 kr	10 212 353 kr	100
Unknown 2K & blank Direct	18 253 kr	10 230 606 kr	100
Unknown 3- & 3A (<18kg) by PP	9 031 kr	10 239 637 kr	100
Bag (>40pcs) Direct	3 587 kr	10 243 224 kr	100
Glass 3G (ex. glass&window) by PP	3 532 kr	10 246 756 kr	100
Unknown 2K & blank by PP	3 492 kr	10 250 248 kr	100
Unknown 3- & 3A (<18kg) Direct	2 115 kr	10 252 363 kr	100
Glass 3G (ex. glass&window) Direct	1 334 kr	10 253 697 kr	100
Unknown 4G	1 141 kr	10 254 838 kr	100
Krympen Direct	425 kr	10 255 263 kr	100
Fine 7&8P (<40pcs) Direct	97 kr	10 255 360 kr	100

Table 29 – Product flows Tied-up value

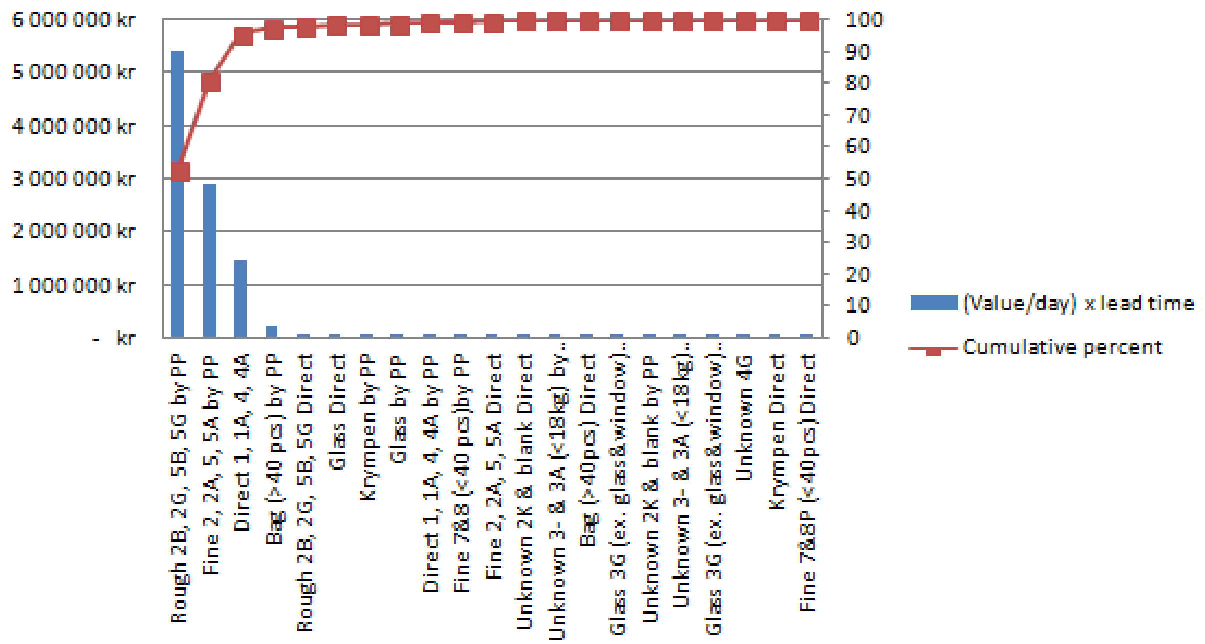


Diagram 11 – Product flows Tied-up value Pareto chart

Studying the Diagram 11, the Rough by Pre-pack- and Fine (2, 2A, 5, 5A) by Pre-pack groups are the ones with the highest tied-up value in the Inbound flow. Table 30 shows that the most value tied up is located in the IS between the Goods reception and the Pre-pack departments, confirming the previous analysis of the Pareto charts.

	(Value/day) x lead time 1->3 (SEK)	(Value/day) x lead time 3->4 (SEK)	Average time 1->3 (days)	Average time 3->4 (days)
Rough 2B, 2G, 5B, 5G by PP	4 858 172 kr	541 024 kr	4,4	0,49
Fine 2, 2A, 5, 5A by PP	2 588 772 kr	321 088 kr	3,87	0,48

Table 30 – Tied-up value and Lead times for the two defined product flows

4.5.3.4. The relation between the departments

One of the aims of this project is to find a common productivity metric for all the three departments at Inbound. Therefore it may be interesting to compare the departments to each other, but it is difficult to only choose one parameter since there is a big variation of products concerning size, value and amount. It has been natural in this project to continue analyze the gathered data on the amount of incoming material reports, quantity and value. The following tables and diagrams shows each department in relation to each other concerning value, quantity and amount of material reports that has been handled during the period of investigation in this project.

4.5.3.5. All flows

Since all product flows are included in the following tables, not all of them go by the Pre-pack department, however it is interesting to see the relation of how much each department handles compared to one another. Following tables comprises the relation concerning value, quantity and material reports.

Value:

The Goods reception and Binning has handled products of higher value than the Pre-pack where there are smaller and less expensive products, they have also handled a higher amount of quantity which also affects the value.

	Goods receiving	Pre pack	Binning
Oct	100 330 052,92 kr	37 124 574,60 kr	97 392 985,37 kr
Nov	98 240 866,99 kr	38 167 742,79 kr	100 193 893,06 kr
Dec	83 987 949,54 kr	33 895 744,96 kr	86 482 510,81 kr
Jan	115 664 807,90 kr	41 981 642,25 kr	105 977 807,65 kr
TOTAL	**398 223 677,35 kr**	**151 169 704,60 kr**	**390 047 196,89 kr**
Feb	- kr	6 983 349,75 kr	8 176 480,46 kr
Blank	- kr	240 070 623,00 kr	- kr

Table 31 – Value comparison between departments

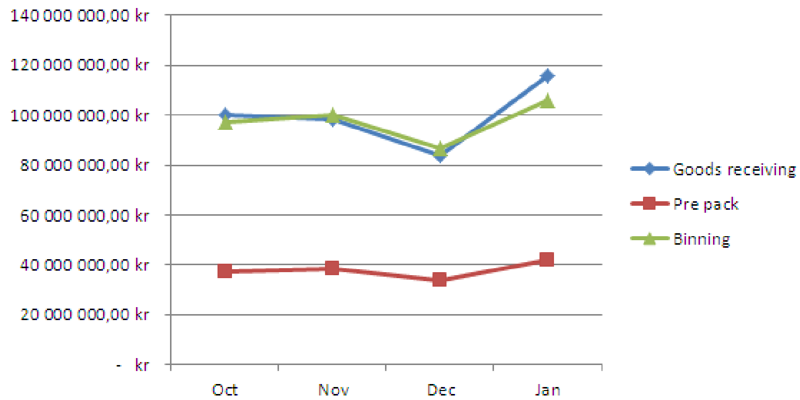


Diagram 12 – Monthly Value comparison between departments

Diagram 12 shows a monthly diagram over the value that has been processed by each department, illustrating how the Goods reception and Binning handles higher value per month than the Pre-pack department. Diagram 13 shows a daily diagram over the value that has been processed by each department, which can be used for daily monitoring.

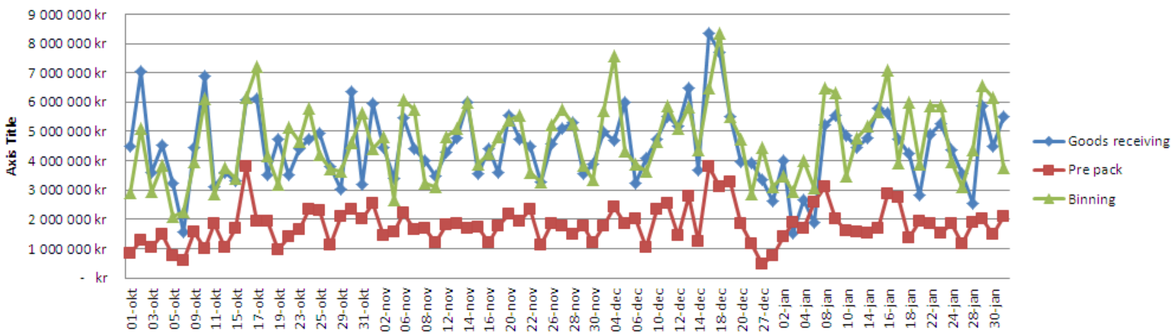


Diagram 13 – Daily Value comparison between departments

Quantity:

Just as with the value diagrams the Goods reception and Binning has handled a higher amount of products than Pre-pack, which also reflects the value curve.

	Goods receiving	Pre pack	Binning
Oct	781 087	324 028	770 144
Nov	816 188	410 507	840 834
Dec	724 296	306 233	797 621
Jan	1 127 936	485 165	974 541
TOTAL	**3 449 507**	**1 525 933**	**3 383 140**
Feb	0	53 019	66 367
Blank	0	1 870 555	0

Table 32 - Quantity comparison between departments

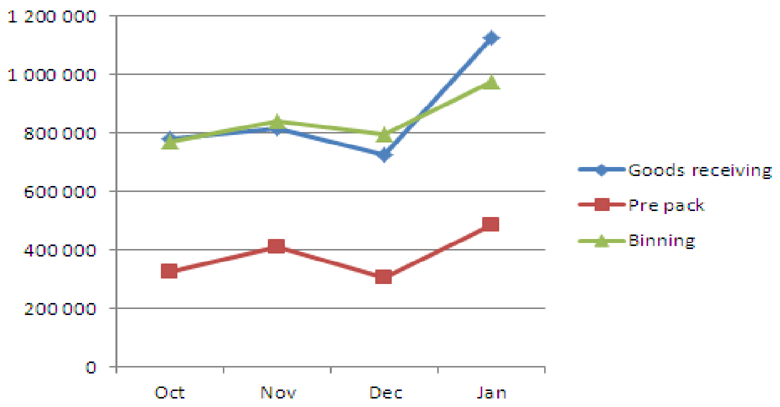


Diagram 14 – Monthly Quantity comparison between departments

Diagram 14 shows a monthly diagram over the quantity that has been processed by each department, where it is illustrated that the Pre-pack department handles half of the amount of products as the other two departments. Diagram 15 shows a daily diagram over the quantity that has been processed by each department, which can be used for daily monitoring as well.

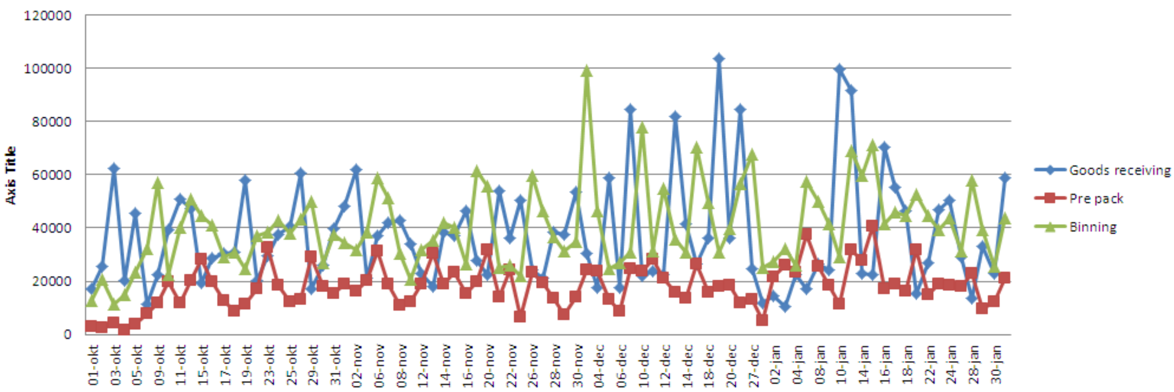


Diagram 15 – Daily Quantity comparison between departments

Using the daily quantity curve of Table 15 for daily monitoring enables to plan resources for tomorrow by the current state. By knowing the capacity of each station the number of operators or hours at Pre-pack can be adjusted by the amount of incoming goods that will go by Pre-pack to avoid having a large intermediate storage.

Material reports:
The Goods reception and Binning has handled a higher amount of material reports than the Pre-pack, which is in relation to the value and quantity diagrams.

	Goods receiving	Pre pack	Binning
Oct	12 161	4 865	11 106
Nov	12 041	5 301	12 213
Dec	9 355	3 547	8 967
Jan	12 200	5 431	11 970
TOTAL	**45 757**	**19 144**	**44 256**
Feb	0	983	1 173
Blank	0	25 630	328

Table 33 - MR comparison between departments

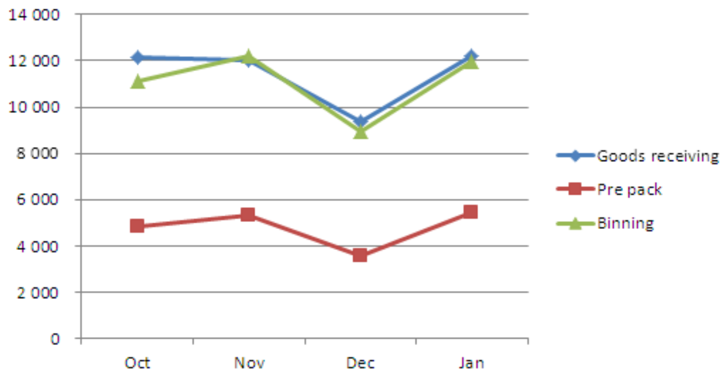


Diagram 16 - MR comparison between departments in months

Diagram 16 shows a monthly diagram over the amount of material reports that has been processed by each department, showing that Pre-pack has handled a third of the amount that has been handled by Goods reception and Binning. Diagram 17 shows a daily diagram over the amount of material reports that has been processed by each department, which also could be used for daily monitoring.

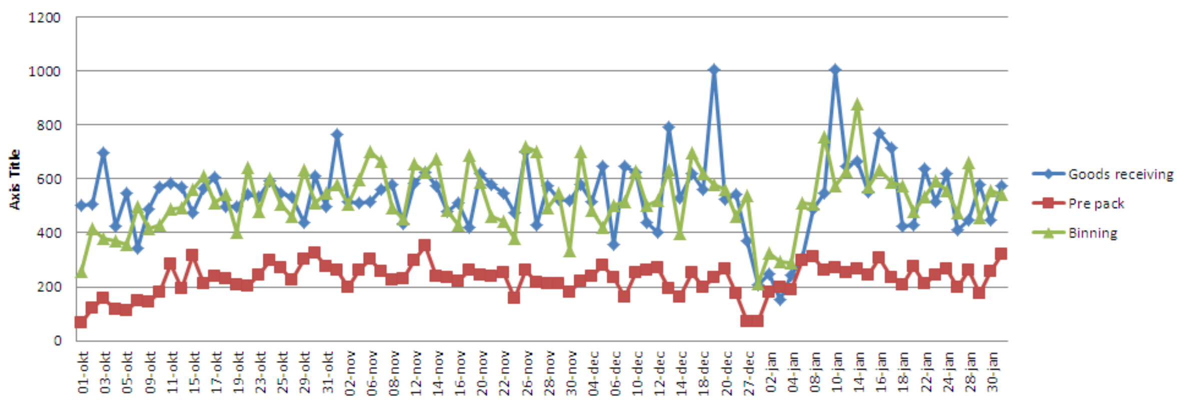


Diagram 17 - MR comparison between departments in days

4.5.3.6. Product flows by Pre-pack

By making a diagram over only the product flows that goes by Pre-pack it is fairer to the Pre-pack department when comparing the department against the Goods reception since the handling is of exactly the same products. The following diagrams will directly show whether Pre-pack is able to keep up same production rate as the Goods reception.

Value:

	Goods receiving	Pre pack	Binning
Oct	41 892 719 kr	37 124 575 kr	35 902 793 kr
Nov	39 367 203 kr	38 167 743 kr	38 655 554 kr
Dec	39 929 839 kr	33 895 745 kr	34 355 961 kr
Jan	36 963 293 kr	41 981 642 kr	41 672 178 kr
Total	**158 153 054 kr**	**151 169 705 kr**	**150 586 486 kr**
Feb	- kr	6 983 350 kr	7 566 569 kr

Table 34 - Value comparison between departments – by Pre-pack

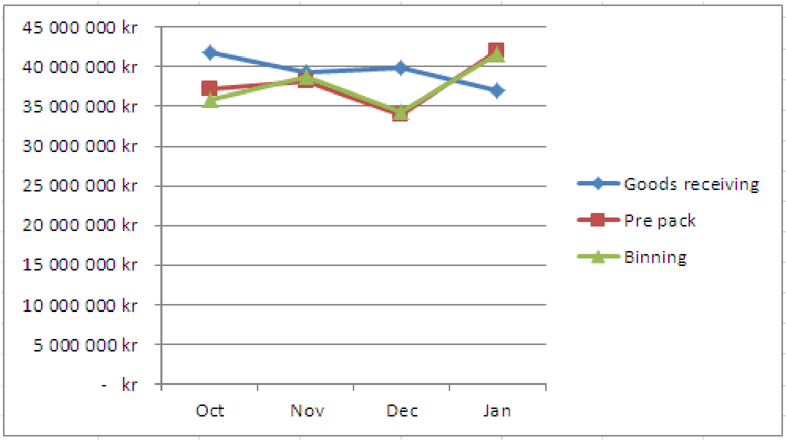


Diagram 18 - Value comparison between departments in months – By Pre-pack

Quantity:

	Goods receiving	Pre pack	Binning
Oct	364 439	324 028	304 731
Nov	421 722	410 507	420 702
Dec	391 314	306 233	311 802
Jan	401 477	485 165	482 813
Total	**1 578 952**	**1 525 933**	**1 520 048**
Feb	0	53 019	58 904

Table 35 – Quantity comparison between departments – by Pre-pack

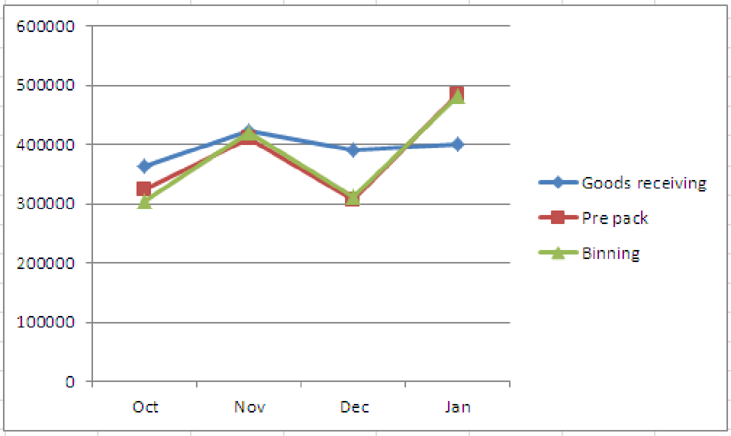


Diagram 19 - Quantity comparison between departments in months – by Pre-pack

Material reports:

	Goods receiving	Pre pack	Binning
Oct	5 661	4 864	4 682
Nov	5 260	5 301	5 356
Dec	4 247	3 546	3 632
Jan	4 939	5 429	5 380
Total	**20 107**	**19 140**	**19 050**
Feb	0	967	1 057

Table 36 - MR comparison between departments – by Pre-pack

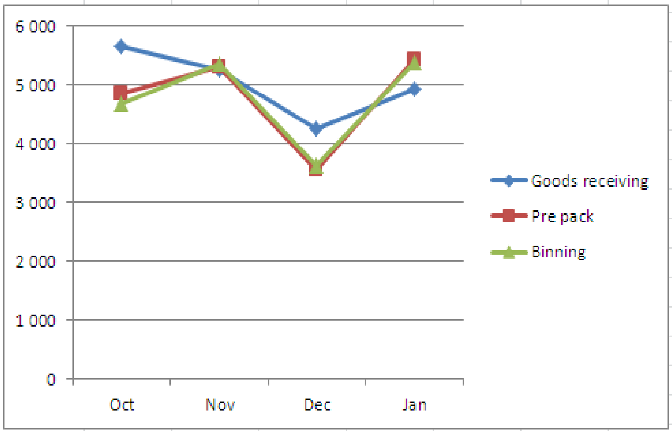


Diagram 20 - MR comparison between departments in months – by Pre-pack

Comparing the diagrams of value, quantity and material reports, the curves are in relation to each other. They also show that the Goods reception has a higher production rate than the Pre-pack. This means that the Pre-pack can't keep up at same speed as the Goods reception which results in intermediate storage before the Pre-pack department. It is interesting that the diagrams of the value, quantity and material reports has alike curves which means it is possible to compare their curves with each other. Previously it has been thought that there is a higher variation and that comparing quantity with material reports or value would not be reasonable.

4.5.4. SUMMARY ANALYSIS OF DATA COLLECTION

The calculations of production capacity and utilization may not be 100 percent accurate, since there are some uncertainties concerning the data and hypotheses has been made in order to perform the calculations. The hypothesis has been made at the Goods reception that 1 pallet is equal to 1 material report, in reality 1 pallet could contain 10 material reports or 1 material report could consist of 10 pallets. Also some delimitation in this project may affect the results of these calculations since some parts are excluded. However based on given information from data collection in this project, this is the data that has been used. It has been known that the Goods reception is the department that is the most difficult to measure, and due to outmoded technologies in this current state there are too many uncertainties e.g. concerning amount of incoming material reports in proportion to handled pallets since there are no data. Concerning the great variation of incoming goods every day, it is very difficult to make certain assumptions and more modern technology would be needed to register the incoming goods to get valid data in order to get 100 percent correct calculations.

Studying the calculations, what they tell is that each department has very different utilization degrees where the Goods reception works at a very high rate, the Pre-pack at a very low rate and the Binning at a perfect rate. This will say assuming that all the data is correct, however based on interviews and discussions the real picture should not vary that much. Because based on observations, interviews and the BEAT-report, these calculations confirm what has been assumed by the project managers. The Goods reception has no planned daily production capacity, the daily goal is to finish all the incoming goods by the end of the day, meaning that they push out the material into the Inbound flow no matter the amount of goods. The Pre-pack has been suspected for having a lower production rate than the other two departments, and the amount of product lying in queue in the intermediate storage for days together with the previously diagrams confirms that they cannot keep up in the same speed as the goods coming in. The Binning is the one department that has seemed not to have any big issues and also having reached their performance goal every day, with no big queue on the squares.

4.6. FLOW MAPPING

The very first map was a drawing with paper and pencil, however to map the flow the VSM tool has been used, using the Microsoft Office Visio program. It gives a good understanding and clear picture of the process and materials flow including parameters as lead times, value, capacity etc. As a first step a map of the total Inbound department has been drawn including all the sub processes where the numbers is an average of all collected data. It has not been at interest to draw a map of all the product group flows, since the biggest impact will come from making changes in the product group flows that will affect lead time and value the most. Previously it was defined that the product flows Rough by Pre-pack and Fine (2, 2A, 5, 5A) by Pre-pack are the flows that ties up the highest value, therefore the interest is in defining these particular flows where VSMs has beach drawn for each of them.

The data in the VSM is collected from the time measurements that has been performed during this project, see Appendix 6, and from the BEAT-report file ”New_tbl_UNIQUE_MR_OKT_JAN_2013_1” created by Rolf Possmark.

In the first VSM which illustrates the whole Inbound flow I have also included the capacity and utilization values that has been calculated for each sub department. These three following VSMs give a visual understanding for the production process and enable to compare the different departments to each other. The maps directly show where in the process the focus on improvement should lie by visually defining the location of longest lead times and highest value.

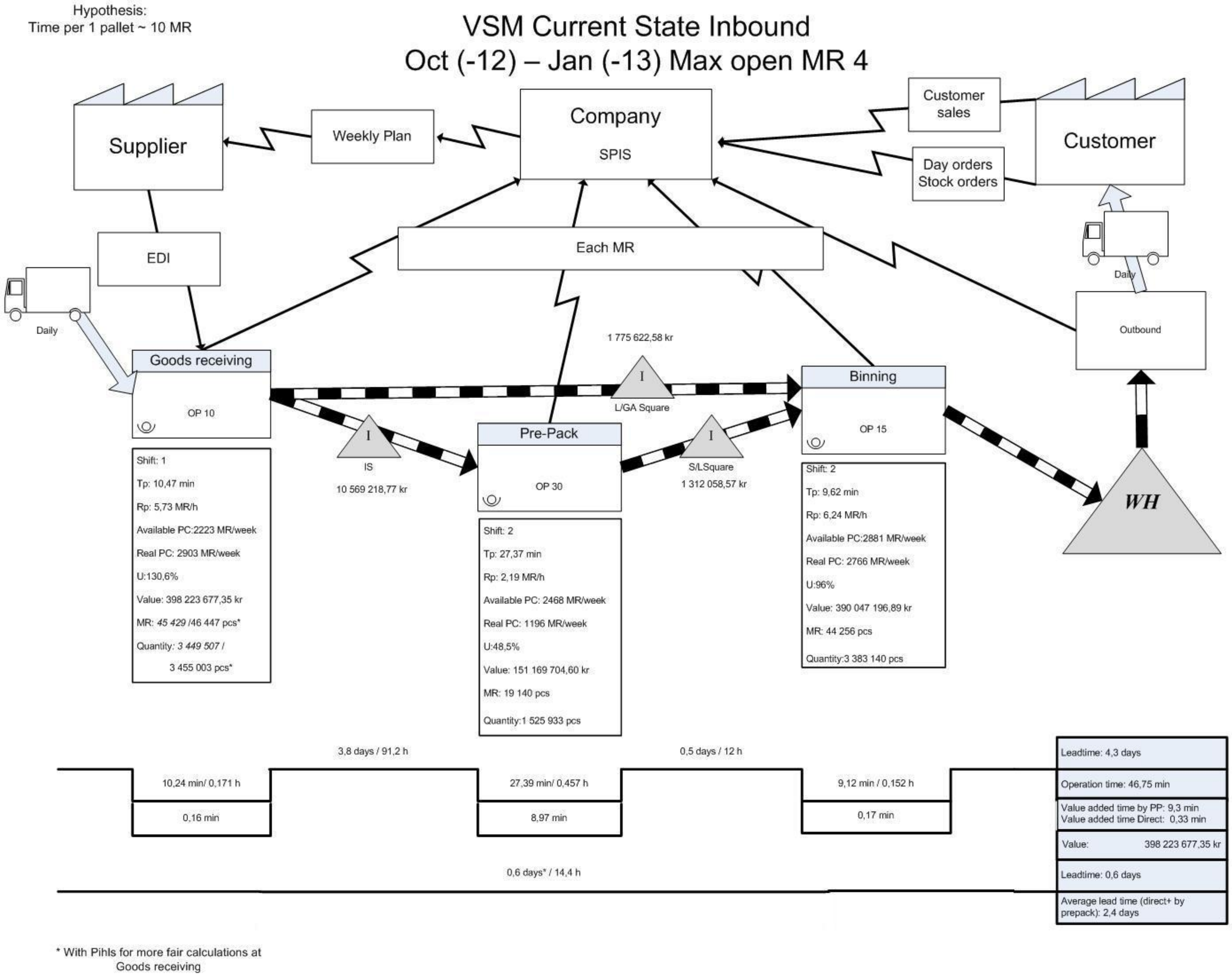


Figure 32 – Inbound VSM Current state

4.6.1. Rough by Pre-pack

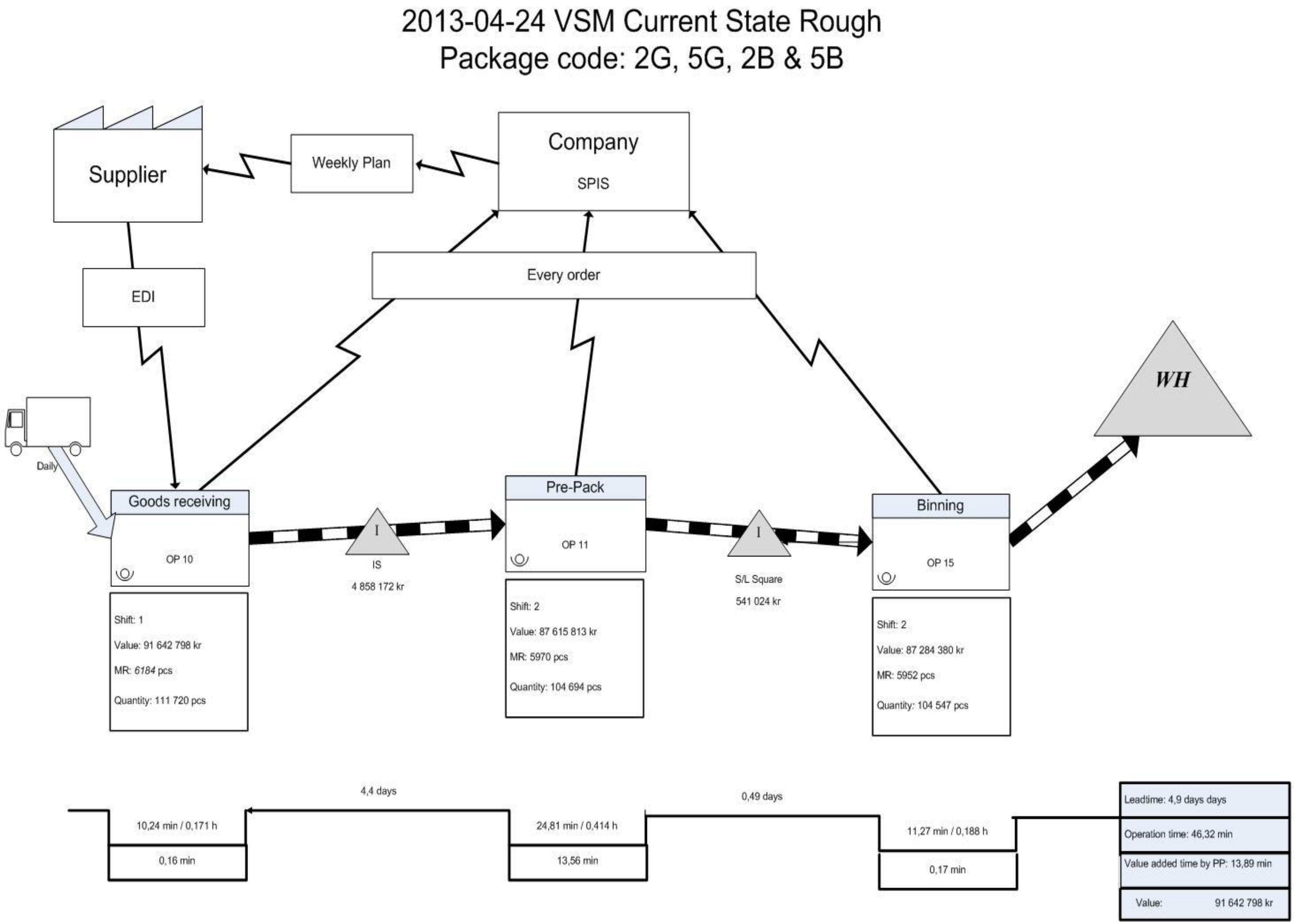


Figure 33 – Rough by Pre-pack VSM Current state

4.6.2. FINE BY PRE-PACK

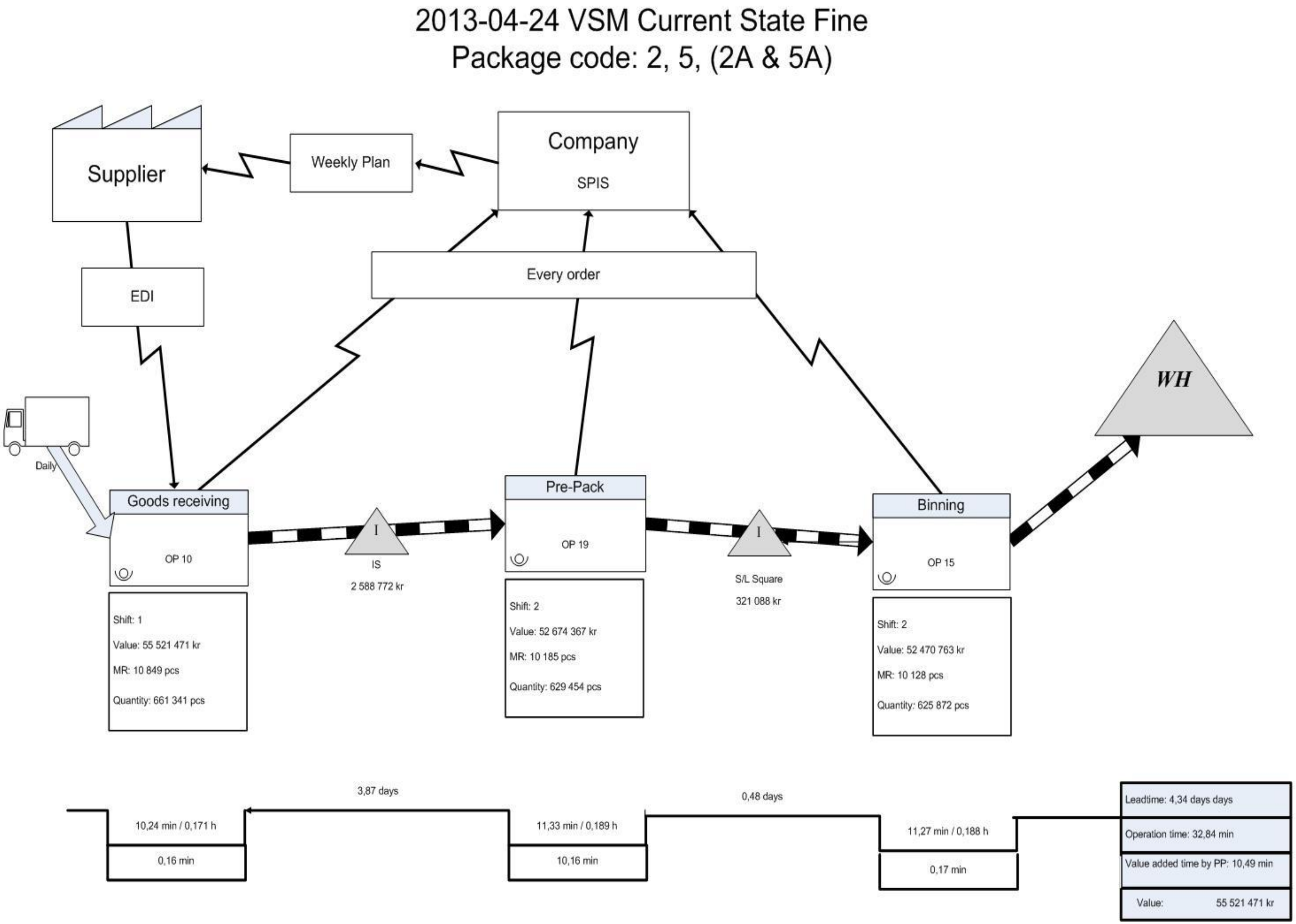


Figure 34 – Fine (2, 2A, 5, 5A) by Pre-pack VSM Current state

4.7. SPAGHETTI DIAGRAMS OF SERVICE FORKLIFT ACTIVITIES

After having analyzed each sub department, it was also interesting to see the work between the departments. Because even if the service forklift operators are included in each department, they are actually performing the work in between the work centers, handling pallets and moving around goods. There is only vague information of what activities they perform, it is known that they are responsible for moving the goods into the right places and embed for the flow, but it is not defined exactly what is being done and in what way. The service forklift operators mainly work based on experience and there are no standards or documentation of the activities being performed. This may result in unnecessary activities and prolonged lead time due to inefficiency. Therefore there was an interest of documenting the flow and activities of the main service forklifts, where the spaghetti diagram tool has been used. For detailed data see Appendix 6.

4.7.1. GOODS RECEPTION SERVICE FORKLIFT

There was a need to examine the activities for the service forklift at the Goods reception since the observations and discussions with production managers and operators informed that there was no standard to the work being performed. It was discovered that the forklift operator works very flexible and chooses the next type of activity by own experience rather than by following standardized instructions. There is however nothing wrong by being flexible, the problem here is that no one else but himself knows how the work is performed and therefore no one else can improve the work until the activities are known. The observations were performed during one day and 43 different types of activities were noticed. Of all the noticed activities, 8 activities were the most commonly performed.

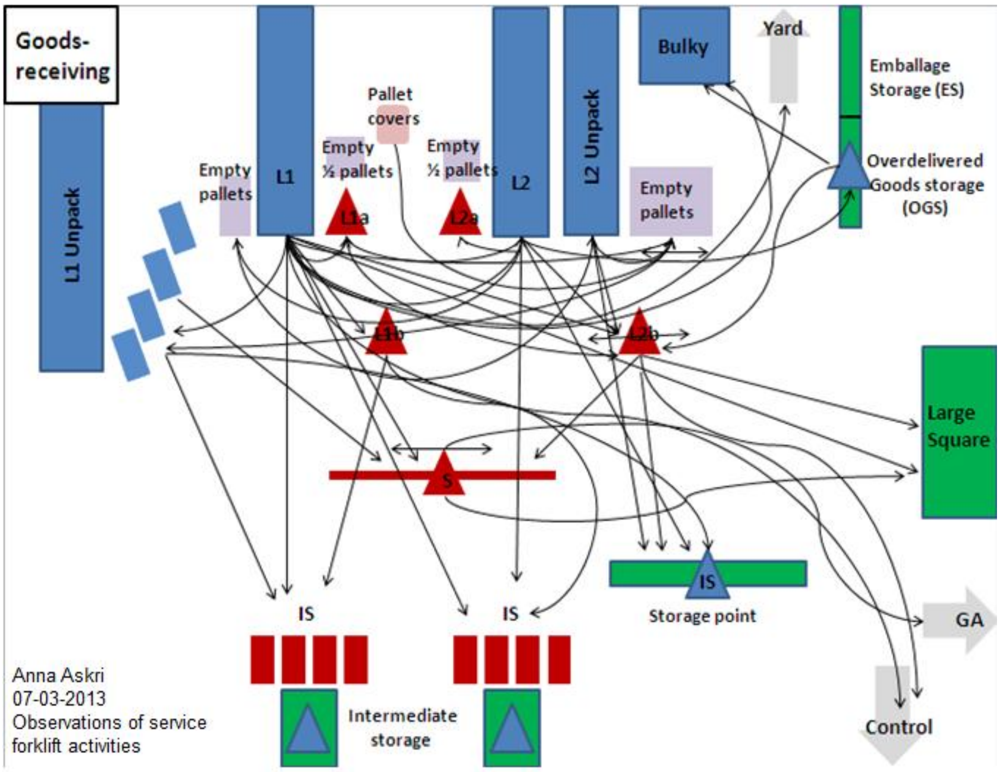


Figure 35 - Spaghetti diagram of service forklift activities at Goods reception

Figure 35 shows a spaghetti diagram of all the service forklift activities. The green color defines storage points that are planned and the red ones are somewhat unnecessary since they contribute to extra handling. While observing the work of the service forklift it was noticed that there were several activities that weren't necessary. Instead of picking up one pallet and driving it directly to the specific place it should end up on, the service forklift handled the same one pallet several times. Instead the goods should be placed directly into the IS (today the Pre-pack service forklift handles the pallets in IS which is considered as extra handling), and on the squares. Observing the Figure 37 the L1a, L1b, L2a and L2b are waste activities, the flow here should be direct. The S storage can be described as an IS within the IS, since pallets that are aimed to go to L- or GA square are stacked here in piles of four to five pallets before being picked up and driven away to the square.

4.7.2. SERVICE FORKLIFT PRE-PACK

The service forklift at the Pre-pack does also work due to experience rather than by standardized directives. The purpose of this forklift is to serve the Fine line operators with job and pick up finished goods and drive them to the small square, but also sort and organize pallets within the intermediate storage points and organize packaging material in the shelves. The intermediate storage is A, B and M in Figure 38, but there is also another storage point that cannot be seen in the picture, however it is located beneath G. The spread of these storage points forces the service forklift to drive more than should be necessary if all intermediate storage were located at same place. The location for the pallets at each point are also determined by the experience of the forklift operator, but also if A and B are full then all other pallets are placed beneath G.

Also in Figure 36 the labeling of the S/L squares are reversed to Figure 35 which might be confusing. This depends on that the fact that the Figure 36 is created by Kim Gabrielson where we did study one service forklift each. While this thesis is in English, Kim has used the Swedish names since it is irrelevant for the company what language is used, but rather the work that is performed. In Figure 36 the large square is referred to as S which in Swedish stands for "stora torget" and the small square as L which stands for "lilla torget".

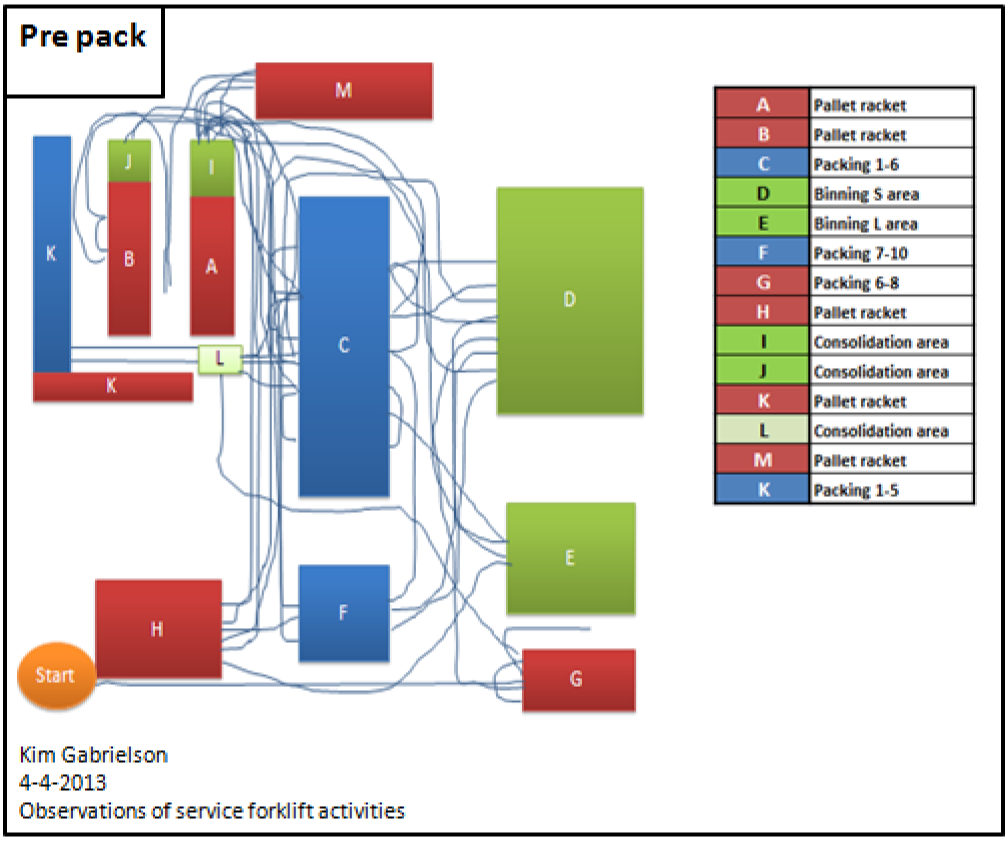


Figure 36 - Spaghetti diagram of service forklift activities at Pre-pack

There is a lot of driving around and I believe it is possible to decrease the forklift driving routes. See the improvement suggestions in chapter "*5.1. Improvement suggestions*".

4.8. SWOT ANALYSIS

To analyze the current state the SWOT tool has been used in order to define positive and negative factors at the Inbound department. There are in total four SWOTs, one for the overall Inbound, and one for each sub department. The SWOT analysis is based on observations, discussions with the operators and interviews (see Appendix 1) with production managers and process developers, in order to strengthen the validity of the analysis. To read the entire SWOT analysis, see Appendix 7.

A lot of problems have been discovered by using the SWOT tool; both small and of larger range. The smaller problems concern things that could be improved within the near future. These concerns routines, outmoded technologies such as old computers and manual work, re-handling of materials, flexibility, unnecessary activities etc. The bigger problems that have been detected will require more of the company both concerning time and investment. These issues concerns pre-advising of goods, technological solutions such as automation, the flow layout, getting the exact information of incoming goods and warehouse system improvements.

However the SWOT analysis has discovered opportunities and strengths as well; where there are several improvement ideas in mind. The most important factor is the company's willingness to change and improve by using new methods. The idea of the future holds more flexibility, more knowledge of the processes, new and better technologies, a more continuous material flow and some layout changes. There are a lot of competence and knowledge among the operators, however more standardized procedures are required.

The SWOT analysis functions as a basis for the improvement suggestions and gives also a good perspective of the current state.

5. RESULT

In this chapter the research questions from the preface chapter are to be answered and improvements to be suggested.

The first question was "*What is efficient material flow and how is it achieved?*". Based on the theoretical part about logistics and lean philosophy I would say an efficient material flow is affected by many parameters such as the layout of the plant, the handling activities, the planning and procurement process, the technology that is being used etc. The goal of an efficient material flow is to be continuous with handling of small amount of products in order to avoid intermediate storage and tied-up capital in front of workstations. The flow should be based on pull and not push as far as possible to avoid work load and high stocks and to be able to plan the resources. It is important to have a balanced work pace in the whole plant or department in order to avoid material to stuck and to avoid the workers become stressed. To achieve a balance and continuous material flow requires a lot of planning and it is important it is achieved already at an early stage as within the demand and material planning. Good planning also requires exceptional communication between departments and between third parties. Besides great planning it is important to have clear goals and standardized activities so that everyone knows what to do and how to do it, in order to avoid waste time and unnecessary activities, but also ease the work of the employees. (Liker. 2004; Petersson et. al., 2009)

The next question was "*What problems/deviations are there?*". This question is answered by the SWOT-analysis, see Appendix 7, however a summary is done under the headline "*5.1. Deviations*" further down in this chapter. The following question was "*How is improvement work operated?"* which is also answered further down in this chapter under the headline "*5.2. Improvement work".* The question "*What kinds of metrics are used in the current state?"* is as well answered below under the headline "*5.3. Metrics*".

"*Which product flow groups stand out in terms of value, quantity, amount of material reports and lead time?".* As previously answered in the "*4. Current state analysis*" chapter the product groups that had the highest value was the Direct, Rough by PP and Fine (2, 2A, 5, 5A) by PP. The product groups that had the highest product quantity was the Direct, Bag by PP and Fine (2, 2A, 5, 5A) by PP. The product groups that had the highest amount of material reports was the Direct and Fine (2, 2A, 5, 5A) by PP. The product groups that had the longest lead time was Rough by PP, Fine by PP, Direct by PP and Glass.

The answer to the question "*How is the value proportion between the three sub departments in Inbound?*" can be found under the headline "*4.5.3.4. The relation between the departments*". Studying the Diagrams 12 and 13 the Pre-pack department handles less value than the other two departments, however the other two departments handles more products and of higher value such as engines etc. The data in these diagrams is based on a specific time period, however it gives a picture of how the value is divided between the three departments.

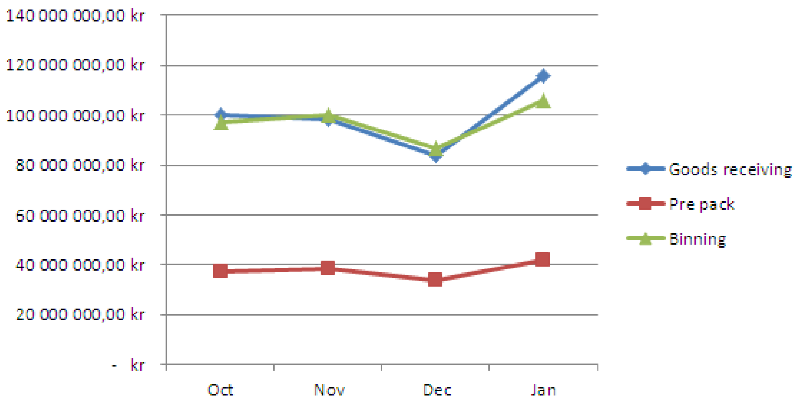


Diagram 21 – Monthly Value comparison between departments

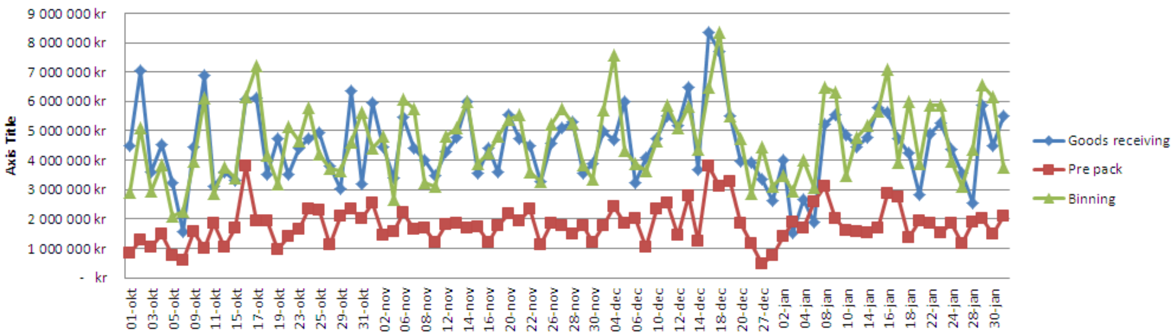


Diagram 22 – Daily Value comparison between departments

The last question "*For how long is the capital tied up in the flow and where is it tied-up?*" is answered under the headline "*4.5.3.3. Tied up capital*". Based on the BEAT-report and data analysis it was defined that there were two product groups that was distinguishing themselves concerning tying up capital. These were the Rough (2B, 2G, 5B, 5G) by Pre-pack and Fine (2, 2A, 5, 5A) by Pre-pack. Based on their daily value and lead time it was defined how much value they tied up and where, see Table 30. The most tied-up value is to be located in the Intermediate Storage between the Goods reception and the Pre-pack departments.

	(Value/day) x lead time 1->3 (SEK)	(Value/day) x lead time 3->4 (SEK)	Average time 1->3 (days)	Average time 3->4 (days)
Rough 2B, 2G, 5B, 5G by PP	4 858 172 kr	541 024 kr	4,4	0,49
Fine 2, 2A, 5, 5A by PP	2 588 772 kr	321 088 kr	3,87	0,48

Table 37 – Tied-up value and Lead times for the two defined product flows

The results of this thesis is that the times of operations and times between operations has been defined, products has been categorized into groups of similar flows and been analyzed. Based on the given products in this project the total incoming value and amount of products has been defined and divided into different flows, where the Pihls products has been sorted out defining the amount that is not handled by Pre-pack. The Tables 22 and 23 has shown that the product group flows Rough (2B, 2G, 5B, 5G) by Pre-pack and Fine (2, 2A, 5, 5A) by Pre-pack are the flows which ties up the highest amount of value and the Figures 24 has shown that these are located in the intermediate storage between the Goods reception and Pre-pack departments. It has been known that a lot of value has been located in IS, but there has not been resources to analyze the data to prove it. This project confirms that the IS ties a lot of value, it is also confirmed that the Pre-pack department produces at a lower rate and do not manage to keep up with the amount of incoming goods from Goods reception, which results in the products ending up in IS in queue. However dividing the products by different groups is new, by knowing what product groups to focus on the company can investigate more detailed and make an action plan to reduce the lead times for these particular groups, which automatically will result in reduced tied up value.

5.1. DEVIATIONS

Following deviations that are defined in this chapter are based on Interviews, see Appendix 1, observations, discussions and the SWOT-analysis, see Appendix 7.

5.1.1. GOODS RECEPTION

The Goods reception department has deviations such as over and under deliveries, damaged goods and wrong packages from supplier, damaged goods from the transportation and wrongly advised goods. Also pre advising from suppliers do not work so well, only 3% of all deliveries are correctly advised, 27% are wrongly advised and the rest are not advised at all. This complicates the work for the operators who have to correct the notifications and manually register which takes longer time and implies the risk of error, especially since different suppliers has different standards on the delivery notes. Sometimes the delivery notes can be absent which prolongs the whole working process. Also there is no detailed information of when goods arrive and how much, in order to plan resources, which often leads to an unleveled supply flow. Another issue that complicates the work of the operators is the outmoded technology. Not only because manual work and slow computers prolongs the operating times, but also increases the risk of errors to occur.

5.1.2. PRE-PACK

The Pre-pack department gets a lot of mixed goods with ordinary goods together with high priority from the Goods reception, which results in that some high priority goods are "delayed". Another deviation is the "new" bag machine that hardly has been used due to wrong setting and also that the supplier did not deliver what was promised. There are also usual for forklifts to break down which slows down the working process and prolongs the lead time. The layout is also not optimal where work stations are quite spread and some operators have long distances to packaging material and computers. There are too few computers and they are too old. Also some operators have to cross forklift aisles which imply a certain risk.

5.1.3. BINNING

The deviations at the Binning department consist of operators forgetting to register the MR or writing wrong when storage location is changed. Another deviation is that not all the forklifts has a computer which results in errors if writing or registering wrong when doing it manually. There is also a need for a new label system where a scanning system should be used for everything and by using scanner errors can be eliminated. Pallets can be mislabeled and goods mixed up. Goods can be placed in the wrong place or left at the old place when there is a change of location.

5.2. IMPROVEMENT WORK

This information is based on interviews with production managers and process developers, see Appendix 1, and observations.

Each department has daily board meetings that are developed from a lean perspective and VPS. These boards raise issues as performance, quality, environment and people, and deviations that every employee can address. The meetings are held at each department by the production manager and then all department managers has their own board meeting together with higher managers, reporting upward in the organization where the most important issues needs to be solved. There are different ways to report deviations, many times simple photographs are used to visualize a problem e.g. mishandled or incorrectly placed items, and sent to the department or unit that either caused it or is able to solve it. It is difficult to find small mistakes and often they are found by observations of the operators. Small deviations are noted on the daily meetings board and if the deviations are big the business developer is contacted.

Volvo is constantly striving to improve their processes, trying to find new methods and ways to solve problems and implementing lean thinking. Currently there has been a big focus on mapping the material flow at the whole plant, defining lead times and bottlenecks and finding the root causes in order to achieve a more efficient flow.

5.3. METRICS

The following information is based on interviews, see Appendix 1, and discussions with production managers and process developers. Current performance metrics differ by each department, where there is a need to compare the departments with each other and having a common performance metric. The company is constantly seeking to find the best type of reliable metrics, trying different measuring factors.

5.3.1. GOODS RECEPTION

Today the production outcome is measured in number of material reports per hour and the quality in number of backed material reports. These metrics are both deceptive since one material report has a high variation in several aspects such as quantity, weight and value. There is an interest of measuring what is to be received instead, since currently it is not certain what is to arrive when, which makes it hard to plan resources. Also measuring parcel amount could maybe be fairer concerning the workload. The quality metrics should show a direct impact.

5.3.2. PRE-PACK

The metrics that are used at Pre-pack are produced units per hour (glass excluded) and in productive hours per number of packages (manual measurements by counting MRs). The shortcoming with the metrics are that they are not in relation to each other where the inflow is measured by number of hours in queue while the out flow is measured by number of produced packages per hour. There is an interest of being able to see how much capacity that is available and how much goods are coming in, in order to plan the resources. Concerning quality there is an interest of being able to see how many errors from Pre-pack that lack origin and how many goods that has been damaged by Pre-pack. Current quality is measured by lack of origin of goods in the inflow, today there are few errors. There is also difference between the glass station and the rest of the Pre-pack, since they do not package everything that is registered and they have other routines which make it hard to have a common metric.

5.3.3. BINNING

The Binning uses lead time as a performance metric, where the goal is 0,7 days and the outcome is 0,6 days. They also have internal measurement of number of shared hours per registered MR, but these are not fair. The metric should be reasonable and achievable and each operator should be able to see their own progress. However since each pallet takes different amount of time it is hard to compare. The focus should be on removing queues and using just-in-time. There is also a common lead time measurement together with Pre-pack that is reported upward in the organization, however it is not fair against Binning since they meet their lead time goal while Pre-pack doesn't. They measure as well number of accidents since Binning operators handles forklifts the most at the warehouse and the risk of accidents is higher.

5.4. IMPROVEMENT SUGGESTIONS

The improvement suggestions are based on the current state analysis where deviations have been identified and the flow analyzed. The suggestions are not placed in any particular order, since they all will contribute to a more efficient flow of materials individually. However the company can choose among the improvements and choose the ones they believe are most realistic to implement in current state.

5.4.1. REDUCING LEAD TIMES AND PRODUCTS FLOW VALUE

These suggestions are based on all data and information in the current state analysis. To be able to give suggestions on reducing lead times and tied up value in the production flow, it has been necessary to observe and map the process and the flow of materials. What type of operations there is, what type of technology, handling activities and deviations. These improvement suggestions are based on theoretical studies of efficient logistics and lean production, and also all the information that has been gathered during this project by observations, documentations, interviews and discussions with operators and managers, trying to find common factors.

In Lean the continuous flow of materials is sufficient and since the production process in this case is handling of products at a central warehouse, it is in a greater extent based on push due to the need of always having products in stock. Therefore there is a high importance in superior planning of incoming material flow. Also eliminating waste activities and stops in the process are of importance. The following improvement suggestions are;

5.4.1.1. Knowing date, time and quantity at arrival

The operators and production leader should know the exact date and time of arrival at the Goods reception. They should know what type of parcel and the amount of it that is coming in. This is sufficient to plan the resources and the work to achieve a more balanced flow in the entire inbound department. By knowing the exact amount and time the production manager is able to plan the resources and the production volumes in order to level out the workload. The advantages of flow planning are better quality, effective tact time and less stress factors. They should be able to receive the exact information in the computer system. Based on discussions and interviews, this is something that should be taken care of by the material planners or transportation planners, to impose requirements on the transportation company. Discussions have stated that this type of project will require a lot of work and time since several parties are involved making this work, however I believe it should be worth it if the planning of the material flow can improve.

5.4.1.2. Pre advised goods

All goods should be pre advised in order to save time and eliminate the unnecessary activity of the operator writing the material reports manually, and also reducing the risk of occurring errors. Introducing a computer system for pre advising that works for all suppliers could save a lot of time, since currently only 3% of all incoming goods are correctly pre advised, see Appendix 1. Since GTO has a lot of suppliers where the contact with some are more intense than with others, using EDA can be a less expensive solution than EDI, where the supplier can get access to the system by online communication. This type of project will also require a lot of time and work, designing a new system and making the suppliers to use the pre advising. However the company has tried this to work for a long time, but as I understand from the interviews and discussions it has not been a priority. It may be about time to invest in this and make it work, because of the benefits of it.

5.4.1.3. Prepare

If the pre advising is trustable and will be implemented fully, it will enable the operators at Goods reception to plan their daily work. Since the operators have great competence they know what goods to handle first in order to make the most efficient work not only for themselves but for the entire Inbound. If the type of parcels that will arrive are known, they can process the miscellaneous packages last since they take much longer time. By knowing the type and delivery of arriving products enables also to sort products of same articles into common pallets instead of pushing out several pallets with smaller amounts. If the operators at Goods reception will be able to do this they will save the handling time further on in the Inbound flow. Another preparing thing that the operators at the Goods reception could do if they knew the exact incoming goods, is that they could prepare the mixed goods that go by Pre-pack for the Binning where the goods are sorted by driving routes at the H/L A-U storage.

5.4.1.4. Technological solutions

Referred to interviews and discussions with operators and managers, the current technology has its boundaries. Many procedures are outmoded and there are more efficient ways to perform work. There is need for faster information collection and exchange, and also to be able to trace the products in the Inbound flow.

- **Scanners & bar codes**

This technology is already wide spread and used by humans at e.g. grocery stores, saving time and minimizing manual handling. This technology enables rapid information exchange and collection. The Binning department is already using scanners and bar codes at the stacker forklifts, implementing this at every forklift will minimize the risk of errors caused by manual work. Scanners and bar codes can as well be used at the Goods reception, scanning the parcels coming in on the conveyor or gate, automatically registering the incoming goods into the system. Also scanning the material reports at the Pre-pack stations would save time.

- **RFID**

Another technology that would save time is RFID that is able to store more information than bar codes and is perfect for tracking products at a warehouse. This makes it possible to control the products flow, saving time by eliminating the searching after items and eases the procurement by knowing that products that are not in stock still may be available and on the way in to the stock, and therefore order the right amount. The great thing with this technology is that the time for reading information is very fast and where a whole truck load can be identified at once.

- **Computers**

There are few computers in use for the operators today especially at the Pre-pack where 30 operators share two computers that are old and slow. Introducing more and faster computers and more printers will decrease the queuing and waiting time. It will also minimize the risk of computer break down.

5.4.1.5. Automation strategies

Using automation speeds up the handling time, reducing the waste time and easing the work for the operators. By putting bar codes or RFID chip onto products the automation system can be informed of the incoming stock. The ultimate automated goods in process shall be transported by conveyors through the flow into automated storage by automated cranes.

- **Specialization of operations**

This strategy focuses on reaching highest possible efficiency level of performance for one specific operation by using special purpose equipment. The Goods reception could improve the handling time by using scanners and bar codes or RFID technology to faster register the information. The Line 1 and 2 could use a handheld or automated traverse to ease the removal of pallet lids. The Bulky should need more than one forklift to handle the transportation of goods within the plant, also there should be requirement on using the handheld traverse when lifting heavy products in order to avoid injuries.

- **Improved material handling and storage**

This strategy focus lies on reducing the WIP and manufacturing lead times by using automated material handling and storage systems. In the intermediate storage between Goods reception and Pre-pack, FIFO lanes and supermarkets could be implemented in order to decrease the handling and waiting time in between operations. This would also help avoid the time of sorting among pallets and replacing them within the IS. A wider use of conveyors in order to achieve a more continuous flow could also be used, especially at the Pre-pack department where the operators should be served with the job.

- **Integration of operations**

This strategy aims of linking several workstations together, by doing this numerous parts can be processed at the same time and increase the overall output. By linking workstations the number of machines can be decreased and automated handling equipment can be used to move parts between stations. This is today performed at some extent, however the workstations (benches) at Pre-pack are quite spread and would need to be more close to each other to decrease the transportation of the service forklift and also operators walking distance to packaging materials and computers.

- **Process control and optimization**

This strategy aims improving product quality and reducing process time by using a wide range of control schemes for the individual process. Implementing standards at each department for each operation and how handling of the materials should be performed would structure the work and improve the lead times.

- **Plant operations control**

This strategy focuses on controlling the whole plant by using a high level of computer network within the factory. This computer network could be described as company's current system SPIS, however the information exchange could be better. There is a need to know where the products are located in the flow and also to know the exact amount of items in stock where the WIP actually should be included. An operator should be able to type in the article number he is searching for and locate where it is in the plant e.g. if it is in the IS or on the square.

5.4.1.6. The layout

To enable continuous movement of materials the stopping time has to be minimized. To achieve a continuous flow the distances between operations should be short and the transports frequent. The workstations at each department should be placed as close as possible to each other, where there is today a spread at the Pre-pack department. The intermediate storage should also be located at the same place and not spread in several places. It should be placed to encourage a natural flow of materials.

5.4.1.7. JIT

Since the production in this project concerns a warehouse it can be difficult to have a complete pull flow, however the customer can be the next production step meaning that the last operation signals to the previous operation when to begin production. A good way to signal the demand is by using Kanban or CONWIP, this would be a good solution to help the operator at the service forklift at Pre-pack. By using cards the forklift operator will instantly see where the finished goods are and go get it instead of driving around and constantly watching whether there are some finished goods somewhere.

5.4.1.8. Standardization

In order to make continuous improvements the process must be stabilized. Standardization concerns standard procedures that should be simple enough to be used on a daily basis. At the Pre-pack department for example this can mean that the operators have instructions for how a product should be packaged and what activities to perform in what order. There should be standard procedures how to handle certain deviations. At the Goods reception department there should be standard procedures on how to handle e.g. goods that has been sent wrong by the supplier. There could also be a standard for what packages to handle first in order to keep an efficient flow. At the Binning department the standards could concern procedures in order to avoid forgetting to register the material reports.

5.4.1.9. Impose requirements on the suppliers

A lot of waste time could be saved if imposing requirements on the suppliers. One issue concerns the goods advising, if all goods became pre advised a lot of time could be saved and risk of errors occurring minimized. Another issue is that there are a lot of products arriving from suppliers within the Volvo Group that has to be repackaged even though they arrive in Volvo packages. There should be a standard on the packages, it is unnecessary to repackage goods concerning both environment but also resources and time. There should either be a standard of packaging range within the Volvo Group or the company has to demand the supplier to use the required packages in order to avoid repackaging. Also concerning the uncertainty of date and time for arriving goods, the company should set requirements on the transportation company or supplier to inform the exact information.

5.4.1.10. Product groups

Divide products into product groups to narrow down and easier control the flow and plan the work. The products can either be divided into groups by packaging/handling codes since they go through alike processes, or they can be divided by family groups. They could also be divided in groups by product packaging sizes.

5.4.1.11. Expand shift hours at Pre-pack

The company could expand the hours at the evening shift at the Pre-pack department by having more operators working in order to catch up with the output from Goods reception, achieving a more balanced work flow.

5.4.1.12. Stopping the process to build in quality (Jidoka)

Jidoka can be compared to automation, by using intelligent equipment that stops itself when problems occur, making it possible to continuously ensure the product quality. Currently the forklifts at Binning that handles pallets at the large square and GA square, have computers and scanners that indicates if the pallet is to be placed at the right shelf or not, eliminating errors. This could be applied at all Binning forklifts. At the Pre-pack the same method could be used to control if the right packages are to be used by scanning the package and the material report.

5.4.1.13. Team work

Making teamwork the foundation in a company will make individuals give more to reach company success. Based on the Interviews, see Appendix 1, the teams at each department could gain more motivation by getting qualitative feedback and encouragement. Doing workshops together may strengthen the group dynamics and gaining trust in the management.

5.4.2. DAILY MANAGEMENT METRICS

The following metrics are the suggestions for the daily management, where I have been trying to find factors that could fit to all the three sub departments. Just to summarize I think thorough production capacity calculations should be performed in order to know how much each sub department are able to handle, based on exact data. Combining that with having information of the incoming goods the resources could be planned to level out the work load on a daily basis.

5.4.2.1. Production capacity

Planning available capacity based on the amount of incoming goods will help in the planning work of recourses to level out the material flow. The daily diagram of receiving quantity under following headline can help the planning work, however if planning for Pre-pack only Pre-pack product group flow should be encountered. For example if the received amount of products at Goods reception is known for day 1, the capacity at Pre-pack can be planned for day 2 in order to meet the incoming amount of goods, to avoid having a high intermediate storage and long queuing time. Also daily utilization diagrams could be used to measure the performance by comparing output with input.

5.4.2.2. Diagrams of lead times, material reports and value

A simple way of comparing the departments with each other is to use diagrams containing daily information about incoming amount of material reports, value and lead times. The diagrams could look like Figure 22, where each curve represents each department. Benefits of using this type of graph is that it gives direct information and by knowing the capacity of each department the management can plan the resources for the next day based on the values of today and control the material flow.

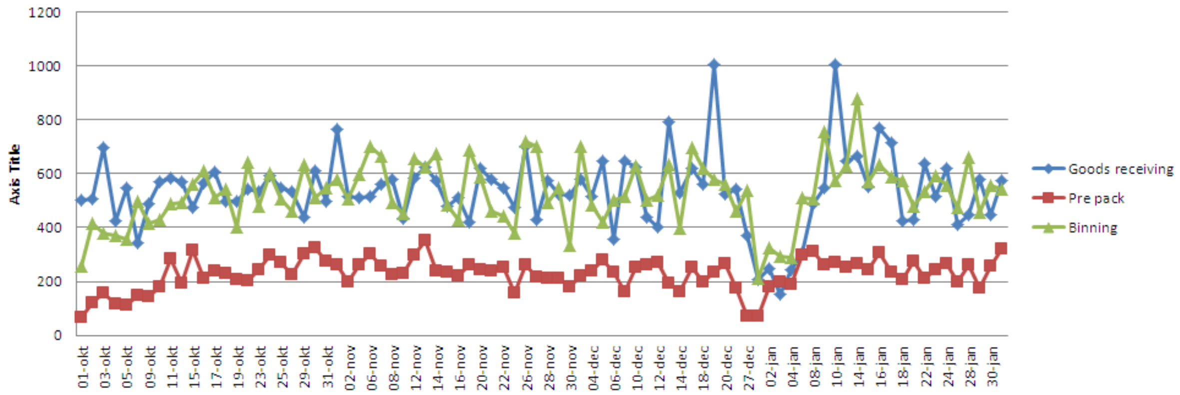


Diagram 23 – Daily control diagram

5.4.2.3. Delivery reliability

This is a service related metric that measures the amount of products delivered on time compared to the total amount of delivered products. The company could set up a goal of the amount of products each sub department should be able to deliver per day, where the delivery is to the next department in the process. The goal should also be based on having a balanced work flow where the utilization should be somewhere between 95-97%. Or it can be used backwards where for example the Pre-pack department can set a daily goal of producing a certain percentage of the incoming goods at Goods reception. Calculations for delivery reliability are to be found under the chapter "*Production concepts & mathematical models"*.

5.4.2.4. Delivery dependability

This metric is also service related and measures the amount of complete flawless products compared to the total amount of products. This metric can be used by the company to measure quality at each sub department. Calculations for delivery dependability are to be found under the chapter "*Production concepts & mathematical models"*.

6. CONCLUSION

The aim of this project was to analyze the current state of the materials flow in Inbound and define where the capital is tied up in the flow. There were many uncertainties about the flow concerning operation times, deviations, differences between product flows and there was a need to map and gather the information. Many problems were unspoken and there was a need to investigate their validity. During the project the company was undergoing changes in the organization and the Inbound department which actually was three different departments were merged into one. I believe this project took place in the right time where several new projects were started up and where a big focus has been on defining the current state and evaluating the procedures and activities in the whole plant. There has been a big will to improve and interest in trying new ways. The people and managers are very much aware that change is needed and I believe starting by analyzing the root causes is significant for improvement work to succeed.

This project has implied an extensive work of the fundamentals at the Inbound department, with focus of finding deviations and root causes. I believe many unspoken problems have now arisen to the surface where they can be analyzed and dealt with. With the new production managers this current state analysis may be a very interesting material in future improvement work. The most value holding product group flows can now be mapped and controlled in order to minimize the long lead time caused by queuing time in intermediate storage and the production capacity at Pre-pack department, and in that way also minimizing the tied up value.

Using value stream mapping is an effective tool for mapping the materials flow which is recommended in future improvement work. However this is something that Volvo already puts a lot of value in, where extensive work is currently performed to measure and map the flow in detail at the entire warehouse. The work of this is fundamental and will help the company in their improvement work a lot since they will get great control over all the details.

It was harder to find good performance metrics that could be commonly used at all three departments, which is also the one problem that the company has. I believe the best solution is to combine the different factors and compare each department by these, rather than deciding one specific factor to measure by. I think lead time is still a good metric, however it can be analyzed more of for example what in the flow that causes its length as in this project it was defined that the long lead time depends on the time in IS. The daily control diagrams can be used to plan resources and even out the work load and where the three sub departments can be compared to each other.

The project approach has followed the DMAIC-model in order to achieve a structured and organized work, and by setting milestones the project time plan has very much been maintained. Thanks to clear directives of the project and guidance by my supervisors the focus has stayed clear and the project narrowed. I believe all the questions in the introduction of this report has been answered and that the aim of the project is fulfilled, however there could be a lot more to investigate and easily to go down in detail in every problem.

I believe now that the problems are defined and what product group flows that the focus should lie on, it is possible to reduce the lead times and tied up capital a lot. Since there are no measurements on future operation times based on each improvement, there cannot be detailed comparison proving that the tied-up capital can be reduced by 20%, however I believe it is very much possible to achieve if dealing with the larger problems and deviations and looking at implementing the improvement suggestions in chapter 5.

7. SUGGESTIONS FOR FUTURE STUDIES

During this project I have gained a lot of knowledge about the Inbound processes and the activities in it. A lot can be improved within the Inbound department, however I think there are other factors that complicates the work at Inbound that occurs in an earlier stage and harms the efficient flow. I believe however the company would gain a lot by dealing with these problems since they affect the flow at Inbound. What this concerns is the pre advising that is not working currently, but if it did it would take away a lot of work load and decrease the risk of errors. Another problem is not knowing the date, time and amount of arriving goods which is significant to be able to plan the resources to achieve a controlled and balanced flow of materials and work. It would also take away the stress factor, not only of the workers, but also of the production managers, by being able to foresee what is to come.

Based on discussions and interviews these two problems are both individually large projects, since they concerns several parties within the supply chain that should agree on same conditions. Both problems require their own projects to dig deeper into the problems and find improvement solutions. Both these problems might also be costly since they require new computer systems where information is to be shared between the different supply chain parties. However improving on these would lead to great improvements in the Inbound department.

There are issues that could be investigated more in detail. I think future projects besides above mentioned could concern studying;

- The Inbound layout, with focus on designing the ultimate materials flow layout
- The production capacity, setting up daily or weekly goals, the planning of resources
- Warehouse management system, being able to follow products in the warehouse
- Automation, searching for further possible solutions

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9. APPENDICES

APPENDIX 1 - INTERVIEWS

The interviews are performed in Swedish and translated into English. They are documented by recorder, by taking notes and some by email. The questions vary from case to case, where some questions only needed to be answered once.

Goods reception:
Lars Ekendahl, previous Production manager
Anders Eklund, current Production manager
Andreas Sweström, previous Process developer

Pre pack:
Per-Eric Klingstedt, previous Process developer
Sara Bäckman, current Production manager

Binning:
Åsa Göhlman, previous Production manager
Rickard Kindlund, previous Process developer, current Production manager

Consultant:
Kim Gabrielson, consultant VSM project

QUESTIONS

GENERAL QUESTIONS

1. What kind of deviations are there at this sub department?
2. Is there any documented data of the deviation?
3. How are the deviations handled?
4. What type of performance metrics are used at this sub department?
5. What are the shortcomings with these metrics?
6. What kind of metrics would you prefer instead? What would you wish to measure concerning performance and quality?
7. What is the planned production rate per day?

SPECIFIC QUESTIONS

1. How is the production rate calculated?
2. How well is the production rate satisfied?
3. What lead times are pursued?
4. What kind of strengths, weaknesses, opportunities and threats are there at this sub-department? (SWOT-analysis)

5. How many shifts, operators per shift and hours per shift are there at this sub-department?
6. Explain the unpacking organization at the Bulky station at the goods receiving.
7. How many of the pallets are High priority? How long time does it take for one HP to go through the entire Inbound flow?
8. Glass station registers the MR as binned and stored, though it's not been packed yet. Why?
9. Describe the activity for each bench at pre pack?

PER-ERIC KLINGSTEDT 13-03-2013 13.00-14.00

What kind of deviations are there at this sub department?

- *A lot of mixed goods from the Goods reception, red (high priority –HP) and green (ordinary) MRs in same pallet.*
- *Breaking forklifts.*
- *The bag machine gets a printer spin where a beam gets ”life of its own”. The new bag machine is not used, we have tried three different bag types, but they doesn't work. It also depends on the supplier of the machine, on wrong settings and that we did not receive what was promised.*

Is there any documented data of the deviation?
No documented data, however pictures taken of deviations are sent to the Goods reception. It's about two pallets a day.

How are the deviations handled?
We go through the mixed pallets and the operators of the service forklifts "spot-check" some pallets.

What type of key performance metrics are used at this sub department?

- *Produced units per hour (for the fine line, rough station, bag stations and krympen)*
- *Productive hours per number of packages (manual measurements of the ”bottom” of the MRs)*

What are the shortcomings with these metrics?
We measure the performance

What kind of metrics would you prefer instead? What would you wish to measure concerning performance and quality?
The metrics should show how we could plan our resources in the future and be able to see what is to be received. Fredrik Tholen (material management) is working on this currently.

We should also update the packages, in order to measure easier.

What is the planned production rate per day?

- *The fine line: planned rate is 78 packages/hour/day, real outcome is 60-65*

- *The rough stations: planned rate is 20 packages/hour/day, real outcome is 18*
- *The bag and krympen: planned rate is 345 packages/hour/day, real outcome is close*
- *The glass station: planned rate is 5 packages/hour/day, real outcome is 4,5*

How is the production rate calculated?
Based on previous data, performed long time ago. Resources times input and times for pre pack.

What lead times are pursued?
Ca 3 days for pre pack, 2 day for entire inbound. Unsure of what these times are based on, since they are "inherited".

What kind of strengths, weaknesses, opportunities and threats are there at this sub-department? (SWOT-analysis)
Strengths:

- *Knowledge of the operators*
- *Flexibility in parts of the rough stations*
- *The productivity has improved since rotation was introduced at the rough station*

Weaknesses:

- *Low flexibility of the staff. They should be able to support other sub-departments, but are not willing to let go of their position. No one volunteers.*
- *The layout is not optimal. No need for the full height and better space areas are needed.*
- *The system in the racking storage, there are three different places and no logic*
- *Currently all the operators share two computers that are quite old, if one breaks then there is only one computer on hand. This also affects the queue. We have discussed having one computer at each bench, but not been implemented with the reasoning that it's not ergonomic, but also expensive.*
- *The pre pack department is considered being the physically easiest, which means that "injured" operators are placed there. This affects the productivity.*

Opportunities:

- *Receiving better reports of incoming goods to be able to plan resources*
- *The Layout*
- *More opportunities to print labels*
- *Educate people e.g. in computing (not interested), lean etc.*
- *Make staff more participant, if they will see the final result they will be more positive*
- *The vision is that the rough station will do a lot themselves, however the service forklift helps since the layout is not optimal. The goal is to have as short distances as possible to keep up the work.*

Threats:

- *If everything becomes supplier packed, then the pre pack department going to disappear.*
- *Staff scared of working shifts*
- *Pihls takes over the packaging if we will receive too much goods.*

How many of the pallets are High priority? How long time does it take for one HP to go through the entire Inbound flow?
About 20% by using gut instinct, not sure of the real number. Within one day the HP pallet should be binned and stored. Not able to predict what pallets will be HP, can only see when MR is printed at the goods receiving.

Glass registers the MR as binned and stored, though it's not been packed yet. Why?
Depends on low frequency items and that only parts of a MR is packaged e.g. 5 of 20. It can also depend on high frequency glass items, possible that orders have been missed. We have considered using Kanban here.
Describe the activity for each bench?
The rough station 3-18 kg:

Bench 1-5: Priority 1 is HP, then green (ordinary) in date order.
Bench 6-8: Max 10 articles per pallet, should go fast with short handling.

The fine line 0-3 kg:

Bench 1-2 and 7-11: Ordinary pallets
Bench 3-6: Only HP pallets

Well: Everything that goes to other fine benches, but also well packages 0-3 kg

How many shifts, operators per shift and hours per shift are there at this sub-department?
The Pre-pack department works 2 shifts per day; The Fine line has 16 operators working day shift 7,8 hours Monday to Thursday and 7,4 hours on Fridays. They also have one operator working 3,9 hours Monday to Thursday and 3,8 hours on Fridays. The service forklift operator is included in the day shift. In the evening shift the Fine line has one operator working 5,9 hours Monday to Thursday and 5 hours on Fridays, and one operator working 8 hours Monday to Thursday and 6 hours on Fridays. The Rough stations has 7 operators working day shift 7,8 hours Monday to Thursday and 7,4 hours on Fridays. Two operators from Glass station are included in the day shift. In the evening 4 operators work 8 hours Monday to Thursday and 6 hour on Fridays.

RICKARD KINDLUND 13-03-2013 14.20-15.00

What kind of deviations are there at this sub department?

- *Forgetting to register the MRs, effects the performance measurements.*
- *Not having computers to all forklifts, however working on implementing this*
- *Writing wrong when location changes in storage*
- *Need a new label system, need to be able to scan everything*

Is there any documented data of the deviation?
Only observations, if there are bigger problems then we contact the VU (business developer). It is difficult to find small mistakes.

How are the deviations handled?
By using computers and scanner it is easier to avoid errors.

What type of performance metrics are used at this sub department?
We are using lead time, this is measured by the system that send daily mails to us. The goals is 0,7 days, the real outcome is 0,6. We do have internal measurements, but they are not fair. We measure number of shared hours per registered MR. We also measure together with pre pack, where the total lead time is added and reported higher in the organization. This is misleading since it is the pre pack that has deficiencies, binning meets the goal.

What are the shortcomings with these metrics?
It is a wrong approach. Need to remove queues, use Jus- in-Time.

What kind of metrics would you prefer instead? What would you wish to measure concerning performance and quality?
-

What is the planned production rate per day?
Nothing. We have suggested 6,5 MR per hour, but it doesn't work and it is not fair.

What lead times are pursued?
See question 4.

What kind of strengths, weaknesses, opportunities and threats are there at this sub-department? (SWOT-analysis)

Strengths:

- *The knowledge of the operators, engagement and good atmosphere.*
- *Bar codes*
- *Route planning (however see weaknesses)*
- *New organization, new thinking, started Lean, VPS*

Weaknesses:

- *Route planning should be an outcome from planning already at the Goods reception*
- *Half full pallets, also here the planning should be performed already at the Goods reception so that binning operators get rid of the sorting and save the number of routes.*
- *Empty pallets, results in too much driving around.*
- *Poor measurements concerning productivity. The Binning is responsible of keeping order at the warehouse, gets risk forms from picking operators. However this maintenance and time is not included in the overall productivity measurements.*

Opportunities:

- *Computers on all forklifts*
- *Being able to guarantee by using bar codes*

Threats:
No threats.

How many shifts, operators per shift and hours per shift are there at this sub-department?
2 shifts per day
9 operators at day shift and 7 at evening shift. Volvo staff works 7,8 hours per shift and consultants work 7,9 hours per shift. There are 7 consultants. At day shift there are 5 Volvo operators and at evening shift there are 4 Volvo operators. During day shift there are one operator working only with the buffer.

Other information:

- *The mission of the Binning is to keep shortest possible lead time and assure that the goods are able to be picked.*
- *One operator works only with refilling the buffer.*
- *There is a risk from the picking queue.*
- *The reorganization affects the inflow. Today Inbound is one big group, previously each sub-department was separate groups. A lot of staff from Binning is on loan to the Pre-pack and Europe group.*
- *The Kit station and Binning becomes one.*
- *During the last two years two cranes have been demolished, the height of the racking storage has been increased and priority items have been introduced.*

ANDREAS SWESTRÖM 14-03-2013 09.00-10.00

What kind of deviations are there at this sub department?

- *The quantity; over and under deliveries, wrong quantity.*
- *The quality; not rust proofed items, damaged goods, wrong packages.*
- *Transportation damages*
- *Pre advising does not work well, the manual work is a risk by typing wrong numbers.*
- *Shipping labels and delivery notes can be incorrect or absent. This should be standardized, requirement on the material management.*
- *Wrong advised goods – happens couple of times a day*
- *(Not pre sorted load in incoming transport, the operators should not be lifting others goods – insurance matters)*

Is there any documented data of the deviation? How are the deviations handled?
They are handled manually by the management boards.

How are the deviations handled?

- *The procurement department control over and under deliveries, see limit values.*
- *Quality reports*

- *The control is handled by the producers*
- *(The yard control is handled by Andreas, Anja, My or VTA)*
- *30% is pre advised, 10% of these are correctly advised. Someone has to be employed to deal with this.*
- *The communication between the procurers and goods receiving has improved.*
- *Large and medium suppliers does as they prefer and package the goods as they wish and not by Volvo standards. The goods receiving has no rights to push suppliers concerning this, the procurers must do it.*
- *TC (technical central) VTA*

What type of performance metrics are used at this sub department?
MR per hour, but it is misleading sine one MR can contain many different items in different sizes that takes different amount of time. One MR of 200 items can take less time than on MR of 2 items.

The quality is measured by number of backed MR.

What are the shortcomings with these metrics?
They are not fair, it is more interesting to measure what is to be received. We know what week the goods arrive, but not what day. All supplies can arrive at the same day and then nothing the other days. We must be able to secure the delivery and be able to plan the resources. We can tact faster, however the other sub-departments would not keep up.

The quality metrics should be something that shows that it is directly affected.

What kind of metrics would you prefer instead? What would you wish to measure concerning performance and quality?
It is better to measure parcel amount when at arrival, it would be fairer concerning the workload.

What is the planned production rate per day?
Want to measure number of MR per operator. It is under development, needs to be measured differently depending on "line".

What lead times are pursued?
There should be no pallets left at the Goods reception by the end of the day. It is visual, goods can be remaining if the delivery was large. The lead time is measured from that the MR is printed to that it is stored.

What kind of strengths, weaknesses, opportunities and threats are there at this sub-department? (SWOT-analysis)
Strengths:

- *High competence*
- *Getting items the right way*
- *The deficiency flow; class 1 HP (machine break at the customer)*

Weaknesses:

- *The system: engine cards*
- *Getting items the wrong way, effects the following stage*
- *Flexibility at the Goods reception, some has more knowledge*
- *Pre advised versus manual registration implies a certain risk*

Opportunities:

- *Pre advised goods*
- *Scan, bar codes*
    - *Better response, being able to locate the position of the items*
    - *Eliminate manual work, workload*
    - *More comprehensive quality checks*
    - *Better feedback towards the procurers*

Threats:

- *Old system (-74)*
    - *Would have received SCM in 2007, currently planned to 2016 (warehouse system)*
    - *Falling behind in the development, there are better solutions*

How many shifts, operators per shift and hours per shift are there at this sub-department?
1 shift per day, 7,8 hour Mondays to Thursdays and 7,6 hours on Fridays. There are 9 operators excluding the service forklift and the operators on the yard.

Explain the unpacking organization at the Bulky station at the goods receiving.
Don't know the proportion.

Åsa Göhlman 19-3-2013

What kind of deviations are there at this sub department?

- *Goods being placed in the wrong place or when place is changed but the goods is left at the old place which results in balance error.*
- *Not registered MR (the goods are at its place, but cannot be seen in the computer which indicates that it is in the flow on its way in).*
- *Mislabeled pallets and mixed up goods.*

Is there any documented data of the deviation?
Everything can be found in BMS (business management system), which assignment there is. This is pure human mistakes that are able to be decreased by using bar codes for all storage locations + system support.

How are the deviations handled?
They are recognized as the issue of today at the daily meetings and distributed within the VU-groups to discuss what can be done to avoid it to happen again. If something is not clear, it can be controlled by checking the BMS.

What type of performance metrics are used at this sub department?
Lead time, productivity and if some items erred in lead time that affects the picking groups negative in their order picking. We also measure the number of accidents since we are the ones who drives forklift most of all at the warehouse.

What are the shortcomings with these metrics?
The productivity, what kind of goal that could be reasonable, it should be achievable yet triggering.

What kind of metrics would you prefer instead? What would you wish to measure concerning performance and quality?
A fair productivity goal that should be triggering for each person by being able to see their own progress. However it is difficult since each pallet takes different amount of time depending on how the situation is when leaving the pallet (if there is place or whether to create place by moving several pallets or compress goods.

What kind of strengths, weaknesses, opportunities and threats are there at this sub-department? (SWOT-analysis)
Strengths:
Our lead time of the direct registered goods is always (often) just under the goal line.

Weaknesses:
Manning (has been, will probably improve by the merging with kit station).

Opportunities:
The flexibility (considering the entire warehouse and not just the binning department). There are a lot to improve that could make work easier.

Threats:
No system support, unreliable appliance (engine system).

KIM GABRIELSON 18-3-2013

What kind of deviations are there at each sub department?
Goods reception:

- *The bottleneck is when pallet waits on the conveyor even though the activity is finished.*
- *Not pre advised goods.*
- *Needing to register manually, should be using scanner instead.*
- *The workers have good routines.*

Pre-pack:

- *The whole process. The operators needs to go getting the packaging themselves.*
- *The material is pushed in, there is no pull.*
- *There are only 3 criteria; HP, P and "green", need more. The waiting time is too long and the handling is same despite different criteria.*

- *The rough stations benches 6-8 are too far away from the other benches.*

Binning:

- *Not a pulling system, only push..*
- *The square is an unnecessary intermediate storage.*
- *The system is old, not able to get info whether the storage place is full. Need a better computer system.*

Do you have any improvement suggestions?

Goods reception:

- *Everything should be pre advised, to know when goods arrive and how much is arriving.*
- *Computerize all registration by using bar codes. Gives control and being able to locate the MR in the flow.*
- *The Goods reception department should prepare for the Binning department. Gather items with equal article numbers from different MR in same pallet. This would result in that the sorting function at the binning would not be needed and also decrease in forklift driving routes.*
- *Should not receive more goods than needed.*

Pre pack:

- *Being able to scan, a control function.*
- *Preparation for the Binning, an entire concept with packages, rust proofing etc.*
- *They have time in the afternoon to prepare for the next shift.*
- *The goal is a continuous flow.*

Binning:

- *Eliminate the sorting station.*
- *The goods should be stored directly, pre advising makes planning possible. Better organization*

What kind of strengths, weaknesses, opportunities and threats are there at Inbound? (SWOT-analysis)

Strengths:

- *The knowledge and experience of the workers.*
- *The company's will to change*
- *Routines, packaging instructions in some of the products at pre pack*

Weaknesses:

- *The processes are old, too little is computerized*
- *Everyone should need positive feedback*
- *The routines are not applied, are built on without being changed. E.g. the service forklift works based on perception and experience rather than routines*

Opportunities:

- *More efficiency, leads to higher competitiveness*
- *Change in structure*
- *Motivate the workers*

Threats:

- *If the approach doesn't change maybe the customers will find less expensive suppliers.*

SARA BÄCKMAN 28-03-2013

What kind of deviations are there at this sub department?

- *The running after packaging material, are not placed in connection with each department*
- *The safety, the operators cross forklift aisles*
- *All rough stations should be placed at same location*
- *Every bench should have their own computer and label printer*
- *The fine line should have a better layout, minimize the surface, more closeness*
- *Queues to the computer, should exist label printers at each bench*
- *The Glass station walks to fine station to print out labels*

What can be improved?

- *An especial printer for batches, the glass operators go to the "return" station to print labels*
- *The placement not optimal for the flow. Should be logical with the inflow*
- *The service forklift at Pre-pack and Goods reception, there should be a better system. There are currently too many unnecessary operations.*
- *Introduced currently: several open MR for one article are being packed simultaneously.*
- *Priority list that affects the service level*
- *Introduce a long work line, there are a lot of long work today*

What are the shortcomings with the metrics? What kind of metrics would you rather prefer?

- *They are not in relation to each other; "in" are measured by number of hours in queue and "out" is measured by number of packages per hour.*
- *Would like to know how many hours that is capable to be produced each day. Be able to see how much capacity that is needed to be able to make a plan.*
- *The Glass station is different since they don't package everything that is registered.*
- *Quality metric: interesting to see how many errors from pre pack that lack origin and how many goods are damaged by repackaging. Otherwise the quality is currently good, we measure how many articles that lack origin in the inflow.*

What kind of strengths, weaknesses, opportunities and threats are there at this sub-department? (SWOT-analysis)
Strengths:

- *Very good quality "out", few errors*
- *The capability to deliver*
- *Even level of hours in queue*
- *Cohesive team, good effect*

Weaknesses:

- *Deficiencies in the flow*
- *"Fool"-time*
- *The unnecessary operations of the service forklift*
- *Few computers and label printers*
- *The "closeness" between the benches*
- *The distance to packaging material*
- *The Glass station*

Opportunities:

- *New technology, speed up*
- *Need to develop the packaging, should be more easy and flexible. More Just-In-Time. Labeling.*
- *Standardization*
- *New thinking*

Threats:

- *If we sell more then we will get more goods and today we don't have the capacity to handle more. Currently we are able to handle 500 hours*
- *Review the entire warehouse, should not become a bottleneck*
- *Far behind in the development compared to other warehouses*

ANDERS EKLUND 05-04-2013

What kind of deviations are there at this sub department? Could something be handled in a better way?
The supply flow should be more leveled. Being able to plan by day rather than by week (delivery precision). Something necessary that doesn't work today is pre advised deliveries. If it did work then we could plan our day in a totally different way and also become more efficient in our goods receiving process.

What are the shortcomings with the metrics? What kind of metrics would you prefer instead?
We measure the amount of MR per day which doesn't reflect the work load. The Quality metrics that we have are the number of control reports and backed MR. they are not ideal, but at least it is something to measure .I would prefer a metric that we can influence ourselves at a higher level than today. I don't know right now what it could be, but some kind of lead time measurement and management metric.

What kind of strengths, weaknesses, opportunities and threats are there at this sub-department? (SWOT-analysis)

Strengths:

- *Great knowledge and competence in the group*
- *A lot of experience*
- *Good commitment*
- *We empty the yard largely each day*

Weaknesses:

- *We have poor redundancy within the group since we do not gladly rotate work*
- *Sometimes we are no negative*
- *Are uncomfortable with change*

Opportunities:

- *Culture development to get good mobility at work and help each other when there is too much to be done*
- *Starting to see Inbound as one unit and being able to rotate over larger areas (not only GR)*
- *Get more efficient by cooperation with different departments and towards materials management*
- *Get through pre advising to become more efficient and be able to use automatic registration of packages (e.g. by bar codes)*

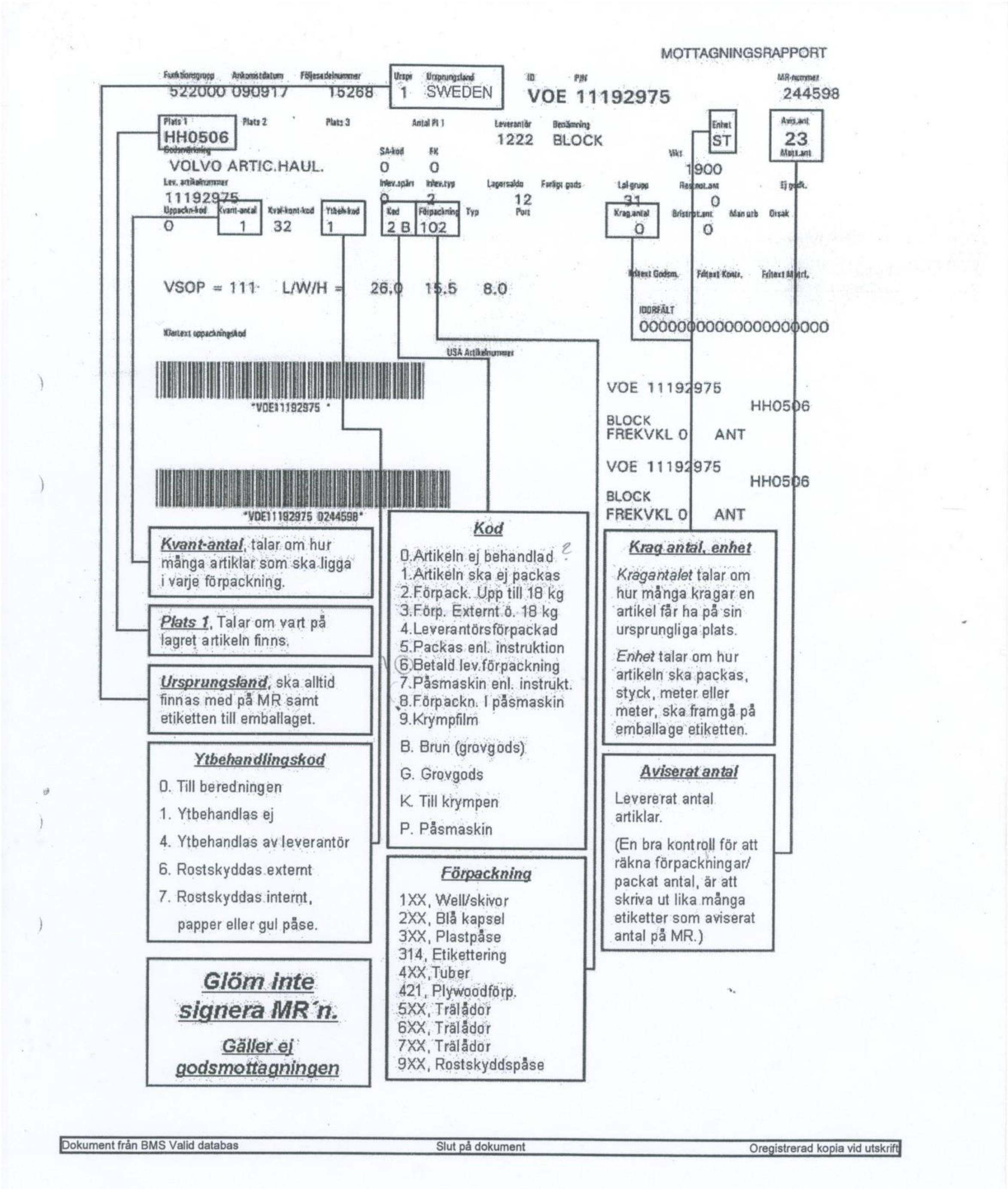
Threats:

- *Reluctance to change*
- *Restrictive investment interest*
- *Reluctance to change in culture*

APPENDIX 2 – DATA COLLECTION TEMPLATE

PROCESSANALYS	Process	Observatör	Datum/tid	Sida	Inbound GM/FP/INL	
Process steg	Operatör				Outbound EU/INT/USA	
Moment	Arbestmoment	Uppmätt tid		Lägsta tiden	Cykeltid	Notering
	godsin					

APPENDIX 3 – MATERIAL REPORT READING INSTRUCTION



APPENDIX 4 – BEAT-REPORT DATA SORTING

The data was collected from excel file ”New_tbl_UNIQUE_MR_OKT_JAN_2013_1” created by Rolf Possmark, 5 April 2013. The file is composed from the Data Warehouse system BEAT. Pivot tables compiled from file “New_tbl_UNIQUE_MR_OKT_JAN_2013_1_PIVOT_new”

1TH

General sorting:
Station 2 date and time (Control station): Blanks
Delivery gate: 924

Sorting out Pihls:
Excluded: Packaging type 400-899 (tube, plywood, metal, wood)
Excluded: Package code 3 and Weight >18 kg
Excluded: Package code 5G Unit (M)

Other:
Excluded: Package Code 5S (kit) and 3S (Rough kit +18kg & bulky packages)
Surface code: 6 (Ärnaberget)

2ND

Unknown codes:

- 1,2,3,4,5 (A) are wrong registered and should be handled as if without letter since they are ordinary 1,2,3,4,5.
- 4G are wrong registered articles.
- Articles without codes are registered and stored before they received codes, mostly old articles.
- 3G are glass products, however this code can include some old articles

APPENDIX 5 – CODES

Packaging codes

Quality control code

0 Article not classified
32 Article classified
24 Article to be controled by the control department
44 - „ -
77 - „ -
76 To be controled by Goods reception

Surface treatment code

0 Article not classified
1 Article shall not be surface treated
4 Article is surface treated by supplier
5 Painting
6 Surface treated externally
7 Rust proofed internally

Packaging code

0 Article not classified
1 Article shall not be packaged
2 Article shall be packaged at department 37315/37316
3 Tubing, tube cutting and packaging over 18 kg. (External packaging)
3 S Article shall be packaged by Kit production (+18kg)
4 Packaged by supplier
5 Article shall be packaged by instruction (Excel-file code 5)
5 S Article packages by Kit production
7P Bag machine. Article shall be packaged by instruction (Excel-fil code 5)
8P Bag machine
9K Krympen

=Pihls

Exclude glass station that also has packaging code 3.
Packages 400-899 are Pihls.

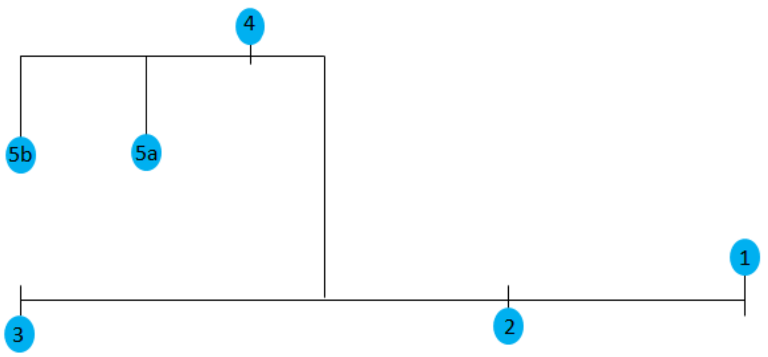
APPENDIX 6 – TIME MEASUREMENTS DATA

Time measurements by Anna Askri and Kim Gabrielson
Feb – April, 2013

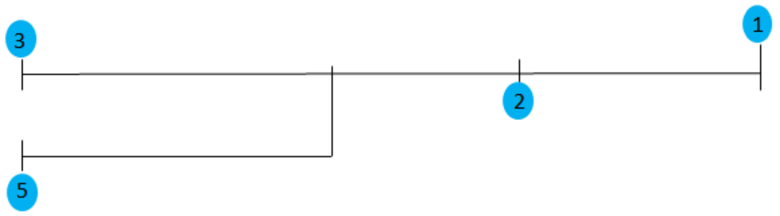
Some cells are empty, these concerns the activities that are not performed as frequently as other activities. Due to time constraints, the frequency, operation time and amount of activities, it was not possible to get 20 measurements for each activity during the projects time period.

1. GOODS RECEPTION

GR Line1



GR Line 2



Line 1																					
Operation	**Time (min)**																				**Average**
Gate->1	4	4,5	4,4	4,8	4,4	7,16	0,9	3,3	0,87	0,83	1,2	2,88	0,88	0,88	0,88	4,25	2,43	4,37	4	0,88	2,89
Note	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,02
1->3	4,7	6,45	1,68	2,76	3,3	2,7	2,4	2,63	1,83	2,02	2,32	5	1,05	2,9	9,17	3,43	2,6	2,5	2,68	10,8	3,65
3->IS	5,4	3,8	0,2	0,73	0,33	0,35	0,7	0,55	0,53	0,82	0,18	0,25	0,22	0,2	0,35	0,2	0,18	0,4	0,45	0,25	0,80
MR time	9,15	0,38	1,47	2,33	2,28	1,07	0,77	0,6													
MR (pcs)	12	4	24	41	37	16	7	18													
MR time/pcs	0,76	0,10	0,06	0,06	0,06	0,07	0,11	0,03													0,16

Line 2											
Operation	Time (min)										**Average**
Gate->1	9,8	1,75	2,1	7,58	3,97	4,17	2	1,95	1,67	2,92	3,791
1->3	7,55	8,33	8,35	5,97	5,1	1,42	1,38	2,22	5,08	5,98	5,138
3->IS*	2,5	0,23	0,38	2,6	0,25	2,03	0,4	1,03	0,3	0,77	1,049
MR time	5,08	1,87	1,27	0,85	0,58	0,58	0,67	2,18	2,22	2,47	
MR (pcs)	10	10	10	10	10	10	10	10	10	10	
Mr time/pcs	0,51	0,19	0,13	0,09	0,06	0,06	0,07	0,22	0,22	0,25	0,178

Bulky																				
Operation	Time (min)																			**Medelvärde**
Get goods	1,18	1,38	0,85	1,45	2,03	1,68	1,22	1,75	1,87	0,95	1,25	1,53	1,28	1,33						1,41
Prepare	3,53	0,65	1,32	0,45	0,73	0,78	5	0,6	8,07	14,67	19,75	5	15	5,95	0,47	0,48	8,93	15	80	9,81
GM-> L/S	0,88	1,2	0,75	0,42																0,81
GM->IS	0,37	0,47	1,45	0,67	1,7															1,17
GM->GA	1,27	1,12	1,13	1,08	1,59	2,25	2,05	2,3	1,1	1,04	0,98	1,3	1,1	1,04	0,98	1,83	1,5	1,1	1,19	1,37
GM->Glass	1,38	2	1,625	1,83	1,7															1,71
GM->B-crane	1,99	1,75	3,55	1,7	1,76	2	1,68													2,06
MR time	0,6	3,37	1,1	1,8	0,7	0,75	0,72	0,8	1,93	6,02										
Mr (pcs)	1	9	4	3	2	2	1	4	5	17										
Mr time/pcs	0,60	0,37	0,28	0,60	0,35	0,38	0,72	0,20	0,39	0,35										0,42

2. Pre-pack

Fine Line											
Walking time (s)											**Average**
Bench 3 (shortest)	20	18	21	17	19	20	19	20	20	19	19,3
Bench 6	35	35	44	37	37	28	27	37	37	38	35,5
Bench 10 (furthest)	62	57	60	62	59	48	60	47	57	51	56,3
Total average time											**37,03**

Pre-pack By Kim 20-11-2012	Distance to emballage back and forth (m)
Bench 1	24,2
Bench 2	18,8
Bench 3	13,4
Bench 4	19,4
Bench 5	23,6
Bench 6	30,4
Bench 7	41,8
Bench 8	47,8
Bench 9	57
Bench 10	61,8
Bench 11(wellpapp)	39,6
Rough Bench 1	10,2
Rough Bench 2	13,8
Rough Bench 3	24,8
Rough Bench 4	29,2
Rough Bench 5	39,2
Rough Bench 6	72
Rough Bench 7	73,8
Rough Bench 8	75,6

Glass **(min)**						**Average**
Get job	0,3	0,58	2,5	1,85		1,31
Prepare*	16,15	23,25	14,35	28,66	13,48	16,48
Packaging	13,26	16,17	7,56			12,33
Leave to GA	2	1,6	0,29			1,30
Leave to storage	2,9					2,90
Sorting	6	4,23				5,12
Inventory	15					15,00
TOTAL						**54,43**

*Unpack, fold cartonnage etc.
time depends on size and quantity

Set up time (computer/labels)				
MR time (s)	Wait. time (s)	Print- time (s)	Labels (pcs)	Tot. time/pcs (s)
6	13	29	50	0,96
8	42	15	20	3,25
12	12	24	50	0,96
10	11	38	47	1,26
16	36	17	40	1,73
15	11	32	69	0,84
15	14	16	36	1,25
20	5	10	7	5,00
10	17	3	1	30,00
16	26	9	30	1,70
9	32	59	129	0,78
7	31	14	28	1,86
8	26	227	500	0,52
10	34	39	17	4,88
13	12	23	39	1,23
8	17	24	50	0,98
7	27	29	64	0,98
9	24	29	33	1,88
17	3	6	5	5,20
25	31	38	83	1,13
6	36	3	1	45,00
20	10	44	100	0,74
29	16	7	16	3,25
12	10	18	35	1,14
10	31	10	17	3,00
15	10	6	14	2,21
			Average time/pcs	**4,68**

Rough Bench 1-5 (min)											**Average**
Get job/pallet	0,60	0,88	0,60	0,95	0,78	1,00	0,91	0,75	0,86	0,92	0,83
Empty pallet	0,92	0,97	1,42	1,33	0,93	0,72	1,95	1,30	1,20	1,50	1,22
MR/get labels/cardboard	3,00	2,45	2,20	2,80	3,10	4,25	4,82	1,87	2,08	1,93	2,85
Fold cardboard	2,38	1,83	1,58	1,88	0,67	0,70	1,18	0,63	2,17	0,55	1,36
Amount cardboard (pcs)	10	6	9	11	4	4	7	4	9	2	
Cardboard type code	116	116	116	116	111	116	156	116	156	112	
Time/cardboard	0,24	0,31	0,18	0,17	0,17	0,18	0,17	0,16	0,24	0,28	0,21
Prepare	3,28	1,38	3,00	2,00	1,67	1,23	0,40	0,53	2,92	1,65	2,26
Padpack	0,48	0,52	1,52	1,12	0,30	0,47	0,42	0,48	0,40	0,38	0,61
Amount padpack (pcs)	10	26	26	18	4	8	7	7	5	6	
Size padpack (cm)	50	80	80	80	100	70	50	70	90	80	
Time/padpack	0,05	0,02	0,06	0,06	0,08	0,06	0,06	0,07	0,08	0,06	0,06
Rustproofing	0,40	0,55	0,33	0,27	0,23	0,27	0,27	0,32	0,17	0,28	0,31
Amount rustproof. (pcs)	8	7	2								
Time/rustproof.	0,05	0,08	0,17								0,10
Get pallet collar	0,68	0,63	0,67	0,67	0,67	0,7	0,67	0,78	0,72	0,72	0,69
Get collar holder	0,25	0,3	0,3	0,32	0,33	0,33	0,33	0,33	0,38	0,29	0,32
TOTAL	9,07	7,01	8,59	8,30	7,72	8,46	9,31	5,79	8,48	7,35	**8,01**

Rough Bench 6-8 (min)											**Average**
Get job/pallet	0,38	2,70	0,75	0,52	1,38	0,70	0,58	1,85	0,62	0,88	1,04
Empty pallet	0,97	0,38	0,35	0,50	1,88	0,73	0,32	1,28	0,42	0,62	0,75
MR/get labels/cardboard	1,85	1,88	5,82	2,12	1,82	3,00	5,48	4,07	2,30	11,15	3,95
Fold cardboard	1,03	1,27	0,33	0,68	1,25	1,25	0,32	0,18	0,23	0,59	0,71
Amount cardboard (pcs)	1	1	1	1	1	1	1	1	1	1	
Cardboard type code											
Time/cardboard	1,03	1,27	0,33	0,68	1,25	1,25	0,32	0,18	0,23	0,27	0,68
Prepare	3,08	1,28	3,00	2,00	1,06	1,23	0,40	0,53	2,92	1,65	2,14
Padpack	0,48	0,52	1,52	1,12	0,30	0,47	0,42	0,48	0,40	0,38	0,61
Amount padpack (pcs)	10	26	26	18	4	8	7	7	5	6	
Size padpack (cm)	50	80	80	80	100	70	50	70	90	80	
Time/padpack	0,05	0,02	0,06	0,06	0,08	0,06	0,06	0,07	0,08	0,06	0,06
Rustproofing	0,40	0,55	0,33	0,27	0,23	0,27	0,27	0,32	0,17	0,28	0,31
Amount rustproof. (pcs)	8	7	2								
Time/rustproof.	0,05	0,08	0,17								0,10
Get pallet collar	0,2	0,47	0,27	0,48	0,62	0,62	0,53	0,63	0,57	0,77	0,52
Get collar holder	0,57	0,35	0,67	0,83	0,75	0,63	0,72	0,46	0,68	0,55	0,62
TOTAL	8,18	8,43	11,41	7,19	8,84	8,22	8,41	9,07	7,82	15,95	**9,35**

Packaging time
Fine Blue (s)
By Kim

Package group	Code	Surf.t.	Quantity	Time 10 pcs	Time min/pcs	Supplier	Weight (kg)
Blue 1	5	7	1	288	0,48	Sandberg & söner	0-5
Blue 1	2	1	1	133	0,22	Mann & Hummel GMP	0-5
Blue 1	5	7	1	472	0,79	Deutz	0-5
Blue 1	5	1	1	393	0,66	Contineta TADI	0-5
Blue 1	5	7	1	520	0,87	Deutz	0-5
Blue 1	2	1	1	159	0,27	Coma tal	0-5
Blue 1	5	1	1	227	0,38	GAK	0-5
Blue 1	5	7	1	782	1,30	Deutz	0-5
Blue 1	2	1	1	111	0,19	Comtomental CORP	0-5
Blue 1	2	1	1	182	0,30	Wabco GMBH & Co	0-5
Blue 1	5	7	1	384	0,64	Carlisle BRA UK	0-5
Blue 2	2	1	1	202	0,34	Deutz	0-5
Blue 2	2	7	1	332	0,55	Deutz	0-5
Blue 2	2	7	1	313	0,52	Deutz	0-5
Blue 2	2	7	1	248	0,41	Deutz	0-5
Blue 2	2	1	1	220	0,37	Deutz	0-5
Blue 2	2	1	1	192	0,32	Deutz	0-5
Blue 3	5	1	10	355	0,59	Volvo CE Korea	0-5
Blue 3	2	7	1	477	0,80	Deutz	0-5
Blue 3	2	7	1	439	0,73	Deutz	0-5
Blue 3	8P	1	1	91	0,15	AQ Wiring System	0-5
Blue 3	2	7	1	425	0,71	Robert Bosch	0-5
Blue 4	2	7	1	395	0,66	Deutz	0-5
Blue 4	5	7	1	333	0,56	Deutz	0-5
Blue 4	2	1	1	345	0,58	Parker	0-5
Blue 4	2	7	1	305	0,51	Deutz	0-5
Blue 4	2	1	1	225	0,38	Valeo auto	0-5
Blue 4	2	1	1	295	0,49	Parker	0-5
Blue 5	2	7	1	450	0,75	Deutz	0-5
Blue 5	2	7	1	525	0,88	Deutz	0-5
Blue 5	5	7	1	751	1,25	W.H. Columbu	0-5
Blue 5	2	7	1	359	0,60	Deutz	0-5
Blue 5	2	7	1	563	0,94	Deutz	0-5
Blue 6	2	1	1	248	0,41	Hella	0-5
Blue 6	2	7	1	403	0,67	Z F Passau	0-5
Blue 6	2	1	1	199	0,33	Parker	0-5
Blue 6	2	1	1	276	0,46	Hella	0-5
Blue 6	5	7	1	212	0,35	KACO	0-5
Blue 7	2	1	1	224	0,37	UAB Kirton	0-5

Blue 7	2	1	1	330	0,55	Deutz	0-5
Blue 7	5	1	1	262	0,44	4088 Hydac fluidte	0-5
Blue 8	2	1	1	471	0,79	Valeo auto	0-5
Blue 8	2	1	1	525	0,88	4123 Hydrac	0-5
Blue 8	2	1	1	213	0,36	Valeo auto	0-5
Blue 9	2	7	1	629	1,05	SKF Service	0-5
Blue 9	5	1	1	409	0,68	Freudenberg SMIR	0-5
Blue 9	2	1	1	320	0,53	SKF	0-5
Blue 9	2	7	1	678	1,13	SKF	0-5
Blue 9	2	7	1	668	1,11	Deutz	0-5
Average time				**358,33**	**s**		
				5,97	**min**		

Packaging time

Fine Bags (s)

By Kim

Package group	Code	Surf.t.	Quantity	Time 10 pcs	Time min/pcs	Supplier	Weight (kg)
Bag 1	2	7	5	262	0,44	Seeger-Orbis	0-5
Bag 1	2	7	1	129	0,22	Mahle Pleuco	0-5
Bag 1	5	7	1	182	0,30	Deutz	0-5
Bag 1	5	7	1	182	0,30	Deutz	0-5
Bag 1	8P	7	1	144	0,24	Shaeffeler Sverige	0-5
Bag 10	2	1	1	221	0,37	Doga	0-5
Bag 10	2	1	1	300	0,50	Stillströms	0-5
Bag 2	2	1	5	213	0,36	Gotlands gummi	0-5
Bag 2	5	1	1	373	0,62	Deutz	0-5
Bag 2	5	1	1	154	0,26	Bosch Rexroth	0-5
Bag 2	5	1	1	130	0,22	Trelleborg	0-5
Bag 2	5	1	1	162	0,27	SKF INT	0-5
Bag 2	1	1	1	166	0,28	Deutz	0-5
Bag 2	5	1	1	148	0,25	Deutz	0-5
Bag 3	5	1	1	243	0,41	Peparationssats	0-5
Bag 3	2	1	1	111	0,19	Z F Passau	0-5
Bag 3	7P	1	1	81	0,14	SKF	0-5
Bag 3	2	4	1	138	0,23	Manuli Hydraulcs	0-5
Bag 3	8P	1	5	237	0,40	Parker	0-5
Bag 4	2	7	1	139	0,23	Trelleborg	0-5
Bag 4	2	7	12	231	0,39	Gotlands gummi	0-5
Bag 4	2	1	1	109	0,18	Trelleborg	0-5
Bag 4	2	1	1	130	0,22	AQ Wiring System	0-5
Bag 4	2	1	1	180	0,30	Specma	0-5
Bag 5	2	1	1	202	0,34	Carlix	0-5
Bag 5	5	1	1	131	0,22	Trelleborg	0-5

Bag 5	2	1	1	168	0,28	AQ Wiring System	0-5
Bag 5	9K	1	1	208	0,35	Deutz	0-5
Bag 5	2	1	1	386	0,64	Elring Klingers	0-5
Bag 6	2	1	1	291	0,49	Manuli Hydraulcs	0-5
Bag 6	4	1	1	200	0,33	Cabeco AB	0-5
Bag 6	2	7	1	354	0,59	Trelleborg	0-5
Bag 6	2	1	1	350	0,58	Manuli Hydraulcs	0-5
Bag 6	9K	1	1	326	0,54	TI Groupe automot	0-5
Bag 7	2	1	1	218	0,36	Deutz	0-5
Bag 7	2	1	1	389	0,65	KG Knutsson	0-5
Bag 8	9K	1	1	431	0,72	Muuli hydralics	0-5
Bag 8	9K	7	1	683	1,14	Deutz	0-5
Bag 8	9K	7	1	230	0,38	Miba steeltec	0-5
Bag 8	9K	1	1	507	0,85	National gummi	0-5
Bag 8	9K	1	1	447	0,75	Faurecia	0-5
Bag 8	9K	1	1	327	0,55	SKF	0-5
Bag 8	9K	7	1	303	0,51	Grimldl	0-5
Bag 9	9K	1	1	406	0,68	Deutz	0-5
Bag 9	9K	1	1	332	0,55	Deutz	0-5
Bag 9	9K	1	1	270	0,45	Deutz	0-5
Bag 9	9K	1	1	297	0,50	Deutz	0-5

Average time	**251,51**	**s**
	4,19	**min**

Average time Fine 1 + Fine 2	**609,84**	**s**
	10,16	**min**

Packaging time
Rough (s)
By Kim

Package group	Code	Surf.t.	Quantity	Time 10 pcs	Time min/pcs	Supplier	Weight (kg)
Well 2	5B	7	1	750	1,25	Deutz	0-5
Well 1	ompack	7	1	593	0,99	Meritor HVS AB	0-5
Well 1	2G	7	1	1236	2,06	SKF Service	0-5
Well 1	ompack	1	1	309	0,52	Meritor HVS AB	0-5
Well 1	2B	7	1	691	1,15	Timken	0-5
Well 1	2B	7	1	523	0,87	Timken	0-5
Well 10	2G	1	1	625	1,04	AQ Wiring System	0-5
Well 10	5G	1	1	1362	2,27	Modine Austria	0-5
Well 13	5G	1	1	628	1,05	Britax PMG LTD	0-5
Well 2	2B	7	1	516	0,86	Deutz	0-5
Well 2	2B	7	1	525	0,88	Deutz	5-10
Well 2	2B	1	1	813	1,36	Intergral accumul	0-5
Well 2	2G	1	1	709	1,18	Upppka	0-5
Well 2	5G	1	1	660	1,10	Ficosa INT	0-5
Well 3	5G	7	1	1216	2,03	Bosch Rexroth	5-10
Well 3	2G	7	1	891	1,49	Bosch Rexroth	5-10
Well 3	2	7	1	762	1,27	Ompack	0-5
Well 3	5B	1	1	396	0,66	Hella	0-5
Well 3	2G	7	1	437	0,73	Trelleborg	0-5
Well 4	5G	7	1	2717	4,53	Deutz	10-15
Well 4	2G	7	1	1884	3,14	Wabco GMBH & Co	10-15
Well 4	2	7	1	619	1,03	Swepart transmiss	5-10
Well 4	5G	1	1	493	0,82	SPAL automotive	0-5
Well 4	2G	7	1	626	1,04	Defontaine SA	0-5
Well 5	2G	1	1	776	1,29	Frederal mogul	0-5
Well 6	5G	1	1	950	1,58	Linak scandinavian	5-10
Well 6	5G	1	1	711	1,19	Parker	0-5
Well 6	2G	7	1	816	1,36		0-5
Well 7	5G	1	1	681	1,14	Deutz	0-5
Well 7	5G	1	1	567	0,95	Ficosa INT	0-5
Well 7	5G	1	1	508	0,85	Ficosa INT	0-5
Well 7	2G	7	1	1072	1,79	Mitsubishi Elec	10-15
Well 8	2G	7	1	790	1,32	SPAL automotive	0-5
Average time				**813,70**	**s**		
				13,56	**min**		

3. BINNING

Small square sorting station (min)											Average
Get empty pallet	1,42	0,68	1,2	0,98	0,27	0,52	0,42	0,2	0,21	0,28	1,03
Get goods from GM	0,85	0,7	1,08	0,7	1,93	0,33	0,27	0,43	0,27	0,47	0,78
Get goods from L square	2,12	2,87	2,18	3,55	4,72	0,47	0,38	3,48	0,43	2,96	3,31
Get goods from PP	0,42	0,45	0,47	0,28	0,35	0,48	0,72	0,52	0,75	0,63	1,01
Sorting	2,33	2,7	3,07	1,13	2,95	1,15	3,18	2,3	1	0,53	2,03
Amount sorted MR	2	13	6	3	10	8	10	8	3	3	6,60
Time sorting/MR	1,17	0,21	0,51	0,38	0,30	0,14	0,32	0,29	0,33	0,18	0,38
Leave to S square	3,55	0,45	0,7	1,22	0,85	0,82	0,98	0,4	0,82	0,25	1,00
Leave empty pallet	0,32	0,37	0,8	0,25	0,34	0,9	0,42	0,31	0,28	0,24	1,41

Small square GH forklift (min) 1 pallet	**Total driving time**	**SVAT)**	**Route**	**NVAT**
2012-11-07	5,9	3,83	SH, 600	2,07
10:30-11:45	12,2	10,46	L.N.E.H.J.M	1,74
	7,6	6,11	U.A.B.T.	1,49
	5,58	3,33	U.A.B.	2,25
	22,3	12,86	S.C.D.R.500	9,44
	14,73	7,46	P.E.F.O.	7,27
2013-02-19	12,61	8,07	U.A.100.D.C.F	4,54
14.30-15.30	12,6	8,06	D.F.M.N.O.P.S.T	4,54
	5,95		New goods, suitable place	5,95
	2,75	1,76	400	0,99
	5,48	3,5	H.M	1,98
	4	2,56	N.G	1,44
	20,16	12,9	P.E.F.D	7,26
	11,1	7,1	S.D.R	4,00
	7,18	2,94	U.A.B.T.	4,24
	2,62	1,67	T	0,95
	9,37	5,99	2 * 400	3,38
	6,45	4,13	U.B	2,32
	9,43	6,03	S.C.D	3,40
	4,98	3,18	B	1,80
	18,32	11,72	A.D.C.G.M.R.T	6,60
	13,92	8,9	U.D.F.P.S	5,02
	5,58		R and new goods	5,58
Average time	**9,20**	**6,03**		**3,17**

Large square GA forklift (min)	Total driving time	SVAT	Route	Pallet amount	Time/ pallet Tot	Time/pallet SVAT	Time/pallet **NVAT**
2012-11-11 08:00-12:00	18,56	12,22	GL.GH				
	12,32	5,06	GH.GB				
	16,35	7,27	GH				
	17,48	7,7	GH				
	14,1	6,63	GA.GH				
	13,37	5,1	GA.GB.GH				
	9,52	3,27	GB				
	10,13	4,32	GA.GX				
	12	5,62	GH.GL				
	4,21	1,55	GH				
21-2-2013	4,35	2	GH200	1	4,35	2,00	**2,35**
	12,07	5,52	GH400,500	3	4,02	1,84	**2,18**
	6,15	2,83	GH100,300	2	3,08	1,42	**1,66**
	6,75	3,1	GH600,200	2	3,38	1,55	**1,83**
	9,08	4,17	GH700,SH100	3	3,03	1,39	**1,64**
	5,97	2,74	GB3251	2	2,99	1,37	**1,62**
	6,45	2,97	GH200,300	2	3,23	1,49	**1,74**
	13,07	6,01	GH300,400	3	4,36	2,00	**2,35**
	6,95	3,2	GH300,GA3000	2	3,48	1,60	**1,88**
	5,07	2,33	GA21,22	2	2,54	1,17	**1,37**
	12,7	5,84	GH300,2000, GL600	3	4,23	1,95	**2,29**
	8,58	3,94	GH500	1	8,58	3,94	**4,64**
	11,68	5,37	GH200,GA6000	3	3,89	1,79	**2,10**
	11,97	5,5	GH7000,400	2	5,99	2,75	**3,24**
	11,93	5,48	GH600,1000,2000	3	3,98	1,83	**2,15**
	7,33	3,37	SH100,300	2	3,67	1,69	**1,98**
	7,08	3,25	GH100,800	2	3,54	1,63	**1,92**
	12,88	5,92	GH600,300,400	3	4,29	1,97	**2,32**
	12,48	5,74	GH500	1	12,48	5,74	**6,74**
	6,68	3,07	GH100,200	2	3,34	1,54	**1,81**
Average time	**10,24**	**4,70**		**2,2**	**4,66**	**2,14**	**2,52**

GA square GA forklift (min)	Tot. driving time	SVAT	NVAT
2012-11-12	23,53	7,76	15,77
09:10-14:00	20,08	4,63	15,45
	5,66	1,93	3,73
	3,66	1,6	2,06
	1,66	0,6	1,06
	6,13	2,88	3,25
	5,28	1,66	3,62
	8,62	2,2	6,42
	11,8	3,48	8,32
	11,21	4,58	6,63
	6,62	1,13	5,49
	9,35	2,42	6,93
	5,06	1,41	3,65
	8,08	2	6,08
Average time	**9,05**	**2,73**	**6,32**

Reporting MR		
Time (min)	MR (pcs)	Time/MR
2,82	32	0,09
0,98	10	0,10
0,62	10	0,06
1,22	10	0,12
1,12	10	0,11
1,58	10	0,16
0,48	7	0,07
0,77	9	0,09
	Average	**0,10**

4. Forklift driving times

Forklift driving times 26-2-2013 PP Fine										
IS-> PP	0,63	0,7	0,42	0,47	0,47	0,4	0,5	0,77	0,97	1,3
PP -> S/L Square	0,33	0,35	0,82	0,52	0,57	0,68	0,33	4,15	4,77	9,4
Bag/Krymp -> S/L Square	8,58	19,67	2,1	1,08	7,72	3,05	11,8	11,32	2,75	6,6
PP Rough										
Get job/pallet 1-5	1	1,45	1,35	0,9						
Leave pallet 1-5	0,58	0,72	0,5	0,5	0,74	2,7	0,52	1,1	0,8	0,98
PP 1-5 -> S/L Square	0,48	0,5	30,83	1,57	22,68	3,68	2,37	2,62	1,87	10,4
PP 6-8 -> S/L Square	1,68	0,7	0,68	0,6	0,93	0,92	0,82	1,4	1,52	
Leave to B-crane 1-5	0,78									
IS										
IS1-> IS2	1,18	2,05	0,9							
Sort IS *	0,87	0,62	0,67							

* add to GR service forklift times for lead times

Service forklift Pre-Pack By Kim Gabrielsson 2013-03-07 and 2013-03-08 (min)											Average
Marked area to pallet racking	1,7	0,3	0,7	0,4	0,8	0,6	0,8	0,4	0,7	0,65	0,71
Marked area to Blue group	0,4	0,3	0,4	0,5	0,3	0,3	0,6	0,65	0,4	0,4	0,43
Marked area to "Krympen"	0,35	0,4	1,2	0,5	0,45	0,5	0,4	0,6	0,4	0,45	0,53
Marked area to Baging machine	0,8	1,1	0,7	0,5	0,6	0,9	0,7	0,5	0,5	0,6	0,69
Marked area to Brown group 1-5	0,6	0,4	0,3	0,4	0,3	0,2	0,4	0,4	0,3	0,4	0,37
Marked area to Brown group 6-8	1,2	1,6	0,8	1,6	1	1,4	1,45	0,9	0,8	0,7	1,15
Blue group to Binning	1,1	0,3	0,4	0,2	0,4	0,4	0,7	0,5	0,3	0,4	0,47
Brown group 1-5 to Binning	1,5	0,5	0,6	0,6	1	0,7	0,7	0,7	0,5	0,5	0,73
"Krympen"/bag machine to Binning	0,65	0,5	0,8	0,7	8,5	0,5	0,5	0,5	0,5	0,5	1,37
From pallet racking to Blue group	0,4	0,8	0,4	0,4	0,5	0,6	0,7	0,5	0,4	0,7	0,54
From pallet racking to Browm group 1-5	0,5	0,5	0,6	0,5	0,7	0,5	0,6	0,5	0,7	0,7	0,58
Moving jobs from pallet racking BG 1-5 to BG 6-8	0,95	0,9									

*= Brown group 6-8

#= 3pallets

¤= 2 pallets

Service forklift Pre-Pack By Kim Gabrielsson 2013-03-07 and 2013-03-08 (min)			
Route	**Time (s)**	**Route**	**Time (s)**
Start - G	16	**I-M**	17
G-K	34	**M-I**	43
K-C	44	**I-M**	24
C-D	25	**M-A**	26
D-C	11	**A-B**	25
C-D	12	**B-B**	20
C-C	29	**B-C**	25
C-F	20	**C-L**	30
F-D	25	**L-E**	11
D-F	22	**E-D**	21
F-D	40	**D-C**	15
D-F	19	**C-I**	11
F-H	20	**I-H**	85
H-E	20	**H-I**	37
E-C	11	**I-H**	25
C-C	11	**H-I**	22
C-L	12	**I-F**	27
L-C	15	**F-J**	29
C-C	24	**J-G**	40
C-C	20	**G-G**	41
C-C	11	**G-G**	15
C-I	30	**G-G1**	25

Service truck times & activities
Goods reception
7-3-2013
By Anna Askri

(min)															**Average**
Empty pallet sorting	0,48	0,2													**0,34**
Empty pallet storage->L1 unpack	0,25	0,27	0,35	0,37											**0,31**
ES->Leave emballage	1,7														**1,70**
L1 -> Empty pallet storage	0,62	0,47	0,27												**0,45**
L1 empty pallet -> L2b	0,32														**0,32**
L1 empty pallet storage->L2 unpack	0,33														**0,33**
L1 unpack->S	0,08														**0,08**
L1->Bulky	0,28	0,27													**0,28**
L1->Control?	0,75														**0,75**
L1->Empty 1/2 pallets	0,27	0,27	0,27	0,17	0,25										**0,53**
L1->IS	0,4	0,18	0,33	0,33	0,2	0,57	0,27	0,27	0,35	0,33	0,37				**0,33**
L1->L1 unpack	0,37														**0,37**
L1->L1b	0,85	0,25	0,83	0,3	0,27	0,27	0,2	0,18	0,17	0,17	0,27				**0,34**
L1->L2->IS	0,6														**0,60**
L1->L2b	0,33	0,17													**0,25**
L1->Large Square	0,5	0,48	0,38	0,43											**0,45**
L1->S	0,43	0,33	0,4	0,37	0,28	0,37	0,5	0,33	0,35	0,18	0,42	0,18	0,17	0,17	**0,32**
L1->Yard	2,53	1,87													**2,20**
L1b->IS	0,32	0,4	0,32	0,55	0,28										**0,37**
L2 unpack-> IS	0,23	0,33	0,27	0,27	0,38										**0,30**
L2 unpack->Empty pallet storage	0,5														**0,50**
L2 unpack->L2b	0,18														**0,18**

L2->IS	0,18	0,22	0,2	0,33	0,23	0,42	0,22	0,23							**0,25**
L2->L1 empty pallet storage->S	0,57														**0,57**
L2->L1a	0,22														**0,22**
L2->L2a	0,3	0,28	0,18	0,1	0,1	0,25	0,4	0,17							**0,22**
L2->OGS	0,53														**0,53**
L2->S	0,32	0,17	0,17	0,27											**0,23**
L2b place pallet on empty pallet	0,17														**0,17**
L2b sorting	0,18														**0,18**
L2b->Control?	1,17														**1,17**
L2b->IS	0,18	0,2	0,22	0,53											**0,28**
L2b->Large Square	0,32	0,33	0,33												**0,33**
OGS->Bulky	0,33														**0,33**
OGS->L2a	0,68														**0,68**
OGS->Leave empty pallet	1,7														**1,70**
Other activity (taping blue cabinet)	5														**5,00**
S sorting	0,17	0,4													**0,29**
S-> Large Square	0,38	0,35	0,3	0,42											**0,36**
S->GA	2,62														**2,62**
Sorting/leave pallet cover	0,72														**0,72**
Taking notes	4,63														**4,63**
Wait	0,22	0,33	0,88	3	0,3										**2,37**

APPENDIX 7 – SWOT ANALYSIS

The SWOT analysis is based on interviews, see Appendix 1, discussions and observations.

INBOUND

Strengths

- Willingness to change
- Good engagement of the leaders
- The encouragement of the department managers
- Becoming one department
- Implementing Lean
- Knowledge of the workers
- Routines, packaging instructions in some of the products at Pre-pack

Weaknesses

- Moderate internal communication between some departments e.g. between Inbound and Procurement
- Blaming other departments for errors e.g. mixed HP & green pallets from GR to PP, or approved deliveries of incorrect amount of goods (pay for nothing), stating PP is a bottleneck etc.
- Not using modern technologies to identify and locate goods in the flow
- The layout – not optimal for continuous flow
- The processes are old, too little is computerized
- The routines are not applied, are built on without being changed. E.g. the service forklift works based on perception and experience rather than routines

Opportunities

- Being able to rotate workers
- Decrease lead time
- Decrease tied-up capital
- Increase capacity
- Pre advised goods
- Continuous material flow
- Improved internal communication
- Eliminate waste activities
- Standardization
- Planning of resources
- More modern way of working
- New technology
- More efficiency, leads to higher competitiveness
- Change in structure

Threats

- Implementation costs
- Capacity - Not being able to keep up with the amount of incoming goods
- If technology is not updated it may be hard to make big improvements concerning cost reductions, capacity and handling of goods
- If the approach doesn't change maybe the customers will find less expensive suppliers

GOODS RECEPTION

Strengths

- Knowledge and experience of the operators
- High competence
- Getting items the right way
- The deficiency flow; class 1 HP (machine break at the supplier)
- Good commitment
- The yard is emptied largely each day

Weaknesses

- Pre advised versus manual registration implies a certain risk
- Not knowing exactly when, what and how much will arrive. Results in not being able to prepare or plan work and resources
- Non pre-advised goods results in not being able to prepare. If the goods are known the operators can plan the process and take care of the miscellaneous pallets last since they take more time on the conveyor
- Ca 30% of incoming goods are pre-advised, 10% of these are correctly performed
- Incorrectly pre-advised goods - see above, this means 27% are incorrectly performed
- Manually remove pallet covers
- Manually searching for the correct MR in the bunch of printed MR
- 80% of all daily goods arrive in the morning at the same time, queue before, during and after
- Outmoded procedures
- Old technology
- Labeling of full pallets and then relabeling at the Binning
- Operator at the yard running back and forth bringing delivery notes to operators at GR
- Supplier sends item to wrong warehouse e.g. Eskilstuna instead of Gent. Non-registered article, making new order to be able to write MR and ship to customer. Time conceiving. Happens daily.
- 3 operators sharing one forklift at Bulky results in waiting time
- The service forklift performs unnecessary activities, re-handling of pallets, unidentified process, no standard work
- The system: engine cards
- Getting items the wrong way, effects the following stage
- Poor redundancy within the group since one do not gladly rotate work

- Are uncomfortable with change

Opportunities

- Pre advised goods
  - Knowing the exact time for arrival to plan work and resources
- Get through pre advising to become more efficient and be able to use automatic registration of packages (e.g. by bar codes)
- Scan, bar codes
  - Better response, being able to locate the position of the items
  - Eliminate manual work, workload
  - More comprehensive quality checks
  - Better feedback towards the procurers
- Communication between operators by the conveyor and the ones by the yard
- Better technology (faster and more updated)
- Communication between operators at goods reception and procurers
- Direct flow from conveyor to storage, no middle activities
- Culture development to get good mobility at work and help each other when there is too much to be done
- Starting to see Inbound as one unit and being able to rotate over larger areas (not only at GR)
- Get more efficient by cooperation with different departments and towards materials management

Threats

- Not being able to plan the work
  - Input lower than forecast results in over staffing
  - Input higher than forecast results in not being able to handle the delivery
  - Disturbing the working balance, stressed operators that needs to work harder to push out the pallets
  - Results in high IS, Pre-pack unable to handle the amount of MRs in the IS at the same rate as they comes in
- Computer breakdown
- Not understanding the purpose of daily meetings
- Not understanding the improvement suggestions, the new thinking
- Convenience (doing the same way as always)
- Old system (-74)
  - Would have received SCM in 2007, currently planned to 2016 (warehouse system)
  - Falling behind in the development, there are better solutions
- Reluctance to change
- Restrictive investment interest
- Reluctance to change in culture

PRE-PACK

Strengths

- Knowledge and experience of the operators
- The Fine line benches 4 to 6 that focuses on High Priority MR, and the bench number 3 that is for fast jobs
- The rotation of workers at the rough station - Flexibility in parts of the rough stations
- The productivity has improved since rotation was introduced at the rough station
- Very good quality ”out”, few errors
- The capability to deliver
- Even level of hours in queue
- Cohesive team

Weaknesses

- Slow computers and printers invites to congestion
- Few computers and label printers
- Currently all the operators share two computers that are quite old, if one breaks then there is only one computer on hand. This also affects the queue. Have discussed having one computer at each bench, but not been implemented with the reasoning that it’s not ergonomic, but also expensive.
- The bag machine that only has been used once
- The system in the racking storage, there are three different places and no logic
- Deficiencies in the flow
- ”Fool”-time
- The unnecessary activities of the service forklift
- The distance to packaging material

  The Rough

- Rough bench 1-5: start working 6.00, the service forklift start working 7.30. The time in between, the Pre-pack operators must themselves sort out the pallets in the intermediate storage, time consuming
- Rough bench 1-5: Sharing one forklift, results in waiting time
- Rough bench 1-5: One operator only using hand forklift, takes longer time
- Getting jobs themselves
- The “closeness” between the benches

  The layout

- Different distances to packaging storage and computer, e.g. Fine bench 10 has ca 62 m back and forth which is ca 48 m longer than the nearest bench (Fine 3). Also bench Rough 6-8 has ca 74 m back and forth to the computer which is ca 64 m longer than the nearest rough bench 1.
- Glass station is located in the other end of the building (quite isolated from the rest of the Pre-pack environment).
- The layout is not optimal. No need for the full height and better space areas are needed.

- The layout does not encourage a continuous flow; there are a lot of sub-activities
- The Pre-pack department is considered being the physically easiest, which means that “injured” operators are placed there. This affects the productivity.

Opportunities

- Glass station to be moved closer to the rest of the Pre-pack department
- A standardized way of working; e.g. pack in a specific order, prepare several packages at the same time than packaging one at a time. Talk with colleagues while working. Delegating work, some pallets are not favorable to pack, therefore some might avoid it for as long as possible while some might more often work with these pallets; decide for each day who will be responsible for these type of jobs so that everyone will be involved.
- Be “served ” with the job
- Having a FIFO system in the IS; perhaps separating the HP and ordinary flows and having a specific storage point in the IS
- The vision is that the rough station will do a lot themselves, however the service forklift helps since the layout is not optimal. The goal is to have as short distances as possible to keep up the work.
- Receiving better reports of incoming goods to be able to plan resources
- The layout
- More opportunities to print labels
- Educate people e.g. in computing, lean etc.
- Make staff more participant, if they will see the final result they will be more positive
- New technology, speed up
- Need to develop the packaging, should be more easy and flexible. More Just-In-Time. Labeling.
- Standardization
- New thinking

Threats

- Not understanding the aim of daily meetings
- Not understanding the aim of improvement suggestions
- Convenience (doing the same way as always)
- Unable to produce at same rate as goods reception
- Computer breakdown
- Staff “scared” of working shifts
- If everything becomes supplier packed, then the Pre-pack department can disappear
- Pihls takes over the packaging if too much goods are received
- If selling more then will get more goods, currently don’t have the capacity to handle more, able to handle 500 hours
- Review the entire warehouse, should not become a bottleneck
- Far behind in the development compared to other warehouses

BINNING

Strengths

- Knowledge, experience and engagement of the operators, and the good atmosphere
- The binning time - keeping standards
- The planning of routes
- Being able to report the MR in the forklift while binning (for the “larger” forklifts)
- The sorting station, however see weaknesses
- Bar codes
- New organization, new thinking, Lean, VPS
- The lead time of the direct registered goods is always (often) just under the goal line

Weaknesses

- Not being able to report the MRs directly in the forklift while binning (A-U route)
- Not being able to see how much of an article is in the shelves; only sees the amount that was registered in the morning, not the current time. If full on shelf then have to drive to the buffer rack (waste time)
- Route planning should be an outcome from planning already at the goods reception (sorting station is a waste activity)
- Half full pallets, the planning should be performed already at the goods reception so that binning operators get rid of the sorting and save the number of routes
- Empty pallets, results in too much driving around.
- Poor measurements concerning productivity. The binning is responsible of keeping order at the warehouse, gets risk forms from picking operators. However this maintenance and time is not included in the overall productivity measurements
- Manning (will probably improve by the merging with kit station)

Opportunities

- Being able to see how much place there is on each rack
- The goods reception embedding the work for the binning department; sorting of same articles from different MRs into same pallet, instead of pushing of several different pallets with same articles. Results in more driving routes and longer time, overwork.
- Being able to see information about the articles in storage, how much there is. Be able to plan the route if a rack is full.
- Computers on all forklifts
- Being able to guarantee by using bar codes

Threats

- Computer breakdown
- No system support, unreliable appliance (engine system)