Reducing lead time and increasing productivity at a mail order distribution center

Analyses and improvements of reverse logistic processes

ELLINOR BELIN
RICHARD HEDMAN

Master thesis at
Department of Materials and Manufacturing Technology
CHALMERS UNIVERSITY OF TECHNOLOGY
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Examiner: Assistant Professor Peter Almström

Supervisor: Assistant Professor Peter Almström
Department of Materials and Manufacturing Technology
Chalmers University of Technology
SE-412 96 Göteborg
Sweden

Performed at: Classified

Supervisor: Super User at the Company

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Abstract

The purposes of this master's thesis are to investigate how lead times of the reverse logistical flow can be reduced and how work methods can be improved at a retailing distribution center. The investigated parts of the distribution center are processes, operations and internal flow related to handling of returned goods. Reverse logistical environments, associated to online and catalog retailing, are characterized by high uncertainties since large diversity of products arrives in small quantities.

The project has been conducted by the use of a methods engineering approach. Several studies were made to collect and compile data in order to present a current state of the investigated area. Results from analyzing the current state showed exceptional long lead times, unstable processes and improvement potential in manual operations. From the results, together with the project's frame of reference, a number of proposed improvements were presented. The improvements aim to reduce lead times in handling of returned goods by reducing buffer sizes, balancing flow of goods and re-planning the manning of workstations. Further, actions which will increase efficiency and simplify routines have also been presented. All suggested improvements contribute to an overall reduction of lead time, a stable flow and increased productivity in returns handling.

Keywords: *Lead time, productivity, returns handling, distribution center*

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Abbreviations

Abbreviation	Explanation
DBR	Drum-buffer-rope
DC	Distribution Center
GTT	Group Timing Technique
IT	Information Technology
MO	Mail Order
MPU	Method Performance Utilization
TOC	Theory of Constraints

1 Introduction

This chapter introduces the master's thesis by providing a brief background of the Company's business and the motivation behind why this project is carried out. This will be followed by the purpose, objectives and the research questions of the master's thesis accompanied by the delimitations.

1.1 Background

The Company offers Internet and Catalogue shopping in several countries. Distribution Centers (DCs) for Internet and Catalogue shopping, henceforth referred to as Mail Order (MO), are sited in three European countries. Two of them operate in Scandinavia while the third one handles the larger share of the MO market and is sited in Central Europe.

A DC is a short-term storage facility for goods located in near proximity to the major market. Strategically located DCs facilitate a rapid processing of orders and shipments of products to customers. Compared to a warehouse the DC's focus is on moving goods rather than on long-term storage, (Jonsson, 2008). The Company's DCs in Scandinavia have the aggregation role with the DC in Central Europe as a central distributor, a wholesaler, who serves them with products. The DC in Central Europe has also the aggregation role but with the products delivered directly from the production companies, meaning that the DC in Central Europe has both the aggregation role and act as a wholesaler. An aggregation role means that a local distributor close to the market delivers those quantities equivalent to each customer's individual needs. The sum of the individual customer's needs is delivered to the distributor directly from the production company or via a central distributor, (Jonsson, 2008). The role of aggregation includes responsibilities for inventory control, and deliveries to customers take place through withdrawals from stock. Work by the distributor will be to break down the consignment from the wholesaler and send individual orders to each customer, i.e. to perform more or less advanced cross-docking activities, (Jonsson, 2008).

There are several departments within the Company's MO DC's production; the Goods Reception which handles received goods, the Dispatch Area where customers' specific orders are picked and packed, the Dispatch of Freight Area which handles outbound goods and incoming customer returns, and the Returns Department where customer returns are handled. All the different departments have sub areas and, at least, one group leader who is responsible for the daily work in his or her area and he or she also plans the manning during shifts. In addition each group leader has the responsibility for a group of workers which rotates between the different areas. The whole group does not necessarily have to work in the same area at the same time, meaning that there can be workers from different groups working in one area. The salary for the workers in the production is based on piece-work contract and the production is running between 6a.m. and 10p.m. Monday to Thursday and between 6a.m. and 4p.m. on Fridays.

During recent years the Company has experienced a trend towards increased demand for MO services. As a result, the workload in DC operations has increased as well. Striving towards efficient flow of goods and increase in productivity are ever present challenges. In order to handle this expansion, while aiming for high profitability and optimal flow of goods, a

Best Practice way of working throughout the organization is required. Due to this, the Company conducted a mapping of the internal logistical flow in all MO DCs during the end of year 2009. The mapping indicated long lead times in several areas; one of them was the department for returns handling.

The Company's customers always have the right to return products, although the legal terms and conditions may vary depending on country. In average 15-30% of sold goods are returned, with diverseness between the MO DCs and depending on season. The returns handling is considered by the Company as an expensive part of the MO DC's operations e.g. due to the long handling procedures and since no direct value is added when processing returned articles. However, returns handling is an important part of customer service. It involves refund, complaint, exchange of products, placing of new orders etc. Returned articles are assumed to be restored into Dispatch Stock within a specified timeframe and thereby made available for picking of new customer orders. Failing to restore articles within the timeframe can lead to articles not being on location during picking rounds and thereby delaying order from being shipped. Efficient processes in returns handling are therefore necessary.

1.2 Purpose and Objectives

The purpose of this master's thesis is to investigate how lead times of the reverse logistical flow can be reduced and how work methods can be improved in the Returns Department. This will be accomplished by using methods engineering in order to identify the root causes, analyze the current state and develop improvement suggestions. The suggested solutions shall lead to an increased productivity and improved customer service. Restoring of returned products, back to Dispatch Stock, shall be carried out aligned with current demand which is directly related to external customers need. Furthermore, the solutions shall strive towards sustaining, and potentially improving, a good work environment.

By taking into account the factors above, following research questions are stated:

- How can lead times be reduced and productivity increased in the Returns Department?
    - What actions need to be taken in order to increase efficiency and simplify the routines in the Returns Department?
    - How can returned goods be prioritized in order to match the demand from Dispatch Department?

1.3 Delimitations

The scope of the master's thesis is focused on improving internal MO DC processes for returns handling. Other internal processes will not be investigated in particular. One of the MO DCs in Scandinavia will serve as base for the research.

2 Frame of Reference

The following chapter introduces the frame of reference used in the master's thesis. Since the general problem of this thesis is something that has been dealt with many times before, a thorough literature study has been conducted in order to draw benefits from previous work. The chapter covers key concepts such as methods engineering and an introduction to Reverse Logistics. Thereafter, other relevant areas such as Theory of Constraints and productivity are presented. The chapter ends with a selection of tools and techniques used in the master's thesis.

2.1 Methods Engineering

Methods engineering is an integrated approach to work system improvements originated from Frederick W. Taylor's time studies and Frank and Lillian Gilbreth's motion studies. In course of time, Taylor's time studies developed in the direction of establishing standard times and Gilbreth's motion studies evolved into a technique for improving work methods. Eventually, the two techniques of time study and motion study were integrated and refined into the widely accepted method, known as methods engineering, applicable to improve and upgrade work systems. The content in methods engineering is quite similar to work study, work simplification, and method study. (Akiyama and Kamata, 2001; Freivalds and Niebel, 2009)

In the early days, methods engineering's focus areas were manufacturing processes and operations and fabrication operations in particular. Today, focus has expanded to include indirect operations peripheral to manufacturing, indirect overhead areas of the company and service work, for example design, material handling, inspection, maintenance and office work. The trend has been to address broader areas, such as production processes, the factory in total or large scale work systems that involve a lot of people and extensive equipment. In recent years methods engineering has also been successfully applied to a wider range of industries, a variety of work systems involving the activities of people in such organizations as; service industries, hospitals, government offices, utilities, and distribution facilities. In other words, method engineering is no longer limited to manufacturing industries. (Akiyama and Kamata, 2001)

As for areas of operations and industries, the application of methods engineering has also increased from the earlier main approach, which was improvement of the existing work systems, to the wider approach, namely design of totally new work systems. Similarly, the essential objective behind design and improvement of work systems through the application of methods engineering has also broadened. Previously, the objective was improvement of labor productivity, while today objectives such as balance between operator and work system from an ergonomic viewpoint and adaptation of the work system to the environment from an ecological viewpoint are becoming important. (Akiyama and Kamata, 2001; Freivalds and Niebel, 2009)

Methods engineering is a structured technique to undertake an engineering task, independent of its purpose which can for example be, as mentioned above, to develop a new product, improve an existing one or develop a process. Methods engineering provides a methodical system for analyzing the present work situation, identifying problems, bringing out and selecting the best improvement ideas, and after implementation of improvements, standardizing the new methods, insuring their adoption, and measuring and evaluating their impact. Methods engineering is an iterative process of studying direct and indirect operations to continuously find possible improvements. (Akiyama and Kamata, 2001; Freivalds and Niebel, 2009)

If the necessary actions follow a procedure, which is determined prior start, when undertaking improvement works by the means of methods engineering following benefits can be obtained, (Akiyama and Kamata, 2001):

- A possibility to, ahead of time, get a good understanding among all the people involved.
- Improvement activities will be more efficient and wasted effort can be avoided.
- By concentrating on the step at hand, the quality of work done for each step will increase.
- Monitoring of progress can be readily done.

2.1.1 Methods engineering program

The following section explains the eight steps in the methods engineering program as described by Freivalds and Niebel (2009). From the various techniques and tools recommended at the steps, appropriate ones will be chosen, based on the object being analyzed.

- **Step 1:** *Select the project.* Step 1 of the methods engineering procedure is to decide what is to be improved, identify the problem and select the scope of the project. Suggested exploratory tools to use at this step are Pareto analysis, cause-and-effect diagrams, Gantt chart, PERT chart and job/worksite analysis guide. Those tools help to make the selection simplified and done in a logic sequence which is easy to understand and present to management.

- **Step 2:** *Get and present the data*. The second step is to collect general data concerning the selected study subject. The data of importance depends on chosen improvement target and can be everything between drawings and specifications to lead times and cycle times. It is necessary to record the collected data in a structured way for future study and analysis. Tools that can be useful at this step are for example operation process chart, flow process chart and flow diagram. Of course, also interviews with concerned persons and observations can be beneficially.

- **Step 3:** *Analyze the data*. When the project goal is improvement or redesign of an existing work system, that work system must first be analyzed and its current conditions accurately understood. The work is to analyze the data collected in step 2 and it is important to take a quantitative approach as much as possible. Further, it is vital to analyze at a level of preciseness adapted to the subject being analyzed, meaning not to coarse nor to detailed. The results should be presented visually, for instance by use of charts, graphs, and drawings. The purpose of analyzing is to identify operations, methods and processes which can be improved, shortened and/or simplified. Among the methods for analysis, process analysis, operation analysis, motion study, time study, work sampling, and flow analysis are widely used.

- **Step 4:** *Develop the ideal method.* At this step the best procedure for each function according to the project objectives shall be selected based on analyzes conducted in step 3. A future ideal state shall be developed with solutions specified according to the research questions stated.

- **Step 5:** *Present and install the method.* When reaching step 5 the proposed method shall be explained in detail to those responsible. The analyst needs to sell the suggestions to management and operators and ensure that the proposed method will provide the results projected. At this step the change management is necessary to consider, but by involving people the resistance to change normally decreases and the suggestions can be reworked once more to ensure that all details are correct.

- **Step 6:** *Develop a job analysis.* When the implementation of the ideal method is completed a job analysis shall be conducted to confirm that the method entails the desired result. The analyst now should take into consideration if operators are adequately selected, the work environment, job descriptions etc.

- **Step 7:** *Establish time standards.* After the installed method is stabilized and has passed its ramp up-time time studies should be conducted to establish a fair and equitable standard. Suitable tools for time studies are e.g. stopwatch time study, work sampling and methods-time measurement.

- **Step 8:** *Follow up the method.* When all changes are implemented it is important to create a follow-up procedure so that system performance can be maintained at the target level. Moreover, it is at this step investigations are made about what kind of improvements that can be done for further development.

According to Niebel and Freivalds (2009), step 6 and step 7 are not strictly part of a methods study, but are necessary in a fully functioning work center.

2.2 Reverse Logistics

Reverse logistics is defined as operations in logistical environments concerning returns and reuse of products and material, (Inderfurth et al, 2000). It can also be included as a key process in reverse supply chains, (Blackburn et al, 2004). Literature dealing with product returns generally falls within the area of closed-loop supply chain management, (Brito and van der Laan, 2007). Closed-loop supply chains relating to product returns can be distinguished as commercial returns, wrong deliveries and recalls. The commercial returns are products that are sold with a return option. Wrong deliveries are products that were refused by customers due to for instance late delivery or contained defects, while recalls are made by the liable company if there are actual or expected problems with the product, (Flapper et al, 2005). Compared to forward logistics the area of reverse logistics is relatively undeveloped, (Blackburn et al, 2004), and there are considerably less literature at hand.

The process of reverse logistics typically initiates by obtaining the used product from the user and transporting it to a facility for sorting, inspection and disposition. The condition of each product needs to be assessed before making any decision whether it should be reused or not. If the product is applicable for reuse efforts are usually made in order to restore the product according to its original specifications, (Blackburn et al, 2004). For manufacturing companies this is referred to as remanufacturing while the fashion industry uses terms as refurbishing or refinishing, (Bonawi-tan et al, 2005). Recovered products are classified as either resalable or non-resalable. Resalable items are reintroduced in the DCs range of products or sold as second hand products. Non-resalable items are normally donated to charitable organizations or discarded, (Bonawi-tan et al, 2005; Blackburn et al, 2004).

2.2.1 Characteristics for online and catalog retailing

Product returns are ever present in online and catalog retailing. Bonawi-tan et al (2005) states that return rates for catalog sales are 10-30% of sold orders while Brito and van deer Laan (2007) report that return rates for fashion items in particular are, on average, 35-40%. The reasons for these returns are partly due to customers being permitted to return products for a small cost, or no cost at all, earlier referred to as “products sold with a return option”, (Flapper et al, 2005). Also, customers cannot feel or try the product before making the order which might contribute further to a high return percentage for fashion items, (Bonawi-tan et al, 2005).

Reverse supply chains are characterized by a high degree of uncertainty. It concerns the ambiguity in forecasting incoming returns by time, quantity and quality meaning; “when”, “how much” and “the state” of the products, (Flapper et al, 2005; Bonawi-tan et al, 2005; de Brito et al, 2001; Brito and van der Laan, 2007). The prognoses for incoming returns are primarily based on historical data. Though, this kind of prognoses are hard to make accurate, (Brito and van der Laan, 2007), and for seasonal products, such as fashion, there might not be any historical data available which further complicates the forecasting processes, (de Koster and Zuidema, 2005). An additional problem specifically related to online and catalog retailing is the large diversity of products arriving in small quantities, (de Brito et al, 2001). Despite all difficulties, concerning forecasting and handling incoming returns, the return operations themselves are characterized by inefficiency and excess material handling, (Bonawi-tan et al, 2005).

2.2.2 Importance of efficient reverse logistics

Returns of commercial products might be considered as an undesirable and costly part of a company’s operations, therefore many reverse supply chain processes are designed to minimize costs. However, a cost efficient supply chain is not necessarily a fast supply chain, (Blackburn et al, 2004). The longer a returned product is delayed from being retrieved, the lower the possibilities of economically possible reuse options, for instance fashion products face a high risk of becoming outdated close to the end of a season, (de Koster and Zuidema, 2005). Also, considering the magnitude of returns in catalog and online retailing returns handling processes can be regarded as a second supplier of products. Reverse supply chains should therefore be designed with regard to responsiveness as well, (Blackburn et al, 2004). Responsiveness in the context of returns handling can for instance be filling back orders effectively, (Bonawi-tan et al, 2005). Consequently, there can be a tradeoff between cost efficiency and responsiveness in a reverse supply chain, and design focus shall be decided upon the time value of the product. The time value is defined as how fast the product value decline, (Blackburn et al, 2004). In summary, Bonawi-tan et al (2005) state that: "*Managing returns wisely means thinking about returned goods not as costly mistakes but as products waiting to be sold profitably – an opportunity to be exploited*".

2.3 Customer Service

Customer service for logistics operations is defined by Jonsson (2008) as: "*Activities between the buyer and seller that enchant or facilitate the sale or the use of the seller's products or services"*. Literature dealing with customer service typically starts by defining who the customers of the organization are. An organization can have both internal and external customers, (Bergman and Klefsjö, 2003). For MO companies external customers naturally are consumers and buyers of the company's products, while internal customers can be centers, departments and/or workstations within the organization. As a part of quality management, improving customer service is about identifying the needs and expectations of the customers. These needs and expectations shall thereafter be fulfilled and preferable exceeded, (Bergman and Klefsjö, 2003).

Sold products are a mix of goods and services. Relating to customer service and satisfaction there are several differences when discussing goods and services. A service is not as substantial as an item and therefore it could be difficult to explain, specify and measure the content of a service, (Jonsson, 2008). Furthermore, services are series of activities, processes, and cannot therefore be as easily tested by the customer prior to use, compared to physical items, (Bergman and Klefsjö, 2003).

2.3.1 Aspects of customer service in returns handling

The customer service commitment is valid throughout the supply chain, as visualized in Figure 2.1.

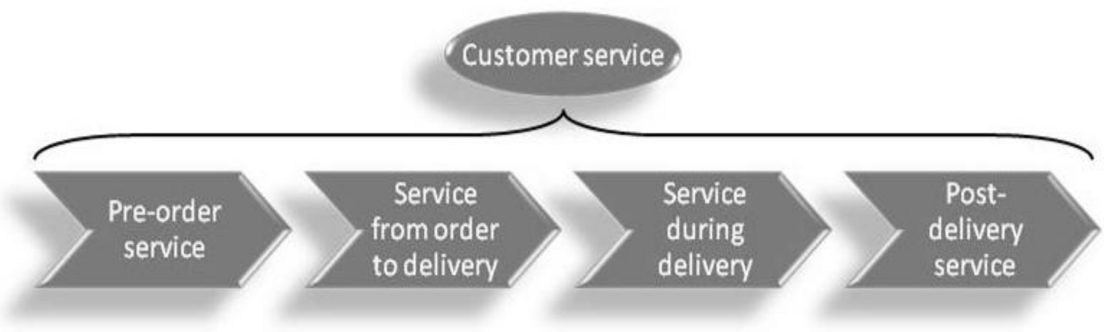


Figure 2.1 Customer service commitments, adapted from Jonsson (2008).

Returns handling is naturally related to the post-delivery service step including both handling and claims of returns, but also processing of used products, (Jonsson, 2008). Quality dimensions relating to customer service in returns handling can be, (Bergman and Klefsjö, 2003; Jonsson, 2008):

- *Reliability* – Referring to doing what you have promised to do, especially for products sold with a return option. Can include routines for invoicing, terms of information and crediting to customers.
- *Access* – How the customer can come in contact with the supplier, concerning availability such as opening hours and technical facilities.
- *Communication* – Ability to have a natural communication between customer and supplier.
- *Responsiveness and courtesy* – The willingness to help the customer and the supplier's behavior towards the customer.

As mentioned in previous chapter, returns handling is a substantial part of catalog and online retailing. Despite the costs and resources necessary to process returns, the decision to accept returns at no cost or little cost can also be seen as an important service element, (Dekker et al, 2004). By utilizing the reverse supply chain, with returns as a second material supplier, returns handling also affects customer service in forward logistics, for instance by filling backlogged orders with returned items faster than await new products from the manufacturer, (Bonawi-tan et al, 2005). The possibility for customers to place new orders, when returning products, can also be seen as an additional service element, (Blackburn et al, 2004).

2.4 Theory of Constraints

Theory of Constraints (TOC) is a system improvement philosophy. In production environments a system can be defined as a network of processes, also referred to as components, transforming inputs into outputs. When focusing only on separate processes the effects of dependences between the system's components are ignored, (Dettmer, 1997). System thinking is a part of *profound knowledge*, formulated by Edwards Deming. The profound knowledge has four elements which constitute a base for managing transformation, (Bergman and Klefsjö, 2003):

- Appreciation for a system.
- Knowledge about variation.
- Theory of knowledge (how and what we do).
- Psychology.

In TOC a system is equivalent to a chain and performance of the entire system is limited by its weakest link, the constraint. Every system must have at least one constraint, (Dettmer, 1997; Raham, 1998). Since TOC states that the constraint determines system's performance a constraint is considered to represent an opportunity for improvement and viewed as something positive, (Raham, 1998). Constraints can be categorized as either *physical* or *policy* related. *Physical* constraints are typically more ease to identify and eliminate, while *policy* constraints, being harder to eliminate, often result in a larger degree of system improvement, (Dettmer, 1997). Constraints can also be placed in a third category, a *market* constraint, meaning when the demand is less than resource capability, **(**Blackstone et al, 2007).

2.4.1 The five focus steps

Approaching system improvement using constraint management can be done according to the *five focus steps*, developed by Eliyahu M. Goldratt, (Dettmer, 1997):

1. Identify the system constraint.
2. Decide how to exploit the constraint.
3. Subordinate everything else.
4. Elevate the constraint.
5. Go back to step 1.

The initial step is about identifying what part of the system that constitutes as a constraint, and also to determine whether it is a *physical* or *policy* constraint. When a constraint has been identified all possible capability of the component shall be utilized as it currently exists. This can result in the component no longer being a constraint. As mentioned earlier, a system always has at least one constraint, therefore the system is still constrained but the constraint itself has moved. Step 4 and 5 shall in those cases be skipped and the process shall restart at step 1. Supposing the component still is the constraint all system resources shall then be subordinated. Thereafter all actions needed to eliminate the constraint shall be taken. When the constraint has been eliminated it is time to go back to step 1. This is a cyclic process of continuous improvement that never ends. **(**Blackstone et al, 2007; Dettmer, 1997; Raham, 1998)

2.4.2 Buffer management

The drum-buffer-rope (DBR) methodology is a part of TOC logistics system and often referred to as buffer management. It evolved from the nine rules of Optimized Production Technology, stated by Eliyahu M. Goldratt, (Dettmer, 1997; Raham, 1998; Blackstone et al, 2007):

1. Balance flow, not capacity.
2. Level of utilization of a non-bottleneck is determined not by its own potential but by some other constraint in the system.
3. Utilization and activation of a resource are not synonymous.
4. An hour lost at a bottleneck is an hour lost for the total system.
5. An hour saved at a non-bottleneck is just a mirage.
6. Bottlenecks govern both throughput and inventory in the system.
7. A transfer batch may not, and many times should not, be equal to the process batch.
8. The process batch should be variable, not fixed.
9. Schedules should be established by looking at all of the constraints simultaneously. Lead times are a result of a schedule and cannot be predetermined.

The *drum* is the heart of the system and beats with the pace at which the constraint works. The *rope* is the communication and material release mechanism which releases material to the first operation in the same pace as the constraint. It provides communication between the systems critical points to ensure their synchronization, (Raham, 1998). The “length” of the rope or the time (amount of the system’s inventory) is determined by the *buffer*. A constraint buffer is placed in front of the capacity constraint resource in order to prevent starvation due to lack of material, **(**Blackstone et al, 2007). Using DBR and buffer management can help to discover causes of disruption in production without disrupting the throughput. Increasing the constraint buffer size will increase protection of the constraint. However, larger buffer sizes will naturally result in a larger amount of inventory and work in process which also increases lead time, **(**Blackstone et al, 2007). By continuously striving towards reducing buffer sizes without disrupting throughput the production’s throughput time can be reduced which likely will result in a reduction of lead time, (Raham, 1998). TOC is commonly used in managing tradeoffs between protecting the constraint and reduce lead times, **(**Blackstone et al, 2007).

2.5 Productivity

A company’s productivity is a key factor for its success on the global market. However, the term productivity is multidimensional and the meaning vary depending on the context within which the term is used. In Industrial Engineering, productivity generally expresses the relation between output and input in the manufacturing transformation process where output is most often produced goods and input is consumed resources. (Tangen, 2005; Smith, 2001; Almström and Kinnander, 2007)

In economic measures productivity is calculated based on financial terms, it can be the relation between value of sales and cost of labor. If a company chooses to outsource the work to low cost countries this productivity figure is improved, but according to Almström and Kinnander (2007), this figure of productivity improvement is superficial. It says nothing about the actual productivity or efficiency on the factory floor of the internal production and the possible productivity potential is often considerably higher than the management of the company in question imagines.

According to Tangen (2002), productivity is closely connected to the use and availability of resources. Simply, productivity is reduced if a company’s resources are not properly used or if there is a lack of them. Further, Tangen (2002) says that productivity is strongly linked to the creation of value; high productivity is achieved when activities and resources in the manufacturing transformation process add value to the produced products, and the opposite of productivity is represented by waste, which must be eliminated in order to improve productivity.

There are numerous of variations on this basic ratio between output and input and when there are multiple input measures or indices, the equation becomes complex and confusing. There are many definitions of productivity and there is not just one best way to measure it. (Tangen, 2005; Smith, 2001; Almström and Kinnander, 2007; Helmrich 2001)

According to Helmrich (2001), the Japanese Shigeyasu Sakamoto (Japan Management Association Consulting Group) introduced a method to express productivity with three factors to facilitate its determination. This method states that productivity is equal to the Method (M) multiplied by Performance (P) multiplied by Utilization (U), expressed as Equation 1, (Helmrich, 2001). This method is called the MPU-method by Saito, (2001), Almström and

Kinnander, (2007) and Helmrich, (2001) among many others. According to these authors, productivity can be improved through improvement of method, improving performance, and improving utilization.

$$\text{Productivity} = M \times P \times U \qquad \text{(Equation 1)}$$

The Method factor is how the work is done, the operating procedures, equipment that is used, machine setup conditions that have been accepted, as well as material-related standards based on the current design of the products, i.e. how smart the work is done. The objective is to search for opportunities to raise the levels of the work standards, for instance change from manual to automatic. (Saito, 2001; Helmrich, 2001; Almström and Kinnander, 2007)

The Performance factor is equal to intensity and accuracy of work performed by an operator or a machine, which depends on work environment, the complexity factor and motivation. The performance factor can also be the quality of material and components. (Saito, 2001; Helmrich, 2001; Almström and Kinnander, 2007)

The Utilization (Planning and Control) factor determines how well the intended method is carried out, how effective management of the operation is, i.e. how large share of worked time that is value adding. It is important to consider to what extent production time (utilization) could be increased through improved planning and control. (Saito, 2001; Helmrich, 2001; Almström and Kinnander, 2007)

2.5.1 Wastes in production

As mentioned, waste is the opposite of adding value. Learning to see waste is often considered to be an important first step in Lean Production.

In production processes the activities can be categorized as value adding, necessary waste and pure waste. Often, pure waste. Often, focus is on optimizing value adding activities and thereby missing the great improvement potential improvement potential in reducing necessary waste and eliminating pure waste. In

Figure 2.2 the three categories are presented as percentage of the total lead time for different improvement approaches, (Blücher and Öjmertz, 2005).

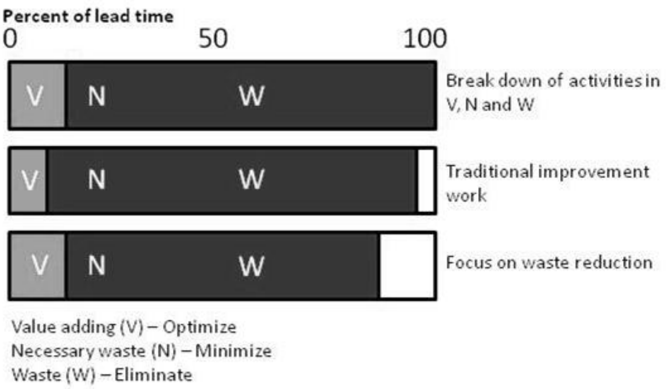


Figure 2.2 Value adding processes, necessary waste and pure waste, adapted from Blücher and Öjmertz (2005).

Table 2.1 presents eight major types of waste formulated in the Toyota Production System, (Liker, 2004).

Table 2.1 Eight forms of waste, adapted from Liker (2004).

Waste	Description
Overproduction	Producing items for which there are no orders, which generates such waste as overstaffing and storage and transportation costs because of excess inventory.
Waiting (time on hand)	Workers merely serving to watch an automated machine or having to stand around waiting for the next process step, tool, supply, part, etc. or just having no work because of stock outs, lot processing delays, equipment downtime, and capacity bottlenecks.
Unnecessary transport or conveyance	Carrying Work In Process (WIP) long distances, creating inefficient transport, or moving materials, parts or finished goods into or out of storage or between processes.
Overprocessing or incorrect processing	Taking unneeded steps to process the parts. Inefficient processing due to poor tool and product design, causing unnecessary motion and producing defects. Waste is generated when providing higher-quality products than is necessary.
Excess inventory	Excess raw material, WIP, or finished goods causing longer lead times, obsolescence, damaged goods, transportation and storage costs, and delay. Also, extra inventory hides problems such as production imbalances, late deliveries from suppliers, defects, equipment downtime, and long setup times.
Unnecessary movement	Any wasted motion employees have to perform during the course of their work, such as looking for, reaching for, or stacking parts, tools, etc. Also walking is waste.
Defects	Production of defective parts or correction. Repair or rework, scrap, replacement production, and inspection mean wasteful handling, time, and effort.
Unused employee creativity	Losing time, ideas, skills, improvements, and learning opportunity by not engaging or listening to your employees.

2.6 Tools and Techniques

Within the area of Industrial Engineering there is a large variety of tools for gathering data, analyzing problems, and improving methods or developing new ones. A selection of tools and techniques used in this master's thesis is presented below. Often tools and techniques requires observations of people working, therefore this subchapter ends by describing the Hawthorne effect.

2.6.1 Work sampling

Compared to traditional time studies, work sampling is considered as a faster and less costly procedure providing equal or better data. It is based on the law of probability where analyzes of work is done by taking a large number of observation at random times, (Freivalds and

Niebel, 2009). A smaller number of likelihood occurrences tend to follow the same distribution pattern that a larger number produces, (Brisley, 2001). Freivalds and Niebel (2009) lists following advantages of a sampling approach compared to time studies:

- It does not require continuous observation by an analyst over a long time.
- Clerical time is diminished.
- The total work hours expended by the analyst are usually much fewer.
- The operator is not subjected to long-period stopwatch observations.
- Crew operations can be readily studied by a single analyst.

The Group Timing Technique (GTT) enables one observer to make a detailed work sampling study on 2 to 15 operators at the same time. In Brisley (2001) Rolf Tiefenthal presents ten steps for conducting a work sampling study using GTT:

1. Define the purpose of the study.
2. Select the operation, group of operators and time periods to be studied.
3. Decide whether to separate the time for each operator.
4. Decide the recording method.
5. Define elements.
6. Define and reproduce study form.
7. Select interval size.
8. Determine study periods and duration.
9. Consider a trial study.
10. Make the study.

Calculating the accuracy of a sample study can be done by investigating the limit error. It is a measure of the degree of bias in measuring, where bias is the amount by which the long-run observed mean value of a set if measurements differ from the true value of the quantity, (Brisley, 2001). Limit error ℓ is calculated as follows:

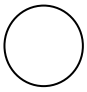
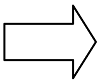
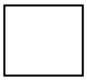
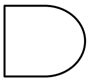
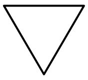
$$\ell = \sqrt{\frac{zp(1-p)}{n}} \qquad \text{(Equation 2)}$$

Where: z = a constant depending on chosen level of confidence.
p = probability of a single occurrence.
n = total number of observations.

2.6.2 Flow process charts

As one of the available problem solving tools in Industrial Engineering applications the flow process charts can be used to facilitate in eliminating hidden costs for a component. Nonproduction activities, such as distances, delays and temporary storages are recorded which also can help in showing how the layout for a plant or process can be improved, (Freivalds and Niebel, 2009). Typically, forms for flow process charts contain the pre-printed symbols, showed in Table 2.2. There is a large variety of basic process charts which can be adapted depending on the needs and objectives of the analyst, (Smith and Loch, 2001).

Table 2.2 Flow process chart symbols, adapted from Smith and Loch (2001).

SYMBOL	ACTIVITY	DEFINITION
	Operation	When something is done to or by the subject being followed at a given work area. Something is being added to or created.
	Transportation	When something is moving or being moved from one workspace or location to another.
	Inspection	When something is checked or verified for quality or examined for information, or the act of doing so.
	Delay	When something or someone waits or is delayed or when flow is interrupted.
	Storage	When something is kept and protected against unauthorized removal.

2.6.3 Brainstorming

Using brainstorming as an idea generating technique is a well accepted and common procedure in many areas. It can be defined as a method of non-critical "group think" with the purpose of producing a large number of possible solutions to a problem, (Buggie, 2003). Brainstorming sessions should be designed to ensure that intuitive thinking is encouraged which lead to individuals picking up each others' ideas and further develop them, (Fortune, 1991). Typical guidelines for brainstorming are, (Fortune, 1991):

- Work in small groups.
- Create an encouraging and supportive atmosphere.
- Welcome unusual ideas and withhold criticism.
- Write up all ideas and display them for all to see.
- When a large quantity of ideas has been generated; compile, improve and combine the ideas into usable options.

2.6.4 Cause-and-effect diagram

Identifying a constraint and determining what to change, meaning to find a form of cause and effect logic, can be done in several ways. This is referred to as the first part of the *Thinking process* in constraint management, (Dettmer, 1997). The tools associated with the *Thinking process* are often mutually supportive with those in quality management, Lean production and process reengineering, **(**Blackstone et al, 2007). The *Current Reality Tree,* developed by Eliyahu M. Goldratt, is an example of such a tool; it is used in problem analysis to provide a basis for understanding complex systems. It is a functional chart that visualizes and relates undesirable effects through a logical chain of cause and effect behind the current situation. An example can be seen in Figure 2.3. By using the *Current Reality Tree* root causes and core problems can be identified. A core problem is defined as a cause that accounts for 70% or more of the undesirable effects found in the tree. Not all core problems, or even root causes, fall within the span of control meaning it is not sure that you can do anything about them. The

Current Reality Tree helps in determining whether causes are within the span of control or the span of influence. (Dettmer, 1997)

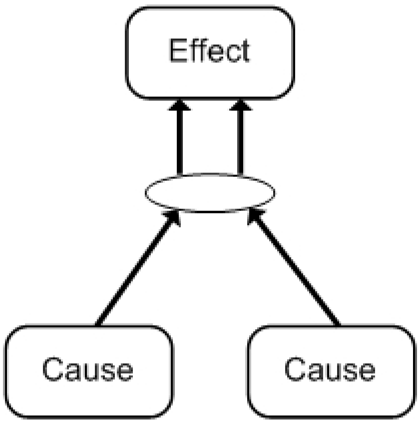


Figure 2.3 Current Reality Tree, adapted from Dettmer (1997).

2.6.5 The Hawthorne effect

One important thing to consider when performing studies of people is the Hawthorne effect. This effect has got its name from a study carried out between year 1924-1932 at Hawthorne Works, one of the Western Electrics factories situated outside Chicago, (Bergman and Klefsjö, 2003). The Hawthorne studies were carried out to assess the impact of working conditions on the motivation and hence the productivity of individuals. The researchers who performed the study focused on a group of production workers and carried out several experiments. The Lightning Study, according to Bergman and Klefsjö (2003) the most well-known of these experiments, initially showed that when lighting level was increased, the productivity level also increased. The correlation between the quantity of light and productivity was investigated; improved lighting resulted in improved motivation which in turn resulted in improved productivity, (Maylor, 2005). But further, the researchers found that the productivity was increased also when lightning was decreased which caused their correlation hypothesis to be rejected. Instead there was a much more important factor at work, namely the attention being paid to this group of workers. The workers' productivity increased because the management displayed an interest in them and their work situation, this finding was far more significant than the finding about the physical conditions. Paying attention to groups improves the likelihood of good performance; this later came to be called the Hawthorne effect. (Bergman and Klefsjö, 2003; Maylor, 2005)

2.7 Change Management

There is a never ending change of the surrounding environment, almost every day a new important discovery or boundary-pushing invention in the scientific fields is made. Additionally, markets change over time. The organizations are also changing in terms of strategies, structures, systems, boundaries and of course in their expectations of staff and managers, (Cameron and Green, 2009). Organizations have to change to encounter changing needs from the environment. Payne (2005) defines *change management* as *"taking action in a planned and proactive way to orchestrate a purposeful transformation"*. A successful change management should take the following three aspects of change into account, no matter if the transformation is major or incremental, (Payne, 2005):

1. The *content* of the change.
2. The *process* of the change.
3. The *human dynamics* of the change.

The first aspect, content of the change, means the ability to answer the question: what will change in the organization? The second aspect refers to how the change will be accomplished and the last one intends how the people in the organization will be affected by the change and, in turn, how this will affect the change. By taking a proactive approach to change management facilitate, for example, minimized impact of change on employee's productivity, avoiding of unnecessary turnover, elimination of adverse impact of customers and to see the desired results of change implemented as soon as possible. (Payne, 2005)

Organizational change has three steps, (Cameron and Green, 2009; Payne, 2005; Nadler and Tushman 2004), which are named differently depending on author. One way to express the steps is by Lewin's three-step model, Figure 2.4, (Cameron and Green, 2009):

- *Unfreezing.* The first step is to unfreeze the current state, which is how the organization functions prior the change. To unfreeze means define the current state, elucidate the driving and resisting forces and envisioning a desired future state. At this step people have to let go of their old ways and, sometimes, their old identity.

- *Changing.* The second step is about moving towards a new state through participation and involvement. It is a neutral zone, the transition state, which is a period when the old state is gone but the new one is not yet fully operational. At this step there is a risk for individuals to become disoriented.

- *Refreezing.* The last step concerns refreezing and stabilizing the new state when reached. This is done by setting policy, rewarding success and establishing new standards.

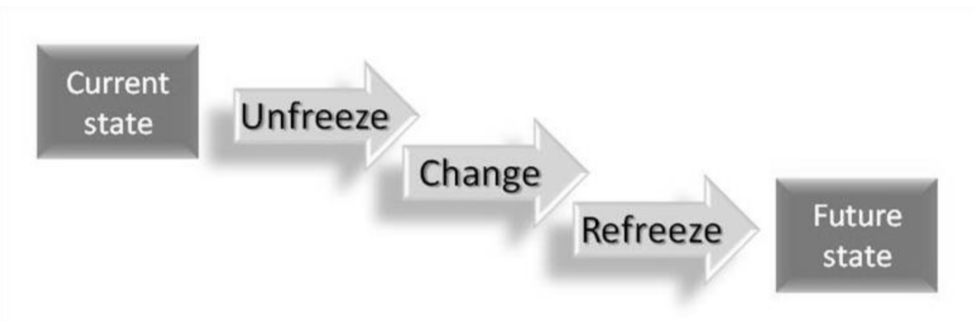


Figure 2.4 Lewin's three-step model for organizational change.

Change leaders need to understand the transition process and take responsibility for planning and managing change. The change leaders can come from anywhere in the organization, from team leaders to first-level supervisors to senior managers. How the transition process is managed spells the difference between an efficient organizational change and a failure. (Payne, 2005)

Nadler and Tushman (2004) state, that there are three types of problem encountered in some form whenever a significant organizational change is attempted. The three types are *the problem of power, the problem of anxiety* and *the problem of organizational control*.

According to Nadler and Tushman (2004), *the problem of power* arises since every organization is a political system which consists of a mixture of individuals and groups competing for power in the current and the future state. In the transition state these dynamics become even more intense since the prior state, with its political implications, is dismantled and a new state takes its place. To handle this problem Nadler and Tushman (2004) recommend the management of the organization's political system to shape and manage the political dynamics associated with the change, both prior to and throughout the transition.

The problem of anxiety appears because a change in an organization involves the transition from something known to something unknown. Individuals have worries, such as whether their skills will be valued and how they will manage with the new circumstances. Therefore, it is critical to motivate individuals, through communicating the nature, extent, and impact of the change and also by rewarding for required behavior, to react constructively to the change. (Nadler and Tushman, 2004)

Further, Nadler and Tushman (2004) state that, *the problem of organizational control* emerges due to that significant changes in organizations tend to disrupt the normal pattern of events within the organization. Changes of this type often damage existing systems of management control. Occasionally, control gets lost during a change because goals, structures and people change. According to this, it will be more difficult to monitor performance and make accurate assumptions during a change than in a more stable state. Nadler and Tushman (2004) claim the need to pay attention to the management of the transition state to systematically manage and ensure effective organizational control during the transition period to manage this problem.

3 Methodology

This chapter will present the research method used in this master's thesis. The first section gives an overall description of the method, and is followed by sections explaining each step in particular.

To fulfill the purpose of the master's thesis a method has been developed, primarily based on the methods engineering program by Freivalds and Niebel (2009) and with influences from Banks methodology described in "Bank's book" by Bank et al (2000). There are several similar versions to be found in projects related to Industrial Engineering. As can be seen in Figure 3.1 the methodology has an iterative approach meaning "Analyze the data" is conducted parallel with the steps "Get and present the data" and "Develop the ideal method".

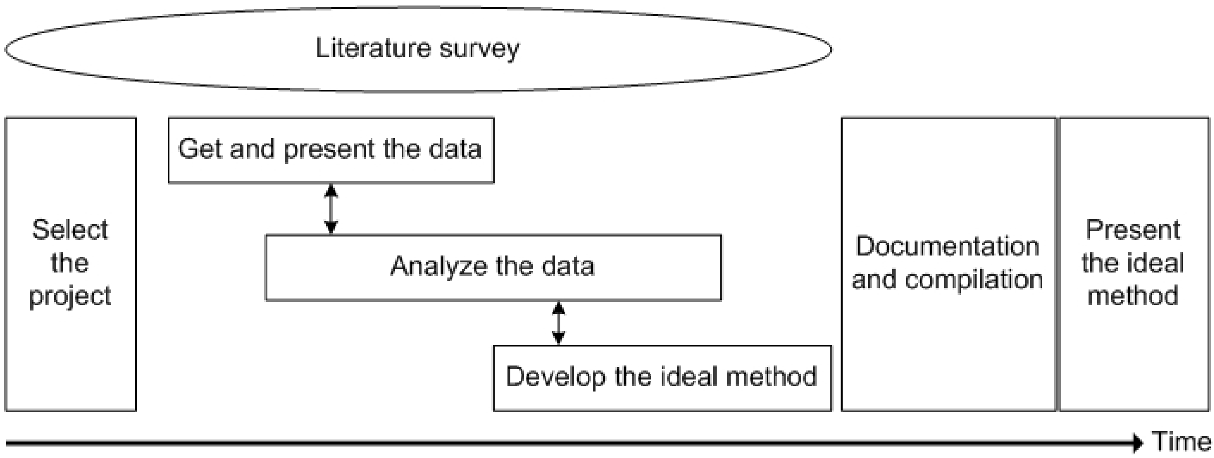


Figure 3.1 Steps in the developed method.

3.1 Step 1: Select the project

Before arriving at the Company the project group was given a report which was compiled during a project with the aim of mapping the internal logistical flow at the Company's all three MO DCs. This together with a two-day company introduction served as a basis to gain understanding of operations, procedures and activities at the Company. In collaboration with production management and the supervisor at Chalmers University of Technology the thesis's scope and delimitations were defined.

To further deepen the understanding of the chosen area a worksite analysis was initiated by performing a general mapping of the internal flow within the Returns Department using flow process charts, which can be found in Appendix – A.

A first literature survey was conducted to find and review applicable methods for data collection and to get a more detailed insight in the area of reverse logistics.

3.2 Step 2: Get and present the data

The Returns Department was divided into three areas; Opening, Booking and Sorting Area. Results from this step are compiled and presented as a current state explaining the present situation in the Returns Department. Aligned with the master thesis's objectives main focus was put on studies and measurements of lead time, manual operations and inventory levels. Four parallel studies were initiated, each described below.

3.2.1 Work sampling

Studies of manual operations using the GTT of work sampling were conducted in the Opening and Booking areas. Each study began by creating a work breakdown structure of the operation, based on observations, to construct a preliminary work sampling form. The preliminary work sampling form was later used during a pre-study where it was decided what activities to focus on. Thereafter, the real work sampling form was constructed. The pre-study was also done to estimate number of samples needed and to determine an appropriate sample interval.

A typical sampling session was designed as follows; 2-4 operators were chosen for observation, the sample interval was set to 15 seconds, meaning that the current activity of each operator was recorded every 15 second. A sampling session normally lasted for 20 minutes and the sessions were randomly distributed during a workday to cover as many shifts as possible. In total 11 500 samples were collected during a three week period. Using Equation 2, calculations of limit error with 95% and 99% confidence from all studies can be found in Appendix – B.

3.2.2 Buffer sampling

In order to record ever changing buffer sizes a sampling approach was chosen. During a period of three weeks, parallel with other studies, the content of each buffer was manually counted. Buffer sampling was conducted between 8a.m. and 4p.m. when activity in the Returns Department was at its highest, and the sample interval was set to half-an-hour. Counting exact number of articles in each buffer would have been time consuming and that level of preciseness was not considered necessary. For Opening and Booking Areas buffer sizes are measured as number of cages while for Sorting Area the buffer size was measured in number of trolleys.

3.2.3 Lead time measurements

When concerning lead time, individual articles or batches are not traceable in the Company's data system. A more hands-on study tracking articles by using paper notes was therefore developed and selected. In addition to record total lead time for articles it was necessary to find out how long time articles spend between each area and each workstation. It required that time was noted for when articles arrived and leaved areas and workstations. A note was developed where time phases between areas, workstations and total lead time could be recorded, the note can be found in Appendix – D. In order to facilitate detection of attached notes on articles they were printed on yellow paper, therefore they are referred to as "yellow notes". For the study to have any statistical significance more than just a handful of articles had to be traced. Since it would not have been manageable for the project team to record times on a large number of notes all employees in the Returns Department were involved. The idea was to let operators record time and date on the note whenever articles with attached notes appeared on their workstation. When articles with attached notes have reached their final destination in Dispatch Stock notes were supposed to be removed and thereafter collected in a box located in Sorting Area.

Staff was informed about "yellow notes" during group meetings and instructions were posted on information boards and workstations. Randomly during a period of three weeks 500 notes were attached to opened articles in Opening Area, typically 5-20 notes per session. Out of 500 notes a total of 372 were retrieved. From this, the total lead time and lead times for each of the phases were calculated.

3.2.4 Collecting production statistics

Data concerning quantity and type of returned articles presented in this report is based on statistics from year 2009. It has been collected from data bases, Microsoft excel-sheets and related documents which were provided by staff from the Company's production office. In addition, unstructured interviews have been performed with key personnel such as returns support, super user, warehouse planner, group leaders and operators. Collection of production statistics also included time coefficients from which the piece-work contract is based on. These coefficients have been used in capacity calculations presented in Appendix – F.

3.3 Step 3: Analyze the data

In order to accurately understand the current situation data was analyzed while it was collected, meaning step 3 was partly performed parallel with step 2, as can be seen in Figure 3.1. This was mainly performed during meetings with key personnel where questions such as "How?" and "Why?" were asked. Further, a brainstorming form was continuously updated with identified problems, areas which needed more attention and solution suggestions.

When a description of the current state had been compiled an additional brainstorming session took place. Empirical data was, when possible, compared with statistics from the Company. Problem areas were identified and further specified with underlying causes. In order to determine what to change, undesirable effects and causes to the current situation were arranged in a cause-and-effect diagram.

Complementary data collections in terms of meetings with key personnel and gathering of statistics were conducted throughout step 3 in order to strengthen assumptions and to eliminate misunderstandings.

3.4 Step 4: Develop and present the ideal method

The ideal method is presented as a framework of suggested solutions to the identified problems from step 3. Solutions were developed aligned with research questions and by using the thesis's frame of reference as a base. The final phases of step 4 include compiling and documenting findings and presenting them to the Company.

4 Current State

This chapter explains the current situation in the MO DC's Returns Department. It initiates by presenting a process overview which is followed by a more thorough description of each area. Results from lead time measurements summarize the description of current state. Information is mainly based on data from studies conducted during step 2 in the methodology.

4.1 Process Overview

Each day 3-4 deliveries with returned orders arrive in cages or boxes at the MO DC and there are in average 210 incoming cages and boxes per week. In average, each cage or box contains 200-300 returned orders. When arriving, return orders are placed in an intermediate storage where the cages and boxes are sorted in date order. Return parcels are then opened and transported to one of the booking buffers, see Figure 4.1. Thereafter, articles are booked into the system, called Start, which handles customer files, invoices, orders, stock balance etc. When booked, each article is checked, refinished, folded and repacked, and then placed on a conveyor belt. The conveyor belt transports articles to the Sorting Area. Booking and refinishing can be performed on either the 1st floor or the 2nd floor. The conveyor belt only works on the 1st floor resulting in manual transportation of articles between 1st and 2nd floor. In the Sorting Area items are sorted into trolleys and when a trolley is considered full it can either be moved to an out buffer or immediately transported to Dispatch Department where articles are manually restored into their stock location which can be either on 1st or 2nd floor.

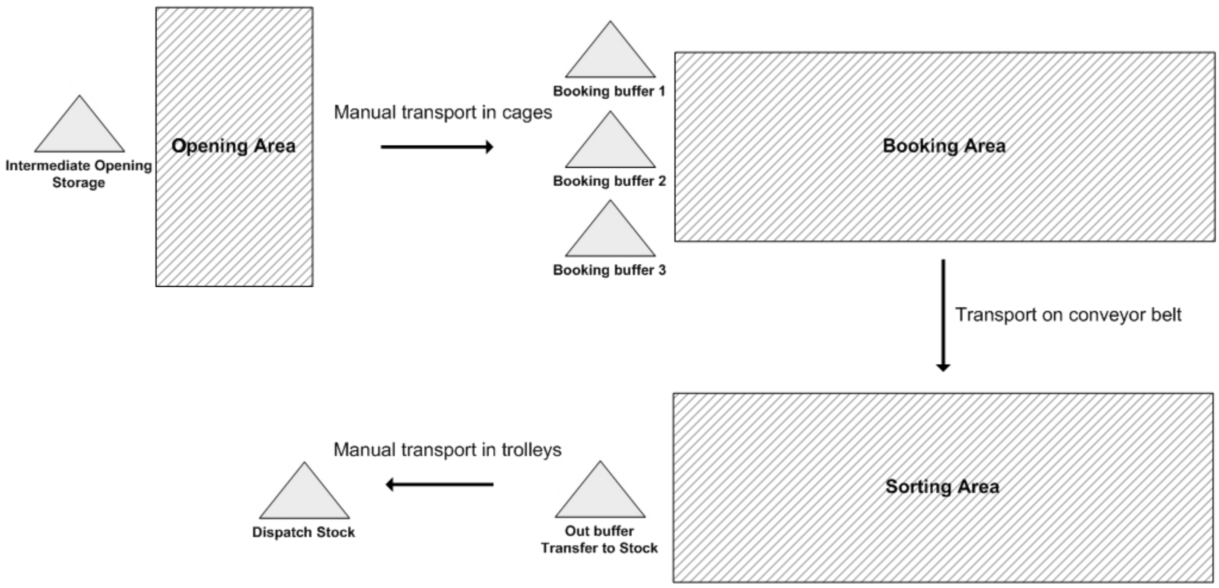


Figure 4.1 An overview of the areas in the Returns Department.

4.2 Description of Areas

Results from studies and data collections, in form of buffer sampling and work sampling, performed in the Returns Department can be found in Appendix – C and Appendix – H, and the different activities and buffers studied are explained and described in more detail when each area is handled in this chapter. When conducting sampling of manual operations and buffer sizes the Returns Department was divided into three areas: Opening Area, Booking Area and Sorting Area.

Three group leaders are responsible for the three different areas in the Returns Department. The manning is weekly planned by the group leaders according to expected returns in relation to articles that were delivered two weeks back in time. Manning can be adjusted by the group leaders during work shifts if a need for this arises. When short on staff, especially during late shift, not all stations in the Returns Department are fully manned.

4.2.1 Opening Area

Opening Area is the first process step in returns handling. Incoming returns are sorted depending on country, distributor and in date order. Returns arrive in large boxes or transport cages which are placed in an intermediate opening storage.

When return orders are to be opened the cage, or box, is inserted and secured in a tilt container. There are always returns from only one country in each cage or box. When tilted, the container feeds bags or parcels with returned articles on to a short conveyor belt which transports returned orders to the workstations, as illustrated in Figure 4.2. The conveyor belt is operated manually by personnel at the workstations. Returns are then opened, unpacked and sorted into transport cages; the work sequence is described in more detail in Table 4.1 and Table 4.2. A photo of a transport cage can be found in Appendix – L.

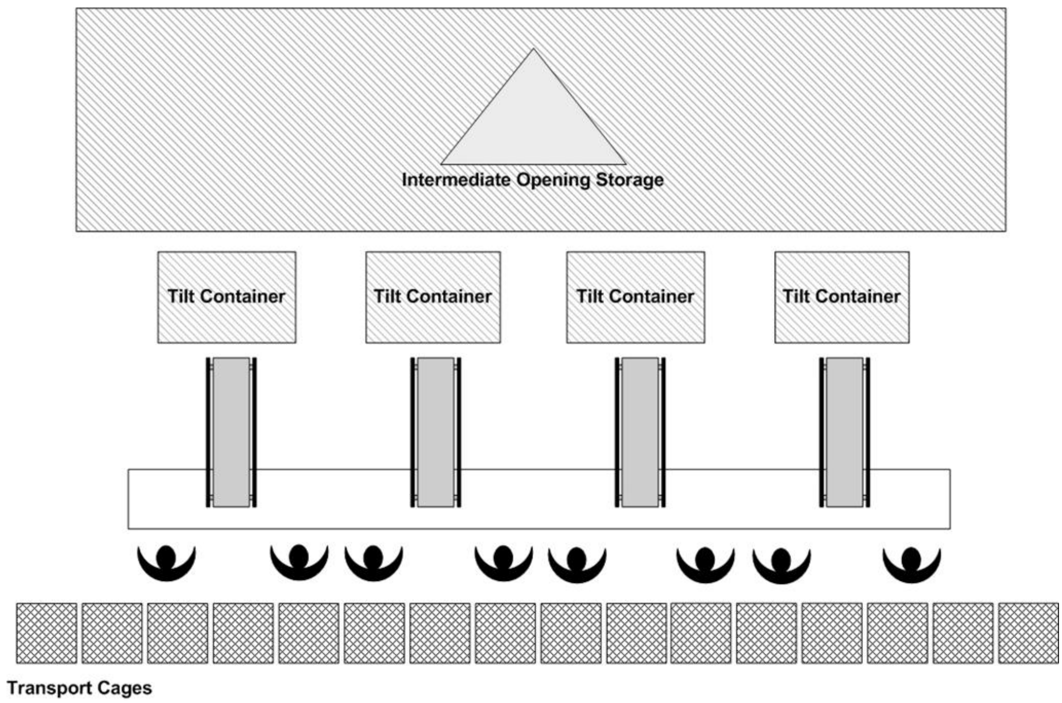


Figure 4.2 The eight workstations in the Opening Area.

There is room for 16 transport cages in which opened orders are placed. Each operator utilizes 3-4 cages and returns are sorted by handwritten text messages in Danish or Finish, unclaimed returns or returns with no text messages. Unclaimed returns are orders that have not been collected by customers at the post offices and are therefore sent back to the Company. Returns with text messages written in Swedish are supposed to be handled by all personnel and are placed in the same cage as those with no text messages. Returns with text messages in Danish and Finish are later processed by staff who can manage the language. When a cage is considered full it is transported to the Booking Area and placed in an in buffer waiting to be processed by one of the booking operators.

Table 4.1 Description of the main activities performed during the opening operation.

No.	Main activities:	Comment:
1	**Open / Unpack**	*Each parcel/bag is cut open and the pieces are unpacked on to the workbench.*
2	**Trash package**	*The empty bags or parcels are thrown away.*
3	**Bundle**	*Unpacked pieces from each shipment are bundled together with the return receipt.*
4	**Put on rubber band**	*Bundled articles need to be kept together. Parcels with many articles are unpacked in cartons; rubber bands are in those cases not sufficient.*
5	**Put in cage**	*The pieces are deposited in a cage behind the operator for transport to one of the booking buffers. Return shipments with hand written messages on the receipt are placed in separate cages depending on country.*

Table 4.2 Description of the support activities performed during the opening operation.

Support activities:	Comment:
Purge opening storage	*Forwarding conveyor belt to feed work station.*
Refill opening storage	*Insert and secure cage or box in tilt container.*
Leave / Get cage	*Transport cage with pieces to booking buffer and get a new empty cage.*
Write / Read info	*Mark new cage with date and/or read text message on return receipt.*
Empty garbages	*Bins for opened bags are emptied in a container close to the Opening Area.*
Get material	
Get rubber band	
Machine maintenance	*Maintenance of tilt container or conveyor belt.*

4.2.2 Booking Area

Here the customer returns are booked, refinished and repacked before being transported to the Sorting Area. Cages with batches of opened orders are fetched from the booking buffer. As can be seen in Figure 4.1, the booking buffer is divided into three zones depending on how returns were sorted by personnel in the Opening Area.

Normally the staff works in groups of three where one is booking and two handles refinishing and repacking, this is henceforth referred to as a 3-group and is illustrated in Figure 4.3. Booking and refinishing operations are later described separately. In total there are 13 3-groups on the 1st floor. Two additional stations for refinishing and repack operations can be utilized when the workload is high. Also, there are three special stations. One for processing unclaimed returns, another at which returns that requires more administration and contact with Customer Service Department are handled. The third station is Return Service and it handles articles with missing or changed stock location label, wrongly booked articles to customer and direct changes.

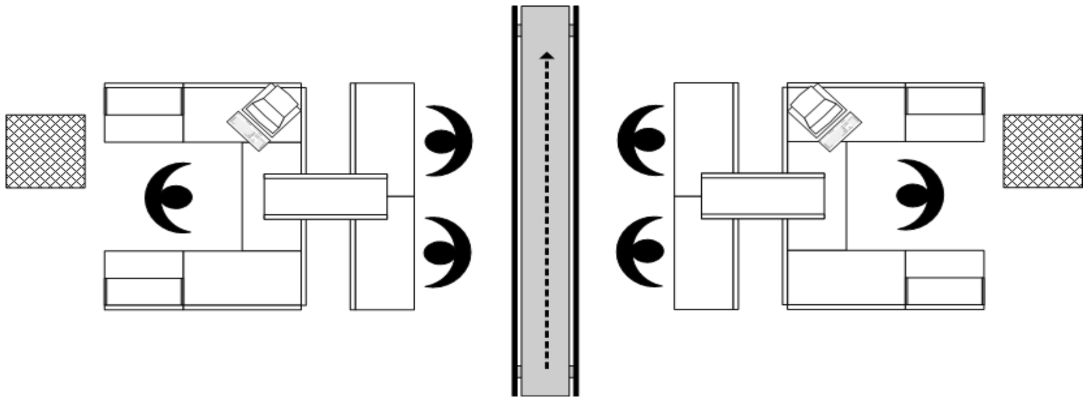


Figure 4.3 Two 3-groups from above.

Due to an increased workload a number of extra stations have been implemented, mainly on the 2nd floor. Three of them are so called single stations where booking, refinishing and repacking are performed by one person alone. In total the 2nd floor has two 3-groups and three single stations. When returns are to be processed on the 2nd floor, cages are fetched from the booking buffer on the 1st floor and transported to the 2nd floor by an elevator. After processed the returns are sorted into one of two cages depending on which chute the return is related to in the Sorting Area. One cage is correlated to chute 1-17 and the other one is correlated to chute 18-33, see Figure 4.4. When considered full, or when work shift ends, the cages are transported back down to 1st floor where they are placed in a mini buffer waiting to be handled by staff from the Sorting Area.

4.2.2.1 Booking

A cage is fetched from the booking buffer with opened returns. The booking operator then gets a number of bundled articles from the cage; the returns are processed for one customer at time. The booking operation starts by scanning the return receipt. This will retrieve information about the customer and the specific return order being processed. On the return receipts there are nine return codes which are filled out by the customer, they specify reason for returning each article. The nine codes can be found in Appendix – I. When an order has been booked return labels are printed for each of the articles, these contain information such as chute in Sorting Area and final location in Dispatch Stock. Before leaving returns in booking chutes the return labels are attached to the articles. The booking operation, divided into main and support activities is in more detail described in Table 4.3 and Table 4.4.

Table 4.3 Description of the main activities performed during the booking operation.

No.	Main activities:	Comment:
1	**Take off rubber band**	*The rubber bands are removed from the order, saved and then returned to the Opening Area.*
2	**Book into computer**	*Scan return's receipt, book returned article and if requested by customer book new orders. Also, a return label is printed for each article.*
3	**Sorting**	*Sorting in order to match the printed return label to right article.*
4	**Put on return label**	*Attach return label on the article's packaging.*
5	**Leave articles**	*Leave articles in booking chute for refinish/repack or reject if the article is defect.*

Table 4.4 Description of the support activities performed during the booking operation.

Support activities:	Comment:
Get articles from cage	*A cage with opened articles is positioned behind the person booking.*
Get / Leave cage	*Get cage with opened articles from booking buffer. Empty cages are returned to the Opening Area.*
Help refinish and repack	*If the booking chute is full the booking station can be utilized for refinish/repacking.*
Job rotation	*Job rotation between booking station and refinish/repack station.*
Read info	*Some return receipts have text messages from customers.*
Unpack	*If articles have been unpacked in cartons.*
Empty garbages	
Get material	

4.2.2.2 Refinishing

Articles are picked from the booking chute, or from a cage if processed at an isolated refinish/repack station. All articles, except the unclaimed, have been to a customer and probably been tried on. It is therefore important to secure that there is no indication of this when the next customer receives the article. Process steps “Refinish” and “Fold” both includes inspection of articles. If a defective article is discovered it is sent back to the booker for correction in relation to stock in hand. Defect articles are thereafter separated as second-hand and will be given to charity or disposed. The refinish and repack process is detailed described in Table 4.5 and Table 4.6.

Table 4.5 Description of the main activities performed during the refinish and repack operation.

No.	Main activities:	Comment:
1	**Get article**	*From booking chute or work bench if packed at a single station.*
2	**Remove return label**	*Return label is put aside while the article is being refinished and repacked.*
3	**Open / Unpack**	*Unpack article from old plastic bag.*
4	**Trash package**	*The old plastic bag is thrown away.*
5	**Refinish**	*Each article is inspected and if necessary refinished.*
6	**Fold**	*Folding of articles according to work instructions.*
7	**Repack**	
8	**Tape**	*Sealing the plastic bag with scotch tape.*
9	**Put on return label**	*Return label is reattached to the new plastic bag.*
10	**Leave article**	*Place on conveyor belt for transport to Sorting Area.*

Table 4.6 Description of the support activities performed during the refinish and repack operation.

Support activities:	Comment:
Job rotation	*Job rotation between booking station and refinish/repack station.*
Get material	*Plastic bags, rolls of adhesive tape etc.*
Empty garbages	

4.2.3 Sorting Area

After being refinished booked returns end up in the Sorting Area. Articles that arrive by the conveyor belt are automatically sorted into one of 33 chutes, see Figure 4.4. A photo of the conveyor belt and two of the chutes can be found in Appendix – N. Each chute represents one or several zones in Dispatch Stock. The articles are sorted so that neighboring stock locations ends up together. Sorting Area is considered fully manned when nine operators are working there, but up to 15 operators can be utilized in extreme cases. Splitting of work tasks and job rotation are decided among the operators themselves; normally 2-3 operators are sorting articles from chutes into trolleys while the remaining operators are restoring articles into Dispatch Stock, both processes are described below. The Sorting Area has a designated operator who acts as coordinator. The coordinator has an overall responsibility in the Sorting Area during the work shift, and the group leaders in Returns Department select the operator who shall act as coordinator for the moment.

4.2.3.1 Sorting

There is one trolley for every two chutes, as can be seen in Figure 4.4. Articles are manually picked from chutes and sorted into trolleys. The trolleys have 48 compartments and the location of each article is set according to a prearranged schedule. A photo showing one side of a trolley can be found in Appendix – M. When a trolley is considered full it is either moved to an out buffer or immediately transported to the Dispatch Stock where the articles are placed at their stock location.

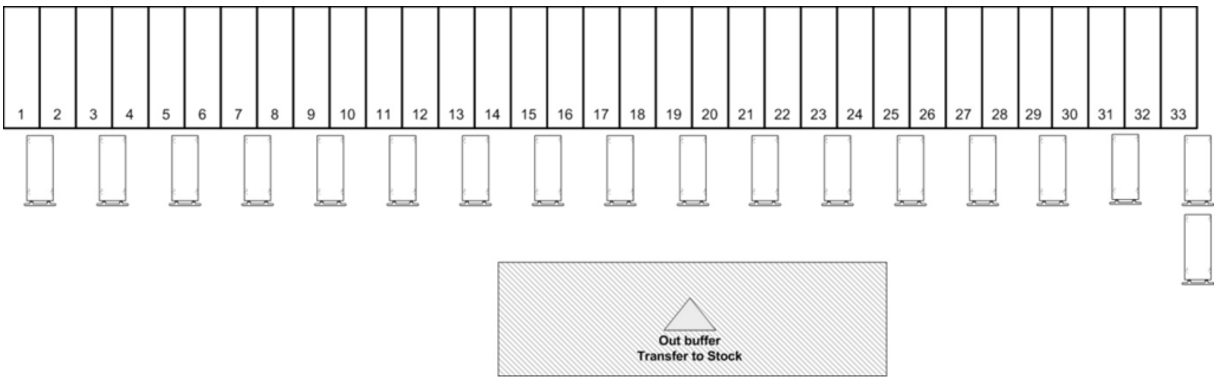


Figure 4.4 The Sorting Area with its 33 chutes, trolleys and the out buffer.

Articles that have been processed and sorted into cages on the 2nd floor are fetched from a mini buffer close to the Sorting Area. Then, they are sorted into a trolley, called 132-trolley[1], which is separated from the trolleys stationed at the chutes. This 132-trolley is planned according to the 33 chutes with one or several compartments for each chute. Articles from the compartments are then sorted from the 132-trolley into the chutes and are thereby placed into the chute's trolley along with those articles that have arrived by conveyor belt. The 132-trolleys occupy 1-2 operators working fulltime during one shift.

[1] 132 is the time code an operator logs into the management system when he or she works with operations in the Sorting Area not included in the piece-work contract.

4.2.3.2 Transfer to Dispatch Stock

Normally trolleys are fetched from the out buffer and transported to the zones in Dispatch Stock and the articles are restored into right stock location. Articles which have been incorrectly sorted or incorrectly booked are brought back to Sorting Area for resorting when the trolley has been emptied.

4.3 Lead Times and Cycle Times

As described in chapter 3, Methodology, the calculated lead times are based on a large amount of data, the raw data can be found in Appendix – J. The lead times are recorded throughout almost the entire Returns Department, starting with the opening procedure and ending when an article is placed at location in Dispatch Stock. The total average lead times, calculated from raw data in Appendix – J, can be seen in Figure 4.5. Further, Figure 4.5 shows how the total lead time is divided into four different phases.

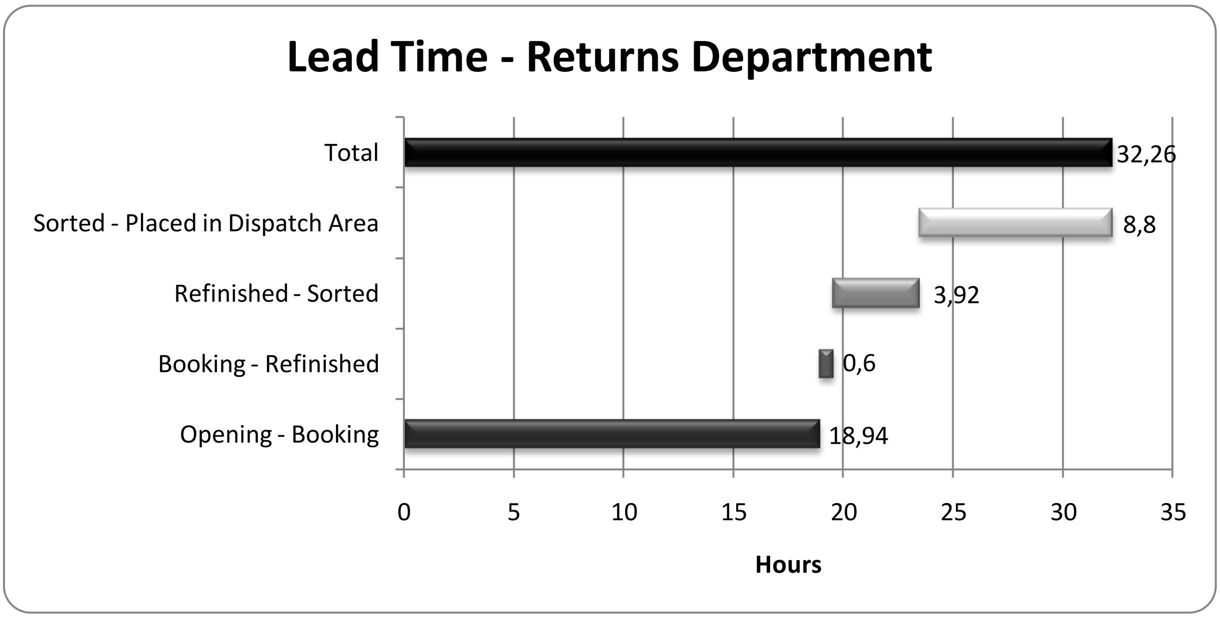


Figure 4.5 Average lead times in Returns Department.

In Table 4.7 calculated average lead times and standard deviations are shown together with measured maximum and minimum times for the four phases and the total lead time as well. Maximum and minimum times for the four phases are from different single notes, while the total minimum time and the total maximum time are from the two notes with the shortest and the longest recorded time in total.

Table 4.7 Calculated average lead times, standard deviations together with measured maximum and minimum times.

Lead Time (hh:mm)	Opening to Booking	Booking to Refinished	Refinished to Sorted	Sorted to Placed in Dispatch Area	Total
Average	18:56	00:36	03:55	08:48	32:16
Stdev	18:43	02:34	09:34	12:50	27:34
Min	00:16	00:01	00:01	00:08	02:23
Max	139:55	25:30	72:38	95:18	163:00

The measured times for all the four phases contains both time for manual handling processes, transportation and waiting time in different buffers. Since the Company has piece-work contract they have time coefficients for almost all manual work processes, except those not contributing to the piece rate.

To calculate cycle times for the manual processes the Company's time coefficients and statistic from year 2009's production have been used. In Table 4.8 at the end of this chapter the manual processes' cycle times are summarized and the utilized coefficients and the calculations can be found in Appendix – F and Appendix – G.

The manual process "Returns opening" is not a part of any of the four lead time phases since the first phase, "Opening – Booking", starts when the opened order is placed in one of the cages next to the operator. The duration of the manual process "Returns opening" vary depending on type of returned order. For a returned order from Sweden the average processing time is calculated to 15.84 seconds per article and for returns from Finland or Denmark the calculated time is 20.16 seconds per article. If the return is an unclaimed order the time for opening decreases down to 9.13 seconds per article.

4.3.1 Opening – Booking

In the first lead time phase, called "Opening – Booking", the return order can be located at three different places after it has been opened and before is has been booked; either in the cage next to the opening station waiting for the cage to be full, in one of the buffers between opening and booking or in a cage at the booking station, and of course it can also be manually transported between the three locations. The measured lead times from opening to booking are plotted in Figure 4.6. This figure visualize the time variations between different orders with almost 140 hours as the longest lead time and 16 minutes as the shortest one, the average lead time is calculated to 18 hours and 56 minutes and the standard deviation is 18 hours and 43 minutes, these times are presented in Table 4.7. Included in this lead time is the manual process for booking the returns into the system, but not the time for refinish and repack an article.

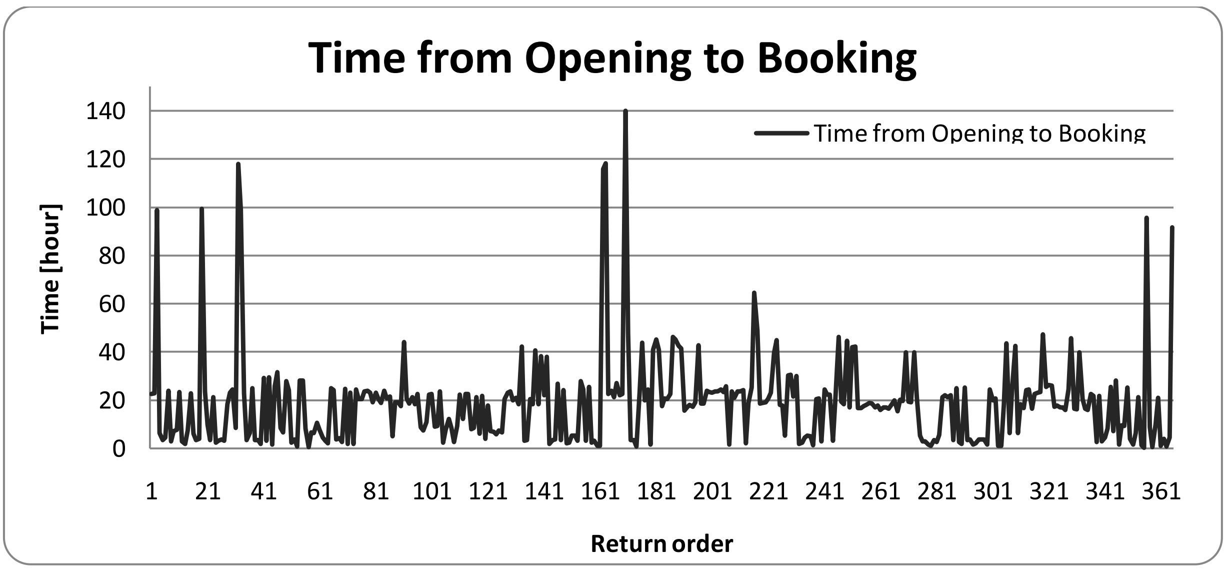


Figure 4.6 Measured lead times from opening to booking.

4.3.2 Booking – Refinished

The lead time between booking and refinishing is more stable than the time between opening and booking. This time persist in average around half-an-hour and it represents the buffer in the booking chute placed in the middle of a 3-group and also the time it takes to manually refinish and repack an article. Table 4.7 shows the average, minimum and maximum lead time for this phase and the plotted time, visualizing the stability, can be found in Appendix – K.

Calculated time for the manual process named "Returns booking" includes both the booking activities and the refinishing and repack activities but of course not the time an article waits in the chute between them. Meaning, when calculating the total cycle time for the manual processes in this area it is the time for one item to move through both processes, without considering the time it waits in the booking chute after being booked and before being refinished and repacked. As for ”Returns opening" also the manual processing time "Returns booking" differs depending on what kind of order being handled. For unclaimed orders the average cycle time is calculated to 29.63 seconds per item. When a returned order that actually has been to a customer is handled the cycle time increases to 120.79 seconds per item due to inspections and repacking, but here there is no difference regarding sender's country.

4.3.3 Refinish – Sorted

After the product has been refinished and repacked the next phase "Refinished – Sorted" starts and the product is either placed on the conveyor belt for transportation to the Sorting Area or placed in a cage for manual transportation to the Sorting Area. According to the Company, the capacity of the conveyor belt is 1575 items/hour. The measured lead times in this phase starts after the product has been refinished and repacked and stops when the product has been sorted into a trolley in the Sorting Area. Here, lead times fluctuate a lot; the average lead time is 3 hours and 55 minutes with a standard deviation of 9 hours and 34 minutes. The maximum measured time is more than 72 hours and the minimum measured time is only 1 minute as can be seen in Table 4.7.

4.3.4 Sorted – Placed in Dispatch Area

The last measured lead time phase is from after the product is sorted into a trolley in Sorting Area until the product is placed at location in Dispatch Stock, this phase is called "Sorted – Placed in Dispatch Area". Also here, lead times have large variations as can be seen in Figure 4.7 which shows the plotted lead times for a large amount of products. As stated in Table 4.7, the average lead time in this phase is 8 hours and 48 minutes and the standard deviation is 12 hours and 50 minutes. The longest measured time is 95 hours and 18 minutes and the shortest time is 8 minutes.

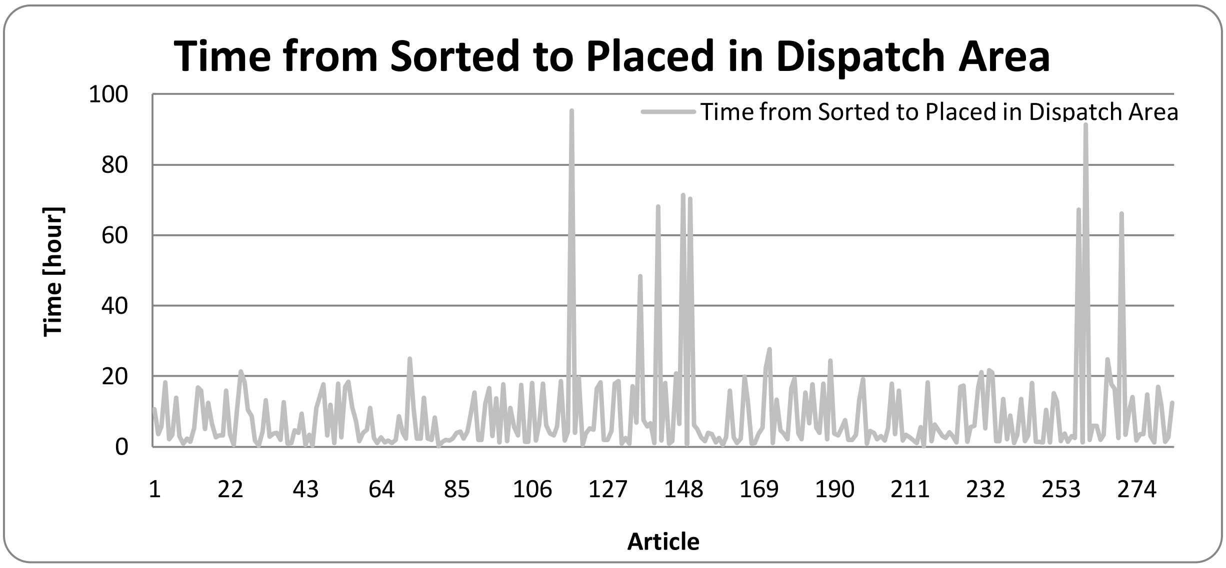


Figure 4.7 Measured lead times from sorted to placed at location in Dispatch Stock.

The third phase “Refinished – Sorted” contains the manual handling for sorting items from chutes in the Sorting Area into trolleys, and the fourth phase “Sorted – Placed in Dispatch Area” contains the manual placement of items at their location in Dispatch Stock. These two manual processing times are, by the Company, merged. Depending on which zone in Dispatch Stock the article belongs to three different time coefficients are used by the Company. For calculating the average cycle time the percentages of those three coefficients are used, resulting in a processing time of 21.77 seconds per item.

4.3.5 Total lead time and capacity

The total lead time for the whole Returns Department is plotted in Figure 4.8. Here the average time is 32 hours and 16 minutes, the standard deviation is 27 hours and 34 minutes, maximum time is 163 hours and the shortest measured lead time is 2 hours and 23 minutes. Plotted lead time-charts for all of the four phases can be found in Appendix – K.

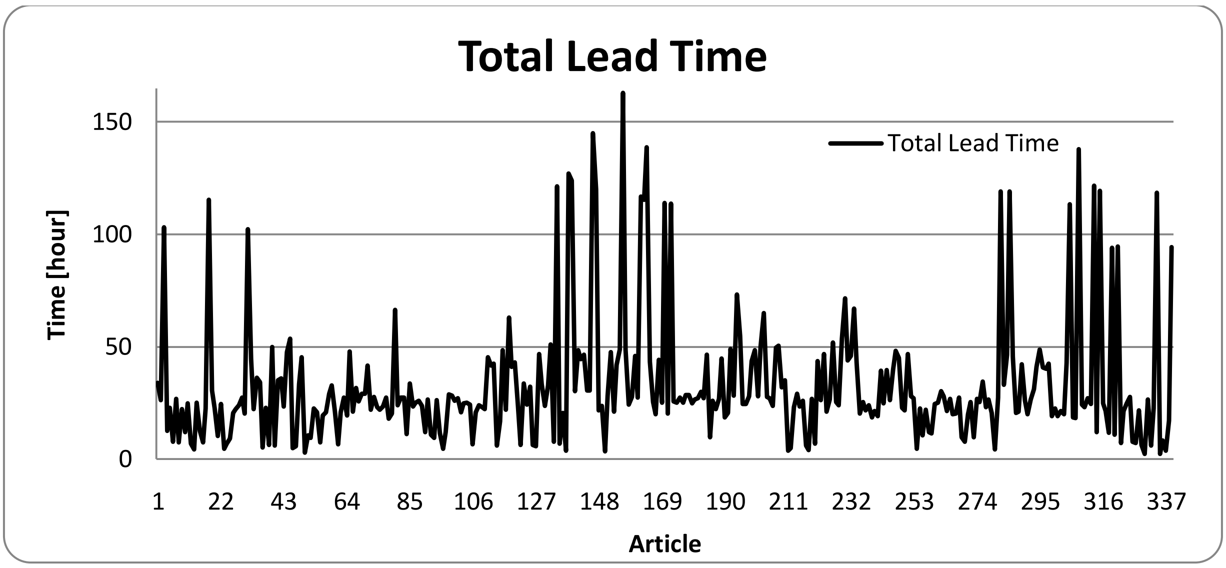


Figure 4.8 Measured total lead times in the Returns Department.

From the times in Table 4.8 and the production statistics from year 2009, Appendix – F, the total output per person have been calculated; all results can be found in Appendix – G.

Table 4.8 Calculated cycle times for the manual processes.

Manual Process	**Opening**			**Booking, Refinishing and Repacking**		**Sorting and Placing at location in Dispatch Stock**
Type of return	Sweden	Finland Denmark	Unclaimed	Returns from customer	Unclaimed	All
Seconds per item	15,84	20,16	9,13	120,79	29,63	21,77

One person working at a pace of 100% in the Opening Area opens 232.78 items per worked hour and full manning in this area, 8 persons, results in 1862.21 items per worked hour. For Booking Area the calculations have been divided depending on what type of returns handled, unclaimed or customer returns, since one person or 3-group always handles just one type at a time. A person who handles unclaimed orders working at a pace of 100% books 121.50 items during one working hour. For customer returns the figures are calculated to 35.44 items per worked hour resulting in 106.32 items per worked hours for a 3-group. With those figures as a base, estimations can be made on how many workers in the Booking Area one person in the Opening Area supplies. The capacity of the conveyor belt is also known as the ratio between number of products and the amount of workers needed in the Sorting Area.

5 Analysis of Current State

The purpose of this master's thesis is to investigate how lead times can be reduced and productivity increased in the Company's Returns Department. A perquisite to improve this is to fully understand the present situation. In the previous chapter the current state of Returns Department is described and will now analyzed in order to define problem areas and to identify underlying factors.

5.1 Lead Times, Cycle Times and Variations

As presented in Figure 4.5, in chapter 4.3 Lead Times and Cycle Times, the total lead time is in average 32 hours and 16 minutes, which correspond to just over 1.34 days. Before ending up at the final location in Dispatch Stock the articles undergo five manual operations with a total processing time of approximately 2 minutes and 20 seconds. In comparison to the total lead time it is no understatement to claim that the processing time only makes up a very small part of the total lead time, as can be seen in Figure 5.1. Consequently there is a large amount of work in process; articles waiting to be processed are delayed in buffers between the different areas. The articles spend in average 59% of the total lead time in buffers between Opening and Booking Areas and in average 27% of the lead time in trolleys in the Sorting Area. Further, average 12% of the lead time is while articles stay in chutes waiting to be sorted into a trolley in the Sorting Area. These 12% also includes transportation time on the conveyor belt between Booking Area and Sorting Area (roughly estimated to average 2 minutes and 47 seconds). The remaining 2% of the total lead time corresponds to the time in 3-groups' booking chutes when an article has been booked and is waiting to be refinished.

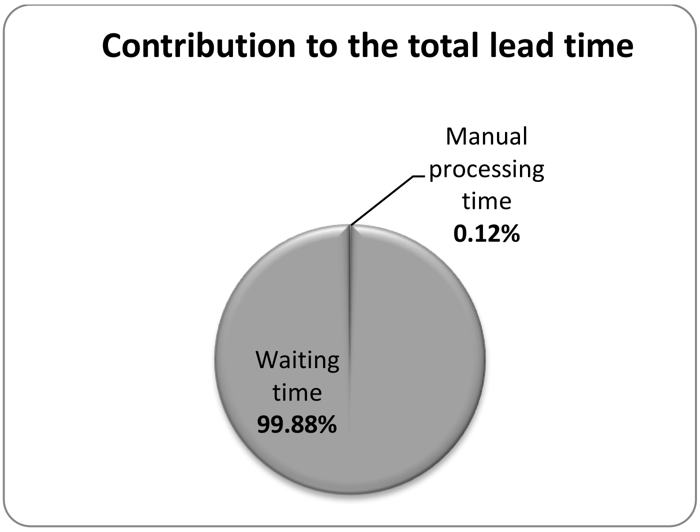


Figure 5.1 Division between manual processing time and waiting time.

The calculated standard deviation of the total lead time is 27 hours and 34 minutes, in relation to 32 hours and 16 minutes in average lead time. This is a clear indication of high variations, typical for an unstable process. This is further proved when considering the minimum measured throughput time of 2 hours and 23 minutes and the maximum adding up to 163 hours. Plotted lead times for all the phases described in chapter 4.3, Lead Times and Cycle Times, can be found in Appendix – K and it is easily seen that all of them are unstable. As for the total lead time, the measured minimum and maximum lead times together with the calculated standard deviations, which are shown in Table 4.7, prove this stated instability throughout the whole Returns Department.

Lead times and variations mentioned above are referred to as “True lead time” for the articles. This means that stops in production, such as nights and weekends, have not been taken into consideration. Though, when subtracting stop times the average lead time of 19 hours and 40 minutes referred to “Lead time - only concerning worked hours”, as can be seen in Appendix – E, is still considerably long and the ratio between the phases is almost the same as for the “True lead time”.

The time from when an article has been booked until it is restored at location in Dispatch Stock is vital. When printing lists with customer orders for new picking rounds in the Dispatch Department returned articles are assumed to be restored within a specified timeframe. This timeframe is variable and set before every new printing session. Currently, the person responsible for setting the timeframe estimates its length based on time of day, manning and amount of returned articles in process. If the timeframe is set inaccurately, in case too short, can lead to returned articles not being restored in time, which in turn can result in articles not being on location during picking rounds and thereby delaying order from being shipped. Setting the timeframe too long can constrain customer orders from being printed and thereby also constrain the orders from being shipped in shortest possible time. Thus, the accuracy in setting the timeframe depends on the experience of the person responsible, but also due to the stability of the Returns Department in supplying Dispatch Stock with returned articles. As can be seen in Figure 5.2 46% of booked articles are not restored in Dispatch Stock within eight hours, which is the default, and maximum, length of the timeframe.

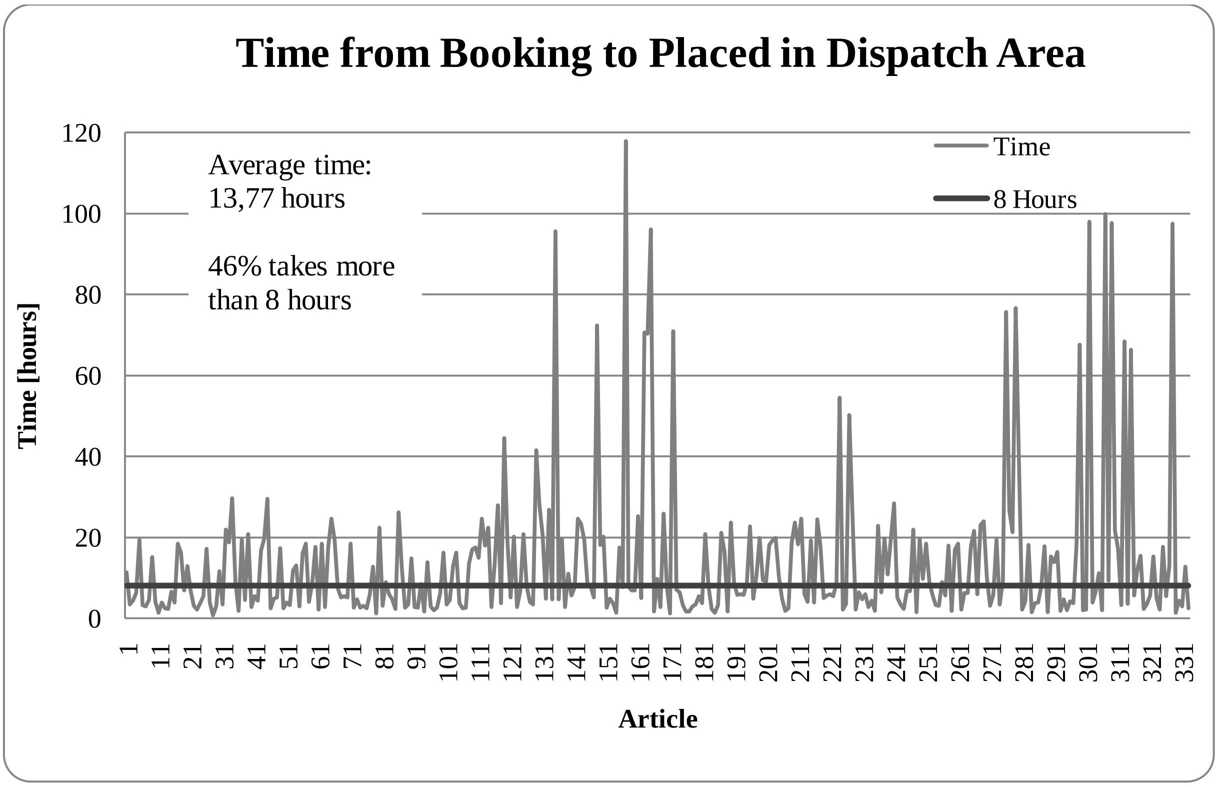


Figure 5.2 Time from when an article is booked until it is placed at location in Dispatch Stock.

When returned articles are booked the return label is printed with information about the article's location in Dispatch Stock. Occasionally, especially during shift of season, the locations in Dispatch Stock are re-planned. The new stock locations are, when re-planned, updated in the data system at 10a.m. Therefore, to avoid articles being restored at wrong locations, booked articles one day must be at location in Dispatch Stock no later than 10a.m. the day after. According to the lead time studies approximately 18% of the booked articles do not reach location in Dispatch before 10a.m. the day after they are booked, which is calculated from the data in Appendix – J.

When comparing average throughput time with manual processing time for each article it was earlier concluded that articles spend large amount of time in buffers and while being transported. The longest waiting time is, by far, between Opening and Booking Areas. Despite processing time in Booking Area being the longest, it does not stand in proportion to the long lead time for that phase. The average lead time between Opening and Booking Area is 18 hours 56 minutes and out of this between 29 seconds (for unclaimed orders) and 1 minute and 42 seconds (for customer returns) being the processing time for booking and refinishing operations. Notable is, that during the lead time measurements the refinish operation was not included in the lead time between Opening and Booking Areas, meaning that the proportion of processing time is in fact even less.

Considering the factors stated above it is reasonable to assume that the inventory level in the booking buffer is too high. This is further proven by results from the buffer sampling, Figure 5.3, showing in average 21-34 cages in the booking buffer which shall be put in relation to the number of workstations. It has also been observed that during afternoons, when manning in Returns Department is low, the manning in Opening Area is high in ratio to Booking Area resulting in a growing booking buffer. The recorded buffer sizes of 40 cages and more in Figure 5.3 were observed during afternoons when manning was low in Booking Area.

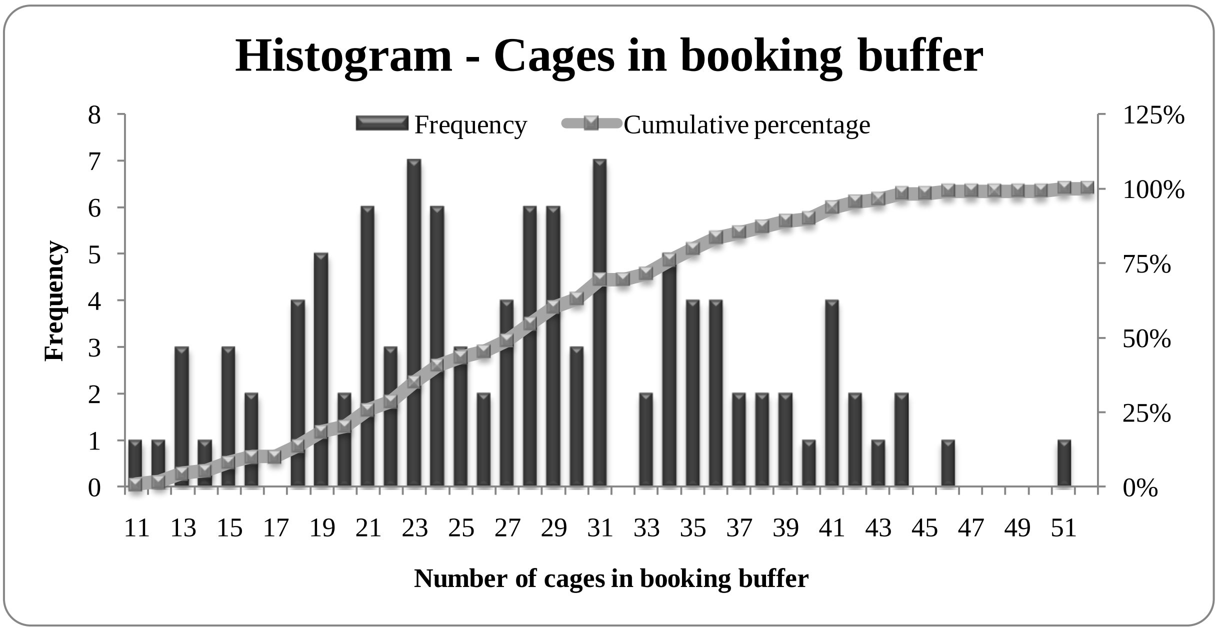


Figure 5.3 Result from sampling of the booking buffer size.

It has been identified that Booking Area's manual processes are those with longest cycle time. The number of workstations in Booking Area is constrained by the capacity of the conveyor belt and as a result the Booking Area, including the conveyor belt, is defined as the system constraint. A buffer shall be placed in front of a constraint, in this case the Booking Area, in order to prevent it from starvation. However, the booking buffer size should be optimized in relation to the need. There is no meaning to overfill the booking buffer since it will lead to more work in process which contributes to long lead times. Today, there is no obvious signal for detecting when an optimal buffer size is reached. Therefore it is a push flow[2] of batches (cages) with articles from Opening Area to Booking Area. When the manning in Opening Area is too high in relation to manning in Booking Area the booking buffer increases fast and becomes way too large, in a sense, the Opening Area is overproducing.

The capacity of the conveyor belt is 1575 units per hour which roughly corresponds to a fully manned Booking Area working at a pace of 100%. However, the piece-work contract encourages the staff to work at a pace over 100%. From production statistics the pace is in average 112% and sometimes up to 125% in the Booking Area. In addition to this the belt is even more strained when processing unclaimed articles since they have a significantly shorter processing time due to not having to be refinished or repacked. 16.4% of returned articles are unclaimed which is a fairly large amount of all returned articles. When the conveyor belt is highly loaded workstations downstream of the flow are sometimes delayed since the operators have to wait for free space on the belt to be able to leave processed articles. The workstation at which mainly unclaimed articles are processed is placed at the beginning of the conveyor belt and because of that unclaimed articles often occupy a lot of space on the belt. If articles are put too close to each other the scanner in the Sorting Area will not be able to read barcodes on the articles travelling on the belt which results in extra work since those articles become wrongly sorted. In general, the conveyor belt has a high error frequency.

Having workstations for booking and refinishing on the 2nd floor is a result from an attempt to increase the booking capacity without further constraining the conveyor belt. Though, workstations on two separate floors will naturally lead to more transportation which contributes to longer lead times. However, the largest impact on the total lead time is the extra handling time which arises when articles from the 2nd floor need to be sorted, referring to when articles undergo three more sorting operations than those arriving by conveyor belt. When articles have been refinished on the 2nd floor they are first roughly sorted according to the chutes in the Sorting Area. In the Sorting Area the cages are emptied and articles are sorted into the so called 132-trolley. When this 132-trolley is full the articles are placed in the chutes. Noticeable, the articles could be sorted directly into the trolleys associated with the chutes, but since the persons working with these "132-articles" are not working as a part of the piece-work contract, this sorting is not considered to be included in their duties. Therefore articles are then sorted from chutes by piece-work contract operators into trolleys in the same way as those articles which have arrived by the conveyor belt. The reason is that this last sorting operation is a part of the piece-work contract and personnel performing the operation get paid accordingly. Besides from being time-consuming these extra sorting operations

[2] Push flow means to produce or process an item without any actual demand.

occupies resources in form of 1-2 operators working full time with sorting “132-articles” during one shift. These operators also handle articles that are wrongly sorted by the conveyor belt. In addition, the 132-trolleys contribute in crowding the Sorting Area which already is considered as narrow and hard to work in.

Articles spend 12% plus 27% of the average total lead time in the Sorting Area. 12% constitutes the time from being refinished to become sorted into a trolley, i.e. travelling on conveyor belt or waiting in a chute. 27% is the time articles spend waiting in trolleys, either next to chutes, in the out buffer or while being transported to location in Dispatch Stock, i.e. time from being sorted into a trolley to become placed at location in Dispatch Stock. One operator in the Sorting Area acts as a coordinator and has the responsibility for the articles from the 2nd floor, to make sure that the area is manned correctly, and to keep an eye on trolleys so they do not stay in the out buffer for a long time. Today, there is no defined time length, only common sense is used. Despite this, articles spend a notable long time in chutes and trolleys waiting to be restored into Dispatch Stock. This indicates that chutes are not emptied as efficient as possible and trolleys are sometimes left waiting next to the chutes or in the out buffer for an unfavorable long time. A trolley is not transported away from the chute unless it is considered full. Therefore, trolleys standing next to low frequent chutes are not handled as often as those next to high frequent chutes. The chutes are, as mentioned, connected to locations in Dispatch Stock and the planning of each chute and trolley is done manually. There is a large diversity of products being returned from customers and high and low frequent products may vary. If the planning is not updated and accurate the trolleys will not be filled evenly and risk to be left standing next to chutes for a long time. Today, there is no way of telling how long a trolley has been standing next to a chute. Further, due to the large diversity of products in relation to number of chutes it can be problematic to plan trolleys to be filled evenly. An additional problem connected to overfull chutes is that articles become wrinkled. In an overfull chute a plastic bag containing an article tend to take in air resulting in the folded article ending up in a “corner” of the plastic bag and thereby become wrinkled.

According to the buffer sampling studies, see Figure 5.4, the out buffer in Sorting Area is only empty approximately 10% of the time. In average there are two trolleys waiting in the out buffer and at times as much as eight trolleys were observed. The things preventing a full trolley from being directly transported to location in Dispatch Stock are having enough resources available and clear routines in the area. In a way, it can be stated that the out buffer is a result from not having enough resources available and it is a contributing cause for the long average lead time of 8 hours and 48 minutes in the last phase.

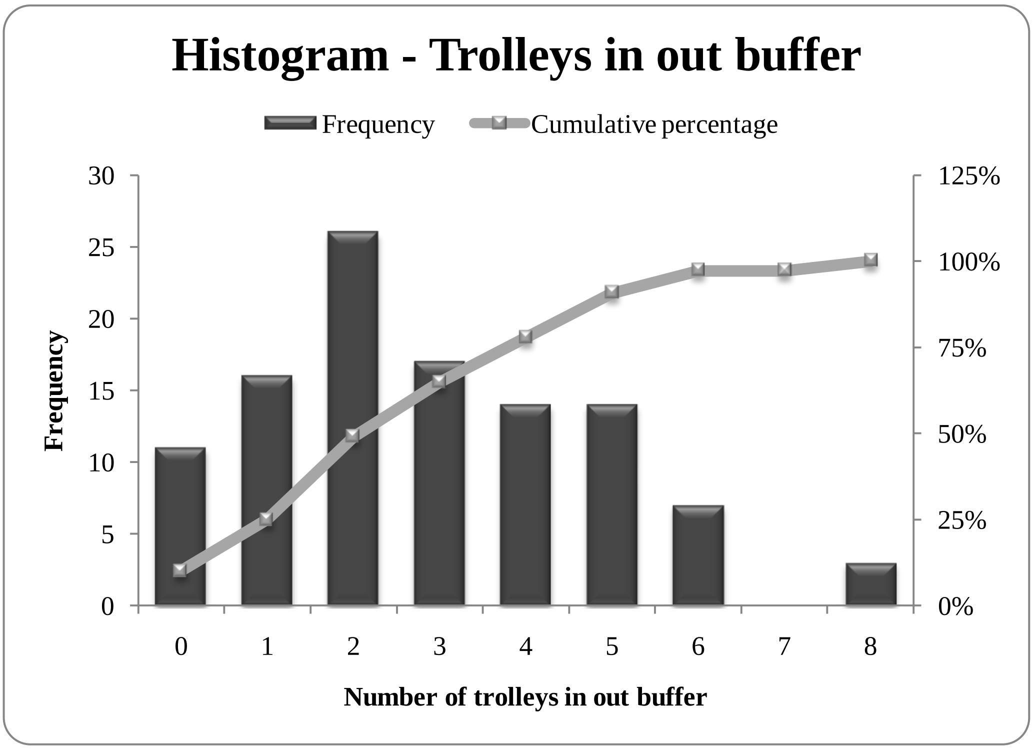


Figure 5.4 Result from sampling of the out buffer size.

Manning of areas within the Returns Department is done by weekly schedules, which are planned from estimated quantities of arriving returns. The schedule mainly concerns working hours from 6a.m. to 3p.m. and during that time the Returns Department is more or less fully manned at all stations. After 3p.m. there are approximately 60-70 persons working in production within the entire DC, all departments therefore have to share the resources and Dispatch Department is often prioritized. In Returns Department after 3p.m., or when the Department is not fully manned, it is not uncommon that allocated resources are more or less concentrated to a single area or two. When resources are not spread evenly the flow of returned articles through the Department is constrained and buffers are growing. To some extent, the high variations in lead time can be explained by no other aid than experience is used when manning the Department. This can result in capacity deviations between the different areas leading to an uneven flow. The calculated capacity presented in Appendix – G is not used by the group leaders for planning the weekly manning. One reason for this could be that there is currently no easy way to include the capacity data and amount of returned goods when planning. Also, it has been identified that time coefficients are not completely reliable. During validation of the calculated capacity, it was discovered that the coefficients gave sufficiently good data for determining the ratio between areas but not accurate enough to be used in capacity calculations for each operator in particular. The coefficients are based on a time study conducted year 1989 and are in need of revision.

To summarize, there is no single cause for the long lead times and this is further visualized in a current reality tree, Figure 5.5. The root cause for even having a Returns Department is that in average 15-18% of sold articles are returned. However, this is outside the sphere of influence. Meaning, that investigate reasons for why customers return articles and how the amount of returns can be reduced are outside the delimitations for this master's thesis. The identified core problems for long lead times are:

- 16.4% of returned articles are unclaimed.
- Number of booking and refinishing stations are constrained by the conveyor belt.
- Manning of areas is based on weekly prognoses.
- Opening process is controlled by arriving goods.
- Batch production.

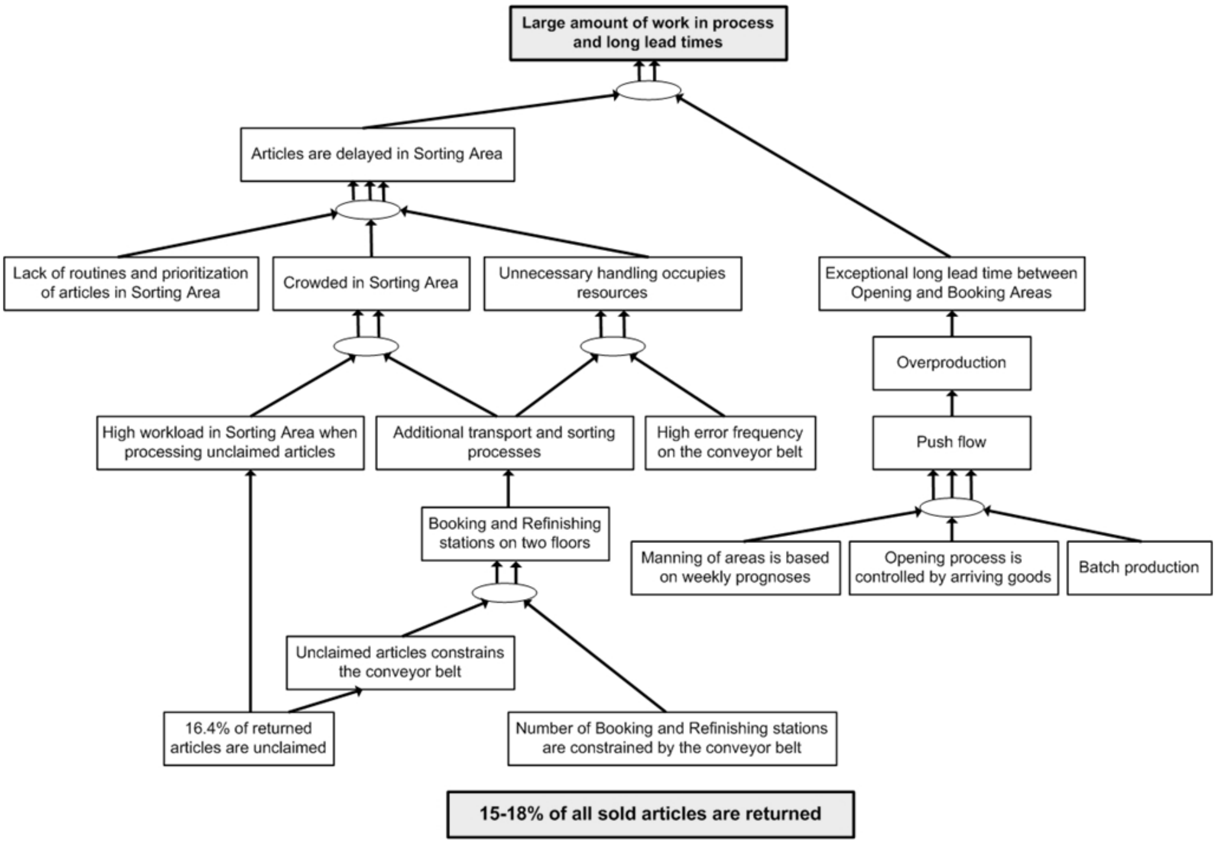


Figure 5.5 The current reality tree showing the causes for long lead times.

5.2 Manual Processes

Since the manual processes, with a ratio of only 0.12%, are such small contributors to the total lead time it is not beneficial to optimize these as an initial approach to reduce lead times. However, during work sampling studies several unnecessary and time consuming steps in the different processes were identified. Eliminating these can still be advantageous. Calculated limit errors of sampled activities, with confidences of 95 and 99%, can be found in Appendix – B. The limit errors displayed in this chapter are with 99% confidence.

5.2.1.1 Opening

Naturally, "Open/Unpack" is the highest frequent activity at the workstations with a ratio of 28.6 ± 1.9%. When summing the percentages of activities "Bundle" and "Put on rubber band" they add up to 25.5 ± 1.4%. Figure 5.6 shows the distribution between the activities performed in Opening Area.

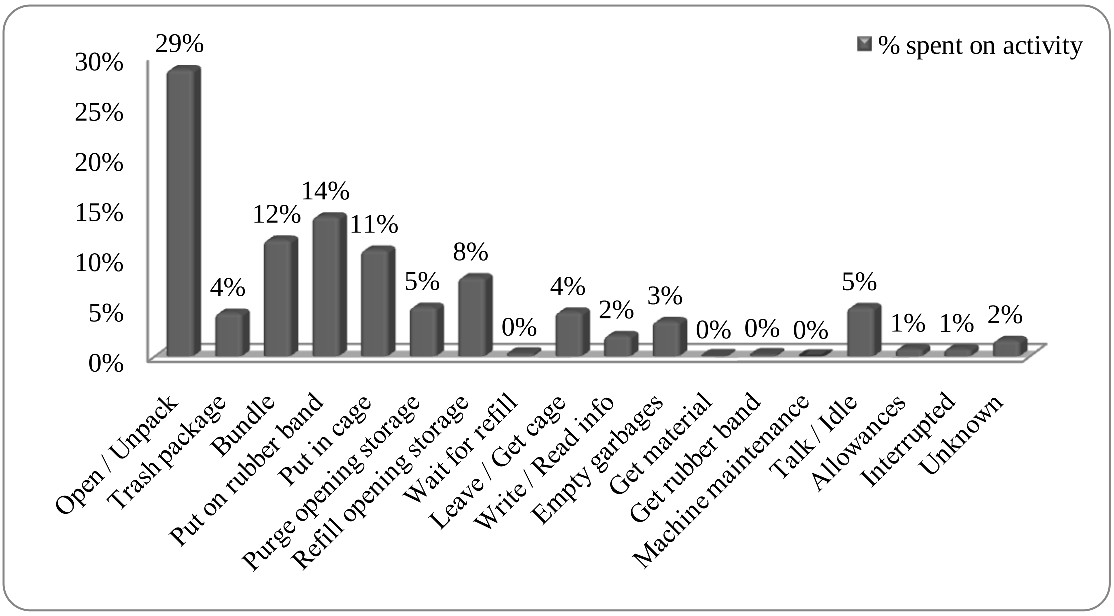


Figure 5.6 Distribution between activities performed in the Opening Area.

When an order is about to be booked the rubber band is immediately removed, it is only needed in order to keep all the articles in a customer order together with the return receipt. The “Bundle” activity is a supporting activity needed in order to put on the rubber band. In relation to “Open/Unpack” actually being the main activity of the area “Bundle” and “Put on rubber band” have a high ratio of the total process without contributing to the area’s output. Time spent on “Bundle” and “Put on rubber band” is almost as much as the time spent on “Open/Unpack”.

5.2.1.2 Booking

Time spent on the activity “Booking into computer” may vary depending on what type of order that shall be booked. As can be seen in Figure 5.7 it constitutes the absolutely most frequent activity with 37.8 ± 2.1%. Returned orders with written text messages from customers are considerably slower to process compared to other returned orders. For reclamation of articles the booking operator has to identify underlying causes, which of course takes time. In addition, some customers might place new orders on the return receipt which then has to be processed. Anyway, all these steps are important elements for providing customer service.

Further, 16.7 ± 1.6% are spent on the activity “Put on return label”. It is a relatively time consuming activity since return labels for the entire order are printed at once and the booking operator has to sort and match each label with its corresponding article. The third highest frequent activity is “Help refinish and repack”, which shall be done when the cage with opened articles is empty and not all booked articles have been refinished and repacked. Despite having two operators working with refinishing and repacking the booking process often has an overcapacity within a 3-group which result in a small buffer between booking and refinishing. Not all booking operators help with refinishing and repacking, instead they go and get a new cage with opened orders and starts over with booking. This often results in an even larger buffer in the booking chute between the two operations.

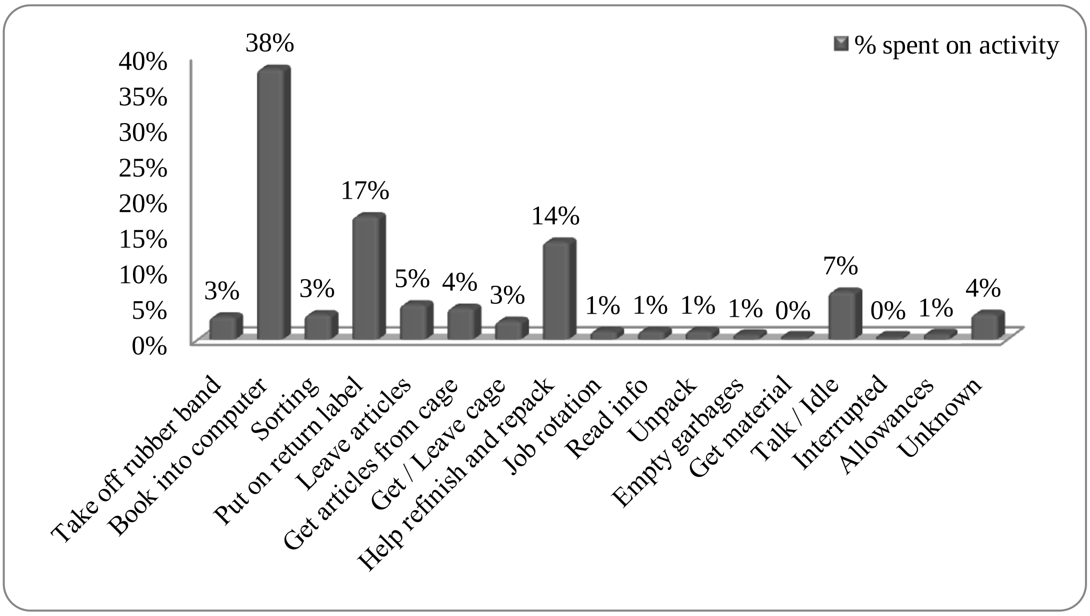


Figure 5.7 Distribution between activities performed when booking returns.

5.2.1.3 Refinishing

While booking has direct customer service aspects when compensating for defect products, wrong deliveries, handling of new orders etc. the refinishing operation indirect affects service to new customers in making articles resalable once more. Naturally, refinishing is not performed for unclaimed articles. As can be seen in Figure 5.8 “Refinish”, “Fold” and “Repack” are the main activities for the operation with a total ratio of 53.3 ± 1.5%. Remaining activities are more evenly distributed. However, “Tape” distinguishes itself by having a slightly higher ratio of 7.78 ± 1.07%.

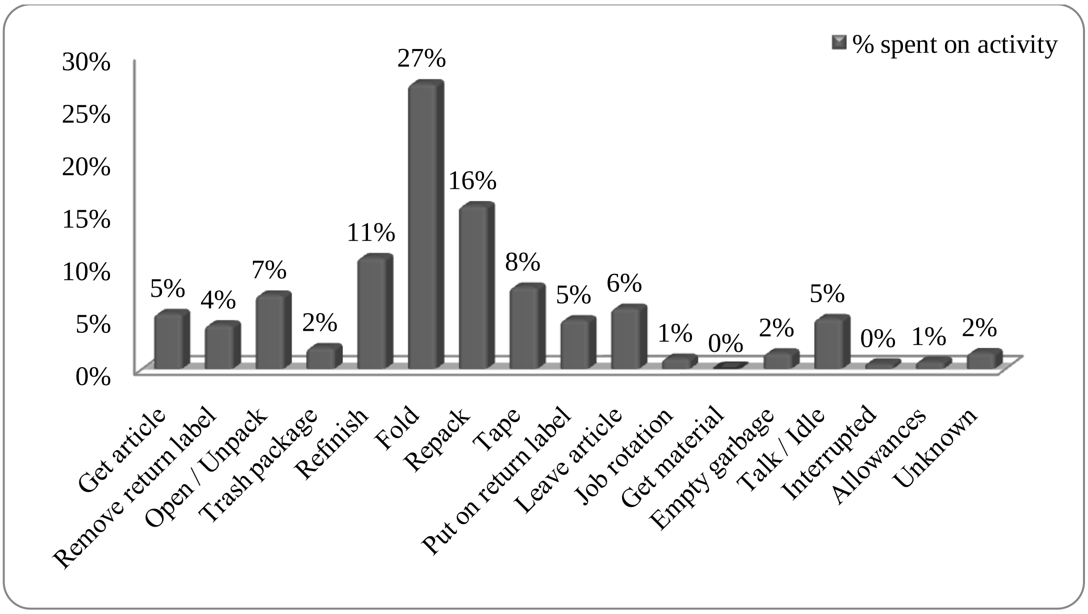


Figure 5.8 Distribution between activities performed when refinishing and repacking returns.

5.3 Improvement Potential

As revealed in this analysis, there are great potential for increasing productivity in the Returns Department. As stated earlier, productivity can be calculated by Equation 1, $M \times P \times U$, and it has emerged that there are potential improvements for all three of them, particularly method and utilization, but some improvements in performance as well.

6 Suggested Solutions

This chapter presents solutions aiming to fulfill the thesis's objectives. They were developed based on the core problems and underlying causes identified when analyzing the current state. Solutions cover all factors in the MPU-method. In order to successfully implement changes in an organization it is important to consider aspects of change management.

6.1 Balance Flow

Opening Area shall not produce and deliver more cages to booking buffer than necessary. The booking buffer shall always be kept at the lowest possible level, without risking starvation in the Booking Area. Today's push flow from Opening to Booking should be rearranged into a pull flow[3]. The level of utilization in Opening Area should be determined by the capacity potential in Booking Area. The idea is to align the amount of articles in each full cage from Opening Area to the capacity of a 3-group in Booking Area. Meaning, one cage generates one hour of work for a 3-group. This will facilitate the calculation of an optimal buffer size. In order to maintain the optimal buffer size, without constantly have to manually count every one of the cages; the number of cages shall be visualized in such way so that indications of starvation or overproduction are easily detected by having a minimum and a maximum level. If the flow is correctly balanced the risk of starvation or overproduction is limited.

From production statistics it is possible to determine the quantity of articles that generates one hour of work for a 3-group. This quantity equals to a certain level of articles in each cage. The level should be visualized inside the cage's compartment. When packed articles reach the marked level the cage should be transported to Booking Area. However, the level in cages corresponding to the determined quantity will vary depending on season since article's average size change accordingly. Because of this size variation, the level in cages needs to be updated regularly. To get a more precise measure of the content in a cage, articles can instead be counted manually by opening operators. Since there are eight opening operators and 16 cages and each operator handles 3-4 cages, it is difficult to keep track of the content in every cage. Therefore, if this kind of measure is required, a transportable counter could be attached to each cage. This can be developed even further by implementing equipment for scanning return receipts, which specifies number of returned articles, and thereby keep track of the content in cages without having to manually use a counter. In addition, a cage expected to generate one hour of work can be used as a simple and motivating performance measure for a 3-group. Meaning, if the content in a cage should take one hour to process the actual processing time will give direct feedback of performance to the 3-group. For this to work accurately it is important that the booking operator helps with refinish and repack operations when booking is completed before getting a new cage.

Naturally, the optimal buffer size is not fixed; it has to be adapted to the current manning in Booking Area. The minimum level of the optimal buffer size must include a safety margin since the Booking Area, including the conveyor belt, is identified as the system constraint. Further, the maximum level of buffer size should prevent overproduction in Opening Area and thus reduce work in process and thereby reduce lead time.

[3] Pull flow means make to order in which the production is based on actual demand.

A way to visualize buffer sizes is by dividing the booking buffer area into zones, where each zone contains a certain amount of cages. Instead of counting individual cages this will facilitate a rapid overview of the buffer size. The current optimal buffer size, together with minimum and maximum levels, should be expressed in number of full zones or number of cages on an information board in close proximity to the booking buffer. In the case of Opening Area repetitively producing cages equal, or above, the maximum level it is an indication of overcapacity in Opening Area. If so, resources from Opening Area should be relocated and utilized where better needed.

Actions:

- Measure and visualize a level in cages so the quantity of articles in one cage generate one work hour for a 3-group. Alternatively, develop and implement a tool for counting number of articles in each cage.
- Calculate optimal buffer level, with minimum and maximum levels.
- Visualize buffer levels.

Balancing the flow between the areas and reducing buffer sizes is a first step towards obtaining a more stable flow. Due to how the Returns Department is built it is not possible to eliminate transportation by cages between Opening and Booking Area without installing other transportation ways, for example conveyor belts. Installing conveyor belt between the areas will not result in a one piece flow of articles since each order contains several articles that need to be kept together with the return receipt until they are booked. However, transportation of orders on a conveyor belt is a huge reduction in batch size compared to full cages. Today's average lead time of almost 19 hours between the areas could, by the use of a conveyor belt, be reduced down to minutes.

6.2 Relocation of Unclaimed Orders

Unclaimed orders, arriving in small quantities with high diversity of articles, can in a sense be compared to mixed boxes[4] relocated from the MO DC in Central Europe. Since there is no risk of written text messages they do not need to be sorted in the Opening Area. Further, they do not need to be refinished only a booking operation is necessary to credit customers and assign a new stock location to each article. When booked, unclaimed articles are placed on the conveyor belt and then handled as normal customer returns. The only things that differentiate unclaimed orders from mixed boxes are higher diversity of articles and debiting of customer. Thus, handling of unclaimed orders can be separated from the Returns Department and redirected to Goods Reception where mixed boxes are handled.

Actions:

- Separate arriving shipments with unclaimed orders from customer returns.
- Develop routines for transporting unclaimed order from Dispatch of Freight Area in Returns Department to Goods Reception.

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[4] A mixed box is an incoming batch with new products. The box has a high diversity of articles in smaller quantities than normal arriving goods.

This will reduce lead time for unclaimed orders since they will reach location in Dispatch Stock faster when processed as incoming goods in relation to being processed as customer returns. Also, there will be reduced strain on the conveyor belt since approximately 16% of the total amount of handled articles is moved from the Returns Department.

6.3 Reduce Transportation and Sorting Processes

Today there is no selection of what is to be processed on the 2nd floor; cages are fetched from the booking buffer according to first in – first out principle, as for the 1st floor. Having booking and refinishing stations on the 2nd floor processing orders without knowing the articles final destination in advance causes extra and unnecessary transport and sorting of articles. In addition, 132-trolleys, which mainly exist due to current operations on 2nd floor, constrain the Sorting Area in terms of occupying recourses and taking up space in an already crowded area. In order to utilize workstations on the 2nd floor in a more efficient way reorganization is needed.

A selection procedure is necessary where only articles that have their final stock location on the 2nd floor should be processed on the 2nd floor. Approximately 16% of the returned articles have their final stock location on the 2nd floor. An article's stock location is not known until it has been booked. Therefore, selection and separation have to be made by the booking operators. The idea is to book all articles on 1st floor and then separate articles which have stock locations on 2nd floor. Meaning, only 2nd floor articles will be refinished, sorted and restored on the 2nd floor. This prevents 2nd floor articles from having to be transported down to 1st floor, mixed with 1st floor returns, separated and again transported to the 2nd floor to be restored. Another argument for separating 1st floor articles from 2nd floor articles is that articles with stock locations on 2nd floor are classified as low frequent, meaning articles with low market demand. This will result in only high frequent articles

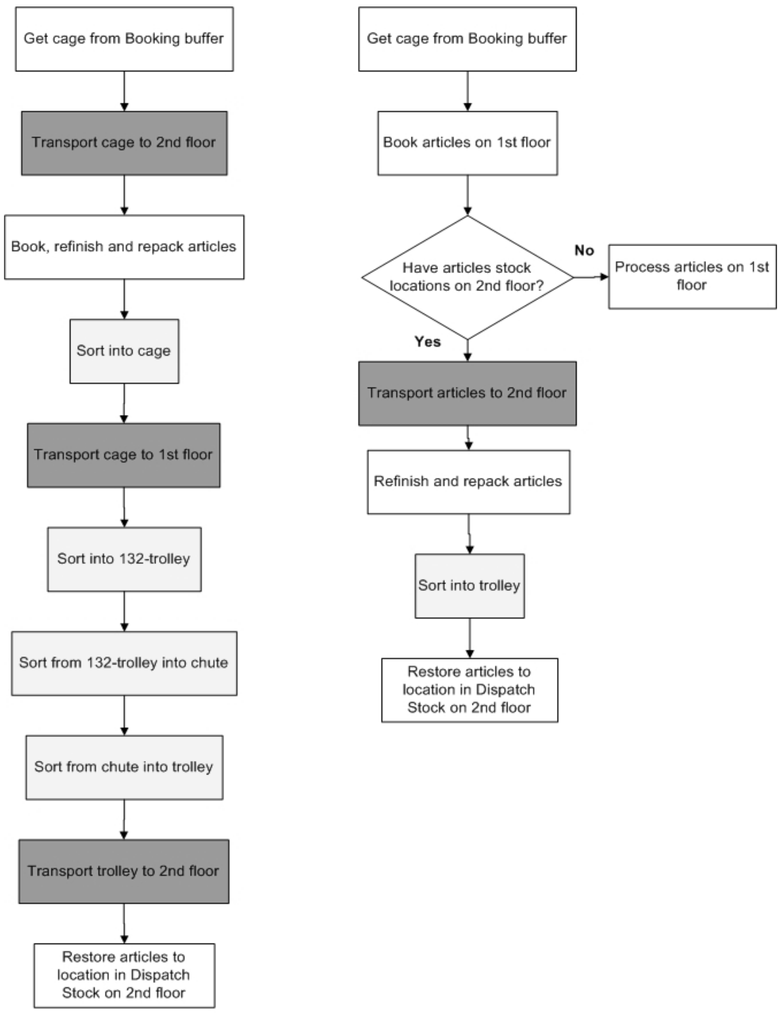

Figure 6.1 Flow charts showing current and suggested operations when handling 2nd floor articles.

utilizing the conveyor belt and the Sorting Area on 1st floor. In Figure 6.1 the need of reducing unnecessary sorting and transport operations is further visualized, the worst case scenario of today is presented next to the process steps in the suggested solution. Light gray fields represents sorting operations while the dark fields are transportation.

Actions:

- All articles are booked on 1st floor.
- Conduct a data system change giving booking operator a clear indication when booking articles that shall be separated to 2nd floor.
- Booking operators separate articles that have final stock location on 2nd floor and place them in a box/cage close to their work station.
- Boxes with 2nd floor articles are collected during "milk rounds" by personnel from 2nd floor.
- Only refinish and repack 2nd floor articles on the 2nd floor.
- Implement sorting procedure on 2nd floor where articles are sorted into trolleys which are planned according to stock locations.

As a consequence, chutes in Sorting Area that previously were correlated with 2nd floor articles are now released and can be used for articles with stock locations on 1st floor. Having more chutes per zone in Dispatch Stock on 1st floor will naturally lead to lower diversity of articles per trolley. This will, if planned accurately, result in decreased length for replenishment rounds when restoring articles into Dispatch Stock and thereby contribute to reducing lead time.

If the solution of separating 1st and 2nd floor articles is implemented the amount of articles that needs to be handled in 132-trolleys is greatly reduced, as can be seen in Figure 6.1. Therefore, fewer resources are needed for sorting operations related to 132-trolleys and smaller quantities of articles are delayed due to these sorting operations. In order to eliminate 132-trolleys completely the conveyor belt has to operate perfect. Though, today the conveyor belt has a high error frequency. Within the framework for this master's thesis no obvious technical solution for improving the conveyor belt has been detected. However, with previous solutions implemented articles that could be sorted elsewhere, referring to unclaimed and 2nd floor articles, have been removed from the belt. This will result in no "unnecessary" items being wrongly sorted and thereby causing longer lead times and extra work. Further, the level of wrongly sorted articles can be kept low since they can be taken care of more efficiently when the articles from 2nd are moved and thereby work with 132-trolleys reduced.

With these suggested improvements in Sorting Area there is a risk of trolleys standing for a long time next to the chutes due to a lower diversity of articles in each chute. Trolleys are therefore not filled up as fast as before. Same applies for 2nd floor trolleys. Naturally, trolleys waiting in Sorting Areas for a long time will increase lead time. This possible increase in lead time can be avoided by implementing a way to detect how long trolleys have been standing in Sorting Area. A simple way to measure time spent in the area is by noting date and time when an empty trolley was placed in front of chute. This can be noted on a small whiteboard attached to each trolley.

Actions:

- Purchase re-attachable whiteboards, one for each trolley station on 1st and 2nd floor.
- Develop routines for how the white boards shall be used, e.g. how to record date and time, maximum time and overall responsible operator.

The use of whiteboards can help in reducing the amount of articles not being placed at correct stock locations in right time even if 1st and 2nd floor articles are not separated. Referring to that stock locations are, when re-planned, updated in the data system at 10a.m. Therefore, articles in Sorting Area booked one day have to be at location in Dispatch Stock before 10a.m. the day after. Further, as mentioned, the person responsible of printing lists with new customer orders in Dispatch Department has to set a timeframe for when booked articles are assumed to be on location in Dispatch Stock. Since the whiteboards show how long each trolley has been waiting in Sorting Area, estimating the length of the timeframe is facilitated.

6.4 Balance Manning

To be able to create a stable flow of articles throughout the Department accurate allocation of resources is required. Plots showing lead time phases in Appendix – K, together with the calculated standard deviations in Table 4.7, chapter 4.3, Lead Times and Cycle Times, prove the high variations in and between areas. Manning shall be planned by considering incoming goods, available resources and at the same time striving towards obtaining a constant flow of goods rather than focusing on single areas. Thereafter, indications of a constrained flow, e.g. in terms of increasing buffers, should be taken into consideration whether resources should be relocated or not. To facilitate this type of manning procedure, a tool should be developed in which parameters such as arriving returns and available resources each day generate a manning proposal. This could for instance be implemented using Microsoft Excel. Though, in order to develop this kind of tool a more thorough study of capacity and performance is necessary. Data for capacity calculations today are based on time studies conducted year 1989 and has not been updated since. When measuring performance in Returns Department everything is based on number of articles booked and worked hours. Efficiency for the whole Department is thereafter calculated using coefficients from the time study. Consequently there are no efficiency or performance measures for operations in Opening and Sorting Areas accurate enough to be used for balancing manning. Therefore, studies regarding this need to be conducted. In addition, the time coefficients for booking and refinishing operations are not separated, they are seen as just one operation. When balancing manning it is favorable to know the capacity of each individual manual operation, therefore a more thorough study should include the Booking Area as well.

Actions:

- Conduct performance and capacity studies for all the manual operations.
- Calculate optimal buffer sizes correlated to manning.
- Develop a tool to be used as an aid when planning allocation of available resources.

The manning shall continuously be validated during work shifts due to differences among individual operator's capacity may vary. This validation can be done by monitoring buffer levels to detect deviations from optimal size.

In Appendix – G capacity calculations are displayed for operators within each area and for each fully manned area. However, as stated above the statistics used are based on booked items from year 2009 and coefficients from the time study conducted year 1989. The time coefficients are not assumed to be completely reliable and therefore not applicable as vital data for developing a planning tool.

Today, the MO DC is almost fully manned between 6a.m. and 3p.m. and due to lack of workstations, mainly in Dispatch Department, it can sometimes be considered crowded. Though, after 3p.m. when MO DC's Departments share a smaller amount of resources not all areas are manned. A way to obtain a more stable utilization of resources, without increasing labor costs, manning could be spread out during all non inconvenient working hours.

Communication and direct feedback are important, therefore it is recommended to introduce a coordinator for all areas, as the Company recently has done in the Sorting Area. The coordinators' assignments are to have overall situation awareness and to communicate with group leaders and the other areas' coordinators.

6.5 Manual Process Improvements

Improving manual processes may not contribute to large reductions in lead time, but continuously striving to eliminate unnecessary process steps is of course favorable. For Opening Area the steps "Bundle" and "Put on rubber band" can be eliminated if orders (articles and return receipts) are placed in boxes after being unpacked. A box should be of a standardized size to fit in a cage and be able to contain several orders while keeping them separated. With changeable "walls" inside the box the number of compartments can be flexible depending on order sizes. It also eases for the booking operator when emptying cages, referring to process step "Get articles from cage" in the booking operation. This solution is aligned with "Balance flow", presented in chapter 6.1, Balance Flow, since the level of articles in a cage is probably more easily measurable if using boxes compared to when stacking bundled articles independently.

Using boxes also facilitates the future concept of reducing batches (cages) down to single or a few orders and developing a constant flow between Opening and Booking Areas. For example, if a conveyor belt is installed between the two areas, boxes will be a way of transporting orders on the belt. If a conveyor belt is implemented return orders still has to be sorted according to country and written text messages. Therefore, there is a need to attach information concerning the box's content so the conveyor belt transports orders to right booking operator.

For booking operation there is no obvious process step to eliminate. However, if the boxes are implemented the activity "Take of rubber band" is automatically removed and as stated above time spent on "Get articles from cage" is reduced. Emptying a cage with orders placed in boxes is assumed to be more efficient than to pick individual orders one by one, it also contributes to obtain an organized workstation. Today, orders are stacked in a pile on the booking operator's work bench.

Finally, an easy way to reduce time spent on "Tape" in refinishing operations is to replace the today used rolls of scotch tape with plastic bags having a self-adhesive sealing. Time spent on "Tape" is $7.78 \pm 1.07\%$. By using plastic bags with self-adhesive sealing the amount of time spent on "Tape" (closing the bag) can now be reduced, and the "saved time" can be used to more necessary activities potentially increasing output. Further, these plastic bags are more efficient in preventing air from entering the bag. This can help to avoid articles from becoming wrinkled when they are waiting in the chutes in Sorting Area.

7 Estimations of Possible Cost Savings

In order to further motivate the impact of suggested solutions this chapter will provide calculations of estimated monetary savings.

7.1 Cost Savings by Balancing Flow and Manning

Balancing flow and manning will reduce buffer sizes and thereby reduce lead times and work in process. Cost savings can be estimated from calculating reduced amount of tied up capital. Today, the booking buffer, together with cages at workstations, is in average 27 + 14 cages and one cage contains 200 articles (roughly estimated). This can, with a good safety margin, be reduced to 13 cages at workstations, one per 3-group, and 13 cages as maximum in booking buffer where each cage contains articles corresponding to one hour of work for a 3-group. From capacity calculations one hour of work is approximately 110 articles. Balancing flow and manning is assumed to reduce waiting time in booking buffer from almost 19 hours down to 2 hours. Those 2 hours derives from having one cage at each workstation and one additional cage per workstation waiting in buffer. Table 7.1 presents the current state and the suggested future state concerning the booking buffer.

Table 7.1 Work in process between Opening and Booking Areas.

	Current state	**Future state**
Number of cages in booking buffer	41	19.5
Number of articles per cage	200	110
Work in process	**8 200 articles**	**2 145 articles**

Work in process = [Number of cages in booking buffer] × [Number of articles per cage]

Reduced amount of work in process = [Current state] - [Future state] ≈ **6 055 articles**

Concerning Sorting Area, the time articles wait between being refinished until sorted is assumed to be reduced from almost four hours down to one hour if the area is correctly manned. The conveyor belt is assumed to work at full capacity, transporting 1575 articles per hour to the Sorting Area. Further, the time between sorted and placed at location in Dispatch Area is assumed to be reduced from almost nine hours down to five hours if the out buffer is eliminated. Table 7.2 shows the current state and suggested future state for the Sorting Area.

Table 7.2 Work in process in Sorting Area.

	Current state	**Future state**
Articles waiting in sorting chutes	6 300	1 575
Number of articles per full trolley	500	500
Number of trolleys next to chutes	18	18
Number of cages in out buffer	2	0
Work in process	**11 300 articles**	**6 075 articles**

Work in process = [Articles waiting in sorting chutes] + $\frac{1}{2}$ × [Number of articles per full trolley] × [[Number of trolleys next to chutes] + [Number of trolleys in out buffer]]

Reduced amount of work in process = [Current state] - [Future state] ≈ **5 225 articles**

Total reduced amount of work in process in the Returns Department, gained from balancing flow and manning, is **11 280 articles.** Savings in tied up capital can be calculated as:

[Reduced amount of work in process] × [Average value per article] × [Interest loss]

Average value per article (net profit) and interest loss are kept confidential by the Company. In addition, all lead time reduction contributes to shortening the time until articles are available for re-selling to new customers.

7.1.1 Implementing conveyor belt between Opening and Booking Areas

If a conveyor belt is implemented between the areas, the booking buffer will be eliminated. Work in process will constitute of articles travelling on the conveyor belt. If approximately two orders per booking operator are travelling on the conveyor belt, the amount of work in process will be reduced from 8 200 articles, as stated in Table 7.1, down to only 80 articles. Calculated from:

[Number of booking operators] × 2 × [Average number of articles per order]

7.2 Cost Savings in Manual Processes

Even though manual processes are such small contributors to the total lead time there are potential cost savings if suggested solutions are implemented. When conducting estimations of following possible cost savings these assumptions were made:

- Work stations are almost fully manned during 9 work hours per day, 6a.m. to 3p.m.
- There are 220 workdays per year.
- One operator costs 215 SEK per hour for the Company including hourly wage and social security contributions.
- Manning in Opening Area is 8 operators.
- Manning in Booking Area is 13 3-groups, meaning 13 booking operators and 26 refinishing operators.

7.2.1 Remove “Put on rubber band”

Today, “Put on rubber band” occupies 14% of the time in Opening Area and “Take of rubber band” occupies 3% of the time in Booking Area. Further, using boxes instead of rubber bands will reduce the time spent on “Get articles from cage”, in Booking Area, with approximately 2%. Also, “Bundle” can approximately be reduced with 8% if this solution is implemented. Altogether this can result in cost savings for:

Opening Area
(14% + 8%) × 9 work hours × 220 workdays × 8 operators × 215 SEK ≈ **750 000 SEK/year**

Booking Area
(3% + 2%) × 9 work hours × 220 workdays × 13 operators × 215 SEK ≈ **275 000 SEK/year**

Total estimated cost saving of eliminating rubber bands and implement boxes instead is therefore approximately **1 025 000 SEK per year**.

7.2.2 Remove "Tape"

Eliminating the use of scotch tape and implementing plastic bags with self-adhesive sealing will approximately reduce time spent on "Tape" with 6%. This can result in a cost saving of:

6% × 9 work hours × 220 work days × 26 operators × 215 SEK ≈ **665 000 SEK/year**

7.3 Cost Savings by Reducing Transportation and Sorting Processes

Time spent on transportation can be significantly reduced since no further transportation is needed than from 1st to 2nd floor. However, the largest cost saving potential is by eliminating number of sorting processes. As stated, additional sorting and transporting operations occupies in average two operators. Implementing the suggested solution can therefore result in cost savings of approximately:

2 operators × 9 work hours × 220 work days × 215 SEK ≈ **850 000 SEK/year**

Instead of resources being occupied with sorting operations they can now be used where better needed, for instance restoring articles into Dispatch Stock and thereby reducing the out buffer.

8 Discussion

This chapter presents a short discussion about how the master's thesis has been conducted and things that could have been done differently.

Using a methods engineering approach have facilitated a structured way of working. Studies to get and present data have involved well established tools, such as work sampling, and also tools developed specifically for this project, referring to "yellow notes", for lead time measurements. Using notes proved to be a well accepted way of measuring lead times. Criticism could be that the project team had little control over the recorded time's accurateness since many employees were involved in handling a large number of notes. However, operators only had to record date and time and results from compiled notes, which showed large time variations, are not assumed to derive from inaccuracy from operators. Additionally, since a large amount of notes were distributed a lot of data was collected and because of that, occasional miswritten notes did not have a substantial effect on the outcome. Some notes had extreme values recorded and were not considered trustworthy, those notes were later removed from the calculations in order not to generate misleading results.

When designing the notes there was a tradeoff between gathering data detailed enough and at the same time not disturbing operators in their work, or gathering more specific data on each note and because of that disturbing the operators more. Since operators are working on a piece-work contract the chosen approach was to disturb them as little as possible. However, it would have been interesting to obtain information concerning more specific lead times, for instance articles processed on 2nd floor, articles with text messages from customers and unclaimed articles or customer returns. This kind of data would have strengthened arguments stated in the analysis even more.

The Hawthorne effect might have influenced the results from both sampling studies and lead time measurements. Though, an increase in productivity due to the Hawthorne effect is assumed to have little effect on the total lead times since manual processes only have a contribution of 0.12% to the total lead time. The ratio between main activities for manual processes, which were studied when conducting work sampling, is deemed not to have been influenced by the Hawthorne effect.

Measurements about how much lead time will be reduced by reorganizing handling processes concerning the 2nd floor would require additional time studies; both in current state and in the suggested future state, to measure differences between processing articles on 1st floor and on 2nd floor before and after solutions are implemented. Since none of the recommended solutions are implemented within the time frame for this master's thesis this was unfortunately not possible.

Proposed solutions will reduce lead times, but profit from time savings is hard to measure in monetary terms. However, estimations of possible cost saving were made. Despite calculations being based on some assumptions and average values, they give a good indication of the potential positive effect the suggested improvements will have if they are implemented. Estimations of cost savings do not include costs for investments, such as purchasing boxes when eliminating rubber bands. In addition, rapid and efficient returns handling is important in a customer service aspect concerning how fast a customer will be credited when returning orders. Moreover, reducing the total lead time will make returned articles available for new customers by being restored into Dispatch Stock faster and thereby further contribute to creating customer service. When printing lists with customer orders for new picking rounds in the Dispatch Department returned articles are assumed to be restored within a specified timeframe. An attempt to measure differences in amount of available orders in Dispatch Department by adjusting this timeframe was planned. These kind of measurements required access to software test environments which were unavailable during this season due to prioritized IT-projects and therefore this kind of study was not able to conduct.

Benchmarking could be favorable for this kind of project since the Company has three DCs in three different countries, and the Company strives towards having a similar way of working throughout the organization. A reference visit to the MO DC in Central Europe was planned in this master’s thesis but cancelled in last minute due to force majeure.

The Company continuously strives to improve operations and procedures and tries to involve operators as much as possible in the improvement work, for instance by using “Process Improvement Groups”. A group consists of operators focused on a specific area within the DC and is supervised by a group leader, this promotes a positive attitude to changes. Also, operators not involved in “Process Improvement Groups” are inclined to changes that can increase their salary due to the piece-work contract. Having personnel with this positive attitude facilitates for managing changes. First step in organizing changes is to define the current state and envisioning a desired future state. It is important that everyone in the organization understands why changes are needed and what they will result in. This master’s thesis has identified core problems and underlying causes together with possible solutions to reach a desired future state. If both operators, group leaders and production management agrees on what changes that are beneficial for all parts and strives towards a common goal, the second step in organizational change is easily managed. However, it is important to consider the typical three types of problem, power, anxiety and organizational control, which can be encountered when a significant organizational change is attempted.

9 Conclusions

It has emerged that lead times are considerably long in the Returns Department. Underlying causes have been identified and suggested solutions will most likely reduce lead times significantly throughout the whole Department. Prioritization of returned articles will be accomplished by separating low frequent articles from high frequent articles and processing them on different floors. Furthermore, improvement suggestions for the manual processes have also been presented.

Proposed changes will result in reduced amount of work hours spent on operations not included in the piece-work contract.

To be able to develop a tool which can be used daily for acquiring a balanced manning complementary time and capacity studies are needed.

Today, transportation of articles is mainly done in large batches; to further reduce lead times and create a stable flow focus has to be on reducing batches and striving towards a flow of single orders and articles.

Balancing flow and manning are estimated to reduce work in process by 11 280 articles. If a conveyor belt between Opening and Booking Areas is implemented work in process will be reduced by 8 120 articles. The calculated cost savings for manual process improvements are:

- Removing rubber bands: 1 025 000 SEK/year.
- Remove tape operation: 665 000 SEK/year.
- Reduce transport and sorting processes: 850 000 SEK/year.

By implementing all suggested improvements for manual processes, a cost saving of 2 540 000 SEK per year is assumed possible.

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Appendix – A

FLOW PROCESS CHART		1. NUMBER	2. PAGE NO.	3. NO. OF PGS
		1	1	1

4. PROCESS	Returns Department, Booking on 1st floor.
6.	☐ MAN OR ☒ MATERIAL
7. CHART BEGINS	Goods in
8. CHART ENDS	Dispatch Stock
9. CHARTED BY	Ellinor Belin and Richard Hedman
10. DATE	
11. ORGANIZATION	Chalmers University of Technology

5. SUMMARY						
a. ACTIONS	b. PRESENT NO.	b. PRESENT TIME	c. PROPOSED NO.	c. PROPOSED TIME	d. DIFFERENCE NO.	d. DIFFERENCE TIME
OPERATIONS	5					
TRANSPORTATIONS	6					
INSPECTIONS	-					
DELAYS	8					
STORAGES	2					
DISTANCE TRAVELED *(Feet)*						

12a. DETAILS OF ☒ PRESENT ☐ PROPOSED METHOD

	12a.	b. OPERATION	TRANSPORT	INSPECTION	DELAY	STORAGE	c. DISTANCE IN FEET	d. QUANTITY	e. TIME	f. ANALYSIS WHY? WHAT?	WHERE?	WHEN?	WHO?	HOW?	g. NOTES	h. ANALYSIS ELIMINATE	COMBINE	CH SEQUENCE	PLACE	PERSON	IMPROVE
1.	Goods in reception					X															
2.	Transport to tilt container		X																		
3.	Waiting in tilt container				X																
4.	Opening operation	X																			
5.	Waiting in cage Opening Area				X																
6.	Transport to booking buffer		X																		
7.	Waiting in booking buffer				X																
8.	Transport to booking station		X																		
9.	Waiting in cage at booking station				X																
10.	Booking operation	X																			
11.	Waiting in chute				X																
12.	Refinish and repack operations	X																			
13.	Transport on conveyor belt		X																		
14.	Waiting in sorting chute				X																
15.	Sorted into trolley	X																			
16.	Waiting in trolley				X																
17.	Trolley moved to out buffer		X																		
18.	Waiting in out buffer				X																
19.	Transport to Dispatch Area		X																		
20.	Placed on location in Dispatch Stock	X																			
21.	Dispatch Stock					X															

FLOW PROCESS CHART

1. NUMBER	2. PAGE NO.	3. NO. OF PGS

4. PROCESS
Returns Department, Booking on 1st floor "worst case".

6. ☐ MAN OR ☒ MATERIAL

7. CHART BEGINS	8. CHART ENDS
Goods in	Dispatch Stock

9. CHARTED BY	10. DATE
Ellinor Belin and Richard Hedman	

11. ORGANIZATION
Chalmers University of Technology

5. SUMMARY

a. ACTIONS	b. PRESENT NO.	b. PRESENT TIME	c. PROPOSED NO.	c. PROPOSED TIME	d. DIFFERENCE NO.	d. DIFFERENCE TIME
OPERATIONS	8					
TRANSPORTATIONS	7					
INSPECTIONS	-					
DELAYS	12					
STORAGES	2					
DISTANCE TRAVELED (Feet)						

12a. DETAILS OF ☐ PRESENT ☐ PROPOSED METHOD

	12a. Details	b. OPERATION	TRANSPORT	INSPECTION	DELAY	STORAGE	c. DISTANCE IN FEET	d. QUANTITY	e. TIME	f. ANALYSIS WHY? WHAT?	WHERE?	WHEN?	WHO?	HOW?	g. NOTES	h. ANALYSIS CH ELIMINATE	COMBINE	SEQUENCE	PLACE	PERSON	IMPROVE
1.	Goods in reception					X															
2.	Transport to tilt container		X																		
3.	Waiting in tilt container				X																
4.	Opening operation	X																			
5.	Waiting in cage Opening Area				X																
6.	Transport to booking buffer		X																		
7.	Waiting in booking buffer				X																
8.	Transport to 2nd floor		X																		
9.	Waiting in cage at workstation				X																
10.	Booking operation	X																			
11.	Waiting in chute				X																
12.	Refinish and repack operation	X																			
13.	Sorted into a cage	X																			
14.	Wait in cage				X																
15.	Transport to mini buffer on 1st floor		X																		
16.	Waiting in mini buffer				X																
17.	Transport to Sorting Area		X																		
18.	Waiting to be sorted				X																
19.	Sorted into 132-trolley	X																			
20.	Waiting to be sorted into chute				X																
21.	Sorted into chute	X																			
22.	Waiting in sorting chute				X																
23.	Sorted into trolley	X																			
24.	Wait in trolley				X																
25.	Transport trolley to out buffer		X																		
26.	Wait in out buffer				X																
27.	Transport to Dispatch Area		X																		
28.	Placed on location in Dispatch Stock	X																			
29.	Dispatch Stock					X															

Appendix – B

Opening

No.	Main process steps:	p	Limit of error 95% confidence	Limit of error 99% confidence
1	Open / Unpack	**28.58%**	1.45%	1.90%
2	Trash package	**4.29%**	0.65%	0.85%
3	Bundle	**11.58%**	1.03%	1.35%
4	Put on rubber band	**13.90%**	1.11%	1.46%
5	Put in cage	**10.58%**	0.99%	1.30%

Support processes:	p	Limit of error 95% confidence	Limit of error 99% confidence
Purge opening storage	**4.88%**	0.69%	0.91%
Refill opening storage	**7.83%**	0.86%	1.13%
Leave / Get Cage	**4.40%**	0.66%	0.86%
Write / Read info	**2.05%**	0.46%	0.60%
Empty garbages	**3.45%**	0.59%	0.77%
Get material	**0.05%**	0.07%	0.10%
Get rubber band	**0.22%**	0.15%	0.20%
Machine maintenance	**0.03%**	0.05%	0.07%

Other:	p	Limit of error 95% confidence	Limit of error 99% confidence
Talk / Idle	**4.86%**	0.69%	0.91%
Allowances	**0.73%**	0.27%	0.36%
Interrupted	**0.70%**	0.27%	0.35%
Unknown	**1.57%**	0.40%	0.52%

Booking

No.	Main process steps:	p	Limit of error 95% confidence	Limit of error 99% confidence
1	Take of rubber band	**3.07%**	0.57%	0.74%
2	Book into computer	**37.84%**	1.59%	2.08%
3	Sorting	**3.37%**	0.59%	0.78%
4	Put on return label	**16.73%**	1.23%	1.61%
5	Leave articles	**4.72%**	0.70%	0.91%

Support processes:	p	Limit of error 95 % confidence	Limit of error 99% confidence
Get articles from cage	**4.25%**	0.66%	0.87%
Get / Leave cage	**2.47%**	0.51%	0.67%
Help refinish and repack	**13.27%**	1.12%	1.46%
Job rotation	**1.07%**	0.34%	0.44%
Read info	**1.10%**	0.34%	0.45%
Unpack	**1.10%**	0.34%	0.45%
Empty garbages	**0.65%**	0.26%	0.35%
Get material	**0.37%**	0.20%	0.26%

Other:	p	Limit of error 95% confidence	Limit of error 99% confidence
Talk / Idle	**6.47%**	0.81%	1.06%
Allowances	**0.73%**	0.28%	0.37%
Interrupted	**0.37%**	0.20%	0.26%
Unknown	**3.43%**	0.60%	0.78%

Refinish and repack

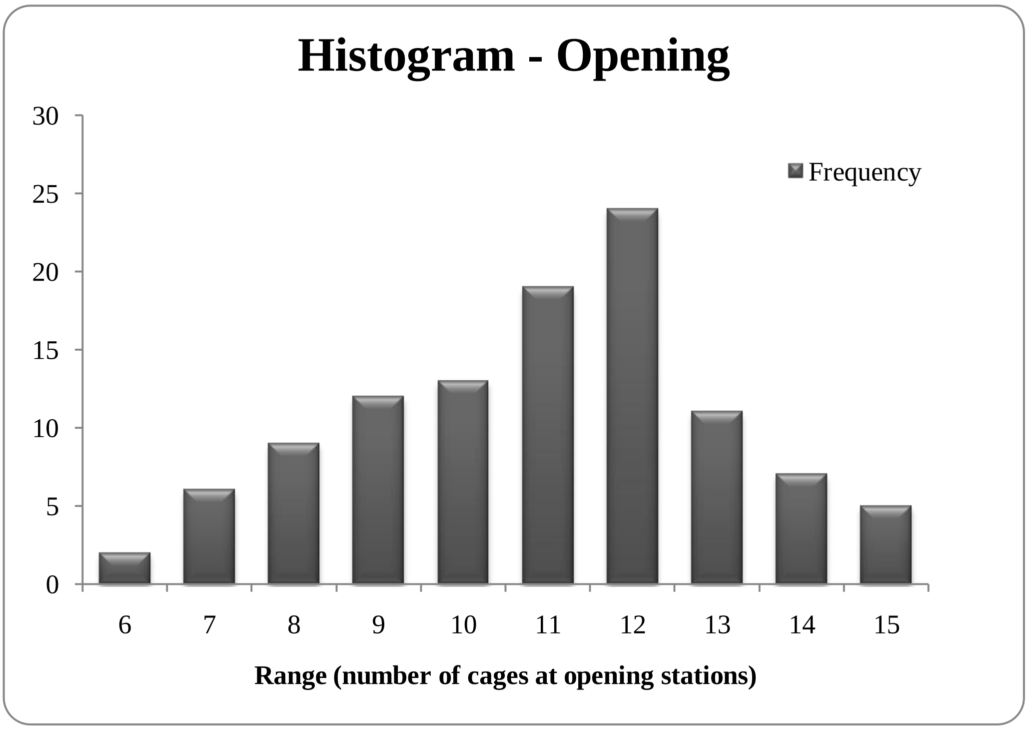
No.	Main process steps:	p	Limit of error 95% confidence	Limit of error 99% confidence
1	Get article	**5.26%**	0.68%	0.89%
2	Remove return label	**4.17%**	0.61%	0.80%
3	Open / Unpack	**7.03%**	0.78%	1.02%
4	Trash package	**2.01%**	0.43%	0.56%
5	Refinish	**10.59%**	0.94%	1.23%
6	Fold	**27.20%**	1.36%	1.78%
7	Pack	**15.54%**	1.11%	1.45%
8	Tape	**7.78%**	0.82%	1.07%
9	Put on return label	**4.65%**	0.64%	0.84%
10	Leave article	**5.77%**	0.71%	0.93%

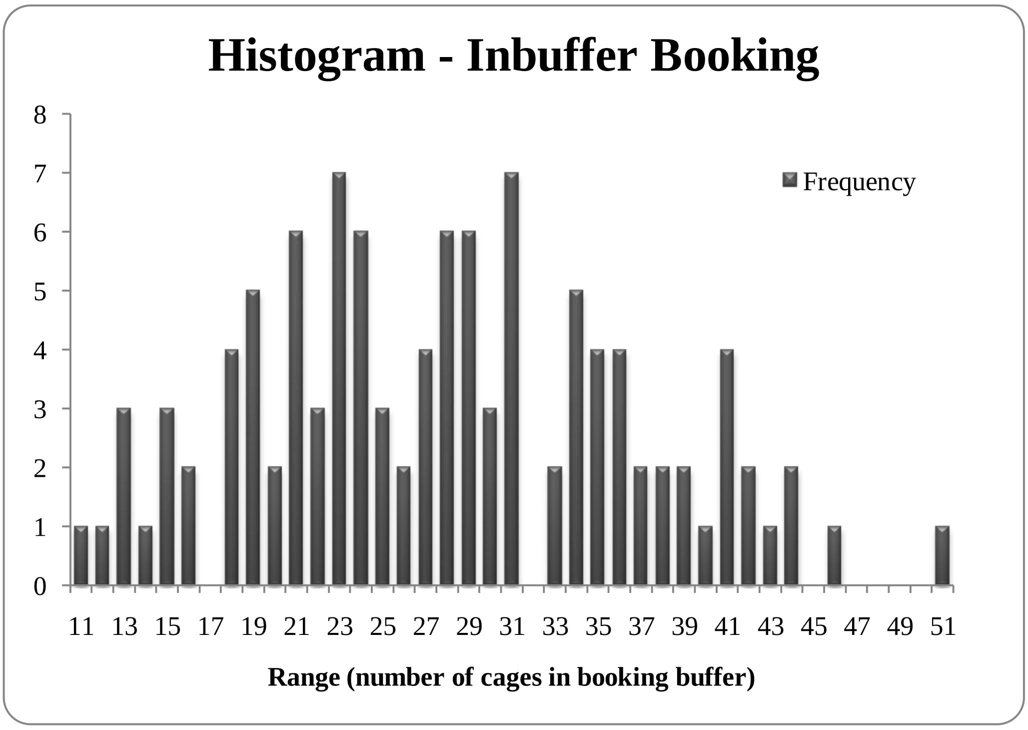
Support processes:	p	Limit of error 95% confidence	Limit of error 99% confidence
Job rotation	**0.99%**	0.30%	0.40%
Empty garbage	**1.50%**	0.37%	0.49%
Get material	**0.02%**	0.05%	0.06%

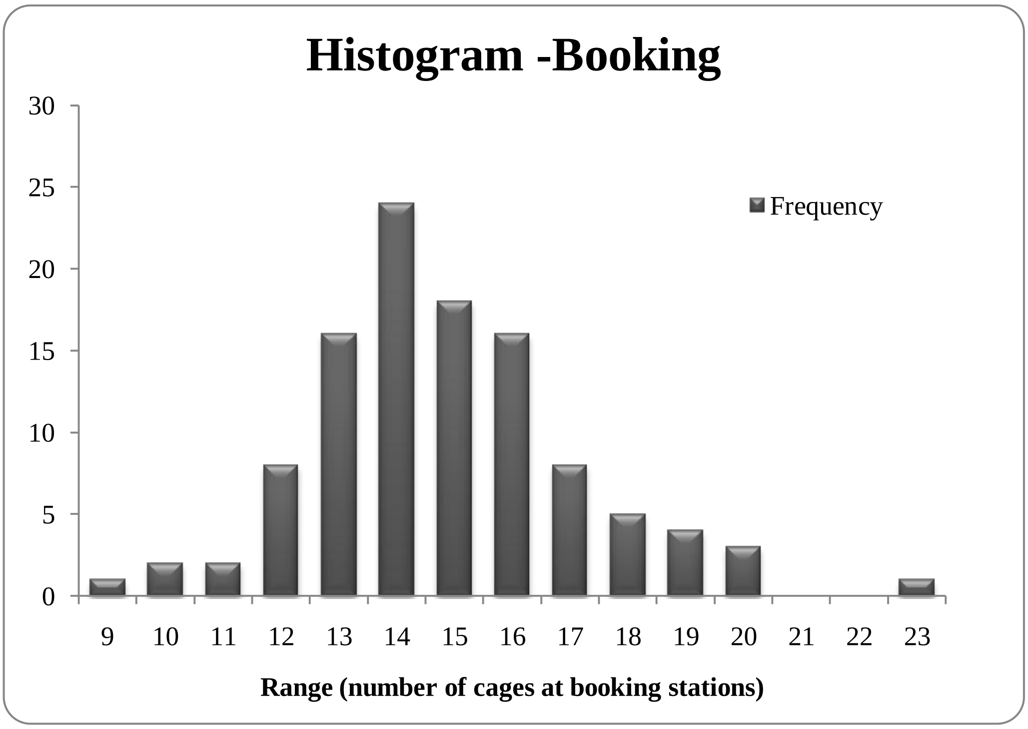
Other:	p	Limit of error 95% confidence	Limit of error 99% confidence
Talk / Idle	**4.78%**	0.65%	0.85%
Allowances	**0.68%**	0.25%	0.33%
Interrupted	**0.48%**	0.21%	0.28%
Unknown	**1.53%**	0.37%	0.49%

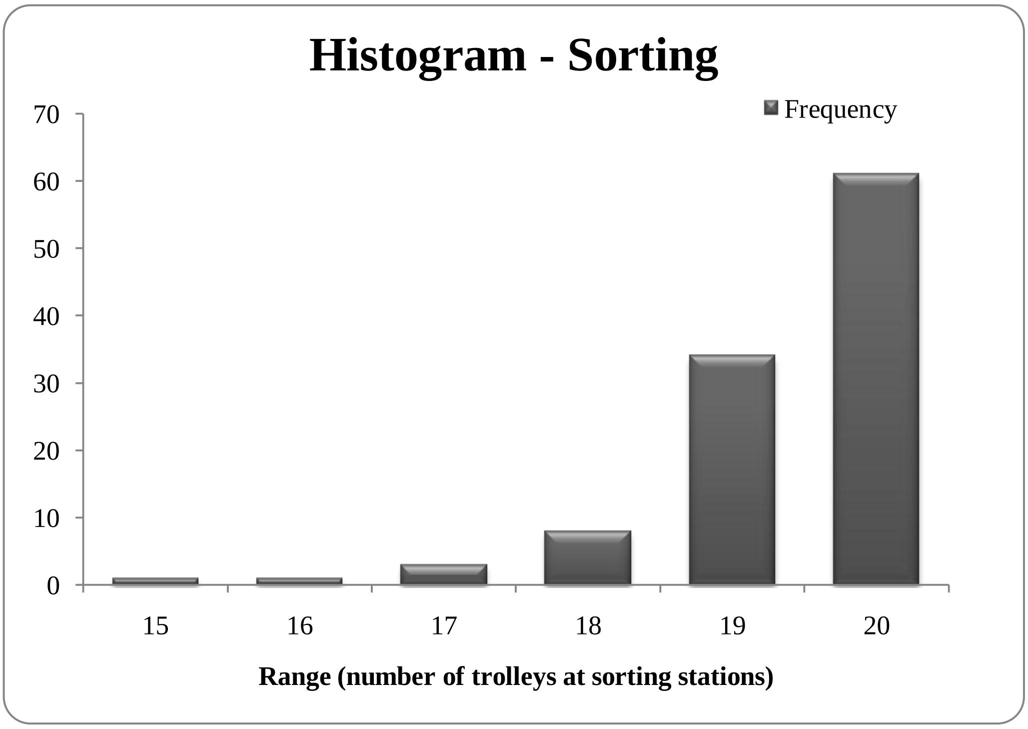
Appendix – C

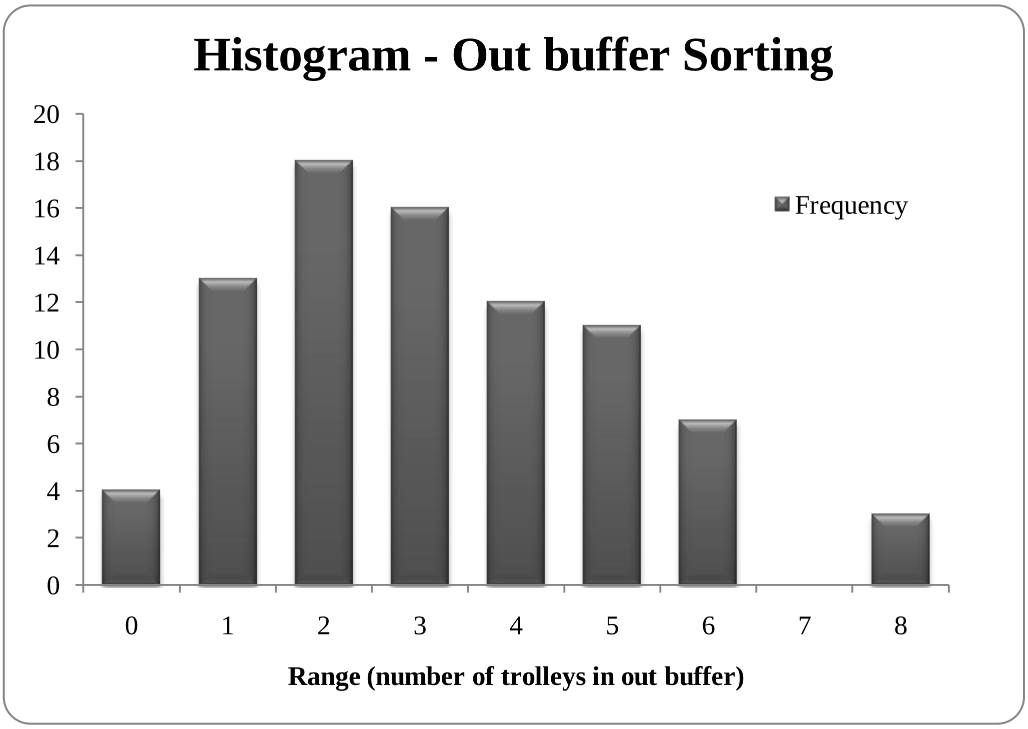
Buffer Sampling






Histogram -Booking
30
25
20
15
10
5
0
Frequency
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
Range (number of cages at booking stations)


Histogram - Sorting
Frequency
70
60
50
40
30
20
10
0
15
16
17
18
19
20
Range (number of trolleys at sorting stations)


Histogram - Out buffer Sorting
20
18
16
14
12
10
8
6
4
2
0
Frequency
0
1
2
3
4
5
6
7
8
Range (number of trolleys in out buffer)

Appendix – D

Translation of “yellow note” used in lead time measurements.

	Date	Time
Placed in cage after opened	/	:
Initiated booking	/	:
After repacked	/	:
Sorted into trolley	/	:
Placed on location in Dispatch Stock	/	:

Instructions for each workstation:

”**Placed in cage after opened”** filled out by Ellinor or Richard.

”**Initiated booking”** filled out by booking operator immediately after booking has been initiated.

”After repacked” filled out before the article is placed on the conveyor belt. The yellow note shall be attached with tape on the same side as the return label.

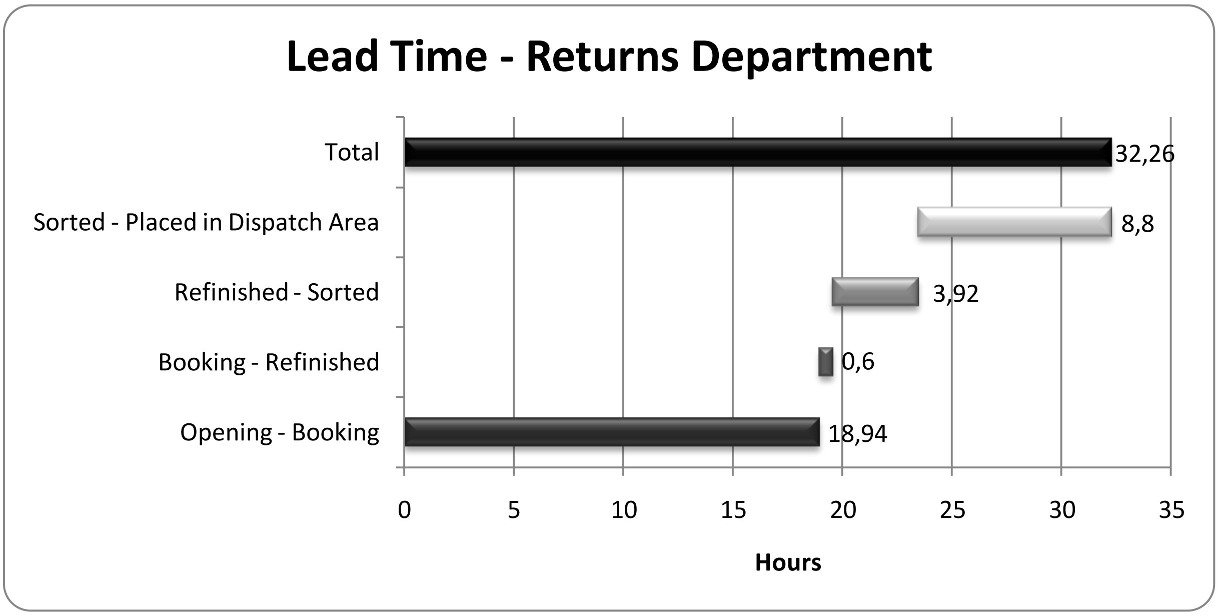
”Sorted into trolley” filled out when an article is picked from sorting chute and sorted into one of the trolley compartments.

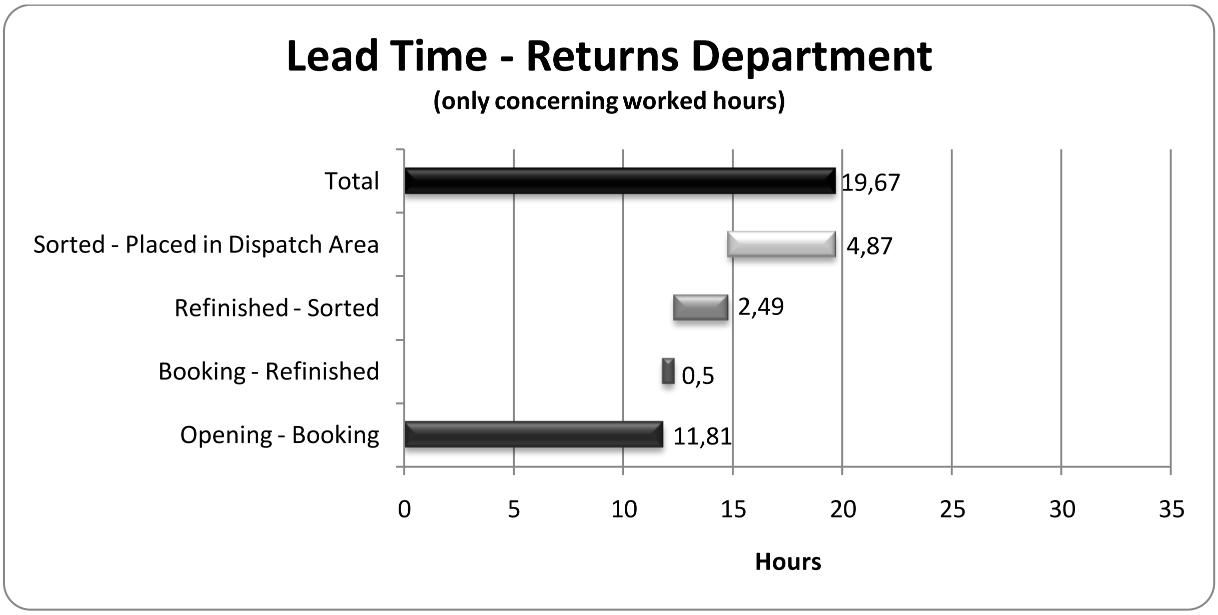
”Placed on location in Dispatch Stock” remove the yellow note when the article has been restored to its location in Dispatch Stock. Fill out time and date, and thereafter leave the yellow note in the box marked with “YELLOW NOTE” in Sorting Area.

OBS! Articles with yellow notes shall <u>not</u> be prioritized or undergo any kind of special treatment.

Thank you for your cooperation!

Appendix – E


Lead Time - Returns Department
Total
Sorted - Placed in Dispatch Area
Refinished - Sorted
Booking - Refinished
Opening - Booking
32,26
8,8
3,92
0,6
18,94
0
5
10
15
20
25
30
35
Hours


Lead Time - Returns Department
(only concerning worked hours)
Total
Sorted - Placed in Dispatch Area
Refinished - Sorted
Booking - Refinished
Opening - Booking
19,67
4,87
2,49
0,5
11,81
0
5
10
15
20
25
30
35
Hours

Appendix – F

Production statistic from year 2009

5.63	items/unclaimed order
2.83	items/returned order
83.098%	customer returns of total incoming orders
16.902%	unclaimed of total incoming orders
36.519%	unclaimed and customer orders from Sweden
46.579%	unclaimed and customer orders from Finland and Denmark
65.747%	items with stock location in zones ABGKLXYZ
7.325%	items with stock location in zones CD
26.927%	items with stock location in zone H

Capacity coefficients

Opening		**coeff.**	**items/hour**
Unclaimed orders	Denmark	0.857	70.0
Unclaimed orders	Finland	0.857	70.0
Unclaimed orders	Sweden	0.857	70.0
Returned orders	Denmark	0.950	63.1
Returned orders	Finland	0.950	63.1
Returned orders	Sweden	0.747	80.3
Booking/Refinish/Repack			
Unclaimed orders	Denmark	0.742	80.9
Unclaimed orders	Finland	0.742	80.9
Unclaimed orders	Sweden	0.742	80.9
Unclaimed items	Denmark	0.362	165.7
Unclaimed items	Finland	0.362	165.7
Unclaimed items	Sweden	0.362	165.7
Returned orders	Denmark	1.268	47.3
Returned orders	Finland	1.268	47.3
Returned orders	Sweden	1.268	47.3
Returned items	Denmark	1.244	48.2
Returned items	Finland	1.244	48.2
Returned items	Sweden	1.244	48.2
New booked articles		0.183	327.9
Sorting and place at stock location in Dispatch Area			
Sort and place articles with stock location in zones ABGKLXYZ		0.361	166.2
Sort and place articles with stock location in zones C,D		0.433	138.6
Sort and place articles with stock location in zone H		0.352	170.5

Appendix – G

Capacity calculations

OPENING

Unclaimed		Finland, Denmark		Sweden	
70	orders/hour	63.1	orders/hour	80.3	orders/hour
0.0194	orders/sec	0.0175	orders/sec	0.0223	orders/sec
51.4286	sec/order	57.0523	sec/order	44.8319	sec/order
5.63	items/order	2.83	items/order	2.83	items/order
0.1095	items/sec	0.0496	items/sec	0.0631	items/sec
9.1347	sec/item	20.1598	sec/item	15.8417	sec/item
394.100	items/hour	178.573	items/hour	227.249	items/hour

Output opening

1 operator	
232.777	items/hour

BOOKING

Unclaimed		Returns from customer	
80.9	"orders"/hour	47.3	"orders"/hour
0.0124	hours/"order"	0.0211	hours/"order"
165.7	items/hour	48.2	items/hour
0.0060	hours/items	0.0207	hours/items
0.0463	hours/order	0.0799	hours/order
21.5806	orders/hour	12.5226	orders/hour
0.3597	orders/min	0.2087	orders/min
0.0060	orders/sec	0.0035	orders/sec
166.8168	sec/order	287.4792	sec/order
0.0338	items/sec	0.0098	items/sec
29.6300	sec/item	101.5828	sec/item
121.4985	items/hour	35.4391	items/hour

Output booking (both unclaimed and returns)

1 operator		3-group	
49.9845	items/hour	149.9536	items/hour

Output booking (only unclaimed)

1 operator	
121.4985	items/hour

Output booking (only returns)

1 operator		3-group	
35.4391	items/hour	106.3172	items/hour

SORTED AND PLACED AT STOCK LOCATION IN DISPATCH AREA

166.2	items/hour	zones ABGKLXYZ
138.6	items/hour	zones CD
170.5	items/hour	zone H

165.3361	items/hour
2.7556	items/min
0.0459	items/sec
21.7738	sec/item
0.0060	hours/item

Output placed at location in Dispatch Area

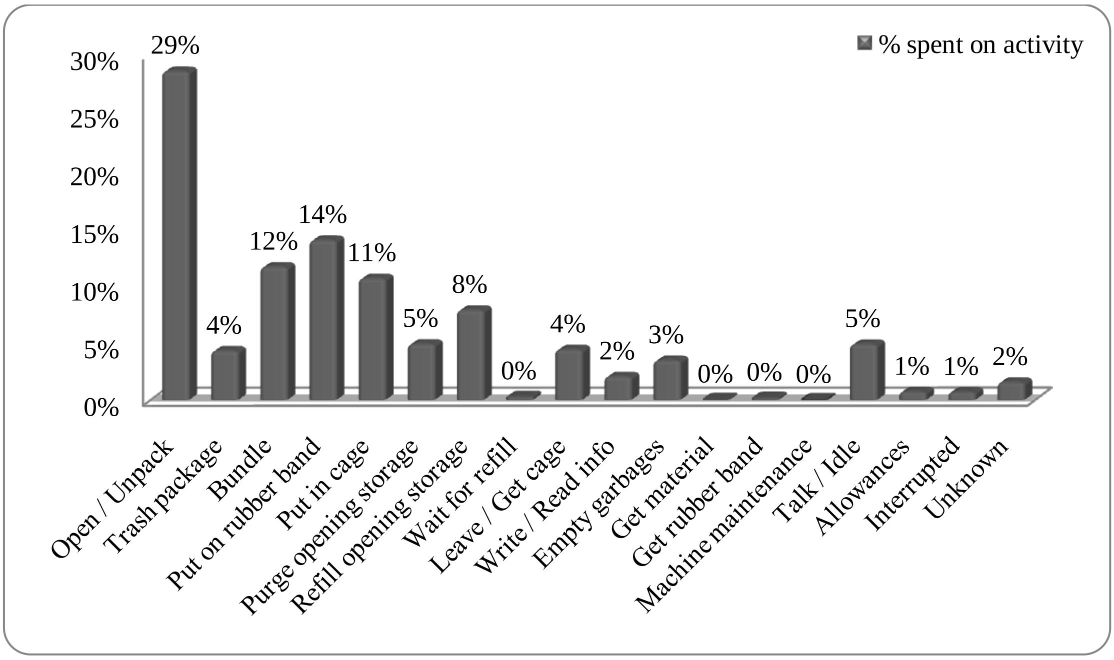
1 operator

165.3361 items/hour

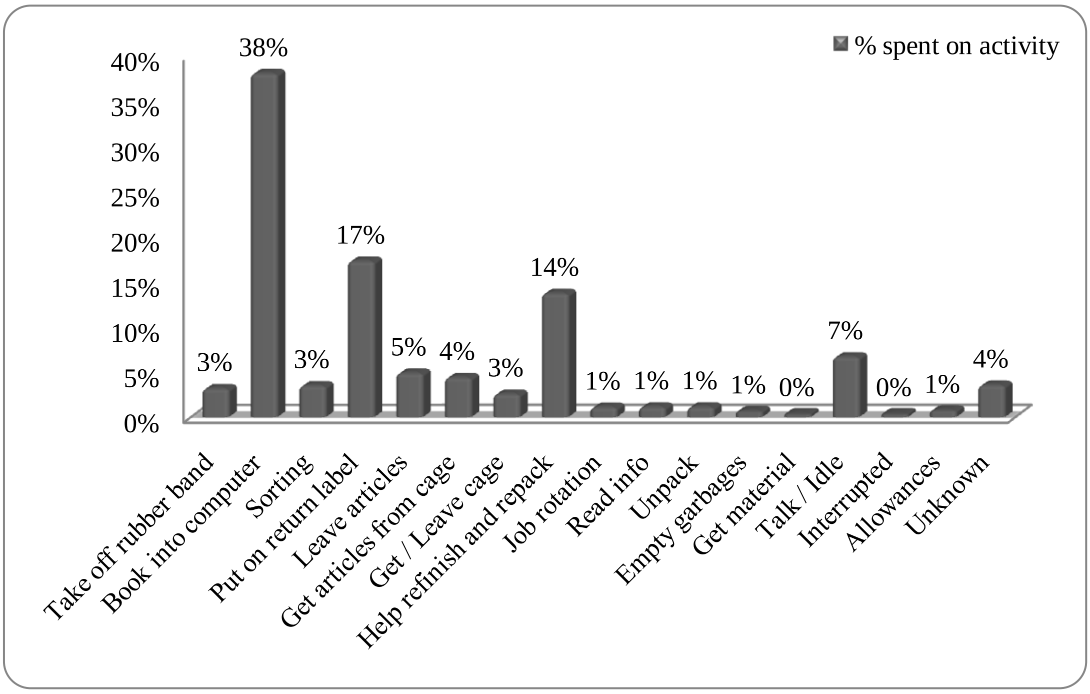
Appendix – H

Work Sampling

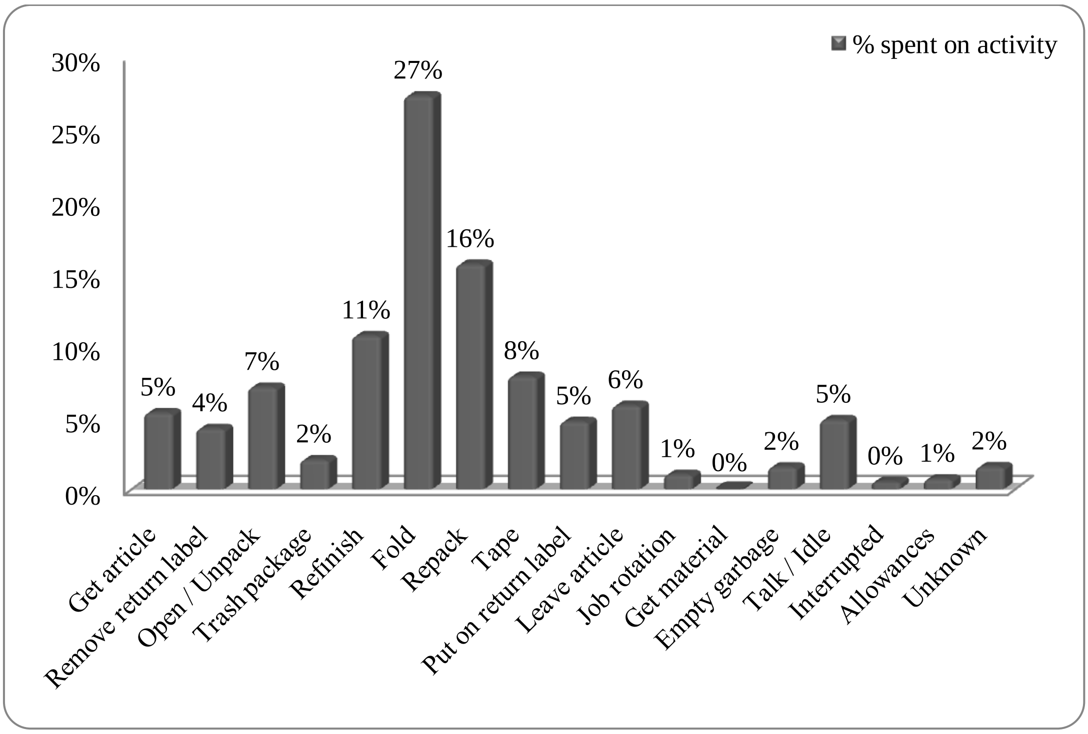
Opening: 3700 samples.



Booking: 3600 samples.



Refinish and repack: 4200 samples.



Appendix – I

The return codes

1	Too small size
2	Too large size
3	Does not correspond to expectations
4	Defect
5	Shrink
6	Defect from laundry
7	Other reasons
8	Wrongly booked
9	Article missing

Additional codes, not issued by customer:

O	Unclaimed
B	Order stopped before delivery

Appendix – J

Opening		Booking		Refinishing		Sorting		Placed in Dispatch Area	
Date	Time	Date	Time	Date	Time	Date	Time	Date	Time
11	08:45	12	07:25	12	07:28	12	08:13	12	18:45
11	08:45	12	07:33	12	07:34	xx	xx	12	10:55
11	08:45	15	11:28	15	12:06	15	12:16	15	15:52
11	08:45	11	15:10	11	15:40	11	15:45	11	21:25
11	08:45	11	12:13	11	12:55	11	13:24	12	07:38
11	08:45	11	13:12	11	14:08	xx	xx	11	16:30
11	08:45	12	08:43	12	09:05	12	09:35	12	11:39
11	09:15	11	12:10	11	12:50	11	13:24	11	16:42
11	09:15	11	16:30	11	17:10	11	17:47	12	07:35
11	09:15	11	17:00	11	17:50	11	18:06	11	21:06
11	09:15	12	08:38	12	08:52	12	09:10	12	10:00
11	09:15	11	12:04	11	13:40	11	13:42	11	16:00
11	09:15	11	11:05	11	11:20	xx	xx	11	13:35
11	09:15	11	16:38	11	16:47	11	16:52	xx	xx
11	09:15	12	08:05	12	08:06	12	09:00	12	10:23
11	09:15	11	15:15	xx	xx	11	16:45	11	21:50
11	11:30	11	14:55	11	15:25	xx	xx	11	18:50
11	11:30	11	15:25	11	16:15	11	17:10	12	09:55
11	11:30	15	14:47	15	14:54	15	15:10	16	07:00
11	10:30	12	10:15	12	11:50	12	12:04	12	17:04
11	11:30	11	21:20	11	21:21	11	21:45	12	10:11
11	11:30	11	14:50	11	15:00	11	15:20	11	21:45
11	12:00	12	09:20	12	09:22	12	09:44	12	12:23
11	12:00	11	14:25	11	14:40	xx	xx	11	16:33
11	12:00	11	15:10	11	15:28	11	15:45	11	18:55
11	12:00	11	15:45	11	16:15	11	18:05	11	21:15
11	12:00	11	15:15	11	15:43	11	16:30	12	08:25
11	12:00	12	06:18	12	06:25	12	06:45	12	10:13
11	12:00	12	11:14	12	11:15	12	11:30	12	11:53
11	12:00	12	12:22	12	12:23	xx	xx	12	15:19
11	12:00	11	20:35	11	21:05	11	21:45	12	08:09
11	12:00	16	10:05	16	10:15	17	08:30	xx	xx
11	12:00	15	14:45	15	14:46	xx	xx	15	18:10
11	12:00	12	10:46	12	10:47	12	11:26	13	08:45
15	08:15	15	11:37	15	12:00	15	12:06	16	06:25
15	08:15	15	14:45	xx	xx	16	09:53	16	20:23
15	08:15	16	09:20	16	09:27	16	09:52	16	18:25
15	08:15	15	11:35	15	11:41	15	11:44	15	13:25
15	08:15	15	11:38	15	11:40	16	06:45	16	07:00
15	08:15	15	10:00	15	10:03	15	10:10	15	14:30
15	08:15	16	13:28	xx	xx	16	21:07	17	10:14

Opening		Booking		Refinishing		Sorting		Placed in Dispatch Area	
Date	Time	Date	Time	Date	Time	Date	Time	Date	Time
15	08:15	15	11:21	15	11:23	15	11:25	15	14:11
15	08:15	16	13:50	16	14:25	16	15:30	16	19:15
15	08:15	15	09:50	15	10:03	15	10:25	xx	xx
15	08:15	16	09:58	16	10:10	17	07:50	xx	xx
15	08:15	16	15:45	xx	xx	16	16:05	16	20:04
15	09:15	15	17:44	15	17:46	xx	xx	xx	xx
15	09:15	15	16:00	15	16:01	16	06:45	16	08:40
15	09:15	16	13:13	16	14:16	16	20:14	17	08:55
15	09:15	16	09:18	16	15:03	17	14:00	17	14:49
15	09:15	15	11:40	15	12:30	15	13:07	15	14:05
15	09:15	15	13:00	15	13:20	xx	xx	xx	xx
15	09:15	15	10:00	15	10:02	15	10:08	15	14:50
15	09:15	16	13:25	xx	xx	16	14:40	16	18:35
15	09:15	16	13:20	16	13:35	16	21:10	17	06:35
15	09:15	15	17:30	15	18:00	xx	xx	xx	xx
15	09:15	15	09:40	15	09:58	15	11:40	15	12:10
15	09:15	15	15:55	15	16:05	15	16:25	15	19:50
15	09:15	15	15:30	15	16:00	xx	xx	15	18:43
15	09:15	15	20:00	15	20:02	16	07:30	16	07:50
15	11:00	15	18:41	15	18:44	15	20:45	16	07:42
15	11:00	15	15:25	xx	xx	xx	xx	15	18:24
15	11:00	15	14:18	15	15:42	15	15:43	16	06:19
15	11:00	15	13:15	15	13:55	15	14:00	16	07:45
15	11:00	16	12:00	16	12:08	16	12:58	16	16:06
15	11:00	16	11:07	xx	xx	xx	xx	16	19:41
15	11:00	15	14:36	15	14:40	15	20:20	16	08:10
15	11:00	15	15:20	15	15:21	15	16:35	15	17:30
15	11:00	15	13:32	15	13:44	15	14:00	16	07:55
15	11:00	16	11:40	16	11:42	16	11:45	16	14:24
15	11:00	15	12:56	15	13:16	15	13:27	16	06:25
15	11:00	16	10:10	16	10:12	16	16:20	17	10:45
15	11:00	15	12:45	15	12:47	15	21:00	16	08:10
15	11:00	16	11:23	xx	xx	16	11:35	16	18:44
15	15:00	16	11:35	16	12:43	16	15:05	16	16:42
15	15:00	16	11:33	16	12:00	16	12:05	xx	xx
15	15:00	16	14:38	16	14:41	16	16:05	16	20:04
15	15:00	16	14:55	16	15:05	16	15:10	16	20:00
15	15:00	16	14:00	xx	xx	16	21:35	17	08:30
15	15:00	16	10:10	16	10:20	16	10:26	16	12:50
15	15:00	16	14:03	xx	xx	xx	xx	16	18:47
15	15:00	16	11:30	16	11:45	16	13:10	16	14:11
15	15:00	16	09:58	16	10:20	16	10:25	16	13:04

Opening		Booking		Refinishing		Sorting		Placed in Dispatch Area	
Date	Time	Date	Time	Date	Time	Date	Time	Date	Time
15	15:00	16	15:00	16	15:01	16	15:19	xx	xx
15	15:00	16	11:50	16	12:03	16	13:06	16	14:20
15	15:00	16	12:25	16	13:00	xx	xx	16	18:19
15	15:00	15	20:04	15	20:17	16	07:04	16	08:52
15	15:00	16	10:00	16	10:30	xx	xx	xx	xx
15	15:00	16	10:02	16	10:13	16	10:20	16	11:17
15	16:45	16	10:15	16	10:45	16	10:50	xx	xx
15	16:45	17	12:53	17	12:55	xx	xx	18	11:15
15	16:45	16	13:33	16	13:40	16	14:50	16	16:39
15	16:45	16	11:13	16	11:21	16	11:31	16	20:08
15	16:45	16	13:55	16	13:56	xx	xx	16	19:50
15	16:45	16	11:11	16	11:18	xx	xx	xx	xx
15	16:45	16	15:20	16	15:25	16	16:05	16	20:02
16	09:00	16	17:50	xx	xx	16	17:59	16	20:10
16	09:00	16	16:30	xx	xx	16	17:40	17	18:39
16	09:00	16	19:48	16	20:25	16	21:35	17	08:15
16	09:00	17	07:24	17	07:45	17	07:48	17	10:01
16	09:00	17	07:28	17	07:45	17	08:35	17	10:54
16	09:00	16	17:55	xx	xx	16	18:53	17	08:45
16	09:00	16	18:15	xx	xx	16	18:49	16	21:00
16	09:00	17	08:45	17	08:46	17	09:35	17	11:25
16	09:00	16	11:29	16	11:40	16	11:45	16	19:55
16	09:00	16	16:50	16	17:45	16	18:20	16	18:30
16	09:00	16	21:11	16	21:15	17	09:40	17	11:05
16	09:00	16	17:35	16	17:46	16	18:38	16	20:33
16	09:00	16	11:35	16	11:43	16	11:50	16	13:35
16	09:00	16	18:20	xx	xx	16	18:40	16	20:57
16	09:00	17	07:27	17	07:45	17	09:55	17	13:45
16	09:00	16	21:09	16	21:15	17	09:00	17	13:19
16	11:00	17	09:32	17	09:38	17	10:40	17	13:00
16	11:00	17	09:32	17	09:37	17	09:44	17	14:05
16	11:00	16	18:55	xx	xx	16	21:45	17	07:45
16	11:00	16	19:35	xx	xx	16	20:24	17	11:49
16	11:00	17	08:20	17	08:47	xx	xx	17	12:00
16	11:00	16	17:00	xx	xx	16	17:10	xx	xx
16	11:00	17	08:50	17	09:00	17	09:20	17	11:16
16	13:00	16	17:00	16	17:30	16	17:45	16	19:40
16	13:00	17	06:43	17	07:40	17	08:40	xx	xx
16	13:00	16	20:15	16	20:40	16	21:36	17	09:51
16	13:00	16	19:50	xx	xx	16	20:16	17	12:50
16	13:00	16	18:45	xx	xx	17	09:05	17	12:10
16	13:00	16	20:20	16	20:30	16	21:35	17	11:15
16	13:00	16	19:38	16	19:50	16	20:23	xx	xx

Opening		Booking		Refinishing		Sorting		Placed in Dispatch Area	
Date	Time	Date	Time	Date	Time	Date	Time	Date	Time
16	14:30	17	11:05	17	11:06	18	10:33	18	11:45
16	14:30	17	13:30	17	13:31	18	15:20	xx	xx
16	14:30	17	14:05	17	14:10	17	14:15	18	08:00
16	14:30	17	10:28	17	10:45	xx	xx	18	08:55
16	14:30	17	11:28	xx	xx	xx	xx	xx	xx
16	14:30	16	17:43	16	18:08	16	18:49	16	20:25
16	14:30	18	08:42	18	08:43	19	07:42	xx	xx
16	16:00	17	10:17	17	10:50	17	13:10	xx	xx
16	16:00	16	19:30	16	21:35	16	21:53	17	08:55
16	16:00	17	12:20	17	12:22	18	10:51	18	16:19
16	16:00	17	10:23	17	10:40	17	10:53	17	14:05
16	16:00	18	08:34	18	08:35	xx	xx	xx	xx
16	16:00	17	10:22	17	10:23	18	13:20	19	06:55
16	16:00	18	06:17	18	06:37	xx	xx	xx	xx
16	16:00	17	14:11	17	14:20	18	07:45	18	09:10
16	16:00	18	06:05	18	06:08	18	09:50	18	11:10
17	08:20	17	10:05	17	10:07	17	10:09	xx	xx
17	08:20	17	11:43	17	12:50	17	13:45	18	07:49
17	08:20	17	12:00	17	12:15	17	13:00	17	14:45
17	08:20	18	11:06	18	11:07	18	11:34	18	17:50
17	08:20	17	11:40	17	11:48	17	14:35	18	08:30
17	08:20	18	08:25	18	08:26	18	10:20	18	16:27
17	08:20	17	10:27	17	10:47	17	10:52	17	14:30
17	08:20	17	10:50	17	10:55	17	10:58	17	14:10
17	08:20	17	13:38	17	13:53	xx	xx	19	07:06
17	08:20	17	13:36	17	14:00	18	11:45	18	17:33
17	08:20	17	11:35	17	11:41	17	13:30	18	08:02
17	08:20	18	12:12	18	12:28	xx	xx	18	17:05
17	08:20	18	08:40	18	08:45	19	09:40	19	11:25
17	10:30	17	13:40	17	13:41	17	14:00	17	18:20
17	10:30	18	12:06	18	12:09	18	12:25	22	11:43
17	10:30	17	12:52	17	12:58	17	13:40	17	17:29
17	10:30	17	13:38	17	13:54	18	09:35	xx	xx
17	10:30	17	11:34	xx	xx	17	11:36	18	07:05
17	10:30	17	11:31	17	11:56	xx	xx	17	14:20
17	10:30	22	06:27	22	06:30	22	17:00	22	17:30
17	10:30	22	08:38	xx	xx	22	10:35	22	14:20
17	10:30	18	08:58	18	09:00	18	11:29	18	16:35
17	10:30	18	10:26	18	10:27	19	06:07	19	10:59
17	10:30	18	07:40	18	10:22	18	14:40	19	07:00
17	10:30	18	13:40	18	13:41	18	14:50	19	09:05
17	10:30	18	08:35	18	08:36	18	15:08	18	17:00
17	10:30	18	09:07	18	09:08	18	15:05	18	17:00

Opening		Booking		Refinishing		Sorting		Placed in Dispatch Area	
Date	Time	Date	Time	Date	Time	Date	Time	Date	Time
17	10:30	23	06:25	xx	xx	23	07:00	23	11:30
17	10:30	19	10:00	19	10:45	xx	xx	22	10:20
17	10:30	17	13:57	17	14:03	17	14:10	18	08:05
17	10:30	17	13:59	17	14:08	17	15:32	18	10:13
17	10:30	17	11:16	17	11:18	17	13:05	17	13:55
17	13:15	18	12:37	18	12:38	xx	xx	18	17:30
17	13:15	19	09:10	xx	xx	19	10:25	19	12:55
17	13:15	18	09:04	18	09:26	18	09:40	18	10:25
17	13:15	18	13:40	18	13:41	18	14:00	19	07:10
17	13:15	17	14:47	17	14:50	17	15:47	xx	xx
17	13:15	19	06:12	19	06:42	19	07:06	19	13:53
17	13:15	19	10:25	19	10:53	22	07:50	24	08:15
17	13:15	19	06:06	19	06:16	19	06:20	19	13:56
17	13:15	18	06:45	18	06:55	18	07:50	18	13:35
17	13:15	18	09:52	18	10:00	18	10:10	18	16:50
17	13:15	18	09:45	18	09:48	19	09:57	19	11:00
17	13:15	18	11:50	18	11:51	xx	xx	18	16:45
17	13:15	19	11:27	19	11:30	19	13:58	22	10:05
17	13:15	19	10:21	19	10:22	22	06:55	22	08:43
17	13:15	19	07:50	xx	xx	22	13:50	23	07:55
17	15:30	19	09:00	xx	xx	19	10:00	19	10:45
17	15:30	18	07:11	18	08:15	xx	xx	18	16:58
17	15:30	18	08:35	18	08:57	18	09:45	18	11:20
17	15:30	18	09:42	18	10:08	18	14:55	19	11:37
17	15:30	18	08:50	18	09:40	18	10:15	18	16:37
17	15:30	xx	xx	19	09:38	19	10:02	22	09:25
17	15:30	18	10:30	18	10:40	18	11:03	18	11:45
17	15:30	19	10:15	19	10:24	19	10:50	22	09:10
17	15:30	18	10:11	18	10:18	18	11:08	18	17:10
17	15:30	18	10:07	18	10:10	18	11:29	18	16:30
22	10:15	23	10:11	23	10:50	23	10:52	23	13:30
22	10:15	23	09:35	23	09:45	23	09:47	23	11:15
22	10:15	xx	xx	23	10:05	23	10:50	23	14:45
22	10:15	xx	xx	23	10:05	23	11:10	23	14:37
22	10:15	23	09:15	23	09:16	23	09:50	23	11:00
22	10:15	23	09:50	23	09:51	xx	xx	23	12:45
22	10:15	23	09:52	23	09:53	23	10:47	23	13:16
22	10:15	23	10:45	23	10:50	23	15:45	23	16:10
22	10:15	23	09:41	23	09:51	23	10:45	23	13:25
22	10:15	23	12:00	23	12:53	23	16:53	24	08:45
22	10:15	22	11:47	22	12:00	22	17:10	22	19:50
22	12:00	23	11:45	23	11:46	xx	xx	23	14:00
22	12:00	23	09:00	23	09:10	23	09:20	23	10:20

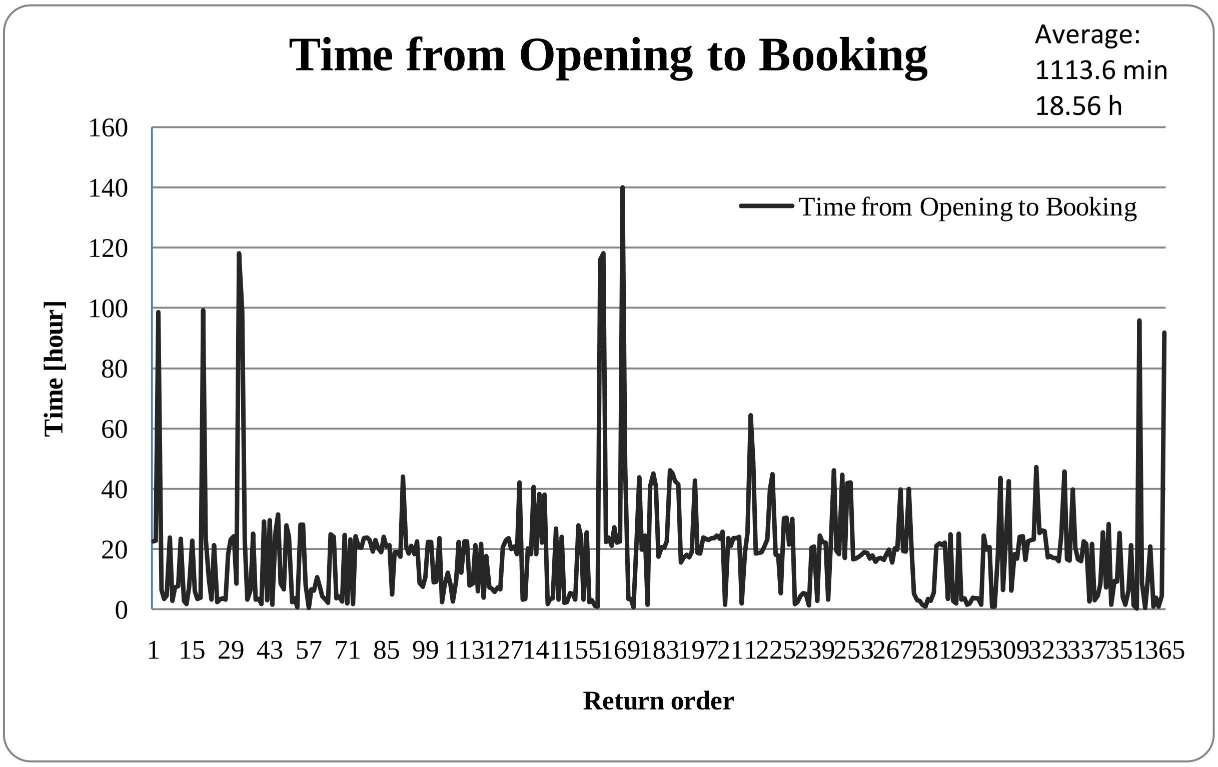
Opening		Booking		Refinishing		Sorting		Placed in Dispatch Area	
Date	Time	Date	Time	Date	Time	Date	Time	Date	Time
22	12:00	23	11:34	23	11:40	23	12:42	23	14:53
22	12:00	23	11:40	23	11:56	23	12:55	24	08:45
22	12:00	23	12:10	23	12:55	xx	xx	xx	xx
22	12:00	22	14:00	22	14:01	22	17:33	23	06:35
22	12:00	23	06:45	23	07:13	23	07:45	23	08:30
22	12:00	23	13:15	23	13:20	24	12:00	24	12:55
22	14:15	xx	xx	23	11:10	23	14:35	23	18:20
22	14:15	25	06:44	25	06:45	xx	xx	25	15:30
22	14:15	24	15:11	24	15:13	xx	xx	24	20:55
22	14:15	23	08:52	23	09:00	xx	xx	23	14:46
22	14:15	23	09:03	23	09:08	23	09:35	23	14:51
22	14:15	23	09:20	23	09:47	xx	xx	23	18:10
22	14:15	23	11:00	23	11:15	23	11:33	24	09:45
22	15:00	xx	xx	23	11:05	23	11:55	24	15:30
22	15:00	23	14:12	23	14:15	23	18:00	23	19:00
22	15:00	24	06:40	xx	xx	xx	xx	24	17:10
22	15:00	24	11:59	24	12:05	24	18:34	25	07:50
22	15:00	23	09:12	23	09:16	23	14:07	23	18:40
22	15:00	23	08:50	23	09:00	23	14:20	23	18:00
23	09:00	23	14:25	23	14:27	24	06:35	24	08:35
23	09:00	24	15:15	24	15:16	24	17:55	25	10:31
23	09:00	24	15:30	24	15:45	24	16:02	25	11:20
23	09:00	24	06:35	24	09:26	xx	xx	24	17:00
23	09:00	24	15:05	24	15:50	24	16:15	24	19:55
23	09:00	23	10:44	23	10:45	xx	xx	23	12:35
23	09:00	23	11:30	23	11:41	23	11:52	23	13:54
23	09:00	23	13:36	23	13:38	23	16:47	24	08:11
23	09:00	23	14:20	23	14:35	24	07:30	24	14:02
23	09:00	23	14:10	23	14:26	23	14:50	24	08:30
23	09:00	23	10:15	23	10:20	xx	xx	24	10:50
23	09:00	xx	xx	23	10:50	xx	xx	23	15:07
23	11:45	xx	xx	23	14:30	xx	xx	23	15:43
23	11:45	24	08:13	24	08:31	24	08:47	xx	xx
23	11:45	24	08:35	24	08:55	24	09:07	24	14:30
23	11:45	23	14:35	23	14:38	23	14:43	23	18:40
23	11:45	24	12:12	24	13:00	24	13:30	25	07:25
23	11:45	24	10:12	24	10:22	24	12:00	24	14:05
23	11:45	24	10:00	24	10:07	24	10:10	25	10:31
23	11:45	23	14:55	23	15:15	xx	xx	24	08:46
23	11:45	24	09:09	24	09:36	24	10:30	24	14:10
23	11:45	25	09:52	25	10:25	xx	xx	25	15:30
23	13:45	24	09:05	24	09:15	24	11:50	24	15:00
23	13:45	24	08:06	24	08:23	24	08:35	24	13:35

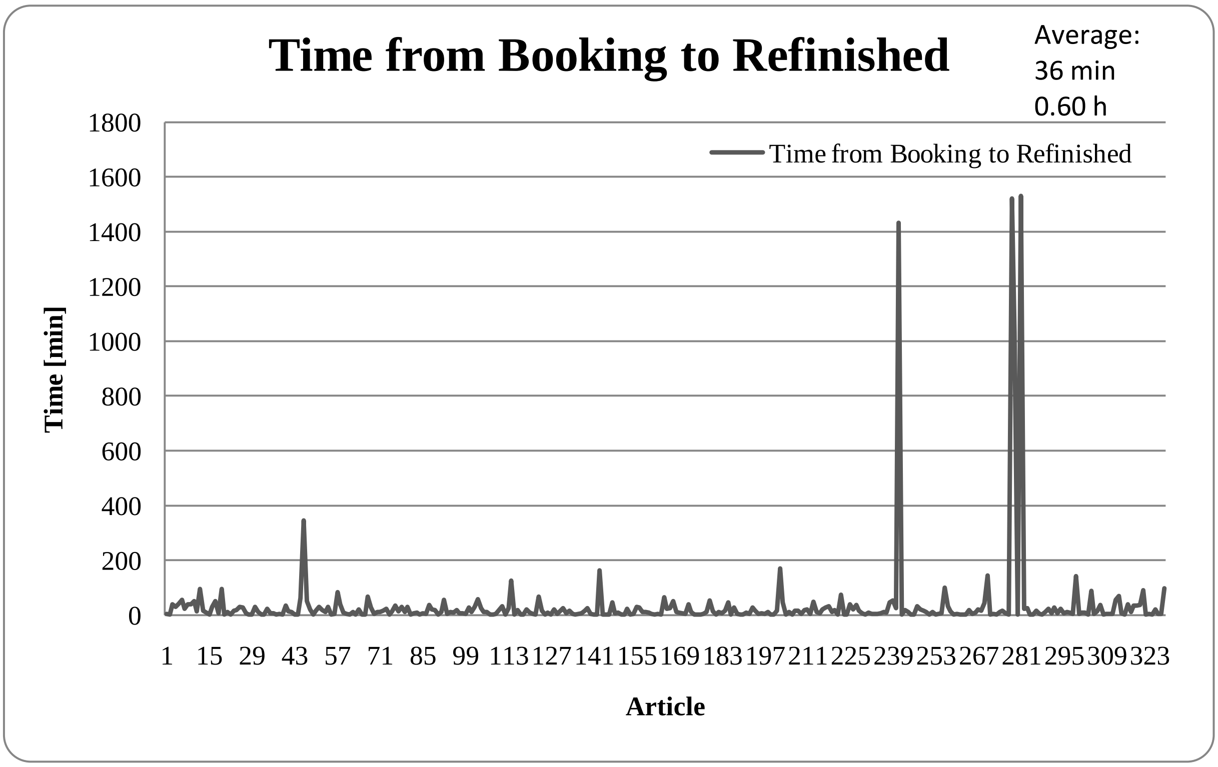
Opening		Booking		Refinishing		Sorting		Placed in Dispatch Area	
Date	Time	Date	Time	Date	Time	Date	Time	Date	Time
23	13:45	25	10:21	25	10:22	25	11:35	25	19:11
23	13:45	24	06:50	24	08:05	26	11:30	26	13:20
23	13:45	25	07:36	25	07:37	25	07:45	25	09:42
23	13:45	25	07:52	25	07:53	25	08:05	25	11:30
23	13:45	24	06:25	24	07:05	25	19:35	26	08:40
23	13:45	24	06:35	24	06:55	xx	xx	xx	xx
23	13:45	24	07:10	24	07:46	24	13:23	25	08:34
23	13:45	24	07:50	24	08:05	24	09:10	24	10:00
23	13:45	24	08:43	24	08:50	24	10:45	24	15:11
23	13:45	24	08:28	24	08:30	24	08:58	xx	xx
23	15:50	24	08:45	24	08:54	24	09:40	24	13:30
23	15:50	24	09:40	24	09:45	xx	xx	24	15:40
23	15:50	24	07:40	24	07:45	24	08:30	24	10:30
23	15:50	24	08:47	24	08:50	24	10:10	24	13:13
23	15:50	24	08:56	24	09:03	24	09:08	24	10:50
23	15:50	24	08:20	24	08:30	xx	xx	25	07:10
23	15:50	24	10:05	24	10:13	24	11:20	24	16:30
23	15:50	24	11:45	24	12:31	24	13:35	25	07:30
23	15:50	24	07:21	24	08:15	24	14:38	24	18:10
23	15:50	24	12:05	24	12:31	24	15:50	25	07:45
23	15:50	24	11:36	25	11:27	25	14:15	25	16:00
23	15:50	25	07:42	25	07:43	25	09:35	25	12:55
23	15:50	24	11:15	24	11:32	24	12:00	24	14:35
23	15:50	24	11:05	24	11:17	24	11:40	24	13:25
23	15:50	25	07:46	25	07:47	25	13:35	25	14:30
24	09:00	25	06:10	25	06:12	25	07:28	25	12:55
24	09:00	24	14:13	24	14:45	xx	xx	25	12:10
24	09:00	24	12:00	24	12:20	24	13:23	24	13:31
24	09:00	24	11:50	24	12:05	24	13:15	25	07:30
24	09:00	24	10:30	24	10:40	24	14:45	xx	xx
24	09:00	24	10:00	24	10:01	24	18:10	24	19:40
24	09:00	24	12:35	24	12:45	xx	xx	25	06:58
24	09:00	24	11:45	24	11:47	24	14:40	24	20:55
24	09:00	24	14:42	24	14:45	24	15:50	24	20:30
24	09:00	25	06:09	25	06:16	25	06:26	25	09:25
24	09:00	25	06:58	xx	xx	25	07:38	25	10:02
24	09:00	25	06:14	25	07:53	25	11:05	25	15:15
24	09:00	25	07:09	25	07:41	25	09:53	25	12:50
24	10:20	24	13:43	24	13:56	xx	xx	25	07:45
24	10:20	25	11:21	25	11:22	25	12:06	25	13:13
24	10:20	24	13:05	24	13:10	24	13:15	25	06:10
24	10:20	24	12:15	24	12:17	24	13:15	25	06:38
24	10:20	25	11:31	25	11:32	25	12:15	25	13:40

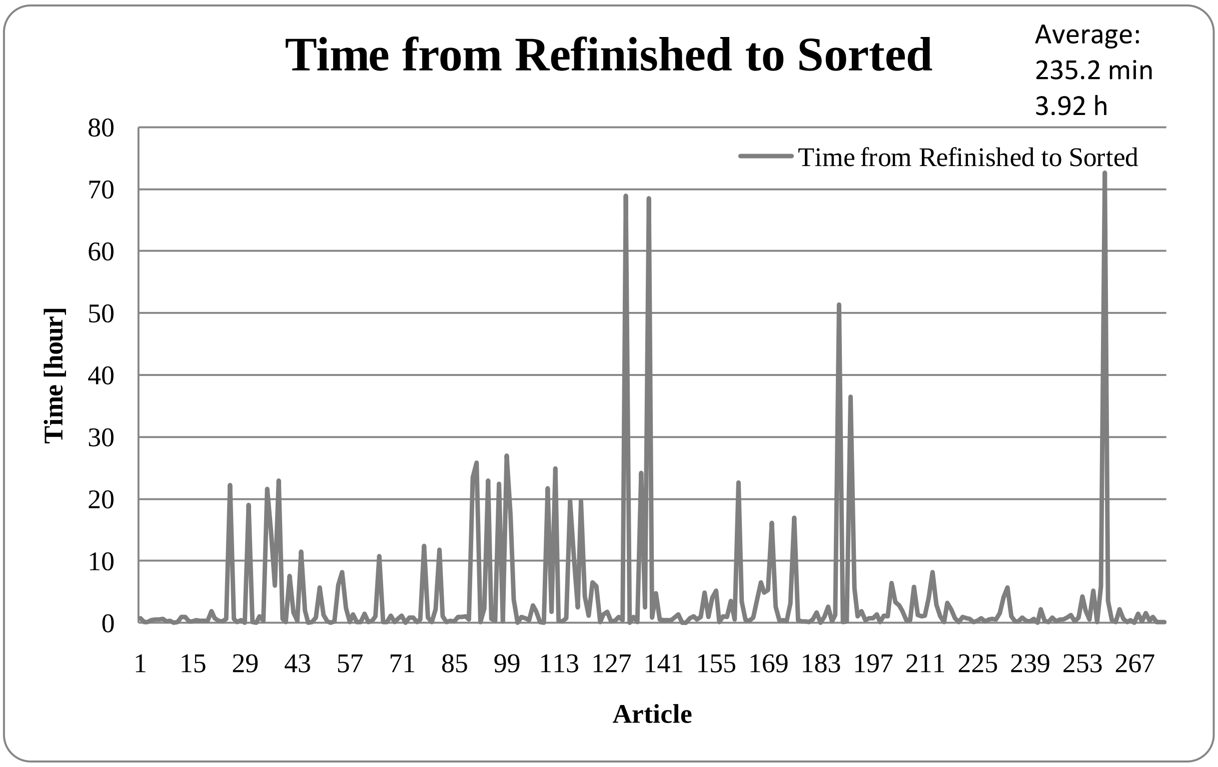
Opening		Booking		Refinishing		Sorting		Placed in Dispatch Area	
Date	Time	Date	Time	Date	Time	Date	Time	Date	Time
24	10:20	24	13:42	24	13:44	24	14:20	24	19:55
24	10:20	24	14:00	24	14:19	24	14:26	xx	xx
24	10:20	24	11:50	24	11:55	24	12:17	24	18:10
24	10:20	24	12:21	24	12:30	24	13:15	25	06:11
24	10:20	24	14:10	24	14:31	24	14:45	25	11:50
24	10:20	24	14:05	24	14:20	24	14:50	24	20:05
24	10:20	24	13:56	24	14:40	24	15:18	25	13:00
24	10:20	24	11:50	24	14:15	24	14:50	25	11:46
24	10:20	25	10:51	25	10:53	xx	xx	25	20:45
24	10:20	25	06:12	25	06:15	25	07:49	25	09:20
24	10:20	25	06:58	25	06:59	25	11:10	25	12:45
24	12:00	24	13:00	24	13:10	24	18:55	25	08:25
24	12:00	24	13:00	24	13:16	24	14:20	24	16:20
24	12:00	25	06:07	25	06:14	25	06:29	25	15:20
24	12:00	26	07:33	26	07:35	xx	xx	29	11:12
24	12:00	24	18:30	25	19:50	25	20:05	25	21:10
24	12:00	25	13:10	26	06:20	26	07:10	26	10:30
24	12:00	26	06:34	26	06:35	xx	xx	29	11:10
24	12:00	24	18:20	25	19:50	25	20:10	26	09:37
24	12:00	25	06:17	25	06:39	25	06:55	25	08:30
24	14:20	25	07:05	25	07:30	25	08:09	25	11:20
24	14:20	25	14:25	25	14:26	25	14:30	26	08:30
24	14:20	25	14:40	xx	xx	25	14:45	25	16:10
24	14:20	25	06:47	25	06:48	25	09:00	25	10:26
24	14:20	25	13:00	25	13:15	xx	xx	25	16:55
24	14:20	25	13:25	xx	xx	25	20:12	25	21:27
24	14:20	25	13:35	xx	xx	25	20:54	26	07:25
24	14:20	26	13:36	26	13:40	26	14:00	26	15:10
24	14:20	25	15:45	25	15:47	25	15:53	26	07:00
24	14:20	25	16:37	25	16:49	25	17:42	26	06:30
24	14:20	25	16:21	25	16:43	xx	xx	26	08:40
24	14:20	25	07:38	25	07:45	25	08:00	25	09:28
24	14:20	25	08:07	25	08:34	25	09:06	25	12:50
24	14:20	25	07:27	25	07:34	25	08:07	25	09:30
24	14:20	25	07:26	25	07:49	25	08:40	25	11:40
24	14:20	25	06:24	25	06:30	25	07:47	25	10:10
24	15:45	25	16:14	xx	xx	xx	xx	26	10:25
24	15:45	26	13:30	26	13:40	26	13:55	29	09:10
24	15:45	25	08:21	25	08:29	xx	xx	25	10:25
24	15:45	25	07:56	25	08:00	25	08:50	25	10:05
24	15:45	26	07:30	26	09:52	26	14:10	30	09:30
24	15:45	25	12:11	25	12:14	25	14:12	25	16:05
24	15:45	25	08:20	25	08:28	25	09:00	25	14:50

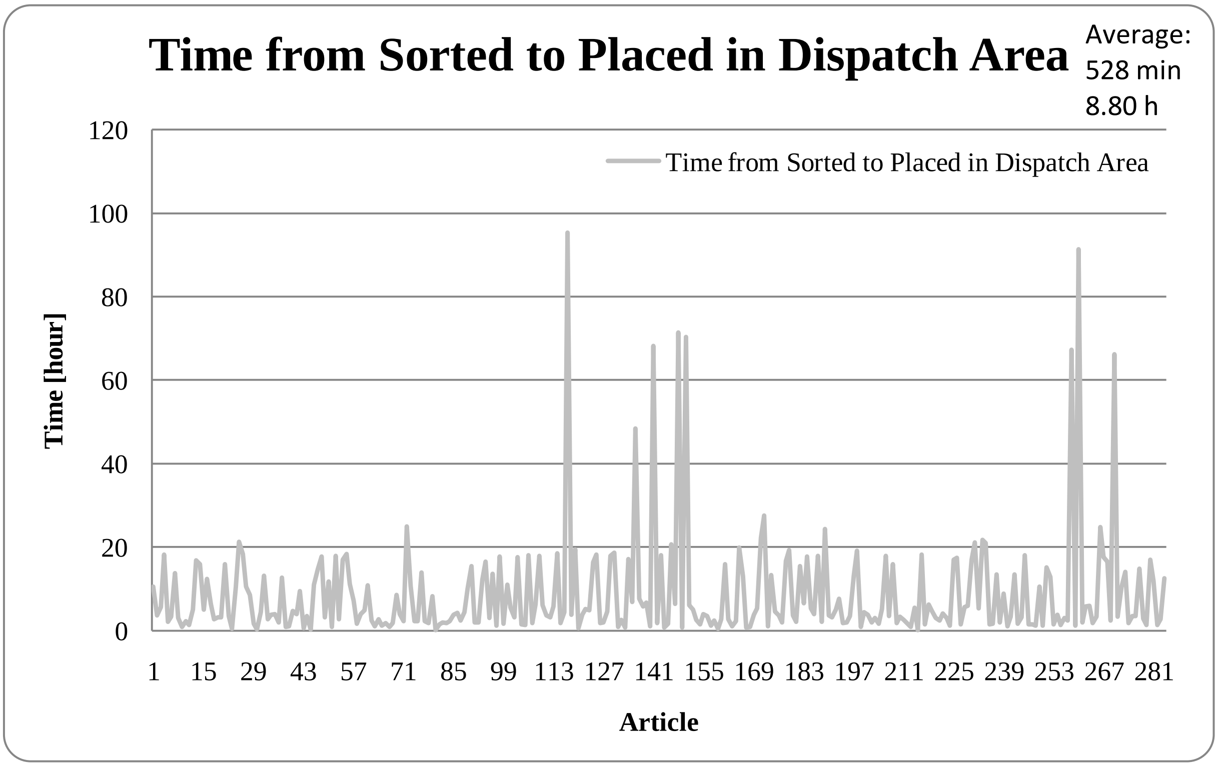
Opening		Booking		Refinishing		Sorting		Placed in Dispatch Area	
Date	Time	Date	Time	Date	Time	Date	Time	Date	Time
24	15:45	25	07:43	25	07:51	25	13:03	25	18:55
24	15:45	25	14:19	25	14:20	25	14:28	25	16:17
25	09:25	26	07:07	26	08:36	xx	xx	30	10:55
25	09:25	25	11:57	25	12:02	25	17:54	25	21:16
25	09:25	26	07:08	26	07:22	29	08:00	30	08:45
25	09:25	25	12:22	25	12:58	25	16:32	26	10:10
25	09:25	25	13:55	25	13:56	25	14:25	26	06:54
25	09:25	25	17:45	xx	xx	xx	xx	25	21:00
25	09:25	26	11:02	26	11:05	xx	xx	29	07:30
25	09:25	25	16:42	xx	xx	25	17:46	25	20:14
25	09:25	26	13:40	26	13:45	26	13:50	29	08:00
25	09:25	25	10:55	25	10:58	25	13:10	25	16:30
25	09:25	25	18:55	25	19:50	25	20:30	26	06:54
25	09:25	25	18:40	25	19:50	25	20:00	26	10:05
25	09:25	26	10:45	26	10:52	26	11:15	26	13:00
25	09:25	25	13:31	25	13:33	25	13:36	25	17:05
25	09:25	25	11:05	25	11:45	25	13:10	25	16:40
25	09:25	25	15:42	xx	xx	25	16:14	26	07:00
25	09:25	26	06:44	26	06:56	26	07:09	xx	xx
25	09:25	25	10:46	25	11:20	25	12:55	25	15:50
25	11:00	25	11:16	25	11:50	25	12:07	25	13:23
25	11:00	29	10:46	29	11:22	xx	xx	xx	xx
25	11:00	25	19:50	xx	xx	25	20:32	26	13:30
25	11:00	25	11:29	25	13:00	xx	xx	25	16:55
25	11:00	25	20:42	25	20:43	25	21:40	26	09:38
25	11:00	26	07:57	26	08:00	xx	xx	30	09:30
25	11:00	25	12:00	25	12:02	25	12:08	25	13:25
25	11:00	25	15:00	25	15:20	xx	xx	25	19:21
25	13:00	25	13:50	25	13:55	25	14:05	25	16:45
25	13:00	25	17:32	25	17:35	25	17:44	26	06:15
25	13:00	29	08:44	29	10:22	xx	xx	29	11:15

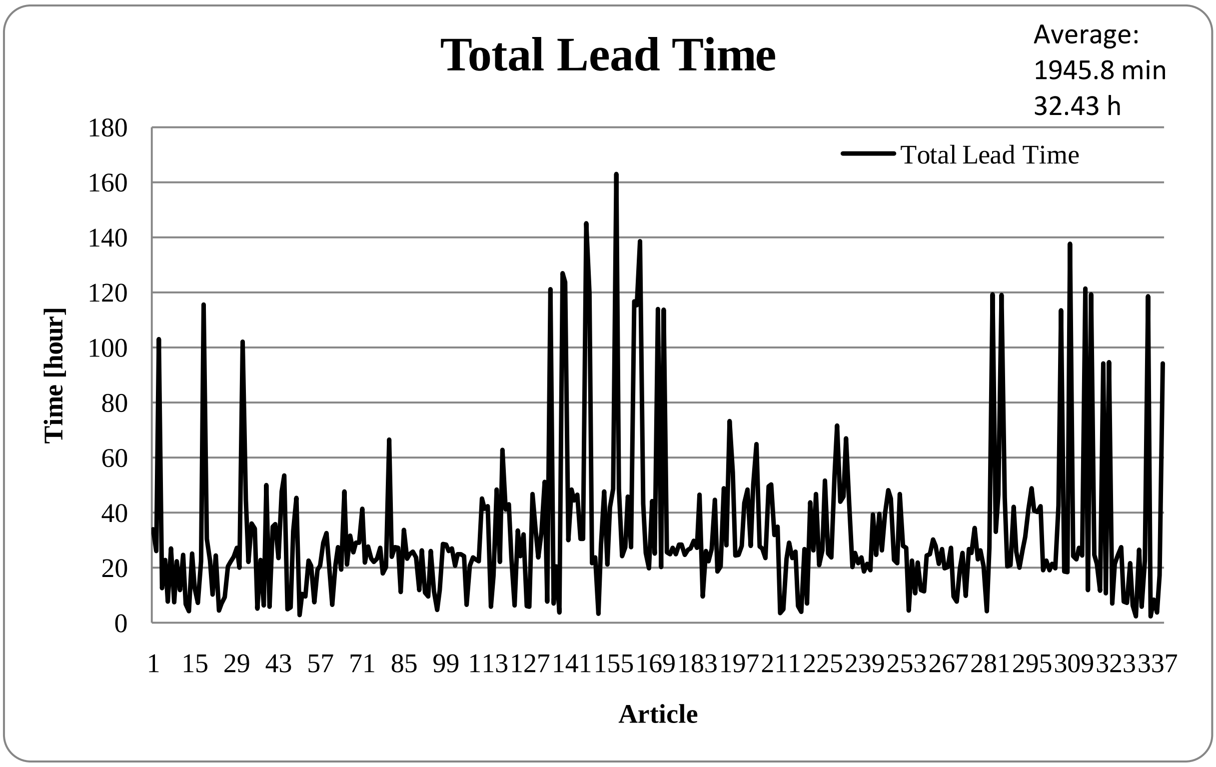
Appendix – K


Time from Opening to Booking
Average:
1113.6 min
18.56 h
Time from Opening to Booking
Time [hour]
0
20
40
60
80
100
120
140
160
1 15 29 43 57 71 85 99 113127141155169183197211225239253267281295309323337351365
Return order


Time from Booking to Refinished
Average:
36 min
0.60 h
Time from Booking to Refinished
Time [min]
0
200
400
600
800
1000
1200
1400
1600
1800
1 15 29 43 57 71 85 99 113 127 141 155 169 183 197 211 225 239 253 267 281 295 309 323
Article


Time from Refinished to Sorted
Average:
235.2 min
3.92 h
Time from Refinished to Sorted
Time [hour]
0
10
20
30
40
50
60
70
80
1 15 29 43 57 71 85 99 113 127 141 155 169 183 197 211 225 239 253 267
Article


Time from Sorted to Placed in Dispatch Area
Average:
528 min
8.80 h
Time from Sorted to Placed in Dispatch Area
Time [hour]
0
20
40
60
80
100
120
1 15 29 43 57 71 85 99 113 127 141 155 169 183 197 211 225 239 253 267 281
Article



Total Lead Time
Average:
1945.8 min
32.43 h
Total Lead Time
Time [hour]
180
160
140
120
100
80
60
40
20
0
1 15 29 43 57 71 85 99 113 127 141 155 169 183 197 211 225 239 253 267 281 295 309 323 337
Article

Appendix – L

Appendix – M

Appendix – N