Eaton Electric ApS

‘Improving order picking and order packaging at Eaton Electric ApS’

Ruben Rouhof

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Management Summary

One of the projects of Eaton Electric is about two dedicated finished goods warehouse areas: Tabula export and Tabula domestic. These areas have their own processes and standard methods for order picking and order packaging; this is hampering the flexibility of the areas. Moreover, Eaton Electric is growing: in 2007 the turnover increased with 20%. Eaton Electric wants to stay efficient; so growing without adding costs to the processes. Therefore it is also important to improve the productivity of the warehouse process.

The Value Stream Map is the foundation in this research by which the current state of the order picking and packaging process is described and assessed. Through this tool we identified and quantified the types of waste in the order picking and packaging process. The main types of waste are waiting and moving. The underlying causes for the waiting times are too much traffic within the Tabula finished goods warehouse and that there is no physical separation between the inbound and outbound dock. The movements, in the form of searching for articles, are caused by the unreliable inventory levels. The inventory count of 2007 shows that on approximately 59% of the locations, the amount of articles is not equal to the amount in the Enterprise Resource Planning.

Based on the findings and the problem analysis the future state Value Stream Map is created with the objective to eliminate the waste activities. These eliminations ensure a higher productivity in the warehouse. To achieve this preferred situation we recommend the following actions:

- Create one packaging area for the Tabula export area and the Tabula domestic area. This increases the flexibility of the area, because every warehouse employee is familiar with the work system. Eaton Electric can then control the peak hours in a better way.
- Separate the flow of the incoming goods and the flow of the outgoing goods; create one inbound dock and one outbound dock to realize a clear separation between them. This avoids conflicting transport flows (congestion) and therefore waiting times.
- Separate the order picking and order packaging activities. This result in less traffic in the warehouse and eliminates the possibilities of traffic jams. In this way Eaton Electric gains approximately 20 hours per week. This has a positive influence on the On Time Performance of Tabula. Moreover, the cycle time of an (average) order will be reduced (for an average order this means a reduction of 25 minutes), because the waste is eliminated (approx. 24 minutes) and there are working more employees on one order. This gives the sales office the possibility to release an order at a later moment so that there are more order lines, coming from the production line, available in the warehouse. This leads to a more streamlined flow.
- Introduce the concept of cycle counting. Cycle counting helps to find the direct source of the discrepancy between the physical and administrative inventory. Moreover, it gives the possibility to adjust the data in the Enterprise Resource Planning. By means of cycle counting Eaton Electric increases the reliability and accurateness of the inventory that results in less waste in the form of extra movements. Without a reliable inventory it is impossible to get an effective order picking and packaging process.

Before the ‘future’ warehouse area can operate in an optimal way it is essential to change the current layout of the warehouse area, to update the system in the barcode scanner, to appoint a supervisor for the area, and to get the warehouse employees aware of the changes.

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Preface

During my bachelor study 'Business Administration' at the University of Twente I have gained a lot of knowledge and skills on several domains in this field of study. To conclude the bachelor study I have to apply this knowledge during an internship and perform an assignment. The output of the assignment constitutes a clear and practical solution to some of the company's questions or concerns.

This report is the result of the internship I have performed from 12 May 2008 until 22 August 2008 at Eaton Electric in Vejle (Denmark). During this period I have investigated the possibilities to improve the order picking and order packaging process in the Tabula finished goods warehouse.

I want to take this opportunity to thank a few persons personally who have supported me during my internship. First of all Menno Visser, manager Operational Excellence of Eaton Electric. He has given me the opportunity to perform an assignment in this company. Also he has guided and supported me very well during my internship. I thank Ahmet Turhan, who follows a traineeship (Engineering Early Professional Development Programme) at Eaton Electric. It was always possible to exchange my ideas with him and to discuss with him about several issues related to my assignment. Also a word of thank to the various people of the office (R&D department, sales office, the department of Operational Excellence, and the management team). These people always had always the willingness to give an answer on different questions. Mr. Bandsma and Mr. Schutten, my internship coordinators of the University of Twente, deserved also a word of thank. They guided me during my internship and have given me useful feedback on the assignment. Moreover I want to thank my fellow student Rutger Alberink. He has performed another assignment within Eaton Electric. We supported each other during this internship and together we had a nice leisure time. This made my time in Denmark more pleasant.

After all I thank all the employees, especially the people in the warehouse, of Eaton Electric who have made my internship at Eaton Electric a very interesting, instructive and nice time.

Vejle, 7 December 2008

Ruben Rouhof

1. Introduction

The bachelor assignment is performed at Eaton Electric ApS. Section 1.1 gives information about this company to get more knowledge of Eaton Electric in general. Section 1.2 describes the main historical facts of Eaton Electric and Section 1.3 describes the organization structure.

1.1 Background information

Eaton Electric is a well-known manufacturer of products within the electric field. The organisation develops, produces, and markets components and switchboards for distribution of low and medium voltage. The company has a long history (Section 1.2) within the electric field. The activities are always focused on placing the company in a significant market position.

Eaton Electric ApS in Vejle is a manufacturer of components for the Tabula and Elatis enclosures. These enclosures are used to build electrical distribution switchboards. Tabula, the most important product (see Figure 1.1) in this research, is a very flexible system, allowing panel builders to build Tabula all over the world. The parts are all standardized and currently sold from the shelf. In addition to the components to build the enclosures, Eaton Electric offers a broad range of switches, parts, and accessories to allow the market to build complete switchboards. The main market is the Original Equipment Manufacturer (OEM) in Germany for Elatis and the domestic market and export for Tabula.

Figure 1.1 Tabula; the product

Eaton Electric ApS is a make to stock organization. Delivery lead times vary from 2 days (stock items to replenish customers stock) to 3 weeks for engineered items. All finished parts are stored in the main warehouse. Based on customer orders the employees pick and pack these parts and get them ready for shipment.

1.2 The history of Eaton Electric ApS

In 1896 Laur. Knudse is established and in 1961 this company opened a factory in Vejle. After a number of takeover purchases and change of names (in chronological sequence LK NES, LK A/S, Holec A/S, and DELTA), in 2003 the American company Eaton Corporation took over the Electrical Division of DELTA. From this moment on the company was called Eaton Holec A/S and is it a part of the worldwide Eaton Corporation.

This last acquisition results to an implementation of a new company philosophy; the Eaton Business System (EBS). The Eaton Business System is the foundation for a high-performance culture in all levels of the company. The Eaton Business System converts the power of many into the power of one Eaton. This signifies encompassing the core values, policies and processes used to conduct business and continually measure, assess and improve performance. The new philosophy means a difference in business culture in comparison with the origin business culture (the Electrical Division of DELTA).

Another important occurrence took place in 2004. Next to the main product Tabula, the production of Elatis is being moved from Germany to Vejle. This transfer had a big impact on the company; there arose a separate factory within the origin Tabula factory. This led to changes in the whole company. For instance the factory got a total redesign to ensure that the activities of Elatis can take place.

1.3 Organization Structure

Eaton Electric ApS is located in Vejle (Denmark) and has in total approximately 135 employees. Eaton Electric has to report their activities and performances to the European division of Eaton. Appendix B shows the organization structure of Eaton Electric ApS in Vejle.

The management of the department ‘Operations & Logistics’ is responsible for the activities that take place in the warehouse. The departments ‘Customer Service’ (sales office) and ‘Planning’ are also important in relation with these warehouse activities. These departments have to support the different tasks within the warehouse.

2. Problem description

Chapter 1 described the company Eaton Electric. This chapter explains in which way the investigation is set up. Section 2.1 gives an identification of the problem. Section 2.2 explains the central problem definition. Section 2.3 contains the formulated objective of this research. Section 2.4 explains the scope of this research. Section 2.5 explains the research questions and Section 2.6 discusses the research design.

2.1 Problem identification

The main products of Eaton Electric are Tabula and Elatis. The finished parts of these products are stored in the main warehouse; so a finished goods warehouse. The warehouse of Eaton Electric has three dedicated areas to store, pick, and pack: the Tabula domestic market, the Tabula export market, and Elatis. The process used in the three warehouse areas is a pick-to-order process. Dependent on the destination of the order, each area has its own process and standard methods. This is hampering the flexibility of the area, because the employees do not understand the working method in another area. Moreover, it creates a need for area specific equipment, because each area needs other tools to perform the activities in a good way. This is expensive. Furthermore, Eaton Electric is growing. In 2007 the turnover increased with 20%. Therefore Eaton Electric wants to improve its efficiency to avoid loss-making business.

2.2 Problem definition

With help of the above problem identification we formulate the following problem definition:

How can the current order picking and packaging process(es) be improved?

The possible improvements will be focused on increasing the flexibility and effectiveness of the areas. Section 2.5 explains the research questions that help to give a proper answer to this problem definition.

2.3 Objectives

The main objective of this research is to identify opportunities to improve the productivity of the current order picking and packaging process. These improvements of the warehouse have to result in a more efficient (streamlined) and flexible process. The improvements have to result also in cost out opportunities.

The following objectives are developed to support the main objective:

- A clear understanding of the current state (order picking and packaging).
- Identify, through systematic analysis, the waste activities.
- Identify opportunities for improvements of the order picking and packaging process that are aligned with the fabrication process.

2.4 Scope of the research

As stated in Section 2.1 there are three different areas with their own processes. Given the time available for this research we have chosen, in dialogue with the management of Eaton Electric, to focus only on the processes within Tabula (the export and domestic area). Because these areas make use of articles with the same characteristics, the areas show resemblances. Based on the findings we will search for opportunities to develop solutions for the Tabula export and domestic area. The process under investigation is the order picking and order packaging process. However we have to consider other activities and methods in the warehouse that could affect the order picking and order packaging process.

2.5 Research questions

To reach the objectives of the research we formulated the following research questions. With help of these research questions we will answer the problem definition.

1) *What is useful theory to describe and assess the current warehouse process?*

With help of suitable models and concepts we will describe the current state of the processes. Moreover, the literature could be an instrument to identify the preferred situation related to this part of the supply chain. In addition the performance indicators, to assess the warehouse processes, will be explained. This first research question will be discussed in Chapter 3.

2) *What is the current state with respect to the order picking and packaging process in the Tabula export and domestic area?*

As said in Section 2.4, there are two dedicated areas under investigation in this report. Both areas have their own processes. Accordingly it is necessary to describe these processes, to get a thorough understanding of the current state of the processes. Therefore we make use of a Value Stream Map. This research question will be mainly descriptive. To walk through all the parts of the process, a clear view of the current situation will be the result.

3) *What are the differences between the current situation and the preferred situation?*

The preferred situation can be illustrated with a Value Stream without non-value added activities. With the help of the third research question we can identify the problems/wastes in the current situation. These problems will be explained. In addition, the problems will be analyzed to identify the causes of these problems.

4) *What are the possibilities to improve the current processes and what will these possibilities deliver?*

To answer this research question it is necessary to look at the previous research question. If there are possibilities to improve we will look in which way Eaton Electric has to implement these improvements.

2.6 Research approach

The research is structured corresponding to the research questions in Section 2.5. Chapter 3 explains the relevant theory to describe and assess the current state of the warehouse processes. Chapter 4 describes the current state of the order picking and packaging process. This chapter gives general information about the warehouse and measures and describes the order picking and packaging process of the Tabula export area and the Tabula domestic area with help of the Value Stream Map. Moreover this chapter describes the warehouse phases that affect the order picking and order packaging process. The Value Stream Map, a key tool of the Eaton Lean System, is the foundation of this research report. This way of research fits with the company policy. To answer the research question related to the current situation we consult several sources within Eaton Electric. We collect relevant documentation on Intranet, Internet, and the Enterprise Resource Planning that is called the Integrated Facility System (IFS). Moreover, systematic observation on each part of the current (order picking and packaging) process takes place. Also interviews and conversations with employees of different departments and disciplines take place. The interviews will be open and semi-structured. The latter means that the questions are determined beforehand. However there is enough space for the interviewed persons to give their opinions and experiences. Chapter 5 discusses and analyses the problems (waste) in the order picking and packaging processes. In this way we can identify the key problems. Chapter 6 designs the solutions with relation to optimize the order picking and packaging process. This means that the non-value added activities will be eliminated as much as possible. In other words, make the order picking and packaging more efficient. The opportunities to improve the processes are discussed (interaction with the persons involved) with the warehouse operatives. This has to result in a basis for improvements. Chapter 7 describes the results that are coming from an experiment. The main objective of this chapter is to identify potential problems/errors. After we have finished our research, Chapter 8 discusses the conclusions and (related) recommendations.

3. Theoretical framework

This chapter discusses the theory we use during our research. Section 3.1 explains the Lean System. The Value Stream Map, an instrument of the Lean System, will be explained in more detail. Section 3.2 explains the principles of customer service; the starting point of the Value Stream Map is the customer. Section 3.3 handles the theory about materials handling, in line with the distinct phases in the warehouse.

3.1 Lean System

The Lean System is developed by Toyota (known as one of the most efficient companies in the world) and focuses on eliminating waste in every business process. The objective of this system is to achieve efficient operations (Womack and Jones, 2003). The Eaton Lean System (ELS) is based on lean thinking and is one of the key tools of the Eaton Business System to achieve operational excellence. Types of waste that are distinguished within Eaton Electric are transportation, errors, waiting times, over production, unnecessary processing, movement, inventory, and unused creativity of the employees.

3.1.1 Instruments of the Eaton Lean System

There are seven common instruments to use in the Eaton Lean System:

- *Value Stream Mapping (VSM)*
  This is an instrument that visualizes three flows to identify improvements: the product flow, the material flow, and information flow. This map can identify the potential non-value added (NVA) or waste.
- *5S*
  The 5S model is the basis for lean manufacturing and the fundament for a disciplined approach of the work place. The model consists of the following elements; sort, set-in-order, shine (regarding cleanliness), standardize, and sustain.
- *Standardized Work*
  Determine the best production method. The supervisors, coordinators, and the mechanics define, maintain, and improve the standardized work documentation.
- *Total Productive Maintenance*
  The goals of this instrument are to guarantee the equipment availability and effectiveness. This is a method that contributes to fast and continuous improvement of processes through elimination of waste.
- *Error Proofing*
  Error proofing is a systematic approach to detect potential errors. This approach has to ensure that these errors do not reach the customers. Error proofing does not occur to avoid flow interruptions.
- *Set up Reduction*
  Set up is the time where the machines have to be set up for the next order. Set up time reduction improves the availability of the machine. This will enlarge the capacity and enables one piece flow.
- *Continuous Flow*
  The definition of continuous flow is the movement from material to value added process to value added process without transport or buffers.
- *Pull System*

Produce the order of the customer on the right moment and the right quantity.

An important lean measurement is the cycle time. Cycle time is the total time that is required to complete one cycle of an operation, before these activities are repeated. This measurement can show the performance of a processing step. The concept cycle time will be discussed in Section 3.2 (Womack and Jones, 2003).

3.1.2 Value Stream Map

As mentioned before, the goal of ELS is to eliminate waste. Waste activities are activities that add costs, but do not add any value to the product; the customer is not willing to pay for these activities. It is obvious that this concept (ELS) is applied on operations in the warehouse too. Therefore it is important to map waste activities in this part of the supply chain. The suitable ELS instrument to use in this research is the Value Stream Map.

Value Stream Mapping is a typical lean method for understanding the sequence of activities and information flows. The Value Stream Map is used to identify the major sources of non-value added time in the current value stream map (the current state). To create the current state it is essential to 'walk the process', talk with the employees, and observe the activities in a systematic way. Moreover, The Value Stream Map is useful to sketch a future state with less non-value added activities. The opportunities to eliminate these activities denote Kaizen events. In Japanese Kaizen means continuous improvement. At this *kai* means 'take out' and *zen* means 'improve'. A Kaizen event symbolizes an opportunity to eliminate waste and make rapid changes in the workplace (Womack and Jones, 2003).

3.2 Customer service

Coyle et al. (1996) argue that customer service is an underlying principle of the outbound logistics systems. From the customers point of view it is essential that the right order is received at the right time, in the right quantity, and in the right quality. A related and influential aspect to these requirements is the cycle time. In the literature four principal activities are distinguished that constitute the order cycle:

- *Order transmittal*
  The time it takes to receive an order from the seller.
- *Order processing*
  The time it requires to process a customer's order and make it ready for delivery (work in process).
- *Order preparation*
  The time it takes to pick and package an order (warehouse).
- *Order shipment*
  This is the time from the moment that the seller loads the truck with the order until the buyer receives it (outbound/shipment).

In these activities are possibilities to reduce, for instance, the order cycle time (Coyle et al., 1996).

The warehouse under investigation is a finished goods warehouse on the level of order picking and order packaging. This is in correspondence with order preparation. In general, finished goods have a higher value and greater risks for loss, damage, and obsolescence in

comparison with for example raw materials. This reason points out that it is important that the finished goods are moving efficiently and rapidly through the warehouse (Coyle et al., 1996).

The most essential objective for a (finished goods) warehouse is to meet the demands of the customer; customer satisfaction. Therefore it is important to consider the standards of performance from the customer's point of view. Coyle et al. (1996) describe five standards of performance from this perspective:

- Orders received on time, also called On Time Performance (OTP).
- Orders received complete.
- Orders received damage free.
- Orders filled accurate.
- Orders billed accurate.

To asses the customer service we will measure the On Time Performance, the orders that are received complete and correct (the right articles) and the orders that are received damage free (conform to the 'contract' between the buyer and seller). The last two standards can be measured on the basis of the customer complaints. These customer complaints could tell us the degree of orders that were incomplete and damaged (non-conformed).

3.3 The warehouse process

Frazelle (2002) assumes that warehouses can be classified in different types, based on the services the warehouses provide. Frazelle classifies the warehouses of manufacturing companies in three types: raw materials, work-in-process, and finished goods warehouses.

Within a warehouse the layout is an essential aspect. To (re)design a layout it is essential to consider the overall flow of goods. The related question to this aspect is whether the flow of inbound and outbound is streamlined in an efficient way. Esmeijer (1996) distinguishes two general routing principles; I-routing and U routing:

- *I-routing*
  This routing principle is in a straight line. The inbound dock is located on the opposite of the outbound dock.
- *U-routing*
  This routing principle means that the route is U-shaped. The inbound and outbound docks are (physical) separated from each other, but are located beside each other.

The main point of this theory is that it is important that there is a physical separation between the incoming and outgoing goods to avoid conflicting transport routes.

The warehouse activities can be divided in a number of distinct phases; receiving materials in the warehouse, storage, order picking & packaging, and shipment (Visser and Van Goor, 2004; Rouwenhorst et al., 1999). This section explains the literature of these phases.

3.3.1 Receiving materials in the warehouse

In this phase the materials are received in the warehouse. This is called inbound inventory as well. At this it is important that (quality) control takes place on the number of supplied materials and eventually damages. An order has to meet the quality standards the buyer sets forth in the purchase agreement.

To smooth the material flow, electronics can help. The use of electronic tools, such as barcode scanners, can eliminate much paperwork. If the employee has to collect the data in a manual way it takes a lot of time (Gademann and Van Dijkhuizen, 2000), (Coyle et al. ,1996).

3.3.2 Storage

After receiving the materials in the warehouse, the articles are put on stock (storage). These articles are also called stock keeping units (SKU). A related question is what and where to store the materials. There are a number of elements in the theory that we can use to answer this question. The first element that can be used is to store the articles into the physical characteristics of these articles, for example the heaviest articles are stored with each other. Second, there is a distinction in bulk inventory and floor stock. The floor stock is intended for order picking. Out of this inventory, on the lowest locations, it is simple for a warehouse employee to pick the articles. The rest is bulk inventory and is often stored on the highest locations. (Visser and Van Goor, 2004).

Besides, Rouwenhorst et al. (1999) distinguish three storage policies; dedicated storage, random storage, and class based storage (CBS). Dedicated storage policies ground on the concept that the articles stands on fixed places in the warehouse. Random storage policies are the opposite of dedicated storage policies. The basis of random policies is that an article could be stored randomly in a warehouse. An advantage of this principle is that the capacity of the warehouse can be better used. The third storage policy is called class-based policies. This means that articles are divided into zones. These zones are often based on their turnover rate.

De Koster et al. (2006) state that the class based storage policy could be coupled with Pareto's ABC analysis. The ABC analysis classifies the articles to their relative importance. The articles are often classified on the basis of the rate of turnover or annual use value. Besides the literature considers other criteria, like lead time, commonality, durability and obsolescence (Ramanathan, 2004). Besides it can help to determine the level of control (Reid and Sanders, 2005). One can take the following steps to group the articles into ABC categories. The first step is to choose the right criterion. The next step is tot calculate actual and cumulative, for example, total sales revenue percentages for each article (Reid and Sanders, 2005).

The subsequent activities in the warehouse process are the order picking and packaging activities. For the warehouse employees, who have to perform these activities, it is important that the articles are stored on the right location and in the right quantity. The reliability of the inventory is an essential aspect. Furthermore, the articles have to be stored in such a way that the pickers could pick the articles in a simple way. It is important that the distribution of the order works out in a fast and effective way.

It is essential that the articles are stored in the right quantity and on the right location. This means that the administrative inventory (the data in ERP) has to be equal to the physical inventory. So we have to analyse the inventory reliability in the current situation; identify the number of locations without inventory discrepancies (Frazelle, 2002).

Furthermore, to improve and streamline the order picking phase (discussed in Section 3.3.3) it is necessary to identify whether the articles are stored in a logic way. It is important that the pickers do not have to lift often to the highest locations in the warehouse. Using a diagram of the number of picks/transactions from the locations of the different aisles we can analyse whether the articles in the Tabula main warehouse are stored in an efficient way.

3.3.3 Order picking and packaging

From scientific studies it has become clear that order picking is the most labour-intensive operation in warehouses with manual system (Gademann and Van Dijkhuizen, 2000). Moreover, it is a capital-intensive operation in warehouses with automated systems (see Table 3.1). The application of the right order picking system could result in improvement of the efficiency. Furthermore, the right order picking system and strategy could improve the way of fulfilling an order in the right way. The choice for an order picking system is not an autonomous issue, because there is always a functional relation between the storage system (Section 3.2.2.1) and the order picking system (Esmeijer, 1996).

Phase	Costs in % of the total costs of the four phases
Receiving the materials	10%
Put on stock (storage)	15%
Order picking	55%
Expedition	20%

Table 3.1 Typical division of the costs related with the different warehouse phases (Gademann and Van Dijkhuizen, 2000).

Esmeijer (1996) distinguishes the order picking process in three key basis systems, the one-dimensional order picking system, the two-dimensional order picking system, and the dynamic order picking system. A one-dimensional order picking system means picking from the floor. A two-dimensional order picking system is picking, with help of equipment, from the desirable height (of the floor stock). Finally, a dynamic order picking system means that the goods are brought to the picker. Examples of this system are the paternoster system and an automatic guided vehicle (AGV).

The theory of Esmeijer is in line with the theory of De Koster (2004). De Koster makes a distinction between manual (employing humans) and automated systems (employing machines). The most common system of those is the manual system. These systems are divided in parts-to-picker and picker-to-parts systems. A combination of these is called ‘put system’.

To improve the picking productivity it is essential to know which picking strategy is used in the current processes. The literature distinguishes three basic picking strategies. The first strategy is named strict order picking. In this strategy the picker completes one order during a pick tour. This strategy is ideal if there are a small number of lines per order, because it requires no sorting operation and it maintains order integrity. The second strategy is named batch picking. This strategy means that a warehouse employee picks articles for several orders at the same time. The last picking strategy is called zone picking. Zone picking is almost the same as the batch picking strategy. In contrast with the batching strategy each picker in this strategy is assigned to one particular zone. (Gademann and Van Dijkhuizen, 2000).

Routing is an important aspect within the order picking process. The literature describes several routing strategies. With help of routing strategies it is possible to determine a route that visits each pick location. It is difficult to achieve an optimal routing strategy (the least travel time). Besides it is for warehouse employees hard to understand. Therefore the literature hands us several heuristics for order picking. Next to the optimal routing strategy, there are three well-known (basic) strategies in the literature:

- *S-Shape (traversal):*
  this heuristic means that the aisles, the picker has to visit, are completely crossed. When the picker has finished the order, the picker goes back to the depot.
  - *Largest Gap*:
    in this strategy the picker goes into an aisle as far as the largest gap within an aisle.
  - *Combined routing strategy*:
    in this heuristic, aisles with order lines that have to be picked are entirely traversed or entered and left at the same end. The raising question on that moment is: 'Should I go to the rear end of the aisle or should I return to the front end?' (Roodbergen, 2001)

Figure 3.1 shows the routing strategies in a graphic way. The warehouses in these graphics are named single-block warehouses. The figures show that the order picker does not move within in an aisle to pick the order lines; the warehouse employee picks the order lines from both rows in one flow.

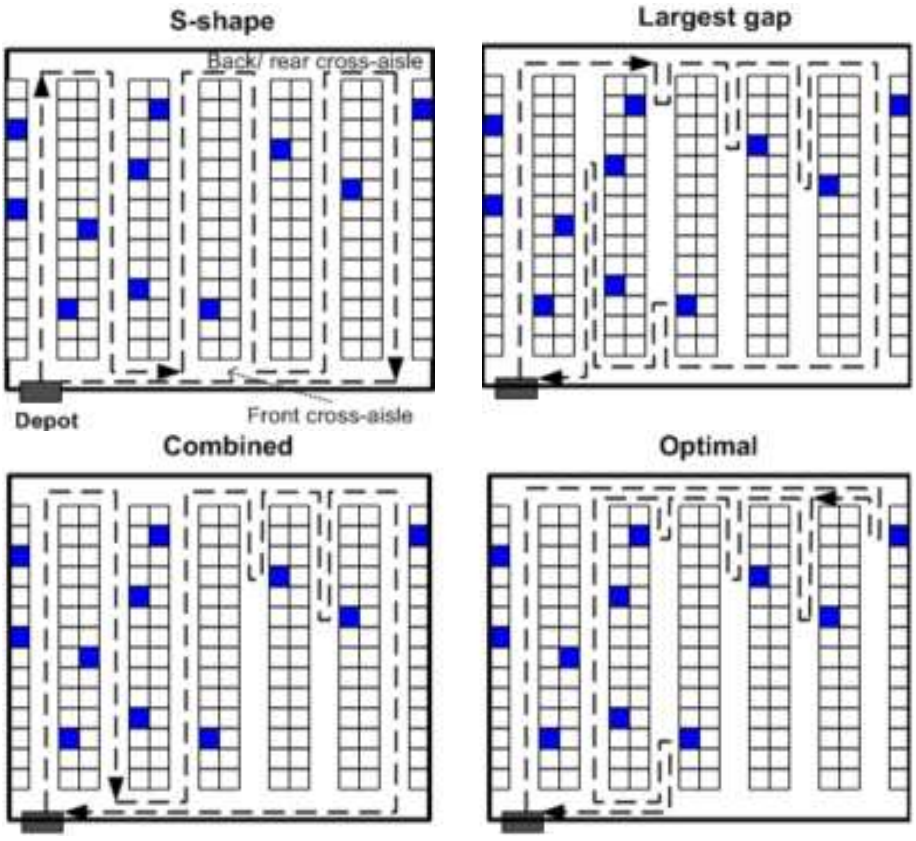


Figure 3.1 Routing heuristics for order picking

After order picking the articles have to be packaged. Packaging is an important activity that can affect the logistic chain. Examples of logistics issues are product identification, product protection, the ease of handling, an efficient use of storage facilities, transportation vehicles, and the environment (Coyle et al., 1996).

Just like in the phase 'receiving the materials in the warehouse', in packaging the use of handheld barcode scanners can play a huge role as well. The barcode scanner can provide data collection in an accurate way and can reduce labour time (labour in the form of operations and data collection). In short, barcode scanners could streamline the packaging processes (Coyle et al., 1996).

The process of order picking and order packaging corresponds to 'order preparation' that is mentioned in Section 3.2. Order preparation stands for the duration to pick and package an order. To operate in an efficient and effective way it is important to analyse and measure these activities. Therefore we use the following performance indicators:

- *The average number of order lines that is picked per hour* (Frazelle, 2002).
  This performance indicator give us an indication of the productivity of the warehouse in the current situation. Because an order contains different numbers of order lines it is necessary that we analyse the order lines picked per hour. If the current process on this aspect is not on an acceptable level, we have to consider opportunities to increase the productivity of this activity.
- *The order picking cycle time* (Frazelle, 2002).
  This performance indicator shows the time that is needed for picking an order or order line. As stated before, customers want the orders on time. To meet this requirement it is important to consider the cycle time of the order picking and packaging process. This factor affects the OTP as well.

3.3.4 Shipment

After order picking and order packaging the complete order will be transferred to the shipment dock. In this process step the materials/goods will be allotted to a truck and it will be loaded to ship it to the customer.

Shipment is also called the outbound. As mentioned before, customer service is a very important topic in the outbound logistic system; the customer wants to get the delivery on (the agreed) time. It is important to select the right equipment to ship the orders. It is also necessary that there is data collection in this process step. Data collection enhances the inventory data integrity (Gademann and Van Dijkhuizen, 2000).

3.4 Conclusion

The foundation in this research is the Value Stream Map. With the help of this lean technique the current situation of the order picking and order packaging process will be analyzed and the future state will be sketched. The future state is an ideal image of the future situation without processing steps that do not add value to the process. The main theoretical concepts in this research will be customer service (OTP, non-conformance, and shipment mistakes), the cycle time of the order picking and order packaging process, the productivity of the order picking process (in terms of order lines picked per hour), and the reliability of the inventory. Chapter 4 focuses on describing the current state of the order picking and packaging process by comparing the involved processing steps with the literature explained in this chapter.

4. The current state of the order picking and packaging processes

Section 4.1 gives general information about the finished goods warehouse. Section 4.2 describes the current situation in the perspective of the customer; customer service. Section 4.3 illustrates with help of the Value Stream Map the current state of the order picking and packaging process of the Tabula export area and the Tabula domestic. To create these current Value Stream Maps we walked the order picking and packaging process from beginning to end and we performed a time study. The other influential warehouse phases related to the order picking and packaging process will be described as well. Appendix C shows the flow charts (input – process – output) of the other distinct phases in the warehouse to get familiar with the whole process in the finished goods warehouse.

4.1 General information

The Tabula export area and the Tabula domestic area pick from the same finished goods warehouse. This main warehouse consists of fourteen rows with (pallet storage) racks, which varies in heights (Figure 4.1). This signifies that the rows consist of a different number of locations. The aisles in the warehouse are narrow; it is impossible to pass by another warehouse employee. In general, the warehouse can be named a single-block warehouse: no cross aisle, for instance, in the middle. In addition to this, the employees make use of a paternoster; an independent vertical dynamic storage system (Figure 4.2).

Figure 4.1 The racks in the main warehouse

Figure 4.2 The Paternoster

In this warehouse (without the paternoster) 1002 different articles are stored. In the paternoster 362 articles are stored. This paternoster counts 61 rows. Every row has a different number of locations. The articles in the warehouse are coming from external suppliers and internal suppliers (the production line of Eaton Electric). To get familiar with the size of the finished goods warehouse, the value of the Tabula warehouse on the 30th of June was about € 1.158.000 (8.633.000 DKK).

The order picking system within the Tabula finished goods warehouse is a two-dimensional order picking system. This means that with help of suitable equipment the orders are picked. However, there is also a dynamic order picking system, because the small articles are stored in the paternoster. So these articles are brought automatically to the picker.

The order picking and packaging process is the most labour-intensive phase in the Tabula finished goods warehouse. Two warehouse employees are responsible for the incoming goods (receiving the materials), one warehouse employee has to put the articles on stock and eight warehouse employees are responsible for order picking and order packaging.

The inbound and the outbound dock are located at the same place. The flow of the receiving materials and the flow of the outgoing orders are going through one door. In other words, there is no clear physical separation between the in- and outbound. Appendix D shows this information.

It is also important to be familiar with the process of placing an order in the perspective from the customer. The customer can place an order in different ways: by telephone, fax, letter, e-mail, and online. The sales office prefers the last way, because this way is less labour-intensive. After the order is placed the sales employee has to enter the right data of the order in the system (IFS). At that moment Eaton Electric has to make a planning for producing the articles. The sales office decides when a warehouse employee can pick an order. For this purpose the sales office sends a pick list (Appendix E) to the system in the barcode scanner of the warehouse employees. This is a list of articles that have to be picked. This list contains only the articles that are actually stored. To create a pick list the sales office has to consider some issues. The sales employees are selecting the orders on delivery time, cycle time, and the articles availability. The sale of Tabula does not have special peaks throughout the year. Only in holidays (summer and Christmas) the sales decrease slightly.

4.2 Customer Service

The customer of the warehouse process is the end customer; in other words the buyer of the Tabula goods. As stated in Section 3.2 it is essential and necessary to consider the performance related to the customer. This section gives an overview of the performance related to this aspect. At this, the influence of the warehouse activities on the customer service becomes clear. We measure the customer service by three indicators:

- On Time Performance.
- Percentage shipping mistakes.
- Percentage of non-conformance.

We will measure these indicators, because of the fact that these data are already measured by Eaton Electric.

The On Time Performance

The On Time Performance (OTP) stands for the percentage of orders/order lines that are delivered, in conformity with the agreement, too early or in time. To identify the influence of Tabula on the OTP, Eaton Electric makes a distinction between *Tabula projects* and *Tabula stockist*. Eaton Electric has to deliver the Tabula projects complete to the customers. The percentage gives an indication of how many customers received their (project)orders on time. Eaton Electric defines Tabula stockist as order lines that are intended to replenish the stock of the customers. It is the goal to deliver these order lines on time, but it is not a requisite. Figure 4.3 shows the statistics of the OTP of the Tabula projects and Figure 4.4 of the Tabula stockist. The graphics shows the average OTP of 2007 and the OTP of the first five months of 2008. The average OTP of 2005 and 2006 was not available.

At the OTP of the Tabula projects there is no separation possible between the OTP of the Tabula export area and the Tabula domestic area, because Eaton Electric measures the OTP per product. Figure 4.3 shows that the OTP does not satisfy the target OTP. The first five months of 2008 shows an average OTP of 47,6 %.

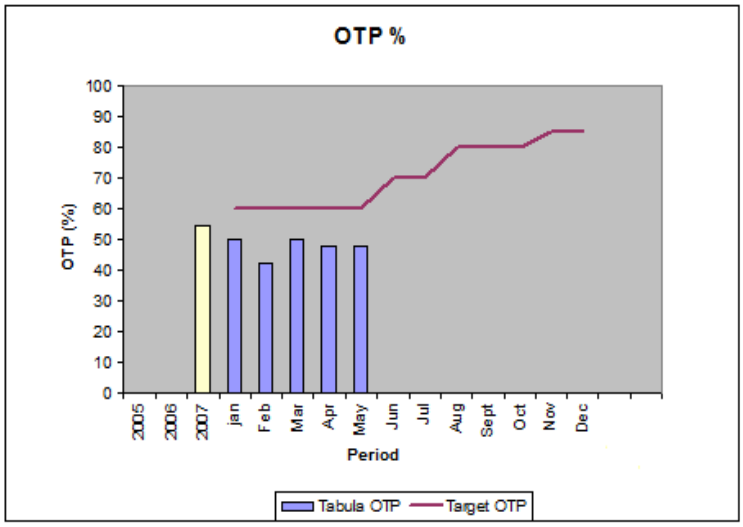


Figure 4.3 OTP of Tabula projects

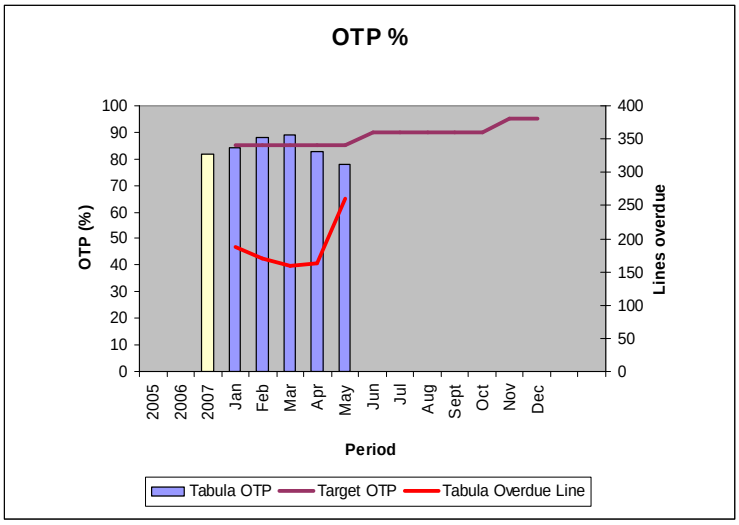


Figure 4.4 OTP of Tabula stockist

Figure 4.4 shows that the actual OTP of *Tabula stockist* varies during the measurements. Besides we can see that there is a correlation with the overdue and the OTP. Overdue lines are the lines that are not shipped on time. A higher OTP is related to a lower amount of lines overdue. Out of the graphics we can conclude that the OTP of the Tabula projects is lower than the OTP of the Tabula stockist. The cause for this difference is that, in contrast to Tabula stockist, the Tabula projects have to be shipped complete. These are requirements of the customer.

There are a lot of factors that influence the OTP; for example the production capacity, the different activities on the production line, the order entry and the activities in the warehouse. In this report the warehouse is the central point. Therefore it is important to know to what degree the activities in the warehouse can affect the OTP. Table 4.1 gives an overview of metrics that affect the on time performance. These data are of week 23 until 27 of 2008. The data is shown in the number of order lines. For instance, to calculate the overall OTP one has to perform the following calculation:

$$\frac{\text{Total lines for shipment} - \text{Total Late}}{\text{Total lines for shipment}} \times 100\ \%$$

The metric ‘not picked’ is related to the warehouse activities. ‘Not picked’ means that the order lines were stored in the warehouse and were reserved to pick, but that these order lines are not picked. A reason for these ‘not picked’ order lines can be the amount of available labor time; the warehouse employees have not enough time to pick the articles. The goal is to decrease the percentage ‘available not picked’ to 0%. The metric ‘not available’ is a metric that has a big influence on the OTP. This metric is related to the activities of the production line. For some reason the production line has not manufactured the articles (order lines) on time. This is the major bottleneck for the OTP.

If we look to the sub table 'department not on time' in Table 4.1 it becomes clear that the door line can be mentioned as the most critical factor. At the moment Eaton Electric is searching for possibilities to outsource a part of the production of the doors.

	Week				
Status	23	24	25	26	27
Partial ship	26	24	65	19	28
Picked not shipped	1	169	9	0	292
Not available	117	162	191	144	204
Not picked	31	37	46	17	165
Total late	**175**	**392**	**311**	**180**	**689**
Total lines for shipment	1302	1934	2557	1610	2901
OTP overall	87%	80%	88%	89%	76%
% not shipped	0%	9%	0%	0%	10%
% available not picked	2%	2%	2%	1%	6%
% not ready	**9%**	**8%**	**7%**	**9%**	**7%**

	Week				
Department not on time	23	24	25	26	27
Door line	59	84	94	76	91
Press	5	11	8	14	30
Imed Profile	N/A	N/A	N/A	4	21
CNC	29	21	30	16	20
Packaging	6	9	16	14	13
Copper	N/A	11	5	5	12
Purchasing	8	5	21	5	5

* N/A = Not Available

Table 4.1 Metrics that affect the On Time Performance

Shipping mistakes

The second indicator is named 'shipping mistakes'. Eaton Electric defines shipping mistakes as mistakes in the form of:

- shipment of wrong parts *or*
- shipment of a wrong quantity.

The figure below shows the data of Tabula with relation to the shipping mistakes from 2001 until 2007 and the first five months of 2008.

As we can see in May 2008, for instance, the number of shipping mistakes was 0,39 mistakes per hundred shipped order lines. The number of shipping mistakes varies per month. In addition, the average number of shipping mistakes vary per year as well.

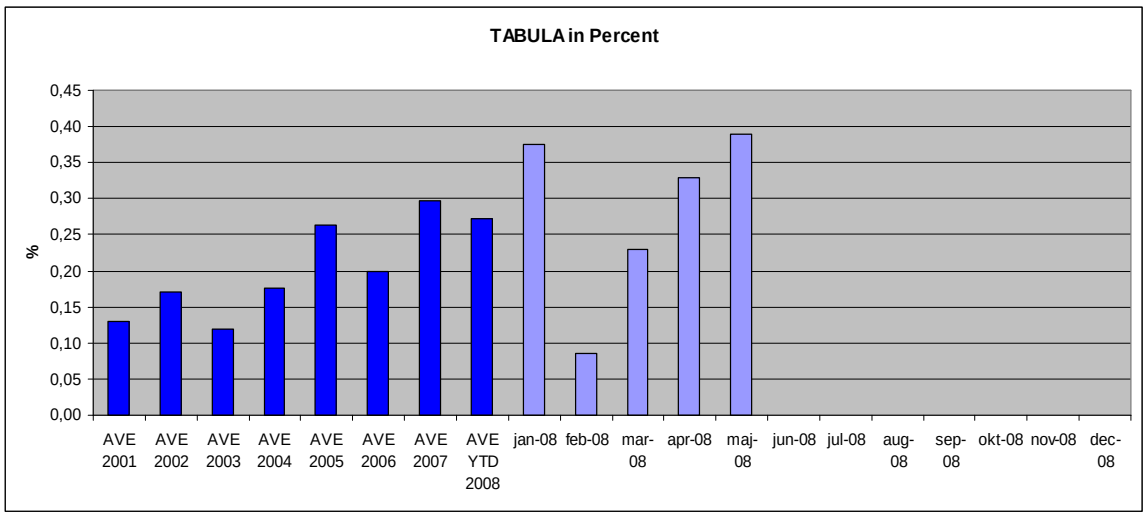


Figure 4.5 Shipping mistakes (source: IFS)

Non-conformance

Eaton Electric measures the non-conformance as well. Eaton defines this measurement as the number of articles that are received non-conformed by the customer. Eaton Electric measured this indicator of all the products. Figure 4.6 shows the data of January until May 2008 and is show in parts-per-million (PPM).

This figure shows that it occurs not often that articles are received damaged or non-conformed. For instance in February 36 parts of a million are received non-conformed. A comparison between the statistics of shipping mistakes and non-conformance explains the shipping mistakes occur more frequently than articles that are received non-conformed.

The indicators with respect to the customer service show us that there are opportunities for improvement. Especially the OTP is not at an acceptable level. Therefore we have to search for possibilities to improve the activities in the warehouse that affect the OTP. As stated the goal is to raise this OTP to 100%. For instance, when all the available order lines are picked in week 23, the OTP will increase with 2,38%.

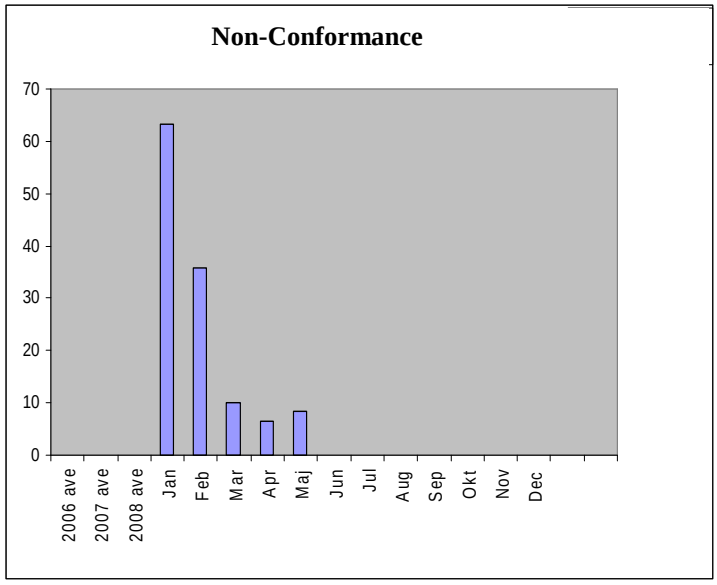


Figure 4.6 Non-conformance (source: IFS)

4.3 The current order picking and packaging process

This section describes the current state of the order picking and packaging process of the Tabula export and Tabula domestic area. The current state will be described with help of the Value Stream Map.

4.3.1 Tabula export area

Six persons work in the Tabula export area, divided in a (morning) shift of four persons and a (evening) shift of two persons. The picking and packaging activities are related; each order has to be picked and packaged by the same person. The equipment of this area consists of one reach truck (shared with the domestic area), one pick truck, and two runners. The customers are coming from all over the world. In other words, the Tabula export area is globally orientated. The main customers are Mueller (Norway), Itec (French), Centralic (Marocco), and several customers coming from the Middle-East (e.g. Dubai). The order sizes in the Tabula export area varies. In the year 2007 the sizes varied from an order that contained 1 order line to an order that contained 350 order lines. In 2007 the average number of order lines per order was about 32.

Value Stream Map

This section shows the Value Stream Map of the current situation (*the current state*) with relation to the order picking and packaging process of the Tabula export area. This VSM gives an overview of which steps can be distinguished and how long each step takes. Because every order (qua number of order lines) and every transaction (qua volume) is different (the process is not standardized), Figure 4.7 represents the time of an average order. The key of the symbols are explained in Appendix F.

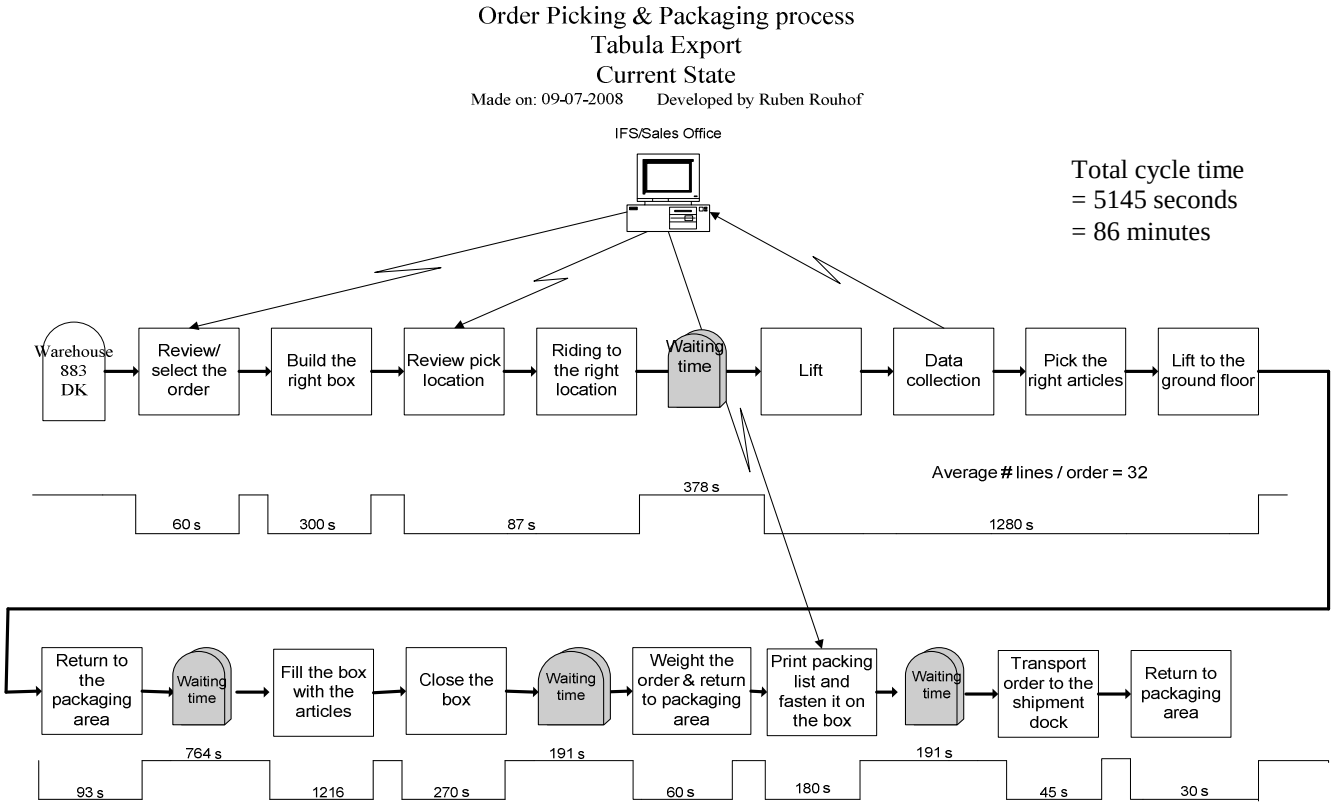


Figure 4.7 Current state Value Stream Map; Tabula export area

The processing steps are measured during a time period of three days. At this, each day there is exclusively one warehouse employee observed the whole day. Appendix G shows the template (a standardized form) that is used to measure the average time of a processing step. The results of the measurements are also shown in Appendix G. These observations make it possible to identify and quantify the waste activities as well. Because we observe a warehouse employee the whole day the waiting times are calculated to an average order. Based on expertise of the warehouse employees the pickers are picking an average of 10 order lines per pick tour. Moreover, one box contains average 30 order lines.

Description of the current picking and packaging activities

The order picking strategy in this warehouse area can be seen as a strict order picking strategy. Each picker is picking its own order. Because of the size of an order (too many order lines) the employees are often unable to pick the order in one pick tour. The barcode system tells the pickers where they have to go (picking sequence).

The picking sequence is based on the packaging method (this will be explained later) and the steps are as follows:

1. long and heavy articles
2. plates
3. picking the articles with a cart
4. picking the articles with a reach truck
5. paternoster
6. coated doors

The logic behind the first step is the fact that the long and heavy articles have to be put in the bottom of the box. This is because of the rule 'no air to the customer'. In the philosophy of the ELS this is waste (muda) of money. The coated doors are put in the top of the box, because these are the most vulnerable articles. The Tabula export area makes also use of kanban cards for some articles from the production line (intermediate profiles). When a location is empty the employees have to scan the kanban card. This gives the production line a signal to produce the articles that are needed.

The packaging process takes place in the same area. The packer has to pack these articles in timber boxes; there are three different box sizes. Depending on the quantity/volume of the order the warehouse employees choose the right box. These packaging activities are labour-intensive. A big order consists of more than one box. The average weight of one filled box is approximately 700 kilogram. Only for Eaton Sweden the articles are packaged on EU pallets. Since these EU pallets are expensive, the pallets are recycled.

The sales office decides when an order is finished. When there are order lines not available to pick, an order has to wait (the box is still open) before it can be shipped. For instance, the production line still has to produce the order lines. The optimal situation is to release an order when all the order lines are available, but because the orders are often too big it is impossible to pick and pack the order within, for instance, three hours (when the last articles became available) before shipment. So the warehouse employees have to wait on a signal before they can close the order. Historical data shows that the time of an open box varies between one day and three weeks. The goal is to complete all the orders on time. If this is not possible the sales office can add order lines until three hours before transport. So it is possible that after this deadline some orders (to replenish the stock of the customer) goes incomplete to the customer. To transport the order (the box) in a right way to the shipment dock, the employee has to affix the box with a pack list. This list gives the customer information about the contents and weight of the box. The pack list is printed automatically.

To know the productivity of this order picking process we measure the average number of order lines picked per employee per hour. To get a reliable and valid result we have taken data out of IFS. We have investigated three periods of a month. Appendix G shows the measurement method. The calculation shows that an employee in the Tabula export market picked approximately 7 order lines per hour (average 211 kilograms per hour).

4.3.2 Tabula domestic area

Three persons work in this area. The warehouse activities are divided in two shifts; one shift (morning) of two persons and one shift (evening) of one person. Each order has to be picked and packaged by the same person. This means that the employees have to pick from the racks and the paternoster by themselves. The equipment of this area consists of order picking barrows, two pick trucks, two small trucks, and one reach truck (this truck is used by all the areas). The costumers of these area are companies of the domestic market; Denmark. The

most important buyers are Lemvigh-Müller, Automatic Syd A/S, Danish Tale, Pro Automatic, and KK-Electronic A/S. The average number of order lines per order in this area is smaller than the average in the Tabula export area, because the Tabula export area gets more project orders. The average in 2007 was approximately 10 order lines per order. However, the sizes varied very much; from 1 to 310 order lines per order (in 2007).

Value Stream Map

The Value Stream Map shows the order picking and packaging process of the Tabula domestic area in the same way as the Value Stream Map of the Tabula export area. This Value Stream Map represents an average order as well. These measurements take place in the same way as in the Tabula export area. The processing steps that are different in comparison with the processing steps in the Tabula export area are shown in the form of ovals.

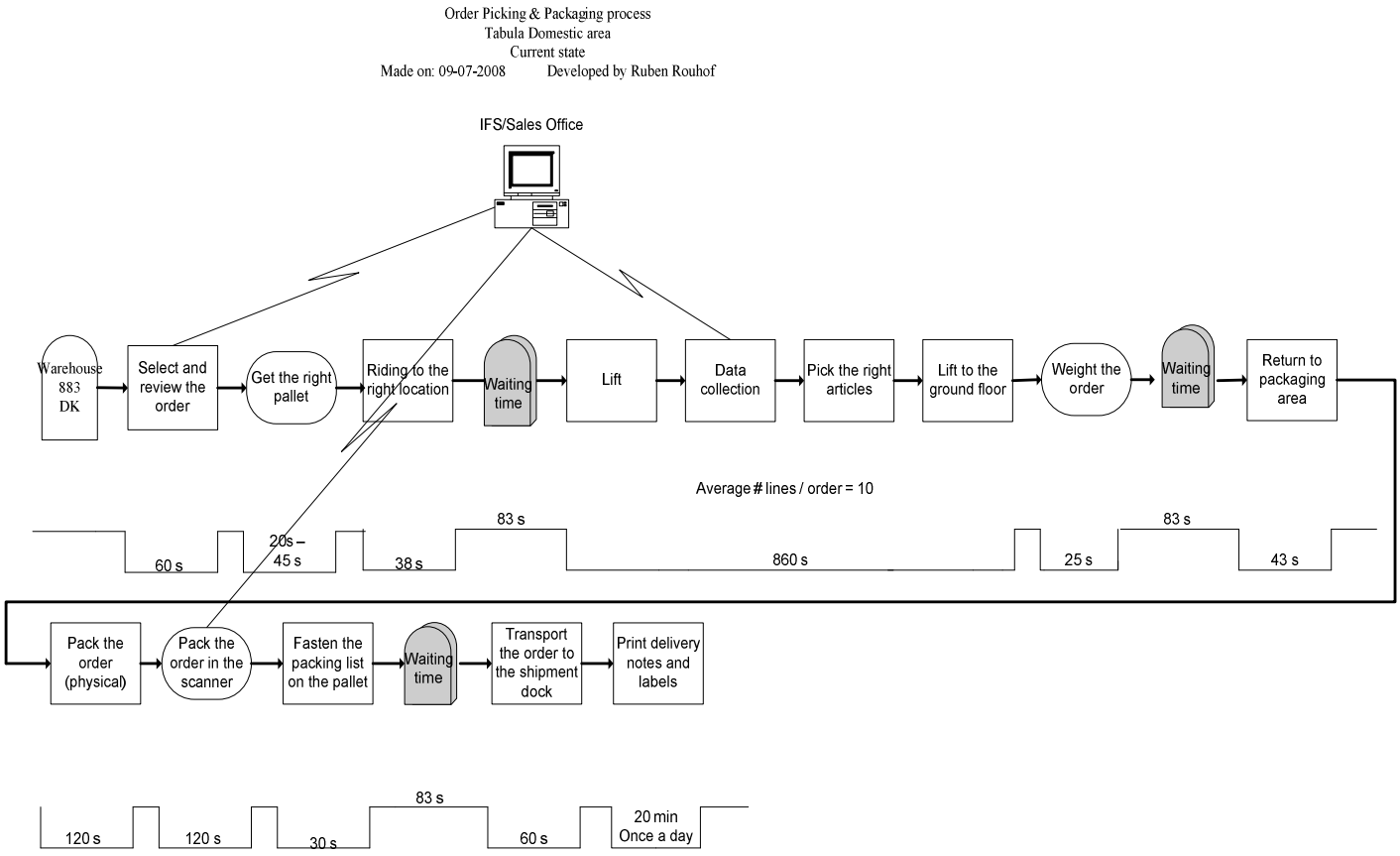


Figure 4.8 Current state Value Stream Map; Tabula domestic area

Description of the current order picking and packaging activities

The Tabula domestic area uses a strict order picking strategy. Each picker has to pick their own orders. It could happen that an order contains too much order lines to pick it in one pick route. To pick the whole order the warehouse employees have to split up the order in parts (pick tours).

This area also uses a barcode scanner. This scanner gives the warehouse employee information about the order lines that have to be picked. However, the warehouse employees

decide their own pick sequence. The system in the barcode scanner is set for the Tabula export area. In the domestic area the picking and packaging activities are also combined; the picker packages the order as well. The employees start with the small articles that go on a pallet. The large articles cross the pallet size. The warehouse employees in this area are picking the orders based on the first-in-first-out (FIFO) principle. This principle means that the employees have to start with the orders that are placed first.

The employees put the articles directly on the right pallet (pack-while-pick). There are pallets in two sizes. Orders (mostly rest orders) with few and small order lines are not put on a pallet. These articles will be shipped in a cardboard box. The packaging activities (fasten the articles on the pallet) take place in another area and are labour-intensive. Data collection takes place with the help of barcode scanning. Besides, this warehouse area uses kanban cards in the same way as the Tabula export area. Furthermore the computer system provides the right labels, delivery notes, and packaging forms.

To measure the productivity of this order picking process we used the same method as in the Tabula export area (see Appendix G). The average number of order lines picked per employee in this area is approximately 10 order lines per hour. At this, the warehouse employees picked an average weight of 162 kilograms per hour. This number of kilograms explains the higher productivity (in terms of order lines per hour) of the Tabula domestic area in comparison with the Tabula export area, because it takes longer time to pick heavy articles than light articles.

4.3.3 Routing within the order picking process in the Tabula main warehouse

Chapter 3 explained that it is essential to recognize the structure of the path that the order pickers cover to pick the order lines. In this way we could conclude whether the pickers walk the route through the warehouse in an efficient way. To analyse these routings we make use of a so-called spaghetti diagram. An example of this spaghetti diagram is shown in Appendix H. In the current situation the pickers use the picking sequence, based on the packaging policy (as mapped in the barcode scanner in the case of the Tabula export area). At this, it becomes clear that the warehouse employee has to pick often per row. A consequence is that the warehouse employees have to return to another pick location in the same row and narrow aisle. However, the employees have to ‘scroll’ in the barcode scanner to search for articles that are suitable to complete the box. This influences the picking sequence. Besides the employees are moving criss-cross through the warehouse. There are no guidelines for the way of driving in the warehouse.

4.4 Other influential process steps in the warehouse

As we can see, out of the two Value Stream Maps, other (warehouse) process steps affect also the efficiency of the order picking and packaging process. Therefore is it important to describe these process steps as well. We will explain the relation of the specific process step with the order picking and packaging process.

4.4.1 Receiving materials in the warehouse

Within this process step there is a distinction between articles coming from external suppliers and articles coming from the production line. So the incoming goods and the materials from the production line are received in a different way. In the first place the incoming

(outsourced) articles are received on a different place in the warehouse (Appendix D). Second, an appropriate employee controls these articles on the amount, specifications, and eventually damages. This control is based on the Eaton Quality System (EQS). The system determines the standardized steps that an employee has to take. The EQS is used by all the Eaton companies in the world. The articles from the production line are not controlled in the warehouse. This control takes place at the production line. The data in this process step is collected in an manual way. The collected data will be entered in IFS. The inbound dock of the outsourced materials is also used as outbound dock. In other words, the inbound and outbound are not physically separated.

4.4.2 Storage

Most articles in the Tabula finished goods warehouse are stored based on their physical characteristics. Namely, the longest and heaviest articles are stored on the side of the walls. Very small articles (e.g. screws) are stored in a paternoster. Furthermore, product families are stored together. The articles are stored based on the picking/packaging sequence. This means for example that the (coated) doors are placed in the same row. The articles are stored on a dedicated based policy: each article is situated on a permanent location. There are exceptions for articles with specific requirements from the customer. These articles do not have a fixed location. For specific articles the warehouse makes use of a bulk inventory and floor stock. Specific articles from the production line (e.g. side plates and doors) are stored in the bulk inventory. These articles can be seen as a buffer and are mostly stored on the highest locations in the row. Nevertheless, most articles are not stored on the principle of bulk and floor stock.

In the current situation one person is responsible to put the articles on stock. This occurs without any automatic tool (e.g. a barcode scanner). Mostly this employee knows, based on his experience, on which locations the articles have to be stored. When the employee doubts about the location, the IFS can be used to know the right location. The warehouse employee is not triggered by a specific sign of the production line. This is totally based on communication with employees of the production line.

4.4.3 Shipment

<u>Tabula export area</u>

After the order is arrived at the shipment dock a warehouse employee has to affix the box with a delivery note. Subsequently this employee has to sort the boxes in a right way to ship the boxes in an efficient way. For example, boxes that have to go to different countries in the Middle-East are put together. It is already made clear that the inbound and outbound are situated at the same place. The docks are not separated. The transporter is the person that has to load the boxes (orders) in the lorry. The employees of Eaton Electric do not have any tasks in this activity. The mode of transportation is different. There are shipments by plane, truck, and ship. It is also possible that couriers take care of the orders. The choice which mode of transport is used is dependent on the destination time, and size of the order.

<u>Shipment Tabula domestic area</u>

The Tabula domestic area uses two shipments docks. The most orders are going to the dock nearby the packaging area (the shipment dock of Elatis as well). However, there are exceptions for two customers (Solar and Flex Towler). Because these customers use other

transport companies, the orders are going to the shipment dock of the Tabula export area. This also applies for the small packages. The reason for a different shipment dock, in comparison with the Tabula export area, is because of the space. It reduces the movements in the export packaging area. The mode of transportation is usually by truck, because the orders are intended for customers in Denmark.

4.5 Conclusion

As stated before, the Tabula export and domestic area make use of the same finished goods warehouse. To search for possibilities to improve (merge) these current processes it is necessary to consider the differences between them. As mentioned in the introduction of this chapter, the flow charts of the processes could tell us in an accurate way in which process steps the processes differ from each other. The differences will be explained in this section.

4.5.1 Method of order picking and packaging

The main difference between the processes is related to the method of packaging. In the Tabula domestic area employees are using other packaging material than in the Tabula export area. To pack the SKUs (Stock Keeping Units) of the order, the Tabula domestic area makes use of pallets. The Tabula export area has to put the units in timber boxes. This difference is because of the orders, that are intended for the export, have to cover a longer distance (longer transportation time and more often load and unload). This means that Eaton Electric has to package these orders in a more careful way (other packaging material) than the orders of the Tabula domestic area. Moreover, the size of the export orders is bigger than the orders of the Tabula domestic area. These orders are not suitable for an EU pallet.

This method of packaging has its effect on the method of picking. As mentioned the barcode scanner is made for the Tabula export area. The picking sequence is adjusted to the packaging method of this area. Because of the different packaging method it is logical that this sequence is not suitable for the Tabula domestic area. Therefore the warehouse employees of the Tabula domestic area are picking often on their own way; not looking to the system in the barcode scanner.

4.5.2 Other differences

The rough sketch of the warehouse (D) shows that the diverse activities do not occur on the same place. First, the packaging activities take place on a different place. Second, the shipment dock (outbound) is situated (for the most orders) on another place. This means that the flow of the goods are very different from each other.

The points in time of the shipments differ too. In the Tabula domestic area the shipments take place every day, because the orders of the Tabula domestic area are often small and the destination of these orders is the domestic market; Denmark. Foreign export occurs two to three times per week (mostly on Tuesday and Friday). The number of shipments in this area depends on the number and destination of the orders.

5. Problem analysis

Chapter 4 described the current situation of the order picking and packaging processes. Section 5.1 shows the current Value Stream Maps with the Kaizen events. Section 5.2 explains and analyses the problems (the non-value added activities) of these processes.

5.1 The Value Stream Map with Kaizen events

In Chapter 4 the current state Value Stream Map showed the processing steps within the order picking and order packaging process of the Tabula export and the Tabula domestic area. Lean thinking focuses on eliminating waste in every process. In the view of the lean system a process without waste is the preferred situation. A comparison between the current state and the future state explains which waste activities have to be eliminated. In this investigation we are focused on the following wastes (Kaizen events):

- Waiting within an aisle before the warehouse employee can pick the articles (A).
- Unnecessary movements, because the inventory level is not right and the routing is not optimal (B).
- Waiting before the warehouse employee can package and the order (C).
- Waiting before the warehouse employee can weigh the order(D).
- Waiting before the warehouse employee can bring the order to the shipment dock (E).

Figures 5.1 and 5.2 show the current Value Stream Maps with Kaizen events. Section 5.2 analyses the waste activities; the underlying causes will be explained.

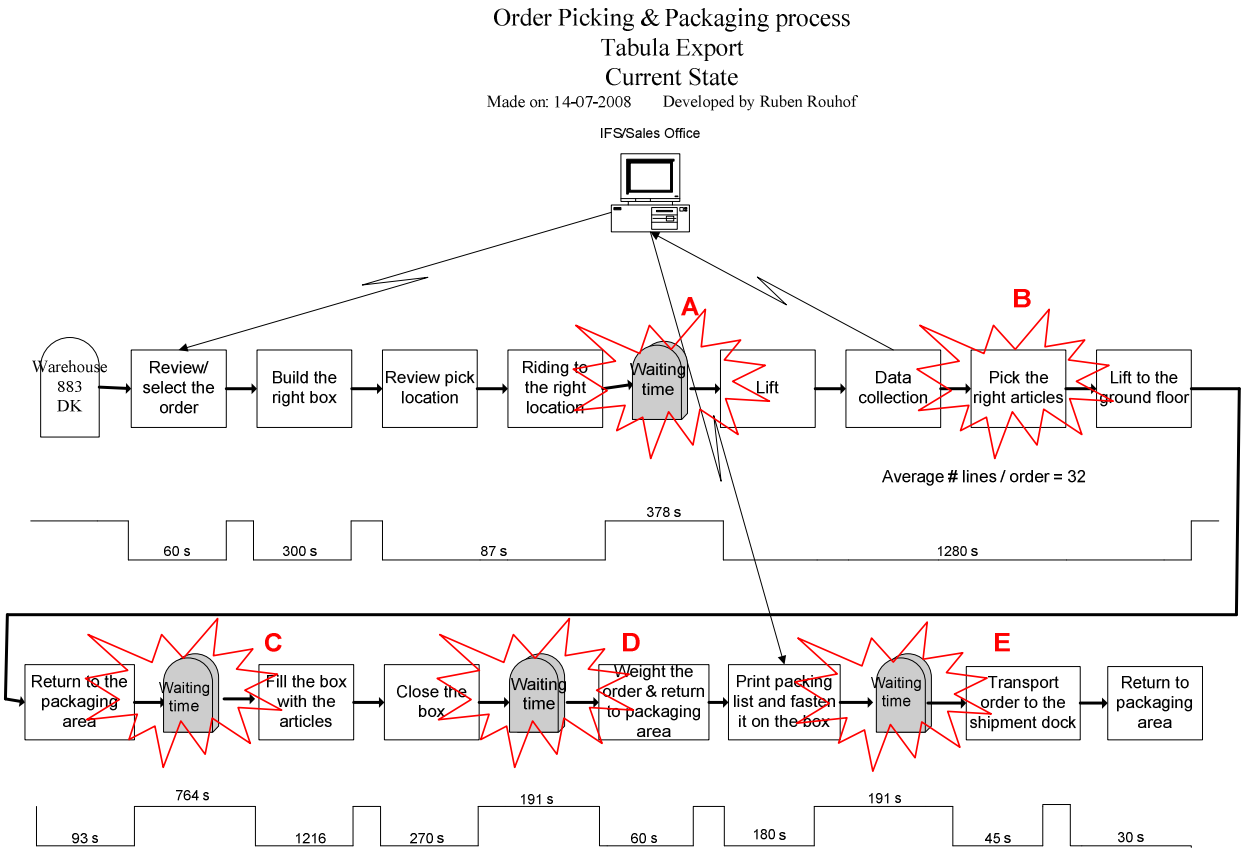


Figure 5.1 Current state Value Stream Map with Kaizen events; Tabula export area

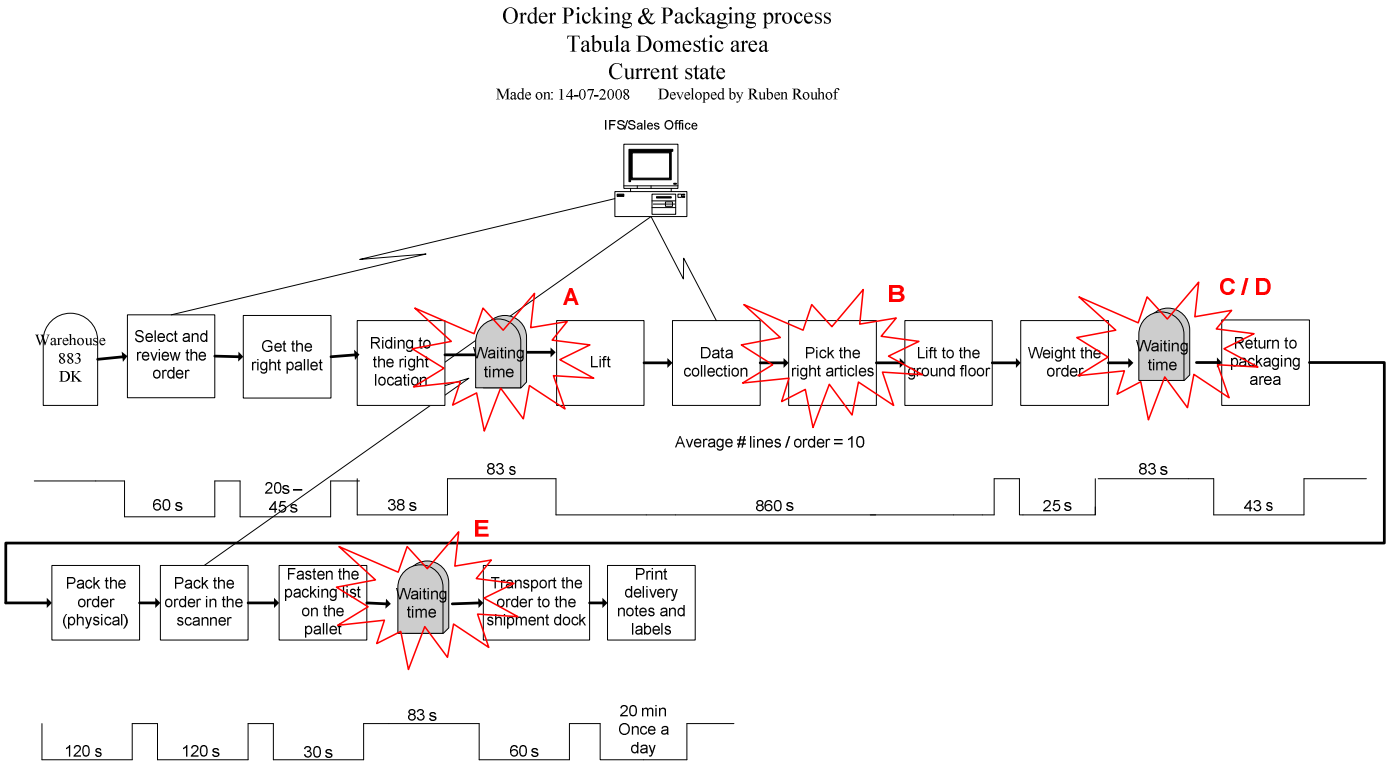


Figure 5.2 Current state Value Stream Map with Kaizen events; Tabula domestic area

5.2 Analysis of the waste activities

First, the Kaizen events in the Value Stream Maps show that there is waste in the form of waiting. As can be seen that these waiting activities occur in different ways (at different processing steps):

- **Kaizen A**: Waiting within an aisle, because a colleague is in the way (congestion). Research shows that each person has to wait approximately 10 minutes per day. This means 378 seconds at an average order of 32 order lines (10 minutes / 50,25 order lines per day * 32 order lines).
- **Kaizen C**: Waiting for a colleague at the packaging area. Because another warehouse employee is picking (also the truck is in the way) there is no space left to package. This is particularly the case at the Tabula export area. This means a waiting time of approximately 20 minutes per day.
- **Kaizen D**: Waiting for a colleague, before the warehouse employee can weigh the order. Research shows that each warehouse employee has to wait about 5 minutes per day.
- **Kaizen E**: Waiting for a colleague (the warehouse employee that is receiving the materials) before the warehouse employee can transport the order to the shipment dock. This means a waiting time of approximately 5 min per day for each warehouse employee.

In total, a warehouse employee has to wait approximately 40 minutes each day (based on observations). This comes to a total waiting time for warehouse employees of approximately 20 hours per week (based on the fact that there are 6 employees working in the warehouse).

An important underlying cause for these waiting times (Kaizen A, C, D) is the amount of traffic in the warehouse. In the normal occupation 6 warehouse operatives are working in the Tabula warehouse. One warehouse employee is storing the articles, three warehouse employees are picking and packaging the articles for the Tabula export area, and two warehouse employees are picking and packaging the articles for the Tabula domestic area. The waiting times are caused by the fact that each employee takes part in the traffic of the warehouse.

Moreover, the conflicting transport flows cause waste in the form of waiting (Kaizen E). Namely, the inbound dock and the outbound dock are located at the same place. The flow of goods goes through the same door; the flow of the incoming articles (receiving the articles coming from the external supplier) and de outgoing articles (shipment) are not separated. These wastes occur in both areas (Tabula export and Tabula domestic). Appendix I shows this situation with help of pictures.

Second, there is waste in the form of unnecessary movements (**Kaizen B**). At this processing step it occurs frequently that the physical inventory in the warehouse is not equal to the data in the IFS; a discrepancy between the administrative inventory and the physical inventory. This leads to extra and unnecessary movements by the warehouse employees. When an location is empty or there are not enough articles on the relevant location the warehouse employees perform a number of activities. The employees search on other places (buffer locations) in the warehouse to find the right articles, go to the production line to see if the articles are stored over there, ask the planner for information, and finally the employees look in the IFS to see if the system is right. These extra activities mean waste of time. To quantify the number of dissimilarities between the physical inventory and the administrative inventory the warehouse employees had to score this on a standard form (Appendix J) when the location is empty or when there are not enough articles on the specific location. However the warehouse employees are not disciplined enough to get reliable results out of this research; observations show that the employees often forgot to score dissimilarities on the standard form. To get a reliable and valid indication of the reliability/accuracy of the inventory we have looked to the inventory count of 2007. This is the annual count of the whole inventory. This count shows that on 266 of the 1083 (counted) locations of the Tabula main warehouse there are not enough articles. This means a percentage of 24,56 %. Moreover the count shows that on 34,16 % of the locations there are stored too much articles. These data shows that the inventory of Tabula main warehouse is not reliable.

During the observations we have seen that the warehouse employees have to pick from location higher than the floor stock. The employees have to pick these articles with help of an truck; lifting to the right tier. The Eaton Lean System focuses on eliminating waste in every operation. In terms of the ELS, lifting is waste in the form of movements. In other words, it is necessary to avoid lifting as much as possible during picking the articles. It is clear that the process step ‘storage’ has influence on the efficiency of order picking. Considering this explanation it is important to identify whether the articles are stored in the right way. Therefore an diagram is developed that points out how many times the warehouse employees have picked articles from each location. The quantity picked per transaction does not play a part in this measurement. The question is whether the articles are stored in such a way that it is uncomplicated and efficient for the warehouse employees. Appendix K shows an example of the diagram. With the help of this diagram we analyse whether the most articles are picked from the floor stock. The diagram applies to the main warehouse of Tabula. The paternoster is left out of consideration, because the paternoster has is own system (parts-to-picker). We have

analysed the data from 1 January 2007 (from then this data was available) until 1 May 2008. The time period under investigation is 16 months. The data is coming from IFS.

Articles that are stored on the first and second tier are situated on floor stock. The warehouse employees can pick these articles in a simple way. However the employees have to pick some articles (the long and heavy ones) from these locations with a truck. This means a small lift time. We can conclude that the articles on floor stock will cost the least time to pick them. Therefore it is necessary to look at the statistics that tell how many transactions (out of the total transactions) are done from these locations. In this way one can get a good indication of the storage method that is used within this warehouse. Table 5.1 shows these statistics per aisle.

Aisle number	% Transactions from floor stock
1 (A – A)	60,41
2 (B – C)	74,19
3 (D – E)	68,05
4 (F – G)	72,94
5 (H – I)	70,96
6 (J – K)	52,38
7 (L – M)	82,74

Table 5.1 % Transaction from floor stock

The average percentage of the total transactions out of the 'floor stock' in the main warehouse is 68,76%. It is impossible to store all the articles on floor stock, because of the available space in the warehouse. The result in aisle number six is considerable. However, we can explain this result, because a lot of locations contains more than one article, because of the small size of the specific article. Besides, in a part of this aisle are long and heavy articles stored. So it is logic that the employees have to pick from higher locations too, because the articles with the same characteristics are stored together. As can be seen in the map (Appendix D and H) the truck has more space to move in this aisle to get the pallet out of the racks. In short, with relation to lifting, we can conclude that the articles are stored in a good way.

Also it became clear that the routing of the order pickers is not always optimal. The warehouse employees crisscrossed the warehouse; there is no system of driving. Besides the warehouse employees are, because of the picking sequence (based on the packaging method), picking by row. The consequence is that the employees are moving back and forth in the (narrow) aisles. Because of this, it impossible for other warehouse employees to pass by this warehouse employee in the aisle. Appendix H shows an example of the routing of a pick tour in the form of a spaghetti diagram.

Another problem in the current situation, that is not a result from the Value Stream Map, is the inflexibility of the Tabula export and the Tabula domestic area. Chapter 4 described the differences between the two areas. The main difference is the different order picking and order packaging method. This is hampering the flexibility. Because of the different picking and packaging processes and standard methods the warehouse employees are not used to work in the other warehouse area. In situations where, for instance, the Tabula export area has to finish the orders for delivery in a very short time (often on Tuesday and Friday) it is

impossible that the warehouse employees of the Tabula domestic area could help, because these employees do not have knowledge of the standard methods of the Tabula export area. Further, these warehouse employees are performing their tasks at a different packaging area.

5.3 Conclusion

Sections 5.1 and 5.2 discussed and analysed the problems and wastes in the current situation. The key Kaizen events in this report are the waste in the form of waiting times and the waste in the form of unnecessary movements (caused by the reliability of the inventory). This focus is chosen, because these types of waste cause the main problems in the current situation (see Figure 5.1 and 5.2). Chapter 6 describes the preferred situation; the future state. This chapter explains what Eaton Electric has to do to achieve the preferred situation (elimination of the waste).

6. The preferred situation for order picking and order packaging

Chapter 5 analysed the problems (waste activities) in the current situation. This chapter discuss the steps that Eaton Electric has to take to achieve this preferred situation (elimination of the waste). Sections 6.1 to 6.5 explains various improvements to reach the preferred future situation. Section 6.6 shows the future state in the form of a Value Stream Map and 6.7 discusses the change management with respect to the employees.

6.1 Create one packaging area

Chapter 5 explains the inflexibility of the warehouse areas. It is an opportunity to merge the processes and to create one packaging area. This means that Eaton Electric has to realize a main packaging area for both areas at one place. In this way Eaton Electric avoids different flows of goods through the warehouse and it is easier to help each other in one packaging area. To merge the processes it is important to develop a picking and packaging method with which all the warehouse employee are familiar. Because of this Eaton Electric increases the flexibility. In rush hours (Tuesday and Friday) the warehouse employees can help each other to finish the urgent orders; the workload is more balanced. This order picking and order packaging method is explained in Section 6.3.

6.2 Separation of the inbound and outbound

The current state Value Stream Maps shows the waste in the form of waiting when the order has to be transported to the outbound dock. Because the inbound is on the same place there are conflicting transport flows. This leads to congestion. It is necessary to realize a clear separation between the flow of incoming goods and the flow of outgoing goods to avoid these conflicting flows. A possibility is to create an outbound dock next to the current inbound/outbound dock. Another possibility is to create the outbound on the other side of the warehouse (on the side of Elatis). In that way Eaton Electric creates a sort of I-routing. However, this leads to conflicting flows of goods with the warehouse area of Elatis. Beside this, the warehouse employees have to cover more distance to transport the complete orders to that outbound dock.

Underneath (Figure 6.1) *area A* shows the in- and outbound dock in the current situation. To get a clear separation it is a possibility to realize an outbound dock next to the current in-and outbound dock (*area B*). It is not necessary to build a new building; a roof is sufficient to store the boxes. Therefore Eaton Electric has to remove the office; the area next to *area A*. The arrows show the direction of the flow of goods. Appendix D shows a map (not on scale) of the current warehouse area in a more detailed way.

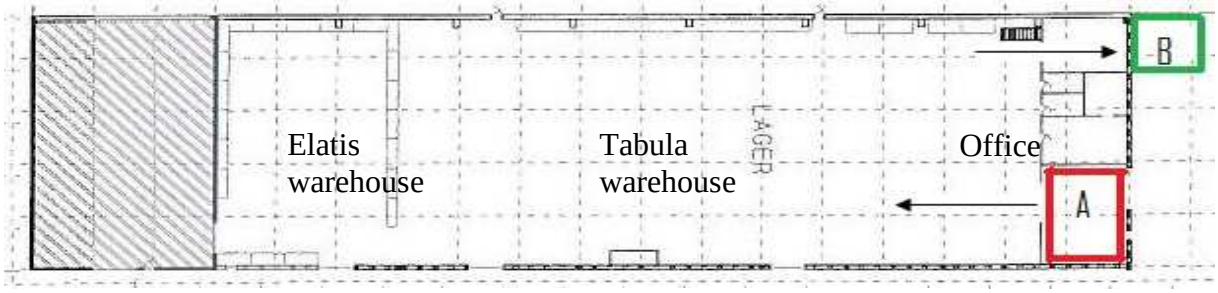


Figure 6.1 Map of the warehouse area without racks (on scale)

6.3 Separate the order picking and order packaging activities

In the current situation the order picking and packing activities are coupled at the Tabula export area and the Tabula domestic area. This means that a warehouse employee first has to pick the articles. Afterwards the same employee has to package these articles. The employees have to do more than one task. We conclude that there are types of waste in both processes, mostly in the form of waiting. This has an unfavourable influence on the effectiveness of the process. Chapter 5 explained an important cause of these waiting times; there is too much traffic within the warehouse.

To achieve a reduction of the amount of traffic in the warehouse (streamlining the process through elimination of the waiting times) it is a possibility to separate the order picking and order packaging activities. This does not mean that the employees only have the skills for order picking or order packaging. Later on in this chapter this will be explained. The separation of the order picking and the order packaging tasks signifies that the picker focuses only his/her attention to order picking. This means that this warehouse employee has to travel to the pick location, has to pick the right articles and has to deliver these articles at the packaging area. Afterwards this warehouse employee has to pick again. In short, the warehouse employee is picking on a continuous basis. The picker does not have to consider the packaging method. This is a responsibility of the packer. The packer does not take part in the picking activities. This warehouse employees has to concentrate only on the packaging activities. This means that the packer has to assemble the box, to package the articles in the right way, to close the box, and to transport the order to the shipment dock. Chapter 7 handles the results and problems coming from an experiment of a separation between order picking an order packaging.

In addition to the elimination of these waiting times, the separation reduces the cycle time to complete an order, because there are working more warehouse employees on an order. In the current situation the sales office has to release an order, in the case of big orders, a long time before the actual shipment. Because of the reduced cycle time/processing time of an order it is possible to release an order later. In this way there are more articles available to pick. At this, it is important to release an order at the moment that all the order lines are available and reserved to pick. This has a favourable influence on the amount of open boxes (see Section 4.3). Because of this Eaton Electric create more flow through the order picking and packaging process.

Another branch of the Eaton Corporation in Birmingham (Reddings Lane, United Kingdom) shows that a separation of these tasks has a positive influence on the cycle time (reduction) and therefore the productivity (increase). Before the separation the productivity was 360 picks per day. After the separation the productivity was 448 picks per day.

Section 4.2 explained the concept of shipping mistakes. In that section it became clear that these shipping mistakes occur more often than articles that are received non-conformed by the customer. The explained separation could have a positive effect on the amount of shipping mistakes. In the current situation, because of the coupled tasks, there is one employee responsible for the amount of articles that are shipped to the customer. With the stated separation there is opportunity to build in an extra point of control (see Figure 6.1). After the employee has picked the articles, the packer controls this amount. Also this employee can control whether the picker has picked the right articles. Through this control point Eaton

Electric lessens the chance of shipping mistakes. The rule is that when there are shipping mistakes Eaton Electric has to pay the transport costs. This is in line with the process of the back order. Eaton Electric saves costs when these shipping mistakes are reduced.

In the current situation the warehouse employees perform the tasks subsequently for one order; order picking and order packaging. These tasks are separated in the future state. At this it is important that every warehouse employee is familiar with the process of order picking and the process of order packaging. Therefore Eaton has to make use of a rotation system; one week the warehouse employee is picking and the other week the warehouse employee is packaging. A discussion with the warehouse employees shows that a rotation system per week will be the most suitable option, because the orders are released per week. Moreover, it costs often (in the case of an export order) a couple of days to pick and package the order. So it is more efficient to rotate per week than for example per day. Due to this rotation system there is no totally division of the function. This in line with the idea of lean; cross-functional worker skills. The most important benefit of this rotation system is that every warehouse employee understand how to perform the tasks. Multi-skilled employees improve the flexibility. In the case of illness it is easier to replace the warehouse employee. Another benefit is that it is better for the ergonomic circumstances of the warehouse employee; the employees do not have to make the same movements every week. Besides it is favorable with respect to the variation in work.

6.4 Supervisor warehouse

The warehouse employees operate on the basis of equality in the current situation. This means that at the end nobody is responsible for the activities. To implement the mentioned changes it is necessary to appoint a person (supervisor) who is responsible for coordinating, planning and managing the warehouse activities. In this way the company avoids disagreements between the employees and it is easier to address someone for the delivered performances. In the current situation no one is correcting each other for mistakes or an undisciplined way of working, because of the equality in the area. The undisciplined way of working causes problems in the current situation. Despite the introduction of 5S (disciplined approach of the work place) we can conclude from observations that the warehouse employees do not follow the rules/standards the whole day. Furthermore, the supervisor can allocate the tasks to the employees in the warehouse (rotation system), so that every employee has the same variation in their work. Moreover, the warehouse employees have the possibility to address the supervisor when there are problems in the warehouse. In the current situation it is not clear which person the employees have to address in problem situations.

6.5 Inventory reliability

The inventory count of 2007 shows that it occurs frequently that the amount of articles that is registered in IFS is not equal to the actual amount of the physical inventory. In other words, there is frequently a discrepancy between the administrative amount and the physical amount. This is hampering the effectiveness of the order picking process. In our opinion it is impossible to get an efficient and effective process in the warehouse when this inequality occurs regularly. Besides, when the article is not available to pick, pack, and ship the company has to back order that article. This means extra costs in the form of transportation. So the inventory levels have to become more reliable and accurate. In this way the company can achieve shorter cycle times and therefore a higher level of customer service (deliveries on the date as agreed).

To improve the accuracy and reliability of the inventory it is good to implement the concept of cycle counting. Cycle counting signifies that the (warehouse) employees have to count the inventory periodically. This means that the counting of the stock can take place every day, week or month. It is not necessary to count every time the whole inventory. This takes too much time. It is essential that these counting activities do not disturb the daily tasks. Besides it is not allowed to count during the picking activities. At that moment the adjustments to the quantities in the system have taken place already, while the physical inventory is changing. For Eaton Electric is it relative simple to introduce the concept of cycle counting, because the system in the barcode scanner has an option to count (a part of) the inventory. In this way Eaton Electric can obtain the results of the count in a quick way.

Counting a fraction of the inventory can help to evaluate the accuracy of the inventory. A more accurate inventory reduces the chance on picking of unreliable locations. This fraction has to be determined before. In this way the responsible employee(s) can make (small) corrections to equalize the administrative amount to the physical amount that is situated in the warehouse. The most important benefit of cycle counting is, however, that it helps to find the source of the error; what is the cause of the dissimilarity? It is important to treat the disease (the cause) and not only the symptoms (discrepancy between the administrative inventory and the physical inventory). With the help of cycle counting Eaton Electric has the opportunity to find the cause of the error, because the time between the current count and the previous count is not long. In this way it is easier to search goal-directed, with the help of the history of that relevant location, to the cause of the discrepancy.

As said it is not necessary to count the whole inventory every time. The raising question is which parts of the inventory have to be counted. A good possibility is to make a distinction between the importance of the articles. The most important articles (the fast movers) have to be counted more frequently than the relative less important articles. With help of an ABC finished goods inventory analysis Eaton Electric can recognize which article numbers have the most importance. Below, the ABC finished goods inventory analysis is shown.

ABC finished goods inventory analysis

To classify the articles in A, B and C groups we make use of Pareto's law. The ABC analysis can help to identify which articles are important for Eaton Electric. As mentioned in Chapter 3 there are several criterions to divide the articles to their importance. In this report the importance of the articles is classified based on the amount of transactions (fast movers vs. slow movers), because this is an important aspect for the order picking process. In other words, the percentage of the total articles that represent 60 to 80% of the activity of the warehouse, measured in terms of total lines picked. ABC analysis implies, with relation to our investigation, that about 10 to 20 % of the inventory articles accounts for approximately 60 to 80 % of the total number of transactions out of the inventory. As mentioned 1002 different articles (based on data of 01-01-2007 to 01-05-2008) are stored in the finished goods warehouse of Tabula and there were 87,478 transactions in these 16 months. Figure 6.2 shows the ABC finished goods inventory analysis.

Out of this diagram and the related table we have, primarily based on theory, made the following classification:

A) About 20 % articles of the finished goods inventory accounts for approx. 62% of the total number of transactions. This means that 203 different articles belong to the A-group.

B) Moderate picked articles, about 30 % of the articles in the FGI, accounts for approx. 29 % of the total number of transactions. This means that the B-group contains 298 different articles.

C) Low picked articles, about 50 % of the articles in the FGI, accounts for approx. 9 % of the total number of transactions. This means that 501 different articles are classified as C articles.

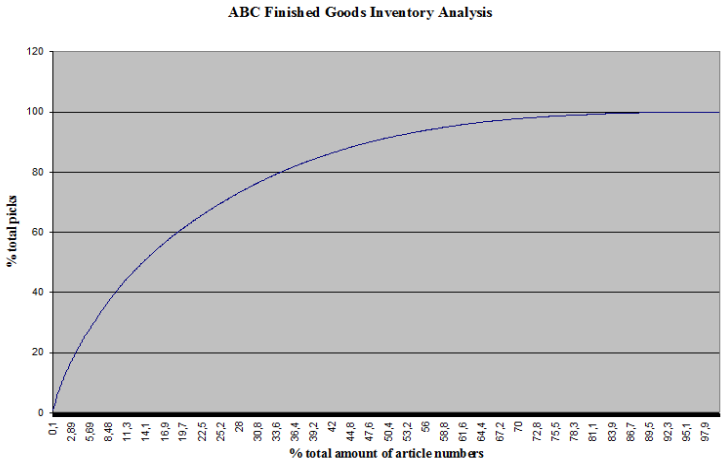


Figure 6.1 ABC Finished Goods Inventory

It is necessary to make a comment with respect to these ABC groups. The classification of the articles is based on data from 1 January 2007 until 1 May 2008. So this classification is valid at this moment. It is for Eaton Electric important to identify from time to time which articles are the most important. In the future the relative importance of the articles could change.

Besides cycle counting there are two possibilities for Eaton Electric to control the accurateness of the inventory. These possibilities are useful in times of pressure. The first method is to control only whether the (right) articles are stored on the right location. In this way the warehouse employee does not have to count the amount of the articles and saves time. Another less time-consuming counting tool is to make use of a so-called empty location control. This means that the employees have to control only the locations that are empty according to the IFS. In this way it is possible to get in a quick way an indication whether the information in the IFS is correct.

In addition to the introduced concept of cycle counting another implementation can help to improve the reliability of the inventory. As stated in Chapter 4 the employee who is responsible for storing the articles, performs his activities manually. The employee does not use an electronic tool. In the current situation the employee has to store the articles based on his experience and knowledge. This can lead to unintentional storing mistakes. A barcode scanner would be an improvement to get the inventory more reliable. This tool makes it possible to perform the tasks in a faster way. Furthermore, the barcode scanner shows the location of the article. This avoids possible mistakes of the employee. Therefore the barcode scanner improves the accuracy of the administrative inventory as well. The employees, who are storing the articles, have to scan the article and the location to be sure that the articles are stored on their dedicated location. When the dedicated location is completely filled with articles, the barcode scanner has to show the buffer location. When this location is also not available, the barcode scanner has to show a randomized location in the warehouse. It is important to store the articles directly on stock, because else the articles become obstacles (Appendix L). This is hampering a streamlined flow within the warehouse. In addition to this it is always important to book the article administrative. In this way the system (IFS) knows

the destination (location) of the article. It is essential to know on which location the articles (and in which amount) are situated in the inventory. This contributes to a more reliable and accurate inventory.

6.6 The future state

The Value Stream Map in Figure 6.2 shows the future state of the order picking and packaging process based on the changes explained in Section 6.1 until Section 6.5. The future state is a wishful (idealistic) thinking situation; no waste in the process. Eaton Electric uses a cyclus of 90 days. After this cyclus Eaton Electric can decide if other adjustments are needed to achieve the future state; the company is focused on continuous improvement. The times in this Value Stream Map are based on an average export order (contains 32 order lines) in view of the experiment in Chapter 7.

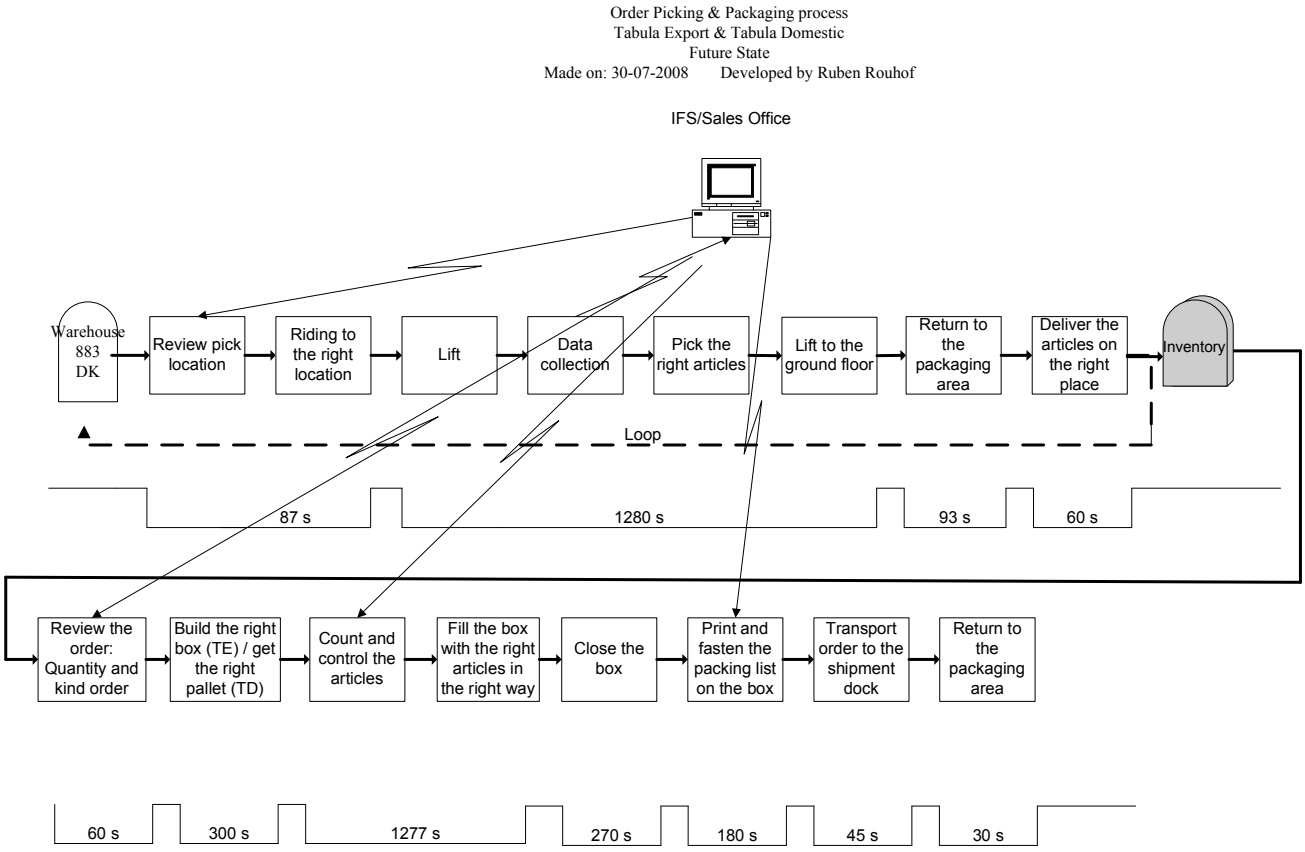


Figure 6.2 Future state Value Stream Map; Tabula export & domestic area warehouse

The most times of the processing steps in this future state are the same as in the current state. The separation does not affect the time of these processing steps, so these times are transferred to the future state. To calculate the time to count the articles at the packaging area we assume (based on observations in the experiment; see Chapter 7) that this takes 5% more time. The processing step 'deliver the articles on the right place' (fixed place in the packaging area) takes average 20 seconds. Moreover, the processing step 'weigh the order' is eliminated. The reason of this elimination is that Eaton Electric has decided to replace the trucks. The new trucks will contain the function that can weigh the order directly; weighing the articles takes therefore no (extra) time.

The future state Value Stream Map shows that the waste in the form of waiting is eliminated. In the current state (export) the cycle time for an average order was in total 5145 seconds. This means approximately 86 minutes (see Figure 4.7). In the future state the warehouse employees (the picker and the packer) are working at the same moment; one warehouse employee is responsible for the picking activities and one warehouse employee is responsible for the packaging activities. The total cycle time to pick and package an average order is 3682 seconds (approximately 61 minutes). At this the cycle time to pick this average order is 1520 seconds (25 minutes). The time to package an average order is 2162 seconds (approximately 36 minutes). The total eliminated time is 1463 seconds. This means that Eaton Electric saves about 24,4 minutes per average order. Per week this a saving of 20 hours. In the light of the productivity in the current situation (7 order lines per hour) this means that the warehouse employees can pick 140 order lines more. This benefit has a positive influence on the metric 'not picked' (see Figure 4.6), because the warehouse employees have more time to pick the reserved order lines. Because of this the warehouse activities can improve the On Time Performance of Tabula.

6.7 Change management

Within Eaton Electric (also in the warehouse) there are working people, who have been working for a long time with the same method of working. After conversations with different employees it became clear that some people are afraid for changes (resist changes). To achieve the future state it is necessary that every involved (warehouse) employee is aware of the change; Eaton Electric has to create support for the changes, so that the employees are accepting the changes. At this, it is important that not only the warehouse employees that are responsible for the order picking and order packaging are involved. Also, for instance, the employees who are responsible for the inbound have to be involved in these changes. The changes affect also their working-method. Therefore it is important that the management of Eaton Electric makes the reasons for the changes clear to the employees. It is good to talk and discuss with the employees about the problems resulting from the current working-method. In this way Eaton Electric can explain the reasons behind the changes. With help of trainings Eaton Electric can show the benefits of the changes for the company as a whole, but also in the perspective of the (warehouse) employee.

6.8 Conclusions

This chapter explained the preferred situation; a situation without waste. To achieve the future state, as illustrated in Figure 6.2, we suggested the following changes to improve the current situation:

- The creation of one packaging area to become more flexible.
- A separation of the inbound and outbound to avoid conflicting transport flows.
- A separation of order picking and order packaging to eliminate waiting times and so increase the productivity.
- The introduction of cycle counting to achieve more reliable and accurate inventory levels.
- The appointment of a supervisor in the warehouse

Chapter 7 will explain the results coming from an experiment of a suggested improvement; the separation between order picking and order packaging.

7. Experiment of the separation between order picking and packaging

Chapter 6 explained the future state of the order picking and order packaging process. The most important and intensive improvement is the separation of the order picking and order packaging process. Before Eaton Electric can implement the mentioned changes it is necessary to investigate whether the separation of the order picking and packaging activities are useful and appropriate. Within Eaton Electric there is a change culture; the company is always open to new ideas that can improve the process. Therefore we decided, in dialogue with the management of Eaton Electric, to investigate the future state (separation of order picking and order packaging) by means of an experiment. Section 7.1 explains the objective and setting of the experiment. Section 7.2 discusses the problems and possibilities and Section 7.3 explains the productivity of the separation between order picking and packaging.

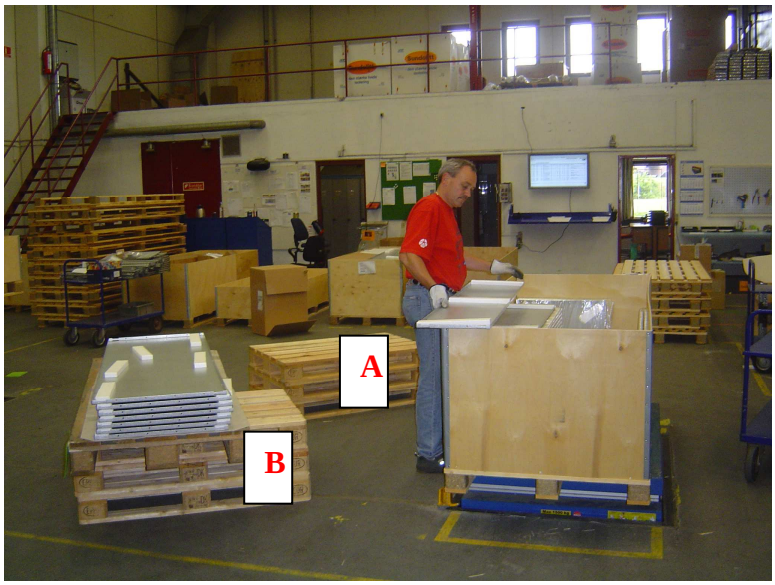
7.1 Objectives and setting of the experiment

The objectives of this experiment are:

- to see what lessons can be learnt during the test. In other words, what are the problems/potential mistakes and what are the possibilities of a separation between order picking and order packaging.
- to examine the productivity of the separation.

To test this separation it is good to involve the warehouse employees in the experiment. These employees are working with the order picking and packaging process all the day, so it is necessary to identify how these persons perceive the changes.

In the experiment there is one warehouse employee responsible for the picking activities and one warehouse employee responsible for the packaging activities. Figure 7.1 shows how the packer is working in the experiment. The two piles of pallets next to the box are used to put on the picked articles; the picker has to put the articles on one of these piles of pallets and packer finally packages the articles in the box.



A, B = fixed places to put on the articles

Figure 7.1 Layout packaging area in the experiment

We have to remark that the test environment is not optimal though:

- The employees, who do not participate in the experiment, are still working with the 'old' method.
- The layout in the test is not optimal; one part of the packaging area is constructed for the test, but the other part is used in the old way.
- The inbound and outbound are not separated in the current situation.
- The warehouse employees are not used to work with another system.

Given the limitations of the test environment we have chosen to test the future state with the Tabula export area. Because within this warehouse area there is more space and there are more physical possibilities to imitate the future state. The possibilities in the Tabula domestic area are not sufficient to perform a good experiment.

7.2 Problems and possibilities

The most important objective of this experiment is to identify potential errors and problems. These errors have to be solved before Eaton Electric can implement the change.

The first problem is the available space. To perform the tasks in a streamlined way the warehouse employees need more space in the packaging area. During the pilot study it became clear that the operators, especially the pickers have to manoeuvre to put the pallet with picked articles on the right place. This limited the space for moving and so a streamlined process. Section 6.1 explains the possibility to create one packaging area for both processes (Tabula export area and Tabula domestic area). With this possibility in mind it is clear that is necessary to create more space. A possibility is to remove the office at the side of the Tabula Export packaging area to create the main packaging area at this place. Section 6.2 explained already that it is necessary to remove the office to realize the recommended place of the outbound dock.

A second problem is the system in the barcode scanner. In the current situation one warehouse employee uses one barcode scanner to perform the tasks. In the future state the tasks are separated. Since the packer has to count the articles at the packaging area it is necessary that this warehouse employee knows how many articles are required to complete the order in an accurate way. This means that the picker has to use a barcode scanner and the packer has to use a barcode scanner. At this, a problem comes to the light. The system in the barcode scanner is namely not live; the system is not updated on a continuous basis. For instance, when the picker has picked an order line it does not appear on the barcode scanner of the packer. Because of this in the experiment the picker and packer communicate with each other to get clear how many articles there should be in the order. This can cause mistakes. It is better to rely on data in the IFS. This is more reliable and it streamlines the process, because the packer does not have to ask the picker all the time.

The start point of the experiment is that the articles of one order go in one box. Sometimes the order is so big that the packer needs more boxes. Therefore we have also investigated the possibility to work with two boxes at the same time. It is namely possible that the articles (order lines) of the order are not suitable to be put into one box. The customer wants to know the content of each box. Therefore it is essential that the right articles are going in the right box. In the experiment this work system causes problems. The packer has to keep in mind which articles are put in the which box. To avoid mistakes it is recommendable to put a barcode label on the box before the warehouse employee starts with packaging the articles.

Before the packer can put an order line in the box the packer has to scan the barcode label on the box and the barcode of the article. In this way the system in the barcode scanner registers the content of each box. This is more reliable than the memory of the responsible warehouse employee.

The picking sequence in the barcode scanner is not optimal. In 2007 the Tabula warehouse areas started to use the barcode scanner. In the course of time some locations were changed, but this is not adjusted in the system of the barcode scanner. To achieve a streamlined process it is necessary and essential to make these adjustments. To get the order picking process more streamlined it is necessary to make these adjustments as soon as possible. Another issue related to the barcode scanner is that the warehouse employees could only see the order lines that are reserved for picking. The order lines of the order that are not available to pick are not programmed in the system. When starting a new order, the warehouse employee does not know what the total order is. Therefore it is possible that the warehouse employee assembles a little box instead of a big box, because the warehouse employee does not know the order lines of the order that has to be shipped.

The third issue is the equipment of the packaging area. In the experiment the warehouse employees used pallets to construct a fixed place to put on the picked articles. These pallets are hampering the flexibility of the warehouse employees during the packaging activities. Because the warehouse employees have to move around the box it is necessary that in the future state these pallets are replaced by moveable tables. This is favourable for the ergonomic circumstances of the warehouse employees. The warehouse employees do not have to carry the articles anymore. Moreover, for the warehouse employees it is more simple to put articles on the moveable table. The pile pallets are namely statically, so with the more dynamic moveable tables it is easier (it comes to less precision) for the trucks to bring the articles on the right place.

In the performed experiment the balance between the order picker and the order packer was good. However, Eaton Electric has to take in account that every order is different. It is impossible to get a total alignment between the activities of the picker and the packer. If the order contains long and heavy articles it is impossible for the packer to follow the picker in a synchronous way (easy to pick, but hard and heavy to package). In that case it is better to have two packers and one picker. Therefore it is essential to review the order (in the case of orders with many order lines), before the warehouse employees start to pick and pack. Eaton Electric has to be flexible with relation to this aspect. At this the appointed supervisor can play an important part; manage and assign people to the tasks. Also during the warehouse activities.

7.3 Productivity

As mentioned before, the results of the experiment are not 100% reliable to asses the future state. However, the results give an indication if the separation is effective. The necessary conditions are not available already, the orders are very different from each other, and it is necessary to take the learning effect in consideration. To perform the tasks in a streamlined way it is clear that the warehouse employees get used to the new work system.

During the experiments that are performed we also measured the productivity; the number of order lines that are picked during that period of time. To compare the current productivity with the productivity in the experiment we get an indication if the productivity is increased.

The first experiment is performed to determine a useful setting. To observe, make adjustments to the start setting, and to discuss with the involved warehouse employees an appropriate test setting is chosen (see figure 7.1).

The productivity is measured during the experiments that are performed. Table 7.1 shows these results.

Date	# Minutes	# Orderlines
11-8	60	23
12-8	60	26
12-8	84	38
14-8	50	25

Table 7.1 Productivity

The results of the experiment show that in the new situation the responsible warehouse employee has picked average about 26 order lines per hour. The productivity in the current situation (one warehouse employee is picking and packaging) is about 7 order lines per hour per employee. This means 14 order lines by two warehouse employees. Based on these results the productivity is increased with 85,7 %. The packaging time does not change significant, because the activities the warehouse employee has to perform are the same in the current and future situation.

7.4 Conclusion

Based on Chapter 6 and the experiment, Eaton Electric has to meet some essential preconditions to achieve the future state; the preferred situation:

- Change the current layout of the warehouse:
    - Create more space to realize one packaging area
    - Separate the inbound and outbound
- Get all the involved employees aware for the change
- Appoint a supervisor for the Tabula warehouse
- Update the system in the barcode scanner
    - The system has to be live
    - The picking sequence has to be updated
    - All the order lines of an order has to be available
- Get the right equipment for the packaging area

If al the conditions are met, the order picking and packaging activities can be separated. This will result in a productivity increase.

8. Conclusions and Recommendations

This report has showed the research to improve the order picking and order packaging process of the Tabula export area and the Tabula domestic area. The problem definition of the research is:

"*How can the current order picking and packaging process(es) be improved?*

This chapter summarizes the most important results with help of the research questions (see Section 2.5). Section 8.1 discusses the conclusions that are coming from the research and Section 8.2 gives recommendations on the basis of these conclusions.

8.1 Conclusions

The Value Stream Map, a key instrument of the Eaton Lean System, is an useful instrument to analyse current processes within a company. With help of this instrument it is possible to identify the non-value added (waste) activities within a process; define Kaizens (improvements) to reach the future situation. In addition, the key performance indicators gives an indication of the performance of the processes.

The current Value Stream Maps show the non-value added activities of the order picking and order packaging process of the Tabula export area and the Tabula domestic area. The causes of these waste activities are not only related to the order picking and order packaging process. Also the warehouse process steps, receiving the materials, storage, and shipment affect the order picking and order packaging process.

Through thorough observations, it became clear that the waste activities are mainly in the form of waiting. Measurements show that a warehouse employee has to wait approximately 40 minutes each day. These waiting times are the result of two main causes:

- The amount of traffic; there are too much employees who take part in the traffic. This leads to congestion within the aisle, packaging area, and the balance.
- The inbound and outbound are not separated. This results in conflicting transport flows.

Another type of waste that is identified is movement. The inventory of the Tabula main warehouse is often not reliable and accurate; the administrative inventory is not equal to the physical inventory. The inventory count of 2007 showed that on 59% of the locations the physical inventory is not equal to the administrative inventory. This leads to search activities at the buffer, production line and other places in the warehouse.

The preferred situation is an order picking and packaging process without activities/processing steps that do not add value to the process; a process without waste. The possibilities to improve the order picking and packaging process and to achieve the preferred situation are shown in Section 8.2.

8.2 Recommendations

Based on the analysis of the problems/waste activities we recommend Eaton Electric to follow the next recommendations to achieve a more effective and efficient order picking and order packaging process.

Eaton Electric has to create one packaging area for the Tabula export area and the Tabula domestic area. This increases the flexibility of the warehouse, because every warehouse employee is familiar with the work method. Because of this, there is the possibility to help each other in times of pressure (deadline pressure; mainly on Tuesday and Friday). This results in a more balanced workload.

Moreover Eaton Electric has to separate the inbound and outbound. This avoids the chance on congestion, caused by the conflicting flows of the inbound and outbound. We recommend to create the outbound at the side of the current inbound/outbound dock of the Tabula export area. In this way the warehouse employees can transport the orders in a quick way to the place of the actual shipment.

To become more flexible it is important that every employee is familiar with the order picking and order packaging process. To eliminate the waiting times Eaton Electric has to separate the tasks of order picking and order packaging. This separation results in less traffic and so a more streamlined process. Besides the cycle time of an order is decreased with help of this separation, because of the eliminated waste in the form of waiting (approx. 24 minutes for an average export order) and the fact that there are more persons working on an order (at least one picker and one packer). This has a positive influence on the availability of the articles. The sales office has the opportunity to release an order (pick list) later on, so that there are more articles available and reserved to pick. This streamlines the order picking and packaging process. Also it affects the On Time Performance in a positive way; there is more time available to pick the reserved articles.

To achieve a more reliable inventory we recommend to introduce the concept of cycle counting. This concept helps to find the source of the dissimilarity between the physical inventory and the administrative inventory. Besides Eaton Electric can adjust the administrative inventory to get a more accurate inventory. It is a good opportunity to couple the counts to the ABC analysis. This means that the articles are classified to their importance; the most important articles (A group) have to be counted more often than the less important articles (B and C group). In addition to this, it is important that the warehouse employee, that is responsible for putting the articles on stock, uses a barcode scanner. This avoids storage mistakes and it makes the inventory levels more reliable, because the system knows exactly which and how much articles are put on stock.

Before the warehouse can operate in a streamlined way it is important that Eaton Electric meets the following essential preconditions:

Get the involved (warehouse) employees aware of the changes
It is important that all the involved (warehouse) employees are aware of the changes. The employees have to accept the changes. Therefore it is essential for Eaton Electric to show the problems in the current situation. In this way Eaton Electric can explain why the different changes are necessary to get a more streamlined process.

Appoint a supervisor for the Tabula warehouse
The appointment of a supervisor is necessary to coordinate, manage and control the activities in the warehouse. The supervisor has to ensure that the employees perform the tasks in a good way; the supervisor is responsible for the performance of the warehouse. At this, the supervisor is responsible for the allocation of the tasks. In addition, the warehouse employees know who to address in problematic situations.

Create more space
Experiments show that there is too little space in the current situation to perform the packaging activities in a streamlined way. To realize one packaging area for the Tabula export and Tabula domestic area it is necessary to create more space. Because of the fact we have recommended that the outbound in the future state will be situated on the side of the packaging area of the Tabula export area it is essential to remove the office. This removal makes it possible to create an exit (outbound) for the outgoing orders and creates space to realize one packaging area.

Update the system in the barcode scanner
The current system in the barcode scanner does not meet the (necessary) requirements to separate the order picking and order packaging activities. The system in the barcode scanner has to be suitable to perform the packaging activities in a good way. In addition to this, it is good to pick per aisle instead of picking per row. The system in the barcode scanner has to be adjusted to achieve this way of picking. In this way Eaton Electric creates one flow through the aisle. This means that the picker visits every pick location within the aisle at the end of the concerning aisle.

Get suitable equipment to perform the (packaging) activities in a good way
To perform the order packaging activities in a good way it is necessary to have the right equipment. In the future state the packers need moveable tables to be more flexible. In the experiments we used two piles of pallets to put on the articles. But the employees have to move around the box, because the box has to be filled in an efficient way. Considering the ergonomic circumstances it is essential that the employees have to carry the articles as less as possible.

Introduce the rotation system in the warehouse
The introduction of a rotation system promotes the flexibility of the order picking and order packaging process. Through rotation of the tasks (order picking and order packaging) every employee is familiar with the working-method (cross-functional worker skills). In the case of illness it is easier to replenish that employee, because all the employees know how to perform the tasks.

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Sources of Eaton Electric ApS

- Integrated Facility System (IFS)
- Intranet (JOE)
- Several company (Eaton Electric) documents related to the warehouse processes
    - Value of the warehouses
    - Actual worked hours
    - List with the picking sequence

List of abbreviations and glossary

Abbreviation	Word	Explanation
	Class-based storage	A storage policy by which the articles in the warehouse are stored in divided zones
EBS	Eaton Business System	
ELS	Eaton Lean System	One of the essential instruments of the Eaton philosophy that focuses on eliminating the waste of all business processes. The Eaton Lean System consists of the following instruments: Value Stream Mapping, 5S, Standardized Work, Total Productive Maintenance, Error Proofing, Set up Reduction, Continuous Flow, and Pull System
EQS	Eaton Quality System	A company philosophy with the goal to create a high-performance culture in all levels of the company
ERP	Enterprise Resource Planning	Large, sophisticated software systems used for identifying and planning the enterprise wide resources needed to coordinate all activities involved in producing and delivering products.
Fast movers Slow movers		SKU Pareto; articles that have to be picked often.
FGW or FGI	Finished Goods Warehouse or Finished Goods Inventory	A type warehouse where finished articles are stored
FIFO	First In First Out	The orders that are placed first by customers are picked/served first
	Heuristic	A science that wants to come to conclusions on the basis of methodology
IFS	Integrated Facility System	The Enterprise Resource System of Eaton Electric. A software packet that is supporting and integrating the different software in the different business processes. In a packet the functions of the independent systems will be integrated, making use of a database
JOE		The name of Intranet within Eaton Electric
Kaizen		Kaizen is often synonymous with Kaizen event. This event means that there are opportunities to improve that part of the process,

		e.g. streamline the processes
OEM	Original Equipment Manufacturer	This is a company that delivers products on behalf of a brand supplier
Order line		An order line is also called 'article' or 'SKU'. Number of lines means the number of different articles in an order. An order line can consist of more than one articles (quantity)
OTP	On Time Performance	The percentage of orders/order lines that are delivered, in conformity with the agreement, too soon or on time.
PPM	Parts-Per-Million	An unity to show data (1/1000000)
Random storage		The basis of random storage is that an article could be stored randomly in a warehouse
Rest order		A rest order contains order lines that were not available to ship with the actually order
SKU	Stock Keeping Unit	See 'Order line'
Tombstone		A symbol in the Value Stream Map to show waiting times.
VSM	Value Stream Map	A ELS instrument that visualizes three flows to identify improvements: the product flow, the material flow, and information flow. This map can identify the potential non-value added (NVA) or waste.

List of figures and tables

Figures

Tables

Appendices

Appendix A Reflection

In this appendix I will give a reflection on the objectives I have drawn up in my preparatory report. In this report I made a distinction between objectives of Eaton Electric and personal objectives.

Reflection on the objectives of Eaton Electric

The objective of Eaton Electric was to investigate the possibilities to improve the order picking and order packaging process of the Tabula export area and the Tabula domestic area. These possibilities/opportunities have to result in a more effective and flexible order picking and order packaging process. The report shows that I developed opportunities to improve the current order picking and packaging process. The results (see Chapter 8; Conclusions and recommendations) coming from the research were showed during a (PowerPoint)presentation to the management team of Eaton Electric and the involved (warehouse) employees. I am convinced that Eaton Electric can benefit from these recommendations.

Reflection on the personal objectives

- *To apply in practice the theoretical concepts I have learned*

  In my bachelor study Business Administration I studied many theoretical concepts about several domains. Eaton Electric offered me the opportunity to apply the learned theory in the domain of the logistics. During the internship I have learned a lot about the tools and instruments (of the Eaton Lean System) that is commonly used within the Eaton Corporation. These tools and instruments were totally new for me, so it was interesting to lose myself in these theoretical concepts and to apply these concepts in practise. Furthermore, I applied several theoretical concepts in practise that I have learned in my study at the university. I can conclude that the theory is not always totally and directly applicable in practise. The situation in practise is always different, so you have to apply the theory in such a way that is relevant and valuable for the specific and practical situation. This was sometimes difficult, but I have learned a lot of it.

- *Learn to work together with other people in the organization; learn to work in a team*

  To perform this assignment in a good way I have worked a lot together with the warehouse employees. From the beginning these employees showed me their working methods. I also had a lot of discussions with them about the main problems in the current situation and how these warehouse employees perceive these problems. Besides I had a lot of conversations with the management of Eaton Electric that is responsible for the activities that take place in the warehouse.

  I have learned a lot of these discussions/conversations and I can conclude that is good to work with other people in the organization. In the first place to exchange ideas with people to know and learn about other perspectives on an issue. This can lead to a new view on specific subjects. Moreover, in my opinion team work leads to synergism. At the end of the internship it was nice to see that other employees of

Eaton Electric ask me for help on certain warehouse issues. In my opinion it is pleasant to help other people when you have knowledge on that specific domain.

Team work; the employees of the Tabula warehouse

- *To become more critical in general about all kinds of information reaching me; processing information in the right way*

  During this internship a lot of information reached me. The first period of the internship I have learned about the work methods of the operators in the warehouse. These warehouse employees explained their way of working. But sometimes the information of the employees are conflicting with each other. This means that is not good to take these information for granted from the first moment. Therefore it was often necessary to control the given information; ask other (warehouse) employees for this kind of information or ask the same employee once more for the information.

  Also I made use of data out of the Enterprise Resource Planning, that is named IFS. I have learned that you have to check these data on completeness and correctness. Besides it is essential to check the calculations. It is necessary that the calculations are reliable, otherwise it is impossible to do pronouncements about the results of it.

- *Make a truly contribution to the organization and her project*
  This objective is already explained at the heading 'Reflection on the objectives of Eaton Electric'.

- *Improve the English language; both in speaking and in writing.*

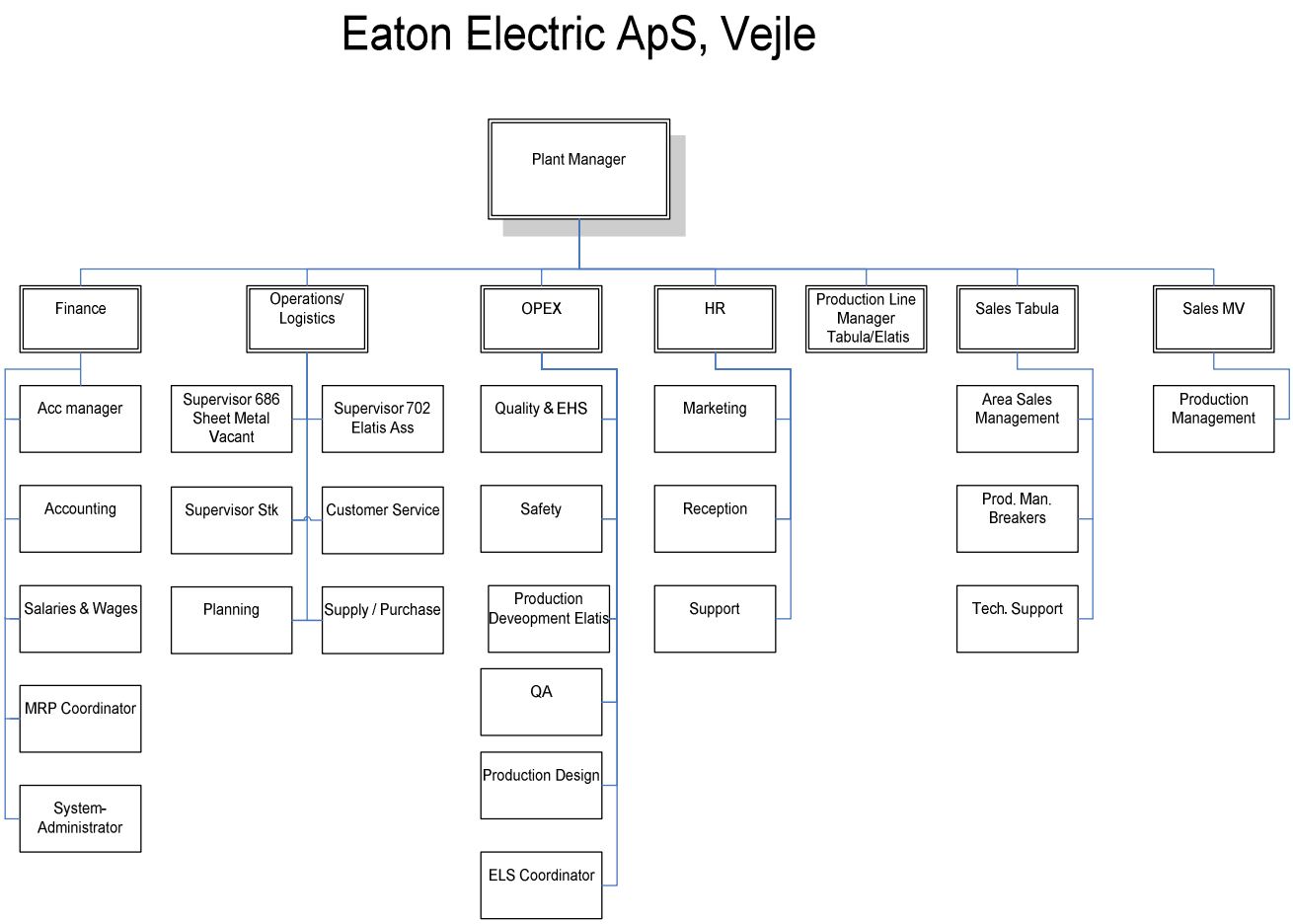
  Students of the University of Twente have two possibilities to perform their assignment, namely intern and extern. Intern means that students perform their assignment within the university.

  Extern signifies that students perform their assignment outside the University. I have chosen for the last option. At this, it was a priority to go to a (English-speaking) foreign country, because I wanted to improve my English.

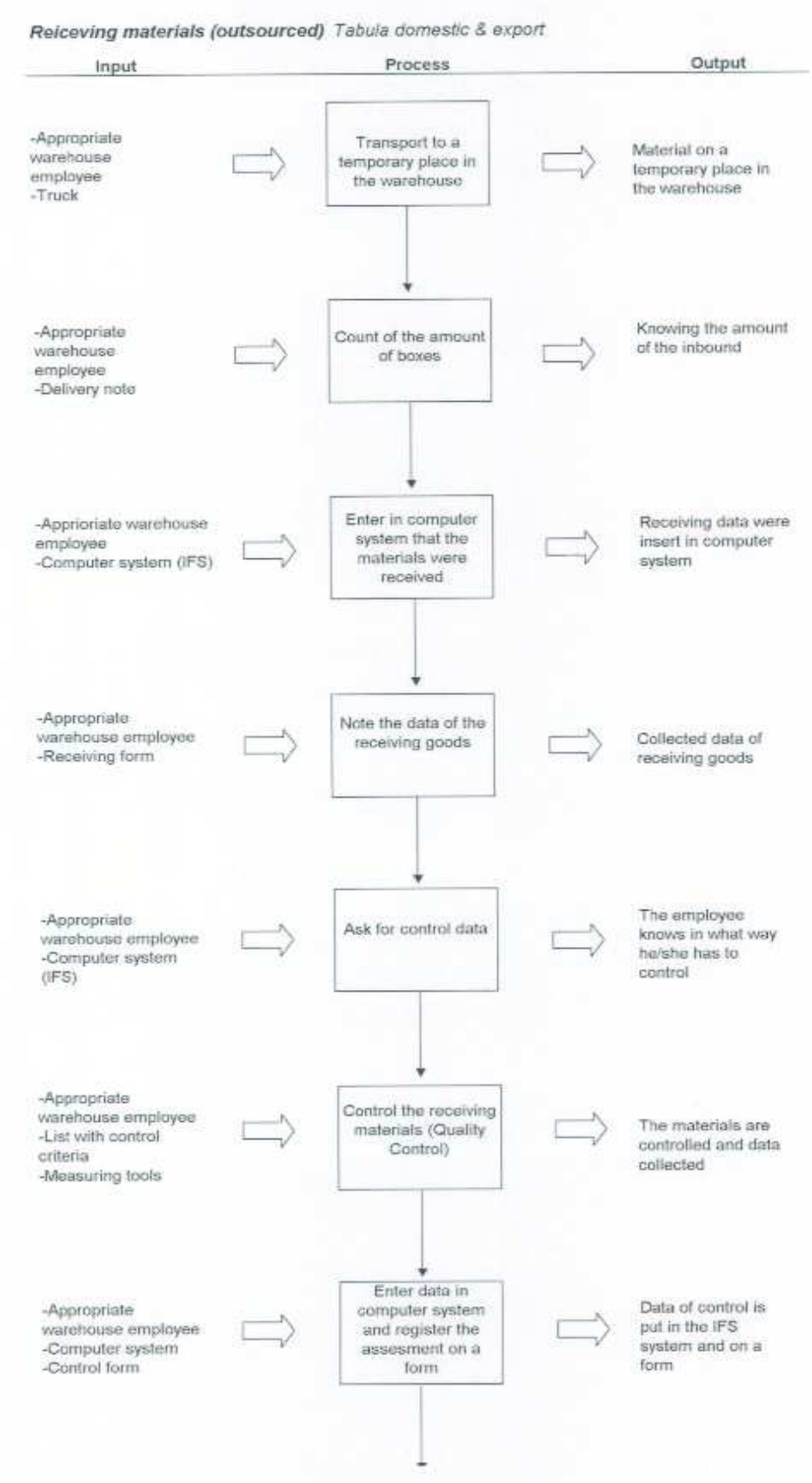
  Eaton Electric is a global company and there are working a lot of nationalities (Danish, Dutch, English, American). The common language in the company is English. To perform the assignment it was necessary to work together with other persons in the company; both the management and the warehouse employees, so it was necessary to speak English. Also I had to present my report for the management team of Eaton Electric and other persons involved with the assignment. It was the first time to do a presentation in English. In the beginning it was strange to talk the whole day in English. Sometime it was difficult to make things clear to persons, but after a while I got more used to the English language so that I could say what I intended. I think my oral usage of the English language is actually improved.

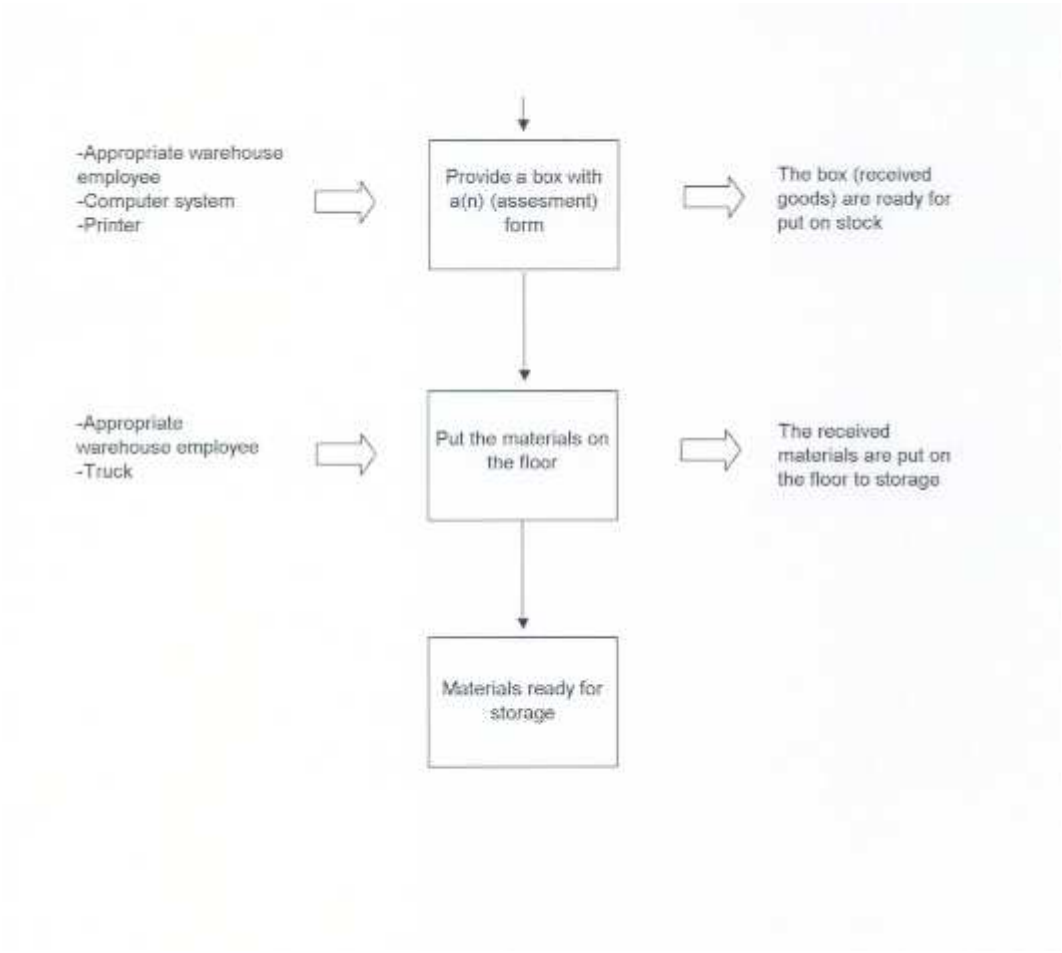
  Because Eaton Electric is a global company I had to write my report in English as well. This was a more difficult task for me than to speak in English. The problems were mainly in the form of word order and the wrong use of words. Despite the English writing skills are still capable for improvement I am convinced that my writing skills are improved. Mainly my English vocabulary is enlarged.

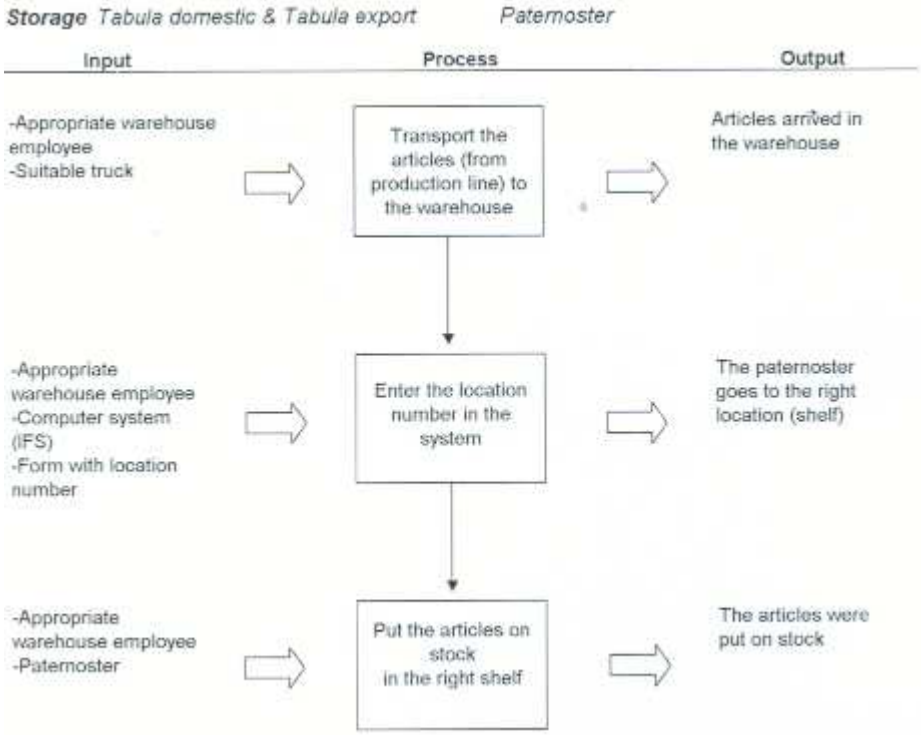
Appendix B Organization Structure

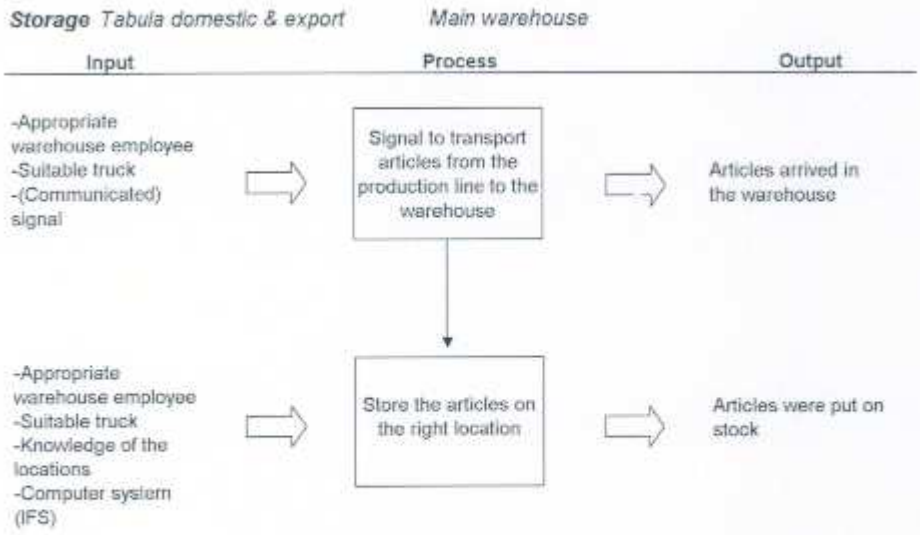


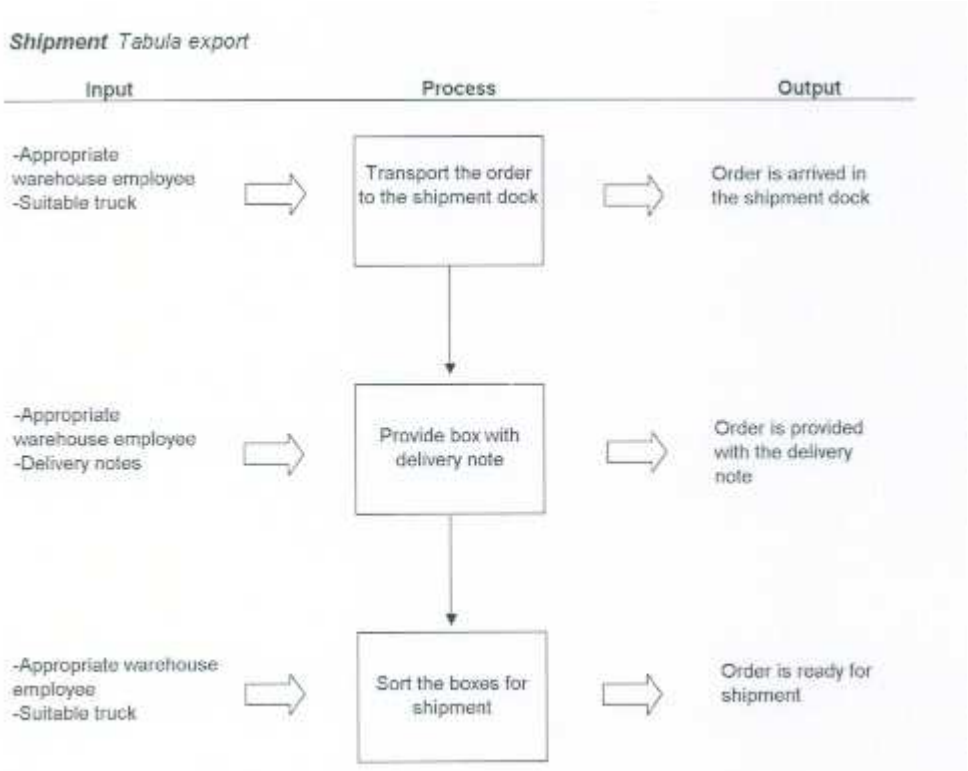
Appendix C The warehouse flow charts

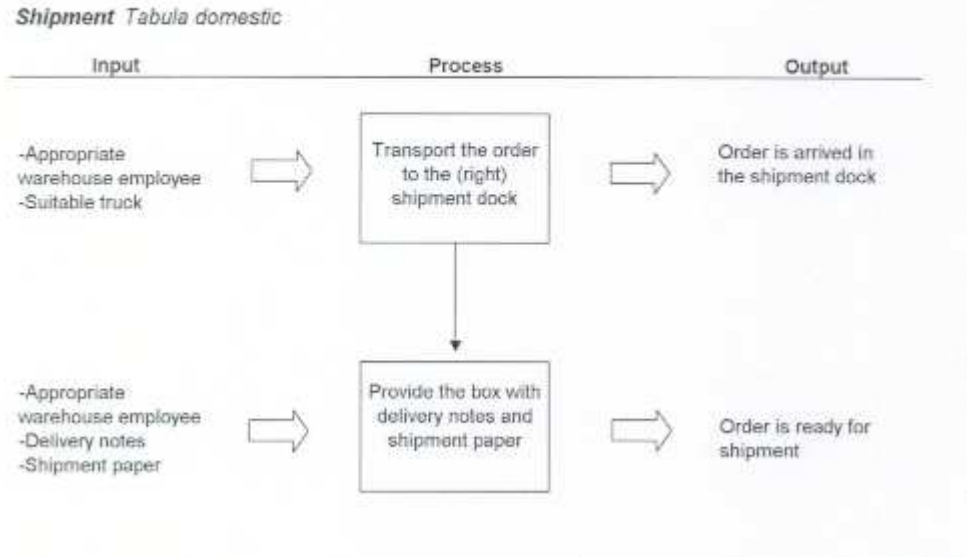



-Appropriate warehouse employee
-Computer system
-Printer
Provide a box with a(n) (assesment) form
The box (received goods) are ready for put on stock
-Appropriate warehouse employee
-Truck
Put the materials on the floor
The received materials are put on the floor to storage
Materials ready for storage

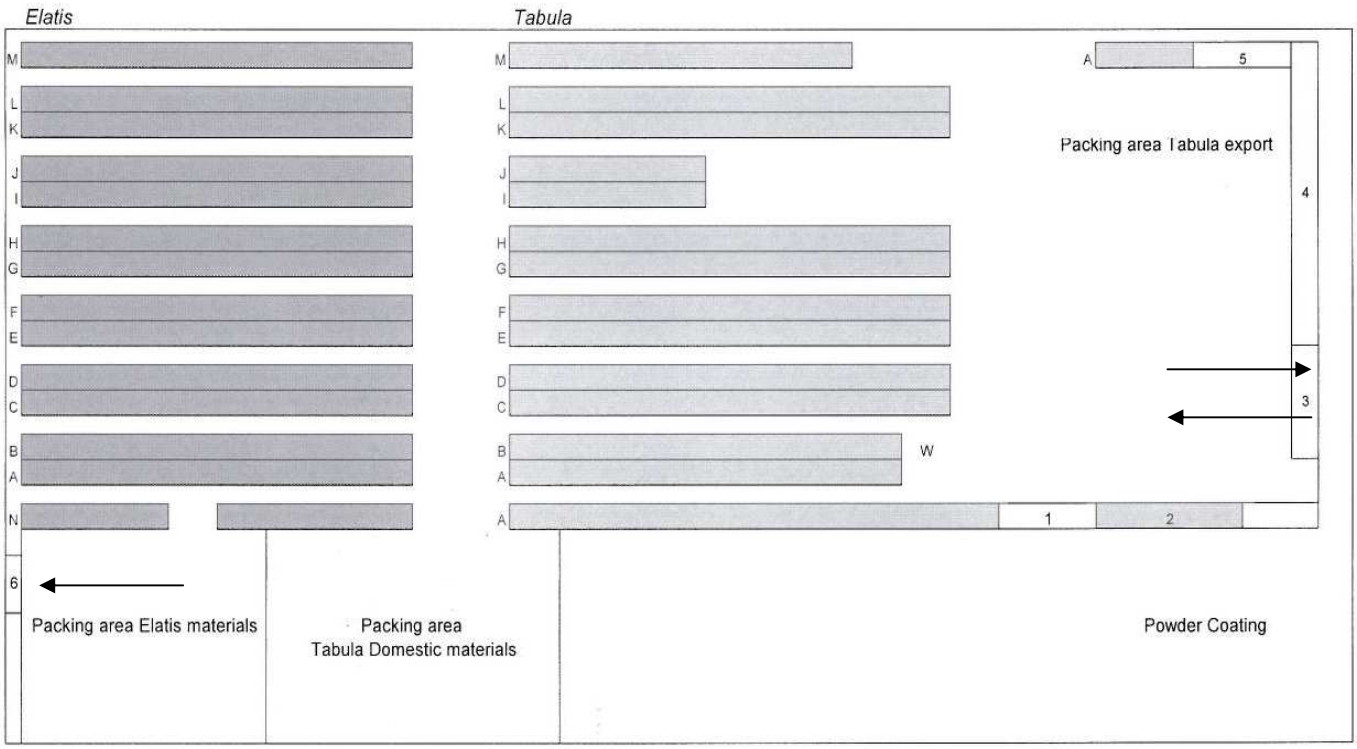

Storage Tabula domestic & Tabula export
Paternoster
Input
Process
Output
-Appropriate warehouse employee
-Suitable truck
Transport the articles (from production line) to the warehouse
Articles arrived in the warehouse
-Appropriate warehouse employee
-Computer system (IFS)
-Form with location number
Enter the location number in the system
The paternoster goes to the right location (shelf)
-Appropriate warehouse employee
-Paternoster
Put the articles on stock in the right shelf
The articles were put on stock


Storage Tabula domestic & export
Main warehouse
Input
Process
Output
-Appropriate warehouse employee
-Suitable truck
-(Communicated) signal
Signal to transport articles from the production line to the warehouse
Articles arrived in the warehouse
-Appropriate warehouse employee
-Suitable truck
-Knowledge of the locations
-Computer system (IFS)
Store the articles on the right location
Articles were put on stock


Shipment Tabula export
Input
Process
Output
-Appropriate warehouse employee
-Suitable truck
Transport the order to the shipment dock
Order is arrived in the shipment dock
-Appropriate warehouse employee
-Delivery notes
Provide box with delivery note
Order is provided with the delivery note
-Appropriate warehouse employee
-Suitable truck
Sort the boxes for shipment
Order is ready for shipment


Shipment Tabula domestic
Input
Process
Output
-Appropriate warehouse employee
-Suitable truck
Transport the order to the (right) shipment dock
Order is arrived in the shipment dock
-Appropriate warehouse employee
-Delivery notes
-Shipment paper
Provide the box with delivery notes and shipment paper
Order is ready for shipment

Appendix D Rough sketch of the current warehouse



Rough sketch of the current warehouse (not to scale).
Developed by Ruben Rouhof

Key to symbols

A, B, C – N	=	the description of a specific row
1	=	inbound articles out of the production line
2	=	the paternoster
3	=	inbound outsourced articles + outbound (shipment dock) Tabula export area and Tabula domestic area
4	=	office
5	=	packaging materials Tabula export area
6	=	outbound (shipment dock) Tabula domestic area and Elatis

Appendix E Example of a pick list

Eaton Electric ApS Plukkeliste: **184443** Ordrenr.: **V63799** Opret.dato: 28-07-08 11:23:14

Ordreinformation

Leveringsadresse: Greenville Electrical Supplies
16 Cedarhurst Road
Newtownbreda Factory
BT8 7RH Belfast
Estate Newtownbreda

STORBRITANIEN OG NORDIRLAND

Leveringssted: Vejle
Lev.beting.: FCA, Excl. Packing
Lev.måde: By Sea
IO-nr.:
Speditør
Vores reference: Lene Olesen
Kundeld: 42803

Antal kasser: Antal paller: Antal pallerammer: Antal langpaller: Emb. diverse:

PLUKKELISTE

Lokationgruppe: **PLUK** Beskrivelse: Plukkelokation

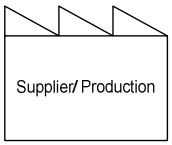
Linie	Varenr.	Antal.	Enhed	Varebeskrivelse	Lager	Reol	Sektion	Hylde	Leveringsd	Plukket antal.
7	**220A3104**	**1,00**	Stk	**Kapslingsprofil l=4M**	883	F0	22	01	01-08-08	
6	**220A3204**	**2,00**	Stk	**Kapslingsprofil l=4M**	883	F0	14	01	01-08-08	
1	**220A3216**	**4,00**	Stk	**Kapslingsprofil l=16M**	883	A0	34	01	01-08-08	
3	**220A6060**	**10,00**	Stk	**Sprosse l=6M**	883	G0	14	02	01-08-08	
12	**220E4557**	**1,00**	Stk	**Grundplade m kant 6x16M**	883	P4	18	01	13-08-08	
11	**220E4565**	**1,00**	Stk	**Grundplade m kant 6x12M**	883	P6	00	00	01-08-08	
10	**220G0204**	**2,00**	Stk	**Beklædning 2x4M grå**	883	B0	12	02	01-08-08	
5	**220G0206**	**2,00**	Stk	**Beklædning 2x6M grå**	883	B0	14	02	01-08-08	
9	**220G0304**	**4,00**	Stk	**Beklædning 3x4M grå**	883	B0	14	01	01-08-08	
8	**220G0416**	**1,00**	Stk	**Beklædning 4x16M grå**	883	H0	16	01	01-08-08	
4	**220G0612**	**1,00**	Stk	**Beklædning 6x12M grå**	883	P3	18	02	01-08-08	

Slut på rapport:

Explanation:
This example of a pick list makes clear that is possible that an order can consist of more than one order line. Moreover, the pick list makes clear that an order line can consist of a different number of that specific order line.

Appendix F Key to the symbols of the Value Stream Map

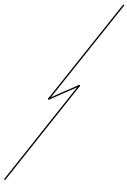
Information system (IFS)



'Supplier of the articles'

The number of supplies

Type of warehouse = 883 stands for the warehouse of Tabula



The flow of information

Kaizen event

The flow of the process

Appendix G Time observation worksheet

Template (Microsoft Office Excel 2003) to measure the processing steps in the process of order picking and order packaging. In this way it is easy to measure the average time of a processing step.

Time Observation Form

Processing step: Observator Date:

Nr.	Operation	1	2	3	4	5	6	7	8	Processing time		Comments
	Information BCS											
	Ride to the right location											
	Pick 1											
	Pick 2											
	Pick 3											
	Pick 4											
	Pick 5											
	Pick 6											
	Pick 7											
	Pick 8											
	Pick 9											
	Pick 10											
	Return											
	Package the articles											
	Total Time											

Measuring method productivity of order picking

We have taken data out of the IFS. We have investigated three periods of a month:
- From 18-02-2008 until 17-03-2008
- From 18-03-2008 until 17-04-2008
- From 18-04-2008 until 17-05-2008

These data can deliver us the number of order lines that is picked per day. To measure the productivity per hour we have divided the number of order lines by the actual number of hours that is worked (clock in, clock out). We have taken the actual hours, because it is possible that an employee was absent (e.g. sickness). To measure the effective hours we deducted the official breaks. The total duration of breaks per day is three quarters. The calculation shows that an employee in the Tabula export market picked approximately 7 order lines per hour (average 211 kilograms per hour).

Results

Tabula export area

Ride to		Pick			Return	Package	# *Picks*
40	16	59	65	33	31	55	5
30	50	26	53	56	40	369	3
30	38	45	20	27	26	58	1
15	36	88	65	18	48	112	1
75	38	39	98		20	53	1
22	90	16	18		23	107	1
15	30	13	27		15	70	1
15	90	19	30		40	103	6
50	25	23	25		70	38	1
20	65	20	27		20	55	1
25	95	25	35		23	205	13
40	173	27	28		35	140	1
15	65	30	47		47	68	1
23	20	18	20		50	212	7
44	100	68	98		30	73	1
40	25	50	20		20	20	1
15	25	37	44		55	60	1
30	35	20	19		26	64	1
15	45	11	28		18	257	1
16	100	36	15		24	40	1
30	45	18	46		12	75	1
4	27	30	34		26	277	19
65	45	18	16		50	84	12
32	35	25	35		12	64	5
20	35	47	37		33	100	4
38	30	32	30		24	200	1
32	65	29	85		30	43	2
28	25	14	64		41	358	9
17	26	52	26		29	65	1
73	47	29	48		45	99	1
25	82	33	28		18	58	1
18	30	30	27		25	110	3
15	10	39	45		16	70	1
47	50	47	58		39	54	1
20	36	36	34		68	223	7
24	23	27	18		22	38	1
41	20	90	58		26	172	1
15	20	18	12		32	97	4
23	15	28	48		42	123	1
30	41	29	42		50	248	5
40	34	92	34		35	57	1
15	55	19	28		22	154	12
44	30	23	25		53	76	1
15	97	31	34		23	183	1
16	26	67	22		21	75	2
30	10	16	13		27	45	1
10	35	98	16		15	65	1
59	27	19	23		23	233	1
18	40	170	40		47	66	3
34	20	38	100		12	53	1
29,06					30	115	1
					27		
		Average pick	40,09091		31,46154	5834	154
						Average package	37,88312

Tabula domestic area

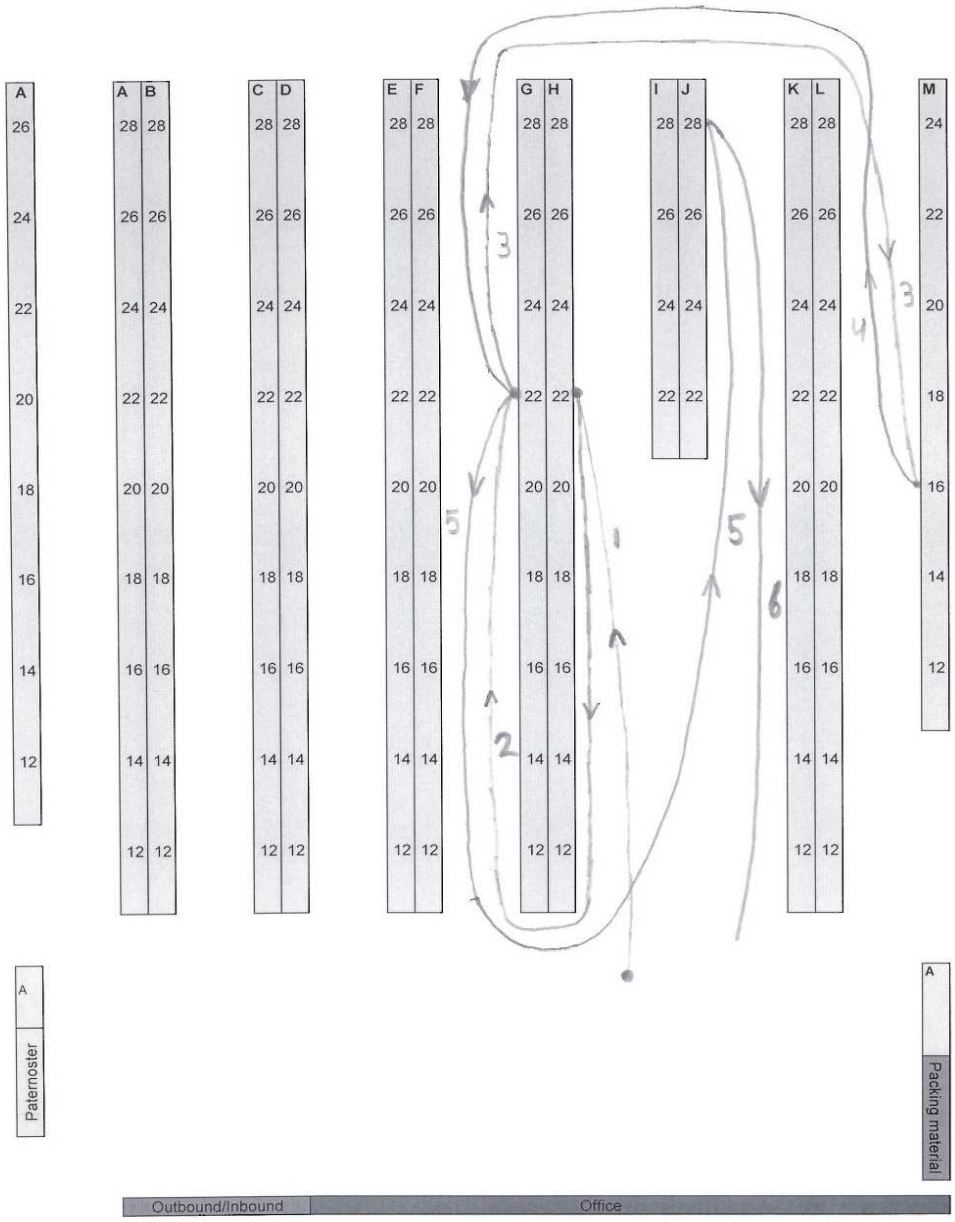
ride to	Pick			return
62	35	42	87	21
35	55	131	137	32
70	17	269	128	47
30	58	145	160	40
35	114	26	131	60
20	195	223	197	57
16	168	33	162	18
55	39	21	42	35
42	80	19	39	44
64	85	18	33	43
36	140	44	45	51
32	120	36	78	30
23	110	25	54	37
18	265	35	112	52
35	210	84	31	36
33	458	126	461	54
66	143	33	123	58
34	145	24	111	56
32	125	56	36	
23	210	213	85	42,83333
43	45	42	26	
	125	74	24	
38,28571	28	86	17	
	29	37	39	
	23	29	119	
	220	31	74	
	73	122	33	
	89	25	28	
	30	139	264	
	71	131	207	
	19	40	51	
	14	58	57	
	45	37	18	
	60	29	21	
	15	31	36	
	45	456	54	
	35	42	20	
	40	38	25	
	40	78	57	
	34	22	33	
	23	207	198	
	59	83	74	
	34	82	106	
	30	129	28	
	30	106	22	
	31	115	52	
	29	189	126	
	87	174	34	
	123	71	84	
	70	43		
	35	204		
	54	40		

Average pick: 66,33333

Appendix H Spaghetti diagram

A so-called spaghetti diagram is a helpful method to analyze the routings of order picking. This a flow charting method that uses a continuous line to outline the path of a part through the phases of order picking.

The underneath ‘spaghetti diagram’ shows a pick tour out of the Tabula export area.



Appendix I Inbound and outbound not separated

Underneath the picture gives a indication why the in-and outbound dock causes waiting times.

The picture shows that the articles en truck(s) form obstacle. Because of this the warehouse employee could not transport the finished boxes to the shipment dock. This results in finished boxes in the packaging area. This limits the space in the packaging area (see picture below).

Appendix J Research to the reliability of the inventory

To investigate the reliability/accuracy of the inventory the warehouse employees have to score the times that the administrative inventory was not equal to the physical/real inventory. In this way it is possible to identify and quantify the number of dissimilarities between the data in IFS and the real inventory. This investigation has a duration of three weeks. At this every week the forms are changed to know the score per week. Underneath the score form is showed. Because of lack of discipline of the employees it is impossible to use these data coming from this research.

	Empty location	**Not enough articles**	**Wrong article on the location**
Not available			
Available on other Location			
Where?			

Appendix K Example of storage diagram

Quantity picks per location	Row	Rack						
	A0							
TIER	12	14	16	18	20	22	24	26
09								
08								
07								
06								
05							9	
04	9	7	13	4	5	4	5	
03	159	152	284	205	232	128	50	24
02	182	261	156	55	32	117	147	52
01	180	328	303	132	65	118	134	49
Total	530	748	756	396	334	367	345	125

Explanation:
The numbers in the diagram show how many times the warehouse employees picked from that location.

Appendix L Illustration of obstacles

Explanation:
The articles in this illustration causes an obstacle in front of the racks. This is hampering a streamlined order picking process.